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Original Article

Algorithmization of IoT Device Control for User Fleet Management in Transport Insurance Systems

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Abstract - *This paper presents an algorithmic approach to monitor and manage Internet of Things (IoT) devices utilized by users in the realm of transport insurance. The proposed solution involves the development of a mobile application capable of retrieving user data from government systems and analyzing vehicle data, including driving behavior, fines, and previous insurance choices. Furthermore, it conducts real-time risk assessments through IoT devices. This research contributes to enhancing user-centric transport insurance services, leveraging IoT technologies for data-driven policy customization and premium calculation.*

Keywords - *Internet of Things, IoT device control, transport auto insurance, mobile application development, user data retrieval through government systems, vehicle data analysis, fines, previous insurance choices, driving test, IoT devices, real-time risk assessment.*

1. Introduction

The modern world is changing rapidly. What was relevant yesterday can become outdated today. High competition levels characterize nearly all sectors of the economy, and the insurance services market is no exception. The insurance market is an essential element of the economy of every developed state. To keep up with the times, insurance companies must continually adopt new technologies to meet consumer needs. For U.S. insurance companies and distributors (insurance agencies) to remain competitive globally, they must align with innovative trends.

In addition to high-tech startups, technological giants like Google, Facebook, Apple, Alibaba, and Tencent have shown interest in the insurance industry. For instance, Amazon collaborates with insurers to provide additional coverage for accidental or manufacturer-induced damage to electronic products sold on its website [1]. In the latest report by IBM (International Business Machines Corporation), many new startups have been launched with investments in insurance companies, leveraging a combination of new technologies such as IoT, Blockchain, Cognitive, Gamification, Chatbot, Enabled, and Virtual Reality. This has led to reduced operational costs, elimination of insurance broker services, lower policy costs, and a change in customer service approaches. According to research by the consulting firm Accenture (Ireland), global investments in the insurance technology industry (Insurtech) significantly increased in 2017, with Europe leading in sector growth. In 2017, the number of deals in the insurance technology sector increased by 39%, and their total value grew by 32% to $2.3 billion [3]. The network effect of mobile phones and the development of applications for these devices ("Apps") have allowed many companies to reach a broader audience than ever before. For example, BIMA uses mobile phones to send SMS messages, provide product information and remind users to pay premiums.

Chatbots, robo-advisors, and virtual insurance agents significantly enhance customer engagement. For example, the American insurer Allstate used a chatbot to assist insurance agents in quoting complex insurance products. The Chinese search engine Baidu also uses artificial intelligence systems to detect patterns that can be used for insurance underwriting. Robotic process automation (RPA) can help reduce manual work, improve service, speed up claims processing, reduce operational costs, and enhance accuracy and compliance. As RPA mimics human activity, it can be seen as a set of software "robots," creating a virtual workforce available 24/7 with full auditability and 100% accuracy.

The Internet of Things (IoT) is a digital-physical device network that interacts with the real world, with each other, and with servers. For example, devices like Fitbit and health apps transmit data to insurers in the life insurance industry. With the use of such apps, insurance companies can more accurately assess the risk of policyholders and adapt their risk management strategies accordingly [11]. Auto insurers can adjust insurance premiums based on how policyholders drive their vehicles. This approach reduces insurance premiums for policyholders and increases pricing accuracy, allowing insurance companies to offer more competitive products. In the mobile app, drivers receive notifications about safe speed, following distance, braking, and acceleration, allowing them to improve their driving skills continually [12].

The ability to purchase insurance policies with bonus options is now possible. The insurance services market is developing rapidly, offering an increasing number of interesting, useful, and convenient innovative products. At the same time, insurers focus on customer satisfaction and improving the services provided.

The application of new technologies in insurance allows insurance companies to create products tailored to customer needs uniquely suited to each client. However, the insurance market faces certain obstacles in adopting new technologies.

2. The degree of problem comprehension.

The implementation of IoT systems in the transportation system is currently limited by security parameters. For instance, the Advanced Traveler Information System (ATIS) and the use of the Internet of Things for vehicle detection enhance the Advanced Traffic Management System (ATMS).

In Japan, IoT systems are being deployed for vehicle navigation and electronic toll collection, improving infrastructure and onboard equipment. It also involves establishing legal and social systems related to travel and transportation.

The United States Department of Transportation has developed its system known as RITA. RITA's primary goals include coordinating, promoting, and reviewing research and development programs, academic and industrial partnerships, managing traffic through the Small Business Innovation Research (SBIR) program, research, analysis, and reporting on transportation statistics, as well as educating special groups and the general public in the field of transportation and related areas.

The Border Information Flow Architecture (BIFA) was the first ITS system introduced by Canada in 1999. BIFA in Canada comprises eight user services, including Information Services, Traffic Management Services, Public Transportation Services, Electronic Payment Services, Commercial Transportation Operations, Emergency Management Services, Vehicle Security and Control Systems, and Information Storage Services.

In Europe, Intelligent Transportation Systems are known as Road Transport Informatics (RTI). RTI consists of access roads to the infrastructure to ensure vehicle safety and software approaches for European road traffic. To enhance active safety, RTI has implemented automatic penalty detection.

Transport for London has developed an application for personal and commercial use. To alleviate traffic congestion and monitor road traffic using the Highway Traffic Viewer (MTV) and MTV online web service, cameras have been installed on roads throughout the country and in information centers across the city. Electronic toll collection is facilitated using a toll collection and management system.

Thus, global transport IoT systems still do not include an insurance system and are primarily focused on traffic and penalties. In the legal sphere, Seyed Morsal Gavami (2019) developed the ATIS web system for a multimodal network. It offers a modified version of the shortest path solution for a fuzzy bicriteria multimodal network [4]. In this system, users can receive diverse and distributed data from various organizations consolidated through Open Geospatial Consortium (OGC) web services. Web Feature Services (WFS) were assigned for each mode of transportation, and the corresponding data was collected and transformed into a standard data format.

Seder and Yu Jian (2019) examined the development of a methodology for determining public transportation routes using smartphone applications to easily access real-time trip planning information. They also considered the legal parameters governing traffic regulation [6].

Thus, the use of IoT transportation technology incorporating parameters of auto insurance is an innovative technology. The novelty of this concept lies in the fact that traffic safety prediction algorithms will be applied to driver and vehicle characteristics to optimize the selection of available insurance packages.

3. Research Objective and Tasks

Research Objective: To develop and optimize the algorithm of a self-learning data collection system based on IoT device data for selecting the best type of auto insurance.

Research Tasks:

- Study best practices and contemporary methods of IoT data collection for insurance.
- Identify key parameters and data required for assessing insurance risks.
- Establish objectives and criteria for the optimal operation of the self-learning system.
- Develop a real-time data collection algorithm from IoT devices.
- Create an algorithm for analyzing the collected data and determining the user's risk profile.

4. Literature Review

Alongside the latest Internet of Things (IoT) devices, Artificial Intelligence (AI) has already begun to transform the insurance world, not only making it more accessible but also significantly improving affordability and underwriting. Some even believe that insurance may someday become a thing of the past.

Machine learning combined with sophisticated AI algorithms has the potential to reshape virtually any industry completely, and insurance is certainly no exception. From the inception of the insurance industry, mathematics was at work; initially, only underwriters could calculate reliable risk rates and offer acceptable payouts that would not bankrupt insurance companies.

With the advancement of AI, it can be employed for logic and math-based repetitive operations at a higher speed and reliability than humans. The real question is how the insurance industry will leverage AI and how it will impact the future of the insurance sector. The application of Internet of Things (IoT) technology is rapidly gaining popularity in the insurance market, actively embraced and funded by leading insurance companies both in the U.S. and globally. IoT refers to a network of physical objects with embedded capabilities to collect information about specific objects and phenomena, as well as the ability to transmit the collected and processed information. Data obtained from such objects and devices can be further analyzed using various data processing approaches to derive valuable algorithms and statistical regularities [2]. The development trends of this technology can be observed by examining the growing number of connected devices, which has been increasing at an incredible rate in recent years. For instance, in 2008, the number of connected devices exceeded the number of people on the planet. By the end of 2023, according to expert estimates, it is expected to reach 50 billion [10].

These technologies are gaining popularity because they enhance comfort and make life easier for people through more efficient task execution. Additionally, smart systems in homes and vehicles genuinely allow clients in developed countries to reduce the cost of the insurance services provided to them. According to NTT Data research, as of 2022, 64% of homeowners intended to install smart systems in their homes, and this group of people was dissatisfied with the services provided by insurance companies in terms of property protection and loss financing. This forced insurance companies to develop service packages that take into account the presence of smart systems in clients' homes, analyzing insurance services by considering their clients' personal data, such as daily routines, driving styles, and physical activity. This allowed insurance customers to influence the pricing of insurance products directly. Thus, we observe how the demand for cutting-edge technologies among clients shapes the offerings of insurance companies. The development of advanced information technologies, significant and rapid improvement in the technological capabilities for processing large amounts of data, and the reduction in the cost of producing various hazard sensors have led to increased innovation funding from insurance companies. According to the Boston Consulting Group's forecasts, from 2015 to 2022, investments in Internet of Things (IoT) technologies in the global insurance market will more than double, from $2 billion to $5 billion [9]. The development of cutting-edge information technologies has provided a significant impetus for the development of auto insurance both in the U.S. and globally, as it is precisely these technologies (Usage-Based Insurance (UBI)) that allowed for the consideration of the individual characteristics of the subjects using vehicles. UBI analyzes numerous data collected through automotive telematics: driving time (day or night), speed, driving style (the program tracks when the vehicle suddenly brakes or accelerates), mileage, and more [12].

Telematic systems are sensors that enable wireless communication and command exchange between a vehicle and external sources [3]. Consequently, insurance companies have the ability to set insurance prices considering behavioral aspects of driving, improve claims processing quality, reduce processing costs, and create insurance products that better cater to customer needs, taking into account their individual characteristics. The rapidly growing demand for this type of insurance is the main reason for the widespread adoption of telematic sensors in the automotive industry. From 2014 to 2018, the use of such sensors in vehicles increased nearly fourfold (Fig. 3). Insurance companies worldwide have developed and employed various Usage-Based Insurance (UBI) business models. However, the most popular ones are PAYD (Pay As You Drive) and PHYD (Pay How You Drive). The first model considers the distance traveled by car and is suitable for people who drive infrequently. The second model considers criteria such as the time of day the driver uses the car, how abruptly they brake, how quickly they accelerate, how sharply they turn, and more. The use of telematics-based insurance is advantageous for young people, as they find it challenging to find affordable car insurance with limited driving experience. Nevertheless, it is worth noting that the use of telematics benefits both insurers and clients.

Another UBI model, fairly new in the insurance market, is MHYD (Manage How You Drive), which is essentially an enhanced version of PHYD. MHYD provides quicker feedback and allows real-time adjustments to driving style, offering advice and highlighting differences between the idealized driving style and the driver's actual behavior. The use of telematic devices will have a significant impact on the insurance services market. Among the main consequences, we can highlight a more precise segmentation of self-insured customers and, by properly distributing responsibilities, the enhancement of claims settlement quality [5]. Another result will be the creation and development of startups offering insurance policies through mobile apps and online channels [3].

Virtual insurance companies in the insurance market are gaining popularity because, according to experts, they can reduce insurance rates by up to 20%.

In some cases, specific startups focus on improving specific aspects of insurance processes, but in the case of peer-to-peer (P2P) business models (a form of individual self-organized risk and capital pool), they can potentially displace traditional insurers [1]. The peculiarities of such companies lie in the fact that clients do not pay premiums to an insurer; instead, funds remain in a common pool from which money is drawn in case of insurance events. Part of the insurance premium goes to the company's development, and part of the money is returned to insured individuals. Annually, clients can expect a 15-20% return on the insurance premium [2]. Another promising innovation direction for the insurance market is the use of artificial intelligence (AI). Artificial intelligence is a unique product of technological progress that enables machines to learn, using human and their own experiences, to adapt to new conditions within the scope of their application, perform diverse tasks previously within the human domain, predict events, and optimize resources of various types. One of the most relevant applications of AI in insurance is data management. AI collects information from various sources: customer chats, feedback forms on company websites, social media messages, emails, financial transaction reports, and more. The AI system determines which department of the insurance company should process the data—for example, the claims department or the service department. This mechanism rapidly responds to customer emails or complaints, thereby increasing customer satisfaction with the company. Another customer interaction mechanism uses AI for text data processing from social media. The program scans for keywords to determine what customers are saying about the insurance company and how they rate the level of service [11]. The Japanese insurance company Mitsui Sumitomo Insurance recently implemented this technology, using a chatbot to handle customer queries. The chatbot has already increased the rate of answered requests to 70-80% and has become an attractive factor for new customers. The use of this technology aims to free employees from routine tasks and delegate them to AI, with the automation of the workflow not resulting in layoffs but rather enhancing the quality of service and employee loyalty [12].

In this way, we see how, in the information society, the activities of insurance companies are transformed through the implementation of advanced information technologies in various areas of operation. The role of technology and its availability in people's lives is increasing, and insurance companies must take this into account in the pursuit of efficient operations. The use of innovations can lead to offering consumers personalized products over which they can have an impact, improving the quality of pre-sale and post-sale customer service, optimizing business processes to reduce costs and increase operational efficiency, ultimately contributing to improved financial results and the company's image.

5. Materials and Methods

5.1. Description of Methods for Collecting and Analyzing Data from IoT Devices

The proposed solution establishes a real-time data reception and processing pipeline for receiving and handling messages from Internet of Things (IoT) devices on the Azure Big Data Analytics platform. The architecture leverages Azure Sphere and Azure IoT Hub for managing telematics messages, while Azure Stream Analytics processes these messages.

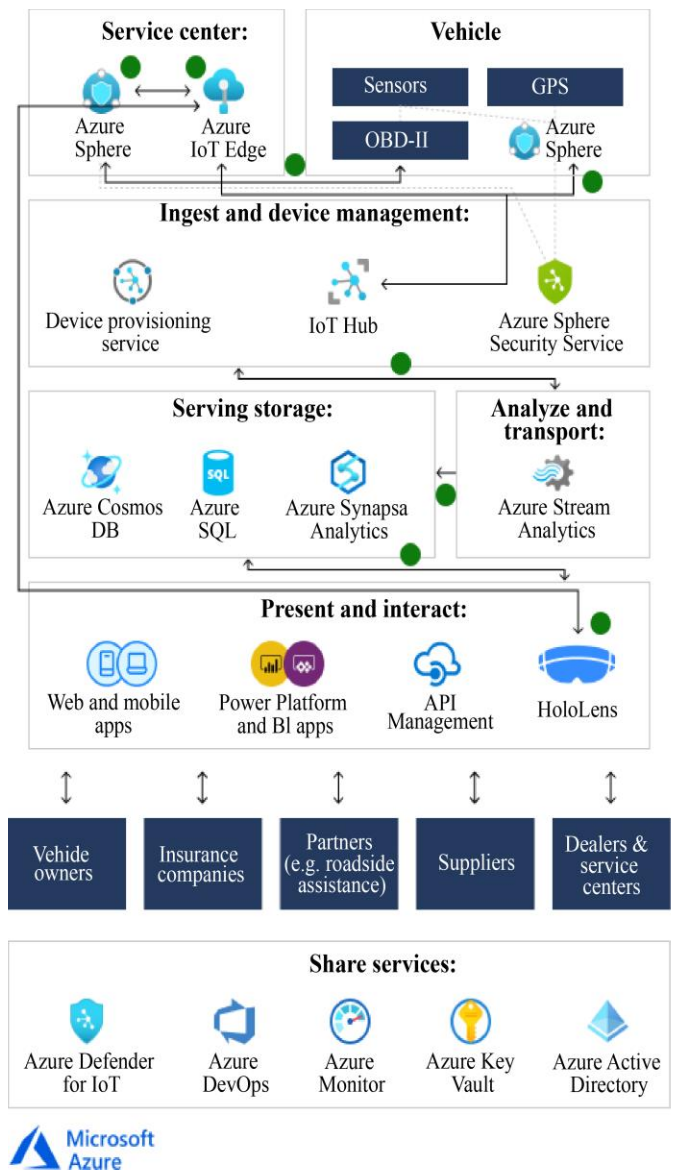

Fig. 1 The architecture for implementing a mobile application based on Azure technology

Fig. 2 Prototype of the mobile application

5.2. Development of the Mobile Application Workflow

Here's a table summarizing the data flow through the solution you described:

Table 1. Data components of the algorithm

Step	Description	Components/Actions/Notes
1	Data ingestion and processing in real-time.	- Azure Stream Analytics ingests messages from Azure IoT Hub. - Processes data based on business logic. - Sends data to the storage layer.
2	Data storage in different databases.	- Azure Cosmos DB for messages. - Azure SQL Database for relational and transactional data. - Azure Synapse for aggregated data.
3	Service layer for various applications.	- Web, mobile, business analytics, and mixed reality applications can be built. - Expose service layer data via APIs for third-party applications.
4	Real-time data from vehicle servicing.	- Azure Sphere device connects to the car's OBD-II port. - Streams OBD-II data to Azure IoT Edge using MQTT. - Data is processed in the message processing pipeline.

The MQTT Generic Broker feature is now available in Azure IoT Edge. The Azure Sphere device will publish messages to the built-in MQTT namespace in IoT Hub

```
import java.util.Scanner;
public class CarInsuranceInIoT {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);

        System.out.print("Enter your full name: ");
        String fullName = scanner.nextLine();

        System.out.print("Enter your driving experience (in years): ");
        int drivingExperience = scanner.nextInt();

        System.out.print("Enter the number of vehicles you own:
```

(devices/{sphere_deviceid}/messages/events/).

The algorithm of the mobile application for car insurance Internet of Things (IoT) for insurance:

```
");
        int numberOfVehicles = scanner.nextInt();

        System.out.print("Enter the number of fines you have: ");
        int numberOfFines = scanner.nextInt();

        System.out.print("Enter the number of accidents you have been involved in: ");
        int numberOfAccidents = scanner.nextInt();

        System.out.print("Enter the market value of your vehicle: ");
        double marketValue = scanner.nextDouble();
```

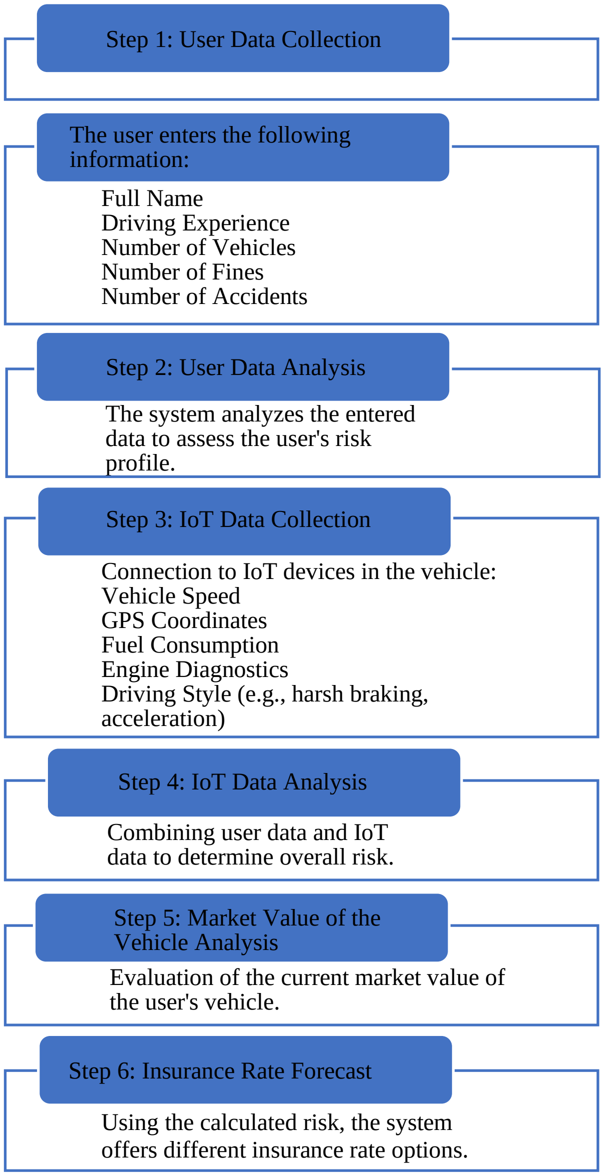

Fig. 3 Steps of adding the IoT devices

```
// Perform analysis of the market value of the vehicle

// Perform forecast of the choice of proposals for car insurance rates

// Print the results
System.out.println("\n--- Car Insurance Application Results ---");
System.out.println("Full Name: " + fullName);
System.out.println("Driving Experience: " + drivingExperience + " years");
System.out.println("Number of Vehicles: " + numberOfVehicles);
System.out.println("Number of Fines: " + numberOfFines);
System.out.println("Number of Accidents: " + numberOfAccidents);
System.out.println("Market Value of Vehicle: $" + marketValue);
  }
}
```

The above code prompts the user to enter their personal data such as full name, driving experience, number of vehicles, number of fines, number of accidents, and the market value of their vehicle. After obtaining the data, the algorithm I developed using Java programming language performs the required analysis and forecast for car insurance rates. Finally, the results are displayed in the console using formatted output.

IoT Edge 1.4 is a supported release. If you are using an earlier release, please refer to the article on Updating IoT Edge.

The IoT Edge runtime is a set of programs that turn a device into an IoT Edge device. Collectively, the IoT Edge runtime components enable IoT Edge devices to receive code to run at the edge and transmit the results.

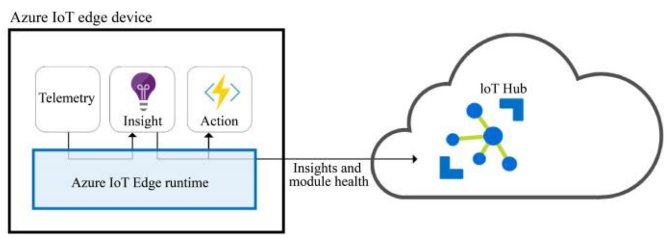

Fig. 4 Azure IoT edge device

The responsibilities of the IoT Edge runtime can be divided into two categories: data exchange and module management.

IoT Edge collects anonymous telemetry data from the runtime and system modules of nodes to improve product quality. This data is referred to as runtime quality telemetry data. The collected telemetry data is periodically sent in device-to-cloud messages from the IoT Edge agent to the IoT Hub in Azure. These messages are not displayed in regular client telemetry and do not consume message quotas.

6. Results and Discussion

The application collects comprehensive information about the car's usage throughout its entire lifecycle. Based on this data, new services can be developed for car enthusiasts in the insurance industry. The data reception and transmission service should facilitate the request and retrieval of car parameters via a Bluetooth device in the form of an OBD2 adapter, as well as package the parameters and transmit them to the application.

I needed to set up a connection with the OBD2 adapter and retrieve data, implementing an algorithm for calculating trip parameters. When developing the application, it was essential to consider that data should be collected and transmitted to the server even when cars are outside the mobile network coverage area.

The application includes several main functional components: connecting to the car via Bluetooth, retrieving data from the vehicle, and selling this data. The application includes a continuously running service that automatically establishes a connection with the OBD2 adapter when detected. The user selects one or more sets of data they are willing to transmit and use.

The application receives the composition of parameters from the marketplace app server for each set to which the owner has given consent. It periodically requests these car parameters from the OBD2 adapter. After receiving all the parameters, the application generates data packets in JSON format for transmission to the telematics platform via a REST interface. A separate JSON is created and transmitted for each parameter set.

I resolved organizational challenges by simplifying communication and initially taking into account that all potential risks would be mitigated.

Key Application Screens:

- Car This screen displays the main sets of car parameters, such as navigation, diagnostics, and trips. The number of parameters for each group is indicated, eliminating the need to enter a section to find out.
- Offers In this section, the car owner's active offers for selling parameter sets for auto insurance packages are collected.
- Parameter Set Configuration Settings can be configured for each parameter set. For instance, the user can set the data transmission frequency from the adapter to the application.
- Change Parameter Set Price The user can modify the price specified in the offer for selling a parameter set. When the price changes, the new cost is displayed.
- Stop Data Transmission Within a parameter set, data transmission from the car to the application can be stopped. There is a dedicated button at the bottom of the screen for this purpose.

For the continuous collection of traffic flow data, planning, informational and entertainment systems, or remote access to crisis resources, such a large number of administrations require a network. In the use case of the Internet of Things in the automotive industry, the organization interacting with vehicles serves as a universal means for all (CV2X). There are two ways to work with C-V2X: from gadget to gadget and from gadget to device. Communication between gadgets provides compatibility between vehicles (V2V), vehicles and infrastructure (V2I), and vehicles and pedestrians (V2P). V2V, V2I, and V2P create connected streets through developments such as collision prevention, transmit speed, area, and course information through a dedicated organization, alert drivers to the need to activate traffic lights/choose timing, and generally enable notifications to pedestrians and cyclists about safety. Gadget-to-arrangement supports correspondence between the vehicle and the network (V2N) through cell organizations, allowing cloud administrations to keep track of these agreements from start to finish, detail current traffic, and manage it.

Progress in the Internet of Things provides various entertainment and information capabilities in vehicles, including navigation routes, telematics, and redirection. In-car Wi-Fi capabilities, supported by the 4G LTE association, have expanded the capabilities of Internet of Things-based telematics in vehicles. So, the overall algorithm will look like this:

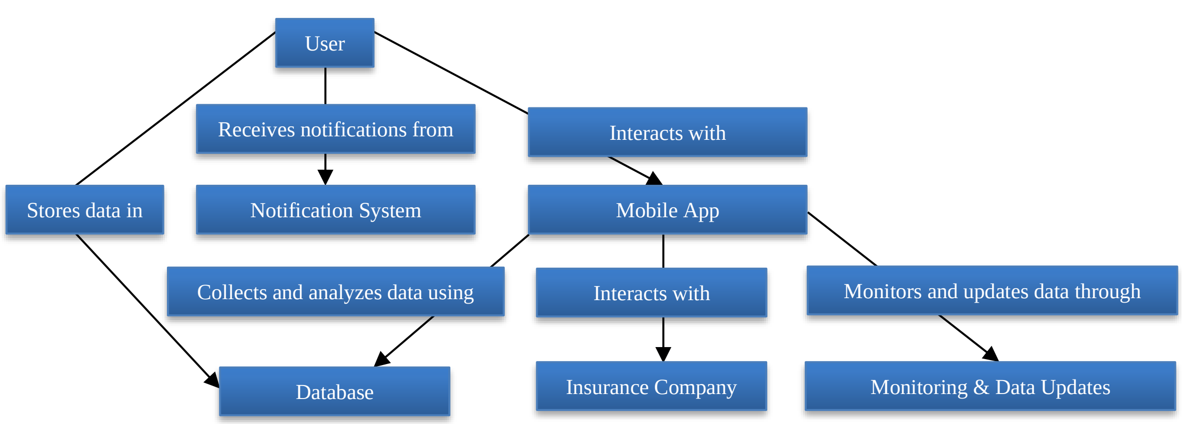

Fig. 5 The overall algorithm

Next, it describes the classes and their relationships in the context of the developed automobile insurance application. You can use this information to create a class diagram following the "classDiagram" format.

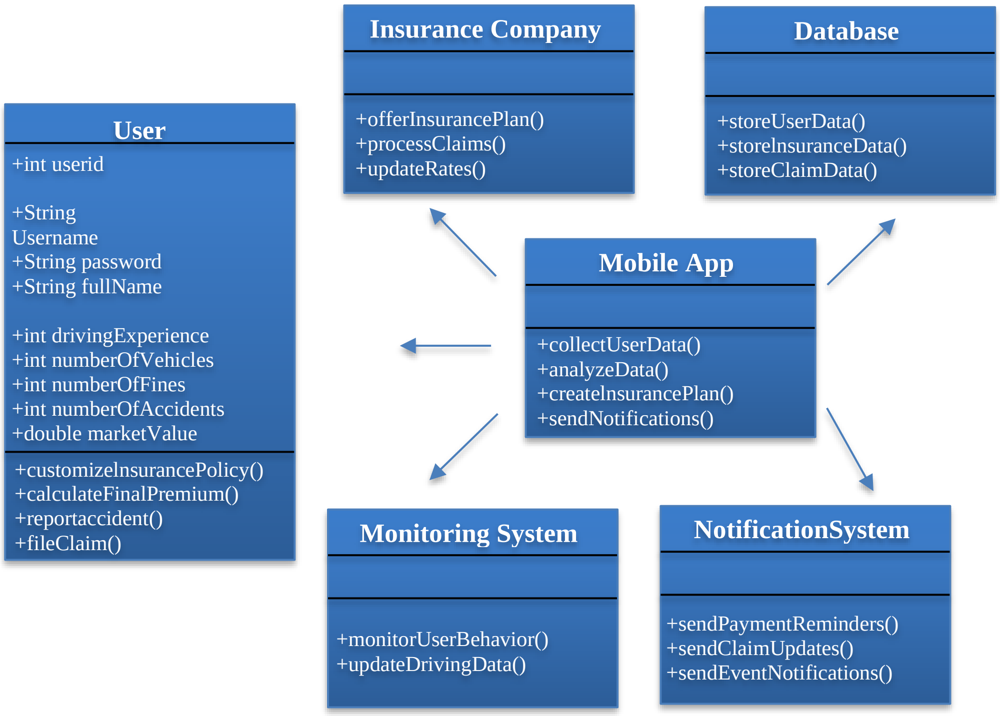

Fig. 6 ClassDiagram

The following diagram represents your description in an Entity-Relationship (ER) format, where USER, MOBILE-APP, DATABASE, NOTIFICATION-SYSTEM, INSURANCE-COMPANY, and MONITORING-SYSTEM represent various entities, and the connections between them indicate their relationships.

To create a table based on a mathematical model and a neural network representing two car insurance package options, we can use fictional data that the model will process to determine the insurance premium.

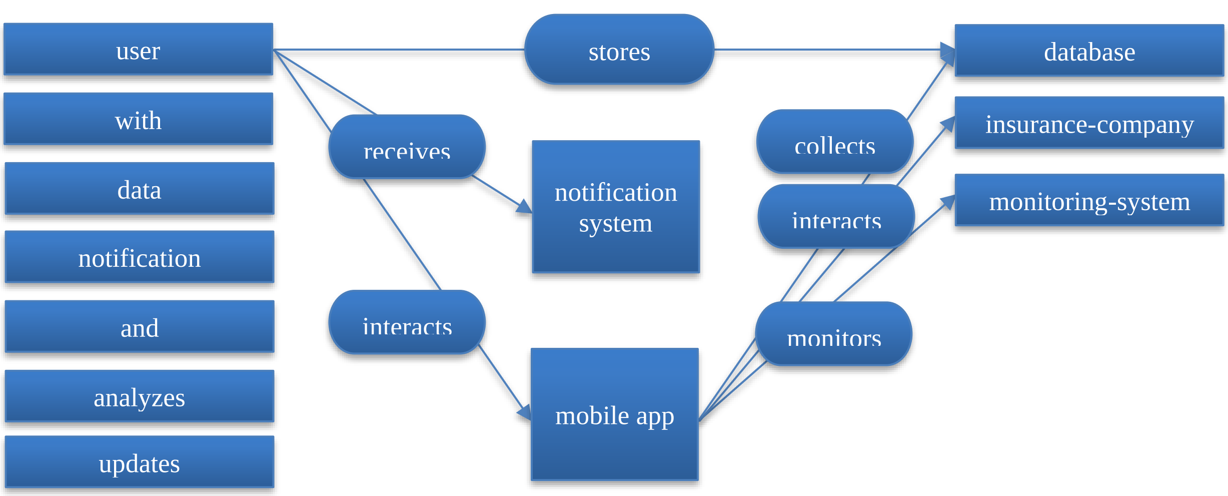

Fig. 7 Entity-Relationship diagram

Below is a table with parameters for user traffic data, user violation and accident data, and vehicle data to present two car insurance package options.

Table 2. Input data

User ID	User Name	User Age	User Gender	Traffic Data	Violations & Accidents	Vehicle Make	Vehicle Model	Vehicle Year	Vehicle Value	Option 1 Premium	Option 2 Premium
001	John	35	Male	High	Yes	Toyota	Camry	2019	$20,000	$1,200	$1,500
002	Sarah	28	Female	Medium	No	Honda	Civic	2018	$15,000	$1,000	$1,250
003	Michael	42	Male	Low	Yes	Ford	Escape	2020	$22,000	$1,300	$1,600
004	Emily	30	Female	High	No	Chevrolet	Malibu	2017	$18,000	$1,100	$1,350
005	David	45	Male	Medium	Yes	Nissan	Altima	2018	$16,000	$1,050	$1,300

Table 3. A car insurance package options

User ID	Vehicle Make	Vehicle Model	Vehicle Year	Vehicle Value	Option 1 Evaluation	Option 2 Evaluation	Premium for Option 1	Premium for Option 2
001	Toyota	Camry	2019	$20,000	0.85	0.75	$1,020	$1,125
002	Honda	Civic	2018	$15,000	0.70	0.65	$1,050	$975
003	Ford	Escape	2020	$22,000	0.80	0.75	$1,040	$1,200
004	Chevrolet	Malibu	2017	$18,000	0.75	0.70	$1,125	$1,050
005	Nissan	Altima	2018	$16,000	0.78	0.72	$1,086	$1,080

In this table, each row represents a different user with their demographic information, traffic data, history of violations and accidents, and details about their vehicle. The last two columns show the premium cost for two different car insurance package options for each user. The premium amounts for Option 1 and Option 2 are based on the mathematical model described in your initial text, which uses RNNs and LSTM layers to predict insurance tariffs based on user and IoT data.

The suggested algorithm additionally serves as an extensive depiction of the user's assessment parameters for the automobile insurance program. Each segment provides an intricate account of a distinct facet of the evaluation, delineating the specific task at hand, delineating the degree of evaluation complexity on a scale ranging from 1 to 5, with 5 representing the utmost complexity, and specifying the participants involved in the assessment process, which may include the User, the System, or both. This comprehensive narrative can be effectively employed as a foundational reference for conducting a comprehensive evaluation of users as part of your automotive insurance program.

These evaluation criteria help determine the user's insurance risk and prepare a suitable insurance offer. Each evaluation step is complex and important in the insurance decision-making process.

In the quest to develop a mobile application for IoT-based auto insurance, harnessing the capabilities of neural networks, several fundamental components and methodologies are brought into play, forming a comprehensive mathematical framework.

Initiating with User Data Collection entails aggregating user-specific personal data, encompassing attributes such as their full name, driving experience, the count of owned vehicles, the tally of incurred fines, and the historical frequency of accidents. These variables collectively manifest as meticulously structured numerical and categorical data, seamlessly amenable to representation within a matrix framework.

Simultaneously, IoT Data Collection assumes paramount significance. The data emanating from IoT devices encompass a spectrum of parameters such as speed, GPS coordinates, and fuel consumption, encapsulating either numerical time series or multifaceted datasets, thereby presenting unique complexities in their manipulation.

Foraying into the realm of Data Preprocessing, neural networks necessitate meticulous data preprocessing. This metamorphosis often encompasses imperative tasks such as data normalization, the artful encoding of categorical variables, and the adept handling of elusive missing values.

The subsequent stride navigates through the labyrinth of Neural Network Architecture Selection. This pivotal decision pivotally hinges upon the inherent nature of the data under scrutiny and the precise objectives in sight. In the context of risk analysis and the prophesying of insurance tariffs, adopting regression neural networks emerges as an apt recourse.

As we traverse forward, Neural Network Training unfurls its canvas. User-related insights, amalgamated with the treasure trove of IoT data, seamlessly transition into the neural network's input stratum. The hallowed target, in this context, invariably pertains to the quantifiable facets of risk or the elucidation of insurance tariff probabilities. The orchestration of this training endeavor comes to life through the astute application of loss functions and optimization techniques, with the overarching aspiration revolving around the minimization of the prediction error, underpinning the pursuit of precision.

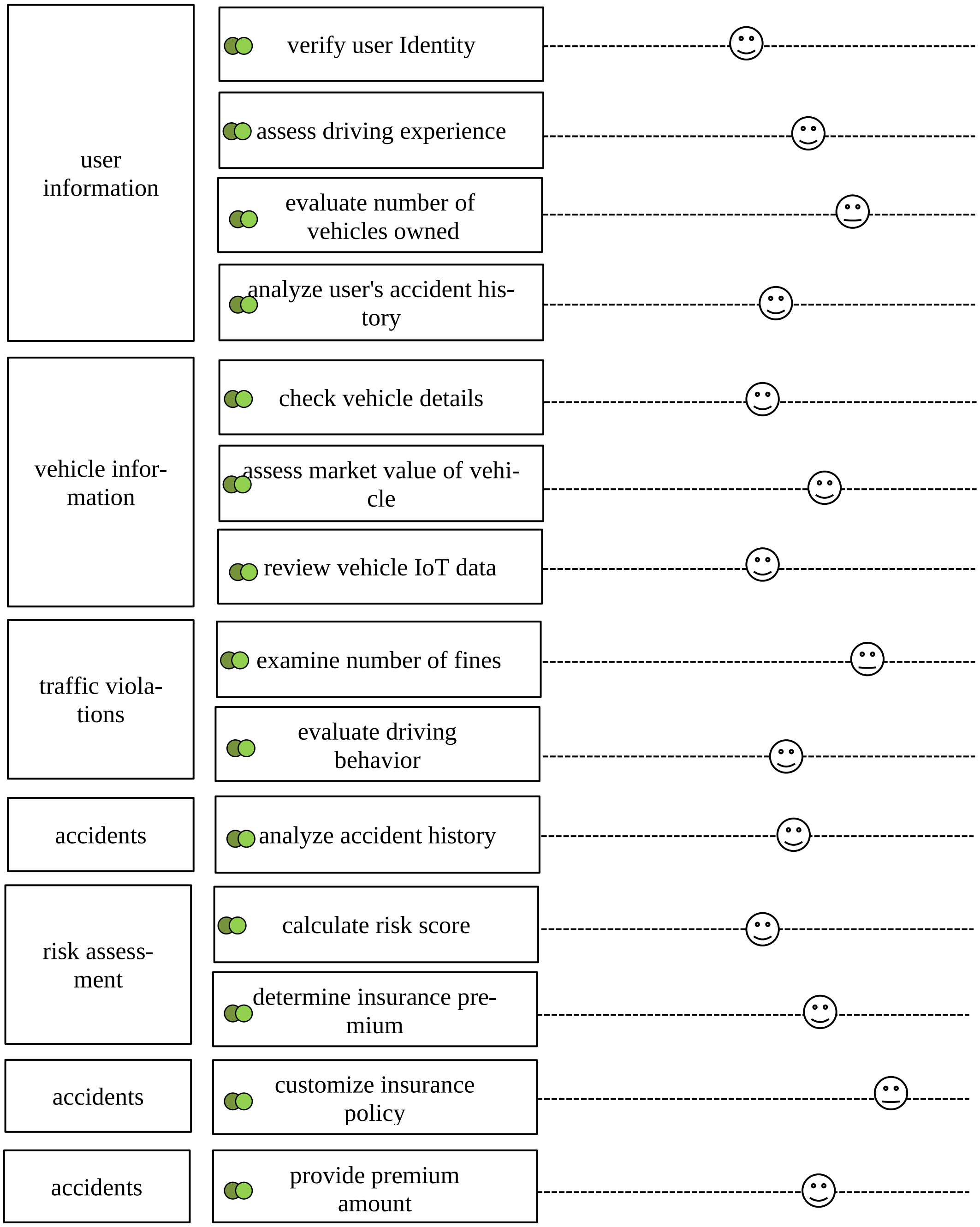

Fig. 8 User insurance assessment

Once the neural network stands duly trained, it embarks on its pivotal role in Insurance Tariff Prediction. Armed with the insights accrued from the training phase, the neural network dons the mantle of an oracle, seamlessly propounding insurance tariffs grounded in the amalgamated user and IoT data realms.

With these predictive insights in hand, the Model Evaluation stage materializes. Rigorous scrutiny awaits the neural network, with performance metrics such as the venerable Mean Squared Error (MSE), the illuminating Coefficient of Determination (R-squared), and an assorted array of evaluative yardsticks. These metrics serve as the litmus test for the model's predictive prowess.

Now, the narrative delves into the realm of Regularization and Optimization. The arsenal of regularization techniques, including L1 and L2 regularization, takes center stage to bolster the model's ability to extrapolate from known data.

The journey culminates with the Deployment and Integration phase. At this juncture, the trained neural network makes its grand debut within the mobile application's architecture, assuming the pivotal role of conducting real-time tariff predictions. It thrives on user-generated input data and IoT-derived insights, synthesizing them into actionable predictions.

The denouement beckons us towards the duality of Updating and Maintenance. This marks the inception of a perpetual cycle of iterative refinement. Regular updates breathe new life into the model and the application, ensuring their ongoing alignment with the influx of novel data streams and their relentless pursuit of optimal performance.

In summation, this encompassing mathematical framework stands as a testament to the amalgamation of machine learning and the formidable domain of deep learning, poised to infuse analytical prowess into the user data, IoT data, and the foresight to predict insurance tariffs in the dynamic realm of mobile auto insurance applications.

In more detail, let's describe the mathematical model using Recurrent Neural Networks (RNNs). In this model, I will use RNNs to predict insurance tariffs based on user and IoT data at different time steps. Here are the formulas and steps for this model. Let X_i be the input data of the user and IoT data at time step i. Each X_i is a feature vector that combines user and IoT data at that time step.

At each time step i, the LSTM layer outputs a prediction of the insurance tariff Y_i based on the data X_i and the internal state of the RNN:

$$h_i = \sigma(W_0 \cdot h_1 + b_0) \quad (1)$$

Where h_i is the hidden state of LSTM at time step i, W_o and b_o are the weights and bias for the output layer, and σ is the activation function, such as sigmoid.

I will use Mean Squared Error (MSE) as the loss function:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \widehat{Y_i})^2 \quad (2)$$

where n is the number of time steps, and Y_i is the actual insurance tariff.

This is a generalized mathematical model, and the specific implementation and parameters may vary depending on the specific task and data. Developing an IoT system for car insurance offers several significant advantages compared to existing solutions for using IoT in transportation. Firstly, the system provides more accurate and personalized driver data and behavior analysis through the use of innovative data collection and analysis methods. This allows insurance companies to more precisely determine risks and rates and provide fairer conditions for customers.

Secondly, the system ensures faster data processing and process optimization, enabling customers to receive quick and precise responses to their inquiries. This increases customer satisfaction and enhances the efficiency of insurance companies.

Finally, the approach emphasizes security and risk management, which are critically important in the insurance industry. We provide the means for secure data protection and preventing security threats.

These advantages make the IoT system for car insurance more advantageous and promising compared to existing solutions for using IoT in transportation.

7. Conclusion

The envisioned mobile application for auto insurance, which harnesses the potential of neural networks while considering an array of personalized driver attributes, boasts a distinctive array of functionalities.

At its core, the application thrives on the principle of Driver Data Personalization. It embarks on a journey to accumulate and meticulously scrutinize a comprehensive spectrum of personal driver-related data. This includes, but is not confined to, a panoramic view of driving experience, a meticulous tally of fines incurred, a comprehensive historical dossier of accidents, a profound exploration of driving styles, an insightful dive into the intricacies of vehicle types, and an encompassing array of additional parameters. This exhaustive data-gathering endeavor lays the foundation for creating highly individualized driver profiles. Within these profiles, the magic unfolds, allowing for the crafting of bespoke insurance tariffs, artfully calibrated to resonate with the unique characteristics of each driver.

Stepping into the realm of IoT Data Utilization, the application paves the way for continuous and symbiotic interaction with the driver's vehicle through a network of IoT devices. These include the likes of GPS modules, motion sensors, and an assortment of data-gathering contraptions. This perpetual dialogue with the vehicle yields a trove of real-time data on driving patterns, distance traversed, and a wealth of other pertinent parameters.

This marriage between IoT technology and the application's core functionality profoundly augments its risk assessment capabilities. Consequently, determining insurance ratings transcends the mundane and attains a heightened level of precision and responsiveness.

The application's crown jewel is arguably its capacity for Personalized Offer Generation. The neural networks that underpin its functionality leverage the entire spectrum of driver data, coupled with an intimate understanding of driving behavior and real-time IoT insights. The culmination of this analytical prowess manifests in the application's ability to peer into the future, forecast impending risks, and extend bespoke insurance tariffs. The net result is a value proposition extending far beyond the generic's confines, offering drivers a palette of insurance offerings that are seamlessly aligned with their unique circumstances and personal profiles. This, in turn, potentially puts users in a new era of advantageous insurance terms and enhanced value propositions for the discerning driver.

One of the standout features of this mobile application is its proficiency in Dynamic Tariff Management. The application operates on a real-time feedback loop that remains acutely attuned to shifts and nuances in driver data and driving patterns. With unwavering vigilance, it recalibrates insurance tariffs in lockstep with these fluctuations, ensuring drivers are perpetually presented with offers that mirror their current realities and evolving circumstances. The result is an agile and adaptive insurance model tailored to the here and now.

The application's unique attribute of Granular Insurance Parameter Control serves as the final brushstroke on this intricate canvas. It is characterized by an exquisite attention to detail, offering an unparalleled level of granularity in assessing insurance parameters. Factors such as the frequency of fines, accident history, and the quantum of kilometers covered within specific timeframes are all scrutinized with precision. This microscopic view into the driver's world empowers them with the ability to craft insurance policies that are finely tuned to their unique requirements and predilections. In essence, it is the epitome of policy personalization, exemplifying flexibility at its finest. In summation, the exceptional qualities of the proposed mobile application reverberate with the resonance of adaptability and personalization. It endeavors to transcend the one-size-fits-all paradigm, ushering in a realm where fairness, competitiveness, and the cultivation of safe and responsible driving take center stage.

References

[1] Md. Tamanna Alam, and Vinay Pathak, "Internet of Things (IoT) Enabled Automation Systems," *International Journal for Scientific Research and Development*, vol. 6, no. 9, pp. 10-14, 2018. [Google Scholar] [Publisher Link]

[2] O.V. Olabodi, "Automation and Computer Technologies in Management Systems: Sci.-Tech. Bibliographic Index / Compiled," *National University of Food Technologie*s, pp. 1-171, 2021.

[3] Orhan Bulan et al., "Segmentation-and Annotation-Free License Plate Recognition with Deep Localization and Failure Identification," *IEEE Transactions on Intelligent Transportation Systems*, vol. 18, no. 9, pp. 2351-2363, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[4] Seyed Morsal Ghavami, "A Web Service Based Advanced Traveller Information System for Itinerary Planning in an Uncertain Multimodal Network," *Geocarto International*, vol. 35, no. 14, pp. 1553-1569, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[5] Alejandro Leo-Ramírez et al., "Solutions to Ventilate Learning Spaces: A Review of Current CO_2 Sensors for IoT Systems," *2021 IEEE 45th Annual Computers, Software, and Applications Conference (COMPSAC)*, pp. 1544-1551, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[6] Jin Li et al., "Research on Multiple Sensors Vehicle Detection with EMD-Based Denoising," *IEEE Internet of Things Journal*, vol. 6, no. 4, pp. 6262-6270, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[7] Janki Mistry, and Ritesh Khatwani, "The Role of the Internet of Things in the Future of Banking, Financial Services, and Insurance," *TechRxiv*, pp. 1-6, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[8] Mobasshir Mahbub, M. Mofazzal Hossain, and Md. Shamrat Apu Gazi, "IoT-Cognizant Cloud-Assisted Energy Efficient Embedded System for Indoor Intelligent Lighting, Air Quality Monitoring, and Ventilation," *Internet of Things*, vol. 11, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[9] Muhammad Syahputra Novelan, and Muhammad Amin, "Monitoring System for Temperature and Humidity Measurement with DHT11 Sensor Using NodeMCU," *International Journal of Innovative Science and Research Technology*, vol. 5, no. 10, pp. 123-128, 2020. [Google Scholar] [Publisher Link]

[10] Scott R. Peppet, *Regulating the Internet of Things: First Steps toward Managing Discrimination, Privacy, Security, and Consent*, Texas Law Review, pp. 1-85, 2014. [Google Scholar] [Publisher Link]

[11] Sunil Raikwal, and Samaya Pillai, "Impact of Internet of Things on Automobile Sector," *AIP Conference Proceedings*, vol. 2519, no. 1, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[12] Shakil Ahmad, and Charu Saxena, "Internet of Things and Blockchain Technologies in the Insurance Sector," *2022 3rd International Conference on Computing, Analytics and Networks (ICAN)*, pp. 1-6, 2022. [CrossRef] [Google Scholar] [Publisher Link]