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Cloud-Based Intelligent Transportation System: Reference Model

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Abstract: While the development of technology and internet infrastructure facilitates many aspects of daily life, it does so based on the processes and data running in the background. With the development of information and communication technology, changes and improvements in people's lives have also had a great impact on Intelligent Transportation Systems. Cloud Computing, which was developed for the storage of data that has been made descriptive of the virtual environment with a reference model setup as the first step. This model is aimed to facilitate the data storage, processing, and transfer process required for Intelligent Transportation Systems. In this study, a reference model on passenger occupancy rate, which is a passenger information system from Cloud Computing-based Intelligent Transportation System components, has been created, and this model has offered suggestions in the form of interface improvement for Sakarya Metropolitan Municipality transportation mobile application SAKUS. It is foreseen that these suggestions will have a great impact on the daily life of the passengers in planning their travels and in turning to alternative modes of transportation.

1. Introduction

The emergence of information and communication technology, as represented by the technological development at the end of the 20th century and the beginning of the 21st century, has mainly affected people's lifestyles and the way in which various activities are carried out, as well as a new type of society, which is increasingly dependent on digital knowledge and Technology, and carry out various activities through the virtualization of media rather than traditional media.

Intelligent Transportation Systems combine information and communication technology into present transportation management systems that assist keep away from traffic congestion and accidents that increase with population growth and cause many unwanted outcomes which include lengthy travel time, air pollution, and fuel consumption [1]. It also hires technology to achieve information at the overall performance of transportation facilities, on-demand for transportation, and mutual communication among vehicles themselves and among them and among roadside devices, in addition to approaching collision accidents [2]. Intelligent transportation systems affect the performance of the transportation system with six main aims [3]: traffic Safety, Mobility, Efficiency, Productivity, Energy and Environment, User Satisfaction. Intelligent Transportation Systems combines these aims with advanced information and communication technology and analysis of solutions to create a complete and accurate transportation management system in real-time [4]. Machine learning algorithms used in intelligent transportation systems will work more effectively which, are regression model, k-Nearest Neighbours (KNN) model, support vector machine, NN model.

Cloud computing has become a common and efficient technology, which allows users to access all types of computing resources, such as shared resources, platforms, applications, and data in data centers distributed on networks such as the Internet [2].With the cloud computing structure used in smart transportation systems, it will be possible to access and interpret data faster. The combination of Intelligent Transportation Systems and Cloud Computing is very important in terms of ease of transportation and data management. The cloud computing model is an excellent platform for processing, collecting, storing, and analyzing data. This technology has become an ideal tool for processing large amounts of traffic data and monitoring the performance of network traffic systems, thereby improving traffic safety and travel safety [5]. With the efficient technology of cloud computing, it is inevitable to realize a faster, easier, more reliable, and more effective transportation system [6]. To present the quality of daily life in a way that supports the decisions and wishes of passengers and end-users, and to turn to smart cities with intelligent transportation. For this reason, a cloud-based intelligent transportation system reference model is the main aim of this paper in terms of the advanced Passenger information system components which inherit the occupancy rate of Passengers in public transport system buses. As stated above, along with the recommendation of this reference model, it is considered as one of the possible outcomes that the use of the intelligent transportation system will provide benefits within the scope of mobility and efficiency. In the smart transportation system, knowing the passenger occupancy rates will enable the resources to be used more effectively, especially for the effective use of public transportation vehicles.

What are cloud computing-based intelligent transportation systems and the background is given in the next, section 2. In section 3, the methodology of the study will be briefly explained and the reference model will be mentioned. In section 4, a reference model for passenger occupancy rates with a cloud-based system will be proposed with a recommendation for SAKUS (Sakarya Metropolitan Municipality Transportation System [7]. This model and study with its advantages and disadvantages will be discussed briefly in section 5 and concluded in section 6.

2. Literature Survey

In terms of the services it provides, cloud computing can be divided into three main models. The first model is called Infrastructure as a Service (IaaS), which represents the lower layer of cloud computing. Provide computing infrastructure without the need to purchase servers. In a data center or room with network equipment, customers purchase these resources as a completely independent service in Figure 1. In the second type, platform as a service (PaaS), this type of cloud computing is mainly composed of libraries, middleware, updates, and runtime tools required by developers to update software as a service. The third type is called software as a service (SaaS).

In Figure 2 [8], the hierarchical model for cloud computing is given. This model can also be called Cloud Computing architecture or reference model. At the bottom, IaaS forms the subplot and hosts the computing, storage, and network resource pool. This model has a universal scope and separates and stores data from everywhere and processes it at the same time. Located in the middle part, PaaS represents the platform level and includes the operating system, database, development environment, informatics architecture, and special software [9]. SaaS at the top includes application resources and translates them into the business model, system management and maintenance, and even to the end-user in an understandable and transferable form.

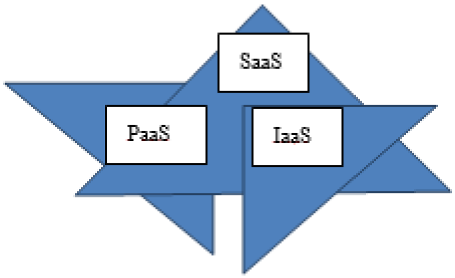

Figure 1: Cloud Service Model

For ITS components to function well, it is necessary to collect data, aggregate and translate this data, and transfer this disseminated information to the user. In the data collection section, there are systems such as sensors, video cameras, and vehicle technologies for instant data. Data aggregating and translating is transformed into information by separating and organizing by private or public entities. This information is disseminated to the end user via smartphones, mobile applications, the internet, dynamic message notifications, or in-car devices. The ITS components and applications specified in Table 1 are formed by these processes.

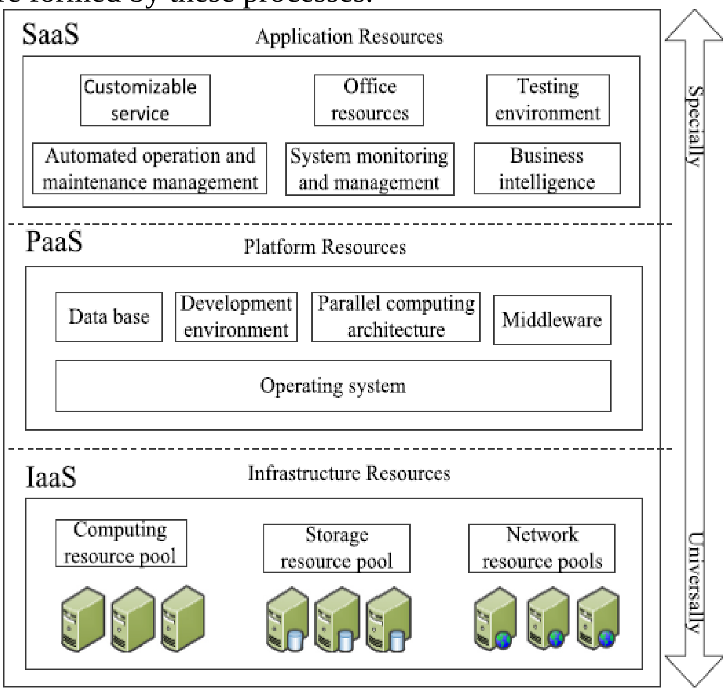

Figure 2: The hierarchical model for cloud computing [8]

Intelligent transportation clouds might offer services reminiscent of decision support, a customary development setting for traffic management strategies, and so on. The cloud computing, users don't get to perceive the main points of the infrastructure within the “clouds;” they have solely understood what resources they need and the way to get acceptable services, which shields the process quality of providing the specified services. With the development of intelligent traffic clouds, varied traffic management systems could connect and share the clouds’ infinite capability [10]. A transportation cloud-primarily based service platform is made exploitation the virtualization and cluster computation options of cloud computing to supply safe, convenient, flexible, and various cloud-based software package development and storage services [11].The operating performance of the system is higher, especially with the machine learning techniques used in the virtualization and clustering process.

Table 1: ITS Components and Application [9]

ITS Components	ITS Components Application
Advanced Traffic Management	Driving aids Emergency management Disaster management Online cost recovery services Personal safety reports
Advanced Passenger Information	Information before/during the trip Route guidance Occupancy Rate
Commercial Vehicle Operations	Electronic clearance of utility vehicles and freight automated road safety control Vehicle administrative operations
Advanced Public Transportation	Public transportation management Payment Method Public on-demand transportation
Vehicle Control And Safety	Intelligent cruise controls Obstacle detection Automated driving Vehicle communications(V2X)

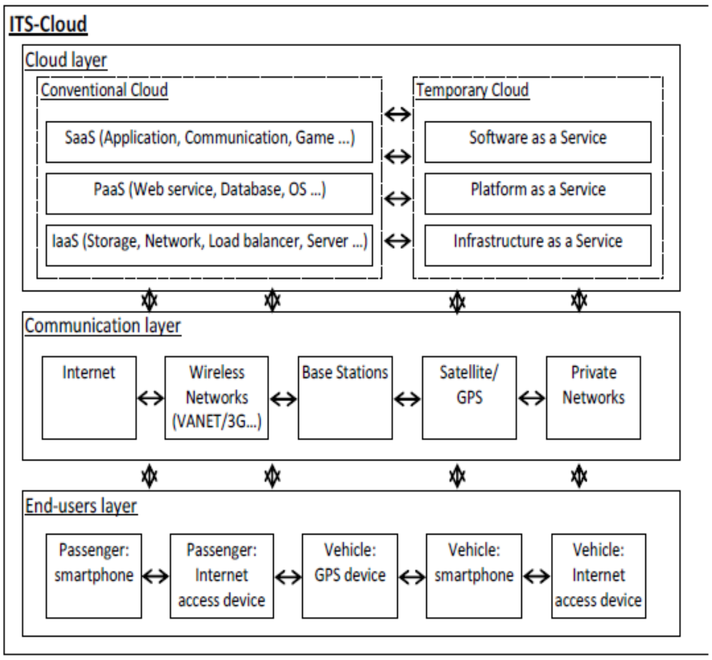

Figure 3: ITS-Cloud architecture [6]

Cloud-based ITS (e.g. Figure 3), initially section supported data acquisition, sensor, network transmission, and alternative technologies, the dynamic info non heritable is distributed to the cloud management platform of the integrated processing of the intelligent transportation network

(ITN) Second phase, the system prediction results and therefore the control theme is obtained, that are sent to the ITS terminal to understand the unified monitoring, management, decision making, and control services for the complete ITN [12]. In this sense, some of the cloud-based studies are given. In the last stage, decision rules are obtained by clustering the data with machine learning technique.

Fornaia et al. [13] give an answer that lets clients request a public automobile for added overall performance that forestalls on the principal road, via high-degree operations for each side, from the client-facet that offers users guide for book transport automobiles, even as server-side assist is supplied to deploy, implement, and display offerings at the Cloud. Thanks to this demand-based system, reducing the traffic load and increasing mobility can be seen as a possible result. However, considering that this demand is created by many users, cloud-based technology is needed here, and the mobility of data is met in this way to ensure mobility in traffic. K. Ashokkumar et al. [2], made contributions with the aid of using featuring a general and multi-layered transport information cloud platform.

Simultaneously helps cloud computing and IoT technologies. This platform helps mechanisms that allow it to acquire and change information among drivers. The authors recommended models for modified data processing, a Naive Bayes model, and a providing Regression model. This system, which is thought to allow drivers and vehicles to communicate with each other based on IoT, is called V2V (Vehicle to Vehicle) and V2X (Vehicle to Anything) in ITS. However, there is a need for a cloud-based system, as this system needs an instantaneous data flow to work effectively, prevent or notify accidents, and also instantaneously.

The study made by Li et al., [10] discusses the integration of big data and smart transportation systems using the cloud base and the examination of these big data as three case studies. These case studies focused on crash analysis in Bogota, bus delay estimation in Vancouver, and smart mobility in Aarhus. These three case studies appear as very important examples to increase safety, mobility, and efficiency within the scope of transportation planning, traffic engineering, and ITS. Using In [11-14], cloud-based ITS for eco-driving, it is aimed to reduce energy consumption. Especially since the climate crisis has come to the agenda, reducing energy consumption has been targeted and made a priority by all countries of the world. With cloud-based ITS, this work has taken an important step for the future, thanks to its data transfer and processing. RAI et al. [15], have been evolved to enforce custom-designed intelligent transportation systems in urban areas. The most important concept of this shape is the interoperability among machine-to-machine era and cloud computing that lets in for seamless configuration and intake of the carrier in addition to velocity with inside the deployment of latest services with the aid of using grouping exclusive devices and get right of entry to networks that can be owned with the aid of using exclusive actors inclusive of telecom device companies and transportation service companies, and governmental organizations. Mathirajan et al. [16], changed into evolved Cloud-Based Decision Support System (C-DSS). The concept of (C-DSS) is primarily based totally on an intelligent version that lets in integrates the strategic hassle with inside the warehouse site (to feature new places and dispose of present sites) and allocating urban buses to warehouses.

3. Method

In particular, the size of the data that emerges as a result of the use of public transportation by a large number of people is also growing. Although it is very difficult to store and process this big data instantly, it enables cooperation with different and interdisciplinary fields in terms of transportation planners. When it comes to ITS and cloud computing, data must be collected, processed, and made meaningful, and transferred to the end-user or passengers. In this way, it should be possible to increase the quality of daily life, make the system relatable, ensure security, and instantly transfer data [17].

The fact that many developed countries and continents define, accept and use ITS and cloud-based components, as well as seeing the Reference Model as the first and important step of them, strengthened the recommendation of this study and strengthened the methodology [18,19]. Of course, the cloud-based ITS Reference model offers a very inclusive and broad framework.

Among the Advanced Passenger Information Systems, the problem encountered as one of the factors affecting the daily lives of the users is the public transport occupancy rates. Peak hours are known as the time intervals when the demand is the most intense and the capacity is at the lowest, which includes the departure times of the passengers in the morning and the return hours from work in the evening. However, some fluctuations experienced during peak hours cause problems in establishing the balance in vehicle densities [20]. There are also cases where passengers cannot use public transport, depending on the occupancy rates, especially during peak hours. For this situation to be solved within the framework of ITS, it is necessary to know the passenger occupancy rates. For this, with cloud computing, instant data collection, processing, and appearing of processed data as information at stops, stations, and on smartphones used by passengers can constitute a solution.

4. Implementing Reference Model for Passenger Occupancy Rate

The Passenger Occupancy Rate can have a huge impact on Passengers' travel planning. When a passenger arrives at the bus stop, they sometimes cannot get on the public transportation vehicles that arrive specifically at peak times, and thus the waiting and dwelling time may increase. However, there are also technologies that do not require the passenger to come to the bus stop. This can appear on mobile applications or web pages where bus locations are displayed and routes are specified. On the other hand, it may not be enough to know when the bus will arrive from these applications. Although the passenger arrives at the stop on time, he may not be able to get on because the buses are full. Considering that the waiting time can be quite high, especially in places with CBD and high population density, having the occupancy rate information available beforehand will allow for a good itinerary.

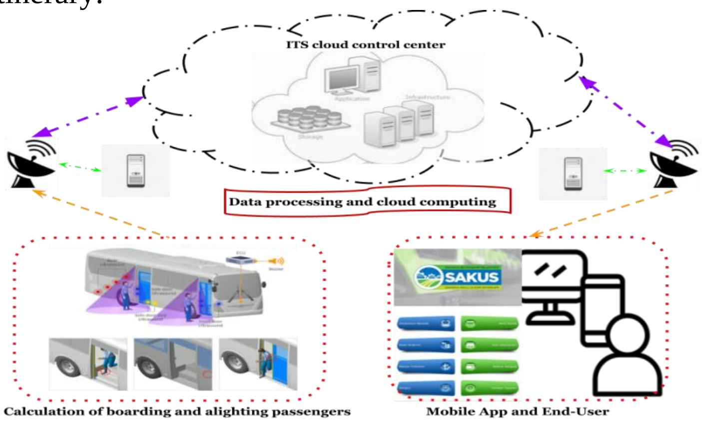

Figure 4: Cloud-Based ITS Reference Model for Passenger Occupancy Rate

By combining a cloud-based system and intelligent transportation systems, it seems possible to solve the occupancy rate problem, especially the category in the passenger information system. Leaving aside the infrastructure and installation costs of this situation as mentioned before to use an existing system and mobile application, a reference model was created on how this system could be on this app. Along with the flow of this model, the usage stages are also given with this model briefly and graphically.

As can be seen in Figure 4, a reference model has been created for the Cloud-based ITS Passenger occupancy rate. In the lower-left corner of this model, a sensor system that can be used to record and calculate passenger occupancy rates is used. This calculation can be done easily with a simple mathematical equation in the cloud system in real-time. In the same figure, a sensor system is chosen for passengers getting on and off the bus. However, instead of this, the number of boarding passengers can also be deduced from the smart card reading system. This enables the system to have low-cost advantages. With the smart card counting system, the sensor system can be combined with, and the sensor set up cost can be decreased half of the price.

After recording and calculating the rate, with the help of satellite systems, 5G, and workstations of these sensors, which provide instant data tracking and counting, the numbers of passengers getting on and off the bus are transferred to the cloud as raw data. These edited and processed data will be transferred to the end-user via the platform (web site) or mobile application, again with the help of satellite systems, 5G, and workstations, over the route they want to use, allowing their journeys to be better planned according to occupancy rate. With this data that is developed and transferred instantly, the end-user will easily access this information with one button. And this may provide better waiting times according to the cloud-based ITS system. With this chance, the planning of the journey as an individual will be more effective in terms of mobility.

SAKUS, the application chosen for the creation of this model, has also changed its interface and made changes to the mobile application without any deformation. This change will be an addition that will instantly show the occupancy rates in the buses belonging to the municipality to the end-user with a single click. In this way, the occupancy rates on the bus line will be determined in percent, and at the same time, access to the number of passengers will be provided. This interface was created as seen in Figures 5 added to the existing interface.

Before the Passenger Occupancy rates, it might be necessary to mention the existing aspect of ITS aspects on this mobile application. When a passenger starts to use this application, he can see the location of the bus as it appears in the upper left corner. At the same time, with the option under this button, they can get a route suggestion showing where they can go. They can top up his smart card online and at the same time, he can access the contact numbers in case of any problem. By activating the smart stop feature with the buttons on the right menu, they can view the arrival time of the coach buses, access the locations of the centres where the transportation card is sold, and query the remaining balance. With the button on the bottom right, they can access the time information showing the departure time of the buses from the main station. This interface was created as seen in Figures 5.

Figure 5: SAKUS current interface and interface with Passenger Occupancy Rate

In this interface Figure 5, the left one is current, and the right one is new with the occupancy rate button below, without changing the icons and buttons in the previous application. This button, called "Yolcu doluluk oranı", exactly corresponds to the name "Passenger Occupancy Rate".

Thanks to this button, passengers will be able to access instantly processed and calculated data in a meaningful way and see the occupancy rates of the buses on the lines they will use. When the passenger presses the button, he/she will be able to see the passenger occupancy rate of the next bus, as explained above, by typing the stop he is at, as a single percentage calculation, as it has been processed with the data received from the smart transportation cards and sensors.

This Cloud-based ITS reference model and the occupancy rate button added with the innovation of the model are one of the additions that seem simple but should be in an urban transportation network. It seems essential that it will enable users to manage time by contributing to mobility, especially in the flow of life that is getting faster and faster. In particular, a cloud-based system, with an artificial intelligence processing capability, will process the data from the sensors on the bus and transfer it to the end-user, which will make the life of the passengers easier in terms of mobility and Intelligent Transportation Systems.

5. Discussion

The existence of such a system in public transportation vehicles, which is one of the most preferred branches of transportation systems, which has a great share in facilitating daily life, will become even easier thanks to cloud computing. Considering the population of a city and the transportation preferences of that population, only cloud-based systems can cope with instantaneous big data. The fact that instantaneous data is received, processed, transferred and stored, and appears to be an indispensable part of the advanced passenger information system, makes this technology more effective. On the other hand, the application of these systems to all bus networks will of course bring a high installation cost. Especially the fact that the sensor systems are expensive will raise some doubts in this regard. However, the application of this change, which we have reflected on our reference model proposal and the application interface, as a pilot system on certain bus lines with a high number of passengers, in Sakarya, will show the satisfaction of the passengers, the effectiveness of transportation and the trend of the tendency to alternative types. For the long term, policy and planning knowledge will be more eligible and these setup costs can be balanced whit the information of further planning problems.

In this model, which is recommended to reduce installation costs, to be useful in calculating the number of passengers, the number of sensors can be reduced by using the smart card system in the calculation of boarding passengers. This smart card data, which will be transferred to the cloud base, can be processed in the same way, made meaningful in the same environment, and transferred to the user. Thus, the installation of infrastructure costs can be reduced. Eventually, this reference model is only a recommendation for bus operation systems. The limitations still exist and there might be some concerns to building this kind of information structure to adapt to an existing system. Initially, it could be a good idea to build this structure for a small number of pilot areas where the system stocks more easily because of crowded passenger populations.

6. Conclusion

In this study, Cloud Computing-based Intelligent Transportation Systems are emphasized, these terms are explained briefly and their places in the literature are mentioned. It is highly used on transportation systems that needed to combine a huge amount of data. It has been shown that cloud-based systems and Intelligent Transportation form an inseparable whole. The reference model, which is a first step for the effective use of this whole, and how it was created, are mentioned. For the background of cloud computing, it is necessary to set up perfect programming without any errors or bias. For this data transfer and process, SAKUS, which is the mobile application of the Metropolitan municipality of Sakarya transportation department, was preferred, and it was shown by making additions to the mobile application interface of the end-user. With these additions, it is envisaged that waiting times on journeys can be reduced, and alternative routes or modes can be directed. In addition, some obstacles were mentioned, and overcoming them was also discussed. In future studies, the mathematical models and pre-cost study of this reference model will be presented, necessary calculations will be made and how it can be presented to the users will be discussed in detail.

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