Oct 28th, 8:00 AM - Oct 29th, 6:00 PM

International Conference on Computer Science

University for Business and Technology - UBT

Oct 28th, 12:00 AM - Oct 29th, 12:00 AM

International Conference on Computer Science

University for Business and Technology - UBT


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International Conference is the 12th international interdisciplinary peer reviewed conference which publishes works of the scientists as well as practitioners in the area where UBT is active in Education, Research and Development. The UBT aims to implement an integrated strategy to establish itself as an internationally competitive, research-intensive institution, committed to the transfer of knowledge and the provision of a world-class education to the most talented students from all backgrounds. It is delivering different courses in science, management and technology. This year we celebrate the 21th Years Anniversary. The main perspective of the conference is to connect scientists and practitioners from different disciplines in the same place and make them be aware of the recent advancements in different research fields, and provide them with a unique forum to share their experiences. It is also the place to support the new academic staff for doing research and publish their work in international standard level. This conference consists of sub conferences in different fields: - Management, Business and Economics - Humanities and Social Sciences (Law, Political Sciences, Media and Communications) - Computer Science and Information Systems - Mechatronics, Robotics, Energy and Systems Engineering - Architecture, Integrated Design, Spatial Planning, Civil Engineering and Infrastructure - Life Sciences and Technologies (Medicine, Nursing, Pharmaceutical Sciences, Phycology, Dentistry, and Food Science),- Art Disciplines (Integrated Design, Music, Fashion, and Art). This conference is the major scientific event of the UBT. It is organizing annually and always in cooperation with the partner universities from the region and Europe. In this case as partner universities are: University of Tirana – Faculty of Economics, University of Korca. As professional partners in this conference are: Kosova Association for Control, Automation and Systems Engineering (KA – CASE), Kosova Association for Modeling and Simulation (KA – SIM), Quality Kosova, Kosova Association for Management. This conference is sponsored by EUROSIM - The European Association of Simulation. We have to thank all Authors, partners, sponsors and also the conference organizing team making this event a real international scientific event. This year we have more application, participants and publication than last year.

Congratulation!

Edmond

Hajrizi, Rector of UBT and Chair of IC – BTI 2023

Content

Development of the application for cinema management with .net technology

Enise Hasanaj[1*], and Lavdim Beqiri[2]

[1]Kosovar, Peja, Kosova
eh47364@ubt-uni.net

[2] Kosovar, Peja, Kosova
lavdim.beqiri@ubt-uni.net

Abstract. The research discusses an internet platform dedicated to cinema management. The platform is built upon two key components: the user-facing part and the backend operations. The visual part, also known as the Frontend in the programming world, is developed using technologies such as HTML, CSS, and JavaScript, offering a simple and user-friendly interface. On the other hand, the server or backend where modifications and updates are made is built using ASP MVC Core and the C# programming language. For data management, SQL Server is used, which facilitates the staff's work in storing and accessing cinema-related information.

Overall, this system allows the administration to have complete control over all cinema functions. Responsibilities are divided among the main administrator, manager, and receptionist, making interaction with customers easier and more efficient. The platform primarily focuses on managing movie titles, screening rooms, movie schedules, reservations, ticket sales, and user management, providing a comprehensive solution for all these needs.

This online interface offers easy and quick access for both staff and customers to obtain the desired information. Another important advantage is that it helps minimize errors that can occur during various processes while significantly reducing operational costs. This platform is designed to be accessible by all team members, from the super-administrator who configures all system parameters to the customers who want to watch a movie, making the cinema available online 24/7.

Keywords: Internet platform, User-facing, Frontend, HTML, CSS, JavaScript, Backend operations, ASP MVC Core, C# programming language, Data management, SQL Server, Administration, Online interface.

1. Introduction

The cinema management system is an online platform built upon Microsoft technology, known as ASP.NET MVC Core and is coded in the C# language. This platform is adaptable and compatible with various browsers and different operating systems. This digital platform provides a convenient way to oversee and coordinate all actions and operations within a cinema, simplifying and automating many daily tasks, contributing to reducing the amount of work required to run the cinema. ((ZHANG, 2006)) It is a valuable tool for having comprehensive oversight and a unified intervention in all actions and activities taking place in the cinema environment. The platform for managing cinema operations is built upon a range of advanced technologies and tools. Here are the technologies and programming languages used to construct and optimize this system:

- Programming language C#
- Development framework ASP.NET Core MVC
- SQL database management system
- Object-relational mapping framework, Entity Framework
- Interface development languages, such as HTML, CSS, and JavaScript
- The library used for JavaScript manipulation is jQuery

- The stylistic and responsive framework, Bootstrap, for user interaction interfaces.

To effectively implement and manage these technologies, specific tools provided by Microsoft were used, which are:

- Development environment Visual Studio 2019
  - Environment for managing and interacting with the database: Microsoft SQL Server Management Studio 18.

2. Analysis of the application

The application's structure is built upon a three-tier model, where each tier has its specific functions and responsibilities, thus simplifying and segregating responsibilities into different logical and physical layers. This structural model is well-known and frequently used in software development, especially in those following the client-server model. This architecture aids in performance optimization by separating the application's logic in a way that each layer focuses solely on what it does best, and this segregation facilitates faster and more robust application development.

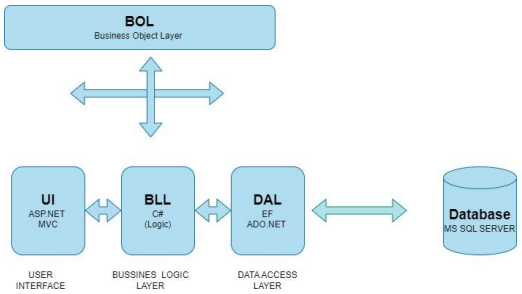

Fig 1. Application architecture

2.1 What is the 3-tier architecture?

The three-tier architecture is a well-structured and organized approach to software development, which is divided into three fundamental levels encompassing different aspects of the application. This division includes: the user interface level, responsible for displaying and user interaction with the application; the application logic level, where data processing and business logic occur; and finally, the data storage level, dedicated to storing, managing, and protecting the application's data. This approach offers a clear segregation of responsibilities and facilitates the management and expansion of the application in the future. (Cloud, 2001) Among the most evident advantages of the three-tier model is the ability to treat each level as an independent entity within the application's infrastructure. This separation consists of:

- The user interface level, which directly relates to how users view and interact with the software.
- The application logic level, where fundamental operations and business decision-making occur.
- And the data level, responsible for storing and managing information. (Hu, 2003)

With this structure, each layer can be treated as an independent project. This means that one development team might work on the user interface while another could focus on the application logic and another on data storage. Furthermore, changes or improvements to one layer can be made without significantly affecting the other layers, allowing for quick adaptation to changing needs or new technologies. This provides flexibility in development and maintenance of the software, making updates, expansions, or necessary changes without disruption or consequence to other parts of the application.

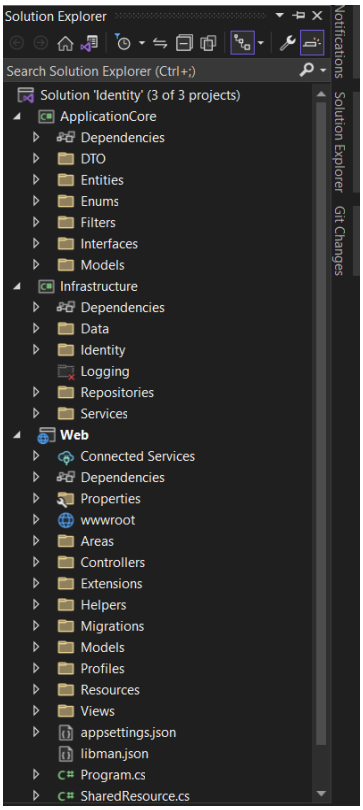

Fig 2. Project structure

The figure above illustrates the construction and organization of the project. This project is divided and structured into three main components:

Application Core - This is the heart of the application and contains the main logic and fundamental functionalities that determine how the application will operate.

Infrastructure - This component is responsible for connecting and integrating various technical resources, such as databases, external services, or any other tool that might be necessary for the proper functioning of the application.

Web - This part represents the interface and visual portion of the application, allowing users to interact and benefit from the functionalities the application offers.

This, dividing the project into these three components ensures that each part has its clear role and responsibility, enabling better management and more effective code development.

2.2 Details of the three layers

Presentation Layer- The layer that is directly experienced by the user is called the presentation layer. It serves as a "contact" between the user and the system and is responsible for presenting data and information in a clear and usable manner. This is where users can see, interact with, and provide feedback on the information presented by the application.

Primarily established to offer a visual and interactive experience for the user, this layer can be realized through a web interface, a desktop application, or an interactive graphical interface, otherwise known as GUI. When it comes to web interfaces, the most common technologies used to construct and style these interfaces are HTML for the structure, CSS for styling, and JavaScript for interaction and dynamics. Everything is designed to ensure a seamless and usable interaction between the user and the application. (IBM Cloud, 2021)

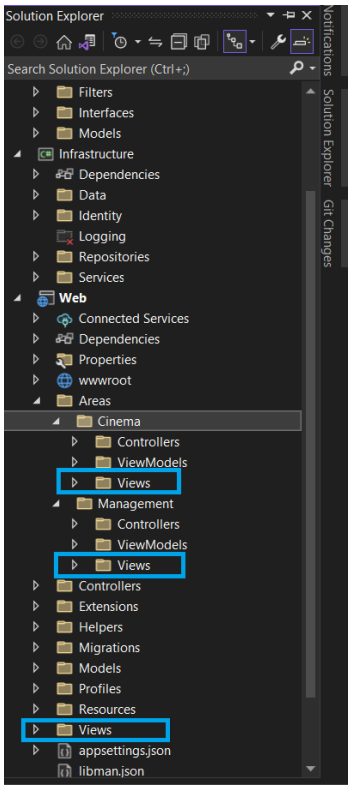

Fig 3. Presentation Layer

The figure shows details of the presentation layer, which I have named "Web". This is the section where information is structured and provided for viewing on a web page. More specifically, the presentation layer is further divided into several sub-layers, each having their specific functions and roles within the application.

These sub-layers are as follows:

User Management Sub-layer: This part is dedicated to the features and interfaces needed for users who are part of the management, providing them with tools and information specific to their role.

Customer Sub-layer: This section is focused on the interaction of customers with the platform, offering them a suitable and easy-to-use experience.

Common Sub-layer: This includes functionalities that are common and necessary for all users, such as authentication and identification processes on the website.

This detailed division and specification help us better understand how information and interactions are organized and provided for the various users of the application.

The application layer-also known as the business logic layer or the middleware layer, is the primary point of interaction and data processing within a computer system. It acts as a mediator between what the user sees and interacts with in the presentation layer and the data stored and managed in the database or the corresponding data layer.

In this area, data received from the user interface is processed and analyzed using a set of rules and logic specific to the application. This includes actions such as validating information, processing various requests, and interacting with the database to perform operations like adding, modifying, or deleting data.

This layer is crucial to ensure the application operates correctly, adhering to all business rules and requirements, and ensuring data is used and processed accurately and efficiently.

The data layer-also known as the primary information store or the data storage center, is the point where all application information is stored and managed. This layer often resides in a database management system, which might be of the relational type such as, for example, Oracle, MySQL, PostgreSQL, MariaDB, or Microsoft SQL Server. However, in cases where the data is less structured and more scalable, a NoSQL database like MongoDB, Cassandra, or CouchDB might be the appropriate solution. (IBM Cloud, 2021)

In a three-tier architecture, communication between the presentation layer and the data layer doesn't occur directly. Instead, every request and response must pass through the application layer, which acts as a mediator, ensuring all data is processed and validated before being stored or presented to the user. This strict separation aids in data protection and ensures the integrity of the information throughout the application. (IBM Cloud, 2021)

2.3 Functional and non-functional requirements

When it comes to building software, it's essential to understand and define the requirements it needs to meet. These requirements assist in determining what the software should do and how it should operate. Typically, these requirements are categorized into two main groups:

Functional Requirements: These are specifications that outline the primary functions and operations that software should provide. They are directly related to the actions and features that the software needs to perform, considering the needs and expectations of its users. This includes, for example, actions like creating an account, modifying a record, or searching for data.

Non-Functional Requirements: While functional requirements determine "what" the software does, non-functional requirements define "how" it performs those tasks. They relate to the quality and performance of the software. This might encompass issues such as how fast an application is, how secure it is from external attacks, or how the software scales when there's a large number of users.

For a more detailed overview of these requirements, I have presented them in a table where they are listed and described in detail.

Table 1. Functional requirement

Category	Functional requirement
Movie	Complete movie registration details Updating movie information Deleting the movie from the database Sorting and filtering movies
Schedules	Updating the schedule's information Deletion of the schedule lists Organizing and filtering the schedule Registration of the schedule for the entire week
Clients	Registration of the client with complete details Reverification and updating of client information

	Removal of a client from the system Organization, searching, and filtering of the client list Client subscriptions Client reservations Viewing the ticket history Changes and updates in the client's profile
Halls	Registration of a new hall with all its dimensions Modification and updating of the hall's information Removal of a hall from the system Management and organization of the halls
Tickets	The capacity to create or generate tickets. The tools to modify or update tickets. The ability to remove or delete tickets. The tools to organize and filter tickets.
Booking	The capacity to make a reservation by selecting the client, schedule, and seat location. The option to review and modify the information of a reservation. The action to remove or cancel an existing reservation. Tools that allow specific sorting and searching of reservations.
The manager	The ability to analyze and view statistical data. The capacity to produce and extract various reports. The option to change and refresh details of the personal profile
Administrators	The capacity to oversee and control financial transactions and payments. The ability to administer and modify ticket information. The option to coordinate and manage hall details. The activity of managing subscriptions and their benefits. The responsibility to organize and change movie data.

	• The possibility to create, modify, and manage various events. • The capacity to monitor and manage clients and their data. • The ability to plan and update schedules. • The option to change and refresh personal profile details.
SuperAdmin	• The ability to oversee and manage all aspects of the system. • Clear and unrestricted access to all functionalities and data of the system. • The capacity to control and manage all users and their roles within the system.
Roles	• The system consists of five user categories: the Client, the Manager, the Administrator, the Receptionist, and the Super Admin. • Responsibilities and access to the system should be divided and determined based on the specific role of each user. • A tailored interface is presented to the user based on their credentials during authentication.

The receptionist	• The capacity to administer and coordinate reservations. • The ability to register new clients in the system. • The option to create and issue tickets. • The activity of modifying and refreshing personal profile data.
Statistics	• All data related to the specific functions of the cinema are recorded and stored automatically. • The data is stored in a format that is suitable for analysis and creating statistics. • Automatic generation of reports and charts based on the gathered data for each functional section of the cinema is allowed.

Table 2. Non-functional requirements

Category	**Non-functional requirements**
Interface	• The user interface should provide familiar and intuitive functionalities for users, allowing for a simple and efficient use. The content and text presented on the interface should be clear and straightforward, ensuring that the user receives the intended message without any ambiguity. It is important for the interface to be "user-friendly", offering an impeccable user experience free from unnecessary

	complications. This assists in the intuitive and comfortable use of the application.
Software Specifications	• It is recommended to choose SQL Server as the base data platform for storage and management of information. This will ensure stability and high performance in data storage.
Availability	• It is expected that the system will be available and operational without interruption at all times, offering uninterrupted access 24 hours a day and 7 days a week. • Data preservation and recovery measures should be fortified and of high maturity, with a clear strategy for backup and restoration of the database. This aims to minimize the risk of information loss and reduce potential periods of application service interruption.

Performance	• It is essential that the system manages and stores a considerable amount of movies and clients efficiently, ensuring that there will be no interruptions or defects during operation. • When specific information is requested, the system's response time to display the data on the user interface should be fast and optimal, not exceeding a threshold of 3 seconds.
Safety	• The system is configured to accommodate different categories of users, and for each of them, there are specific levels of authorization and access. • Every transaction and communication within the system must offer a high level of security, relying on the most advanced and current technologies in the field of data security. • User passwords should be processed and stored in an encrypted (hash) manner, ensuring protection from unauthorized access. • The Super Admin figure will have the authority and capacity to intervene and manage all aspects of the system, allowing them to resolve any issue or problem that may arise.

2.4 Diagrams

Use Case diagram is an important tool for focusing on the main functionalities and the way users interact with a system or application. This diagram illustrates the primary behavior and functions of an application, reflecting

specific use cases and the actors that interact with them. Through it, a clear picture is created of what the user can do with the system and how the system responds to these requests. ((Gemino, 2009)

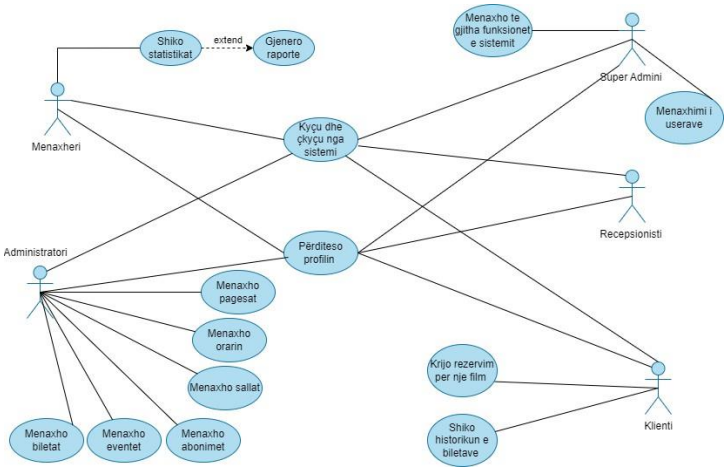

Figure 1: Use Case Diagram

The figure presents the Use Case Diagram for the entire system platform. Analyzing this diagram indicates that different users have varying levels of access and interaction depending on their function or role within the system. Meanwhile, there are five categories of users: four of them are responsible for managing and directing the system, while the fifth category is dedicated to clients who use the services provided by this system.

Class Diagram In the field of software engineering, a class diagram based on the Unified Modeling Language (UML) is a tool that represents the static construction and organization of a system. This diagram provides a detailed view of the structure of an application or system, revealing the classes that compose it, the specific features or attributes pertaining to each class, the functions or methods they perform, and the connections and relationships that exist between them. It is a visual representation that helps developers better understand and organize the interconnected components of the system they are building.

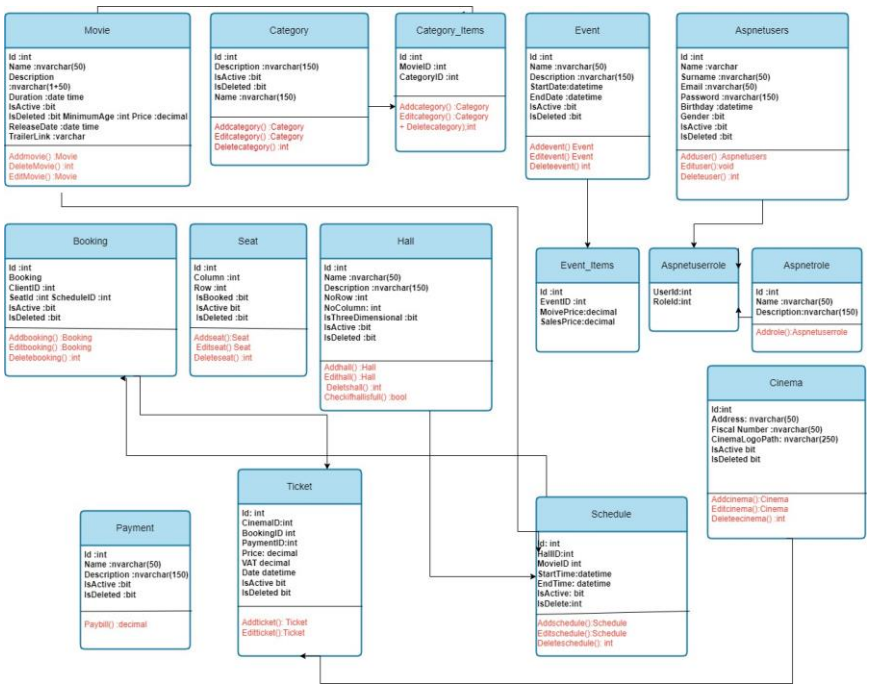

Figure 6. Class diagram

In the figure, the class structure diagram of the system is presented, revealing their fundamental components, such as the features and functions they include. This visualization brings out the interactions and connections between these classes, offering a clear view of how they are organized and interact within the overall system structure

The Entity Relationship Diagram visualizes how data is connected and structured amongst themselves. An entity represents a distinct unit or component of information. When we talk about a group of entities, we refer to a series of units with similar characteristics and features. Each entity is described by specific attributes that define its features or specifications.

By clarifying these entities and their connections, the diagram conveys a picture of the data's organization and interaction within a system. This type of diagram is a key tool to assist developers in building and optimizing a database structure

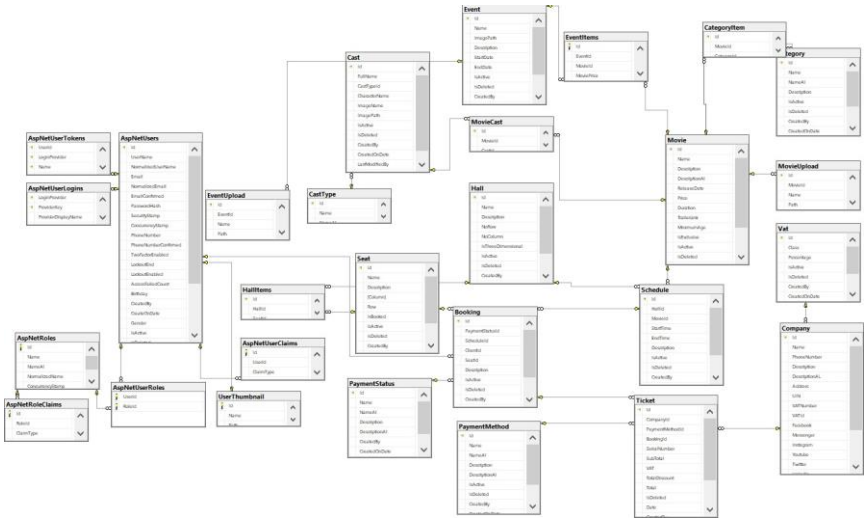

Figure 7: Entity Relationship Diagram

In this figure, the basic structure of the application's database is presented, where tables, along with their distinct characteristics, are distributed and connected. These reflective connections can be unique, multiple, or inverse, creating a network of links between the tables. This provides a clear understanding of how data interacts and is organized within the database system.

2.5 Configuration

The process of structuring the application is the responsibility of the super-administrator and includes three essential phases:

Setting the company parameters

Configuring the connections with social networks Determining and configuring the system parameters.

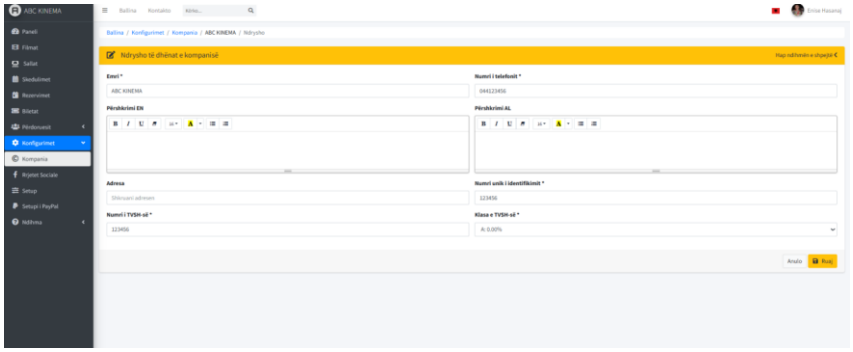

Figure 8: Setting the company parameters (Configuration)

In the figure, you can see the interface for entering the company's data, which will be the basis for calculating and invoicing tickets.

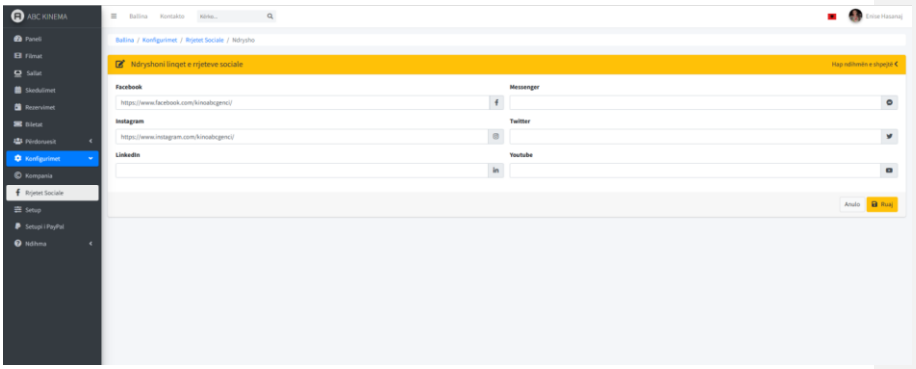

Figure 9: Configuring connections with social networks (Configuration of all social networks)

The figure displays the interface for setting up social network connections. These connections will be visible to clients in their interface.

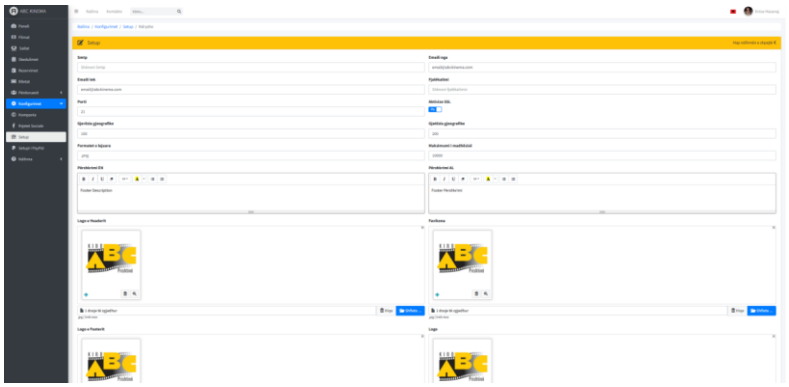

Figure 10: Determining and configuring the system parameters

The figure shows the interface where technical data for configuration is required. This includes details such as the SMTP server data for transmitting electronic messages, the geographical location of the company on the map, the file extensions that can be uploaded, the maximum upload capacity, the description and emblems of the company, and more.

3. RESULTS

After dividing the application into three main components - the part dedicated to management, the part addressing client needs, and the part functioning as a common platform for all functions - it's important to emphasize that this separation was done with the intent of optimizing and personalizing the experience for different users. Considering this division, below I have presented the visual aspect of each of these components, illustrating their interaction and specific function within the application's structure.

3.1 Management Part

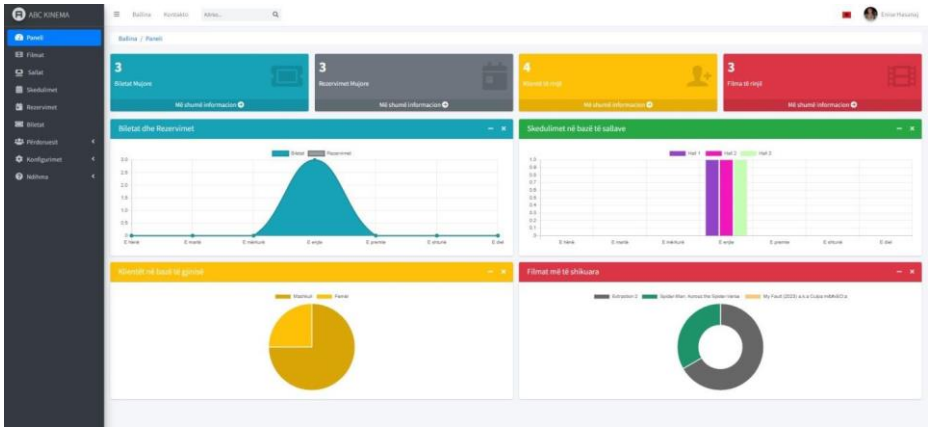

Figure 11: Control and Statistics Interface

In the figure, the control and statistics section is presented, which is an interface that allows managers and authorized users to view and analyze data in graphical and numerical form. This interface provides a clear overview of the system's performance, helping users make informed decisions based on concrete data.

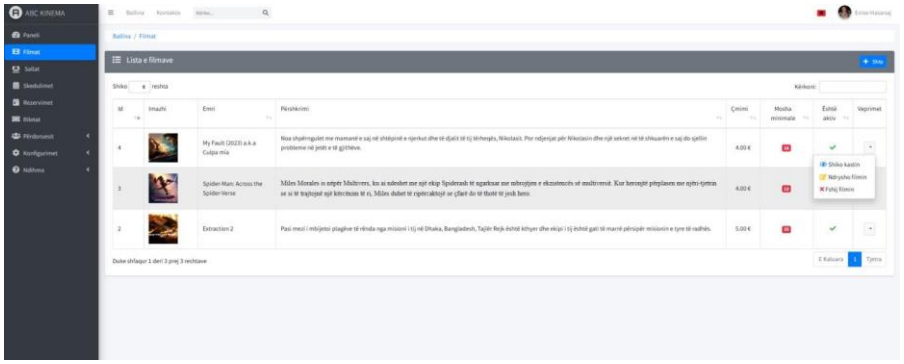

Figure 12: List of Movies

In this interface, there is a structured list of movies and their main details. For each movie, an image is displayed reflecting its content or the main scene, accompanied by a short description giving viewers a clear idea of what to expect from the movie. The movie's name is prominently displayed, while other details, such as the ticket price and the recommended viewer age, are clearly marked. Additionally, there's an indicator showing whether the movie is currently being shown or not. At the end of each row, there are additional options that allow actions such as editing, deleting, or adding new information for the specific movie.

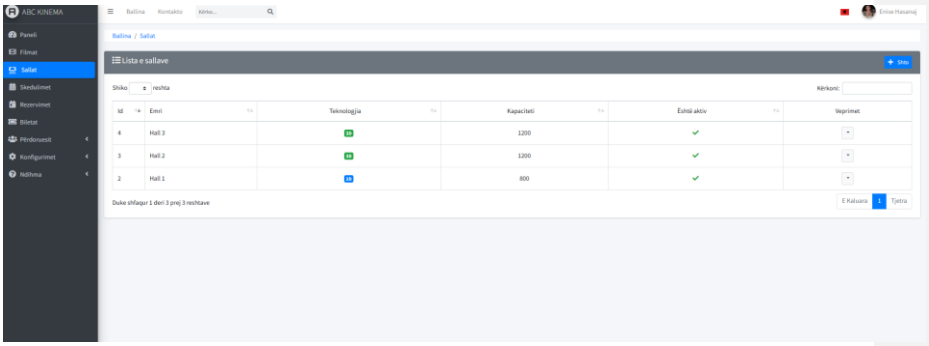

Figure 13: List of Halls

In this interface, a detailed list of halls and their specifications can be seen. For each hall, its name is clearly highlighted followed by the movie projection technology in 2D or 3D format. Next, the capacity of the hall shows the number of seats available for the audience. Also, a visual indicator shows whether the hall is currently active and available for screenings or not. For each hall, there are options available that offer the possibility to change the hall's data or, in certain cases, to delete the hall from the system.

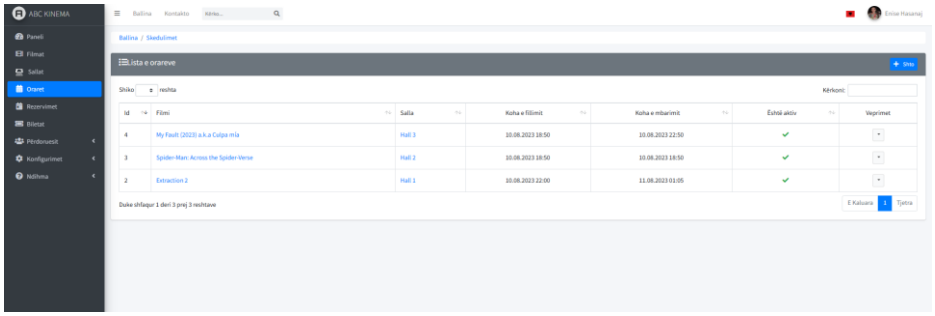

Figure 14: Schedule List

In this figure, a list of movie screening schedules and their specifications is displayed. For each screening, the movie title that will be shown is emphasized first. Subsequently, details about the hall where the movie will be screened are provided, giving an idea about the ambiance and the technology used. The start time of the movie screening is highlighted with the exact date and hour. Following that, comes the end time of the movie, indicating its duration. An indicator shows whether the movie screening is active or not. Additionally, options are integrated that allow changes to the schedules or other related data, as well as the ability to modify or delete schedules from the system

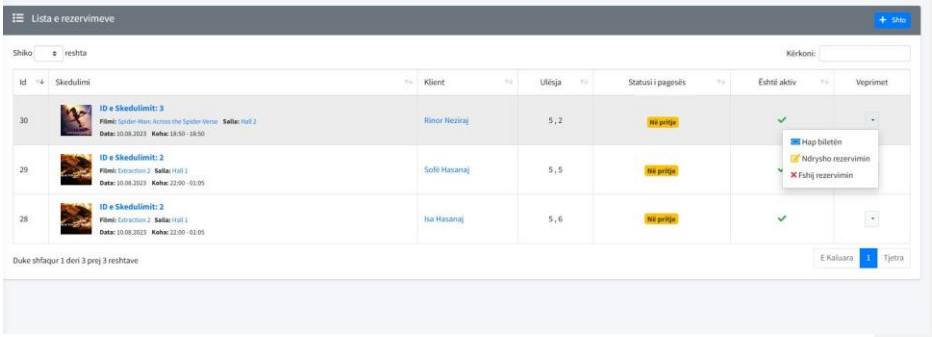

Figure 15: List of Reservations

In this figure, a detailed overview of reservations and the accompanying data is presented. Each reservation has an identifier known as "Reservation ID". This identifier is linked to specific details such as: the movie that's been reserved, the hall it will be screened in, as well as the date and time of the screening. The client who made the reservation is highlighted by name. On this list, users can also see the seat chosen by the client and the payment status, which can indicate whether the payment is still pending or has been completed. This list also provides information regarding the reservation's activity - whether it's still valid or not. To conclude, users have several options at their disposal to intervene in the reservation, including generating the ticket, modifying the reservation, or deleting it

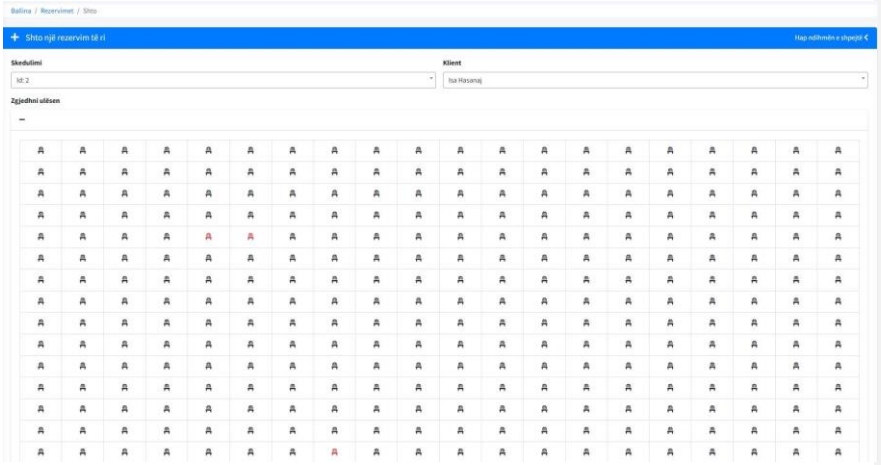

Figure 16: Interface for Adding Reservations

In this figure, the interface for adding reservations is displayed. All users who are part of the staff can access it. When clicking on "Add Reservation", the movie's ID and the name of the client wanting to make a reservation are shown. Also, the seat selection for the client is facilitated. Seats that are already reserved are displayed in red, while the available seats are marked in gray

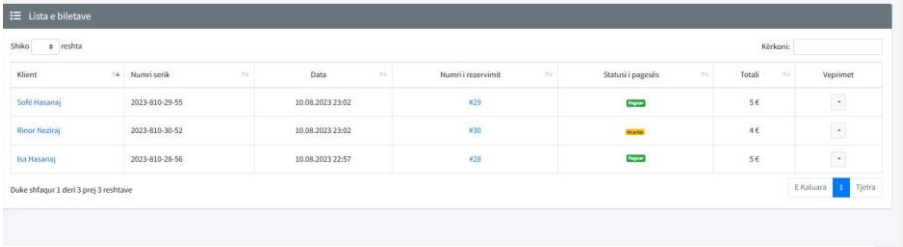

Figure 17: List of Tickets

In this figure, a list of tickets and their corresponding details is presented. Each displayed ticket has several essential pieces of information. This includes the name of the client who purchased the ticket, a serial number that uniquely identifies the ticket, the date and time when the ticket was issued, and a number associated with the anticipated reservation. The payment status is a key component of the list, indicating whether the ticket has been fully paid for or is still awaiting payment completion. The total amount paid or due is also highlighted. Lastly, users have several options available to intervene or take additional actions regarding the ticket, whether through modifications, verifications, or other action

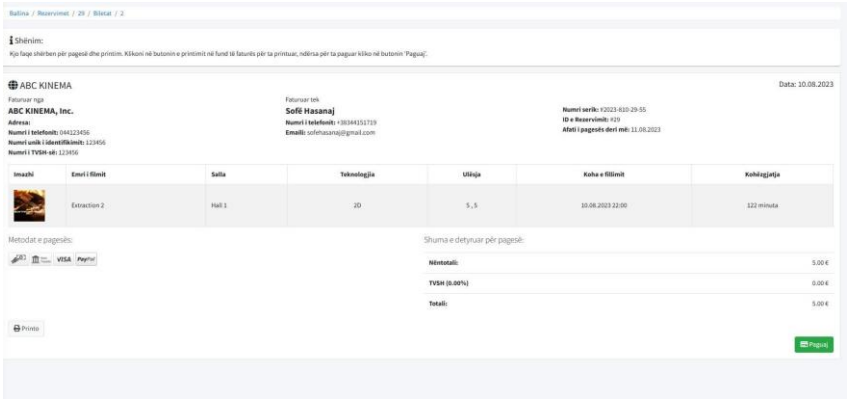

Figure 18: Ticket Generation

In this figure, ticket generation for all staff members is presented. They can generate a ticket, where during this ticket generation process all the cinema's details and the data of the client who made the reservation are displayed. A portion of the ticket displays the ticket's serial number, the reservation ID, and the payment deadline. Also, information about the movie the client has chosen to watch is presented, including elements like the movie poster image, the movie's name, the hall the client has chosen, and the selected technology for viewing the movie (2D or 3D). Additionally, the ticket is attached with information about the number and the seat chosen by the client, as well as the start and end times of the movie screening. Also, on the ticket, there is a payment option where users have several possible payment methods such as cash, Visa card, and PayPal, presented on the right side of the ticket. The obligated payment amount is clearly displayed, along with other options. Besides the aforementioned details, the ticket also displays an option to print the ticket.

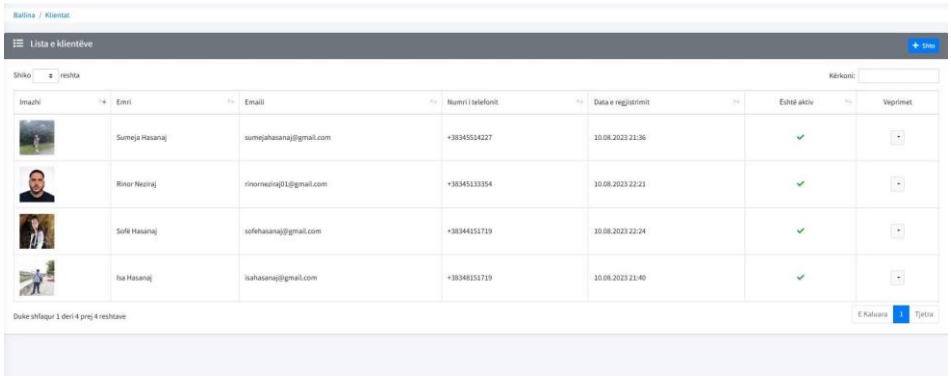

Figure 19: Client List

In this figure, an overview of clients and their defining data is seen. Each client on this list is identified through several key elements. Besides the client's image which offers visual identification, the first and last name are emphasized for quick recognition. The email and phone number provide means of communication with the client. The registration date indicates when the client first joined the service or platform. Additionally, the client's activity status is displayed to show whether their account is active or not. For each client, there are options for intervention or further modifications, which may include changes to their data or the deletion of their account

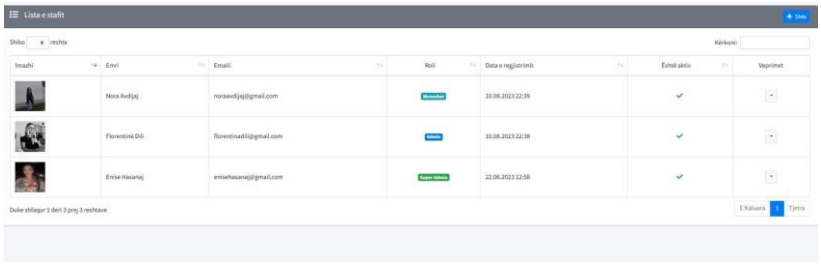

Figure 20: Staff List

In this figure, a comprehensive list of staff members and their specifics is displayed. Each member is represented with a photo that aids in quick visual recognition. The first and last names are clearly displayed for recognizing each staff individual. The email address assists in electronic identification and communication with them. Furthermore, the role of each member is specified, indicating which position they occupy, such as admin, superadmin, receptionist, or manager. The registration date has its significance, indicating when this member joined the team. Information about status indicates whether that staff member's profile is currently active or not. Additionally, there are options to intervene in each member's profile, altering or updating it as needed

3.2 Pjesa e klientit

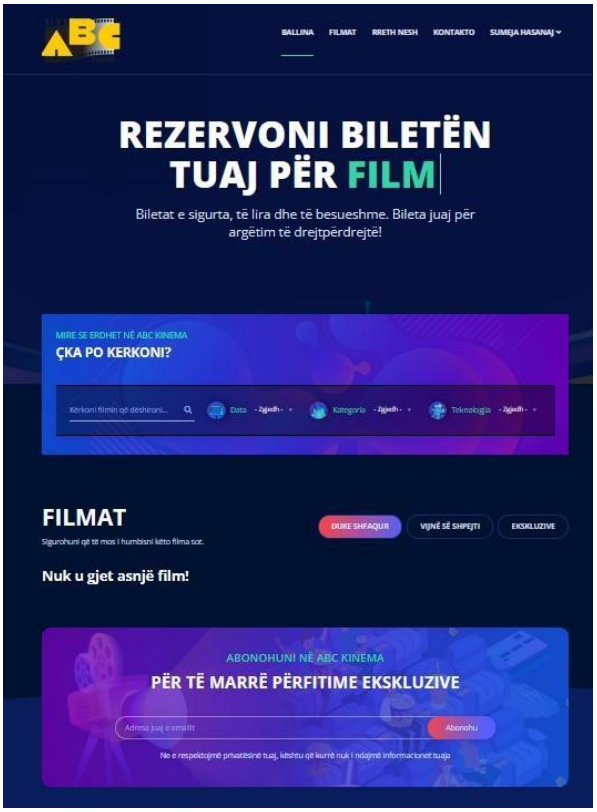

Figure 21: Main Homepage

On the system's homepage, the client is presented with an attractive and functional interface that aids in simple and quick navigation. Upon entering the system, the first thing that catches the eye is a central section where several motivational quotes or brief information about the latest movies and suggestions to make a ticket reservation are placed.

Furthermore, a search engine is integrated. Clients can directly search for the movies they have in mind by typing the movie title or part of it. This facilitates a faster and clearer use of the platform.

On the right side of the screen, a special section is dedicated to upcoming movies in the cinema. This helps clients consider and plan their upcoming cinema visits.

One of the most distinctive features of the interface is the "subscribe" or subscription option. Clients who choose to subscribe can enjoy a range of exclusive advantages and benefits on the platform, such as discounts, early information on movie premieres, or special offers. On the main homepage interface, at the top, a structured horizontal menu offers straightforward navigation for the user. Following the "Home" option is the "Movies" option. When the user clicks on it, they are directed to a page where all the movies offered by the cinema are displayed. Movies can be sorted by release date, popularity, or category, and descriptions and showtimes can be viewed.

Next in the menu is the "About Us" option. This section provides a detailed overview of the

platform and its history, mission, and vision, as well as other information that can help clients familiarize themselves better with the company and the services it offers.

The "Contact" option is for users wishing to communicate with the cinema staff. This page may contain a form for sending messages, contact details like phone numbers, email address, and the cinema's physical address.

At the end of the menu, the "Join Us" or "Sign Up" option is crucial for new clients. Clicking on it takes them to a page where they can create an account and benefit from all the platform's features.

This complete and well-organized menu ensures that every client can easily find what they are looking for and benefit from a rich and swift experience on the cinema platform.

Through this interface, clients feel welcomed and informed, being offered an excellent and unparalleled user experience on this cinema platform.

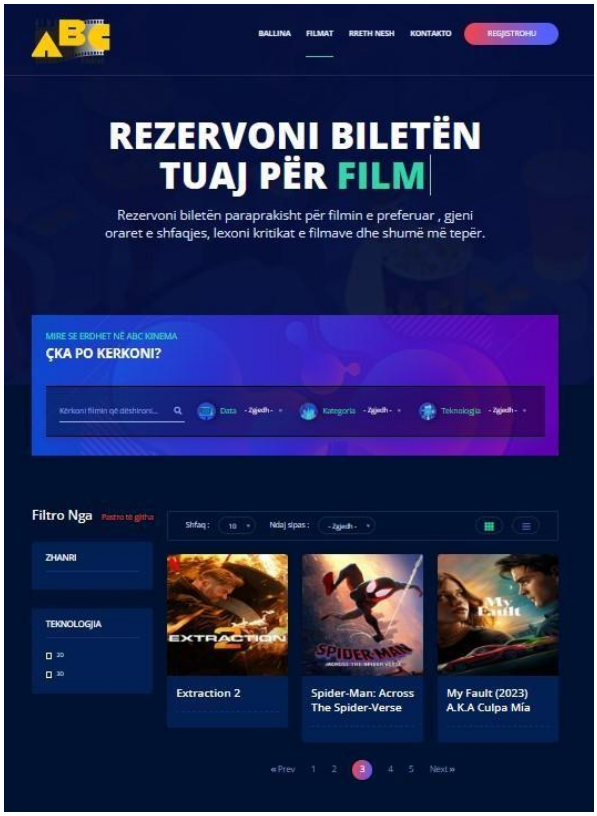

Figure 22: Movie Interface

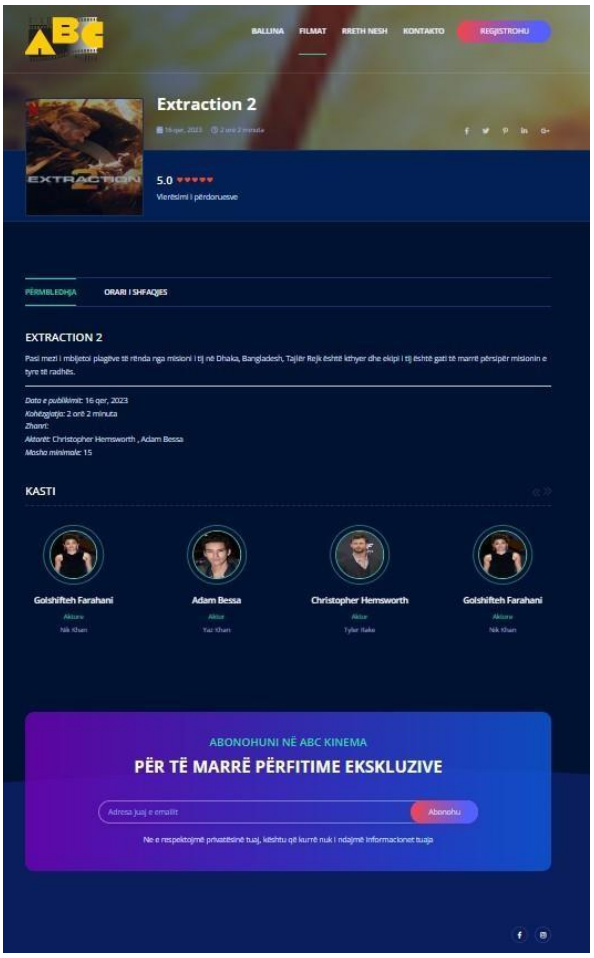

Figure 23: Movie Details

In the "Movies" menu option, users have the opportunity to explore the films offered by the cinema. When selecting a specific movie from the list, they are directed to a detailed page for that film. On this detailed page, at the top, the movie's name is displayed. Also prominently placed is an image of the film, usually the official poster or a primary scene. Below the image, users can see the genre of the film, which could be, for instance, action, drama, comedy, etc.

The release date and duration of the movie are situated in a separate section, giving users a clear idea of when the movie was released and its length.

The movie's description is located in a distinct part, usually below the main image or to its right. This description provides a brief overview of the film's main events and themes without giving away any spoilers.

In another section, the recommended age for viewing the film is displayed, assisting parents in making informed decisions about whether their children should watch the movie.

At the bottom of the page, a section is dedicated to the actors and the main crew involved in the film. Here, the names of the main actors are shown, and in some cases, their photographs, as well as the roles they play in the movie.

This detailed page offers a comprehensive overview to engage users and inform them about

various aspects of the movie before deciding to watch it in the cinema.

3.3 Common Parts

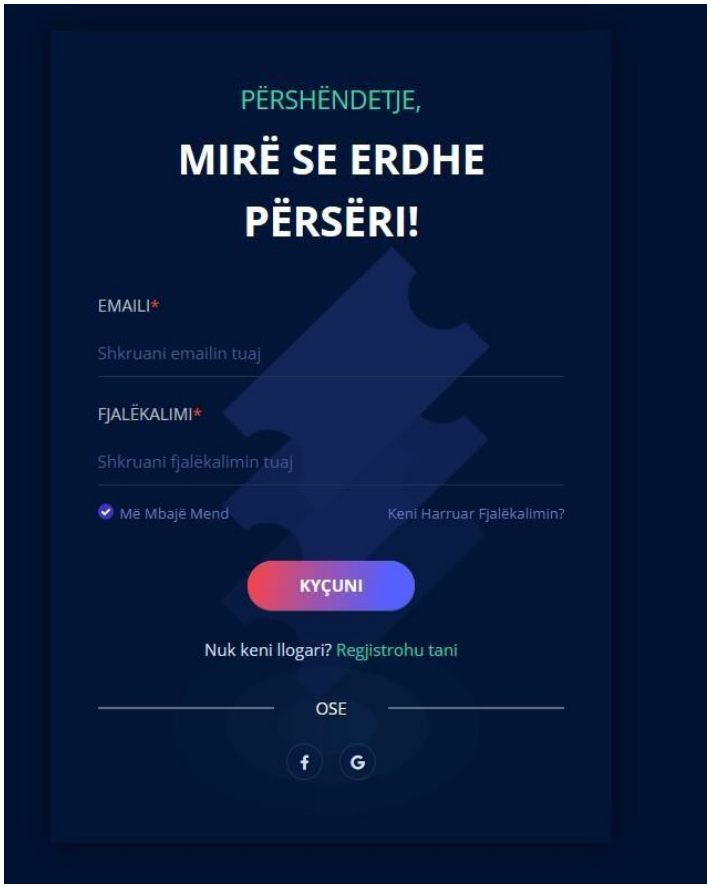

Figure 24: Login

In this figure, we see a user authentication interface. This interface is designed in a simple and effective manner, where users have the option to log into the system using their previously registered personal data. However, for those who want a faster and more secure method, there's also the option to authenticate using their Facebook or Google accounts. This offers an alternative and easy route for users who don't want to type in their credentials every time they wish to access the application.

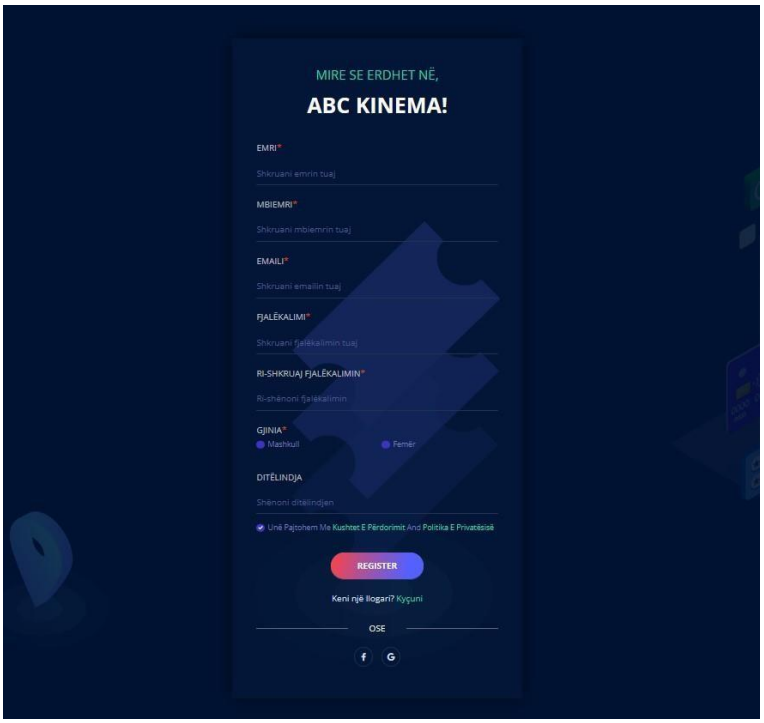

Figure 25: Registration

In this figure, an interface dedicated to creating a new account in the system is presented. The interface offers a simple and intuitive way to register the user's basic information. In addition to the possibility of using existing data from Facebook or Google accounts, users have the option to fill out manual fields such as: first name, last name, email, and password. An important feature of this form is the requirement to enter the password twice, a step that ensures users are aware of their choice and prevents potential mistakes. Additionally, the interface requests the user to specify their gender and date of birth, helping in creating a more complete and personalized user profile

4. Conclusion

Through the development of this project, I have reached a digital solution that assists us in managing all operations within the cinema, in an impeccable manner. This new technology allows us to coordinate and control all aspects of film operations with ease, while simultaneously reducing the workload within the work environment and contributing to the simplification of all procedures.

This project serves as an advanced tool to optimize and automate all processes. It provides us with a comprehensive solution for management, enabling control over every aspect of operations taking place within the cinema. From ticket purchases to the organization of screenings, from monitoring variable inventory to coordinating staff, this innovative platform offers stable and clear real-time control.

One of the main advantages of this project is its ability to enhance the quality of operations through the automation of routine tasks. This not only eases the workload for cinema staff but also increases the overall efficiency and precision of processes. Moreover, this project aids in creating a more refined experience for cinema customers, as the time and resources taken for management are used more intelligently and effectively.

In conclusion, this digital management solution offers us the opportunity to increase efficiency and control in all spheres of the cinema. From organizing daily tasks to achieving long-term strategic goals, this innovative platform brings about a significant change in the way we operate. This is not just technology, but a trustworthy partner that aids in the growth and success of your film business.

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APPENDICES

Project\Web\Startup.cs

```
using System; using Web.Models;
```

```
using Microsoft.AspNetCore.Builder; using
Microsoft.AspNetCore.Hosting; using
Microsoft.AspNetCore.Http; using
Microsoft.AspNetCore.Identity; using
Microsoft.AspNetCore.Mvc; using
Microsoft.EntityFrameworkCore;
using Microsoft.Extensions.Configuration;
using Microsoft.Extensions.DependencyInjection; using
Microsoft.Extensions.Hosting;
using Infrastructure.Identity; using
ApplicationCore.Entities; using
ApplicationCore.Interfaces; using
Infrastructure.Services; usingInfrastructure.Repositories;
using Microsoft.AspNetCore.Mvc.Razor; using
System.Globalization;
using Microsoft.AspNetCore.Localization; using
System.Collections.Generic;
usingMicrosoft.Extensions.Options; using AutoMapper;
usingMicrosoft.Extensions.Localization; using Web.Helpers;
using Rotativa.AspNetCore;

namespace Web {
    public class Startup {
        public Startup(IConfiguration configuration) { Configuration = configuration;
        }

        public IConfiguration Configuration { get; }

        // This method gets called by the runtime. Use this method to add services to the container.
        public void ConfigureServices(IServiceCollection services)
    {
        services.Configure < RequestLocalizationOptions > (options => { var en = new CultureInfo("en-US");
            en.NumberFormat.NumberDecimalSeparator = "."; en.DateTimeFormat.ShortDatePattern =
            "dd/MM/yyyy"; en.DateTimeFormat.LongTimePattern = "dd/MM/yyyy";
            en.DateTimeFormat.ShortTimePattern = "HH:mm"; en.DateTimeFormat.LongTimePattern =
            "HH:mm";
            var al = new CultureInfo("sq-AL"); al.DateTimeFormat.ShortDatePattern = "dd.MM.yyyy";
            al.DateTimeFormat.LongTimePattern = "dd.MM.yyyy"; al.DateTimeFormat.ShortTimePattern =
            "HH:mm"; al.DateTimeFormat.LongTimePattern = "HH:mm";
            al.NumberFormat.NumberDecimalSeparator = ".";

            var supportedCultures = new []
            {
                en,
                    al
            };

            options.DefaultRequestCulture = new RequestCulture(en, en); options.SupportedCultures =
            supportedCultures; options.SupportedUICultures = supportedCultures;

});

        services.Configure < CookiePolicyOptions > (options => {
            // This lambda determines whether user consent for non- essential cookies is needed for a
    given request.
            options.CheckConsentNeeded = context => false; // was true options.MinimumSameSitePolicy = SameSiteMode.None;
```

```
        });

        services.Configure < CookieTempDataProviderOptions > (options
=> {
            options.Cookie.IsEssential = true;
        });

        services.AddSession(options => { options.Cookie.IsEssential = true;
        });

        services.AddAuthentication()
            .AddFacebook(facebookOptions => {
                facebookOptions.AppId                                                    =
Configuration["Authentication:Facebook:AppId"];
                facebookOptions.AppSecret                                                =
Configuration["Authentication:Facebook:AppSecret"];
                facebookOptions.Scope.Add("public_profile"); facebookOptions.Scope.Add("email");
                //facebookOptions.ClaimActions.MapJsonKey("firstName",
"first_name");
                //facebookOptions.ClaimActions.MapJsonKey("lastName",
"last_name");
                //facebookOptions.ClaimActions.MapJsonKey("birthday",
"birthday");
                //facebookOptions.ClaimActions.MapJsonKey("gender",
"gender");
            })
            .AddGoogle(googleOptions => {
                googleOptions.ClientId                                                   =
Configuration["Authentication:Google:ClientId"];
                googleOptions.ClientSecret                                               =
Configuration["Authentication:Google:ClientSecret"];
            });

        services.AddDbContext < ApplicationDbContext > (options =>

options.UseSqlServer(Configuration.GetConnectionString("DefaultConnecti on")));

        services.AddDbContext < ApplicationDBContext > (options =>

options.UseSqlServer(Configuration.GetConnectionString("DefaultConnecti on")));

        services.AddIdentity < ApplicationUser, ApplicationRole > ()
            .AddEntityFrameworkStores < ApplicationDbContext > ()
                .AddDefaultTokenProviders();

        services.Configure < IdentityOptions > (options => {
            // Password settings. options.Password.RequireDigit = true;
            options.Password.RequireLowercase = true;
            options.Password.RequireNonAlphanumeric = true;
            options.Password.RequireUppercase = true; options.Password.RequiredLength =
            6;
            options.Password.RequiredUniqueChars = 1;

            // Lockout settings.
            options.Lockout.DefaultLockoutTimeSpan                                       =
TimeSpan.FromMinutes(5);
            options.Lockout.MaxFailedAccessAttempts = 5; options.Lockout.AllowedForNewUsers = true;

            // User settings. options.User.AllowedUserNameCharacters=
```

```
"abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789-._@+"; options.User.RequireUniqueEmail = true;
            });

            services.AddAuthorization(option => { option.AddPolicy("SuperAdmin",  policy                          =>
policy.RequireRole("Super Admin"));
                option.AddPolicy("Admin",                                       policy                          =>
policy.RequireRole("Admin", "Super Admin"));
                option.AddPolicy("Manager",                                      policy                         =>
policy.RequireRole("Admin", "Super Admin", "Manager"));
                option.AddPolicy("Receptionist",                                        policy                  =>
policy.RequireRole("Admin", "Super Admin", "Receptionist"));
                option.AddPolicy("Client",                                       policy                         =>
policy.RequireRole("Client"));
            });

            services.ConfigureApplicationCookie(options => {
                // Cookie settings options.Cookie.HttpOnly = true;
                options.ExpireTimeSpan = TimeSpan.FromMinutes(5);

                //options.LoginPath = "/Identity/Account/Login";
                //options.AccessDeniedPath                                                                      =
"/Identity/Account/AccessDenied";
                options.SlidingExpiration = true;
            });


services.AddAutoMapper(AppDomain.CurrentDomain.GetAssemblies());


            // Add application services.
            services.AddTransient < ISelectListService, SelectListService >
();
            services.AddTransient < IEmailSender, EmailSender > (); services.AddTransient < IBookingRepository,
            BookingRepository >
();
            services.AddTransient < ICategoryRepository, CategoryRepository
> ();
            services.AddTransient < IEventRepository, EventRepository > (); services.AddTransient < IHallRepository, HallRepository >
            (); services.AddTransient  <  IMoviesRepository,  MovieRepository  >

();          services.AddTransient < IScheduleRepository, ScheduleRepository

> ();        services.AddTransient  <  ISeatRepository,  SeatRepository  >  ();  services.AddTransient  <  IErrorLogRepository,
            ErrorLogRepository

> ();        services.AddTransient  <  IErrorLogService,  ErrorLogService  >  ();  services.AddTransient  <
            IUserRepository, UserRepository > (); services.AddTransient < IRolesRepository, RolesRepository > ();
            services.AddTransient  <  IUserService,  UserService  >  ();  services.AddTransient  <  IFileHelper,
            FileHelper > (); services.AddTransient  <  IThumbnailService,  humbnailService  >

            services.AddTransient < ICompanyRepository, CompanyRepository >

();          services.AddTransient < IVatRepository, VatRepository > (); services.AddTransient  <  ITicketRepository,  TicketRepository  >

();          services.AddTransient < ISetupRepository, SetupRepository > (); services.AddTransient          <
                                                    IMovieCastRepository,

();
MovieCastRepository > ();
            services.AddTransient  <  ICastRepository,  CastRepository  >  ();  services.AddTransient  <  ICastTypeRepository,
            CastTypeRepository
```

```
> ();
            //services.AddScoped<INewsletterService, NewsletterService>();
            //services.AddTransient<IRepository,Repository>(); services.AddControllersWithViews();

            services.AddLocalization(opts => { opts.ResourcesPath = "Resources"; });

            services.AddMvc()
                .AddViewLocalization( LanguageViewLocationExpanderFormat.Suffix, opts => {
                    opts.ResourcesPath = "Resources"; })
                .AddDataAnnotationsLocalization();
        }

        // This method gets called by the runtime. Use this method to configure the HTTP request pipeline.
        [Obsolete]
            public void Configure(IApplicationBuilder app, IWebHostEnvironment env)
        {
            if (env.IsDevelopment()) { app.UseDeveloperExceptionPage();
                app.UseDatabaseErrorPage();
            }
            else {
                app.UseExceptionHandler("/Home/Error");
                // The default HSTS value is 30 days. You may want to change this for production scenarios, see https://aka.ms/aspnetcore- hsts.
                app.UseHsts();
            }

            app.UseHttpsRedirection(); app.UseStaticFiles();
            var options = app.ApplicationServices.GetService < IOptions < RequestLocalizationOptions >> ();
            app.UseRequestLocalization(options.Value); app.UseCookiePolicy();

            app.UseRouting();

            app.UseAuthentication(); app.UseAuthorization();
            app.UseSession(); // was added

            app.UseEndpoints(endpoints => { endpoints.MapControllerRoute(name: "MyArea",
                                                pattern: "{area:exists}/{controller=Home}/{action=Index}/{id?}"); endpoints.MapControllerRoute(name: "default",
                                                pattern: "{area=Cinema}/{controller=Home}/{action=Index}/{id?}");
            });


RotativaConfiguration.Setup((Microsoft.AspNetCore.Hosting.IHostingEnvir onment)env, "Rotativa");

        }
}
}
```

This is the application's configuration code. It consists of two main methods: ConfigureServices and Configure.

ConfigureServices:
This method is used to configure services that will be available throughout the application. In addition to the standard ASP.NET Core services, additional services for authentication, the database, and various

application services have been added.

Localization configuration has been set up for two languages: en-US and sq-AL. Support for authentication with Facebook and Google has been added.
Authorization policies are configured.
Services for sending emails, services assisting in handling drop-down lists, etc. are registered. Use of AutoMapper to facilitate mapping between models and application objects.

Configure:
This method is used to determine how HTTP requests will be processed by the application. This includes:
• Defining the development and production environments.
• Using authentication and authorization.
• Setting up the controller routes.
• Adding a middleware, a tool for generating PDFs with ASP.NET Core.

Project\Web\Helpers\FileHelper.cs

```
using ApplicationCore.Enums; using
ApplicationCore.Interfaces;
using Microsoft.AspNetCore.Hosting; using
Microsoft.AspNetCore.Http; using System;
usingSystem.Collections.Generic; using System.IO;
using System.Linq;
using System.Threading.Tasks;


namespace Web.Helpers
{
    public class FileHelper : IFileHelper
    {
        private IWebHostEnvironment _env;
        private IThumbnailService _thumbnailService;

        public FileHelper(IWebHostEnvironment env, IThumbnailService thumbnailService)
        {
            _env = env;
            _thumbnailService = thumbnailService;
        }

        public string GetProperFilePath(FileTypes type, Thumbnails thumbnail, string path)
        {
            var properPath = ""; try
            {
                var fileNameWithoutExtension =
Path.GetFileNameWithoutExtension(path);
                var fileExtension = Path.GetExtension(path);
```

```
                    var pathWithoutFileName = Path.GetDirectoryName(path); var test =
                    Path.GetFullPath(path);

                    var newFileName =
$"{fileNameWithoutExtension}_{(int)thumbnail}{fileExtension}"; var pathArray = path.Split('/');

                    pathArray[pathArray.Length - 1] = newFileName; properPath =

                    string.Join('/', pathArray);

                    var absolutePath = pathWithoutFileName.Substring(1) + "\\" + newFileName;
                    absolutePath = _env.WebRootPath + absolutePath; if
                    (!File.Exists(absolutePath))
                    {
                        throw new Exception();
                    }

                }
                catch (Exception)
                {
                    properPath = $"~/images/default-images/product-
default_{(int)thumbnail}.jpg";
                }

                return properPath;

            }
            public string GetProperFilePath(FileTypes type, Thumbnails thumbnail, string path, bool forLogo)
            {
                var properPath = ""; try
                {
                    var fileNameWithoutExtension =
Path.GetFileNameWithoutExtension(path);
                    var fileExtension = Path.GetExtension(path);

                    var pathWithoutFileName = Path.GetDirectoryName(path); var test =
                    Path.GetFullPath(path);
```

```
                var newFileName = $"{fileNameWithoutExtension}_{(int)thumbnail}{fileExtension}"; var pathArray = path.Split('/');

                pathArray[pathArray.Length - 1] = newFileName; properPath =

                string.Join('/', pathArray);

                var absolutePath = pathWithoutFileName.Substring(1) + "\\" + newFileName;
                absolutePath = _env.WebRootPath + absolutePath; if
                (!File.Exists(absolutePath))
                {
                    throw new Exception();
                }

            }
            catch (Exception)
            {
                properPath = null;
            }

            return properPath;

        }
        public string GetFavIconFilePath(string path)
        {
            string properPath; try
            {
                var fileNameWithoutExtension = Path.GetFileNameWithoutExtension(path);
                var fileExtension = Path.GetExtension(path);

                var pathWithoutFileName = Path.GetDirectoryName(path); var test =
                Path.GetFullPath(path);
                var newFileName = Path.GetFileName(path);

                //var newFileName = $"{fileNameWithoutExtension}_{(int)thumbnail}{fileExtension}"; var pathArray = path.Split('/');
```

```
                pathArray[pathArray.Length - 1] = newFileName; properPath = string.Join('/', pathArray);

                var absolutePath = pathWithoutFileName.Substring(1) + "\\" + newFileName;
                absolutePath = _env.WebRootPath + absolutePath; if
                (!File.Exists(absolutePath))
                {
                    throw new Exception();
                }

            }
            catch (Exception)
            {
                properPath = null;
            }

            return properPath;

        }
        public void SaveFile(FileTypes type, IFormFile file, string folderName, string id, params int[]
thumbnails)
        {
            var filePath = Path.Combine(_env.WebRootPath, "uploads", folderName, id, type.ToString());
            if (!Directory.Exists(filePath))
            {
                Directory.CreateDirectory(filePath);
            }
            (new FileInfo(filePath)).Directory.Create();
            using (var fileStream = new
FileStream(Path.Combine(filePath, file.FileName), FileMode.Create))
            {
                file.CopyTo(fileStream);

                fileStream.Close();
            }
            var fileNameWithoutExtension =
Path.GetFileNameWithoutExtension(file.FileName);
            var fileExtenstion = Path.GetExtension(file.FileName);

            foreach (var item in thumbnails)
            {
```

```
                    string thumbnailPath = Path.Combine(filePath, $"{fileNameWithoutExtension}_{item}{fileExtenstion}");
                    _thumbnailService.GenerateThumbnail(item, Path.Combine(filePath, file.FileName), thumbnailPath);
                }
            }

            public void SaveFavIcon(FileTypes type, IFormFile file, string folderName, string id)
            {
                var filePath = Path.Combine(_env.WebRootPath, "uploads", folderName, id, type.ToString());
                if (!Directory.Exists(filePath))
                {
                    Directory.CreateDirectory(filePath);
                }
                (new FileInfo(filePath)).Directory.Create();
                using (var fileStream = new FileStream(Path.Combine(filePath, file.FileName), FileMode.Create))
                {
                    file.CopyTo(fileStream);

                    fileStream.Close();
                }
            }
            public void SaveImage(FileTypes type, IFormFile file, string folderName, string id)
            {
                var filePath = Path.Combine(_env.WebRootPath, "uploads", folderName, id, type.ToString());
                if (!Directory.Exists(filePath))
                {
                    Directory.CreateDirectory(filePath);
                }
                (new FileInfo(filePath)).Directory.Create();
                using (var fileStream = new FileStream(Path.Combine(filePath, file.FileName), FileMode.Create))
                {
                    file.CopyTo(fileStream);
                    fileStream.Close();
                }

                var fileNameWithoutExtension = Path.GetFileNameWithoutExtension(file.FileName);
```

```
                var fileExtenstion = Path.GetExtension(file.FileName);

            }

        }
}
```

This part of the code assists in managing files and aids in storing and retrieving various files.
The FileManager class is a helper for different file operations, including saving and retrieving files and assisting in generating different files, such as thumbnails (small images).

Project\Web\Helpers\IFileHelper.cs

```
using ApplicationCore.Enums; using
Microsoft.AspNetCore.Http; using System;
usingSystem.Collections.Generic; using System.Linq;
using System.Threading.Tasks;

namespace Web.Helpers
{
    public interface IFileHelper
    {
        void SaveFile(FileTypes type, IFormFile file, string
folderName, string id, params int[] thumbnails);
        void SaveFavIcon(FileTypes type, IFormFile file, string
folderName, string id);
        string GetProperFilePath(FileTypes type, Thumbnails thumbnail, string path);
        string GetProperFilePath(FileTypes type, Thumbnails thumbnail, string path, bool forLogo);
        string GetFavIconFilePath(string path);
        void SaveImage(FileTypes type, IFormFile file, string
folderName, string id);
    }
}
```

This is an interface that specifies the helper operations for files, so it's a helper for FileHelper.cs.

Design and development of high performance and scalable recommendation mechanism using Kafka, Spring Boot and collaborative filtering algorithms

Ilirian Thaçi[1] and Edmond Jajaga[2]
[1]it47621@ubt-uni.net, [2]edmond.jajaga@ubt-uni.net
University for Business and Technology, 10000 Prishtine, Kosovo

Abstract. Recommender systems play a crucial role in daily life, filtering vast information to enhance user experience. This document focuses on an efficient and scalable recommendation mechanism, integrating Kafka, Spring Boot, and collaborative filtering algorithms. This advanced model aims to deliver highly personalized and accurate recommendations. The integration capitalizes on Kafka's role as a distributed streaming platform for real-time data handling, complemented by Spring Boot's agility in microservices development. The collaborative filtering algorithms, such as matrix factorization, examine user interactions to provide precise recommendations. This technology combination creates a modern, high-performance recommendation system meeting the evolving needs of users for advanced suggestions across platforms.

Keywords: Recommender systems, Kafka, Spring Boot

1 Introduction

The rapid growth of data in the digital world has led to the development of recommendation systems, which are essential for businesses to provide personalized experiences to users. Traditional methods, which are based on user preferences and item similarities, face limitations in handling large-scale data and providing real-time recommendations. Collaborative filtering algorithms, which analyze users' behaviors, preferences, and item interactions, can generate personalized recommendations that match users' interests.[1] However, microservices face challenges in data management, such as data movement, component division, and storage. This research aims to develop a high-performance scalable recommendation mechanism using Kafka as an asynchronous queue and Spring Boot for efficient backend development.[2] This implementation aims to address the challenges of handling large-scale data and achieving real-time performance, enabling businesses to improve user experiences, customer satisfaction, and revenue growth.

2 Conceptual design

Let us begin with higher level approach through the conceptual design of our high-performance recommender system. Fusing two microservices, a Kafka message broker, and Kafka Streams, this innovative architecture ensures real-time, personalized recommendations, setting the stage for optimal user experiences. Explore the seamless integration and dynamic processes driving the heart of our recommendation engine.[3] This procedure is shown in the flowchart depicted in Figure 1, offering a visual guide to the intricacies of our system's architecture.

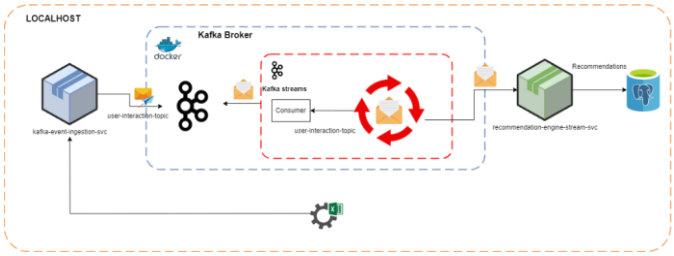

Fig. 1. The architecture of the application

The high-performance recommender mechanism features two integrated microservices and a Kafka message broker, utilizing Kafka Streams for real-time personalized recommendations. The kafka-event-ingestion-svc microservice efficiently tracks user interactions, publishing events to the Kafka broker, while the recommendation-engine-stream-svc microservice continuously processes incoming data streams to enhance its recommendation models. In the architecture's central hub, Kafka and Kafka Streams connect the two microservices, ensuring real-time data processing and transformation.[4] By incorporating Kafka Streams, the recommendation engine efficiently processes user data, allowing the recommendation-engine-stream-svc microservice to deliver personalized recommendations without latency. This integration of two microservices, the Kafka broker, and Kafka Streams results in a scalable and high-performance recommendation engine, providing up-to-date and accurate suggestions for optimal user experiences.[3]

As users interact with the system, their actions are instantly processed, and it adapts its suggestions in real-time. This ensures that the highly scalable, high-performance recommendation engine remains a primary

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option for delivering the best possible user experiences. By seamlessly integrating user interactions, real-time data processing, and advanced recommendation algorithms, our system not only delivers precise and timely suggestions but also stands as a testament to innovation in providing a seamless and personalized user experience.

The recommendation engine's core process involves a streamlined data pipeline powered by Kafka and microservices, crucial for the efficiency of our high-performance scalable system. The initial step includes collecting diverse user interactions, managed by the kafka-event-ingestion-svc microservice, which efficiently captures events like product views and purchases. Using Kafka's produce-consume model, these interactions are seamlessly fed into the system as event streams, providing a robust real-time data acquisition process. Subsequently, the raw data undergoes preprocessing, involving tasks such as cleaning and normalization, to enhance its quality and relevance. This ensures that collaborative filtering algorithms receive high-quality input data, resulting in accurate and meaningful personalized recommendations.[5] The final stage occurs in Kafka Streams, transforming the data structures and optimizing performance for collaborative filtering algorithms, delivering accurate, real-time, and personalized recommendations to users.

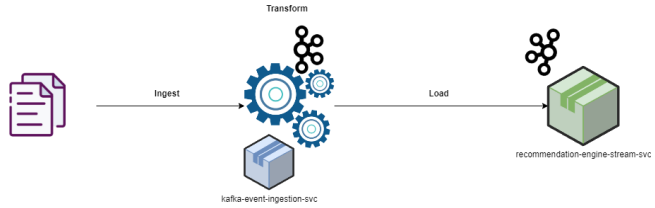

Fig. 2. Data pipeline of the application

3 Implementation

Within the realm of our system's implementation, a pivotal method orchestrates the processing of user interaction events. This method, named processUserInteractionEvents, is a key component of our data pipeline, efficiently managing the complexities of user interactions. The comprehensive workflow encapsulated in this method involves the extraction, deserialization, grouping, and aggregation of user interactions, leading to the generation of item-to-item recommendations. The visual representation below illustrates the intricate details of this code, serving as a guide to comprehend the main processing mechanism for incoming data. Dive into the visual representation to gain a clearer understanding of how our system navigates through the data processing journey, optimizing the generation of personalized recommendations for our users.

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```
@Slf4j
@Component
@RequiredArgsConstructor
public class EventStreamProcessor {

  private ObjectMapper objectMapper = new ObjectMapper();

  @Autowired
  private RecommendationService recommendationService;

  @Autowired
  public void processUserInteractionEvents(StreamsBuilder streamsBuilder) {
      KStream<Long,List<UserInteraction>> eventsStream=
  streamsBuilder.stream("user-interactions-topic");

      eventsStream.flatMapValues(value -> {
            try{
                List<UserInteraction> userList =
  objectMapper.readValue(objectMapper.writeValueAsString(value), new
  TypeReference<List<UserInteraction>>() {});
              return userList;
            }catch(JsonProcessingException e){

              throw new RuntimeException("Error deserializing user
              interactions" ,e);
            }
        })
        .groupBy((key,interaction) -> {
            return interaction.getUserId();
          }
        )
         .aggreagte(() -> new FastByIDMap<PreferenceArray>(), (key,
         interaction,aggregate) -> {
                    long userId = interaction.getUserId();
                    List<Long> itemIds = interaction.getItemId();
                    long rating = interaction.getRating();

                    PreferenceArray preferenceArraay = new
         GenericUserPreferenceArray(itemIds.size());
                    for(int i = 0; i<itemIds.size(); i++) {
                        long itemId = itemIds.get(i);
                        preferenceArray.setUserID(i, userId);
                        preferenceArray.setItemID(i, itemId);
                        preferenceArray.setValue(i, rating);
                     }

                     aggregate.put(userId, preferenceArray);
                     return aggregate;
                }
          )
          .toStream()
          .forEach((key, converted) -> {
            recommendationService.generateItemToItemRecommendations(converted);
        });
  }
```

Fig. 3. Event Stream processor code

The processUserInteractionEvents method plays a pivotal role in the Kafka Streams application, retrieving a stream of user interaction events from the "user-interactions-topic".[6] Subsequently, the method utilizes the flatMapValues operation to deserialize JSON data within each record, transforming it into a list of users.

These UserInteraction objects are then grouped based on userId through the groupBy operation. The ensuing step involves aggregation, where grouped interactions are consolidated into a FastByIDMap<PreferenceArray> using the aggregate operation. A loop logic within this aggregation process meticulously initializes PreferenceArray instances with user, item, and rating data. The result, a stream of aggregated user preferences, is converted back to a KStream using the toStream() operation. For each user's aggregated preferences, the method invokes the recommendationService.generateItemToItemRecommendations, signaling the generation of item-to-item recommendations grounded in the processed user interactions. Exception handling mechanisms fortify the code against potential JSON deserialization errors, ensuring the application's robustness. Overall, this method encapsulates a comprehensive workflow, seamlessly handling data processing, aggregation, and recommendation generation within the Kafka Streams framework.

4 Performance analysis

In our effort to develop an advanced recommendation system, we have carefully implemented the described architecture. To assess its efficiency, we delved into a performance analysis, closely examining execution times across datasets and microservices. Notably, the introduction of the kafka-event-ingestion-svc microservice emerges as a transformative element, elevating our system to a modern recommendation framework. Despite the minor impact on execution time, the benefits it brings are monumental. Our system

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now boasts scalability, fault tolerance, and the ability to process and transform incoming data streams in real-time. This achievement is underpinned by an independent and loosely coupled architecture, a testament to the balance we have struck between performance optimization and the numerous advantages this modernized system affords. The detailed analysis depicted in Fig. 4, uncovers the intricate dynamics that drive our recommendation system toward efficiency and innovation. Namely, the decision to separate and delegate specific tasks to “Kafka-event-ingestion-svc" and leverage Kafka Streams for pre-aggregation in the streaming pipeline proved beneficial. While there was a noticeable increase in processing time for “kafka-event-ingestion-svc", the overall gain in efficiency was substantial, achieving a higher reduction in processing time compared to a consolidated approach. The division of responsibilities allowed for parallel processing, enhancing the overall throughput of the recommendation system. The trade-off of increased time in one microservice was outweighed by the considerable time savings achieved in the primary recommendation engine. This optimization is particularly worthy when compared to traditional recommendation systems, where performance gains are distinct.

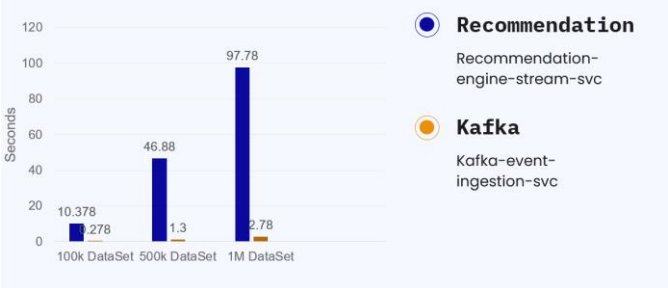

Fig. 4. Execution time comparison

5 Conclusion

This proposal introduces an item-based collaborative filtering approach to enhance recommender systems in e-commerce, particularly addressing challenges related to data sparsity as user and item number increase. The approach leverages a microservices architecture, building on Kafka's scalability, real-time processing, flexibility, and security benefits. By focusing on typical items and reducing noise in data dimensions, the method calculates similarity and makes accurate predictions, improving accuracy and reducing execution time compared to traditional collaborative filtering methods. While enhancing the recommendation system's overall quality, it acknowledges potential limitations in datasets with insufficient user ratings, leading to accuracy issues, especially in cold start scenarios where generating recommendations may take time based on user-item interactions.

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System for registration and management of workers

Edison Kastrati [1], Faton Kabashi[2], Lamir Shkurti[3] [1,2,3] UBT, Higher Education Institution, Kosova
Email: ek48548@ubt-uni.net, faton.kabashi@ubt-uni.net, lamir.shkurti@ubt-uni.net

***Abstract*— Nowadays, almost all businesses, regardlessof the number of employees, need to register and manage those employees, but the quality of registration and management depends on several factors. One of the mostimportant factors is technology, which has revolutionized almost every profession and business. With the boom thattechnology has, businesses are moving from the more primitive way of storing data on paper to the more advanced one in computer programs such as Excel, etc., or programs that are created and intended for this topic,as it is in our case. This degree topic presents a web-based application that is efficient and secure for employee registration and management. The application will have a real-time database that will provide access at any time for the administrator to the data of the company's employees. The user interface of the application is designed to be easy to navigate and "friendly", it is also designed to adapt to different types of web browsers. Moreover, the application also includes the feature for generating detailed reports and extracting information specific to any workplace as needed. This project will be created using spring boot as framework for back end, thymeleaf and bootstrap for frontend and mysql for database.**

Keywords— System, registration, management, business, workers.

I. INTRODUCTION

In a time characterized by the digital age and the evolution of technology, every day the demand for support on digital platforms increases, where fast and efficient management of workers is essential for businesses to advance and be competitive in the market. The system will have a GUI as friendly as possible and the level of access to the system willbe divided into different roles. An administration panel will enable the user to supervise workers' registrations in the most efficient way, behind the administration panel there will be two functional tables where sectors will be registered in one, if there is more than one, and in the other the workers are registered, the tables will be crud foam data that are found inthe database of the application. The department table will include the attributes ID and the name of the department, while the employee table will have ID, first name, last name, age, phone number, nationality, salary and sector to which it belongs. The connection of these two tables will be one-to- many where a sector can have many workers, while theopposite does not apply. So, an employee can only have one sector, some of these attributes may not even be filled, for example, nationality may be left blank as this is also regulated by law. The level of access to the system will be divided into three different levels. The first role is employee (simple user), who can only view the data stored in the database. The secondrole is Manager where, in addition to being able to view the data, he can also add new data and update them. And the lastrole is Admin where there is no limit in functions.

For this project to be able to be published on the Internet, it must work through the www system, through various browsers that are on the Internet that display images, texts, videos, etc., so through these www browsers they can be connected to our application in the future.

II. PROBLEM STATEMENT

In contemporary organizations and companies, the use or adoption of HRMS has become ubiquitous, promising simpler processes and functions for managing workers to improve organizations. The goals of the system are to achieve various functionalities through this application to enable faster work, to increase performance efficiency and security for the decisions made and the greatest advancement of the organization. The studies will be based on the current requirements of organizations that use similar systems for registration and management of workers. Some of the main factors for the success of the system are: the continuous increase in performance, the addition of functionalities in the future and the updating of the technologies used to create thesystem.

Another key factor is the commitment of workers who are administrators of these systems, the dedication they have to work can lead to the development of the organization or the opposite can damage the organization. Many studies nowadays done on this topic are about the functionalities andbenefits as much as possible, but they do not talk much about the psychological aspect of the workers, for example: how tobe motivated as much as possible in this aspect. In addition, with the dynamics that technology has taken, many jobs or professions are moving from office work to remote work or work from home, as was the case of Covid-19 that was mentioned above, so this shows or should be an incentive to work a little more in terms of training workers' skills, why notalso in terms of psychology. This research does not focus on the side of user training, but tries to provide the easiest and most satisfying interaction between users and the system through the interaction with the most refined technologies.

III. METHODOLOGY

In this study, a mixture of research methods was used for the impact that HRMS has on the productivity of organizations or companies. The mixed method of research allows the use of two methods of extracting information such as quantitative data and qualitative knowledge from the participants. In this study, the qualitative data were collectedafter an interview with a company in the city of Prizren, which is small in size with 18 employees, given what is considered quantitative. The company in question deals withthe sale of building materials, but also with construction itself. After the interview with the owner of this company, I realized that from this company 8 of those workers work at the company's location and the other 10, divided into two groups of 5 people, work at the company's workshop. This has led the company to start using a computer system for employee management even though the number of employees is not that large, this has made the job of registering and managing employees much easier for thecompany. The system that this company uses is quite advanced, which for each worker who registers in the systemis saved with personal data such as name, surname, salary and the work sector that will work, data that must be recorded during registration, but which also has optional data for marking or adding columns such as age, nationality, etc. In addition, the system automatically saves the date of registration during the registration of workers. For the easiest possible management of workers, their system has several advanced functions, for example, filtering workers based on a certain attribute. For everyone registered in the system, there is also the input of mistakes, whether they are good or bad. All these functionalities have made the owner of this company express himself very satisfied with the system and how much it has facilitated his work for the management of workers and shows that based on the development of his company, he plans to increase the number in the future of workers, but why not the addition of new sectors. The method of data collection was through conversation with the owner of the company and all these data were obtained with his permission, assuring him of confidentiality for the data of this company. This study used a mix of research methods for selection, analysis, ethical issues and data limitations.

IV. THE PROPOSED SYSTEM

HRMS or called in the Albanian language the human resource management system is a system or more precisely asoftware that is used for the registration of workers managing from the first step which is registration to salary management and other work cycles. Managers and HR staff are the primary users, given that they direct the day-to-day operations of the workforce and are responsible for compliance and performance reporting. However, HR is not the only department that benefits. Companies can empower managers and workers with self-service for shared tasks—an important point of departure for new hires. Managers can usean HRMS to generate data on workforce trends and their business implications [1].

Some of the main requirements included in the system are:

- Creation of departments
- Registration of workers
- CRUD forms for both tables
- Assignment of user roles

The flow of how the work of this system will be organized is divided into phases:

1. Using the Agile methodology
2. Structuring the database
3. Implementation of the project

Phase 1. Agile (Scrum)

Scrum is an Agile project management framework that helps teams' structure and manage their work through a set of values, principles and practices. Like a rugby team (from which it gets its name) training for the big game, scrum encourages teams to learn through experience, organize themselves as they work on a problem, and reflect on their wins and losses to continually improve [2]. Scrum as amethod includes several stages such as:

1. The beginning
2. Planning
3. Implementation
4. Review
5. Publication

The project is organized in such a way that we first created a board (Trello) where we created all the tasks to manage theproject creation process in the best possible way. Trello is a visual project management tool that helps individuals and teams organize and prioritize their work. It allows users to create boards to represent different projects, and within eachboard, users can add lists of five to represent different stages of a project and cards to represent individual tasks or ideas [8]. Users can add comments, attachments and deadlines to cards and move them from one list to another to reflect the progress of a project. Trello is designed to be user-friendly and flexible, making it a popular solution for individuals and teams looking to streamline their workflow [8]. Although Trello is more designed for scrum Kanban, it can also be used for agile as in our case. Each created task has its title and description. Each step is based on sprints, where tasks are initially added to the Backlog as shown in the figure:

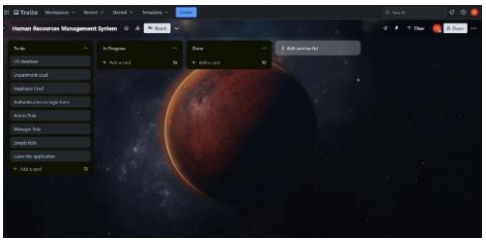

Figure 1. Tasks (Backlog)

For each task created in the backlog, there is a title and details that clearly show the requirements, for example the "department" task.

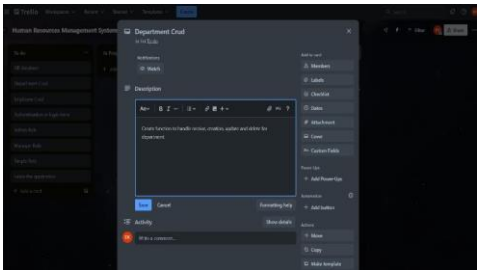

Figure 2. Details of tasks

The organization of the system is done in three sprints, the first sprint includes the structuring of the database, the second sprint includes the creation of crud tableau forms and in the last stage the assignment of roles for users.

The sprints are organized in three phases:

- To Do – tasks that are planned to be created,
- In Progress – task currently in process,
- Done – task completed.

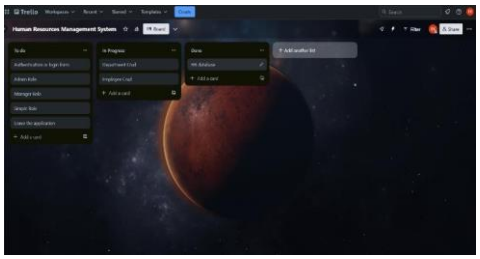

Figure 3. Phases of tasks

After the finalization of the project, all tasks will be placed in the Done phase.

The organization of the system in the second phase that was mentioned above is the creation or structuring of the database, the tables with the relevant attributes are listed below.

The Department table has the following attributes:

1. Department Id
2. Department Name

The Employee table has the attributes:

1. Employee Id
2. Employee Name
3. Employee Surname
4. Employee Age
5. Employee Salary
6. Employee Phone Number
7. Employee Email
8. Employee Nationality
9. Employee Department

The Users table has the attributes:

1. Username
2. Password
3. Enabled

The Authorities table has the attributes:

1. Username
2. Authority

The connection of these tables is done through the primary key and foreign key switches, the department table with the employee table has a one-to-many relationship where a department can have many employees, the department's primary key, which is the department Id, is connected to the employee's foreign key, which is the employee Department. Also, the user and authorities' tables have a one-to-many relationship where a user can have more than one role, so username in the users table is the primary key where it is related to the foreign key of the authorities' username. The following figure shows the structure of the database:

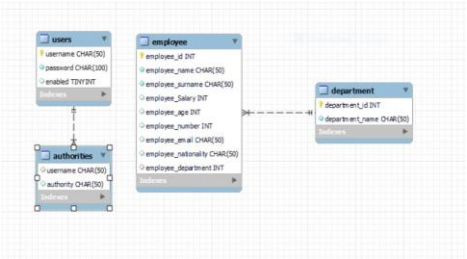

Figure 4. Structure of the database

The third and final phase of the project is the implementation of what the system's GUI will look like. The result of the system is divided into two parts, the first result will display the basic functionalities which are the department and employee tables with the crud form functions. Whereas, the second result will show a more advanced result of the application, which is also the final version of the system, in this result the addition of user roles has also been made. But before we start with the elaboration of the application, a brief description of the technologies used for the project will be made.

Spring Boot – Java spring boot is an open-source tool that makes it easier to use the Java-based framework for creating microservices and web pages. For any definition of Spring Boot, I have to start the conversation with Java – one of the most popular and widely used computer development languages for developing applications. Developers all over the world start their coding journey by learning Java. Flexible and user-friendly, Java is preferred by developers for a

variety of applications, everything from social media, web applications, and gaming applications to networking andenterprise applications [3]. Using the framework, large chunks of code are automatically added for developers to useand add new code as their needs dictate. These frameworks lighten the developer's load for almost any need, whether theyare developing mobile apps and web apps or working with desktops and APIs. Frameworks make creating applications faster, easier, and more secure by providing code with reusable tools to help tie the various elements of a software development project together [3]. This is where Spring comesin. Spring is an open-source project that provides an efficient, modular approach to creating Java applications. The Spring family began in 2003 as a response to the complexity of early Java development and provides support for Java application development. The name spring usually refers to the application framework itself or the whole set of projects or modules. Java Spring Boot is specific module that is built as an extension of Spring [3].

MySQL – MySQL is the most popular open-source databasein the world. Based on DB-Engines, MySQL ranks as the second most popular database, after Oracle database. MySQL supports some of the most popular applications, including Facebook, Twitter, Netflix, Uber, Airbnb, Shopify and Booking.com. Since MySQL is open source, it includes many features developed in close collaboration with users for morethan 25 years. So, it is very likely that your favorite application or programming language is supported by MySql database [4]. MySQL is a rational database management system. Databases are the essential data store for all software applications. For example, whenever a user performs an Internet search, logs into an account, or completes a transaction, a database system stores that information so thatit can be accessed by that user in the future [4]. A rational database stores data in separate tables instead of putting it all in one big repository. The database structure is organized into physical files optimized for speed. The logical data model, with objects such as data tables, views, rows, and columns, provides a flexible programming environment. You set rules that govern the relationships between different data fields, such as one-to-one, one-to-many, unique, required, or optional, and "pointers" between different tables. The database enforces these rules so that with a well-designed database your application will never see data that is inconsistent, duplicate. orphan, obsolete or missing [4].

Thymeleaf – Thymeleaf is a modern template engine for server-side Java, both for web and standalone environments, capable of processing HTML, XML, Java Script, CSS and even plain text [5]. The main goal of Thymeleaf is to provide an elegant and highly maintainable way to create templates. To achieve this, it relies on the concept of natural patterns toinject its own logic into template files in a way that does not affect the template being used as a design prototype. This improves design communication and bridges the gap between design and development teams [5]. Thymeleaf is also designed from the ground up with web standards in mind – especially HTML5 allowing you to create fully valid templates if that's what you need [14]. Out of the box thymeleaf allows you to process six types of templates, eachof which is called a template model: Html, Xml, Text, Java Script, CSS, Raw [5].

Bootstrap – bootstrap is a free, open-source framework for web development. It is designed to facilitate the process of developing web pages that are also responsive, it is the first for mobile by providing a collection of syntaxes for templatemodels [6]. In other words, bootstrap helps web developers build websites faster as they don't need to worry about basic commands and functions. It consists of scripts based on Html, Css and Js for various functions and components related to web design [6]. The main objective of bootstrap is to create responsive websites. It ensures that all interface elements of a website work optimally on all screen sizes [6].

Html – Html (Hypertext Markup Language) is the most basic building block of the web. It defines the meaning and structure of the content of web pages. Technologies other than Html are generally used to describe a web page's appearance/presentation (Css) or functionality/behavior (Java Script). "Hypertext" refers to the links that connect webpages to each other, either within a single web site or between web pages. Links are a fundamental aspect of the web. By uploading content to the Internet and linking it to sites created by other people, you become an active participant in the Word Wide Web [7]. Html uses markup to markup text, images, and other content for display in a web browser. Html markup includes special "elements" such as <head>, <title>, <body>, <header>, <footer>, <article>, <section>, <p>, , , <img >, <aside>, <audio>, <canvas>, <datalist>, <details>, <embed>, <nav>, <search>, <output>, <progress>, <video>, <ul>, <ol>, <li> and many others [7]. An Html element is separated from other text in a document by "tags", which consist of the name of the element inside a case-insensitive tag. That is, it can be written in uppercase, lowercase or mixed letters. For example, the <title> tag can be written as <Title>, or <TITLE>, or in some other form. However, the convention and recommended practice is to write tags in lowercase letters [7].

Css – Cascading Style Sheets is a style sheet language used to describe the presentation of a document written in Html or Xml (including Xml dialects such as Svg, MathMl or XHtml). CSS describes how elements should be rendered onscreen, on paper, in speech, or in other media [7]. CSS is among the core languages of the open web and isstandardized across all web browsers according to W3C specifications. Previously the development of different parts of the Css specification was done synchronously, which allowed versioning of the latest recommendations. You may have heard of Css1, Css2.1 or even Css3. There will never bea Css3 and Css4 instead, everything is now Css without a version number [7]. A part of the code for creating the application is presented in Appendix A where it shows how this application was created.

A. Result A

In the first result after starting the web application, the main web page or home page will appear, which contains some information and the navbar for navigating the system, which contains home page, department, employee, and in the second result, the option to logout will also appear. The following figure shows the view of the home page:

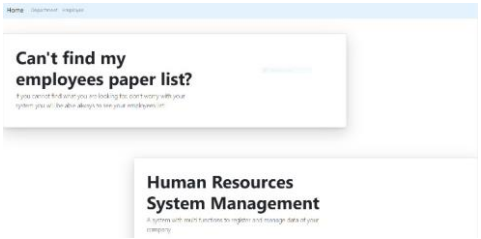

Figure 5. Home Page

From the home page, you can navigate through the navbar to department or employee, the first case to department where a list of several departments will appear "GET" with the id data and the name of the department, then there is an option with buttons that can do data update and data deletion. The figure below presents the complete list of departments.

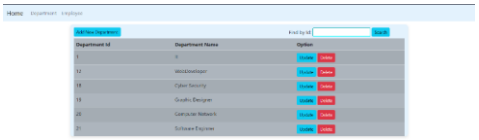

Figure 6. List and departments

From there the user can add "ADD" a new named department since the attribute department Id is generated automatically, it increases by one after each addition of the department.

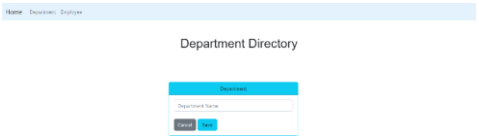

Figure 7. Addition of the department

This form also appears when pressing the "UPDATE" data update button, but in this case the form is filled with the current data stored in the database and the user selects which one he wants to modify.

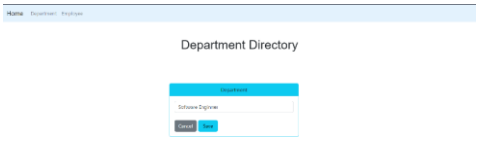

Figure 8. Department update

The figure above showed how the application looks when the department update can be done. While the following figure, i.e. figure 12, shows how to delete a "DELETE" department, since it asks the user if he is sure about the deletion.

Figure 9. Deletion of the department

In addition to these, the functionality that a crud form has, there is also the option of filtering data, for example, in our case finding a certain department through ID.

Figure 10. Department filtering by ID

If they do not find any department with a given id in the table, no data is displayed. Then, from the department, we can navigate to employee, and the "GET" list with registered workers appears. The figure below lists all the workers stored in the database:

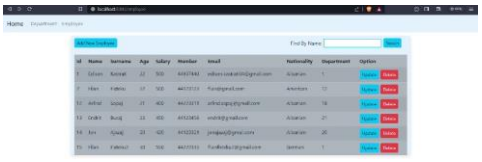

Figure 11. List of workers

Then, there is the option of adding workers with their data, as in the department, here too the id is generated automatically (increased by one). The next figure shows the "ADD" input form for adding workers to the database:

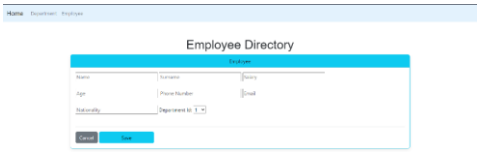

Figure 12. Registration of workers

After registration, those data can be updated, if desired, with "UPDATE" and here it is the same way, the input forms are filled with the current data, if any data does not change, it is saved again in the database.

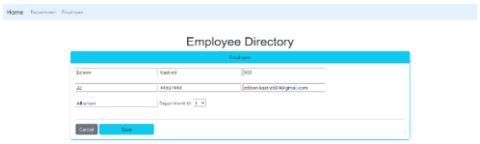

Figure 13. Updating workers' data

To complete the functionality of the crud form, there is the option of deleting workers "DELETE", which also requires confirmation for deletion.

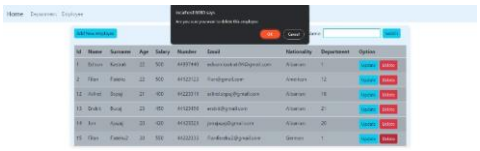

Figure 14. Deleting a workshop

As a conclusion of the first result, unlike the department table, which was filtering based on the department id, in workers there is a function for filtering workers based on name, so it shows more than one person if they have the same name

Figure 15. Sorting workers by name

B. Result B

In the second result, which is also the final result of the system, in addition to the functions mentioned above, the roles in the application have been added, more precisely, there are three roles:

1. Simple user
2. Manager
3. Administrator

In the first role as a simple user there is a limited number of functions that he can perform, with this role the user can access the system and see the lists of departments and workers, but in addition he can also add any department or workers. And finally, you can also use the filtering functions.

In the second role as a manager, we can say that this role is a step higher than the role of a simple user, since in addition to the functions mentioned above, I can also update the data of departments and workers.

The third and last role is administrator where there is no limit to system functions. He has access to each function, such as the complete crud form, get, add, update and delete, as well as filtering, so this role is different from the other, since I can also delete data in the system that affects the masts in the database.

Identification and authorization in the application is done through spring security, which offers an easy and fast way to access the application, the users and authorities' tables are the default that the spring boot code accepts, but if we want to name them according to our wishes then we need to write a few more lines of code to link them.

Table 1. Roles and limitations in functions

Role	Department	Employee
Simple user	Get, Add	Get, Add
Manager	Get, Add, Update	Get, Add, Update
Administrator	Get, Add, Update, Delete	Get, Add, Update, Delete

In this result, after starting the application, the login form appears to identify the user with the given username and password stored in the database. The figure below shows how the login form of the application looks like.

Figure 16. Login form

After the user enters the correct data, he is identified and allowed to continue, which is directed to the main page or home page. If the entered data is not correct with those stored

in the database, then an error or a message appears indicatingthat the data do not match, so they are invalid.

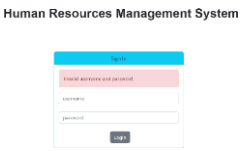

Figure 17. Data entered incorrectly in the login form

After going through the application identification process, there is a button to logout in the navbar or the top left part.

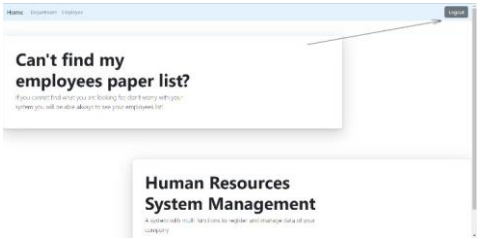

Figure 18. Logout button

After pressing that button, it goes back to the login form, where it displays a message that the logout has been successful, and if you want to enter the application again, youmust enter your data.

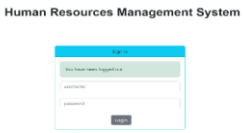

Figure 19. Logout me successful

If any of the users tries to do an action that their role does notallow, then the application will redirect them to the interfacewhere it tells them that this action is not allowed based on their role and that they should go back.

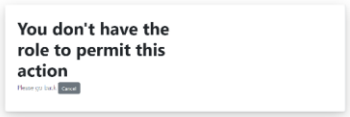

Figure 20. Role restrictions

V. CONCLUSION AND DISCUSSION

This project was based on the digitization of systems for registration and management of workers. This system is database based as every data in the system is stored and managed in the database. Based on the research done, it was concluded that these hrms systems have made a revolution in human resource management and how profitable they have been for companies, all thanks to technology. This created system does not differ much from the current systems since itwas created in such a way as to follow the trend of the systems, since the collection of information is also done fromthe current systems that are on the market. The development of the application was done by framing the Srum (Agile) method where project management was achieved more easily. Special attention has been paid to the phases of analysis, design, implementation and testing. The technologies used in this application are chosen as desired, but also because they are widely used technologies in the market. But that this work can be achieved with the use of other technologies. In conclusion, we can say that the systemmeets the minimum expectations and is a safe and reliable system. It works adequately, but in the future, why not add other functions that help develop the system.

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Blockchain in education: opportunities, applicationsand challenges

Elira Shala[1], Faton Kabashi[2], Lamir Shkurti[3], Mirlinda Selimaj[4], Laura Gjikokaj[5]
[1,2,3,4,5] UBT, Higher Education Institution, Kosova
Email: es43694@ubt-uni.net, faton.kabashi@ubt-uni.net, lamir.shkurti@ubt-uni.net,
mirlinda.selimaj@ubt-uni.net,laura.gjikokaj@ubt-uni.net

Abstract— Blockchain is a decentralized data storage technology that has received a lot of attention in recent years, extending its application to many fields. At first it was thought that this technology could be used only in the finance sector, but later its uses have expanded to many sectors including education. Blockchain technology has several characteristics that make it suitable for application in systems where transparency is required, the assurance that the data being stored is unchanged. The potential this technology has shown to democratize data, reduce fraud and eliminate data manipulation has made it a transformative tool for many sectors, both public and private. The purpose of this thesis was to investigate what opportunities this technology offers for the education sector, what are its current applications and applications for the future and what are some of the main challenges that arise during the integration of this technology. The results of the research showed that the opportunities that this technology offers for the education sector are numerous. One of them is the verification of digital certificates and transcripts. By harnessing the power of Blockchain, educational institutions can issue indestructible digital credentials where qualifications can be verified with a high degree of reliability. This reduces the risk of manipulation and preserves data integrity. Blockchain has found application in what is known as 'continuous learning' where the record is kept for the whole the student's academic journey. Also, Blockchain offers opportunities and has found application in Peer-to-Peer decentralized learning platforms where educators from all over the world connect and communicate without any intermediaries and barriers. This also helps create more personalized and individual learning experiences. In many countries, Blockchain is also used to reduce the administrative burden by automating processes such as student admission, registration, payments, etc. In this way, efficiency is increased and errors are reduced. Many popular platforms such as Duolingo and Khan Academy have implemented this technology in their systems. Some of the challenges identified were: lack of knowledge about technology, lack of infrastructure for implementation, standards that regulate its work, etc.

Keywords— blockchain, education, application, opportunities, challenge.

INTRODUCTION

Blockchain technology has the ability to completely change how education is run [3]. In record time, the cryptocurrency industry has grown exponentially. The number of one bitcoin has increased significantly. In 2017, the price was around $1,000, while in November 2021, the price has gone up to $68,000. So, in a period of four years, the price for one bitcoin has increased by more than 60 times [1]. During this period, however, there have been fluctuations, often even drastic decreases that have made people doubt whether it is worth investing in this technology. But what exactly is a bitcoin? Bit-coin is a digital, virtual currency, the purpose of which is to enable parties to make payments directly through an international payment system, without the need for the intermediary of a third party/body, such as banks [1]. Bit-coin is not used by central banks, governments or other public and state institutions, as there are still no laws or articles that would enable and regulate their use [2]. So, in the world it is still not recognized as a genuine currency such as the euro, the dollar, etc. As is the case with physical gold, bitcoin's importance and what made it popular comes from the perception that it retains its value over time, is an anonymous means of payment, and therefore protects against inflation, although none of these features have yet have stood the test of time, so their validity still needs to be tested [2]. Blockchain is the technology behind cryptocurrencies. It is an open-source system that is located in a decentralized computer network (e.g. the Internet) that records transactions between parties in a verifiable and permanent way [6]. Blockchain promotes accountability as the records are immutable which offers a potential for exploitation in many cases. Blockchain is a technology that can be used beyond payments, it can be extended to supply chain management, financial services etc. [6]. Like any new technology or product Bitcoin has immediately attracted fans interested in innovation and the perceived lack of government control [5]. Traders immediately saw it as an alternative to traditional investments such as stocks, bonds, treasury bills, etc. This trading momentum led precisely to the increase in the value of Bitcoin in the market. Various companies such as PayPal, Microsoft, Starbucks, AT&T accept Bitcoin as a form of payment, such transactions are usually processed by

a third party, therefore their use in everyday commerce remains quite limited [5]. The introduction of cryptocurrencies and blockchain technology is part of a broader wave of technology that facilitates peer-to-peer communication. It supports individualized products and increased flexibility in production methods. For big platforms like Amazon, Alibaba, Uber and Airbnb, cryptocurrencies have changed the way business is done [4]. Cryptocurrencies are by far considered the most advanced application of blockchain technology. So, they create money and enable exchanges without the mediation of financial institutions [4].

Blockchain has attracted the attention of many sectors, including education. In this sector, it is thought to have the potential to change or transform many processes, starting from the verification of students' diplomas to the creation of platforms for personalized learning. These make it a technology worth investing in, but always keeping in mind the risks and challenges that will be discussed in this thesis.

PROBLEM STATEMENT

The field of education has undergone major changes and reforms in recent years. The transition from learning with books in traditional classrooms to learning through technology tools has opened up new opportunities for this sector. After the pandemic, it can be said that there was a revolution in the education system, since the entire learning process went completely online, that is, learning through various online platforms. This transition naturally had its challenges, but the benefits were numerous. Blockchain technology aims to revolutionize this sector even more. Although its potential is great, there is a lack of studies on how concretely this technology can contribute to education. In this thesis, it is intended to analyze how this technology can help to overcome some difficulties that are currently present in education, how it can automate some processes in order to increase efficiency and what are the challenges for the implementation of Blockchain technology in the education sector.

METHODOLOGY

The methodology used in the research is combined (mixed). The work is based on secondary data which have been collected from various sources such as books, scientific articles, various websites on the Internet. These data have been processed and analyzed with the help of the systematic literature review method. Through this method, the concepts related to the Blockchain technology were selected, which were then processed and in the form of theoretical findings, only those key concepts that explain what this technology is are presented. The key part of the paper deals with the analysis of the case study which is the integration of Blockchain in the field of education. Here we analyze some possible applications in automating processes and addressing some of the challenges currently facing the education sector. It is worth mentioning that some of these platforms have already been implemented and the first results of their use have come out, while some platforms are still considered as projects that can be implemented in the future (if the necessary resources exist). So, it can be said that Blockchain is a mix between theory and practice, i.e. a combination between what has been implemented and what can be implemented.

THEORETICAL BACKGROUND

What is Blockchain technology?

Blockchain is a distributed data ledger that is controlled by a collection of computers that are not owned by a single entity and is regulated by established and recognized cryptographic rules [10]. A blockchain is essentially a distributed database with records of all digital transactions or events that have been executed between participating parties. This register is divided into blocks of data which are connected to each other and protected through cryptography, thus creating a chain or "blockchain". Because of this particular structure, it becomes difficult to change or falsify information after it has been added to the blockchain [9]. Each transaction in what is called a "public ledger" is verified with the joint approval of the majority of participants in the system. To use a simple analogy, it is easier to steal a cookie from a cookie jar stored in an isolated location than it is to steal a cookie from a cookie jar stored in a market, being watched by thousands of people. Blockchain works on the same principle [9].

Bitcoin is the most representative example related to Blockchain technology which is also the most discussed because it helps create a billion-dollar market with anonymous transactions without any government control [12]. Many researchers, businessmen have considered this technology an epochal discovery. The use of software that enables the circulation of digital money has the potential to transform the finance sector and beyond [12]. All of our online transactions have one thing in common: they rely on the trust we have to have that someone is telling us the truth. For example, we must believe that the email service provider is telling the truth when it confirms that the email was received by the recipient, or a bank that tells us that the transfer has arrived at the destination after we sent the money, etc. [13]. The fact is that we live in the digital world relying on third parties for the security and privacy of our digital assets. The problem is that these systems can be hacked, manipulated or damaged. This is when Blockchain comes to our rescue. It has the potential to change the digital world by allowing transactions to be verified through a common approval. They did this without infringing or damaging the privacy of digital resources and the persons involved. Common approval (consensus) and anonymity are the two essential characteristics or attributes of Blockchain technology [13].

Working Principles of Blockchain Technology

Online or Internet commerce is closely related to financial institutions that serve as trusted third parties that process and stand between every electronic financial transaction. The role

and duty of this third party is to verify, control and maintain the legitimacy of transactions [8]. However, the attacks on these systems which are almost inevitable have increased the insecurities of the users that they have to depend entirely on these institutions. Most financial institutions work with poorly designed systems, with many deficiencies in terms of security. This makes them a convenient target for a potential attacker. Figure 1 shows the realization of transactions in traditional systems in a metaphorical way, in which a third party (bank, Paypal) is the intermediary [8].

Bitcoin uses what is known as "cryptographic proof" to secure transactions between parties on the Internet. Each transaction is protected through a digital signature. Each transaction is sent to the receiver who with the public key can verify the transaction of the sender who signed it with the private key that only he/she has in his/her possession. To spend money, the owner of the cryptocurrency must verify that they own the private key. Each transaction is passed (distributed) to each node of the Bitcoin network and only after being verified is that transaction recorded in the "public ledger" [7].

Each transaction must be verified and validated before being recorded in this ledger. Before a transaction is recorded, two things must be verified [7]:

The spender (the one who sends money) is the owner of the cryptocurrency – this is achieved through the digital signature of the transaction.

The spender (owner) has enough cryptocurrency in his account – this is achieved by comparing the value of each transaction against the public ledger to ensure that the sender has sufficient balance in the personal account.

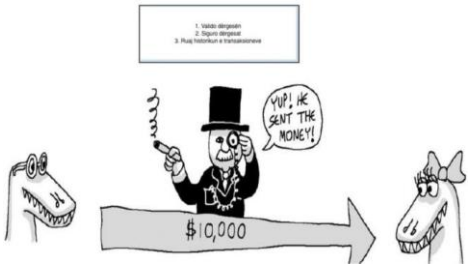


Figure 1. Realization of financial transactions on the Internet mediated by a third party (bank, Paypal, etc.)

The issue that arises during the execution of transactions is the maintenance of their queues which are distributed among all the nodes of the Bitcoin network. Transactions may not be transmitted in the order in which they were sent, therefore there is a need for a system that does not allow what is known as "double spending" [6]. Because transactions pass from node to node on the Bitcoin network there is no guarantee that the order in which they are accepted is the same as the order in which they were created (generated). So, the system must guarantee that no more than one payment can be made with the same amount. This is a challenge for distributed systems, but it is nevertheless solved in Bitcoin. When a user tries to spend their cryptocurrency, nodes in the network verify it against the blockchain to ensure that that currency has not been used before [6].

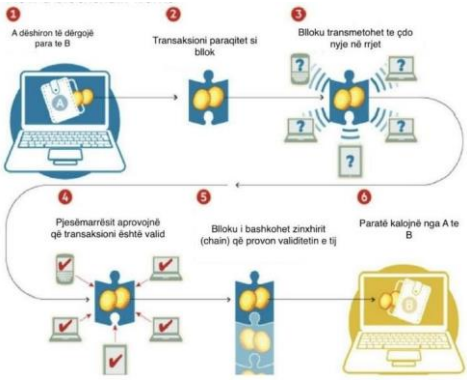


Figure 2. Schema of transaction realization in Blockchain technology

Features of Blockchain technology

According to [9], some of the characteristics that distinguish Blockchain technology from others, especially from traditional ones, are related to:

Decentralization – in Blockchain there is no single point of failure. In a blockchain network, data and transactions are verified by many participants and not just by a central authority as is usually the case with most traditional systems.

Transparency – all transactions that are carried out are visible and can be seen by all participants in the network. However, the identity of the persons behind these transactions remains unknown (anonymous).

Security – A block cannot be attached to the chain unless it has been first verified by a network of computers known as miners. So, in this case, we are dealing with a security that preserves the integrity of the data, because this information has been subjected to numerous filters and preliminary checks.

Validation algorithms – these are techniques that are used as a means to determine the validity of data. Examples include: proof of work (prof of work) or... Within this we also have the use of cryptographic algorithms which ensure that transactions are carried out by legitimate parties. Each participant is in possession of a public and private key.

There are six main components through which a blockchain is created [9]:

Block – contains a list of transactions, with details or additional data. Different blockchains can store different data. Each block has a unique hash which is a cryptographic string generated by the algorithm. When a block is created, its hash is also calculated. A change within the block will affect the hash change, thus guaranteeing data integrity. Each block references the hash of the previous block, creating a chain of blocks. This ensures that the blocks and the data within them are in a specific order and interrelated.

Chain – when blocks are connected to each other using their respective hashes, they form a chain. This chain ensures that blocks are placed in a linear, chronological order.

Nodes – There are individual computers that participate in a blockchain network. Each of them keeps a copy and can validate transactions. Nodes can have different roles depending on the blockchain: full nodes (store the entire blockchain), light nodes (store only part of the blockchain) as well as mining nodes which participate in the creation of new nodes.

Approval Mechanisms – These are protocols that are used to reach agreement within the network about the validity of a transaction and what the next block should do. They ensure that all nodes have the same (consistent) view of a version of the blockchain.

Distributed Ledger – Blockchain is distributed across all nodes in the network. Each node has an identical copy of this ledger, which is continuously updated and synchronized across all nodes in parallel.

Diggers - also known as validators. These are entities whose responsibility is to validate and add new transactions to a blockchain. They do this by solving difficult (complex) mathematical problems such as the case with "proof of work".

Figure 3 shows a simple diagram of some of the components of the blockchain and the interaction between them.

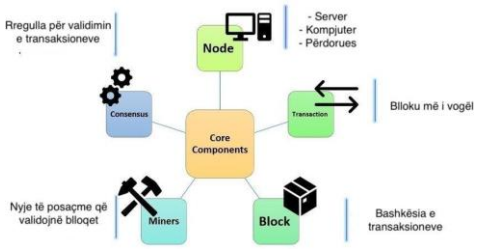


Figure 3. Components of blockchain technology

Blockchain Applications

Blockchain technology was originally intended to be used only for digital currencies, but over time it has developed to provide solutions for multiple sectors due to several features such as transparency, security and decentralization. In this part we will mention only some of the areas in which blockchain has found an application and has been successful, that is, it has produced positive results [13].

Voting systems

The application of blockchain to voting systems has received considerable attention in recent years. This is because of the advantages it can bring to this process. The blockchain's public ledger means that all votes can be seen and verified by authorized parties, thus ensuring the transparency of the election process. Blockchain encryption ensures that once a vote is recorded, it cannot be changed. This enables remote voting, allowing citizens, especially those with mobility difficulties, to cast their vote easily. An unaltered registered vote means that the results can be audited even after the election process is over. The voter's privacy is preserved through the blockchain. As long as all the votes are transparent, the identity of the voter will remain secret thus maintaining the secrecy of the vote [4].

Before voting, a voter must be verified. This can be done in various ways, such as digital identification systems. Once logged in, the voter accepts a digital ballot. They cast their vote which is then converted into a transaction on the blockchain. This vote (transaction) is then validated by the nodes (these can be special nodes created for this work) and the same is added to the blockchain. Once the voting period is over, the votes are tallied by the blockchain, ensuring a transparent and secure voting process. The results can be announced and verified by third parties independently, through access to the blockchain [13].

Health systems

The application of blockchain technology in the health sector offers numerous opportunities to address challenges related to privacy, interoperability and security. Because the data in the ledger is immutable, it means that once a patient's health data is recorded, it cannot be changed. With the increasing number of cases where healthcare systems are attacked, the decentralized nature of blockchain and its cryptographic nature provides a more secure method to store patient information. Another problem with traditional systems concerns their interoperability. Different service delivery systems often encounter difficulties in exchanging data. Blockchain provides a standard platform so that different systems can communicate and access records [14].

By implementing Blockchain, patients can view their medical history, from different providers. Patients can control who can access their data. Instead of a centralized database, the data is stored in several nodes thus increasing security. So, it can be seen that the advantages of Blockchain

implementation in this sector are many, therefore many countries have started to do so [14].

Blockchain Benefits and Challenges

The reasons for such a big boom in Blockchain technology are precisely related to the many advantages it offers in the various environments in which it is implemented. The first advantage is about transparency. All participants in the network have access to the blockchain and audit stages [14]. All transactions are encrypted and linked to previous transactions, which increases their security. By eliminating intermediaries such as banks or other state-owned financial institutions and by automating processes, the cost of operation can be reduced. For each transaction, its origin is known, which can be used to prove the authenticity of the assets. Through blockchain, efficiency is also increased, as transactions are processed faster than in traditional methods [7].

Despite the advantages and benefits, this technology has its own challenges. The first challenge is that the concept and technology behind Blockchain can be difficult for a wider public to understand. For businesses and institutions, integrating blockchain into existing systems can be challenging [5]. The decentralized nature of the blockchain makes it difficult to create a mechanism that regulates its operation. Governments and regulatory organizations are still at a loss as to how they can regulate Blockchain activities, especially cryptocurrencies. There are platforms and protocols in the market that do not follow certain standards. This can cause problems in adoption and interoperability. Another challenge is memory space. As new blocks are created, the size of the blockchain increases [5].

APPLICATION OF BLOCKCHAIN IN EDUCATION

Opportunities that Blockchain offers for education

That being said, Blockchain has the potential to change an entire industry, including education. Its decentralized nature offers a host of promising opportunities for the education sector. Many of these opportunities have been used, that is, they have been implemented in practice, while other opportunities are expected to be used in the future. Because the core of this technology is decentralization, it paves the way for the creation of transparent, secure and efficient systems. Since these characteristics are known mainly in the field of finance, i.e. cryptocurrencies, their application in the field of education opens other possible paths [11].

One of the most transformative aspects of Blockchain in the field of education is the issuance and verification of digital certificates and transcripts. So, gone are the days when you had to wait for the verification and validation of a transcript. By harnessing the power of Blockchain, institutions can issue invulnerable/vulnerable digital credentials, easing the process for students and institutions themselves, as qualifications can be verified with a high degree of reliability. This reduces the risk of fraud, manipulation and maintains the integrity of qualifications in the field of education [11].

Nowadays, education is not limited to the four walls of a classroom or the years spent in formal education. The new and current paradigm is 'lifelong learning' or what is becoming known as 'lifelong learning'. Blockchain offers students to have in their hands the register that contains their entire academic journey from formal schooling to various work groups. This helps to create a more complete picture of the individual's academic journey, which is useful for the students themselves but also for potential employers [16].

In parallel, Blockchain shows a potential for Learning Platforms which are based on a decentralized Peer-to-Peer system. This is an opportunity for students and educators from all over the world to connect directly, eliminate barriers and not need intermediaries to communicate and collaborate. This helps create a more personalized and individual learning experience. These platforms democratize the sphere of education, making quality education more accessible and affordable for everyone [16].

Blockchain technology also offers potential in the governance of educational institutions. The reduction of the administrative burden, which is achieved through the automation of tasks through smart contracts, can improve processes such as admission, registration, student payments, making these processes more efficient and less error-prone. The transparency that Blockchain offers can also be used for the distribution of scholarships, ensuring that scholarships, funds, are allocated accurately and according to merit. This increases the trust between the recipient and the applicant [16].

By decentralizing the space where notes are stored, students gain more control over their data, i.e. they are given more autonomy to determine who can access this data, thereby increasing the degree of privacy which further helps reduce of the possibility of data misuse and manipulation [17].

Applications of Blockchain in Education

Blockchain technology looks very promising for the education sector due to its potential to provide transparency, security and records that are tamper-proof. Although it is still in the early stages of testing, it is beginning to find application. Some of these applications are:

Digital transcripts and certificates

One of the most applicable forms of blockchain in education is the distribution of digital diplomas and transcripts. Through this technology, a person's academic record can be stored securely and permanently, which can then be easily shared and verified. In this way, the possibility of creating false diplomas is excluded and the verification process is simpler [16].

Peer-to-Peer Learning Platforms

Peer-to-Peer learning platforms represent a shift from the traditional top-down learning model to a more decentralized

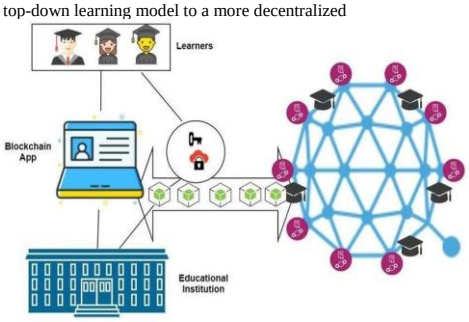


Figure 4. Application of Blockchain in Education

approach where individuals learn from each other. In these platforms, users interact and learn from each other without the help of a central (controlling) authority or an instructor who leads the process. This can be in the form of online platforms, applications or offline communities [17].

Blockchain technology can support decentralized peer-to- peer platforms where educators and learners can interact directly without the need for intermediaries.

Blockchain facilitates payment and other obligations imposed on users on these platforms. Blockchain on these platforms can be applied in several ways [17]:

Verification – Blockchain technology is used to verify the authenticity of educational content and the credentials of content contributors.

Smart contracts – these can facilitate processes such as automatic payments for premium content or the formalization of collaboration between mentors and students.

Immutable Logs – Blockchain creates permanent logs for the progress of the student's engagement, for the achievements and evaluations received during different periods of using the platform.

Two of the very successful platforms that work according to the 'Peer-to-Peer' principle are Khan Academy and Duolingo [17]. Although Khan Academy started as a video lecture series, this platform has evolved to encourage community participation, discussion and feedback. On the other hand, DuoLingo is a language learning platform that also works according to the principle or approach of collaboration, where different users contribute content and translations [17].

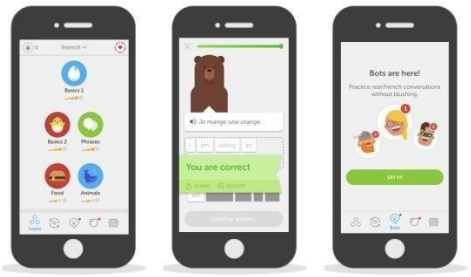


Figure 5. Duolingo – Peer-to-Peer platform which supports Blockchain technology

In Duolingo, users go through different lectures, earn points according to the experience they accumulate and practice the language through interactive exercises. Duolingo works according to the client-server architecture, while users access the platform through web browsers or mobile applications that connect to Duolingo servers to read and process lectures, record progress, and synchronize data [17].

Khan Academy, on the other hand, offers educational content in the form of quizzes, videos and articles on various subjects and topics. Similar to Duolingo, Khan Academy relies on a client-server architecture where content is accessed from a web browser. Both platforms have found space and opportunities to integrate blockchain. In both, users (students) after completing a course or developing a certain skill, are provided with a certificate. These digital credentials must be verifiable by third parties, such as employers or educational institutions. Blockchain technology enables such a thing [17].

Khan Academy offers courses in various subjects and fields and therefore it integrates Blockchain to issue certificates which validate the student's achievements in a particular field.

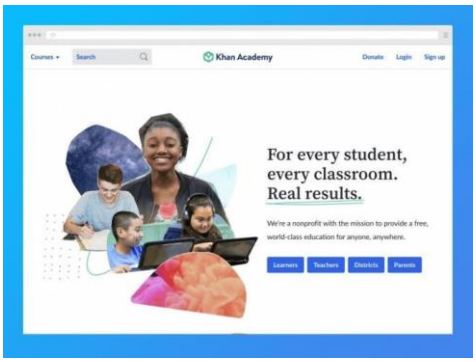


Figure 6. Khan Academy – Peer-to-Peer platform which supports Blockchain technology

Platforms for the protection of intellectual property

Blockchain technology has emerged as a tool with the potential to change the way intellectual property is handled and protected. The steps to accomplish this are as follows [18]:

Proof of Authorship – Blockchain can be used to timestamp the moment an intellectual property work is created. In this way, the connection between the one who wrote it and the actual work can be made.

Content Authenticity Verification – All creators of a work can register their original work on the Blockchain. This ensures that a registry exists unaltered and original of a work which cannot be claimed to belong to anyone other than the person who wrote or created it.

Digital Rights Management – Blockchain can facilitate digital rights management by creating a decentralized and transparent system where content creators can create rules around how their content is stored and distributed. For example blockchain can be used to ensure that only authorized users can access, modify or distribute certain content.

Licensing – Through blockchain, authors can license their work through what are known as smart contracts.

Decentralized learning resources

Decentralized learning resources are a good opportunity to share, store and access data. Using the principles of decentralization, these libraries aim to create an open platform for the distribution of information and knowledge. These systems operate on a peer-to-peer network instead of using a centralized server. This means that the content, be it books or other supplementary learning materials, is stored on several nodes or computers on the network, making the system more resistant to data loss or what is known as a 'single point of failure' where in case of failure of the single node where the data is stored, the whole system goes out of order [18].

If several copies are stored on this network, the loss of data on one node does not impair the availability or accessibility of the content. This decentralized nature of the system makes it more difficult for authorities or other actors with malicious intent to censor or delete content. Decentralized libraries aim to make information more accessible to all those who have an Internet connection, thus overcoming geographical barriers or other obstacles that arise during access to data. Most importantly, Blockchain technology that relies on the principle of decentralization ensures that content remains unaltered and authentic [18].

Creating such a system has its advantages but of course also its challenges. The main advantage is that this system ensures that information is preserved for future generations regardless of whether the central servers or specific organizations cease to exist. Also, not needing a centralized infrastructure can reduce maintenance costs. In this system, everyone is free to contribute and this affects the enrichment of the content. Finally, removing or placing a material is a transparent and visible process for everyone [18].

Some of the challenges have to do with the fact that because data is stored on nodes, a large memory space is needed. Also, efficient search and categorization of content is more challenging for a decentralized system than a centralized system. Without a central authority that controls and analyzes the quality of the material being posted, concerns may arise about the accuracy and quality of the material [18].

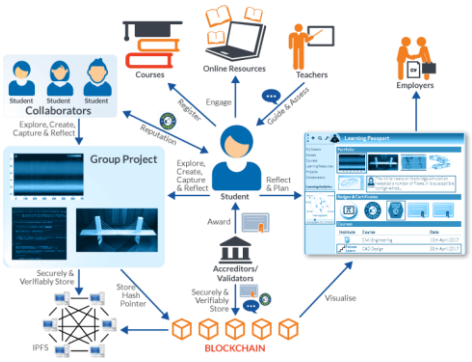


Figure 7. A possible application of Blockchain in the field of education

Challenges of applying Blockchain in education

Despite the fact that Blockchain technology offers numerous opportunities and potential for the education sector, a significant number of challenges are announced when considering the implementation of this technology. Some of the challenges for the integration of this technology according to the study of [15] may be the limited knowledge that educators and other parties have about the use of this technology. This inevitably leads to misunderstandings, resistance to technology adoption and inappropriate applications. On the other hand, most institutions do not have their IT infrastructure developed enough to implement this technology in the right way. Most of them still work with traditional systems and integration implies quite large investments [14]. Integration is not only technically challenging but also costly. For the proper implementation of the technology, staff training is needed, the reorientation of the processes, which must be carefully considered [14]

One of the important challenges identified for Blockchain is security. While Blockchain has fairly solid security, the immutable nature of this technology means that once data is written, it cannot be altered [15]. This can cause consequences, especially with data protection regulators, which grant and guarantee individuals the right to change/improve or delete their data [15].

Another challenge is related to laws and regulations. The dynamic space of Blockchain regulators, especially in terms

of data protection and verifications outside the country of origin, can be an obstacle for institutions that have goals to adopt this technology [12]. The lack of standards regarding the use of this technology is another concern. In order for it to be recognized in a general (universal) way, there must be a standard for which all parties agree. Without this there is a risk of fragmentation, where different institutions apply and use different standards, causing these interoperability problems [12].

CONCLUSION AND DISCUSSION Blockchain technology can be said to have significantly

changed or transformed the digital space. This innovation is quite promising and it is thought that its integration will create new standards for the way different industries operate. The characteristics of this technology such as decentralization, immutability and transparency make it a technology with the power to impact almost any field or activity of human life.

The fact that Blockchain technology is finding application in almost every sector shows how adaptable it is. From the finance behind cryptocurrencies like Bitcoin to supply chain, healthcare, real estate, the arts, this technology seems to know limits. The possibilities offered by technology are numerous. Through it, organizations are protecting sensitive data from unauthorized intervention by third parties. The purpose of this diploma topic was to analyze what opportunities this technology offers for the education sector. From the analysis, it was understood that there are many opportunities for this sector. Currently, the number of educational institutions that have implemented this technology is not large, but in the future such a thing is expected to change. The reason why we do not have a mass adoption of Blockchain in education is related to some of its challenges or limitations. The main ones are: limited knowledge about this technology, inadequate infrastructure for implementation, lack of standardization, interoperability with current systems, those considered as 'legacy systems', etc. Moreover, putting this technology into use requires quite large investments not only in equipment and infrastructure but also in knowledge and development of skills for the people who will use it. The complexity of this technology together with the aforementioned aspects are a serious barrier to a possible and rapid adoption of the technology.In terms of applications, Blockchain technology has today found a place in popular education applications such as Duolingo and Khan Academy. So, the applications are in both the private and public sectors. Both platforms use Blockchain to issue certificates to students who successfully reach the various assessment stages. These certificates are protected against forgery and can be used by third parties for various verifications. Also, many universities in the world, mainly those from developed countries such as the United States of America, have integrated or are in the process of integrating Blockchain into their student management platforms.

Deep learning's impact on autonomous vehicleevolution

Endrit Berisha[1], Faton Kabashi[2], Lamir Shkurti[3], Vehebi Sofiu[4], Mirlinda Selimaj[5] [1, 2, 3,4,5] UBT, Higher Education Institution, Kosova
Email: eb47780@ubt-uni.net, faton.kabashi@ubt-uni.net, lamir.shkurti@ubt-uni.net, vehebi.sofiu@ubt-uni.net,mirlinda.selimaj@ubt-uni.net

***Abstract*— This paper presents a comprehensive exploration of the evolving landscape of autonomous vehicle technologies, focusing on both modular and end- to-end learning paradigms, with an emphasis on the significant role of deep learning. Through a combined approach of qualitative analysis and comparative review, the study draws on numerous sources, including researchpapers, industry documentation and real-world case studies, to assess the impact of deep learning on these paradigms. The initial findings highlight substantial advancements in autonomous vehicle development due to deep learning, particularly in areas like perception, decision-making and system adaptability. However, these areas operating independently within modular paradigm systems have their limitations, including issues related to maintenance, interpretation and incomplete information. On the other hand, end-to-end systems, represented by industry leaders such as Comma.ai, show a strong ability to be more adaptable, operate efficiently and provide cost-effective autonomous vehicle solutions. Furthermore, Tesla's transition from a modular approach to a vision-centered, end-to-end model underscores the growing potential of this paradigm. While the research explores both paradigms, the future of autonomous vehicle development lies in deep learning- powered end-to-end systems.**

Keywords— Deep learning, autonomous, vehicle evolution.

I. INTRODUCTION

As technology advances, cars are increasingly being equipped with autonomous driving capabilities, enabling efficient navigation through traffic and enhanced safety. Over the past two decades, autonomous vehicles have evolved from a once-fictional concept to a possible reality, making significant progress in the field of intelligent systems. This journey began with initial trials by General Motors and the Radio Corporation of America's Sarnoff Laboratory in the 1950s [1]. During these early stages, the companies developed prototypes guided by wires embedded in the road and showcased concept cars with electronic guidance and radar assistance, laying the groundwork for a transformative journey in transportation. At the center of this technological evolution is the profound impact of deep learning, a branch of Artificial Intelligence (AI) that mimics human knowledge while demonstrating remarkable capabilities to acquire learning patterns and representations from large-scale datasets [2].

Early concepts of integrating neural networks in autonomous cars emerged in 1995, focusing primarily on controlling and braking functions [3]. As technology has advanced, these vehicles began incorporating more sophisticated sensors, showcasing the rapid evolution of autonomous driving capabilities. Vision is a major sensor used by humans and as such, the growing AI field should also focus around vision [4]. The large amount of labeled and rich driving data enables deep neural networks to understand complex patterns. The aim of this thesis is to provide a thorough exploration into the influence of deep learning on the evolution and development of autonomous vehicles. This involves delving into the principles of deep learning, understanding its integration with autonomous vehicles, exploring its practical applications and examining its role in shaping vehicular perception and decision-making.

To achieve this objective, the thesis begins by presenting the fundamentals of deep learning, emphasizing their significance in the context of autonomous vehicles. Upon this foundation, the research delves into the central problem, outlines the methodology and investigates recent advancements, specifically highlighting the modular paradigm and end-to-end learning in autonomous driving.

Considering the latest advancements in deep learning and the potential of end-to-end learning, this paradigm will have a significant impact on the field of autonomous vehicles. To guide this exploration, the thesis addresses three central research questions:

1. What role has deep learning played in the development of autonomous vehicles?
2. What are the limitations of the modular paradigm in autonomous vehicles?
3. Can an end-to-end learning system that mimics human driving emerge as an effective approach towards achieving fully autonomous vehicles?

By addressing these questions, this research aims to uncover the role of deep learning in the ongoing evolution of autonomous vehicles.

II. PROBLEM STATEMENT

While humans have proven to be competent drivers, several issues still affect road safety, efficiency and accessibility. The congestion in rapidly growing cities only make things worse, causing frustrating delays and limiting how easily people can get around. Fully self-driving cars havethe potential to not only solve these problems but also change the way we travel. They have the potential to make driving safer through better predictive abilities, optimize traffic flow and improve travel accessibility.

This thesis explores the profound impact of deep learning on the development and advancement of autonomous vehicles, focusing on how these systems can learn by using extensive diverse driving data and machine learning to enhance decision-making and adaptability. The research centers on questions regarding the role of deep learning in the evolution of autonomous vehicle technology, the limitations of the modular paradigm and whether end-to-end learning can emerge as a potent and effective way to achieve fully self- driving cars. This research is focused on tackling these challenges and explore their implications for the future of autonomous vehicles.

III. METHODOLOGY

3.1 Research Design and Data Collection

This study primarily employs a qualitative and explanatory research design. Its main goal is to explore the connection between deep learning and autonomous vehicles, examining both the modular and end-to-end learning paradigm. Data for this research are collected from various sources, including academic journals, research papers and online repositories. Moreover, insights from industry reports produced by leading companies in the autonomous vehicles sector will also be integrated into the thesis. The literature review plays a pivotalrole in this section, as it will provide the foundation for selecting the essential criteria for the comparative analysis based on prior research

3.2 Comparative Analysis

The criteria selected for the comparative analysis are crucial in assessing the effectiveness of different approaches toward autonomous vehicle technology. Once these key criteria are established, a comprehensive performance examination of technological advancements in deep learning as opposed to classical methods will be conducted. This will be followed bya comparison between modular and end-to-end learning paradigms. This comparison aims to clarify the effectiveness, challenges, limitations and potential advancements each paradigm brings to enhancing autonomous vehicle functionality.

The analysis will delve into challenges outlined in the preceding literature review, with a focus on vehicle adaptability, modeling real-world complexity and ensuring safety. Furthermore, real-world case studies involving autonomous driving systems employing either of these paradigms will be thoroughly analyzed. These case scenarios will provide insight into the models used, their application and any challenges they encounter. Metrics such as miles driven per disengagement will serve as key indicators in evaluating system reliability and real-world performance. Additionally, the analysis will help to better understand how each approach works in real-world situations

IV. FINDINGS

4.1 Deep Learning in Autonomous Vehicles

4.1.1 Technological Advancements

The use of deep learning has profoundly changed how autonomous vehicles are developed. It primarily enhances accuracy, adaptability and understanding that were previously hard to achieve with classical computational methods. These improvements have affected autonomous driving technology, including vehicle perception, decision making, sensor fusion and end-to-end learning as a unified system. The rise of CNNs in perception was marked by their outstanding performance in the ImageNet challenge, as detailed in [5]. In autonomous driving, deep learning significantly enhances object detection both in 2D and 3D spaces. For instance, the Faster R-CNN algorithm excels in 2D object detection, identifying on-road obstacles effectively[6]. In the 3D space, both the MSL3D framework and PointPillars algorithm are noteworthy. MSL3D improves 3Ddetection accuracy by utilizing multiple sensors [7], while PointPillars fast-tracks reliable 3D object detection using point cloud columns [8]. Furthermore, point-based methods like PointNet++ and PointRCNN demonstrate adeptness in processing point cloud data for real-time 3D object detection[9]. Collectively, these algorithms underscore the significantrole of deep learning in advancing object detection within autonomous driving systems. On the other hand, image segmentation helps to identify and categorize various scene elements. Key algorithms in autonomous driving like FCN [10] and improved SOLOv2 [11] contribute to effective segmentation. Also notable are U-Net Incpetion [12] and SegNet [13], each proficient in distinguishing various objectsand features in driving scenarios, thereby further enhancing the vehicle's perception and navigation capabilities.

In the decision-making layer, the study at [14] introduces an imitation learning approach, employing a modified Dagger [15] algorithm with a weighted loss function, which imitatesexpert behavior, particularly in near-collision scenarios, outshining general model-based methods. In Contrast, [16] uses an RL-based method to learn trajectory parameters for various dynamic changing highway scenarios. In recent research, the concept of end-to-end learning has been explored to enhance autonomous navigation to direct learning from raw sensory inputs to control outputs. This study [17] introduces a direct end-to-end behavior cloning approach, utilizing a neural network to enhance autonomous navigation in complex urban environments, thereby achieving significant improvements in goal-oriented navigation andtraffic management in simulations. Moreover, [18] focuses

on developing a driving policy that adapts to diverse visual conditions and scenarios, achieving high success rates on driving benchmarks without requiring privileged information like perception. Deep learning has paved the way for more capable and versatile autonomous driving systems, offering superior adaptability in perception, decision-making and the end-to-end learning paradigm.

4.1.2 Performance Milestones

Perception: Research into the exploration of perception methods reveals the importance of sensor fusion, combining data from cameras, LiDAR and RADAR. The perception layer is responsible for the initial processing of this data, essential for identifying objects on the road. In computer vision for autonomous vehicles, the literature highlights two critical perception components: object detection and image segmentation. Historically, object detection has seen substantial evolution, with early methods like Viola-Jones (created in 2001) and HOG (Histogram of Oriented Gradients, introduced in 2005) playing key roles in early advancements [19]. For example, Viola-Jones efficiently detects faces using Haar-like features, while HOG, primarily designed for pedestrian detection, focuses on gradient and orientation analysis within a grid-based system and is also adaptable for detecting various other object classes. However, these techniques were limited by their reliance on hand-engineered features and inability to generalize well in diverse, dynamic scenarios.

The advent of deep learning, especially with CNNs, has enhanced performance and flexibility, moving beyond hand-crafted features of previous methods. This shift has led to significant advancements in areas ranging from autonomous vehicles to healthcare.

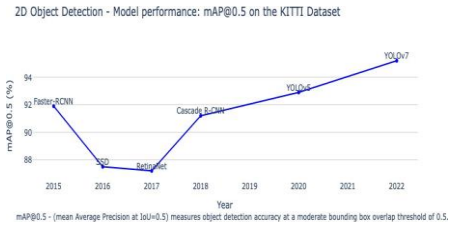


Figure 1. Object Detection Performance Analysis

This chart, informed by data sourced from [20], illustrates the progression in the mean Average Precision (mAP) scores of various fundamental deep learning models over the years, highlighting their effectiveness in 2D object detection. The models in this study were evaluated using the KITTI object detection dataset known for its real-world driving scenarios, which includes diverse road environments. Image segmentation, as mentioned in the literature review, plays a crucial role in extracting valuable information from images. In the past, classical methods were used to highlight features, find edges or create binary images. While these methods helped to extract valuable insights, they had limitations, especially with complex images. In recent years, deep learning has revolutionized image interpretation. Autonomous vehicles can learn a lot from a single road image, given the clarity and organization of roads.

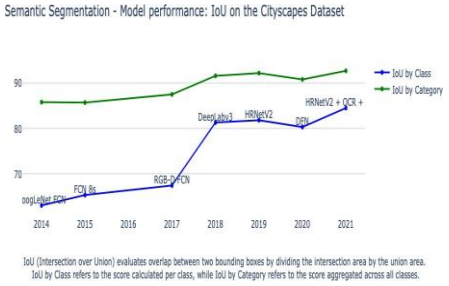


Figure 2. Semantic Segmentation Performance Analysis

With data derived from [21], the displayed chart traces the evolution of various semantic segmentation models over the years by analyzing the IoU score for class and category performance using the Cityscapes dataset.

Localization: The review detailed essential localization techniques, from precise navigation to more adaptive strategies and also touched on SLAM (Simultaneous Localization and Mapping) algorithms. These algorithms are vital for enabling vehicles to navigate successfully through unknown environments. Traditional SLAM methods, usually using specialized sensors, are known for precise localization and mapping, making them reliable for autonomous vehicles' safety needs. However, the development of deep learning technology has provided new ways to solve this problem. Deep learning enhances SLAM systems by providing advanced perception tools for complex environments, enabling high-level scene understanding and facilitating adaptive learning capabilities for autonomous vehicles in unfamiliar scenarios.

Appendix 1 compares various odometry techniques in autonomous vehicles, emphasizing each model's performance through average translation errors from the KITTI odometry benchmark.

Classical feature-based techniques remain more effective in precision for autonomous vehicle localization and mapping, evidenced by lower error rates. However, deep learning techniques are narrowing the gap, demonstrating increasing potential in complex environments.

Planning: The literature review examines how essential planning is for autonomous vehicles, especially when they face unexpected road situations. It looks at three main aspects:

- High-level planning: Involving the strategy for the vehicle's route from start to finish.

- Behavioral planning: Focused on the vehicle's interactions with its environment.
- Motion planning: The process of plotting immediate actions an autonomous vehicle takes.

Appendix 2 below presents a comprehensive comparison of various studies related to decision-making in autonomous driving. Each study utilizes different methods on specific scenarios to test their approaches. The results demonstrate the effectiveness of each method in the given scenario and the simulation indicates the environment used for testing the models.

4.2 Limitations of the Modular Paradigm

The modular approach, which is predominant in current autonomous vehicle systems, pirates on a classical robotic architecture, often expanding on the sense-plan-act paradigm. In the literature review, modular approaches in autonomous vehicle applications, particularly in aspects such as perception, localization and planning, have shown significant progress. However, these approaches also encounter limitations, especially when dealing with the dynamic complexities of real-world driving scenarios.

Perception: Modern autonomous vehicles are equipped with advanced sensors, collecting data to inform driving decision. Significant advancements have been made in addressing current perception-related algorithms. Waymo, one of the leading pioneers in autonomous driving, has advanced perception technology through years of dedicated research [49]. They integrate hand-crafted features with machine learning, improving system reliability and performance in diverse driving conditions. Most of the disengagements are not perception failures but instead, they occur in the planning layer. While modern algorithms excel at perceiving the environment, the challenge lies not in data acquisition but in its interpretation. For instance, they may misidentify unexpected roadside objects as threats due to the hand-crafted representation, reflecting limitations in the planning layer's decision-making information.

Localization: One area that has witnessed improvements in the field of autonomous vehicles is known as localization. Many autonomous vehicle companies in the industry, likely use a combination of advanced technologies such as LiDAR and detailed pre-made maps to achieve a high level of accuracy. While these methods can provide extremely precise results, they are difficult to maintain as the world changes and often require expensive financial investment. Expanding to new regions requires creating other detailed high-definition (HD) maps, making it a time-consuming and expensive endeavor.

Planning: Lastly, planning within the context of autonomous driving emerges as the hardest challenge. This process is quite complex because it needs to combine information from sensors, environmental data and make decisions in real-time.

- Behavior Planning, which decides how an autonomous vehicle should act based on the information it has gathered through perceptions and its representation of the world can be very challenging. This challenge arises in situations where the data from the preceding layers are incomplete or ambiguous, complicating complex interactions.
- Motion Planning, which involves generating feasible path or trajectories for the autonomous vehicle to follow, taking into account local obstacles, traffic rules and vehicle's own dynamic can also be very difficult. If there were inaccuracies in the information provided by perception or if the behavior planning made suboptimal decisions, the motion planner can only work with the data it receives. This highlights the importance of having accurate and reliable data from perception, localization and robust decision-making from behavior planning to ensure that motion planning can operate effectively.

Through only perception and localization, achieving a plausible miles-per-disengagement rate using this approach becomes an attainable goal. While the planning layer is undoubtedly important, achieving this rate does not require complexity and sophistication. Despite making a lot of progress in these areas, these companies often encounter difficulties to make their solutions work on a large scale.

In conclusion, a review of these limitations makes it clear that methods within the modular paradigm encounter challenges in real-world applications. Plus, because different parts of the self-driving system rely on each other, it's becoming more and more obvious that there is a need for complete and joined-up solutions to handle the complexities of autonomous driving effectively.

4.3 End-to-End Paradigm

Considering the previously discussed limitations of modular techniques, trying to solve hard problems using a highly modular structured and carefully designed decision-making system can become very complex. In contrast, the end-to-end learning system approach involves treating the combination of vision sensing, prediction and planning as one big problem. It tackles this problem by utilizing a wide range of driving data to find solutions.

Similar end-to-end learning strategies have proven effective in diverse domains. For example, advancements in understanding human linguistic patterns are evident with multimodal large language model like GPT-4 [50] and the mastery of intricate games shown by MuZero [51]. The problem complexity of these challenges makes traditional structured layers hard to handle them.

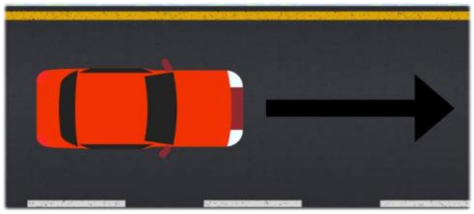
The end-to-end approach, as opposed to being one large system, can also be composed of smaller parts, which means that there can still be essential small layers like image segmentation to enhance the prediction. Here, the main idea

is that these systems are trained end-to-end, promoting a more cost-effective approach.

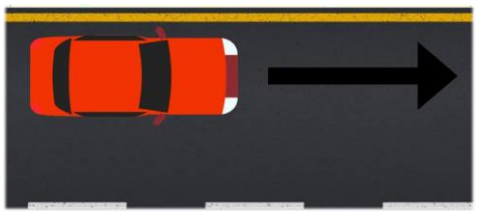
Challenges in Supervised Learning: In the initial framework of developing end-to-end learning systems, researchers focused on implementing advanced supervised sequence models. Yet, these models encounter difficulties in long-termplanning. This is due to uncertainties, the complexity of sequential decisions and the need to predict other agents' behavior over extended timeframes. These systems are generally constrained to short-term predictions, providing insights into potential road conditions for only about 2 to 3 seconds ahead.

Another architecture examined in the context of supervised learning is behavior cloning.

In behavior cloning, the model replicates observed actions without an underlying understanding of the goals. As discussed in the review an interesting challenge is covariate shift. Consider two scenarios:



Scenario 1



Scenario 2

In the training data, the model might output one of the predictions to "drive straight".
While this works in Scenario 1, it becomes problematic in Scenario 2. Here, the car remains on the left, mimicking past data without attempting to correct its course, which can result in accidents. This suggests that supervised learning approaches, when applied to end-to-end learning, encounter a lot of limitations in their effectiveness.

Reinforcement Learning: Unlike methods that rely on fixed datasets, this new framework requires interaction with an environment for learning because it needs to explore different actions. In the context of autonomous driving research, RL is often employed by evaluating the driving scenarios in a simulator. These simulators adopt diverse approaches, ranging from realistic game-engine-based environments like CARLA [52] to those that utilize real-world routes with slightvisual modifications.
The RL approach addresses the limitations of the supervised learning approach behavioral cloning, where predictions can diverge from actual behavior. It uses a reward function to guide learning as pointed out in the literature review. Instead of just copying what a human would do, RL agent can ask, "Would a human think this action is good or bad?" This helpsthe system learn to make decisions similar to how a human driving scenario would be.

4.4 Use Cases

Use Case 1: Waymo's Modular Approach

When we think about self-driving cars, one name that comes to mind is Waymo, which is Google's self-driving car company [53]. Waymo represents what we typically categorize as
"Level 4" self-driving technology.

The chart presented below provides an overview of disengagement events in the year 2022 [54] for companies that have maintained an average mileage exceeding 4,000 miles.

Figure 3. Disengagement Events

This chart, highlights Waymo's performance, particularly in terms of miles per disengagement, suggesting that their technology stands out as one of the most advanced in the field.
Model: Waymo with its modular architecture, serves as the core for Waymo One [53] the firm's autonomous ride-sharing service. The architecture comprises an advanced sensor suite including lidar, cameras and radar, providing hand- engineered rules and machine learning algorithms to handlea variety of driving scenarios.

Effectiveness: The service is designed to offer an autonomous ride-sharing solution to users within restricted areas. The modular approach allows for specialized handling of different driving tasks, enhancing safety within the controlled environments of the service.

Challenges: Despite the advancements, the high cost of integrating Waymo's technology, estimated at around
$180,000 [55], poses a significant barrier. Moreover, the services they provide, such as ride-sharing, represent only a

fraction of how people usually get around, as mostindividuals continue to rely on personal vehicles.

Use Case 2: Comma.ai's End-to-End Planner

Model: Comma.ai employs an end-to-end machine learning model which processes data from various sensors on the car and outputs driving commands directly. Their system mimics human driving, processing frames to generate trajectory outputs for 3D space navigation, similar to human behavior. This trajectory is represented in x, y, z coordinates, measuredin meters [56].

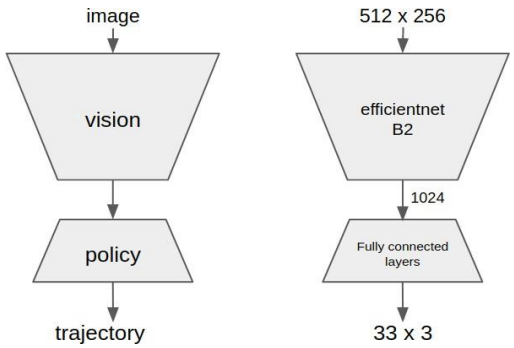


Figure 4. Comma.ai End-to-End Planner

Usage: Comma.ai provides a devkit known as the "Comma 3X", which is installed in a supported existing vehicle, adding autonomous driving features using their open-source software, openpilot. The devkits' cost ranges from $1,250 to
$2,199 and they are compatible with over 250 vehicle models across various brands [57].

Effectiveness: Comma.ai's approach lies in its community- driven development and open-source nature. The end-to-end approach allows for the continuous improvement of the driving model through learning from both real-world and simulated data. It simplifies the system by reducing the needfor manual feature extraction or complex logic, which in turn,could lead to faster development and deployment cycles.

Use Case 3: Tesla's Transition to End-to-End Approach

Model: Tesla has transitioned from a modular approach to anend-to-end deep learning architecture for its autonomous driving technology [58]. The new model integrates perception and planning blocks into a cohesive system, trained jointly to minimize a loss function, as opposed to training each block independently.

Usage: The end-to-end deep learning model is designed to eliminate manual rules and trajectory decision-making used in the planning stage. This transition replaces hardcoded instructions like "maintain a safe following distance from the vehicle in front, e.g., a 3-second gap", with deep learning models, making the system more adaptive to real-world driving scenarios.

Effectiveness: By training all components of the system jointly, Tesla aims to create a more cohesive systems that canhandle many different situations on the road. This approach follows a trend in the industry of using deep learning to deal with complex tasks without needing manual input or fixed rules.

4.5 Future Perspectives

The journey toward fully autonomous vehicles continues, even with the recent advancements in deep learning and RL for autonomous vehicles. This section discusses the future directions of deep learning in the context of autonomous vehicles.

1. Interpretability - End-to-end systems in autonomous vehicles often operate as "black boxes" making it difficult tounderstand and trace the decision-making processes that control the vehicle. Efforts are underway to develop transparent, understandable AI with intermediate representations and to integrate robust methods that ensure trust between the system and humans.

2. Large foundational models - There is a direction to develop a highly robust foundational model using a fully end- to-end unsupervised approach, similar to how autoencoders work on visual features, projecting outputs into discrete rather than continuous spaces. The advantage of this approach lies in its similarity to language processing, where generative pre-trained transformers style models are employed for prediction tasks. This framework is attracting considerable attention in current research movements and could significantly enhance the reliability and adaptability ofautonomous vehicles.

3. Simulation-to-Real - The frequent iterations during model training make direct deployment in the real world challenging. Hence, simulations are employed initially. Nonetheless, challenges persist when transitioning from simulations to real-world applications due to substantial differences between the two environments. The focus of current research is shifting towards simulations that incorporate real-world routes with minor visual alterations.

To summarize, these advancements mark important steps in the ongoing progress, each with the potential to significantlyshape the future of autonomous driving systems.

V. CONCLUSION AND DISCUSSION

Autonomous vehicles have undergone in a lot of transformations with the advent of deep learning. The findings of this thesis underscore the impact of deep learningin advancing the state-of-the-art autonomous vehicle technology, with a particular emphasis on the modular and end-to-end learning paradigms.

1. Deep learning in autonomous vehicles:

- By leveraging architectures such as Deep CNNs and RL,these models have substantially improved perception and decision-making, thus addressing the first research question.

2. Modular paradigm limitations:

- The cost of specialized sensors and the incomplete data that can come from the above layers can generate errors to the lower layers, thus addressing the second research question.

3. End-to-End approach:

- By treating autonomous driving as, a single problem, it sidesteps the modular paradigm's limitations. The case of Comma.ai illustrates the end-to-end learning approach, with its model processing sensor data to deliver driving commands directly, like a human would. On a larger scale, Tesla's transition to an end-to-end approach aims to create a more adaptive system that can handle varied road situations, moving beyond the rigid rule-based systems of the modular approach.
- To determine whether end-to-end learning is an effective approach for achieving fully self-driving cars, it's essential that these systems be adaptable, capable of learning from available data and able to ensure safety while evolving with changing driving norms. This addresses the third research question.

The journey towards fully autonomous vehicles is marked by technological shifts with deep learning ahead. The modular approach, exemplified by Waymo, has shown solid performance in controlled settings but faces scalability challenges. On the other hand, the end-to-end paradigm, presents a promising route towards cost-effective and scalable autonomous vehicles. The future of autonomous driving is focused on addressing key focus areas like interpretability, large foundational model development, simulation-to-real for further advancements of this technology.

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Appendix 1

Table 1. Odometry Techniques and Performance Analysis on the KITTI dataset

	Date	Loop-Closure	Sensor	Model	Sequences	Translation %
	2017	Yes	M	DeepVO [22]	[3,4,5,6,7,10]	5.96
	2018	No	S	UnDeepVO [23]	[0,2,5,7,8]	4.07
	2022	**No**	**M**	**SelfVIO** [24]	**[0,2,5,7,8,9,10]**	**1.24**
Deep	2020	Yes	M	DAVO [25]	[3,4,5,6,7,10]	3.91
Learning	2017	No	M	SfmLearner [26]	[0-11]	29.71
	2019	Yes	M	[27]	[3,4,5,6,7,10]	3.47
	2022	Yes	M	VRVO	[9, 10]	2.1
	2019	No	L	LO-NET [28]	[0-11]	1.29

	2020	No	R	VIOLearner [29]	[0,2,5,7,8,9,10]	4.48
	2023	**No**	**S**	**SOFT2** [30]	**[0,2,3,4,5,6,7,9,10]**	**0.39**
	2017	Yes	M/S	ORB-SLAM2 [31]	[0-11]	0.76
Classical	2014	Yes	S	LSD-SLAM [32]	[0-11]	0.91
	2021	Yes	M	OV2SLAM [33]	[0-11]	0.94
	2015	No	M/L	V-LOAM [34]	[11-21]	0.54
	2020	Yes	S	D3VO [35]	[1,2,6,8,9,10]	0.88
Hybrid	**2018**	**No**	**M**	**DVSO** [36]	**[0-11]**	**0.77**
	2021	Yes	M	LIFT-SLAM [37]	[0-11]	11.30
	2019	Yes	M	NeuralBundler [38]	[0-11]	6.64

- *Date*: The year of the published model
- *Loop-Closure*: Ability to recognize previously visited places, reducing accumulated error
- *Sensor*: Type M, S, L R, abbreviated for Monocular Camera, Stereo Camera, Lidar or RGB-D
- *Model*: The name of the algorithm
- *Sequences:* Used from the KITTI odometry benchmark to evaluate the model
- Translation %: Represents the average translational RMSE drift (%) over distances of 100m-800m, as measured using the KITTI odometry benchmark. The best-performing model is highlighted with bold text

Appendix 2

Table 2. Comparative Analysis of Autonomous Vehicle Decision-Making Studies

Study	Method	Type	Scenario	Results	Simulation
[39]	DQN with ε-greedy Policy	Behavioral	Lane-change/car-follow decision	Successfully navigated scenarios with sudden roadblocks or construction areas, efficiently deciding on actions	SUMO
[40]	Multi-Agent DQN	Behavioral	Lane-change/speed-adjust decisions	Improved average speed (up to 25.7%), reduced collisions (by 62.5%), enhanced driving comfort (up to 60.2%) outperforming existing multi-agent RL techniques.	SUMO
[41]	Multi-Agent RL	Behavioral	On-ramp merging decisions	Achieved 0 collisions, higher average speeds and efficient training across all traffic densities.	Custom (Highway-env)
[42]	Deep RL with Expert Guidance	Behavioral	Overtaking Decisions	Achieved computation time of 0.86ms, speed of 57.2m/s and vehicle collision rate of0.3. It outperformed baselines in rewards, efficiency and	Custom

				safety.	
[43]	DQN for Decision Making	Behavioral	Overtaking Decisions	Had a 92.2% successful overtaking rate and a collision rate of 3.3%. Compatible with existing planners, validated in real-world experiments with iseAuto.	LGSVL
[44]	Hierarchical Deep RL with Attention Mechanism	Behavioral	Lane Change in Dense Traffic	Achieved a success rate of 60-80% in different trials, increased average speed to 23.2 m/s and improved the number of lane changes to 17.	LGSVL
[45]	GCN-LSTM	Behavioral	Vehicle Trajectory	Outperforms generic models, especially for longer prediction horizons.	CARLA
[46]	LK-SDE	Motion	Trajectory Generation and Prediction	Outperforms baselines in smoothness, physical feasibility and explainability.	-
[47]	Crowd-aware RL for Multi-Agent Pathfinding	Motion	Path Finding	Outperforms state-of-the-art methods, with up to 58% improvement in makespan and collision count and up to 5% in success rate.	-
[48]	Multi-Agent RL, Coordinated Policy Optimization (CoPO)	Behavioral	Traffic Simulation/Various Scenarios	Superior success rates: roundabout: 73.67 ±3.71, intersection: 78.97 ±4.23, tollgate: 86.13 ±1.76, bottleneck: 79.68 ±2.91, parking lot: 65.04 ±1.59, efficiency and safety.	MetaDrive

- *Study*: The reference to the published study or paper
- *Method*: Techniques used in the study, which range from deep learning to RL
- *Type*: The study is focused on behavioral aspects or motion planning
- *Scenario*: Driving situations where the methods were tested
- *Results:* Key findings of each study, indicating the method's improvement over previous techniques
- *Simulation:* Indicates the simulation environment or tool used for testing or developing the methods.

Navigating the Future of Hospital Management: A Digital Solution for Departmental Coordination

Gresa Shala1*, Vehebi Sofiu1, Faton Kabashi1, Lamir Shkurti1, Mirlinda Selimaj1,

1UBT – Higher Education Institution, Kalabria 65, 10000, Prishtinë, Kosovë

Abstract. Efficient hospital management and seamless departmental coordination are essential components of high-quality healthcare delivery. In this era of advancing technology, digital solutions have emerged as powerful tools to address the complexities and challenges faced by healthcare institutions. This paper explores the impact of digital solutions on hospital management, emphasizing the role of EMRs in revolutionizing information accessibility, care continuity, and decision support for healthcare professionals. The integration of blockchain technology further enhances data integrity, addressing concerns about security. Mobile health applications, illustrated by solutions like the 'Automated Hospital Ward Management System' and 'Smart Hospital Ward Management System with mobile robot WARDBOT,' showcase the potential of mobile technology in streamlining processes and improving operational efficiency. The exploration of hospital management mobile applications underscores their versatility and functionality. As the healthcare industry stands on the cusp of a digital revolution, the strategic integration of these digital solutions promises enhanced operational excellence, improved patient outcomes, and superior departmental coordination. This research contributes valuable insights to empower healthcare institutions in embracing digital innovations for a more connected, efficient, and patient-centric future in hospital management.

Keywords: digital solutions, efficient management, electronic medical records, mobile applications

Introduction

The healthcare landscape is currently undergoing a significant transformation driven by advances in information technology and digital innovation. As healthcare institutions strive to deliver high-quality patient care, the effective coordination of various medical services and resources has become paramount. This paper explores the emerging role of digital solutions in shaping the future of hospital management, a transformation that holds the promise of operational excellence and improved patient outcomes. Hospital management is a complex challenge, encompassing various domains such as patient care, medication management, resource allocation, and data security. Historically, these domains have been managed through disjointed systems and manual processes, resulting in inefficiencies, errors, and communication gaps. However, the digital age has ushered in a new era, offering innovative tools and technologies to address these challenges.

The importance of efficient hospital management and departmental coordination is underscored by extensive research. Gopal et al. [1] highlights the significance of digital transformation and information technologies in shaping the healthcare landscape. Within this context, this paper embarks on a journey to explore the evolving landscape of digital solutions tailored for hospital management. Our exploration encompasses a range of technologies and applications that have gained prominence in recent years. These include hospital information systems to manage hospital departments, mobile health applications that facilitate hospital operations, and the transformative potential of block chain technology in securing and streamlining Electronic Medical Record (EMR) management. By synthesizing insights from academic research and real-world case studies, this paper aims to shed light on the usability, efficiency, and potential impact of these digital innovations. The healthcare landscape stands at the precipice of a digital revolution, where the strategic integration of technology promises to navigate the future of hospital management. Through this exploration, we aim to contribute to

the growing body of knowledge in this domain, providing insights that can empower healthcare institutions to embrace digital solutions for improved departmental coordination, ultimately leading to more effective patient care.

Literature Review

The literature review reveals a transformative shift in healthcare management fueled by digital solutions. Gopal et al. [1] emphasize the impact of digital transformation and information technologies on healthcare, promising operational excellence and improved patient outcomes. Hospital Information Systems (HIS) and Electronic Medical Records (EMRs) integration streamline coordination, ensuring efficient patient care [2]. EMRs, despite challenges, emerge as pivotal for effective hospital department management, while innovations like block chain-backed systems offer secure, decentralized frameworks [3]. Mobile applications, exemplified by solutions such as 'Automated Hospital Ward Management System' (AHWMS), demonstrate the potential of mobile technology to enhance hospital processes [4] The literature underscores the broader digital revolution in healthcare, where the strategic integration of these solutions holds the promise of operational excellence, improved outcomes, and enhanced departmental coordination.

Digital Solutions for Hospital Management

Hospital Information Systems (HIS) streamline healthcare coordination by centrally managing patient data, including electronic medical records, to enhance clinical, administrative, and financial processes within hospitals. HIS can help in department coordination by supporting automated patient data transfers between departments and institutions, enabling graphic or digitized diagnostic images from the hospital database based on the integrated retrieval system, and facilitating communication through the Laboratory Information System. Additionally, HIS can assist in the registration of human resources and their properties, thereby contributing to efficient department coordination [2]. The correlation between EMR and HIS lies in the integration of EMR as a module within the broader HIS framework. The EMR module serves as a fully integrated knowledge repository for medical and clinical records of patients within the hospital, providing access to critical and complete patient data. This integration leads to high-quality, cost-effective, and efficient patient care, as it allows for seamless access to patient records and information across various departments and personnel within the hospital.

Electronic Medical Records

EMRs have fundamentally transformed healthcare information management within hospital departments by consolidating patient data, including medical history, diagnoses, medications, and treatment plans, into a comprehensive electronic format. This adoption brings numerous advantages to hospital department management. Primarily, EMRs enhance data accessibility, enabling healthcare professionals in different departments to retrieve and update patient information in real-time. This fosters seamless communication and collaboration among healthcare teams, supporting a holistic approach to patient care. For instance, physicians can swiftly review a patient's medical history during consultations, aiding more informed decision-making. Silo-Carroll et al.'s [2] seminal work corroborates the positive impact of EMR adoption on health care quality, patient safety, and efficiency. Moreover, EMRs contribute to care continuity by providing a centralized platform for tracking patient progress across various departments, crucial in complex cases involving multiple specialists. The ability to share up-to-date information promotes coordinated and efficient care delivery. In addition to enhancing communication and coordination, EMRs offer advanced functionalities, including decision support tools that assist healthcare providers in evidence-based decision-making. This includes clinical guidelines, alerts for potential drug interactions, and reminders for preventive care measures. Consequently, hospital departments with EHRs can elevate the quality of patient care while minimizing the risk of errors. While EMR implementation poses challenges such as data security concerns, interoperability issues, and initial costs, the long-term benefits in terms of streamlined workflows, improved patient outcomes, and overall efficiency establish EHRs as a pivotal digital solution for effective hospital department management. Furthermore, recent research by Hang, Choi, and Kim [3] introduces an innovative EMR integrity management system based on a medical block chain platform. This system, designed specifically for

hospital management, ensures the immutability of various medical data, including EMRs, patient visits, prescriptions, billing, and Iota data. Operating on a network of trusted validating peers, the architecture employs consensus protocols and cryptographic primitives to maintain data consistency. According to the research, different user roles within the hospital, including administrators, doctors, pharmacists, and patients, can securely interact with the system and manage access permissions through smart contracts. Hang, Choi, and Kim's [3] groundbreaking EMR integrity management system utilizes block chain technology to guarantee tamper-proof medical records, offering a decentralized, trust-based framework that facilitates secure data sharing among healthcare stakeholders. This forward-thinking approach has the potential to streamline hospital operations, enhance patient care, and uphold the privacy and accuracy of critical medical information in an era where data integrity and accessibility are paramount.

Mobile Applications

The role of mobile technology in healthcare, as initially defined in 2003 and expanded over time, extends beyond mobile phones to encompass a wide range of technological solutions for addressing healthcare challenges. These solutions primarily facilitate the exchange of various forms of information, providing substantial opportunities for the advancement of developing countries and communities [6]. Within the realm of digital solutions for healthcare management, two noteworthy studies have emerged, each contributing to more efficient and streamlined hospital department operations. The first example, presented by Dasanayake et al. [4], introduces the 'Automated Hospital Ward Management System' (AHWMS) and its integration with the mobile robotic platform 'WDBOT.' AHWMS is a comprehensive solution that employs a sophisticated database management system and an intuitive mobile application, harnessing wireless connectivity to enhance healthcare delivery within the hospital department. According to the study, this system caters to the multifaceted demands of healthcare professionals, streamlining key processes like patient admission, medicine management, and record maintenance. Notably, the integration with 'WDBOT' has transformed medicine distribution within the department, relieving nursing staff of burdensome tasks and saving valuable time. In the second example, Dasanayake et al. [7] detail the 'Smart Hospital Ward Management System with mobile robot WARDBOT,' a solution that focuses on hospital department management as well. The study reveals that this advanced system leverages efficient database management, user-friendly mobile applications, and seamless wireless connectivity to meet the requirements of healthcare professionals. In addition to patient registration and record-keeping, this system excels in managing medical supplies and ward preparation. The integration of WARDBOT into this solution plays a crucial role in drug distribution and the preparation of hospital wards, significantly reducing the workload of nursing staff and saving time. Both solutions are anchored in well-structured MySQL databases, accessed through intuitive web interfaces on tablet devices. Mobile applications in the health sector have the potential to reduce costs, improve healthcare quality, and encourage preventive measures, ultimately leading to long-term enhancements in health outcomes [6]. These mobile applications utilize a variety of sensors, including motion sensors, cameras, and proximity sensors, enabling the collection and transmission of health-related data. They are increasingly used to monitor health through various digital devices like smartphones, wearable technology, and residential tools, offering real-time, objective data collection compared to traditional episodic clinic visits. This transformation is driven by major technology companies' investments in the healthcare sector, expanding their role from hardware providers to potentially serving as vital vehicles for healthcare provision. In their 2020 study titled "A research on the classification and applicability of mobile health applications," Pires et al. [8] identified several distinct categories of mobile health applications, each with its own unique purpose and functionality. Here is a summarization of this study's categories, with an example app representing each one:

Medical Information and Education Apps

Medscape [9] is a free mobile health application that serves as a comprehensive resource for healthcare professionals. It provides access to a vast drug reference, a disease library, medical procedures, protocols, and a drug interaction checker, facilitating clinical decision-making and keeping healthcare practitioners updated.

Personal Care and Health Monitoring Apps:

MyPlate [10] is an illustrative free mobile health application designed for users seeking to manage their diet, weight, and physical activity. This app features a calorie counter, customized goals based on individual profiles, weight tracking, and other tools to support

personal health and wellness.

Psychological Well-being Apps:

Relax Melodies [11] is a free mobile health application tailored for enhancing mental well-being. It offers access to a diverse array of ambient sounds, customizable volume settings, and binaural beats for brainwave synchronization. This app is particularly helpful for relaxation, guided meditation, sleep improvement, and stress relief.

Educational Apps for Healthcare Professionals:

Electronic Preventive Services Selector (ePSS) [12] is a free mobile health application created to assist healthcare professionals. It features a range of calculators and tools, which align with the recommendations of the US Preventive Services Task Force (USPSTF). This app empowers professionals to perform various screenings based on patient-specific characteristics like age, gender, and behavioral risk factors.

Social Networking Apps for Health Professionals:

Doximity (Medicine Made Mobile) [13] is an influential social network designed to foster communication and collaboration among healthcare professionals. This mobile health application goes beyond traditional networking, offering an extensive peer-to-peer communication toolkit, secure e-fax capabilities, direct messaging, and a community platform centered on shared medical interests.

Hospital Management Mobile Applications

Our introduction of the "Hospital Management Mobile Applications" category expands the discussion beyond the studies by Pires et al. [8]. To provide context, we draw from Olivero et al. [14] who conducted the first comprehensive overview of smartphone and tablet applications specifically designed for hospital management. Their research revealed that these applications are still relatively uncommon, with limited downloads. The majority of these apps focus on "Health operators and patients' management," while other categories such as "Resources, equipment, and meals dispatch" and "Quality assessment" are less prevalent. According to the study, language limitations, with most apps available only in English, and the complexity of hospital administration may hinder their broader adoption. Additionally, the majority of these apps are free to download, although they may lack the customization and prompt service offered by traditional licensed software. Considering these findings, Olivero et al. suggested the need for cross-sectoral applications designed in accordance with national standards and government agency contributions. An example in the realm of hospital management software within this category is "eHospital Systems," [15] designed to facilitate healthcare practitioners in optimizing clinical and administrative processes, particularly emphasizing tasks such as appointment scheduling and lab management. It offers a wide array of features, encompassing inpatient and outpatient management, inventory control, role-based access management, discharge summaries, claims processing, regulatory compliance, and more. This example application empowers medical institutions to efficiently manage physician schedules, maintain organized patient records, simplify payment processing, and streamline pre-admission procedures. Moreover, patients can benefit from a self-service portal for appointment scheduling, access to test results, and secure communication with their healthcare providers. It plays a crucial role in supporting pharmacies by enhancing drug distribution, prescription processing, inventory management, and billing procedures. "eHospital Systems" is compatible with a range of devices, including Android, iPad, and iPhone, allowing for versatility in its use. Furthermore, it provides an Application Programming Interface (API) for integration and customization. Additionally, "eHospital Systems" seamlessly integrates with various other applications, such as Quickbooks Online, Google Calendar, and Twilio, further enhancing its functionality and versatility. It is important to note that "eHospital Systems" is introduced here for illustrative purposes only and is not part of the original studies referenced. Its inclusion broadens our understanding of the diverse landscape of hospital management software in the context of mobile health applications.

Conclusion

In conclusion, the healthcare landscape is undergoing a significant digital transformation, marked by the integration of Electronic Medical Records (EMRs) within Hospital Information Systems (HIS). This shift is addressing historical challenges, providing streamlined workflows, and enhancing patient outcomes, despite initial concerns about data security. The incorporation of blockchain technology further fortifies data integrity. Mobile health applications, exemplified by solutions like the 'Automated Hospital Ward Management

System' (AHWMS) [4] and 'Smart Hospital Ward Management System with mobile robot WARDBOT,' [7] demonstrate the potential of mobile technology to streamline hospital processes, alleviate healthcare professionals' tasks, and save valuable time. In the realm of hospital management mobile applications, the versatility and functionality of these solutions highlight their potential to optimize clinical and administrative processes. As the healthcare industry stands on the brink of a digital revolution, the strategic integration of these digital solutions promises operational excellence, improved patient outcomes, and enhanced departmental coordination. This exploration contributes valuable insights to empower healthcare institutions to embrace digital innovations for a more connected, efficient, and patient-centric future in hospital management.

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Optimization

problems

Nazmi Misini [1]
[1] UBT,Higher Education Institution,Kosova
[1] nazmi.misini@ubt-uni.net

Abstract

Optimization is a process that aims to find the best, most favorable, or most optimized solution for a given problem. This process includes the use of mathematical techniques, algorithms and specialized methods to identify the values of the variables that minimize, or maximize a certain function, which is called an objective function. The use of these methods helps to find valid and efficient solutions for optimization problems, bringing significant benefits in many areas of life and industry. The main goal of optimization is to identify the best or most favorable solution in the context of a given problem.

Optimization problems are present in many fields of life and sciences such as: engineering and design, transportation and logistics, artificial intelligence and machine learning, energy and natural resources, network management and telecommunications, sciences and environment, robotics and automation, economics , informatics, biology, statistics, finance, social sciences, genetic algorithms, metaheuristics, etc. To solve optimization problems, specialized optimization algorithms and methods are used, including browsing algorithms, linear programming, genetic algorithms, clustering methods and many others. etc. These algorithms help in finding valid and efficient solutions for various optimization problems.

In this paper, we will deal with some different problems from the real daily life of society. In solving such practical problems, the most important problem is often converting them into mathematical optimization problems by constructing a function that must be maximized or minimized.

Key words: optimization, minimization, maximization, variable, mathematical optimization.

Introduction

The methods that we will discuss in this paper for finding extremes find practical applications in many areas of life. A businessman seeks to minimize costs and maximize profits. A traveler seeks to minimize travel time. In this paper we will solve problems such as the maximization of surfaces, volumes, and benefits, as well as the minimization of distances, time, and cost.

In solving such practical problems, the most important problem is often converting them into mathematical optimization problems by constructing a function to be maximized or minimized.

Steps in solving optimization problems:

1. **Understand the problem**: Read the problem carefully to find out what the problem is asking. Then, underline the important pieces of information in the problem.
2. **Draw a diagram (optional):** It is always helpful to sum up the entire problem in a simple diagram so to prevent reading the problem repeatedly.
3. **Introduce notion and express it in terms of variables**: Assign a symbol to the quantity that has to be maximized or minimized. (Let us call it Z for now). Assign variable names to the unknowns and express Z as a function of those variables.
4. **Try to express notion in terms of one variable**: If Z has been expressed as a function of more than one variable (step 4), use the information in the problem to eliminate all but one of the variables and use that to express Z.
5. **Differentiate function and equate it to zero to obtain critical points:** Differentiate Z with respect to the variable you choose and equate it to zero to obtain the values of that variable (critical points).
6. **Test critical points for max/min using the second derivative**: To test whether the critical points are a max or min (concave down or up respectively), we take the second derivative of Z and plug in the critical points obtained in step 6 to see whether we get a positive value (minimum) or a negative value (maximum.)

7. **Use the required critical point to find the optimal answer**: Once we know what critical points we are using, we plug that in Z to obtain the answer to our problem.

Now let us use these steps on a few examples!

Example 1

A rectangular storage container with an open top needs to have a volume of 10 m^3 . The length of its base is twice the width. Material for the base costs \$10 per m^2 . Material for the sides costs \$6 per m^2 . Find the cost of the material for the cheapest container.

SOLUTION:

STEP 1: We have:

a) Rectangular box with open top (**info**)

b) Volume of the box is 10 m^3 (**info**)

c) Length of the base is twice its width (**info**)

d) Material for the base costs \$10 / m^2 and material for the sides costs \$6 / m^2 (**info**)

e) The cost of the material for the **cheapest** container (**objective**)

STEP 2:

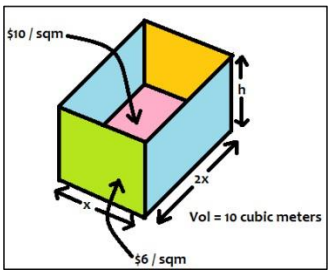

Fig.1

STEP 3: Let us assume the height of the box is **h** and the width of the box is **x**. Then from the information given, we obtain the length of the box as **2x**. Let the cost of the box be **C**.

Cost = \$10(area of base) + \$6(area of 2 long sides) + \$6(area of 2 short sides) which gives,

$Cost = (10 \cdot x \cdot 2x) + (2 \cdot 6 \cdot x \cdot h) + (2 \cdot 6 \cdot 2x \cdot h) = 20x^2 + 12 \cdot x \cdot h + 24 \cdot x \cdot h = 20x^2 + 36 \cdot x \cdot h$

STEP 4: Since **C** is expressed in terms of both **x** and **h**, we need to try to express **S** with only one variable. From the information given, we have the volume of the box = 10m^3 , which means:

$$x \cdot 2x \cdot h = 10 \text{ or } h = \frac{10}{2x^2}.$$

Putting this value of h in **C** we get:

$C(x) = 20x^2 + \frac{36x10}{2x^2}$. When we simplify this, $C(x) = 20x^2 + \frac{180}{x}$, which we need to **minimize**.

Example 2. A farmer has 2400m of wire and wants to fence a rectangular field which is bounded on one side by a river. He wants to fence off the part of the field shown in the picture.

What are the dimensions of the field so that it has the largest view?

solution

We would like to maximize the function **S** of the straight line. Let **x** and **y** be the latitude and longitude of the ruler (in meters). Then, express **S** in terms of **x** and **y**:

$S = x + y$

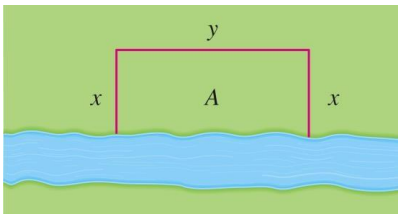

Fig.2

We want to express **S** as a function of only one variable, so we eliminate **y** by expressing it as a function of **x**. To do this, we use the information given that the total length is **2400m**, thus:

2x + y = 2400

From this equation we have **y = 2400 - 2x**, which gives the expression:

$S = x(2400 - 2x)$

$S = 2400x - 2x^2$

We note that $x \geq 0$ and $x \leq 1200$.(otherwise it would be **S < 0**). So the

function we want to maximize is:

$S(x) = 2400x - 2x^2$ and $0 \leq x \leq 1200$

Derivative of $S(x) = 2400x - 2x^2$, will be:

$S'(x) = 2400 - 4x$, therefore to find the critical points we solve the equation: 2400 - 4x = 0
whose solution is: **x = 600**.

The maximum value of **S** can occur either at the **critical point** or at the **edges of the interval**.

Since **S(0) = 0**, **S(600) = 720,000**, and **S(1200) = 0**, the closed interval method gives the maximum value

S(600) = 720,000.

So, the rectangular field should be **600m wide** and **1200m long**.

Example 3. A cylindrical container is made to hold 1L of oil. Find the dimensions that minimize the cost of the metal needed to make the oil container.

Solution: Let **r** be the radius and **h** the height of the cylinder (both in centimeters). In order to minimize the metal cost, we minimize the total surface area of the cylinder. The lateral surface is a rectangle with dimensions: $2r$ and **h ,** Therefore the surface is:

$S = 2\pi r^2 + 2\pi rh$ and $V = \pi r^2 h$, to eliminate use the fact that the volume is 1L, which falls to be: **V=1000cm³**. Therefore:

$\pi r^2 h = 1000$, and from here: $h = \frac{1000}{\pi r^2}$

By substituting this in the expression of syprina we will have:

$S = 2\pi r^2 + 2\pi r \frac{1000}{\pi r^2} = 2\pi r^2 + \frac{2000}{r}$

Then the function we want to minimize is:

$S(r) = 2\pi r^2 + \frac{2000}{r} > 0$

r

To find the critical point, we derive the expression: $S(r) = 2\pi r^2 + \frac{2000}{r}$ and we will have:

r

Then: $S'(r) = 0$ when $\pi r^3 - 500 = 0$, therefore the only critical point is: $r = \sqrt[3]{\frac{500}{\pi}}$

Since the definition set of S is $(0, \infty)$, we can notice that $S'(r) < 0$ for $r < \sqrt[3]{\frac{500}{\pi}}$

And $S'(r) > 0$ for $r > \sqrt[3]{\frac{500}{\pi}}$

So $r = \sqrt[3]{\frac{500}{\pi}}$ constitutes the local minimum point.

The corresponding value of **h** with respect to **r** is:

$h = \frac{1000}{\pi r^2} = \frac{1000}{\pi \left(\sqrt[3]{\frac{500}{\pi}}\right)^2} = \frac{1000}{2 \cdot 500 \cdot 3\sqrt{\frac{500}{\pi}}} = 2\sqrt[3]{\frac{500}{\pi}} = 2r$

Therefore to minimize the production cost of the cylindrical container the radius of the base should be: $r = \sqrt[3]{\frac{500}{\pi}}$ and the height twice the radius **(h=2r).**

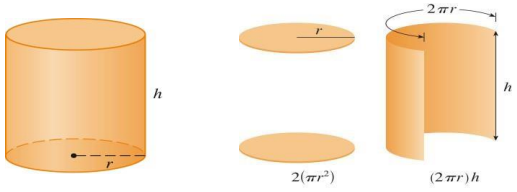

Fig.3

Example Find the point of the parabola $y^2 = 2x$ which is closer to the point **(1;4).**

Solution: The distance between point **(1;4)** and **(x;y**) is:

$$d = \sqrt{(x-1)^2 + (y-4)^2}$$

But if (x; y) is located on the parabola, then $x = \frac{y^2}{2}$, so the expression for **d** becomes:

$$d = \sqrt{\left(\frac{1}{2}y^2 - 1\right)^2 + (y-4)^2}$$

(or else we could substitute $y = \sqrt{2x}$ to derive d in terms of **x** only)

Instead of minimizing **d** we minimize : d^2

$$d^2 = f(y) = \frac{1}{2}y^2 - 1^2 + y - 4^2$$

Deriving we have:

$$f'(y) = 2\cdot\frac{1}{2}y^2 - 1\cdot y - 2\cdot y - 4 = y^3 - 8$$

thus $f'(y) = 0$, **y=2** .We note that $f'(y) < 0$ when **y < 2** and $f'(y) > 0$ when **y>2**, so by the first derivative test and the absolute extreme value test, the absolute minimum occurs for **y = 2**. The corresponding value of x is: $x = \frac{y^2}{2} = 2$.

So the point on the parabola $y^2 = 2x$ that is closest to the point **(1;4)** is **(2;2).**

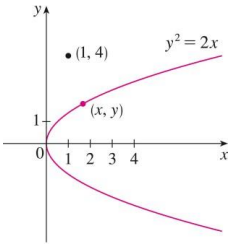

Fig.4

Example 5. A man launched his boat on a river bank **3 km** wide at point **A** and wants to reach point **B**, **8 km** away from the corresponding point of **A** on the other side of the river, as quickly as possible. He can steer the boat straight to point **C** and then go to **B**, but he can go directly to point **B**, but he can also go first to a point **D** between **C** and **B** and from there to **B**. If that he drives at **6km=h** and runs at **8km=h**, where should he go to reach **B** as fast as possible? (We admit that the speed of the river is negligible compared to the speed at which a person paddles.)

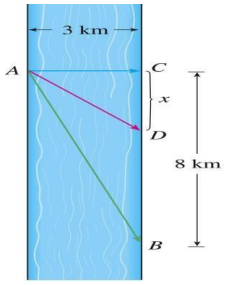

Fig.5

Solution:

Let **x** be the distance from **C** to **D**. Then the running distance is: $|DB| = 8 - x$, and the sailing distance is: $|AD| = \sqrt{x^2+9}$ Then the sailing time is: $\frac{\sqrt{x^2+9}}{6}$ and running time: $\frac{8-x}{8}$ and the total time as a function of **x** is:

$$T(x) = \frac{\sqrt{x^2+9}}{6} + \frac{8-x}{8}$$

The definition set of the function **T** is **[0;8].** Note that if **x = 0** he drives to **C** and if x = 8 he drives directly to **B**. The derivative of **T** is:

$$T'(x) = \frac{x}{6\sqrt{x^2+9}} - \frac{1}{8}$$

Therefore using the fact that $x = 0$ have $T'(x) = 0$, it follows that:

$$\frac{x}{6\sqrt{x^2+9}} = \frac{1}{8} \Leftrightarrow 4x = 3\sqrt{x^2+9} \Leftrightarrow$$

$$\Leftrightarrow 16x^2 = 9x^2 + 9 \Leftrightarrow x = \frac{9}{\sqrt{7}}$$

The only critical point is $x = \frac{9}{\sqrt{7}}$. To see where the minimum is located, at the critical point or at the edges of the definition set **[0;8]** ,we calculate T at all three points from the expression: $T(x) = \frac{\sqrt{x^2+9}}{6} + \frac{8-x}{8}$, and we will have:

$T(0) = 1.5$

$T\left(\frac{9}{\sqrt{7}}\right) = 1 + \frac{\sqrt{7}}{8} = 1.33$

$T(8) \approx \frac{\sqrt{73}}{6} \approx 1.42$

Since the smallest value of these values is located for $x = \frac{9}{\sqrt{7}}$ then the absolute minimum is located right here.

Example 6. Find the area of the largest rectangle that can be inscribed in a semicircle with radius **r**.

Solution: Let be the semicircle of the circle with radius **r**, $x^2 + y^2 = r^2$ centered at the origin of the coordinates. The inscribed word means that the rectangle has two vertices on the semicircle and two more vertices on the **x**-axis. Let **(x;y)** be a vertex located in the first quadrant. Then, the rectangle has sides of length **2x** and **y**, so its surface will be $S = 2 \cdot x \cdot y$.

To eliminate **y** we use the fact that **(x;y)** is on the circle $x^2 + y^2 = r^2$ and from here: $y = \sqrt{r^2 - x^2}$

$S = 2xy = 2x\sqrt{r^2 - x^2}$, The set of definitions of this function is $0 \le x \le r$ also the derivative:

$S'(r) = 2\sqrt{r^2 - x^2} + \frac{2x^2}{\sqrt{r^2 - x^2}} = \frac{2r^2 - 2x^2}{\sqrt{r^2 - x^2}}$, which is zero when:

$2x^2 = r^2$ thus $x = \frac{r}{\sqrt{2}}$

This value of **x** gives the maximum value of **S** since **S(0) = 0** and **S(r) = 0**. Since the surface of the largest rectangle inscribed in the semicircle is:

$$S\left(\frac{r}{\sqrt{2}}\right) = 2\frac{r}{\sqrt{2}}\sqrt{r^2 - \frac{r^2}{2}} = 2\frac{r}{\sqrt{2}}\sqrt{\frac{2r^2 - r^2}{2}} = 2\frac{r}{\sqrt{2}}\sqrt{\frac{r^2}{2}} = 2\frac{r}{\sqrt{2}}\frac{r}{\sqrt{2}} = r^2$$

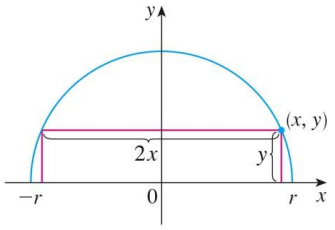

Fig.6

Example 7 Calculate the arc length of the given curve with the function:

$f(x) = \sqrt{x - x^2} + \arcsin\sqrt{x}$

Solution:

Since the limits of integration are not given, we first look for the area of definition of the function:

$x \square x^2 \square 0 \square$ $x \square 0$ $\square$ $x \square \square 0,1 \square$ *and* $f'(x) \square \frac{1 \square x}{\sqrt{x}\sqrt{1 \square x}} \square \frac{\sqrt{1 \square x}}{\sqrt{1 \square x}} \square \frac{1 \square x}{\sqrt{x}} \square \sqrt{\frac{1-x}{x}}$

Therefore, the arc length of the curve will be:

$$L \square \int_0^1 \sqrt{1+\left[f'(x)\right]^2}\,dx \square \int_0^1 \sqrt{1+\frac{1-x}{x}}\,dx \square \int_0^1 \sqrt{\frac{1}{x}}dx \square 2\sqrt{x}\Big|_0^1 \square 2$$

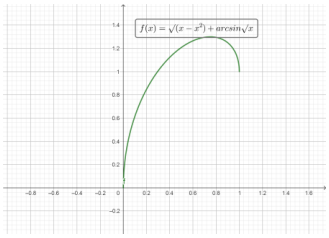

Fig.7

Example 8 *Consider a ball thrown vertically upwards from the ground. The ball position at each instant follows the function:* $h(t) \square 40 \square t \square 5t^2$ *, where* ***h*** *is expressed in meters and* ***t*** *in seconds.*

Determine: ***(a)*** *The height at which the ball lies* ***1 second*** *after the throw;* ***(b)*** *The instant at which it is* ***75m*** *from the ground;* ***(c)*** *The maximum height reached by the ball and* ***(d)*** *The instant when the ball returns to the ground.*

Solution

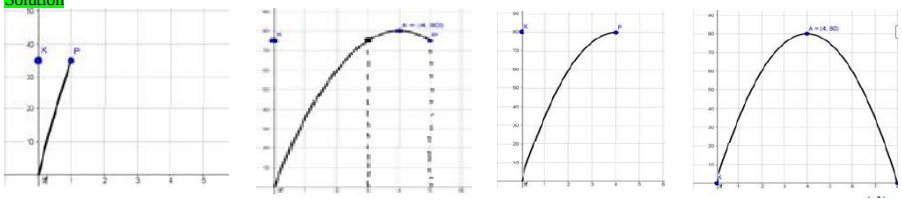

Fig.8

a) To find the height of the ball after the first second, we act in this way: we replace the value **t=1** in the above equation and we will have: $h(1) \square 40 \square 1 \square 5 \square 1^2 \square 40 \square 5 \square 35m$.

b) To find the answer after how long will the ball reach the height of **75 meters**, we act in this way:

$h(t) \square 40 \square t \square 5t^2 \square 75 / : 5$

$\square t^2 \square 8t \square 15 \square 0 / \square(\square 1)$

$t^2 \square 8t \square 15 \square 0 \square \square t \square 3 \square \square t \square 5 \square \square 0 \square t \square 3$ *and* $t \square 5$

c) The maximum height the ball will reach for the time: $t \square \square \frac{b}{2 \square a} \square \square \frac{(\square 8)}{2 \square 1} \square \frac{8}{2} \square 4$sec.

The max height of the ball is:

$h(4) \square 40 \square 4 \square 5 \square 4^2 \square 160 \square 5 \square 16 \square 160 \square 80 \square 80m$

d) The ball will touch the ground again for time t=8 sec.

Example The profit (in thousands of dollars) of a company is given by: $P(x) = 5000 + 1000x - 5x^2$

where **x** is the amount (in thousands of dollars) the company spends on advertising.

1. Find the amount, **x**, that the company has to spend to maximize its profit.
2. Find the maximum profit **Pmax**.

Zgjidhje

a. Function **P** that gives the profit is a quadratic function with the leading coefficient **a = -5**.

This function (profit) has a maximum value at: $x = h = -\frac{b}{2a}$

$$x = h = -\frac{b}{2a} = -\frac{1000}{2(-5)} = -\frac{1000}{-10} = 100$$

b. The maximum profit **Pmax**, when **x = 100** thousands is spent on advertising, is given by the maximum value of **function P**

$$k = c - \frac{b^2}{4a}$$

c. The maximum profit **Pmax**, when **x = 100** thousands is spent on advertising, is also given by **P(h = 100)**

$P(100) = 5000 + 1000(100) - 5(100)^2 = 55000$.

d. When the company spends **100** thousands dollars on advertising, the profit is maximum and equals **55000** dollars.

e. Shown below is the graph of **P(x),** notice the maximum point, vertex, at **(100 , 55000)**.

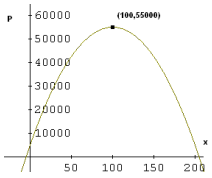

Fig.9

Example 10 An object is thrown vertically upward with an initial velocity of $\mathbf{V_0}$ feet/sec. Its distance **S(t)**, in feet, above ground is given by : $S(t) = -16t^2 + v_0 t$

Find $v_0 = ?$,so that the highest point the object can reach is **300 feet above ground**.

Zgjidhje

a. **S(t)** is a quadratic function and the maximum value of **S(t)** is given by :

$$k = c - \frac{b^2}{4a} = 0 - \frac{v_0^2}{4(-16)}$$

b. This maximum value of **S(t)** has to be **300** feet in order for the object to reach a maximum distance above ground of **300** feet.

$$\frac{v_0^2}{4 \cdot 16} = 300$$

c. we now solve $\frac{v_0^2}{4 \cdot 16} = 300$ for $\mathbf{v_0}$

$$\frac{v_0^2}{4 \cdot 16} = 300 \Rightarrow v_0^2 = 64 \cdot 300 \Rightarrow v_0^2 = 19200 \Rightarrow v_0 = \sqrt{19200} \Rightarrow v_0 = 138.564 \text{ feet/sec}.$$

The graph of S(t) for $v_0 \approx 138.564$ **feet/sec** is shown below.

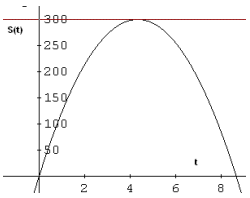

Fig.10

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Using blockchain in healthcare

Erodina Sejdiu[1], Faton Kabashi[2]
[1, 2] UBT, Higher Education Institution, Kosova Email: es49107@ubt-uni.net, faton.kabashi@ubt-uni.net

***Abstract*— Blockchain technology has emerged as a technology innovation with the potential to transform various industries, including healthcare. The use of blockchain technology in healthcare is a promising solution that has the potential to revolutionize the way healthcare data is managed and shared. Blockchain technology provides a decentralized and intangible system that can be accessed by authorized parties from anywhere in the world. Blockchain enables secure and transparent management of trial data, ensuring the integrity of results and preventing data manipulation. Smart contracts can automate consent management, simplify participant recruitment, and facilitate data sharing between researchers while protecting patient privacy. This means that healthcare data can be shared securely and efficiently between patients, healthcare providers and other stakeholders. Additionally, the use of blockchain technology can help ensure the integrity and authenticity of healthcare data, which is critical to ensuring patient safety and privacy.**

Blockchain also enables the creation of decentralized platforms for sharing anonymous health data, fostering collaboration and accelerating medical research and innovation. Also, blockchain technology can improve the pharmaceutical supply chain by tracking the movement of drugs from manufacturers to patients. By recording every transaction on the blockchain, stakeholders can ensure the authenticity and origin of drugs, reduce counterfeiting and improve drug safety. This abstract highlights the benefits of using blockchain technology in healthcare, including increased security, improved data sharing, and improved patient outcomes.

Keywords — Blockchain, Healthcare, application.

I. Introduction

The first blockchain was conceived by Satoshi Nakamoto in 2008 [1], who improved the design significantly by using a method to mark time blocks without requiring them to be signed by another third party and introducing a difficulty parameter that stabilizes the rate at which blocks are added to the chain. The following year the design was implemented by Nakamoto as a core component of the bitcoin cryptocurrency, where it serves as the public ledger for all transactions on the net.

In 2014 the file size of the bitcoin blockchain, containing the data of all transactions that have occurred on the network, reached 20 GB [2]. In January 2015 the size had increased again, almost 30 GB and then in 2016 to 2017, the bitcoin block increased from 50 Gb to 100 GB in size [3]. The words blockchain and blockchain were used in Satoshi Nakamoto's original paper, but were popularized as a single word blockchain in 2016. Trade and industry groups came together to create the Global Blockchain Forum in 2016, which was an initiative of the Chamber of Commerce and Industry. digital commerce. In 2019 Gartner reported that 5% of CIOs believed that blockchain was a game changer for their business [4]. Blockchain is a technology that is applied to create innovative solutions in certain sectors, including healthcare. Blockchain has great potential to improve healthcare by providing a secure and reliable network to store and share health information. For example, blockchain can help ensure the privacy and security of health data, allowing access to it only for authorized persons. Blockchain can also help improve coordination between doctors and health institutions, allowing access to patients' health data in a secure and reliable network. The blockchain network is used in healthcare systems to exchange and store patient data. Blockchain applications accurately identify large and dangerous errors in medicine, and avoid specific threats, help for the decentralized protection of medical data, also help pharmaceuticals from counterfeiting, where all drugs are tracked and the detection of the cause of counterfeiting. There are many interesting applications of blockchain in healthcare. Some of these include storing health data on a secure and reliable network, facilitating the exchange of health data between doctors and health institutions, and facilitating fast and secure payments for health care.

II. Literature review

Blockchain technology has been proposed as a solution to several challenges facing the healthcare industry, including data security, interoperability and patient privacy. Several studies have explored the potential benefits and challenges of applying blockchain to healthcare and proposed various use cases for the technology.

A study by Kshetri [5] identified several potential use cases for blockchain in healthcare, including secure medical data sharing, supply chain management, and clinical trials. The study suggested that blockchain could improve the transparency and security of medical records by allowing patients to control their records and giving access only to authorized parties. The study also noted that blockchain can increase supply chain traceability and accountability by providing real-time tracking of medical products and preventing counterfeiting. Finally, the study suggested that blockchain could facilitate the sharing of clinical trial data between researchers, patients and regulators, leading to more efficient and effective drug development.

Another study by Peters and Panayi [6] explored the use of blockchain in healthcare for identity management and patient consent. The study proposed a blockchain-based patient consent system that would allow patients to control their data and grant access to healthcare providers and researchers. The study suggested that this system could improve the efficiency and security of patient consent and reduce the administrative burden on health care providers.

Another study by Zhang et al. [7] assessed the potential of blockchain in healthcare for improving medication adherence. The study proposed a blockchain-based medication management system that would provide patients with personalized reminders and incentives for taking their medication. The study suggested that this system could improve medication adherence and reduce healthcare costs.

In another study, Griggs et al. [8] adopted a private blockchain based on the Ethereum Protocol to facilitate not only the safe use of medical sensors, but also the elimination of risks associated with a remote patient monitoring system. Their blockchain-based strategy can provide real-time remote monitoring, allowing practitioners to track patient status from remote locations where they keep secure and up-to-date records.

Wang et al. [9] proposed a blockchain framework, based on parallel execution and artificial health care systems, to assess the health care status of patients' diseases, this method evaluates the patient's general condition, diagnosis and treatment process. This system has been tested in real as well as artificial health care systems to evaluate the accuracy of the diagnosis and the effect of the treatment.

Another study by Mannaro et al. [10] suggested DermoNet, a method which serves to assist patients with dermatological problems through an online dermatological consultation through a tele-dermatology monitoring system.

Jiang et al. [11] developed BloCHIE, unique blockchain-oriented platform for healthcare information exchange. The platform which evaluates requests for sharing personal healthcare data and electronic medical records, and deals with various other forms of data by implementing blockchains within different sources. The platform is accompanied by on- and off-chain verification processes.

Cryan, M.A. [12] proposed a systematic and innovative architecture using blockchain technology to address critical data security issues and implement a blockchain software system throughout the hospital system.

Additionally, the studies highlighted the need for further research to explore the effectiveness and scalability of blockchain in healthcare and to identify best practices for its implementation.

III. Problem statment

The future of blockchain technology in healthcare is the purpose of this research and the achievement of some results related to this technology. Blockchain impact and applications in healthcare, problems, challenges and more. The result of this paper is expected to be the gaining of knowledge about blockchain in health care, namely understanding how and where this technology can affect in the future. The overall objective is to explain the development of blockchain technology and its use. The problems that have brought us to this research are:

- Lack of knowledge about blockchain technology in general.
- What impact this technology has and will have on health?
- What are the benefits?
- The main challenges when using this technology.

IV. Blockchain techonlogy

Blockchain technology is a decentralized and secure system for storing and transferring data. It is used to maintain a record of transactions on a shared network that all network participants can see and verify. This technology can be used to provide transparency and security in many areas, including finance, healthcare, logistics and many others. Blockchain has a large number of advantages, including security, appeal of trust and transparency. Blockchain technology works through a shared ledger of transactions, which is divided into variable blocks. Each block contains a number of transactions validated and verified by network participants. Blocks are linked together in a common string, creating a complete transaction log. This technology is safe and reliable, as all transactions are verified by network participants and cannot be changed or deleted.

Blockchain is a database, where the storage devices for the database are not connected in a common place, but hold a list of data, called blocks. This technology uses a shared and decentralized database, where each block has a time and a link to a previous block. The ledger serves as a transaction log, where it is divided into blocks that participate in a transaction with details such as price and others. Block verification is implemented and secured by encryption by blockchain members [13]. A digital medical record, where every entry is a block. There is a time and date when the record was created. Where this entry cannot be changed because the treatment or diagnosis must be clear and unmodified. Only the doctor, who has the private key, and the patient, who has the other can access the information, and then the information is shared only when one of these users shares the keys with a third party with a specialist, where this describes a blockchain based on medical data. To store the network there are cryptocurrencies that make the incentive to the blockchain, a cryptocurrency will increase in value as the transaction volume increases and as the blockchain network becomes more economically and socially useful. Cryptography ensures that users edit only the parts of the blockchain for which they have the necessary private keys. Blockchains are secure databases by design. The concept was

introduced in 2008 by Satoshi Nakamoto, and was implemented in 2009 as part of the digital currency Bitcoin, using such a system.

V. Application of Blockchain in Healthcare

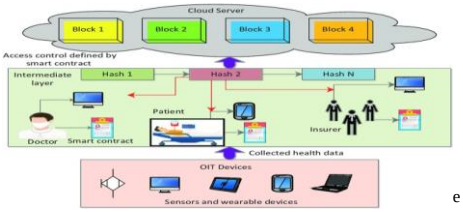
In healthcare, blockchain applications are used for everything from securing patient data to managing the pharmaceutical supply chain.

Blockchain offers tremendous opportunities for storing a large amount of data, which facilitates the work of doctors and healthcare providers, and also offers opportunities for making payments and processing complex transactions.

While the blockchain is transparent it is also private, hiding the identity of each individual with complex and secure codes that can protect the sensitivity of medical data. The decentralized nature of the technology also allows patients, doctors and healthcare providers to share the same information quickly and securely.

A. Where Blockchain is Used in Healthcare

Blockchain in healthcare organizations: improves decision- making as blockchain allows several doctors from different countries to view the same data in real time, transforms patient medical records into a decentralized system that cannot be tampered with, accelerates medical credentialing.



e

Blockchain in patients: Blockchain technology can be used to ensure that patients' health data is secure and privatized. Blockchain is a technology that can be used to build secure and decentralized records of data, making it harder for others to access them without the patient's permission. This can help reduce the risk of misuse of patients' health data and increase patients' trust in the healthcare system. An example of an app that uses blockchain technology to secure health data is the MediLedger app, which tracks medications from the manufacturer to the pharmacy, ensuring that medications are safe and of trusted origin. It empowers patients to take ownership of their medical data, supports consent mechanisms that prevent healthcare providers from accessing information without patient permission, enables patients to participate in research and monetize their data without mediator [14].

Blockchain in pharmaceuticals: supports the reliable and auditable documentation of clinical trials with its immutable data and also allows the detection of counterfeit drugs. To ensure the authenticity and traceability of drugs, pharmaceutical companies decide which actors in the supply chain act as miners, where they can be sellers, manufacturers and distributors, from the position in the supply chain, each individual has different rights: laboratories can register drugs, and merchants can verify transactions. Then when a drug is produced, a hash is generated that contains all the information about the product. As the drug moves from one entity to another, the information is stored where it is easier to find the drugs.

B. What is blockchain used for in healthcare?

Blockchain is used to record data information immutably and transparently, where none of the parties has asymmetric power over the data, enables access and transfer of data between multiple parties, to ensure a common source of truth. Blockchain enables verification of identity attributes without revealing any sensitive information.

Blockchain is also used for real-time payments and transactions, the exchange of tokens with intrinsic value traded between multiple parties. Virtual currencies can also be linked to fiat currencies, with equivalent values held in escrow accounts. Blockchain systems can help secure IoT remote monitoring devices: Blockchain cryptography ensures that only authorized parties can access personal data, which is stored on the blockchain as a unique hash function (any change in data source will create a different hash function and a user must have a specific set of cryptographic keys to decrypt the hash function in the source data) once the patient data is recorded in the ledger as a hash function, it is almost impossible to confusing as it would require access to all stored copies.

Blockchain is used for drug traceability where it provides a reliable solution for ensuring the authenticity of drugs as it enables the tracing of any drug to its roots. Blockchain can be used to aggregate drug-related data. Each block containing the drug content may have a hash associated with another block and a timestamp that we cannot change. In blockchain transactions can be visible to all authorized parties and the movement of drugs from party to party can be tracked in real time. Drug buyers ensure the authenticity of purchased products by scanning the QR code and searching for information about the manufacturer and other parties in the supply chain. Therefore, the distribution of a fake drug will be almost impossible in such an organization [15].

Blockchain is used to provide the possibility of payment in cryptocurrency Blockchain made it possible to receive medical care and pay for it with cryptocurrency, because there are cases where blockchain in healthcare is related to payment. One such example is Aveon Health, a technology- focused medical group Aveon Health recognizes the

advantages of using the virtual currency Bitcoin. Bitcoin users can send and receive electronically using the wallet software. A Micropayment is another idea that is enabled through Blockchain. Micropayments are unique models that serve patients by following the instructions of their doctors and adhering to them, operating only a specific blockchain, so this model will record everything about the patient's activities for re-examination of the training [16].

VI. Avantages and disavantages of Blockchain in Healthcare

A. Advantages of Blockchain in Healthcare

The main advantages of implementing Blockchain in healthcare are:

- Electronic health records (EHRs) made them more accessible, more accurate, more secure, and less expensive to create and maintain.
- Allows medical researchers to share their work, collaborate and obtain consent for data collection and access.
- Blockchain protects a healthcare system's data from cyber-attacks.
- Transforms patient medical records into a decentralized system that cannot be tampered with.
- Accelerates medical credentialing.

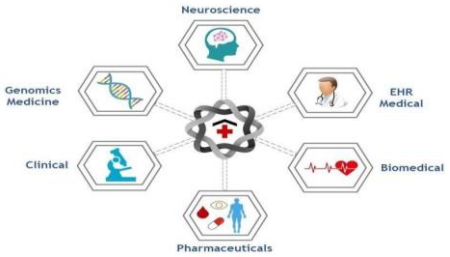


Figure 2 - Advantages of Blockchain

1. Supply Chain Transparency

The main challenge in healthcare is to ensure the origin of medical goods and their authenticity. So, the help of a blockchain-based system can track items from production to every stage through the supply chain, a method that enables customers to have complete visibility and transparency of the goods they purchase. Supply chain transparency is a top priority, especially in markets where fake prescription drugs cause hundreds of thousands of deaths a year. Key uses of Blockchain when paired with AI:

Customer Trust: The ability to track the origin of each package end-to-end, integrating with manufacturers, wholesalers, shipping, etc.

Supply chain optimization: Once all the data is in one place, companies apply AI to better predict demand and optimize supply accordingly.

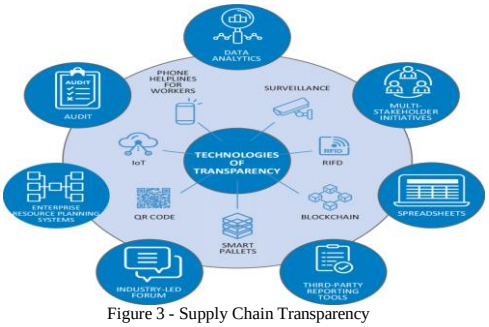


Figure 3 - Supply Chain Transparency

2. *Management and sharing of patient data*

The Office of Health and Human Services received notifications of over 350 data breaches resulting in the disclosure of many medical records. HIPAA has strict restrictions on the privacy of patient data. So this data cannot be isolated as some other party other than the patient, and their doctor may need to access their well-being. At the same time, handling patient data using a traditional approach can be a complex task as these data are distributed across different healthcare databases. Blockchain enables solutions by providing a unified platform for storing and managing all relevant data in one place, while maintaining access control and security. Part of the patient data can be stored as blockchain blocks identifiable through the unique patient ID. This method authorizes the sharing of health information without revealing whether the patient wishes to remain anonymous. The reliable solution is blockchain with standard access, information about each patient is distributed in multiple systems that do not interact, this makes it difficult to collect health data for a certain population group. Blockchain becomes a secure means for individuals to participate in population health studies and monetize the outcome of these studies.

B. Disadvantages of Blockchain in Healthcare

Although Blockchain can be of great benefit to healthcare, there are still major challenges to be addressed before full-scale implementation. The disadvantages of using blockchain in healthcare are as follows:

Low transaction speed: since each transaction needs to be stored in the blockchain, it takes time to collect all the transactions and aggregate them into a block. The high number of transactions in a single block has an average block processing time of about 10 minutes, the transaction speed is theoretically 100 transactions per minute. All transactions are

confirmed only after the block is mined and takes about 10 minutes (on average).

High data demand: Blockchain stores a copy of every transaction that has ever happened on a network, and also on all computers connected to the network, this process is very data intensive and the actual Bitcoin Blockchain is about 1 TB in size and growing daily.

High power consumption: Traditional blockchain uses consensus algorithm which is PoW. This technique of hashing calculations consumes high energy because a large number of networked computers compete at the same time against each other to find a suitable hash**.**

Pseudo anonymity: Due to the decentralized nature of the blockchain, the transaction information becomes public in cryptocurrencies, so the user's privacy is compromised, and the authors proposed the encryption scheme as a quasi- homomorphic metric to hide the transaction amounts, the authors combined the ring signature technology with the existing blockchain system to ensure user privacy in the transparent blockchain environment**.**

High-resolution data: Another technical disadvantage of blockchain is that it is not ideal for data with high temporal resolution and has trouble handling multidimensional data, such as complex text, images, and graphs. Since it is an open network where anyone can join, massive computing power is required to effectively resist tampering.

Uncertainty about the technology: There is still a lot of uncertainty about the blockchain, because it causes problems regarding the legality of this technology (eg for access management) to implement changes in the current infrastructure for this technology must first be legally approved.

Onboarding: For this technology to work, every organization involved needs to be on board with it.

VII. Conclusions

In conclusion, blockchain technology has emerged as a promising solution in the healthcare industry, offering numerous benefits in various fields. It offers enhanced security and privacy features, ensuring the protection of sensitive patient data while allowing seamless data sharing and collaboration between healthcare professionals. Using blockchain, healthcare organizations can improve decision- making processes by enabling real-time access to data from multiple sources across different geographic locations. The decentralized nature of blockchain facilitates the transformation of patient medical records into a transparent and harmless system. This ensures the integrity and immutability of medical data, eliminating the risk of unauthorized modifications. Additionally, patients gain greater control over their medical information, empowering them to actively participate in their health care and make informed decisions. Consent mechanisms supported by blockchain technology enable patients to manage access to their data, preventing healthcare providers from accessing information without clear permission.

In the pharmaceutical sector, blockchain offers powerful solutions for drug traceability and the fight against counterfeit drugs. Using the immutable and transparent nature of the blockchain, the entire supply chain of a drug can be accurately tracked in real time. Pharmaceutical companies can build trust and ensure the authenticity of drugs by recording every transaction and movement on the blockchain. This allows buyers to verify the legitimacy of a product by scanning QR codes and accessing information about the manufacturer and the entire supply chain. With blockchain, the distribution of counterfeit drugs becomes significantly more challenging. Additionally, blockchain technology enables secure and efficient real-time payments and transactions within the healthcare ecosystem. Through the use of tokens with intrinsic value, blockchain facilitates seamless and transparent financial interactions between multiple parties. Virtual currencies can be linked to fiat currencies, providing liquidity and facilitating transactions while maintaining the security and transparency inherent in blockchain systems.

Overall, blockchain technology has tremendous potential in healthcare, revolutionizing data management, increasing patient empowerment, improving supply chain integrity, and streamlining financial transactions. By leveraging the unique features of blockchain, the healthcare industry can achieve greater efficiency, security and collaboration, ultimately leading to improved patient outcomes and a more sustainable healthcare ecosystem.

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Internet of things(IOT) in education: Opportunities and Challenges

Labinot Krasniqi[1], Faton Kabashi[2]
[1, 2] UBT, Higher Education Institution, Kosova
Email: lk34259@ubt-uni.net, faton.kabashi@ubt-uni.net

***Abstract*—Nowadays, the Internet has become an indispensable part of life, Internet of Things (IoT) devices are growing rapidly in many aspects by allowing the connection and remote control of a network infrastructure that makes human life more convenient and easier. The trend of IoT in education has started to prevail, which leads to the need to design suitable educational activities. A widely adopted educational model that responds to this demand is the STEAM education model. The Internet of Things (IoT) has the potential to transform education by profoundly changing the way schools, colleges, and universities collect data, interface with users, and automate processes. IoT refers to the networking of physical objects through the use of embedded sensors, actuators, and other devices that can collect and transmit information about campus activity in real time. When IoT is combined with technologies such as user mobility and data analytics, it brings a new paradigm to education. This research aims to gather evidence and document the Internet of Things (IoT) in education and the main aim is to elaborate on the opportunities and challenges of IoT in education.**

Keywords—IoT, education, challenges, opportunities, technology.

I. Introduction

The launch of global 5G has brought new driving forces to the Internet of Things (IoT) industry, and countries around the world have already adopted IoT as their national strategic industry. The Internet of Things (IoT) is a technology that enables objects to connect to each other using the Internet, in order to offer the collection and transfer of data without the need for human intervention. This technology allows objects connected to the Internet to exchange information and be controlled remotely. The spread of IoT nowadays has risen to a high intensity, penetrating everywhere such as cities, homes, universities, factories, organizations and other places. This technology has brought many benefits in daily life by providing smart services anytime and anywhere. These changes in people have changed the way of life, making it easier and more efficient [1]. The innovation of IoT technology has fueled the growth of the social economy and is having a transformative impact on society. In the final analysis, the competition of IoT technology among countries is the competition of technological innovation talents [2] Therefore, universities around the world have begun to build new IoT engineering degrees and explore teaching new curricula. Affected by the reform of engineering education, researchers from various countries have focused on engineering practice for the IoT engineering branch and developed various forms of curriculum design. Many teachers still use the past experiment teaching model of imitation in the creative course. The teaching process lacks innovation and design, which is not suitable for cultivating the student's innovative spirit and creativity [3]. Therefore, the advantages of applying innovative courses in engineering education are reflected in open innovation, exploration experience and allow students learn practical skills in the product manufacturing process. The disadvantage of this method is that it pays attention to the production of products in practice and ignores the teaching of theoretical knowledge and lacks a useful teaching model. From the perspective of interdisciplinary innovation, "Engineering(E)"in science, technology, engineering and mathematics (STEAM) is a "bridge" that connects the knowledge of scientific, mathematical and technical disciplines. The integration of STEAM education and creative education will comprehensively promote the cultivation of students 'innovative ability and high-level thinking ability, and compensate for the lack of theoretical knowledge learning in the creative course [4]. This research will examine the use of the Internet of Things (IoT) in education. The focus of this research is on the opportunities and challenges of IoT in education.

II. Literature review

According to [5] IoT is not a specific industry, but a new stage of intelligence and information development. IoT includes every field in the science and technology system, and its technologies cover most subjects. It is a challenge for schools and universities to assign the IoT major to undergraduate students. The term "Internet of Things" (IoT) according to [6] has recently become popular to emphasize the vision of a global infrastructure that connects physical objects/things, using the same Internet Protocol, allowing them to communicate and exchange information.

According to [7] the term "IoT" was coined by Kevin Ashton in 1999 to refer to "uniquely identifiable objects/things and their virtual representations in an Internet-like structure". According to the analytics firm [8], 8.4 billion "things" were connected to the Internet in 2017, excluding laptops, computers, tablets and mobile phones. This number is set to grow to reach 20.4 billion deployed IoT devices by 2020[7]. In 2020, the number of IoT devices continued to grow along with mobile IoT, which now operated on 2G, 3G, 4G and 5G as well as in LoRaWAN and the long-term evolution for machines, or LTE-M. Various IoT architectures have been proposed by researchers. For the Internet of Things (the merging of the physical world and the

information world), [9] proposed an autonomy-oriented architecture for the IoT; and [10] described a practical realization of an IoT architecture at the University of Padua. For the Internet of Service (connecting the physical world and the Internet to provide services to things) [11] proposed a system architecture for the Web of Things; and [12] provided an implementation of the Web of Things vision. For the Internet of Brain Computing (cyberworld meets brain computing). IoT is also being used for more pragmatic scenarios in education. For example, an IoT-based system aimed at increasing children's knowledge of agricultural food production and consumption was proposed. Other studies on deploying IoT to educate students with special needs exists according to [6] for children with autism spectrum disorders.

III. Problem statement

This research aims to gather evidence and document the Internet of Things (IoT) in education. Impact and application of IoT in education, opportunities, challenges etc. The results of this research are expected to be knowledge about IoT technology in education as well as the possibilities of future application of this technology. The main aim is to elaborate on the opportunities and challenges of IoT in education. The problems that bring us to this research are:

• Lack of knowledge regarding IoT technology.
• What impact does and will the application of IoT technology in education have?
• What are the possibilities?
• The main challenges of applying IoT technology.

IV. IOT - THEORETICAL BACKGROUND

The IOT concept was created by a member of the Radio Frequency Identification (RFID) development community in 1999 and has recently become more relevant to the practical world mainly due to the growth of mobile devices, integrated communication and ubiquitous, iCloud computer and data [3]. Imagine a world where billions of objects can sense, communicate and share information, all interconnected through public or private Internet Protocol (IP) networks. These interconnected facilities have data regularly collected, analyzed and used to initiate action, providing a wealth of intelligence for planning, management and decision making. This is the world of the Internet of Things (IOT). The common definition of Internet of Things is defined as: Internet of Things (IOT) is a network of physical objects. The Internet is not just a network of computers, but it has evolved into a network of devices of all types and sizes, vehicles, smartphones, home appliances, toys, cameras, medical instruments and industrial systems, animals, people, buildings, all of connected, all communication and information exchange based on defined protocols to achieve intelligent rerouting, positioning, tracking, security and control and even real-time online personal monitoring, online improvement, control and process administration[13] .

We define IoT in three categories as follows: The Internet of Things is an Internet of three things: (1). People with people, (2) People with car/things, (3) Things/cars to things/cars, Internet interaction.

Internet of Things Vision: The Internet of Things (IoT) is a concept and a paradigm that considers the pervasive presence in the environment of a variety of things/objects that through wireless and wired connections and unique addressing schemes are able to interact with each other and collaborate with other things/objects to create new applications/services and achieve common goals. In this context, the challenges of research and development to create a smart world are great. A world where the real, digital and virtual are converging to create intelligent environments that make energy, transport, cities and many other areas smarter. [13].

Figure 1. Internet of things (IoT) [13]

The Internet of Things refers to the general idea of things, especially everyday objects, that are readable, detectable, localized, addressable through information sensing equipment, and/or controllable via the Internet, regardless of the means of communication (either via RFID, wireless LAN, wide area networks, or other means). Everyday objects include not only the electronic devices we encounter or the products of the highest technological development such as vehicles and appliances, but things we do not usually think of as electronic at all - such as food, clothing, chairs, animals, trees, water, etc. [14]

A. Technologies Enabling IoT

The Internet of Things (IoT) is a global infrastructure for the information society, enabling advanced services by connecting things (physical and virtual) based on existing and emerging interoperable information technologies and communication. With the Internet of Things, communication via the Internet extends to all the things that surround us. The Internet of Things is much more than machine-to-machine communication, wireless sensor networks, sensor networks, 2G/3G/4G, GSM, GPRS, RFID, WI-FI, GPS, microcontrollers, microprocessors, etc. These are considered as the technological possibilities that make possible the applications of "Internet of Things" [13]. The technologies that enable the Internet of Things are considered and can be grouped into three categories: (1) technologies that enable "things" to receive contextual information, (2) technologies that enable "things" to process contextual information, and (3) technologies to improve security and privacy. In this context, it is possible to scale the level of diversity to a number of manageable connectivity technologies that address the needs of IoT applications, adopted by the market, they are already proven to be usable, supported by a strong technology alliance. Examples of standards in these categories include wired and wireless technologies such as Ethernet, WI-FI, Bluetooth, ZigBee, GSM and GPRS [14].

B. Characteristics and structure of IoT

More broadly about the structure of IoT are presented the following technologies which influenced the development and

innovation of IoT.

• Network connectivity- Network technologies enable the communication of objects in different locations, there are a large number of network technologies used for different purposes depending on the application, eg: Personal Area Networks (PANs)

• Systems of embedded - Today one of the big challenges is also in embedded systems which in a system (computers) are equipped with processors, memory, peripheral devices, etc.

• Sensors and actuators - Sensors are technical components which are used to measure the quality or the amount of any physical or chemical property such as: temperature, speed, etc.

• Cloud Computing - Cloud Computing is a technology in which software, hardware, and other services are provided as a set of virtualized resources on a network, primarily the Internet.

• Increased data quality - Increased data quality improves business processes and models, providing better data quality provides better decision-making in various processes.

• New markets - A computerized world can open the door to innovations that help things and people interact, according to studies in 2025, IoT will have an economic impact of 11 trillion dollars per year [15]. To make the IoT concept clearer and more understandable, Figure 2 is presented, which describes the IoT structure in detail.

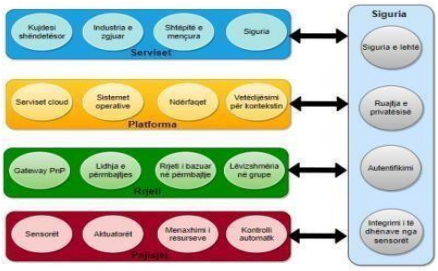


Figure 2. Structure of Iot **[16].**

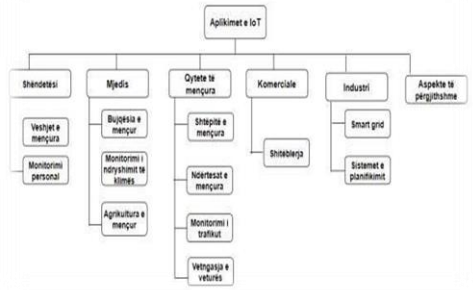
From Figure 2 we understand that IoT consists of four layers which are: Service Layer (service layer), Platform Layer (platform layer), Network Layer (network layer) and Device Layer (device layer).

C. The application of IoT in various fields

Internet of things as a special field of great importance of the XXI century has entered our lives and is increasingly managing life processes. IoT is considered an ecosystem that contains intelligent objects equipped with sensors, networking, and various technology processes that all together provide an intelligent environment to end users. We all now know the impact of IoT, but to have a better 'view' about its application, Figure 3 is presented which shows the application of IoT in different spheres [17].

Figure 3. IoT application structure in different fields

Today IoT has wide applications which are quite useful to people. The fields in which IoT is applied, in addition to those mentioned above in Figure 4, are presented below. The IoT application covers "smart" environments/spaces in areas such



as: transportation, buildings, city, lifestyle, retail, agriculture, factory, supply chain, emergency, healthcare, user interaction, culture and tourism, environment, energy.

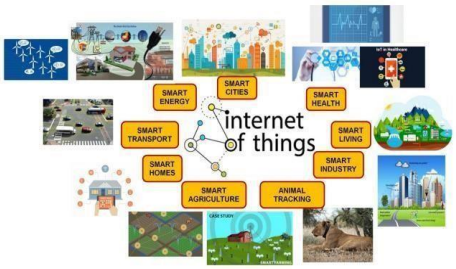


Figure 4. Application of IoT in different fields **[13]**

V. Application of IOT in education

Education has changed from a knowledge transfer model to an active self-directed collaborative model due to the impact of technology in today's educational institutions. This has forced many institutions to rethink teaching and learning. The impact of technology can be seen in many aspects of education from engaging students in learning and content creation to helping teachers deliver personalized content and improve student outcomes. There are currently seven categories of technologies, tools and strategies that drive innovation in education:

1. Consumer Technologies,
2. Digital Strategies,
3. Enabling Technologies,
4. Internet technologies,
5. Learning Technologies,
6. Social Media Technologies and
7. Visualization Technologies

IoT is a subcategory of Internet technology that supports education in many ways. IoT solutions enable educational institutions to collect a large amount of data from sensors and

devices which perform meaningful actions based on this data. Such systems allow the student to explore an environment using built-in sensors, QR codes, and other technologies. With IoT devices, teachers and administrators can collect data about a student's learning style, progress, and areas of difficulty. It is an interesting and innovative field in education that can help improve teaching and learning. A smart classroom can be defined as an intelligent environment equipped with various types of hardware and software modules. Video projectors, cameras, sensors, and facial recognition algorithms are examples of modules that monitor various parameters of the physical environment or student attributes such as concentration, performance, and achievement [18].

A. Benefits of IoT in Education

The biggest benefits of IoT in education is the personalized and unique interaction with the student. It helps the student not only get personal recommendations and academic topics, but also can solve learning issues when they are in academic difficulties by sending alerts to the administrators. Internet of Things (IoT) has brought great changes in the field of education and has provided many benefits to students, teachers and institutes Improving teaching and learning. IoT is in many universities in the form of "police cameras, temperature controls and

access to buildings, lights, energy". Intelligent objects can to be used in classes for him improved teaching and students. According to the current application of IoT in education, we will categorize the ways in which the benefits of IoT in education they are divided into four groups and discuss how the new platform can shape smart education for the next generation [18].

- The Management of Energize in University and Eco-Monitoring System
- Secure login control University and in the classroom
- Health monitoring students
- Improving teaching and learning.

VI. Avantages and disavantages of IOT in education

It is not logical nor will it be fair to compare traditional education with education in the Internet of Things environment, as education has not directly transitioned from classroom education to IoT education. Education has developed along with the development of technology gradually. One of the most important advantages of online education is access to the place of education from anywhere, in addition to the lack of cost. On the other hand, online education is perceived as the result of depriving students of social life at the university and the lack of direct orientation (face to face) as well as the non-preference for applied studies. With the development of IoT, education tried to take advantage of this development. Now, the educational environment has been able to take advantage of all the social media to compensate for the lack of social life. Students can get to know each other better, share their interests and build a social life on these social media as well as in real life [19].

The great benefit that has been the main reason for the development of education in the IoT environment is the possibility of using this technology to develop online applied education. The main advantage of IoT in educational institutions is the ability to collect and analyze educational data. By connecting physical objects such as sensors and cameras, educational institutions can collect more comprehensive data on student performance as well as the effectiveness of their teaching methods. This data can be used to identify areas of improvement and optimize learning strategies. One of the most significant advantages of IoT in education is the ability to improve the learning experience for students.

IoT devices can collect and analyze data on student performance, allowing educators to customize learning plans and provide targeted support. Using IoT in education can help students develop technical skills, such as programming, data analysis and project management, that are important in the world of information and communication technology. Another advantage of IoT in education is the potential for increased collaboration between students, teachers and parents. IoT devices can facilitate communication and information sharing, making it easier for all parties to stay informed and engaged in the learning process. IoT also allows for increased automation of processes. For example, sensors and cameras can be used to monitor student attendance and alert administrators when a student is absent. Automated systems can also be used to manage classrooms and control access to resources. This makes it easier for teachers to manage their classrooms and for administrators to monitor student activities. In addition, IoT enables better communication between teachers, students and administrators. Through connected devices, teachers and students can communicate with each other in real time, allowing for more efficient collaboration and information exchange [20].

IoT is a great use for higher education. It has overcome the disadvantages of online education; moreover, it strengthens the advantages. The future will bring new developments every day, which can be useful for education; however, the most important point to conclude here is that we should use it in the right way. Understanding IoT with its advantages and disadvantages will bring its true vision and this is where we can benefit from it very well. IOT and advancement in technology can reduce barriers to technology adoption and increase its rate in higher education. IoT removes traditional barriers to teaching and learning and creates powerful, hybrid learning environments using smart devices, also allowing students to connect with experts from around the world, also developing social educational software within an IoT context in the future [19].

However, the disadvantages of IoT in education we can also mention some possible obstacles to consider when implementing IoT in educational institutions. For example, increased use of technology can lead to privacy issues as student data is collected and stored. Furthermore, the cost of IoT implementation can be a deterrent for many schools and universities in integrating IoT devices and systems especially for schools with limited budgets [20].

The use of IoT in education can create a huge dependence on technology, making students dependent on devices and internet connection to learn and to complete their tasks and if the use of IoT is not well planned and appropriate, it may happen that students revert to a passive learning, relying only on the information provided by the devices, instead of developing

critical and analytical skills.

VII. Conclusions

In conclusion, technology has brought about changes in society at a dizzying pace. This has contributed to the challenge of the education system to immerse itself in new intelligent devices that have exploded in institutions, bringing a change in the way we have understood teaching until now. This paper will present the basic concepts in the technology called Internet of Things, the opportunities and challenges of IoT in education. In summary, this paper reorganizes the IoT architecture, based on which a dimension model is proposed to classify the complex IoT technologies, and a layer model is built for system presentation. After analyzing relevant issues on industry and education, we come to the conclusion that IoT is not a specific industry, but a new stage of intelligence and informatization development. IoT includes every field in the science and technology system and its technologies cover most subjects. From this work we can understand that this technology is quite innovative which is being used all over the world every day and more. The use of IoT is wide in many different fields, one of the fields in which it is applied is also in education. To better understand the operation of IoT in education we have described the potential benefits of IoT in education, then explained the opportunities and challenges of IoT in education. The main qualities that may pose a challenge for IoT in education are shown: security, scalability and humanization. In the rest of the paper, the advantages and disadvantages of IoT in education are explained. From the obtained results, it can be concluded that the implementation of IoT in education is still in its early stages, but it is shaping up to transform education and support the learning process, creating a multitude of opportunities for teachers, students and others.

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Internet of Things (IoT) in Healthcare

Ibadete Gashi[1], Faton Kabashi[2]
[1, 2] UBT, Higher Education Institution, Kosova
Email: ig47496@ubt-uni.net, faton.kabashi@ubt-uni.net

***Abstract*— The Internet of Things is a technology that promises to significantly change people's lives in today's world. In recent years, IoT has impacted every aspect of life, including healthcare, where it has become highly productive in improving the quality of medical services provided to patients. Using sensors, IoT is capable of continuously and in real-time monitoring the health status of patients. This is particularly helpful for patients with chronic illnesses as it can assist in preventing various complications. Below, we will discuss the theoretical context of IoT, explaining the concepts of IoE (Internet of Everything), IoT architecture, and the role of telemedicine. An analysis is then conducted on several IoT devices used for health monitoring. This includes the Helo Wristband for blood pressure monitoring, AliveCor for heart monitoring, Baby Check for infant health monitoring, and an analysis of the case study of the use of the Smart Sock. The results encompass demographic aspects, physiological norms, false-positive alarm cases, and clinical significance. Through this study, the aim is to provide a detailed overview of the impact of IoT on health monitoring, addressing challenges and advancements in this technology in the healthcare field.**

Keywords— Internet of Things, Healthcare, Smart Sock.

Introduction

The concept of the Internet of Things (IoT) dates back to 1832 when the first electromagnetic telegraph was configured. With this device, it was possible to establish direct communication between two machines using the transfer of electrical signals. However, the true history of the Internet of Things began to take shape with the invention of the internet in the late 1960s. The first IoT device was created at Carnegie Mellon University in the early 1980s. A group of students at the university installed microswitches in a Coca-Cola vending machine, allowing it to report how many cans were available and whether they were cold through a network.

It was in 1990 when John Romkey first connected a toaster to the internet. A year later, a group of students at the University of Cambridge came up with the idea of using an internet camera prototype to monitor the coffee supply in a coffee machine. They achieved this by programming the internet camera to take pictures of the coffee inside the machine three times a minute. These photos were then sent to a local computer where it could be checked if there was coffee available.

Despite the concept dating back to 1832, the term "Internet of Things" wasn't coined until 1999 by Kevin Ashton. He used the phrase "Internet of Things" as the title of his project presentation related to a sensor he was working on at Procter & Gamble. He included the word "internet" to draw attention, as the internet was a hot topic at the time. In the early 21st century, the Internet of Things became a common topic used by the media, and significant developments were made, paving the way for the future of IoT. In 2000, LG Electronics introduced the world's first smart refrigerator, enabling consumers to order food online. Following this innovation, in 2005, a rabbit-shaped robot capable of providing weather forecasts, the latest news, and stock market changes was created [1]. The Internet of Things encompasses a network of physical objects, or "things," that are integrated into this network through sensors, software, and various technologies. The purpose is to connect these devices and systems and exchange data among them via the internet. These devices can range from everyday household items to more sophisticated industrial objects. Now that everyday objects can be connected to the internet through integrated devices, physical things can collect data and transmit it with minimal human interaction [2].

The number of IoT-connected devices exceeds 27 billion today, and experts expect it to reach more than 100 billion devices by 2030. This is due to the continuous advancement of new technology in every sector. The adoption of the Internet of Things is happening in every industry, including healthcare [3].

Literature review

To conduct the literature review, studies published between 2018 and 2023 were considered. The studies were retrieved from Google Scholar, IEEE Xplore, Elsevier, and Research Gate.

Sivani, T., and Sushruta Mishra [4] in their work provided an overview of IoT applications in healthcare, including remote patient monitoring, smart wearable devices, and technological data analytics.

Albahri, et al. [5] in their research offered a summary of IoT technologies and their applications in healthcare environments. It covers remote monitoring, telemedicine, and the challenges and opportunities presented by IoT in healthcare.

Jamil, et al. [6] focused on healthcare monitoring systems, discussing IoT technologies used for monitoring vital signs and health parameters of patients. It reviews the hardware and software components of IoT-based healthcare systems.

Abdulmalek, et al. [7] explored the application of IoT in healthcare, emphasizing its role in improving patient care, monitoring chronic diseases, and enhancing healthcare object management. It also discusses privacy and security concerns.

Problem statement

The number of various health issues continues to rise, posing a constant risk to individuals. With the increase in health problems, we also see a rise in the number of patients, which in turn leads to a shortage of healthcare professionals. In these circumstances, IoT has become more applicable in healthcare and the healthcare field in general. Effective healthcare is characterized by speed and accuracy. The best way to achieve these characteristics is by relying on a wide range of IoT-connected healthcare systems. Through IoT, the digital identity of each patient is maintained.

One concerning issue is healthcare for newborn babies. Sudden Infant Death Syndrome (SIDS) is the primary fear for new parents today. The cause of SIDS is often a blockage of the airways. In most cases, this tragedy occurs while the infant is sleeping or crying unexpectedly, without any warning signs. An effective solution to this problem is seen in the use of IoT devices, which can monitor the health of newborns in real-time using smart sensors. The collected data can then be sent to their parents.

Research Questions:

1. How can IoT devices enrich traditional methods of newborn healthcare?
2. How can IoT devices collect data to improve newborn

healthcare?
3. How effective can an IoT device be in preventing SIDS in newborns?

IOT-THEORETICAL BACKGROUND

Over time, the use of the internet has evolved in nature and complexity, going through several developmental phases. Web 1.0 allowed users to read content, while Web 2.0 introduced the capability to create and share content with others. Web 3.0 brought semantics, facilitating easier communication between humans and machines. Web 4.0 is characterized by the ubiquitous connection of the web with users at all times and in all places, offering personalized services enabled by continuous data collection. Amid this internet development, one of the standout themes is undoubtedly IoT, which signifies a single object with three characteristics: connectivity everywhere and with identity.

IoT has four features that address challenges for users. First, the system is complex and ubiquitous, leading to an increase in the generated data. Second, devices make autonomous decisions without user intervention, thus reducing user autonomy. The third feature or challenge is that ambiguity outweighs visibility. The decisions IoT devices make can be undesirable and difficult for users to manage and monitor, leaving users unaware of data collection and potential risks. The fourth challenge is that with the use of these devices, internet security and privacy threats will increase [8].

Internet of Eveything (IoE)

As a new technology, IoT represents a modern wireless telecommunication network. IoT can also be referred to as the Internet of Everything, as it consists of every web-enabled device that collects and transfers data gathered from their surrounding environments. These interconnected devices are considered intelligent since they can facilitate machine-to-machine (M2M) communication and take actions based on the information they exchange among themselves. Most of these devices operate autonomously without the need for human intervention, although human interaction with these devices is not excluded. Users can provide instructions to these devices and have access to the data collected by them. The 5G internet generation has the potential to unlock IoT and actualize the physical world, which is expected to transform our lives in the next 25 years. IoT has made significant strides in hospitals and other medical facilities in a relatively short time and is further evolving, revolutionizing the field of healthcare.

IoT Ecosystem

The IoT ecosystem is composed of various components that enable its integration into different fields. Among these components, we can mention sensors, connectivity methods, artificial intelligence (AI), and the user interface (Figure 1).

IoT Devices

IoT devices refer to hardware components such as sensors, various household devices, smart machines, and more. These devices are programmed for specific applications and collect, store, and transmit data using the internet. By integrating these hardware components into other devices such as smartphones, industrial equipment, and medical devices, they offer a wide range of applications. Their structure can be quite simple for some devices, while others are more complex and sophisticated. Thanks to cost-effective computer chips and wireless networks, these devices exchange data at high speeds.

Sensors

Another vital component of the IoT ecosystem is sensors. Sensors detect and monitor the external environment, collecting information. They then transform this information into readable and understandable signals for humans and machines. Sensors come in various types, some being active and others passive, and they can be analog or digital. Among the most well-known sensors used in IoT systems are optical sensors, temperature sensors, humidity sensors, pressure sensors, and more.

Connectivity

Since IoT operates through the internet, connectivity is a key aspect of the IoT ecosystem. Depending on the size and scope of the IoT system, these networking connections scale. The types of these connections include:

- LAN (Local Area Network): This represents a set of interconnected devices in a single physical location, such as an office, building, or home. If it's a home network with one user, it's called a small LAN, while a LAN in an enterprise or school with thousands of users and devices is called a large LAN [9].
- PAN (Personal Area Network): It is a network for personal zones through which information is exchanged between individuals in proximity.
- MAN (Metropolitan Area Network): This is a computer network that connects computers within a metropolitan area, typically a city or an area with many buildings.
- WAN (Wide Area Network): It's a network that collects connected local area networks (LANs). The WAN's reach is extensive, and in essence, it represents a network of networks. The internet is the widest-reaching WAN in the country.

Artificial Intelligence (AI)

When looked at individually, IoT and AI represent two technologies with significant potential, productivity, and high capability. However, when these two are combined, the effectiveness increases even further. If a system is capable of reading a list of tasks and performing them intelligently, it is known as an artificial intelligence system. If we create a device by blending IoT and AI technologies, the result will be a device capable of data analysis and making intelligent decisions without the need for human involvement, and this represents the essence of the Internet of Things concept [10].

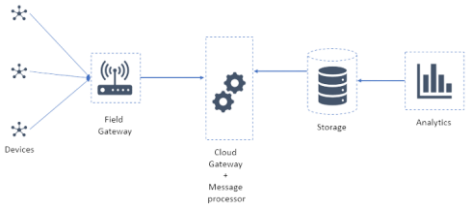

Figure 5. The basic structure of the IoT system.

IoT Architecture

IoT architecture refers to the use of sensors, actuators, processors, and transmitters. IoT represents a technology that operates by combining several other technologies that work together. IoT architecture involves a four-step process in which data flows from devices connected via sensors within a network. It then moves to the cloud to derive meaningful results, which need to be intelligently processed, analyzed, and stored. Various researchers have presented different versions of IoT architecture.

6) Three-layer architecture of IoT

One of the accepted models of IoT architecture is composed of three layers, which is generally acknowledged by academia and industry. Introduced since the early days of IoT

technology, this architecture consists of the following layers: Perception, Network, and Application (Figure 2).

Perception Layer: It is responsible for perceiving the physical entities of things that surround us and are an integral part of the IoT ecosystem. This perception is enabled and based on sensing technologies such as RFID, WSN, GPS, NFC, medical sensors, etc. As a solution for objects that cannot be directly sensed, microchips are considered, which are attached to objects to provide sensing capabilities. Nanotechnologies and integrated intelligence play an essential role in creating small-sized chips that can be embedded within everyday objects, enabling them to have processing capabilities.

Network Layer: After collecting data from the Perception layer, the Network layer processes this data. After processing, this layer also transmits the data to the Application layer through network technologies such as Wi-Fi, LAN, 3G/4G, Bluetooth, and infra-red technologies. Due to the large amount of data being transmitted, it is necessary to implement a reliable program that handles the storage and processing of this data. Such a program is known as Cloud computing.

Application Layer: The data processed in the Network layer is used in the Application layer. This layer is also the front-end interface of the architecture, enabling the IoT device to reach its intended potential. By providing necessary tools such as actuators, this layer allows developers to realize the IoT perspective. Various applications can be developed, such as logistics management, identity verification, smart transportation, etc.

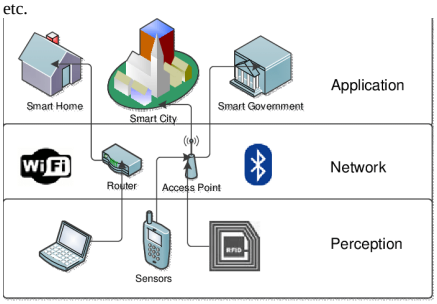

Figure 6. The three-layer architecture of IoT.

Five-Layer Architecture of IoT

With technological advancements over the years, IoT technology has progressed and improved. One of the changes within the IoT system is the addition of two layers to its architecture. The processing and business layers have been added, turning the three-layer architecture into a five-layer architecture (Figure 3). This version is considered a more comprehensive explanation of IoT architecture. The perception and application layers are the same as in the three-layer architecture, and below, we will discuss the other three layers.

Transport Layer: This layer is responsible for directing the data received from the sensor layer to the processing layer. This direction is achieved through networks such as Wi-Fi, Bluetooth, 3G, LAN, RFID, NFC, etc.

Processing Layer: Also known as the middle layer, this layer is responsible for acquiring, storing, analyzing, and processing large amounts of data from the transport layer. By using various technologies such as databases, cloud computing, and modules for processing large data sets, this layer manages and provides a range of services to the lower layers.

Business Layer: The entire IoT system is controlled by the business layer, ranging from applications, business models to user security and privacy. The way technology is distributed to the user, along with the technologies used by a device, determines the success of a device. The distribution of technology is a task handled by the business layer. By creating graphs and diagrams, this layer analyzes results and determines ways to improve the device [11].

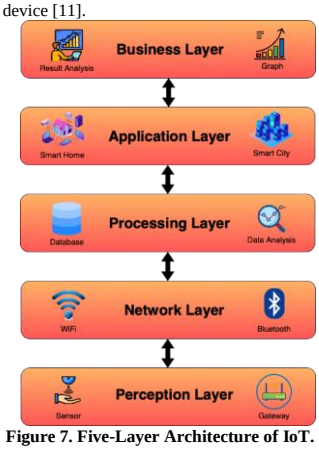

Figure 7. Five-Layer Architecture of IoT.

IoT Architecture in Healthcare

Continua is a healthcare alliance composed of more than 220 organizations. This organization has released an end-to-end (E2E) architecture that will be used for healthcare-related applications (Figure 4). The formation of this alliance is considered a historic achievement that is expected to create a sustainable environment with interoperability of connected healthcare systems. This E2E architecture provides an architectural overview of the ecosystem, including three network interfaces, four types of devices, and explains the limitations of the topology. With this architecture, data is transmitted from patient healthcare devices to hospitals or medical offices. Continua has created a design guide that specifies the core criteria. These criteria ensure interoperability among the components used in health monitoring and wellness applications [12].

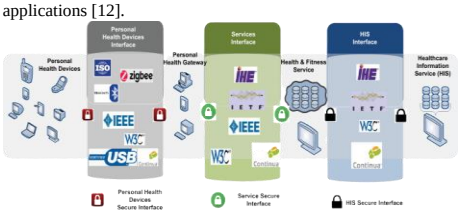

Figure 8. IoT Architecture for Healthcare Proposed by Continua.

Telemedicine, Healthcare, and Medical IoT

Telemedicine and Medical IoT are two terms where the difference between them is small, and this difference is related to how they use IoT. Telemedicine refers to the use of medical data transmitted from one location to another using electronic communications. This communication aims to improve and preserve the patient's health condition. Telemedicine is closely related to the term telehealth, which is used more broadly to refer to remote healthcare (Figure 5), excluding clinical services. Components of telemedicine and telehealth include remote monitoring of vital signs, ongoing medical education, video conferences, telehealth call centers, and the transmission of medical images. In short, telemedicine is the use of IoT for medical purposes and describes the modernization of healthcare through the

use of information technology.

Healthcare, as a type of medical care, aims to monitor and support chronic conditions and implement preventive measures to ensure a healthy lifestyle. IoT in healthcare describes a range of devices and technologies used to support personal health. These systems and devices provide personalized services designed for an individual. Personal healthcare systems that use IoT include glucose level monitors, heart rate pacemakers, various cloud computing services, and devices for monitoring children and infants [13].

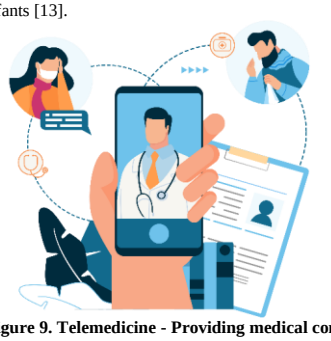

Figure 9. Telemedicine - Providing medical consultations with patients remotely.

IOT DEVICES AND THEIR METHODOLOGY

One of the most recent advancements in healthcare is smart healthcare. Traditional healthcare methods involved patients visiting doctors to report issues such as breathing problems, blood sugar levels, and more. Now, with the help of sensors, smartphone applications, and other IoT devices, data can be collected and sent to the doctor, allowing remote monitoring of the patient's condition. There are many devices used for health monitoring, and below, we will discuss some of the most widely used.

Helo Wristband

An intelligent device for real-time 24/7 health monitoring, with disease prediction capabilities as shown in Figure 6. This device has active sensors that monitor the human body. It monitors blood pressure, heart rate, ECG/EKG, sleep quality, emotions, steps, calories, fatigue, and more. It also has an SOS function where, if the person wearing the wristband encounters a problem, signals are sent to their family members, who can track their GPS location. Other features expected to be added to this device include monitoring blood sugar, blood oxygen levels, temperature, alcohol levels, and serving as a mosquito repellent [14].

Figure 10. Helo-Health Monitoring Wristband.

Pajisja për monitorim të presionit të gjakut me valë

In Figure 7, an intelligent device is presented, which is used by the patient in cases when they suspect they have high blood pressure, such as hypertension. It has been developed with the assistance of cardiologists and subsequently clinically tested to provide accurate results. It offers easy usage, with just a press of a button and Wi-Fi connectivity to the application, you can measure and monitor blood pressure accurately. The application also offers the possibility of creating a health diary that the patient can share with their doctor [15].

Figure 11. Device for blood pressure monitoring with waves.

AliveCor Heart Monitor

This device has the shape of a phone case, as seen in Figure 8, but it can also be a peripheral device that attaches to the back of the phone. It is used to monitor and record the user's EKG. Through waves, it connects to the phone's application, where the collected recordings can be viewed and analyzed [16].

Figure 12. Sensor for EKG monitoring in the form of a phone case.

Smart Devices for Infant Health Monitoring

There are many cases where a small device is attached to the baby's arm, tracking the temperature and the baby's body position (Figure 9). It transmits the baby's statistics to the smartphone application. In cases where it detects a significant increase or decrease in temperature, an alarm is triggered as a warning sign. The device is made up of hospital-grade fabric and is safe to wear for extended periods [17].

Figure 13. Baby Check - a temperature and body position monitor.

Smart Sock

The Owlet Smart Sock sensor (Figure 10) is used to monitor the heart rate and oxygen levels of infants. The infant is monitored in real-time while sleeping. This device is also connected to a smartphone application, through which the parent will be notified if the heart rate and oxygen level are outside the normal range. Below, we will discuss this sensor in more detail, as it is considered one of the best sensors for infant monitoring.

Figure 14. Owlet Smart Sock 2.

The Motive for Using Smart Sock

The motive behind proposing the use of Smart Sock is the reduction of sudden infant deaths (SIDS). Sudden Infant Death Syndrome can have several causes, but difficulties in breathing are considered the main reason. SIDS can occur in any healthy infant and often happens when the baby is asleep [18].

Configuration and Operation of Smart Sock

This intelligent and reliable device consists of the base station, which has two micro-USB ports. One port is used for charging the base station, while the other is used for charging the sensor that will be placed on the sock (Figure 11). Through this sensor, the sock communicates with the base station via a wireless connection.

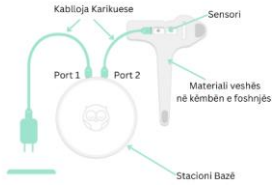

Figure 15. Parts of Owlet Smart Sock 2.

The Base Station should also connect to the mobile application via Wi-Fi. From there, the parent receives information about the baby's heart rate and oxygen levels (Figure 12). The application will send notifications in the form of alarms when these heart rates and oxygen levels in the baby are outside the normal range. Through the application, the parent understands the reason for the alarm trigger. The sensor's battery can last up to 18 hours without needing charging. The Base Station serves as a basic informant by issuing visual and auditory signals in cases where there are abnormal changes in heart rate or oxygen levels.

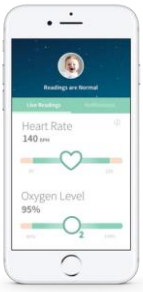

Figure 16. Reading heart rates and oxygen levels from the application.

The base station changes color depending on the information it provides. There are 5 types of notifications, and each has a specific color (Figure 13). The white color indicates that the device is charging properly, the yellow color indicates that the sock is not properly placed on the baby's foot. The blue color indicates that the sock is out of range and cannot communicate with the base. The red color, the most alarming one, indicates that the heart rate or oxygen levels are outside normal levels. The green color signals that the device is receiving data properly, and there are no issues with the baby [19]. The collected data will be stored in a reliable Cloud-based database. Even if there is a Wi-Fi or power interruption, monitoring of the baby continues for up to 18 hours, keeping vital data at the local level, and as soon as the connection is restored, the data is uploaded to the Cloud.

Figure 17. Different signaling colors of the Base.

OSS USE CASE STUDY AND RESULTS

A study conducted by [20] has reported the initial experience of monitoring the cardiorespiratory system at home in 47,495 newborn infants using OSS. The study period started in October 2015 and lasted until May 2017. Due to the extended study duration, the collection of demographic data for OSS users was only conducted for active users in May 2017. The number of these users was 5,125 or 24.2% of all participants (Table 1).

Demographic Results

15% of the monitored infants were preterm babies, while 85% were full-term healthy infants. The majority of users were individuals who had become parents for the first time and were in their 30s. The primary reason for using OSS was to ease their peace of mind, while other reasons included the infant being diagnosed with breathing or heart problems. According to the responses received, approximately 8% of users had a history of SIDS in the past, and about 15% of infants had just been discharged from the neonatal intensive care unit (NICU).

Table 1. Demographic data of active OSS users.

The demographic survey data group (n = 5125)	Percentage
Newborn Profile	
Full-term newborns	85%
Preterm newborns	15%
Parent Profile	
Parent Age Category	

• 30-39 years	61%
• 21-29 years	31%
• 40+years	7%
College-educated families	70%
Families with at least 1 healthcare industry professional	37%
Families at or below average income	28%
Reasons for Using OSS	
History of SIDS (parent or close relative)	8%
Infant diagnosed with breathing or heart problems	12%
Post NICU for newborns	13%
First-time parent	30%
Sense of "peace of mind"	44%
Parental Outcome of Using OSS	
Following safe sleep guidelines	82%
Improved sleep quality for parents	94%
Reduced anxiety	96%

Physiological Normative Results

Gestational age in prematurely born infants was difficult to verify, so the physiological normative findings only include full-term infants. The normal average heart rate for these infants was 136 bpm in the first month and 106 bpm in the 12th month, while the average blood oxygen level (SpO2) in the first month of life was 96%, and 97% in the 12th month. Table 2 presents the averages of heart rate and SpO2 for 39,326 infants.

Table 2. Average by age for the long-term monitored newborns (n = 39,626).

Age after birth (n)	**Heart rate frequency ± DS**	**SpO 2 (%) ± DS**
1 month (15 372)	136 ± 9,0	96 ± 1,7
2 months (19 729)	131 ± 8,2	97 ± 1,6
3 months (20 443)	122 ± 7,5	97 ± 1,6
4 months (20 168)	116 ± 7,4	97 ± 1,6
5 months (19 357)	114 ± 7,5	97 ± 1,9
6 months (18 103)	112 ± 7,2	97 ± 1,5
7 months (16 268)	111 ± 7.1	97 ± 1,4
8 months (13 806)	110 ± 7.1	97 ± 1,4
9 months (10 917)	109 ± 7.2	98 ± 1,4
10 months (8357)	108 ± 7.2	98 ± 1,4
11 months (6166)	107 ± 7.2	98 ± 1,4
12 months (4459)	106 ± 7,6	97 ± 1,4

False-Positive Alarms and Clinical Significance

The most frequent alerts (Red Alerts) were for low oxygen levels (71%). For high or low heart rates, the alerts were relatively few, around 18% and 10%, respectively. From the use of the OSS, it was observed that clinically significant alerts were constantly accumulating and repeating. For example, a monitored infant had no alarms for 6 months, but then alarms started occurring up to 10 times a day. Through a medical review analyzing the data collected by the device, it was discovered that the infant had been infected with respiratory syncytial virus (RSV).

Users were asked to report alarms that were clinically significant. From the data collected until October 2015, a total of 80 cases were reported where OSS alerts had either prevented a critical event or assisted in diagnosing a disease the infant had but had been overlooked. Out of these cases, 49 or 61%, upon verification by a doctor, were found to be clinically significant. The other 31 cases, or 39%, were clinically insignificant, meaning the alarm might have been triggered by excessive movement of the infant or improper device placement.

From the clinically significant cases, it was possible to diagnose 23 infants with respiratory syncytial virus (RSV), 7 infants with supraventricular tachycardia (SVT), 7 infants with breathing difficulties, 5 infants with airway obstructions due to poor sleeping positions, 3 infants with congenital heart defects, and 3 other infants with apnea.

CONCLUSION AND DISCUSSION

More than 27 billion devices are connected to IoT today, and this number is expected to reach 100 billion by 2030. IoT is a continuously growing technology that is touching every aspect of life, especially healthcare. Healthcare becomes more effective when characterized by accuracy and speed. The best way to achieve these characteristics is by relying on a wide range of healthcare systems connected to IoT. Through IoT, the digital identity of all patients can be preserved. The benefits of applying IoT in healthcare are numerous, ranging from providing remote medical assistance, real-time health monitoring, to collecting and processing patient data.

IoT devices are ideal for measuring vital signs such as pulse, heart rate, body temperature, oxygen levels in the blood, blood pressure, glucose levels, and more. These devices collect data from the surrounding environment through various sensors. These devices are user-friendly, so even patients can use them from home to monitor physiological values if they have adequate values.

This thesis also discussed neonatal healthcare, especially finding a monitoring method for the prevention of SIDS (sudden infant death syndrome). A solution proposed is the use of an IoT device called the Owlet Smart Sock. This device provides information about a baby's heart rate and oxygen levels in real-time. A study was conducted to assess the effectiveness of this device, which showed that it had reported a total of 80 cases. Thanks to its alerts, critical events were prevented or assisted in diagnosing any diseases the baby might have had, but which would have otherwise been overlooked.

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Development and Evaluation of a Real-TimeCommunication Web Application Using WebSocket's, React, Node.js, and MongoDB

Albijon Hyseni[1*], Lamir Shkurti[1], Faton Kabashi[2], and VehebiSofiu[2]

[1,2]UBT, Prishtina, Kosovo
{ah48831, lamir.shkurti, faton.kabashi,vehebi.sofiu}@ubt-uni.net

Abstract. Web applications are becoming increasingly popular in recent years and have changed the way people communicate on the web. These applications have become an essential part of our daily lives, as they allow us to communicate with people in real time and stay connected with friends, family and colleagues around the world. In the present tense applications for real-time communication have become even more important as work in distance and social distancing have become a normal aspect of our lives.
In this paper, we have created a web application that will facilitate real-time communication between users. The application was developed with the most modern technologies, using React, for the front-end part which helps us to create dynamic components and reusable. The back-end part was developed with Node.js while the database was created with MongoDB. To achieve real-time communication between two users, we have implemented the Socket.IO package, a widely utilized tool for establishing secure and reliable connections. The application addresses the needs of remote communication by creating a safe, convenient and reliable environment for the community. We tested our application under the demands of 100 users in simultaneous communication. The application showed good performance. Also, we analyzed the performance of our application by creating the same application with PHP and MySQL technology. Research shows that the chat application built with React and MongoDB, Node.js outperforms the application built with PHP and MySQL in real time in terms of speed.

Keywords: chat, Chat Application, Socket.IO, Node.js, React.js MongoDB, PHP, MySQL

1 Introduction

In the age of digitalization, effective communication remains the fundamental basis of personal and professional interactions. The advent of technology has not only overcome the problems of geographic location but has also transformed the very essence of how we connect and communicate. Digital communication has become a critical component of modern society, providing users with the ability to connect, communicate, and share information with people around the world. The advantages of digital communication are many, including speed, convenience, and accessibility. With digital communication platforms such as email, face-to-face meetings, and social networking platforms, users can communicate with each other in real-time, share photos and videos, and even participate in group chats and activities regardless of geographical location, time zone, or distance.

This has opened up new opportunities for various collaborations, learning, and commerce, allowing users to connect and share information with others quickly and efficiently. Digital communication has also changed the way businesses operate, enabling companies to expand their operations beyond physical boundaries, access new markets and customers, and communicate and collaborate with employees and partners in real-time. This has helped increase productivity, efficiency, and innovation in many industries, contributing to economic growth and development.

Digital communication has also played a critical role in breaking down barriers to social and political participation, allowing users to connect and mobilize for social and political causes, and sharing information and ideas.

Digital communication has had a profound impact on almost every aspect of modern life, providing users with new and powerful forms of connection, communication, and access to various information and resources. By enabling greater collaboration, information sharing, and social and political inclusion, digital communication has helped promote a more inclusive, interconnected, and empowered global society.

Recognizing this evolution and the growing need for easy and fast communication, we present our app, a platform tailored to help users connect with each other.

Our application is created using some new and efficient technologies. Using React for the frontend, the application provides a dynamic and attractive interface. While Redux manages the application state, facilitating efficient data management. On the other hand, we will use Node.js for the backend, providing a powerful and scalable server environment. Additionally, MongoDB, a NoSQL database, will efficiently manage application data with flexibility. In conclusion, Socket.IO will enable real-time bidirectional communication, transforming the application into a platform where conversations take place seamlessly and instantly. This combination of React, Node.js, MongoDB, and Socket.IO forms the foundation of the application's architecture, promising an incredible, real-time communication experience.

This combination of technologies enables us to deliver a comprehensive app experience, allowing users to effortlessly register, securely log in, establish connections with friends within the app, and exercise control over their personal information by enabling updates and modifications as needed.

The integration of these technologies ensures a seamless and user-centric platform that meets the diverse needs of our users.

2 Related Work

There are specific studies for building real-time chat applications in various techniques with different programming languages in the past, including Noor Sabah [1], Eric Obadjere Nyerhovwo [2], Nidhi Zala [3], Kuldeep Gupta [4], Diotra Henriyan [5], Dr. Dileep Kumar Yadav [6].

Noor Sabah, et al. [1] Introduces the escalating role of mobile devices in daily life, specifically focusing on the burgeoning popularity of chat applications due to their real-time messaging and versatile features such as text, image, and file exchange across platforms like Android and iOS. The distinction between client-server and peer-to-peer network architectures is highlighted, emphasizing the importance of security and privacy, often underestimated in popular chat applications. The prevalence of inadequate security measures in existing applications is addressed,advocating for end-to-end encryption to protect messages from both service providers and potential attackers.

Eric Obadjere Nyerhovwo [2] CHATTY was conceptualized not merely as another chat application, but with the intent to elevate the user experience through a clean UI and a robust app structure within a secure broadcast network. It represents a contemporary approach to internet security in communication platforms.

The UI design was thoughtfully influenced by existing chat applications to provide users with a fresh yet familiar interface. The implementation leverages a unique combination of Flutter, Node.js, Hive, and MongoDB, with Flutter for app structure and UI, Node.js for server setup, Hive for local database in Flutter, and MongoDB for the central network database. Utilizing an end-to-end connection stream, data transfer seamlessly occurs between the client and server. In testing, the application exhibited optimal performance with no lag, garnering an impressive 95% acceptance rate among potential users.

Nidhi Zala, et al. [3] identified the problem in real-time chat applications lies in their disparate features and functionalities across different platforms. This project seeks to consolidate various features like invitation sending, online indicators, typing notifications, message storage, chatting, audio and video calls, and screen sharing into a single application. Contrary to the notion that having multiple applications is unfavorable, studying various existing applications provided invaluable insights into what to develop and how to choose appropriate technologies and techniques. Notable applications examined during the research include Flowdock, Gitter, Hangouts, Discord, Messenger, Rocket.chat, Skype, Slack, Telegram, and Whatsapp, with a primary focus on Gitter and Slack due to their developer-centric approach and successover time. These platforms were recognized for their developer-oriented features and productivity focus, making them ideal subjects for further research. The global community of developers is continually striving to enhance user experiences and improve application development workflows. Development stacks, such as MEAN and MERN, have gained prominence, streamlining the development of web applications by leveraging current frameworks like JavaScript.

Kuldeep Gupta, et al. [4] This project aims to develop an online chat system enabling real-time communication through web browsers. The implementation will utilize the WebRTC approach, which allows seamless real-time communication without requiring additional browser plugins, provided the browser supports WebRTC, like Google Chrome. However, for screen sharing functionality, a plugin installation will be necessary. The motivation behind creating this chat app is to foster a sense of unity within an organization comprising various departments and locations. The app aims to facilitate communication, ensuring authentication for user security and offering diverse styles for user comfort. While providing typical chat functionalities, CZAT stands out by allowing users to like specific messages and create numerous communities.

Diotra Henriyan, et al. [5] The proposed chat application encompasses web-based and mobile platforms, designed to facilitate communication and specifically support the city of Bandung and the wider Indonesian populace. Leveraging technologies such as Node.js, Socket.io, MongoDB, and Java, the application aims to offer seamless, real- time communication. The test results demonstrate that the core functionality of the chat application, namely sending and receiving messages, is highly efficient. Chat applications constructed using Node.js, MongoDB, and Socket.io exhibit notably faster performance, enabling real-time communication. In contrast, those developed with PHP and MySQL tend to lag in achieving real-time capabilities.

Dr. Dileep Kumar Yadav, et al. [6] The conception of this video chat application revolves around fostering cohesion within organizations with diverse departments and locations. The application prioritizes user safety and offers a plethora of user-friendly styles. It is designed to support users like any other chat app, with the added feature ofmessage categorization and the ability to create numerous communities. The application indicates user activity status and provides solutions catering to a diverse user base to ensure privacy and a conducive environment. Additionally, itincorporates a user gallery, allowing easy access to all published photos without the need to navigate through chat histories.

3 System Design

The system design of our chat application is a comprehensive integration of the latesttechnologies, each playing a key role in providing functionality, real-time applicationperformance and capabilities. At its core, the application is structured around a client- server architecture. Below are listed the technologies along with their explanations: **Explanation of technologies:**

3.1 React

ReactJS, often referred to simply as React, stands as a powerful and widely used library that is open-source, maintained by Facebook, and has a large community of developers. It is designed to simplify the creation of interactive and dynamic user interfaces for web applications. React works on the principle of component-based architecture, where the application is divided into smaller, reusable components, each managing its own state.

3.2 Redux

Redux is a powerful open-source JavaScript library commonly used to manage application state in a predictable way. It is often used with frameworks like React for developing user interfaces, but it can be used with any other framework or library. At its core, Redux follows a unidirectional data flow architecture, which ensures that dataflows in a single direction through the application.

3.3 Node.js

Node.js is an open-source, cross-platform, server-side JavaScript runtime environmentbuilt on Chrome's V8 JavaScript engine. It was developed by Ryan Dahl in 2009 and has since become a fundamental tool for developing scalable network applications. One of the key features of Node.js is its event-driven, non-blocking I/O model. This allows it to efficiently handle a large number of concurrent connections, making it ideal for real-time applications. Node.js uses modules, which are reusable pieces of code, to structure applications. There is an extensive ecosystem of libraries available through NPM making it easy for developers to find and integrate functionality into their applications. Node.js is commonly used to develop server-side applications, suchas web servers and APIs. It excels in handling I/O-related operations, such as reading or writing to a database, making it suitable for data-intensive applications.

3.4 MongoDB

MongoDB is an open-source and widely used NoSQL database management system that stores data in a flexible, JSON-like format. It was developed by MongoDB Inc. and was first released in 2009. MongoDB has gained considerable attention in recent years due to its scalability, performance, and ease of use. MongoDB stores data in a flexible, schema-free format called BSON, a JSON-like binary representation of documents.

3.5 Socket.IO

Socket.IO is an open-source JavaScript library that enables bidirectional real-time communication between clients and servers. This library was created in 2010 and has since become a fundamental tool for developing interactive real-time applications.

Socket.IO facilitates real-time communication by establishing a persistent connection between client and server. This allows for immediate data exchange and without the need to send successive client requests. Socket.IO uses WebSocket, a modern protocol that provides a full-duplex communication channel over a single TCP connection. When available, WebSocket is the primary transport mechanism, enablingefficient real-time communication.

The combination of the above technologies allows our users to send and receive messages in real time. With the help of Socket.IO, users can communicate effectively,and the server assists in filtering and adding an additional level of message validation to ensure proper message exchange. Additionally, the database allows for storing and retrieving messages whenever needed.

5

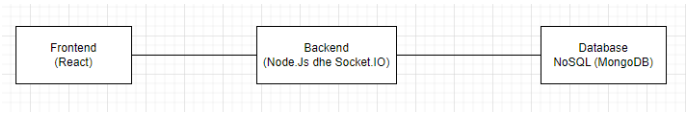

Figure 1: Web Architecture Diagram

Required tools to design applications are as follows:

- REST API: backend: handles all server logic and allows users to communicate inreal time with the help of socket.io
- Npm - used to run ReactJS: is a package manager for JavaScript that allows the installation of various packages.
- Visual Studio Code – code editor: VS code is where the application code is written.
- Socket.IO - a library that facilitates real-time, two-way communication between clients and servers.

4 Proposed Architecture

Our application utilizes a client-server architecture to facilitate seamless user interactions. Upon initial use, users are required to complete a registration process, providing necessary credentials and information. Once registered, users gain access to the application's functionalities, enabling them to initiate conversations with various individuals after establishing connections within the app. The underlying architecture employs a client-server model, where client-side interfaces handle user interactions and requests, while the server manages data processing and storage. Specifically, all user messages and associated data are stored and managed within a MongoDB database, ensuring efficient and organized handling of communication data for enhanced user experience and system performance.

To access the application's features and services, users are required to complete a registration process, where they provide essential details such as a username, email, and password. These details are pivotal for creating a personalized account within the application. The registration information is securely stored in a MongoDB database, ensuring robust data management and accessibility. Particularly, stringent security measures are implemented to protect user privacy, with passwords being encrypted using industry-standard encryption algorithms before being stored in the database. This encryption process adds an extra layer of security, safeguarding sensitive user data against unauthorized access or potential breaches.

Before storing any passwords in our database, we utilize the bcrypt library, a trusted and widely recognized encryption tool. Bcrypt employs a secure one-way hashing function, ensuring that passwords are transformed into an irreversible and complex string of characters. This encryption technique adds a strong layer of security, making it exceedingly challenging for any potential malicious actors to decipher or compromise the stored passwords. By prioritizing the use of bcrypt for password encryption, we can confidently assure our users that their confidential information remains secure and confidential within our system.

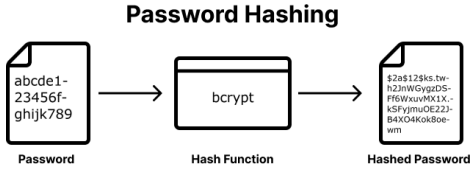

Figure 2: Password Hashing Diagram

For seamless usage of our application, users are required to log in using their credentials. Logging in is essential to accessing the app's functionalities and personalizing the user experience. Once logged in, users can connect with friends within the app, and an online status indicator becomes visible to these connected friends. This feature enables a real-time understanding of their friends' availability, enhancing communication and interaction by providing information on who is currently online, fostering a more engaging and dynamic user experience.

Within our application, users possess the capability to create and engage in conversations with their friends. This functionality allows for seamless communication, enhancing user interaction and fostering meaningful connections. Users can exchange messages within these conversations and, if desired, have the option to delete the conversation, providing control and flexibility over their messaging history. Additionally, our platform features real-time notifications, enabling users to see when their friends are typing, enhancing the conversational experience. Moreover, users are informed of their friends' online or offline status, facilitating timely communication and promoting effective engagement. These features collectively aim to optimize the user experience, making communication within the application efficient, intuitive, and enjoyable.

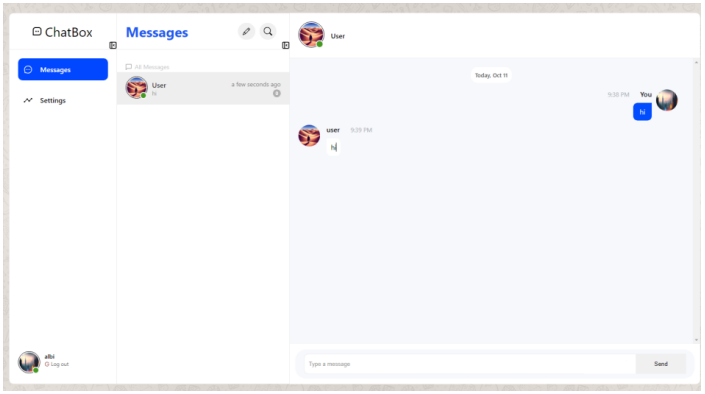

Figure 3: Conversations Page Design

Our application offers users the flexibility to modify their personal information and update their profiles as needed. This feature empowers users to maintain accurate and up-to-date details, reflecting their evolving preferences and circumstances. Whether it's updating their username, email, profile picture, or any other relevant information, our platform ensures a smooth and user-friendly experience for making these modifications. The ability to change personal information and tailor their profiles enable users to present themselves authentically within the app, fostering a sense of customization and control over their digital presence.

5 Results

The application encompasses fundamental features essential to user functionality. It includes a registration page, a login interface, a platform to establish connections with other app users, seamless message exchange capabilities, real-time typing notifications, an indicator for online status, and a dedicated page enabling users to modify their personal information.

Given the app's intended purpose, it was primarily developed as a demonstrative model showcasing the process of building a chat application, rather than being engineered to support a large volume of users.

We have successfully developed and thoroughly tested the application, subjecting it to the demands of 100 users engaging in simultaneous communication. Remarkably, the app exhibited commendable performance, functioning seamlessly under this load. It's important to note that while the app excelled in this testing scenario, its core design wasn't primarily intended to handle such extensive user loads, emphasizing its versatility and efficiency even beyond its designed scope.

We also analyzed the performance of our application by creating the same application with PHP and MySQL technology. The research demonstrates that the chat appcreated with React and MongoDB, Node.js outperforms the application built with PHP and MySQL in real-time

Table 1. Testing CPU performance data from both applications: Node.JS, Socket.IO and MongoDB with PHP and MYSQL

No	Chat with Node.js Mongodb and Socket.io based (in seconds)	Chat with PHP and MySQL based (in seconds)
1	0.11	1.53
2	0.13	1.42
3	0.16	2.01
4	0.11	1.42
5	0.11	1.32
6	0.14	1.53
7	0.15	1.51
8	0.20	1.37
9	0.16	1.97
10	0.17	1.32

The research demonstrate that the chat app created with React and MongoDB, Node.js outperforms the application built with PHP and MySQL in real-time.

6 Conclusions

In conclusion, this paper has been an exploration and implementation of modern technologies to develop our application. Throughout the course of this work, we have successfully met the set objectives and met the set goals. Using technologies such as Node.js, MongoDB, React, Redux and Socket.IO, we have developed a robust and interactive platform that facilitates real-time communication between users.

One of the most challenging aspects of our project was establishing real-time communication between clients, enabling seamless and immediate messaging. This presents a problem, as traditional HTTP communication is based on request-response and does not support real-time updates. However, we successfully overcame this problem by leveraging the features of the Socket.IO package. Socket.IO proved to be the solution to this challenge by providing a reliable and efficient solution for bidirectional real-time communication because we were able to establish persistent connections between clients and the server, allowing instant messaging and updates toreal time.

Using the features of these technologies, we have created a web application that enables seamless communication and interaction between users.

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Review of Artificial Intelligence Implementation in Electronic DesignAutomation Methods and Tools

Katerina Kostova[1], Lavdim Menxhiqi[2], Blerim Zylfiu[2], Galia Marinova[1]

[1]Technical University of Sofia, Sofia, Bulgaria
kmkostova@tu-sofia.bg, gim@tu-sofia.bg
[2]University for Business and Technology – UBT,Pristina, Kosovo
{lavdim.menxhiqi. blerim.zylfiu}@ubt-uni.net

Abstract. The paper is a review of the implementation of artificial intelligence (AI) in electronic design automation methods and tools. The implementation of AI in Modelling, Simulation, Synthesis, and integrated circuit (IC) Layout electronic design automation (EDA) Tools is first considered then the AI for printed circuit board (PCB) design tools is studied. The knowledge base and machine learning (supervised and reinforced learning) with neural networks (NN), multi-objective optimization, and hybrid method and the corresponding mathematical methods are discussed. Validation examples are considered. Since AI is a breakthrough innovation factor, the impact of its current and expected implementation in EDA tools by company developers on the market is discussed.

Keywords: AI, ML, EDA tools, EDA companies, Modeling, Simulation, Synthesis, IC Layout design, PCB design.

1 Introduction

The incorporation of Electronic Design Automation (EDA) integration can enhance product development and design processes by harnessing knowledge and reasoning capabilities. This transformation has a profound impact on the utilization and effectiveness of EDA systems. While initially conceived as a basic tool, top-tier EDA software solutions have evolved to encompass sophisticated functionalities, enabling users to execute tasks that were once beyond the realm of traditional methods. Artificial Intelligence (AI) stands as a pivotal force propelling the potential of EDA tonew heights. Several leading EDA software solutions have begun integrating Artificial Intelligence.

The infusion of AI into EDA yields several noteworthy outcomes. AI can amass and generate knowledge-based information, seamlessly integrating it into EDA procedures to amplify automation. AI algorithms possess the capacity to autonomously implement necessary design adjustments, obviating the need for human intervention. AI can also expedite the testing and simulation processes, thereby reducing design time. [1]

The papers study the implementation of AI for solving EDA tasks in structural/behavioral/topological design areas with different AI approaches, mathematical methods, and validation examples as presented in Table 1.

Table 1. AI for solving EDA tasks and applications and in the design area with different AI approaches and mathematical methods.

Application designs	Design tasks/ Design area	AI approach	Mathematical methods	EDA tools
Analog circuits RF circuits	Modeling/ Behavioral area Simulation/ Behavioral area Synthesis/ Structural area Optimization/ Behavioral, Structural, and Topology areas IC topology design/ Topology area	Knowledge base/Expert system Machine Learning (supervised/ reinforced learning) •NN •Multi-objective optimization •Hybrid	•Artificial Neural network (ANN) •Bayesian Neural Network (BNN) •k-nearest neighbors (KNN) •Deep learning (DL) •Genetic algorithm (GA) •Decision tree •Random forest •Strength Pareto Evolutionary Algorithm-2 (SPEA2), •Bayesian Optimization •Evolutionary algorithm optimization •Lower Confidence Bound (LCB) functions •Non-Dominated Sorting Genetic Algorithm II (NSGAII) •Multiobjective evolutionary algorithm based on decomposition (MOEA/D) •Bayesian Regression •Support Vector Machines (SVM), •Polynomial Regression, •Sparse regression •Rectified linear unit (ReLU)	Spice simulator
PCB design	PCB Layout design/ Topology area			Continuity, New Celus [5], JITX [4], Circuit Tree [6], Tomy Day and Circuit Mind,

The report in [21] discusses the potential financial impacts of AI using general industry trends and the known benefits of AI. The metrics of operational efficiency, cost savings, revenue growth, customer satisfaction, and market share are explored ina qualitative manner.

2 Implementation of AI in Modelling, Simulation, Synthesis, and IC Layout EDA Tools

AI is implemented in Modelling, Simulation, Synthesis, and IC Layout EDA Tools.

2.1 Behavioral Verilog-A models based on Machine Learning in TechModeler

TechModeler [2] employs neural network-based modeling and is capable of handling a substantial quantity of variables and nonlinear occurrences for temperature impact and autonomous warming depiction, corner representation for device disparities, reliability simulations for both devices and circuits and sound representation. The theorem of generality asserts that a neural network featuring a sole concealed layer has the capability to approximate a continuous function to an aspired accuracy level. By employing a sufficient number of concealed neurons, it is conceivable to identify a neural network whose output is represented with the desired precision for all input scenarios.

2.1 AI in Analog IC Design

Analog integrated circuits (ICs) continue to lack a significant level of automation, which is customary in fully automated digital circuit design. Instead, they rely on the designer's expertise.

The research in [9] primarily concentrates on techniques to reduce the design cycles of analog circuits, specifically in the topological layout design. Various automation methodologies are explored. Advances in high-performance computing hardware have opened doors to machine-learning solutions for designers. Reference
[9] conducts an examination of machine learning methods applied in analog circuit sizing and evaluates their efficacy.

Three primary categories of machine learning techniques are investigated:

- Artificial neural networks (ANNs) (both shallow and deep) utilize supervised and reinforcement learning methods [14] to model intricate nonlinear problems, thanks to high-speed computers. The fundamental concept of ANNs involves constructing a model that approximates the actual solution for a problem based on a dataset (training phase). Concurrently, the model should possess the ability to generalize and predict new outcomes for previously unseen data (testing phase) with predefined accuracy. Validation using operational amplifiers is accessible. The automated sizing of all operational amplifier components offers advantages to circuit designers, allowingthem to concentrate more on optimizing macro-system performance and architecture. The criteria for assessing supervised learning in analog circuit design, as proposed in [9], include: Dataset generation approach; Feature selection; Complexity of ANNs; Utilized IC fabrication process; Targeted circuit types; and Method for validating results. In IC design, Reinforcement Learning is not widely employed.
- Multi-objective optimization employing various heuristic and stochastic strategies, simulation-based optimizations such as Bayesian, particle swarm, Gaussian process, simulated annealing, and genetic algorithms (although not strictly considered ML techniques).
- Hybrid approaches that combine global optimization and ANNs. The concept behind hybrid methods is to initially employ multivariate polynomial regression to estimate performance trade-offs in optimization and predict circuit performance under new conditions. Subsequently, the outputs are input into an ANN, which learns fromthese updated examples to predict device sizes corresponding to the new performance.

The objective is to efficiently reuse existing designs to predict circuit performance under novel circumstances.

A portion of the ANN design is tackled by a genetic algorithm (GA), iteratively deciding which performance metrics and design constraints to include as input features during training. Constraints on design parameters become additional inputs to the GA-ANN combination, aiding in reducing under-determination levels.

A learning framework based on evolutionary algorithm optimization, coupled with an embedded ANN, entails deriving a new design from the previous one (a population-based method) at each optimization step. The ANN aids in the sampling process, selecting the best candidate design for the next generation. Predicting

whether a design surpasses its parent is executed by a Bayesian ANN that emulatesthe circuit simulator with enhanced speed. Initially, SPICE simulations are used alongside the GA, and a trained ANN determines the local minimum search for neighboring design regions.

Hybrid techniques harness ANNs for diverse purposes, either replacing time- consuming IC simulators that impede global optimization or expediting sampling or search exploration within the algorithm itself. In some instances, hybrid methods employ a genetic algorithm to design the optimal ANN structure and select featuresfor training.

Monte Carlo simulations [18] are employed to develop and train artificial intelligence (AI) and machine learning (ML) models. They aid in evaluating model performance, estimating uncertainties in predictions, and determining confidence intervals for model outputs. Monte Carlo simulations prove particularly valuable in reinforcement learning, where they facilitate the exploration and optimization of decision-making strategies within complex environments.

2.2 Machine learning techniques in analog/RF integrated circuit design

Machine learning methodologies in analog/RF integrated circuit design are examined in [10]. ML training and simulation generate a model that adapts thespecified objectives of RF design. Decision Tree can be employed to automatize the selection of a circuit topology based on the desired specifications; Random Forest is utilized to detect potential rare occurrences during the Monte Carlo simulation of RF design. Support Vector Machines and ANN-based strategies are frequently employed to acquire the functional models of analog circuits.

- SVM is applied for modeling Analog Circuits - GaAs transistors and Analog Circuits-CMOS. ANN is utilized for modeling AMS circuits-CMOS, RF-microwave components, HMT and MESFETs, RF-CPW components, and RF-UC-PBG rectangular waveguide [10].
- ML-driven IC circuit synthesis applications for Analog Circuit Enhancement encompass KNN, ANN +SPEA2/GA, Bayesian Optimization (GP+LCB+NSGA-II BNN+LCB+MOEA/D), for Performance Space Exploration, include Bayesian Regression (GA+SVMs), Polynomial Regression, ANN-based information retrieval +Sparse regression [10],
- Techniques employed for Analog Circuit Synthesis consist of ANN (GRP+MLP), DL+RELU, Polynomial Regression + ANN, RL (L2DC), and Deep RL, for RF Circuit Synthesis - GA+ANN(MLP) [10].
- ML applications for layout automation in Placement incorporate ANN with nxWxH neurons, and ANN with 3 or 4 concealed layers., for Routing - ANN is employed as VAE [10].

Pareto optimal fronts are estimated for the designed circuit in a novel context.

The SPICE tool serves the simulation phase in ML-based analog/RF circuit optimization.

3 Implementation of AI in PCB Design Tools

The electronics industry has witnessed a significant rise in the adoption of artificial intelligence (AI) in the field of PCB design. AI-driven approaches have emerged as powerful tools, revolutionizing traditional design processes and addressing various design challenges. The integration of AI in PCB design offers numerous benefits, although it also raises considerations regarding limitations and potential concerns [3] [12] [13].

The rising integration of AI into PCB design stems from a variety of reasons. First off, the escalating complexity of electronic systems calls for advanced design approaches. AI algorithms are particularly adept at managing large datasets and intricate decision-making processes. They harness the power of machine learning to sift through extensive design data, identify patterns, and make well-informed decisions around component placement, routing, and optimization. This empowers PCB designers to effectively address complicated design issues and secure

exceptional outcomes [3] [13].

In the world of PCB design, strategies powered by AI bring several advantages to the table. One of the standout benefits is a significant boost in design productivity. AI algorithms have the capability to take over repetitive and time-intensive tasks, such as figuring out component placement, routing, and analyzing signal integrity. This automation allows designers to free up their time and concentrate on more critical design aspects like system-level optimization and innovation. Thanks to the heightened efficiency and productivity AI tools offer, the design cycle is sped up, paving the way for electronic products to reach the market more swiftly [8].

Moreover, integrating AI into PCB design proves effective in overcoming prevalent design hurdles. For example, smart algorithms have the ability to fine-tune component placement to keep signal interference to a minimum, cut down on electromagnetic coupling, and enhance thermal management. By evaluating different design constraints and performance needs, AI algorithms can pinpoint the best solutions that comply with design specifications, all while taking into account elements like power distribution, signal integrity, and heat dissipation. These features lead to an uplift in design quality, fewer design iterations, and a boost in the overall performance of the electronic system [3] [13].

Furthermore, AI-driven tools facilitate design exploration and optimization. They can generate and evaluate multiple design alternatives, considering different trade-offs between cost, performance, and manufacturability. Designers can explore design spaces more efficiently, allowing for better exploration of innovative ideas and design improvements. AI algorithms can quickly assess the impact of design changes, enabling rapid prototyping and iteration. This iterative design process leads to faster convergence on an optimal design, ultimately enhancing the final product's qualityand functionality [13].

In [11], a proficient system employing statistical examination of the defect repository is employed to diminish the duration required for PCB testing. Leveraging insights from the defect data, the defect pattern can govern operations at the production facility.

AI-powered PCB design tools and solutions intensively developed are: Continuity[4], New Celus (Germany)[5], JTX, Circuit Tree [6], Tomy Day, and Circuit Mind and Zuken [3][7].

4 Market Impact of the Integration of AI in EDA Tools

AI is a breakthrough innovation factor [19, 20], and the impact of its current and expected implementation in EDA tools by company developers on the market is considered in this section.

A recent investigation [21] suggests that enterprises employing artificial intelligence (AI) and its affiliated technologies are poised to secure superior profits as opposed to those that abstain from their utilization. The imminent horizon appears to herald a prosperous period for entities that are implementing AI. The amalgamation ofAI and exploratory data analysis (EDA) can expedite product innovation.

In the forthcoming years, firms channeling resources into AI are anticipated to reap greater short-term advantages. The outlook for the design, automotive, engineering, and manufacturing sectors is predominantly contingent on AI technologies.

The evolving technology industry is marked by innovation and the increasing significance of technologies, like artificial intelligence generative design, and machinelearning. According to GlobalDatas report [17] on Innovation in Artificial Intelligence; AI assisted CAD there have been over 3.6 million patents filed in the technology sector in years. The progression of these innovations is not a path. Rather resembles an S-shaped curve starting with emergence moving towards adoption and eventually reaching maturity.

Within this realm of innovations, AI-assisted computer-aided design (CAD) stands out as a transformative breakthrough. This technology leverages the capabilities of intelligence to automate design processes. Its advantages include design creation, streamlined workflows, and improved user interfaces. This innovation represents a shift from methods to AI-powered processes that save time while enhancing accuracy.

GlobalData identifies over 900 companies involved in the development and application of AI-assisted CAD. These companies encompass stakeholders such as technology vendors established tech firms with a standing presence, in the industry as well as emerging start-ups. The report classifies these companies based on two factors; "Application diversity" and "Geographic reach". The first term refers to the uses associated with each patent classifying companies as diversified innovators. The second term represents the countries where each patent is registered indicating its impact [17].

Leading the way, in patent filings is the State Grid Corporation of China primarily concentrating on developing testing techniques for wind power plant parameters. Other important players in this field include Halliburton, Siemens, Arrow Electronics, and Vektor Medical all making contributions, to this domain.

The advent of Artificial Intelligence (AI) has revolutionized many industries, including Printed Circuit Board (PCB) design. This report investigates the impact of AI on the financial performance of three leading companies in this sector: Zuken (Japan) [15], JITX (USA), and Continuity, now Celus (Germany) [3][4][5][16]. The state-of-the-art of the market impact can be centered around five key areas: operational efficiency, cost savings, revenue growth, customer satisfaction, and market share.

- Operational Efficiency: The integration of AI into the design process could reduce the time required for design tasks, indicating an improvement in operational efficiency.
- Cost Savings: AI implementation in design tasks may reduce related expenses, suggesting a positive impact on financials.
- Cost Savings: AI implementation in design tasks may reduce related expenses, suggesting a positive impact on financials.
- Revenue Growth: The successful integration of AI tools could potentially boost the market demand for their services, indicating an increase in revenue.
- Customer Satisfaction: By reducing human error and enhancing design quality, AI can potentially improve customer satisfaction rates.
- Market Share: An increase in market share following AI implementation maysuggest that the company's AI solutions are competitive and well-r.

The integration of AI in PCB design appears to offer substantial financial benefits such as increased efficiency, reduced costs, improved customer satisfaction, and potential for market share growth. However, the magnitude of these benefits will depend on the specific AI technologies used and the effectiveness of their integration.

5 Conclusions

The overview of the implementation of AI in EDA methods and tools has permitted us to identify the state-of-the-art in EDA tasks and applications and the design area with different AI approaches and mathematical methods. It was noticed that research in AI for EDA is intensifying and s number of solutions are already available. Challenges are also identified.

Machine learning-supported methods for automated dimensioning have not been investigated for analog circuits where transistors function as toggles. Circuits necessitating lengthy transient assessments are unsuitable for hybrid methodologies employing evolutionary algorithms, which are also time-consuming.

Despite the many benefits, the integration of AI in PCB design also presents certain limitations and potential concerns. One limitation is the need for large amounts of high-quality training data. AI algorithms rely on extensive datasets to learn and make accurate predictions. Obtaining comprehensive and diverse datasets specific to PCB design can be challenging, particularly in specialized domains or niche applications. Acquiring and curating relevant training data remains crucial to ensure the effectiveness and reliability of AI-driven design tools.

Another concern is the interpretability and transparency of AI-generated designs. As AI algorithms often operate as black boxes, it can be challenging to understand thedecision-making process and validate the rationale behind design choices. Ensuring

transparency and providing designers with insights into the reasoning behind AI- generated design recommendations is vital for trust and effective collaboration between AI and human designers.

Additionally, the expertise and experience of human designers remain invaluable. While AI algorithms can automate certain aspects of the design process, humancreativity, domain knowledge, and intuition are still essential for tackling complex design challenges and pushing the boundaries of innovation. The successful integration of AI in PCB design requires a collaborative approach, where AI augments human expertise and provides powerful design tools, while human designers contribute their unique insights and creativity.

The hardest problem in AI is to give the ability to distinguish between the relevant and irrelevant.

AI holds significant potential for companies in the PCB design industry. While the exact financial impacts will vary among companies, the general trend suggests that AI can lead to increased efficiency, cost savings, improved customer satisfaction, and increased market share. As AI technology continues to advance, its potential financial benefits are likely to increase. Further research involving specific financial data wouldprovide more concrete insights into the financial impacts of AI on these companies.

In the forthcoming era, the impacts of AI-linked CAD technologies are poised to intensify even more.[1]

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Creating a Block-Diagram System for Continuous and Discrete-Time Signals

Vehebi Sofiu[1], Gresa Shala[1], Faton Kabashi[1], Lamir Shkurti[1], Mirlinda Selimaj[1].

[1]UBT- Higher Education Institution, Kalabria 65, 10000, Prishtinë, Kosovë.

Abstract: Understanding and analyzing the behavior of systems is essential for designing engineering solutions for efficient and reliable signals. Concise mathematical descriptions of linear time-invariant systems that provide powerful techniques for system modeling, prototyping, analysis, and simulation. This paper delves into the study of transform system function algebra, analytical representations of block diagrams for continuous-time signals through practical differentiators. Modeling algebra consists of blocks that represent different parts of a system and signaling lines that define the relationships between the blocks. Block diagrams are used in electronic fields such as feedback, communication and signal control theory. Realization of practical signal systems is functionalized with: integrators, differentiators, adders and algorithmic multipliers as basic elements used to build the block diagram. The realization of a continuous-time system means the representations of the verbal description in the innovative practices of the representations of the differential equations with the sampling theorem corresponding to the function of Laplace and Z-Transforms as a simulating connection of the signal. Graphical simulation for static and dynamic systems where the block diagram is represented by other product functions complicates the system over time since the signal inputs are not in step with the time space based on the model configuration and problem solving algorithms. The degree of convolution in this research shows that the signal is implied by the algebraic scaling operations of the properties of the Fourier transforms from which the operational simulation manipulations are performed using the MATLAB platform.

Keywords: Block Diagram, Mathematical Modulation, Signal, Transformations, Configurations.

1. Introduction

New representations of developmental technologies are valuable because they generate different functions with new thoughts and provide assurance in professional engineering with patterns of matrix interaction [1]. In general, the adoption of the diagram block identifies components with continuous and discrete time and describes the communication information between system digitization and artificial intelligence [2]. Although signals can be represented in many ways, in all cases, information is contained in a pattern of variations [3]. Signals are represented mathematically as functions of one or more independent variables. During communication the signal is represented analytically as the function of time, and has the representation of a system of intelligent machines which is represented with the features labeled as oriented models dedicated to spatial variables [4].

A common convention of the independent variable of the mathematical representation of a signal as a continuous time and Discrete may not enter as a specific function by the fact that it does not respond to the set time. Continuous-time signals are defined along a continuum of sequences from time to time and are thus represented by a continuous independent variable with representations of numbers regardless of the process of fidbek concepts [5]. Continuous-time signals are often called analog signals with non-dependent variables. Discrete-time signals are defined by different discretion where the independent variable has discrete values; that is, the discrete-time signal has representations with sequences of numbers [6]. In discrete-time signals there are certain conditions of sequences with smaller frequencies where their contributions are entirely equivalent [7]. Independent variables that allow sharing of information with specific conditions brings a new dynamic of repeating hybrid specifications either in a continuous or discrete time [8]. Simulation of a modified design diagram block can completely cover the state space where the signal amplitude can be continuous or discrete, this completes a topological response in solving problems by case [9]. Digital signals are those for which time and amplitude are discrete. Signal processing systems can be classified in the same lines as signals. Algebraic operators define the semantics of the diagram block with the connection of systems according to the specifics emanating from the verified algorithmic control [10]. Continuous-time systems are systems with components also arranged for inbound and out-of-module synajles. Discrete-time systems are those for which both inputs and output are discrete-time signals [11]. In a digital system with the presence of multiple overlapping frequencies it deals with the transformation of signals that are discrete in both amplitude and time. However, the theory of discrete-time signals and systems is also extremely useful for digital signals and systems, if the signal amplitudes are well quantized with basic ferquences of 50 Hz or 60Hz [12]. To create a system for continuous and discrete-time signals, we can easily use block-diagram elements to present system components and signal flow such as: Continuous and discrete-time components, connecting blocks, sign to indicate the flow of signals between different components, the summary points where signals are added or subtracted, integration and differentiation: with a block having a "System" inside, Inputs and Output, the input signal with an arrow pointing towards the system, the output signal with a sign indicates output from the system [13]. If the system has a transition from the time-continued signal to the discrete time signal or vice versa we compulsorily use a block to represent the sample and retention operation [14]. If the system includes discrete-time components then we will show the clock or the ignition signal.for a system with a continuous-time sensor, followed by a digital discrete-time filter and a continuous-time actuator [15]. The block diagram may look like: Copy signal code with continuous time --> [Sensor] Analog-to-Digital Converter --> [ADC] --> [Digital filter] --> [DAC] --> [Activizer] --> Continuous time outing. Here, [ADC] represents the analog-to-digital converter, Digital-to-Analog Converter [DAC] represents the digital-to-analog converter. The specifics of the system determine the details of the block-diagram and you can adapt the components and operations involved in the particular scenario anymore [16].

2. Experimental Methods and materials

The diagram of a system describes the inner approach of a mathematical connection between information entering the system and information arising from the same reports [17]. We define an elementary diagram block with a dynamic system whose samples consist of blocks connected by lines that indicate the relationship of the blocks of that system [18]. To map out the visualization approach practically the diagram is shaped by inputs and outputs of figure 1 models.

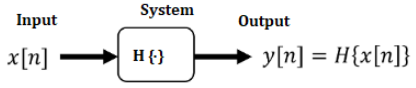

Figure 1. Block the generating system diagram.

In this diagram, x[n] is the input of the information by which the system block manipulates and y[n] is the information produced. To unify the general representation systems is accomplished by a system with H {·} function that the signal is divided into the function. One of the important parameters is the sample time indicating the speed at which the element block is executed in the signal simulation [19]. A system divided into two blocks is mathematically defined as a unique operator or transformation that maps an input signal to an output signal for both times [20]. This is defined as the approach of a system that means obtaining information of a continuous time network corresponding to the system transfer function or to the differential equation y (t) = T[x(t)]. Where x (n) is the input signal, y (n) is the output signal, T[] is the transformation that characterizes the behavior of the system [19].

$$Y(n) = T[x(n)] \quad (1)$$

or

$$x(n) \underline{T} y(n) \quad (2)$$

Where, T is the period of the interaction of the network or the general algorithm that is applied in time to continue x (n) or excitation to get the output response y (n). The transfer system can be accomplished by integrating perodoration or in cases where noise is interfered with at high frequencies is amplified the differentiator [21]. To change the diagram block in time to continue for a system used: Integrator, additive and multiplier. The integrator is an element that integrates the information at the entrance of the system and transfers it to the function of the ideal integrator at the exit of the system according to figure 2

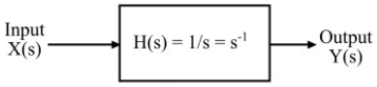

Figure 2. Transformation of signal in continuous time

Creating a block-diagram for continuous-time signals is a good way to visualize the structure and flow of such a system by formula (3).

$$H(s) = \frac{1}{s} = s^{-1} \quad (3)$$

Continuous-time signal sources are visualized by a system input sinusoid even for complex cases where filters, amplifiers, or system components are represented using different blocks [22]. If the system has many different components we necessarily use separate blocks for each mathematical operation [23]. For analytical operations such as multiplication, subtraction, integration, or differentiation we use appropriate blocks figure 3. We use dedicated blocks or blocks of collection points for multiplying and collecting signals. Representation of the output signal of the sitem oriented with an arrow indicates the direction of the signal flow according to the formula (2). Based on the structure and components of the particular system we will use graphical software such as Visio, PowerPoint, or other software to help create algorithmic block-diagram [24]. Digital systems are represented by blocks of different arrow-related elements which also fulfill the purpose of showing the direction of discrete signal flow:

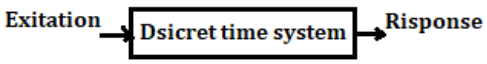

Figure 3. Block diagram of the Discrete time system

Adder is an element which is used to perform the addition and subtraction of signals [25]. In electronic access communication are included digital devices and adder analogues which is the algebraic sum of all variables entering the system. Graphically, it is represented by a small circle that has at least two entrance terminals and a dales terminal. Connecting the two block-diagrams in the series means that the output of one block is connected to the input of the next block. This is a graphically represented way of showing that a block's output signal was used as input for the next block. The connection of systems in series mathematically can be described as in figure 4:

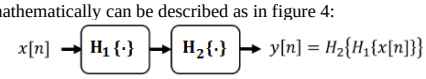

Figure 4. Connecting two block diagrams in series.

Connecting the two block-diagrams in parallel means that the two blocks have a common input and distribute their outputs at a common point. This is a graphically represented way of showing that some signals are independent of each other and emerge from the common point figure 5.

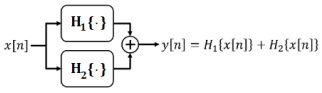

Figure 5. Connecting the diagram block in parallel.

Systems with different element blocks associated with different symbols and elements also fulfill the direction of signal flow with some common elements such as: Collecting two signals $y(n)=x_1(n)+x_2(n)$, Multiplying as the constant fraction $y(n)=ax(n)$, the time delay element such as excitation of the preliminary element (n-1) where the patraq is $y(n)=x(n-1)$, the unit advancement element which is represented $y(n)=x(n+1)$. A reaction relation with elements of the combined unit in return is described mathematically as in figure 6.

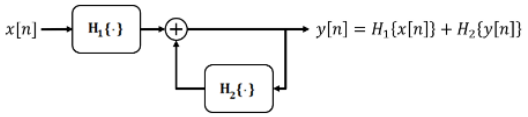

Figure 6. Connecting block diagram with return of unit.

3. Element of unit advancement

The earliest applications of this structured element proves that whatever mathematical model advances the theoretical model signal in practical application, that is, the mathematical elements respond to simulated electronic data. Although, as we can see, this element is not physically feasible unless the response and harassment are stored or recorded as a form according to figure 7.

Figure 7. Element of excited unit advancement.

Now that we have careful block selection for parameters which should be simulated numerically according to test procedures with basic elements of discrete-time systems, now we can optimize the equation with the help of block-diagram as the equation:

$$y(n)=y(n-1)+x(n-1)+2x(n) \quad (3)$$

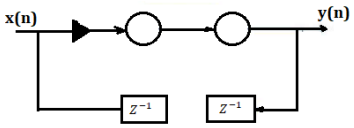

Figure 8. Block delay diagram at excited times

To optimize the equation with the help of block-diagram, you can use a set of systems before building the finished block-diagram structure. In this case we have a discrete-time connection with the static definition where I can use the information to create the block-diagram. A functional representation of the system by means of the equation finds applicability in order: The memory block represents y (n-1), this block is used to keep the last y (n) value in function for the next cycle. Time Delay Block: Presents x (n-1), because it is a change with a discrete time period. Multiplication Block: Presents 2x (n). Adding Block: Representing the entire fair part of the equation y (n) = y (n−1) + x (n−1) + 2x(n). Without procedure we connect the appropriately created blocks using arrows to indicate the direction of information generation. To make the block-diagram clearer and more understandable, we can use a specialized block-diagram creation software or even a graphics application. In such an environment, you can put the names of the blocks and use colors and labels to make the diagram more appropriate.

4. Discussion of Results

Appearances of equations with practically modeled signals have simplified complex memory cases using arrow blocks and interlocking lines. Function excitation algorithms simplify workflows, organize processes, or display the relationship between different systems. Systems consist of one or more inputs and one or more outputs. Their frames connect the inputs and outputs of different blocks resulting that the diagram will accurately represent such a system. The frequency domain approach provides insights into the components present in the spectral signal by visualizing the winning presentations of the original domain in the mathematical module system. More equations are essential in various applications, such as telecommunications signal discretization and information analysis. Analytical modulation analysis has designed and optimized signal processing systems, extracting specific components of the varables or eliminating unwanted approaches. In interpreting modeling findings, we observed that the dominant components of operations amplify different frequencies in the amplitude spectrum, providing insight into complex equations. Relations between the fomuli have created functional connections between practical components that affect signal behavior and waveform. Time domain representations such as spectrogram continuites reveal dynamic changes in frequency content over time with analytical simulation. Efficiency analysis of algorithms contributes to the optimization of frequency domain analysis. Analysis of the impact and intervention of properties can improve frequency distortions in time-invariance environments. Expansion of the analysis can provide an overview of time diagrams in the frequency domain of complex signals. Processing real-time algorithms based on transformative equations can address signal processing challenges in new technological applications. Exploring efficient algorithms, hardware acceleration techniques, and parallel computing can enable the optimization of signals and and its simulation with the MATLAB platform. Each block in this paper has created a subsystem, and the interconnection of different subsystems - through signals - constitutes the main system. The concept of the system contains the mathematical operation symbol or the name of the mathematical function that is performed in the introduction to produce the output. In the block diagram, the signals flow unilaterally, as shown by the tip of the arrow. Indicating the arrowhead is required to specify a signal. The intuitive representation of signals in discrete time involves the return of a sequence of samples to a polynomial. The use of mathematical operations solves complex equations derived from the discretization of equations with different components. In these simulation practices we managed to change the signals in the frequency domain after the application of transformative analytical methods with

frequency comp8onents in the case of impusiv signal. This analysis is essential in understanding how these analytical equations work and how they affect the characteristics of the signals.

1

5. Conclusion

Block-diagram is a mathematical tool used for modulating signals with continuous and discrete time. Algorithmic modulation of digital signals enables the analysis of control systems for computation with coplex component. Function advancement equations allow to transform signals from time domain to frequency domain, simplifying the analysis and design of digital systems. We have seen some of the frequency simulations with transformative properties change the cohesion of linearity and convulsion. Also during the research work was done exploring the processing of signals with the control systems of equations to create system stability. Operationalization in the field of signal processing becomes practical applications of sequences with connection of block diagrams. Difference variable is a mathematical technique that is used to transform data from discrete-time continuous-invariance, that is, the continental-time domain into the complex frequency domain. The main purpose of this paper has greatly emphasized the approach of complicated functions in operationalizing the functionality of digital systems. If we compare the communication approach of sinayl transforms with algorithmic communication, the, a general tool for solving discrete convergence problems that are also presented for continuous-time signals is presented. This simulation model is possible with the determination of a suitable operational domain space (ROC) for dominant algebraic inflections. In particular, the transfer function of the quantifying functions to an invariant linear discrete time system (DLTI), along with its divergence region, fully defines the right information search system. The estimated transfer function in the unit circle in the complex plane is actually the system frequency response. Discrete time classifications - continued are also useful for analysis of linear time-invariant systems (LTI), practically applicable in many areas of information control and processing. This practical form provides full applicability to the frequency response of a digital system, which is essential to understanding its behavior and performance. Linear functions are closely related to the transformation of series which are used to transform signals in continuous time from time domain to complex frequency domain. Equations of a discrete-time signal can be obtained real if the signal transformation is started at a specific point in the functional plane space. The function system is a powerful tool that uses many engineering fields to analyze systems in continuous and discrete times. The connection between functional transformation and the diagram block approach enables us to analyze systems with unified approaches. As the result of functional mathematics increases we have managed to recover the periodicity in different areas of frequencies with specific spectra. The interpretation of findings for the analysis of our work throughout these discussions of the modeling of analytic simulations of continuous and discrete signals has worked the part of the recovery of the analytics of algorithms in the fields of different configurations and frequencies using MATLAB platform simulation. In numerous signal models with artificial intelligence techniques we have fully elaborated on the complexity and variations present in real-world signals. Inclusion of real situations can increase the applicability and generalization of findings. The simulations are based on practical numbers that are well analyzed and as such are idealized in the operational system. Realistic modeling of exploration has improved the validity of mathematical results of different equations with different frequencies. The choice of simulation parameters or frequency resolution, has affected the performance of the frequency domain display and the mathematical equation.

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A DSL Framework for requirements engineering.

Tea Tavanxhiu[1], Kozeta Sevani[1]

[1]University of TiranaTirana, Albania
tea.tavanxhiu@unitir.edu.al kozeta.sevrani@unitir.edu.al

Abstract. This research paper explores the integration of Domain-Specific Languages (DSLs) as a modeling framework for requirement engineering in software development lifecycle. The instantiation of the DSL is enabled form a proposed architecture of the Framework. The study investigates the benefits and challenges of using DSLs, emphasizing increased involvement of domain experts, reduced delivery time gaps, wider visibility, and reduced technology dependency. Through an Active Design Research (ADR) methodology, the paper consists in the execution of the first ADR cycle, proposing design principles for a DSL Framework. The findings highlight the importance of integrating domain knowledge, conceptual modeling, and semantic enrichment in requirement engineering. Further refinement of the empirical studies and feedback gathering from users on the proposed DSL framework will be part of the research project of the authors starting with this.

Keywords: requirement engineering, information system design theory, action design research, domain specific language.

1 Introduction

The software development life cycle is complex and, in most cases, seen as an interdisciplinary project when correlated to the context of the usage of the application itself as well as the human interaction with the software. Requirement engineering is one of the initial phases of the software development lifecycle and is ofen referred to process of understanding of the stakeholder's needs and documenting such needs onceanalysed. [1] It is as well considered as one of the most relevant topics of evaluation of the software quality and this calls for the need of continuos improvement of the undersatndng, approaches and tools used to conduct such phase during the development process of the software.

There are multiple suggestions in the literature of what can be used for conducting the requirement engineering phase, and the scope of this research paper is to focus on a framework that considers the specificities of the domain and the problem/need at hand. We strongly believe that the interdisciplinarity of the information systemsderives in an important rate from the requirement engineering process, and in this contex, we present two main arguments related to requirement engineeringframeworks and domain-specific language (DSL) as a modeling framework for requirement engineering. The first argument discusses various requirement engineering frameworks and theories, highlighting the need for a comprehensive approach that integrates domain knowledge, conceptual modeling, and semantic enrichment. The second argument focuses on the potential benefits and challenges of using DSLs as a modeling framework for requirement engineering, emphasizing the advantages of increased involvement of domain experts, gap reduction in delivery time, wider visibility, and reduced dependency on technology.

There are two research questions being addressed in this paper.

Research Question 1: How can the integration with DSL enhance the requirement engineering aprocesses?

Research Question 2: What are the benefits and challenges of using Domain-Specific Languages (DSLs) as a modeling framework for requirement engineering?

The chosen methodology to conduct the research is through Active Design Research due to its ability to intercorrelate the domain expertise of practitioners with the literature and theory research during all the phases of an ADR cycle. This research conducts one ADR cycle while proposing the outputs of the evaluation, reflection, andlearning phase as an input to the second ADR cycle and future work.

1.1 Requirement engineering frameworks and relevant theories

Requirement engineering is a discipline that is primarly related to software engineering, although there is trace in the literature that there are correlations between requirement engineering and knowledge problem in the theory of a problem domain [33]. When engineering the requirements an iterative process starting with the problem and context identification, moving toward domain analysis and theory adeguation, and concluding with implementation and evaluation. Given the nature of the requirement engineering discipline mostly focused on action design problems, we have chosen for this research work the Action Design Research methodology.

Consulting the body of literature [2][3], there is trace of proposed ideas for a framework to depict requirements using a specific DSL, the Unified Modeling Language (UML). The main phases identified in a framework of interest for our research [2] include the feasibility study, the requirement collection and specification, the analysis of business requirements, the system requirement modeling, and the system design, which executed in a cycle might propose some main building blocks for such a framework.

The NATURE framework [4] is a more mature framework and provides a rigorous foundation for requirements engineering and it integrates various disciplines by suggesting that the major divisions in the domain theory are [4] the conceptual model construction and the enrichment of the modeling languages and it's semantics. During our research on the NATURE framework, we came across some really useful publications [5],[6],[7],[8],[9],[10] that actually have conducted research work based on the Nature Framework. These publications have progressed and applied the framework to the domain of action research and this plays in favor of the maturity of the franmewor. Publications such as [11], [12], [13] are of important interest ot our work given the very close nature of research to ths paper.We will refer to the NATURE framework as an important example of an early work that identified and highlighted the need of a comprehensive approach to requirements engineering.

1.2 Domain specific language as a modeling framework for requirement engineering

Requirement engineering is a knowledge problem and as such the solving of the problem requires action design research and a design problem analysis [14]. Domain knowledge is a critical component in the analysis and assessment of requirement engineering. The framework proposed in this paper attemots to integrate the convergence of influences coming from domain knowledge and domain-specific language, thereby proposing an operative approach to the requirement engineering

and modeling procedures.

DSL enable domain experts to directly contribute to the development effort by autonomously specifying parts of the solution.[15] The advantages of using a DSL based framework for requirement gathering analysis, modeling and engineering wouldbe as following:

- Increased involvement of the business domain experts in the requirementanalysis and modeling processes.
- Gap reduction in terms of time to delivery of the operational and functional requirements.
- Greater insight from industry professionals and experts into thecomprehensive scope of designed requirements for the software application.
- Higher understanding of the intercorrelated engineered or to be engineered functionalities due to the multidisciplinary background of the business domain experts.
- Reduced dependency from the technology stack and provide an abstract meta- model of design that can be applied in different applications.

Even though DSL can be a good solution to building abstract modeling languages thatdo not need to be instantiated but might as well be re-used in different software

environments, it is important to acknowledge the challenges and limits it poses. As discussed in [16] these challenges and problems lie within the following categories of model abstraction, model decomposition, model translation and a main noted problemis the model adaption in other applications.

To bypass these problems this paper proposes an instantiable framework that lies upon an application and the DSL is implemented within the framework, leaving everypossible application untouched with the DSL logic, syntax, and complexity. This would enable the maintenance of the framework and the DSL, the communication with multiple applications regardless from their architecture or technology stack and the enrichment in a single DSL meta-framework of all identified and mapped operational, functional, transactional, or non-functional requirements.

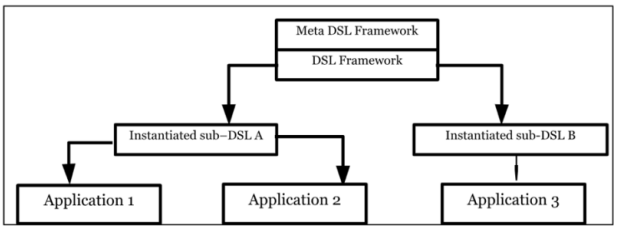

Table 1. Proposed DSL Framework

2 Information Systems Design Theory

The present paper focuses on the Theory for Design and Action as the primary theory type of interest, which is action-oriented and primarily concerned with practical aspects of designing, building, and implementing information systems. As per the categorization of theories, there exist five macro types [17], and Information Systems Design Theory (ISDT) falls under this category. The ISDT provides design principles that facilitate the accomplishment of specific objectives in real-world settings, withoutrestricting hypothetical evaluations to controlled experimental environments. Also, it equips theoretical instructions for developing and enabling a specific type of information system, while also contributing to the expansion of knowledge in the field[18], [19].

Design Product		
1.	Meta-requirements	Describes the class of goals to which the theory applies
2.	Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3.	Kernel theories	Theories from natural or social sciences governing design requirements
4.	Testable design product hypotheses	Used to test whether the meta-design hypotheses satisfies the meta-requirements
Design Process		
1.	Design method	A description of procedure(s) for artifact construction
2.	Kernel theories	Theories from natural or social sciences governing design process itself
3.	Testable design process hypotheses	Used to verify whether the design hypotheses method results in an artifact which is consistent with the meta-design

Table 1. Components of an Information System Design Theory [18]

3 Research approach

The research approach of this paper to formulate an Information System Design Theory follows the framework proposed by Walles et al [18] and the design principles of the framework are based on the reusability principles of Iivari et al [20] and the approach of Sein et al [21] to construct, intervene and evaluate IT-artifact within an organization which will lead to the contribution into design principles and theories.

The sensitivity toward the usage of theory while conducting the research is inspiredby Iivari [22] and as such it is important for this research to incorporate theoretical foundations. ADR as a method that combines action research and design science research, aims to develop innovative IT solutions while simultaneously addressing organizational or societal problems. To be aware of the challenges that ADR poses asa chosen methodology and to be able to correctly address the nascent problems from using it, we will base the usability of this methodology to the finding of Haj-Bolouriet al [23].

Empirical findings and kernel theories will contribute to the creation of the Information System Design Theory of this paper.

4 Action Design Research cycle

The ISTD of this paper has been generated by running one cycle of the ADR - method. While identifying the practice inspired research principle which derives from multiple workshops with supply chain management experts and practitioners, we haveintentionally gone through a thorough literature research to gather a full understandingand to base the paper on a theory-integrated base.

These two principles from the problem formulation phase have been used to generatea class of features for the proposed framework which after implementation are evaluated.

The first ADR cycle will be followed by to other ADR cycles to complete the whole research project and the outputs, evaluations, and reflections from the first ADR cycle will serve as an initial analysis in the problem formulation phase of the second ADR cycle.

The whole three predicted cycles will be complemented with the reflection and learning principle to finalize the research project with generalized outcomes and a contribution to the exiting knowledge on the usage of DSL for requirement engineering.

The first activities toward the identification and formulation of the problem have been2 workshops with practitioners from the supply chain management industry and the abstract outcomes are as following:

- DSL shall empower the practitioners and consultants of the organization to model and engineer new requirements (functional, transactional, operational)form the frequently changing dynamics of the organization due to inner and outer factors.
- A DSL Framework laying outside of the applications that provides requirement engineering for the applications, would ease the process of technology change, reengineering of applications and the procurement process of applications.
- The DSL syntax is a layer of complexity that need to be overcome with the proper interactive training and documentation for the practitioners.
- The technology stack of the Framework should be able to offer microservices and operate in different communication methods. Very new but relevant communication method should be implemented within the Framework.
- The implementation process should ensure the completeness of all requirement engineering categories possible in the domain of interest. All novel requirement engineering cases should fall within the identified, analyzed and implemented categories of requirement engineering.

The scope of these two workshops was to address questions, issues and problems

deriving from the industry in understanding the system requirements and needs in terms of modeling and engineering day-to-day requirements through a DSL. The workshop topics of discussion were combined with the theoretical background from the literature review process. An alpha prototype was generated which had implemented 5 macro categories of requirement engineering areas and 497 types of specific requirement engineering cases in total for all 5 categories.

The identified categories of interest for the alpha prototype are displayed in Table 2.

Macro category of requirement engineering area in the alpha prototype	**Total number of requirement engineering cases implemented through a DSL in the framework**
Accounting	103
Business	100
Finance	100
Marketing	99
Statistics	95

Table 2. Identified macro categories of requirement engineering in the alpha prototype and the respective number of requirement engineering cases analyzed and coded in the Framework.

The alpha prototype of the framework was developed with the primary objective of providing an evaluation basis for both researchers or practitioners who are part of this research project. Furthermore, it aimed to offer insightful input for the subsequent ADR cycle that would be subject to future design decisions.

The reflection and learning stage provided important feedback toward the challenges that such Framework would pose to a possible implementation in an organization such as the ability from a practitioner perspective to abstract upon the granularity of the specific case of requirement engineering and the capability to categorize such specific case. The maintenance of the framework also requires further investigation, analysis and poses a governance topic for discussion in future ADR cycles.

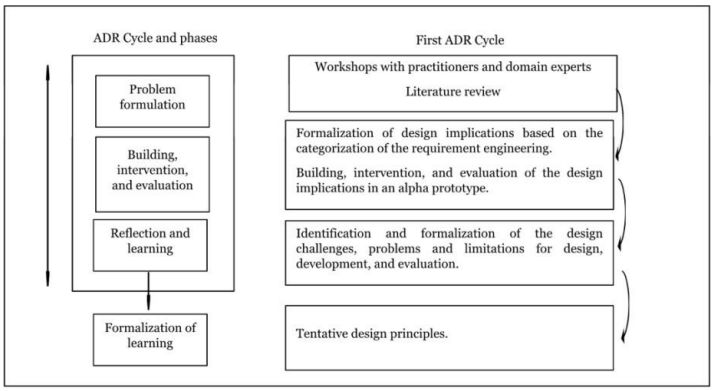

Table 3. ADR executed cycle.

In the first cycle of ADR, the evaluation phase plays a very important role in providing crucial feedback regarding the feasibility of the project and its potential to contribute to the design principles of ISDT. The design principles themselves have undergone evaluation through the interaction with practitioners. In the followingparagraph, we shall delve further into the findings and contributions of said evaluation.

5 Information Systems Design Theory for the DSL Framework Relying on the framework for Information System Design Theory proposed by Walls et al [18], we have executed all the necessary phases prescribed by the DSR methodology. This involved identification of the core theories regading DSL andrequirement engineering, determination of the requirements for the proposed artifact,establishment of features that would direct the design process of the artifact, development of the artifact, implementation, and eventual evaluation.

We used Action Design Research in this research project to undertake an analysis of the relationship between requirement engineering and information system design (ISD).

We are aware that requirement engineering is more frequently linked to software engineering than to Information System Design. This study focuses on understanding and proposing a multidisciplinary approach in the requirement identification, modeling, and engineering processes, particularly in the context of ISD's designprocess and theory, by examining the existing literature. The studies cited as [24], [25], and [26] offer insightful information and support our initial presumtion.

Based on the input from the workshop, and a consultation to existing literature on the classification, categorization, and modelling of DSL [27], [28], [29], we have modeled 5 main categories which result with a common usage in different industries and can be a good ground for the evaluation of the alpha prototype.

In this paper, we have used the FEDS framework proposed by Venable et al [30] as guiding principle to ensure that the contribution constituent of the structure focuses on the impact of the investigation on the subject region during the assessment stage.

The evaluands in this case are the requirement engineering cases that were categorized. The artefacts/evaluands are evaluated altogether divided by category, after the design artefacts is developed. A naturalistic evaluation assessed the impact made by the framework by using the categories of implemented DSL in the framework above two applications in the Supply Chain Management digital environment of a retail company. The evaluation is performed using two specific information systems in an organization with real and impacting problems deriving from the requirement engineering processes. The evaluation phase was successfully completed with a good level of user acceptance of the DSL Framework and a set of challenges, comments, and ideas that will be used as input during the problem formulation stage of the upcoming cycle of the ADR.

The kernel theories for the Information System Design Theory used for this researchare categorized as following:

- Requirement engineering
- Literature on DSL and DSL Frameworks
- DSL Modeling and Semantics
- Domain knowledge on business processes.

The design principles produced by the design theory consultation and the design process of the artifact are explicites in the next paragraphs. .

The first design principle identifies the multidisciplinary character of requirement engineering and calls for a significant contribution for a significant contribution from domain knowledge and cross-correlation with practitioners and experts in the field. [1], [4],[6].

From the literature research we have identified that an underlying set of operational, transactional, functional, and non-functional requirements deriving from the organizations will conduct a reciprocal interaction process between the researcher, domain experts, practitioners, and end users of the proposed framework.

The second design concept focuses on the definition of a model and the semantics of the innovative DSL that is used in the proposed framework based on the rules already in place and a review of other relevant used DSLs. [15], [28], [31], [32]. To properly conduct the construction of the DSL we have conducted an iterative process of

domain definition and scope of the DSL, semantics and the communication microservices toward the information systems, evaluation, testing and continuous refinement and enrichment of the cases and categories of DSLs.

6 Conclusion and future work

Following the recommendations from Walls et al. [18] and Gregor et al. [19] for creating, formulating, and formalizing the design principles of Information System Design theory, this paper describes the execution of the first ADR cycle for the development of an implemented artifact.

Such principles can help practitioners and research in providing a theory-based guidelines for the construction of Framework that uses DSL in requirement engineering, as well providing theory-based principles that can be subject to further empirical evaluation.

These design principles are formulated and sustained both by empirical activities and from kernel theories and as such can be validated and considered a valuable contribution to the ISDT for a DSL Framework.

We acknowledge that the generalization of the rules and knowledge to the Design Theory is limited by the reflection and learning stages of the ADR cycle described in this paper. More additional ADR cycles will be required to validate, improve, and generalize the suggested design principles before they can be considered as novelty and an ISDT contribution to a DSL Framework for Requirement Engineering.

Drawing upon the investigations conducted in our paper, it has been determined that the assimilation of domain expertise, conceptual modeling, and semantic augmentation into requirement engineering frameworks can yield noteworthyenhancements in the quest for a comprehensive approach to information system modeling. This is particularly significant when contemplating the proficiency of end users. Theoretically, our research refers to a framework that comprises domain knowledge and provides a Domain-Specific Language (DSL) to expert users of the organizations for modeling information systems based on business requirements. This is mostly beneficial in terms of defining data flows and engineering functional requirements.

By utilizing domain-specific concepts, terminology, and syntax through the DSL, expert users can effectively capture and represent the complex details of the organization's requirements that might change over time. This facilitates better communication between domain experts and system designers, leading to a more exact and comprehensive representation of the desired information system.

Additionally, the framework can now capture the semantic meaning underlying the requirements thanks to the introduction of conceptual modeling approaches and semantic enrichment, ensuring that the system's architecture closely matches the intended business objectives. This not only enhances the clarity and understanding of the information system but also improves its overall effectiveness and efficiency.

Nevertheless, it is important to acknowledge that our conclusions are derived from a theoretical examination. Further empirical studies and real-world implementations are necessary to authenticate the practical benefits and potential challenges associated with integrating domain knowledge, conceptual modeling, and semantic enrichment into requirement engineering frameworks.

Using Domain-Specific Languages (DSLs) as a modeling framework for requirement engineering offers several benefits, as already mentioned in the research work, but it also presents challenges across different domains. These challenges should be taken inconsideration while addressing the second research question and they are divided into three main areas. The first area consist in the technological gap from a system perspective in accepting modeling requests from the DSL Framework. Second area consists in the exper - user perspective and their ability to bypass the important learning curbe for the usage of the specific implemented DSL. Last, there are challenges to be addressed from a system architectural perspective, as this approach

would require a convergence in the Framework of all the existing architectural infrastructures (or at least the selected ones) that will exchange requirement engineering and modeling with the DSL framework.
This paper indicates that there will be future ADR cycle and that the problem formulation phase will start with the challenges and issues regarding the proposed artifact identified during the Reflection and Learning phase of the first ADR cycle. The problem formulation phase of the future ADR cycle will be subject to empirical studies, workshops and response gathering from end-users that experienced the requirement engineering through the alpha prototype of proposed DSL Framework.

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A Comparative Analysis of Pathfinding Algorithms in NPC Movement Systems for Computer Games

Vesa Morina[1], Rinesa Rafuna[2]
[1]UBT – Higher Education Institution,
Prishtine, Kosovo
vesa.morina@ubt-uni.net

[2]UBT – Higher Education Institution,
Prishtine, Kosovo
rr47042@ubt-uni.net

Abstract. Abstract. Non-Player Characters (NPCs) play a pivotal role in computer games, making them a focal point for game developers. The cornerstone of NPC behavior lies in the design of efficient pathfinding strategies, which are integral components of the underlying Artificial Intelligence (AI) models. This paper delves into the algorithms essential for realizing NPC pathfinding, with a specific emphasis on two prominent methods: the Dijkstra algorithm and the A* algorithm. Our study is rooted in an extensive review of existing research in this domain, followed by a comprehensive comparative analysis of these algorithms. Through this comparison, we aim to shed light on the advancements achieved in this field thus far. Furthermore, we provide a succinct summary of the limitations and challenges that warrant continued investigation and research efforts. By offering a nuanced exploration of pathfinding algorithms and their implications for NPC movement systems in computer games, this paper contributes to the ongoing evolution of AI in gaming and serves as a valuable resource for game developers and researchers alike.

Keywords: Pathfinding Algorithms, Non-Player Characters (NPCs), Artificial Intelligence (AI) in Gaming, Dijkstra Algorithm and A* Algorithm

1 Introduction

Since ancient times, games have been a significant source of entertainment for diverse generations, regardless of their type. In recent decades, with the continuous development of technology, especially personal computing devices, the popularity of games has grown to such an extent that today, the computer gaming industry is one of the billion-dollar industries. In the last year alone, it has generated revenues of up to 197 billion dollars in South America. Considering such statistics, which predict an approximately 36% increase in revenues in the next three years solely in South America's electronic gaming industry, game developers are increasingly interested in advancing technologies for development, as well as existing algorithms, which are essential for the development of the majority of games. The primary aim of this study is the analysis of the most widely used general algorithms for pathfinding, employed in the development of computer games. Observing the massive prevalence of these types of games, pathfinding algorithms have become a focal point of study for developers [1].

2 Identifying the problem

During the development of NPCs, two main problems are commonly encountered, which can often arise throughout the game development process. The first problem is the excessive CPU usage by pathfinding algorithms for NPCs, which can negatively impact the game's quality. This issue is particularly prevalent in computer games that feature a large number of NPCs, such as Call of Duty, Hogwarts Legacy, Elden Ring, Dark Souls, etc. A common phenomenon is that some algorithms may perform the required tasks in a specific game but have weaknesses, such as not guaranteeing the destination, not finding the shortest path to the destination, or unnecessarily traversing multiple routes before finding the correct path. Meanwhile, other algorithms may avoid these problems, but their implementation is not always the most optimal way to create NPCs. The second problem that may arise is the lack of inclusion of tactical information in decision-making. This means that even though an NPC calculates the shortest path to a point, that path may be entirely unnecessary from a player's perspective [2]. Multi-agent pathfinding, the study of finding paths for more than one NPC (Non-Player Character), is a critical aspect that specifically addresses the issue of route finding when there are multiple NPCs, a scenario prevalent in most games. These NPCs may need to behave in two ways: each having its own goal (having different destinations) or all having a common objective. In contrast to single NPC pathfinding studies, a study conducted by Botea [3] explicitly mentions two challenges that arise in cases of multi-agent pathfinding. The first challenge is the size of the joint action space, which becomes exponential with the number of NPCs. This complexity poses difficulties in finding a method for the global planning of this aspect. Additionally, considering that optimizing methods for a single NPC do not directly translate when there are multiple NPCs, collision management between NPCs becomes a crucial consideration. These challenges present significant hurdles, especially given that every exponential increase is a substantial CPU expense, impacting the overall gaming experience for the player.

Alongside memory consumption, a closely associated problem is the prolonged execution time. This is because we might have a game with a visually appealing and intricate map for the player's view, but the map takes a significant amount of time to load entirely. Additionally, character movements may experience delays as the CPU is occupied with executing background algorithms responsible for bringing NPC participants in the game to life. In such cases, the game loses its effectiveness, and the player's interest dwindles. Some studies have shown satisfactory results in scenarios with thousands of NPCs only when executed on supercomputers, which are impractical for widespread use. Nowadays, there has been a shift in approaching this problem by transitioning some algorithms from CPU to GPU, and performance analysis is now based on GPU [4].

3 Identifying the solution

Game developers are often tempted to create their characters based on AI, using the latest methods and algorithms that are increasingly trendy and widely used but often come with significant complexity. When, during development, AI has not yet learned to perform the intended tasks, developers frequently resort to basic algorithms, which have been in use since the Pacman game development era in 1979. The use of basic algorithms is always an efficient way to achieve the desired goal. However, even these algorithms do not guarantee success in every scenario. Therefore, a common solution is the combination of these algorithms and their modification in a way that minimizes errors and issues, making them virtually imperceptible to the player's eye. The algorithms under study will primarily focus on Dijkstra's algorithm and the A* algorithm. The emphasis lies on these algorithms because they are among the most commonly used in solving pathfinding problems in game development. Millington and Funge highlight in their book that the Dijkstra's algorithm is often employed in tactical decision-making rather than pathfinding. They assert that it serves as a simpler version of the A* algorithm, making it a starting point for understanding the latter.
To conduct a comprehensive analysis of each algorithm, it is essential to outline the problem each algorithm addresses, the approach it takes to solve that problem, the code or pseudocode representing the algorithm, the data structures used during its development, its performance, and any shortcomings observed during execution. This structured approach will facilitate a concise examination of these two algorithms [5].

In order to address the challenges related to memory consumption and execution time in gaming scenarios, a comparative study of these algorithms will be analysed. By analysing these studies and their performance metrics in order to identify potential optimizations, we aim to determine which algorithm proves more effective in enhancing overall gameplay experience.

4 Comparison of Algorithms

Efficiency Comparison

This study was conducted in three distinct environments, differing in obstacle positioning. The first environment arranges obstacles based on a grid model, the second adopts a symmetrical but non-grid pattern, and the third employs a random layout. Three different algorithms (A*, D*, Dijkstra) were tested, with the focus directed towards the comparative analysis of A* and Dijkstra.

For this study, the A* algorithm utilized the Manhattan distance as a heuristic. This choice was justified by the assumption that, for the majority of nodes, the distance to the destination must traverse at least one other non-destination node, causing the path to deviate from a straight line. The experiment comprised 50 trials for each algorithm, with results from each contributing to the overall conclusions drawn. According to the obtained results, Dijkstra exhibited the lowest efficiency due to its exhaustive exploration of the entire surface, lacking any space-constraining methods. The length of the paths found by all algorithms was similar, with the primary distinction lying in the number of visited nodes, where Dijkstra showed the highest count. Overall, the A* algorithm demonstrated significantly more satisfactory results than Dijkstra [6].

Comparative Analysis of A*, Dijkstra, and BFS Pathfinding Algorithms in the Maze Runner Game

This study was conducted in a game called Maze Runner, where the player has the ability to utilize obstacles and place them in the path of a Non-Player Character (NPC). The NPC's task is to navigate from the starting point to the destination, overcoming obstacles placed by the player in the process. Based on experiments of this study, it was concluded that both A* and Dijkstra algorithms can be employed to find the shortest path in the Maze Runner game. However, the A* algorithm, considering its minimal computation process and relatively short search time, proves to be particularly suitable for such games. This conclusion was drawn from evaluating the efficiency of both algorithms in the specific context of Maze Runner [7].

This study was conducted on a single map, where each algorithm was applied only once, a choice justified by the researcher based on the primarily deterministic nature of the results. The tests conducted for this study measured the algorithm's execution time, the number of expanded nodes, the length of the path, and the number of nodes in the found path. The algorithm's execution time and the length of the found path are key determinants of algorithm efficiency. The results of this study are categorized into different algorithms, the outcomes of which will be compared with those of the A* algorithm. Among these algorithms, Dijkstra exhibited the least satisfactory results, while among the others, only Theta* was slightly slower compared to A*, whereas IDA* and HPA* were not recommended for use in such cases due to unsatisfactory results. It was emphasized that HPA* could be beneficial in scenarios where the developed application is time-sensitive and requires frequent Pathfinding usage [8].

5 Importance of NPCs

Non-Player Characters (NPCs) play a pivotal role in the gaming experience, shaping the virtual world and influencing the player's journey. Their significance lies in adding depth, complexity, and realism to the game environment. NPCs contribute to the narrative, offering quests, challenges, and interactions that enhance the overall gameplay. Moreover, NPCs often serve as crucial elements in multiplayer and role-playing games, facilitating dynamic social interactions and strategic collaborations. The importance of well-designed NPCs becomes evident in players' preferences, with certain characters becoming favorites and influencing the overall enjoyment of the gaming experience [9].

6 Conclusion

Across all studies, the primary goal is to create as many Non-Player Characters (NPCs) as possible, ones that are realistic enough for the game, capable of making intelligent strategic choices, and not distinguishable from other characters. This is presented as achievable through algorithms and the implementation of AI in the game. However, when it comes to increasing the number of these characters or expanding their intelligent activities, a significant drop in game quality has been observed. One of the simplest activities that NPCs should perform is to move from one position to another in the same way as a player-controlled character. Studies in this aspect have concluded that this can be achieved through search algorithms such as Dijkstra, A*, BFS, DFS, etc., but not all yield satisfactory results. Thus far, the most successful algorithm in this regard appears to be the A* algorithm and its variants. However, even this algorithm, in certain cases, does not optimize computer performance to the desired extent. The primary approach noted is the optimization and modification of the conditions under which this algorithm is applied, such as changing graphs and other data structures, combining algorithms, etc., which have been positive but not to the desired extent. Another relatively recent approach is the choice of the processor on which the algorithm will be executed. This approach, as a new idea, has shown positive results but is currently limited to certain GPUs (specifically those of NVIDIA). Additionally, due to the vast number of possibilities and maps, conclusive results on efficiency are yet to be determined. From all the studies, we can conclude that there are positive developments in this direction, but there is ample room for optimization. Therefore, there is still no definitive answer to what the ultimate solution for this problem might be.

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Using the Internet of Things in personal health

[1]Mehmeti Eros, [2]Leka Hizer
[12th] UBT, Higher Education Institution, Kosova
[1]em52473@ubt-uni.net , [2]hizer.leka@ubt-uni.net

Abstract:With the increase in development of technology and with the evolution of the Internet, a wide network was created, which is composed of devices with different sizes and multiple functions, known as Internet of Things (IoT). Internet of Things has found high usability in different industry sectors, like:military sector, aerial, educational, medical and in many other sectors. It had a great influence in the medical sector, by making the process of monitoring medical data easier, medication management, diagnosis of diseases, saving and better analysis of the data, and reducing patients expenses. These monitoring devices like smartphones, smartwatches, glucose and oxygen monitors, have applications that collect patient data in real time, afterwards the data is shown to the users. They use different sensors to monitor metrics like heartbeats, quality and longevity of sleep, burned calories and many more. The potential for future development of Internet of Things in the personal health aspect is really high, also including here mental health which will be discussed in this thesis.

Keywords: Internet of Things, Electronic Health, Electrocardiogram, Internet of Body, etc.

INTRODUCTION

The head of the DARPA agency, J.C.R. Licklider envisioned a global network in which all computers are interconnected. With the development of this concept, ARPANET was created as a result in 1969. Then, from 1980 it began to be used by the public. In the early 1980s, David Nichols, a student from Carnegie Mellon University, created what is considered to be the first IoT device. He, together with some of his colleagues, worked in a Coca-Cola machine, where the inventory and temperature of the drinks were constantly displayed. [1] While in 1991, John Romkey and Simon Hackett created the Internet Toaster. This toaster was connected to the Internet through TCP/IP protocols. It only had the turn on functionality and the darkness of the toast depended on how long the toaster was on. [2] Until recently, the Internet of Things was not considered a single technology, but rather as a collection of experiments. However, this changed in 1999, when Kevin Ashton coined the term "Internet of Things". [3]

LITERATURE REVIEW

2.1 Internet of Medical Things

Medical devices and equipment that are connected to each other through computer networks represent the Internet of Medical Things. IoMT has many use cases, some of them are: hospital monitoring of patients with chronic diseases, tracking the location of patients admitted to the hospital, collecting personal data from smartwatches and many other uses. The devices are then connected to the cloud platform where the extracted data will be stored. Through IoMT, the amount of data that can be monitored by users has increased. [4]

2.2 The impact of the Internet of Medical Things

1

With the development of the Internet of Things, there was also a revolution in healthcare. Some of the changes that flow as a result of this development are:the increase in the accuracy of data, patient care, development of the work environment and the facilitation of the work for medical personnel. This is how many categories were created, such as:

2.2.1 Internet of Things for Patients - The amount of information needed by patients for follow-up of the disease by doctors depends on the disease. For example, patients who have chronic diseases such as diabetes, hypertension, cardiopathy, these diseases need for more information to be monitored so the management or prevention of deterioration of the condition can happen. Therefore, monitoring devices such as smartphones and smartwatches were created to wirelessly monitor their health.

2.2.2 Internet of Things for Medical Staff - Authorized medical personnel have access to where their patient data is stored. In this way, they can monitor the health of the patients, analyze the data and then give the correct diagnosis based on the analysis done.

2.2.3 Internet of Things for Healthcare Providers - In order to make asset management more effective, various medical devices such as oxygen pumps, defibrillators, and other devices are equipped with sensors.

2.2.4 Internet of Things for Health Insurance Providers - Medical insurance companies make it possible for patients to recover by paying for their expenses at health facilities. However, there are many people who want to trick these companies. The implementation of the Internet of Things has made the work of the companies easier, as there is now continuous monitoring of data, which reduces the opportunities for fraud. [5]

2.3 IoMT Advantages

The Internet of Medical Things opened many doors for significant changes in patient care. Globally renowned company Goldman Sachs has reported that medical organizations save $300 billion a year by implementing remote patient monitoring. Another benefit that came from the integration of monitoring devices and applications is the reduction of human error that can be created by medical personnel. [6]

Improving patient care

More sources of information - With the creation of numerous technologies, medical personnel are now provided with a wealth of patient data. One of the examples of these technologies that are worth mentioning are smart tablets. These tablets contain nanosensors, through which it can be known whether or not the patient has consumed the necessary medications.

Early intervention - Using wearable monitoring devices such as fitness bands and smart watches by patients, doctors will be informed about changes in patients' condition and the appearance of worsening symptoms of the disease. This allows doctors to quickly notice diseases and allows them to intervene early before the disease progresses to more difficult stages.

Cost reduction for patients

Remote monitoring and eHealth - The medical staff has access to the patients' medical data, which are continuously obtained from the monitoring devices in real time. When there are negative changes in these data, there is a worsening of the patient's condition, then the appropriate doctors are immediately notified. However, if there is no significant difference, the patient does not need to travel and spend unnecessarily.

High operational efficiency - In addition to monitoring and storing patients' medical data, the Internet of Medical Things also offers the storing of other information. It can be used to present the medical personnel found in a health institution, the medical equipment that the institution possesses as well as its infrastructure, i.e. where the wards are located and how they are divided. The presentation of this information increases the efficiency of the work and the allocation of medical resources according to the place where they are needed the most.

Improving patient experience

Flexible treatment plan - By using apps and monitoring devices to send monitored information to doctors, patients are given access to the right healthcare regardless of their location.

Easy to implement and use - The Internet of Medical Things devices and monitoring applications are designed to be very easy to use, so they can be used by people of all ages, but there are exceptions. Transmitting data to the right sources is also not complicated. Using artificial intelligence, monitored information is presented to patients in ways that are most understandable to them.

Reduction of work for medical staff

Rarer visists - Due to continuous data monitoring, doctors are aware of their patients' condition by accessing their data. This eliminated unnecessary visits, which saved medical staff time as well as reduced patient costs.

Easier access to data - Authorized doctors have access to all patient data using electronic devices, such as tablets, after they have been stored in the right place by nurses or medical devices. [7]

2.4 IoMT Disadvantages

2.4.1 Data Security - Protecting user data from unauthorized access is one of the biggest concerns presented. Collected information such as name, location, gender, blood pressure, pulse goes through computer networks. This causes worry from patients, as they are not sure what will happen with this data. Their data is stored in the cloud, which is constantly under attack by people who want unauthorized access to steal information.

2.4.2 Battery lifetime - In order for electronic devices to work, they need electricity. Portable devices such as phones and watches rely on their batteries to function. The most commonly used batteries are lithium-ion batteries, which found use in laptops and other portable devices. The longer the battery lasts, so will the

device. As technology develops, the battery can now operate under a safe circuit. This enables the battery to continuously output stable current.

1

2.4.3 Processing power - Previously, medical records were stored in paper form, so they accumulated a lot over time and caused a mess. Whereas, nowadays the data is stored in digital form in the cloud. In order to predict the disease, in addition to the general data collected, the physical indicators as well as the present symptoms should also be recorded. However, there are cases when not all symptoms will appear and this makes the doctor's work difficult for the proper diagnosis of the patient. Ali cloud software company has provided medical assistance, offering the classification of diseases using images stored in the cloud. They did this by analyzing the images in the cloud, and see if there is any shadow in the cloud which symbolizes the disease. This method is 92% accurate. 92% is a pretty high number in terms of health, but not enough. Diagnostic accuracy should be higher, where 100% accuracy is preferred.

2.4.5 Monitoring responsibility - As medical practices develop, sometimes disagreements can arise between patients and medical staff. Before the digital system was developed, in the traditional system, when an error occurred or a dispute arose, all medical personnel including doctors and nurses who were involved in the case would be contacted by the patient's health insurance company and the relevant attorney. However, now with the integration of IoMT, the procedure has changed. If a patient is using a monitoring device prescribed by his/her doctor, the data obtained from the device will be stored in the platform 1. Then, the collected data will be analyzed by the appropriate group 2, which are members of a certain medical company 3. If a disease has appeared in the patient, but the data collected by the monitoring equipment does not present the proper signs that the disease has appeared, then the doctor cannot notice it and thus problems appear. When it comes to compensating the patient for the risk created to his health, it is not known from whom to ask for it.

2.4.6 Difficulty of use for older people - The use of technology has created a love-hate relationship among the elderly. They like the portability that these devices offer, but they don't like when their functions are complicated. Devices like phones and smart watches are very important for data collection. However, due to the complexity of activating some applications, they decide not to monitor their health at all. Therefore, when designing monitoring devices and applications, it is preferable that they be as simple as possible for use by all ages. Some devices are very difficult to operate, such as ECG monitors which have a large number of buttons. Thus, they are forced to seek the help of other people. [8]

2.5 The application of IoMT

Internet of Body - Using the human body, health or physical data is collected. The devices receive the data and transmit it between IoT networks to the places where it will be stored. The collected data is analyzed, and then the results are sent to the users. IoB has found multiple implementations in the human body. Examples of implementation are: biometric verifications, artificial organs, smart capsules and various implants. This concept includes almost any technology that can be implemented on the body or worn.

Wristbands - They include the most advanced medical Internet of Things technology group, ranging from smartwatches to fitness trackers. In addition to the many medical uses, these devices can also be used for other functions to check the time, weather, messages, etc. The bands monitor various metrics such as heart rate, breathing, oxygen content, body temperature, but can also be used for monitoring the user's emotional state.

Hearing aids – To make life easier for people with hearing problems, hearing aids have integrated the latest technology. Various systems were created, such as the Whisper system, which is one of the most popular systems in the IoMT. This system combined artificial intelligence along with the latest developments in IoT to improve the listening experience for their customers. The system is constantly improving by learning from the situations and problems it has solved before.

Glucose Monitoring – Over 11% of the US population has been diagnosed with diabetes and this number is expected to grow exponentially. Thus arose the need to provide a solution against this disease. Abbott Laboratories created the glucose monitoring system as a solution to this. Using the sensors, the glucose level is constantly monitored. If any changes occur, the user will be notified on the phone device to which they have connected the glucose monitor.

Emotional State - Apart from improving physical condition by using IoT, people nowadays can also improve their emotional state. To stimulate peace and increase productivity, the company FeelZing created bandages that produce electrical waves that affect the human nervous system. This method was proven to be effective and safe, by over 30 thousand studies.

Robotic surgeries – Engineers from around the world, along with surgeons, worked together to create robots that will perform complex surgical procedures. Now, the created robots can perform these procedures better than the surgeons themselves. Robots have found use in numerous medical operations. These include:back, heart, urological and gynecological surgeries. These robots are used in many institutes, but the most well-known is the Da Vinci Surgical Systems Institute. Surgical operations performed by robots are faster, safer and reduce the chances of patient infections. [9]

2.6 IoT data security techniques

Internet of Things device manufacturers in addition to creating devices with multiple functions to improve the work experience for users, they must also focus on the security of these devices. As the number of IoT devices increases, so does the number of security challenges. An example of these challenges is the Mirai software, which spread in 2016. This software creates what is known as a botnet. A botnet is a network of computers and devices infected with bot malware that are controlled by hackers remotely. Thus, a large number of online sites had problems because of it. [10] In September 2016, Mirai attacked various services such as Krebs on Security and OVH through DDOS attacks. All the attacks spread from small IoT devices like cameras, routers, air controllers etc. The number of compromised devices reached 600,000 thousand devices. [11]

2.6.1 User Authentication

Authentication based on shared keys - The server and the user have the same username and password. The user sets the name and password, then if these two are similar to the name and password stored on the server, the user is logged in. Accessing websites, emails, depositing and withdrawing money from ATMs all come under shared key authentication.

Authentication based on biological characteristics - It refers to physical characteristics such as voice, fingerprints and the iris of the eye. In IoT, the cloud and the devices must be authenticated so that the cloud believes the device is trustworthy. If the device is not trusted, data can be stolen or manipulated. This form of authentication requires authentication devices to work based on real time, this removes the risk of using static images or data manipulation.

2.6.2 OTA Security

2

OTA (Over the air) - has an important role in the development of the Internet of Things. It is used to update the firmware of IoT devices. It provides better services to users after the update as well as repairs system vulnerabilities. Device firmware through updates implements security algorithms with the help of OTA, which protects the device from Trojan attacks.

Risk Modeling - is the process of optimizing the security of a system by identifying security risks and creating methods to prevent or reduce them. It can identify problems in a very short time. It tries to understand the ways in which attackers will compromise the system and whether the corresponding protection functions are in place. Through risk modeling, security strategies are created during system design rather than after the system is introduced to the market.If the system is placed on the market, security methods cannot be implemented because it is very difficult to implement them on a large number of devices, which can cause numerous problems. [12]

2.7 Security challenges and solutions

Lack of standardization - It is one of the biggest security challenges in the Internet of Things. Since there are a very large number of devices and protocols, it is difficult to ensure that they are compatible with each other.

Solution:Creating and applying standards for IoT devices and protocols. This includes standards for data security, device security, and communication protocols.

Lack of authentication - Many IoT devices are designed with minimal security, making them highly vulnerable to attack.

Solution:Implementing more secure security methods, such as two-factor authentication. This authentication allows only the right people to access the device.

Insufficient software security - Internet of Things devices are placed in integrated systems that have limited resources, making it difficult to secure them. Also, these systems have specialized hardware and software, which creates new security challenges.

Solution:Using secured firmware verifies that the device has a reliable software. Through secure firmware update processes, it is ensured that the device has the latest firmware version and the updates are authentic and it’s not tampered with.

Insufficient network security - IoT devices are sometimes connected to the Internet using unsecured networks. An attacker can disrupt communication between the device and the Internet, accessing sensitive data.

Solution: Implementation of secure network protocols, such as HTTPS and VPN, which enable data to be transferred securely. VPN is used to encrypt communication between IoT devices and the Internet, to make it difficult for attackers to access data.

Difficulty in detecting and responding to risks - Internet of Things devices such as thermostats, security cameras and other smart devices often work in the background constantly collecting and transferring data. Since these devices have minimal user usage, it can be difficult to identify and manage security risks. An attacker can gain access to the device without the user's knowledge.

Solution:Implementation of security monitoring and incident response processes. For example, security software may be installed on the device. This software monitors network traffic and alerts administrators to any potential threats. [13]

METHODOLOGY

3.1 Data gathering

To solve the problems identified above, I have developed a methodology which contains several steps. Initially, a literature review was done which was used to provide information related to IoT and its impact on the healthcare sector. The literature review was done by analyzing online articles, books and previous research papers on platforms such as ResearchGate. The primary purpose of this analysis is to understand the essence of this topic by me as well as by its readers.

After reviewing the literature in the results section, I presented the questions posed in the created questionnaire. Through these questions, statistics were collected regarding the Internet of Things as well as its use for health monitoring by the respondents. The questionnaire was designed in such a way that the presented questions yield results of high importance. After completing the questionnaire, all responses were collected from the Google Form and then analyzed. The data extracted from the questionnaire were analyzed using the SPSS statistical program. After the analysis, the data were interpreted in different visual forms, in the form of tables as well as in the form of graphs (pie-chart). Tables were created using descriptive statistics.

The questions posed are:

1. Are you a smartphone or smartwatch user?

2. Do you use apps on your smartphone or smartwatch to monitor your personal health?

3. What type of information do you monitor the most through these personal health apps?

4. How often do you use your smartwatch or personal health monitoring apps on your smartphone in a week?

5. How do you think the use of health monitoring apps has affected the way you take care of your health?

6. Which of these opportunities do you think is most important to develop in health monitoring applications in the future?

7. What health-related information you read on the Internet interests you the most?

3.2 Results

The following chapter will present the data collected from the questionnaire, which was created as a form of research related to the paper. The questions presented in the questionnaire were asked in order to obtain opinions from the respondents regarding the Internet of Things as well as its impact on their health. The

questions are focused on the use of smart devices such as smartphones and smartwatches for monitoring the respondents' health. Questions are presented regarding the number of users of IoT devices, the number of users of monitoring applications, the most monitored data, the impact of the use of these devices and applications on their lives, as well as the interests they have in the medical aspect.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Smartphone	94	79.0	79.0	79.0
	Smartwatch	2	1.7	1.7	80.7
	Te dyja	23	19.3	19.3	100.0
	Total	119	100.0	100.0	

Table 1.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Po	91	76.5	76.5	76.5
	Jo	28	23.5	23.5	100.0
	Total	119	100.0	100.0	

Table 2.

1=Rrahjet e zemrës,2=Kaloritë e djegura,3=Hapat e bërë,4=Gjatësia dhe cilësia e gjumit,5=Nuk monitorojë asnjë lloj informacioni

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rrahjet e zemrës	3	2.5	2.5	2.5
	1, 2	1	.8	.8	3.4
	1, 2, 3	13	10.9	10.9	14.3
	1, 2, 3, 4	13	10.9	10.9	25.2
	1, 3	5	4.2	4.2	29.4
	1, 3, 4	4	3.4	3.4	32.8
	1, 4	1	.8	.8	33.6
	2, 3	18	15.1	15.1	48.7
	2, 3, 4	4	3.4	3.4	52.1
	2, 4	1	.8	.8	52.9
	Hapat e bërë	23	19.3	19.3	72.3
	3, 4	8	6.7	6.7	79.0
	Nuk monitorojë asnjë lloj informacioni	25	21.0	21.0	100.0
	Total	119	100.0	100.0	

Table 3.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rrallë	22	18.5	18.5	18.5
	Disa herë	36	30.3	30.3	48.7
	Çdo ditë	33	27.7	27.7	76.5
	Shumë herë në ditë	5	4.2	4.2	80.7
	Asnjëherë	23	19.3	19.3	100.0
	Total	119	100.0	100.0	

Table 4.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Shumë pozitivisht	33	27.7	28.0	28.0
	Pak pozitivisht	42	35.3	35.6	63.6
	Nuk ka ndryshuar	43	36.1	36.4	100.0
	Total	118	99.2	100.0	
Missing	System	1	.8		
Total		119	100.0		

Table 5.

2

1=Përmirësimi i saktësisë të të dhënave të monitoruara,2=Ndërfaqe më intuitive dhe tërheqëse,3=Më shumë informacion dhe këshilla shëndetësore të personalizuara

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	1.7	1.7	1.7
	Përmirësimi i saktësisë të të dhënave të monitoruara	28	23.5	23.5	25.2
	1, 2	4	3.4	3.4	28.6
	1, 2, 3	22	18.5	18.5	47.1
	1, 3	22	18.5	18.5	65.5
	Ndërfaqe më intuitive dhe tërheqëse	5	4.2	4.2	69.7
	2, 3	5	4.2	4.2	73.9
	Më shumë informacion dhe këshilla shëndetësore të personalizuara	31	26.1	26.1	100.0
	Total	119	100.0	100.0	

Table 6.

1=Të ushqyerit e shëndetshëm,2=Ushtrimet gjimnastikore dhe sporti, 3=Kujdesi, si të ruhemi nga virusët,4=Mjekimi alternativ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	1.7	1.7	1.7
	Të ushqyerit e shëndetshëm	29	24.4	24.4	26.1
	1, 2	38	31.9	31.9	58.0
	1, 2, 3	5	4.2	4.2	62.2
	1, 2, 3, 4	10	8.4	8.4	70.6
	1, 2, 4	7	5.9	5.9	76.5
	1, 3	4	3.4	3.4	79.8
	1, 3, 4	1	.8	.8	80.7
	1, 4	1	.8	.8	81.5
	Ushtrimet gjimnastikore dhe sporti	12	10.1	10.1	91.6
	2, 3	3	2.5	2.5	94.1
	2, 4	2	1.7	1.7	95.8
	Kujdesi, si të ruhemi nga virusët	2	1.7	1.7	97.5
	3, 4	2	1.7	1.7	99.2
	Mjekimi alternativ	1	.8	.8	100.0
	Total	119	100.0	100.0	

Table 7.

CONCLUSION

4.1 Discussions

First, I will begin by presenting the key findings that have emerged through this paper. The enormous impact

that the Internet of Things has had on the health sector has been revealed. It was revealed how extensive the integration of this technology is, by examining the various devices where it has been applied. By using various sensors, smart devices such as phones, watches and many other devices monitor various information. Thus, with the help of these devices, the number of diseases was significantly reduced. Also, with the help of the questionnaire, some conclusions were drawn regarding the use of the Internet of Things in personal health. They are: the number of users of health monitoring applications is significantly high, the most monitored data are steps taken and calories burned which are considered generic data. Next, we will talk about the high potential that the Internet of Things has for future development, starting with its use for the treatment of mental health problems.

4.1.1 Using the Internet of Things in mental health treatment

Mental health care systems using Internet of Things devices provide real-time data on the mental state of patients. These systems collect data such as sleep patterns, heart rate and activity level. Then the data is used to monitor the patient's condition, identify changes in the condition and create special treatments. For example, if the patient's heart rate increases, the relevant doctor will be notified who will then take appropriate steps for the patient's recovery. Another advantage of the Internet of Things in mental health is the diagnosis of patients, which is much more accurate. By means of the collected data, a model of the patients' behaviors is created and thus the decisions made are based on a lot of evidence. Wearable devices such as smart watches and fitness bands send alerts to their wearers if their mental health is deteriorating. This prevents the creation of any more serious situations. These devices also offer cognitive behavioral therapy (CBT) among other apps and tools. This form of therapy has been very effective in managing mental health symptoms. [14]

4.1.2 The first non-invasive cortisol detector

A very important goal of technology for treating mental health is the reduction of the stress hormone, cortisol. Cortisol levels should be monitored 24/7. Now, its level can be monitored without the need to draw blood, not spending unnecessary time sending samples to laboratories. Taking blood is a stressful situation for many people who are afraid, while in order for cortisol to be reduced they need to be relaxed. Thus, the first non-invasive device for detecting cortisol from skin sweat was created. The system consists of a carbon layer, which has a large number of holes on the back.

Cortisol antibodies are located here. Drops of sweat released from the skin enter these holes and create a chemical reaction that is detected by the device and measured by it. Thus, real-time stress monitoring is done. Cortisol levels are constantly monitored and observed if there are major changes and to react immediately before the situation worsens. [15]

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Lagjja Kalabria p.n KS - 10000, Prishtinë
+383 38 541 400
+383 38 542 138

www.ubt-uni.net
conferences@ubt-uni.net

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