DEPENDENCE OF PUBLIC TRANSPORT ON CLOUD TECHNOLOGIES

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Abstract: *With the majority of the world's population now living in cities, the importance of distributed transport systems integration is increasing. This requires improved integrated transport infrastructures and communication within cities to reduce the cost of congestion on the roads, provide an efficient and convenient system for travelers and improve the management and future planning of public transport within cities. By sharing large amounts of transport data with the public, including automatic passenger counting information, pollution and traffic congestion can be managed to better levels and subsequently lead to improved overall public transport services.*

The present paper aims at arguing the growing dependence of the efficient urban transport on the new technologies. The growing demand for cloud computing together with Internet of Things is based on the numerous advantages going along with this technology, provided that it is used appropriately. Cloud Computing is a revolution that will define Information Technology in the second decade of the 21st Century.

Keywords: URBAN SMART TRANSPORT, INTELLIGENT TRANSPORTATION SYSTEMS, CLOUD TECHNOLOGIES, IOT

1. Introduction

Intelligent Transport Systems (ITS) are one of ICT-enabled benefits for society, which make the transport more efficient, faster, easier and reliable. Nowadays one of the most important aims of ITS is that these systems must become faster commonly used. Internet services are one of such solutions, cloud computing services, in particular. Generally the cloud computing is Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid.

ITS as important infrastructure services make a city "livable" by improving capacity, travel experience and making it safer, more efficient and more secure. For instance, Singapore already set up an excellent example based on Internet of Things (IoT) to connect, collect and comprehend. The Land Transport Authority plans routes and establishes minimum service standards for bus lines managed by the Singapore Bus Service and Singapore Mass Rapid Transit.

Smart cities rely not only on sensors within the city infrastructure, but also on a large number of devices that sense and integrate their data into technology platforms used for analyzing the habits and situations of individuals and city-large communities. Fig. 1 presents a conceptual framework of urban smart transportation based on cloud and IoT. Contemporary smart urban transport systems: (1) employ secured IoT to generate big data, which comprise billions of devices that sense, communicate, compute and potentially actuate, massive connected via GIS-Twidely available real time communication network (e.g. 4G, Wi-Fi, Bluetooth); (2) generate big data with "4Vs" features, as raw material facing great challenges, (3) rely on resilient cloud computing to store, manage, mine and create values for insight as the solution to many of our society's traffic and transportation problems (4) in an era of data abundance, there is a clear need for visualization tools to provide insight into how coordinated systems should be expected to operate under different parameter settings and to document coordinated system behavior.

Cloud computing is utilized to meet the requirements on infrastructure for big data. It is presented a framework for data received from highly distributed, heterogeneous, decentralized, real and virtual devices that can be automatically managed, analyzed and controlled by distributed cloud-based services. Also it is discussed an emerging IoT architecture, large scale sensor network applications, federating Traffic and Transportation Smart 3 sensor networks, sensor data and related context capturing techniques, challenges in cloud-based management, storing, archiving and processing of sensor data. It is provided an overview of service-generated big data and big data-as-a-service, employed to provide common big data related services (e.g. accessing service-generated big data and data analytics results) to users to enhance efficiency and reduce cost. It has been proposed [1] urban traffic management systems using intelligent transportation cloud which generate, store, manage, test, optimize and use mobile traffic strategy agents to maximize advantages of cloud computing and agent technology to effectively control and manage urban traffic systems. It was also presented a multilayered IoT-based vehicular data cloud platform with an intelligent parking cloud service and a vehicular data mining cloud service. [1]

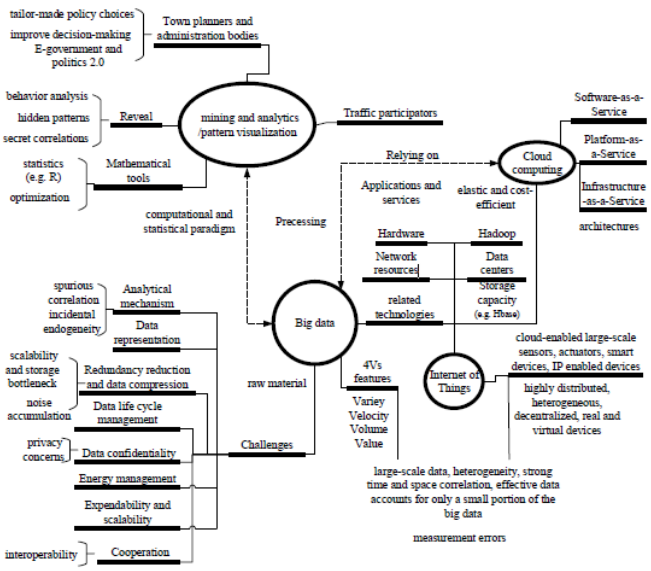
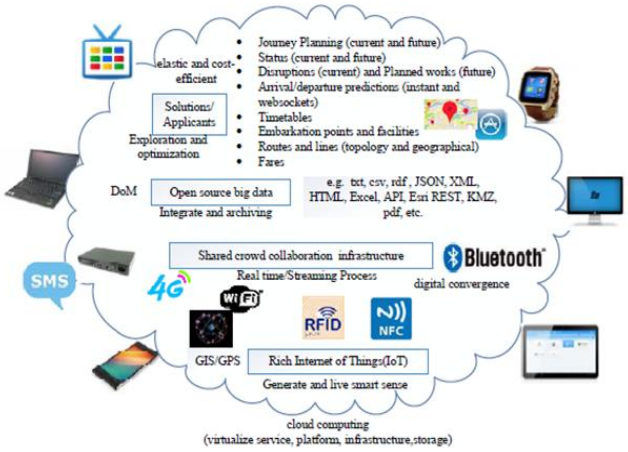


Fig.1. *Conceptual framework of urban smart transport based on cloud and IoT [1]*

1.1 Route Map for Deploying Big Traffic Data on the Cloud

Within the tendency of asset-light, cloud computing with certain service-level agreement is under consideration. The term "moving to cloud" also refers to an organization moving away from a traditional capital expenditure model (buy the dedicated hardware and depreciate it over a period of time) to the operating expense model (use a shared cloud infrastructure and pay as one uses it). Fig. 2 represents big open traffic data on cloud with IoT infrastructure, illustrated with the available options at each level. When generated, big data is transferred in real time with streaming process through communication network (such as Bluetooth, Wi-Fi, 4G) to be stored (e.g. MongoDB), which usually is combined with ETL (Extract, Transform and Load) process. Harry Strasser's vision is for a connected world and digital (technological) convergence where everything in people's life will have computing power, wireless connectivity and many smart sensors [1].



Notes: DoM (Document Object Model); Esri REST (Representational State Transfer); KMZ (Google Earth Placemark File)

Fig.2. *Cloud framework for utilizing open traffic data based on multilayered IoT [1]*

2. Public Transport and Cloud Technologies

Public transport especially buses are getting crowded day-by-day due to heavy demand of transport facility. Moreover the frequency of the buses are not well regulated. Either the buses lines up at one time or buses get delayed for a long time. This kind of chaos is mainly due to irregular planning of bus intervals and not knowing the details of the amount of passengers expected at a time. A system is necessary in which the number of passengers at a bus stop can be calculated and the bus service can be regulated depending on the passenger's arrival. Cloud is the best platform to implement this system as the storage is dynamic in cloud and interface can be easily provided to people using IaaS.

For many years, the transportation industry has been exchanging information, such as passenger counts and vehicle diagnostics, through a local network. Using cloud services to store fleet data may be where web-based capabilities can have the biggest effect in the transportation industry.

Many vendors provide online hosting or software-as-a-service (SaaS) models to transportation organizations. SaaS essentially allows the customer to rent the software and access it online for a monthly fee. While these tools can benefit the business side of the transportation industry, the real value comes when the cloud intersects directly with fleet management devices. By passing SaaS and simply passing data directly from the device to the cloud saves time and also money.

It typically takes months or even years to plan, procure and deploy IT infrastructure to connect embedded transportation devices to the network and capture valuable data. Transportation agencies (such as the Center for Public Mobility in Bulgaria, i. e. CGM) use GPS devices, passenger counters, fare collectors and other devices to capture key data. Traditionally, these devices are plugged into a hard-wired Internet connection, and the data is downloaded onto a local PC connected to a network. The data is downloaded at specified intervals, such as each night or once per week. Very often the data is either never used or analyzed once per month or even once per year to make service changes.

The device cloud is a term to describe how organizations can bring data from device to business application with an integrated solution to turn bits of data into valuable and actionable information. By storing device data in the cloud, both public and private transportation agencies can access data in real-time.

The device cloud is also scalable, secure and many times more cost-effective than traditional infrastructure for transportation IT departments. As cloud computing becomes more mainstream, transportation agencies are evaluating whether a cloud solution can be an efficient alternative to traditional computing networks.

Storing transportation data in a central online location can be more efficient for transportation agencies. Currently, agencies collect various measurements (as the travel time and fare collection). Then, multiple departments and employees manage each of those measurements and create reports for managers to compare and contrast data.

When all of these measures are stored in the cloud, transportation executives can access the data anytime and anywhere through a secure online portal. They can create a custom dashboard that pulls only the data they need, and they can look at the fleet over the past week, or even since they began storing data in the cloud. This concept goes beyond simply gathering the various databases into one location — a device cloud solution instead pulls the data directly from the devices (fare collection, GPS, etc.) and into one central cloud database [2].

Connecting transportation devices to the cloud proves invaluable in analyzing data. For example, consider a standard bus with the following systems: a camera, fare collection, passenger counting, WiFi and GPS. Suppose the transportation agency holds a board meeting and wants to justify the free Wi-Fi it offers to customers. Next, the general manager asks his employees for a few reports on fare collection and passenger counts to justify the free Wi-Fi.

Under the old technology, each of these data points is provided by different software and different vendors. Multiple employees collect the data and deliver it to the general manager, who then analyzes it and presents the results to the board. Each report is slightly different since they are not integrated, and the general manager then spends his or her time comparing the reports to determine if the number of users and the fares collected justifies the free Wi-Fi.

With a cloud computing infrastructure, the cloud service can pull information from all of the databases together into one simple and secure dashboard. At any moment, the general manager can generate a report containing both fare collection and passenger counting with a single click.

There are operational efficiencies to be gained from cloud computing to eliminate the hours of recurring time used to generate the same reports month after month and year after year. Using Cloud also makes it possible to take quick decisions. In addition to increasing efficiency with a simple dashboard, cloud computing can also provide the benefit of more immediate, near real-time data. Since data is sent to the cloud almost continuously, managers can see realistic snapshots at any moment.

For example, suppose a major snowstorm hits New York City. The transportation agency wants to know not only where all of the buses are, but how many people are on each bus. Instead of relying solely on GPS data to find the bus locations, the agency can also get accurate data on how many passengers are on each bus. If one bus were to go missing, they would quickly know exactly how many passengers to look for and be better prepared to handle any emergency situation.

Another example is with the high prices of gas. Gas prices are already high, but suppose a natural disaster caused them to skyrocket in a night. The transportation agency needs data fast in order to shorten routes and save fuel. Instead of having to wait weeks or even months to adjust routes, the agency can see an accurate snapshot of routes and usage and make quick changes.

3. Bus Management System Using Cloud Platform

Let take a look at a Regulating Bus Management System using Cloud platform that is going to be used in the near future.

The existing system of the public transport system has not been properly scheduled in most of the countries which leads to overcrowding of passengers in buses. This problem of crowding is mainly due to the unplanned bus management system. Bus transport system does not accounts for the total number of passengers in the bus stop. One problem might be the calculation of the total number of passengers at a stop and regulating the bus service accordingly using dynamic resource allocation in cloud. This can be implemented using Windows Azure. Azure has capacity to handle data outburst.

There are many tracking systems to monitor the traffic flow like taxi tracking in Melbourne, Brisbane and Adelaide used to get the closest free taxi to a waiting customer. Bus tracking systems are already in use in Perth and Adelaide, but they are used to help customers know when bus is due to arrive. The public transport management system could indicates the delay in bus timing as well as when the bus load is full.

However, this method does not take into account the number of passengers boarding and departing in the initial stage and hence regulating the transport becomes a difficult task [3]. The Transit Management System is used in advanced public transport systems. They mainly focus on Fleet Management, Traveler Information, Electronic Fare Payment and Transportation Demand Management. The automatic vehicle identification helps only in monitoring the vehicle and not the passengers count. The Transport Asset Management System has a great disadvantage of manual entry of the data which is prone to high error in the data entered. Bus management system with comprehensive CAD/AVL (Automatic Vehicle Location) passenger information system satisfies the major need of monitoring the bus routes in an efficient way, but they mainly suffer from high cost and they fails in performance when the population is more. All the above disadvantages can be sorted out by the system which uses cloud computing to monitor passenger population and regulate the frequency of the buses.

The proposed system [3] has the following objectives: to find the passenger population in bus stops using message service and online bus pass; regulate the bus frequency depending on the passenger population; create software in cloud to calculate the passenger population and regulate the buses by redirecting more buses to highly populated stops and reducing the bus flow to less populated stops by intimating the transport authority; allocating the resources properly in cloud by using gossip protocol; using GPS system with the cloud to find the delay in buses and inform the passengers through their cell phones. The following algorithm could be used to calculate the passenger count in a stop [3].

- Bus pass holders register their source and destination in online through the interface provided to them as shown in Fig 3.
- Ad-hoc users are requested to send a message with the source, destination and time frame prior to the time of journey to the cloud software.
- The software in the cloud evaluates the request and intimates the passenger with the bus number.
- If the passenger goes late to the stop or early to the stop the passenger is requested to send a message to the cloud software.

The following algorithm is incorporated to intimate the passenger with the bus number and regulate the buses based on population at a stop as shown in Fig. 4. [3]

- The software in the Cloud Middleware gets the data of the source, destination and time frame request from the passengers and calculate the number of boarding and departing passengers at each stop based on the data present in the tables which is updated automatically based on the request of Ad-hoc passengers and bus-pass holders during registration.
- Then, the system checks whether there is any empty seats available in the bus based on the conductor information at each stop.
- If the seats were empty, the regular schedule of buses is followed.
- Else, the system instructs the addition of new bus to the route to the Transport Department.
- The passengers are informed with the bus number after validation of the seat availability in the bus through a particular route.

***Fig.3**. Flow chart of the proposed system [3]*

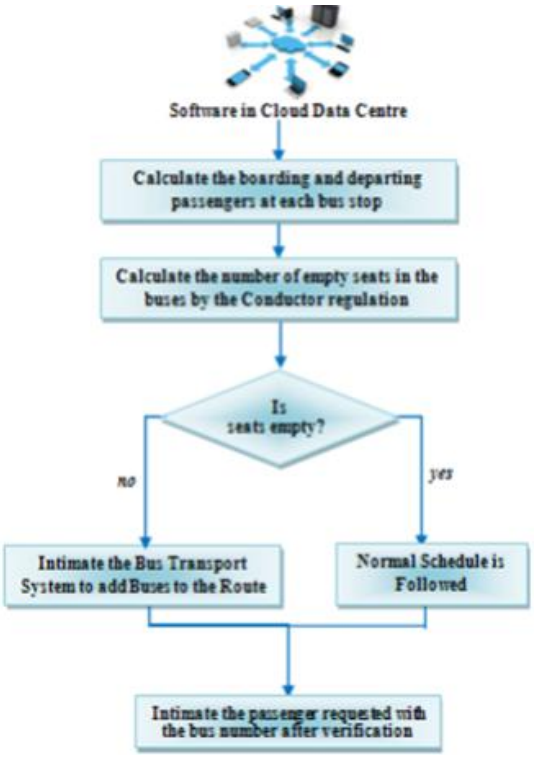


***Fig.4**. Function of software in cloud data center [3]*

4. The Ways Cloud is Changing Transportation

Some ways that Cloud is changing transportation are as follows [4].

- Self-Driving Cars: Late in the summer of 2016, Uber rolled out its first self-driving car fleet in Pittsburgh, ushering in a new era of transportation. While retail self-driving cars will not hit the road for another half-decade, this innovation was important because of how everything connects back to the cloud. As the future envisions robots driving instead of humans, cloud computing will support these initiatives to offer the best directions, collision avoidance, and onboard entertainment to help drivers pass the time. Finally, car ownership will diminish as more individuals choose self-driving vehicles to offset the cost of insurance and gas.

- Airline (and Train/Boat) Availability: While Uber was rolling out self-driving cars, other airlines were experiencing unfortunate downtime. Airlines must figure out ways to reduce delays and offer faster updates to their customers through continuous deployment applications such as IBM *UrbanCode* or through the leveraging of APIs within *Bluemix* (the IBM cloud platform). *UrbanCode* Deploy is an application release automation solution that combines robust visibility, traceability and auditing capabilities. It allows to seamlessly deploy to distributed data centers, cloud and virtualized environments - on demand or on a schedule. With a greater reliance on cloud technologies, customers can enjoy better uptime and service so they can get to their destinations on-time and without exhaustion. This will extend to other forms of transportation including trains, boats, and buses.

- Traffic Lights: We all know the dreaded feeling of multiple traffic lights in a row. Not only is the experience annoying, but we end up getting to our destination a half hour later than expected with a cramp in our leg from hitting the brakes. Coupled with self-driving cars, the all-red trip will be a thing of the past with cloud-optimized trip tracking and notifications. Not only will we hit green lights (most of the time), but people will have the feeling a lot more relaxed pulling up to their destination.

- Traffic Congestion: The rise of self-driving cars will effectively eliminate traffic congestion as the vehicles will communicate with each other, reducing the needless braking and cutting off that have made driving so aggravating. The only thing remaining will be how these cars drive on aging infrastructure.

- Entertainment: As cars become self-driving and reliant on the cloud, passengers will need more to keep themselves occupied. For the business person, this presents an opportunity to use productivity applications while families may take the extra time to learn or watch a movie. Everything that you see now on your mobile devices will now appear in the cloud, creating an even more connected experience that consumer brands can tap into.

5. Cloud and the Airline Transport Industry

In addition, let review the Airline Industry in the Amazon (AWS) Cloud.

The airline industry has always been ripe for technological innovation. Areas such as flight optimization and predictive maintenance, along with the large amounts of data generated from bookings and reservation systems, provide an opportunity to accelerate aviation's digital transformation through analytics-based applications and large-scale integration in the cloud.

The benefits of the cloud for the airline industry are clear. Cloud computing can be used in the airline industry in a variety of ways, including estimating travel times, identifying aircraft, emission controls, traffic modeling, integrating fare management and increasing effectiveness of customer loyalty programs.

Cloud computing also provides airlines with a highly scalable infrastructure as well as availability and innovation. When it comes to availability for example, airlines can store their availability data in the public cloud. This data can then be accessed by an airline's website, a travel agency or other source. Carriers can then manage this availability for the different channels through a single source.

Amazon Web-Services (AWS) gives airlines the opportunity to leverage the benefits of the cloud for application development, deployment and management – and for managing the mass amounts of content and data that these carriers hold. Understanding these challenges, airlines such as LOT Polish Airlines, GOL Airlines, and Qantas have all recently turned to AWS cloud services for their data needs.

To comply with industry regulations, airlines can also use the Amazon Shared Responsibility Model to help cover companies on the physical security of their data center. As well, they can use Amazon Redshift to provide database encryption for clusters and help protect data at rest. When customers enable encryption for a cluster, Amazon Redshift encrypts all data, including backups, by using hardware-accelerated Advanced Encryption Standard (AES)-256 symmetric keys. To run robust operations on top of Amazon, including, for example, complete control over security groups' configuration, airlines can automate their AWS backup and recovery across accounts with the ability to keep multiple replicas of the data across AWS regions. [5]

6. Conclusion

Cloud computing is in the early adoption state in the transportation industry. This new form of computing is perfect to provide solutions to a host of business problems within large and small organizations as well as the public transport. Proven solutions are available and ready to be deployed. By implementing cloud technologies, the daily life of people will become less tense and troublesome, also the transportation industry can begin to embrace this trend so prevalent in the business world today.

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