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Research paper

Self-Sustainable Intelligent Transportation System

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Abstract

Intelligent Transportation Systems (ITS) today have a significant impact on community's well-being and satisfaction. It coordinates traffic movement and manages the capacity of highways and freeways by ultimately minimizing congestions and travel times. The amount of traffic data generated from these systems is increasing dramatically. This creates new challenges for data transmission, storage, and retrieval. Existing big-data solutions addresses such issues and provides real-time services of processing, storing and retrieving the data. Many technologies have emerged to make the best use of big-data solutions in combination with cloud computing technologies. Integrating these technologies within the ITS is a key objective of this research in addition to other objectives including maintaining secure transmission to preserve data integrity and to guarantee self-sustainability for autonomous error and failure recovery. The framework of the proposed module includes a multi-stage approach. The first stage is data acquirement from real-time sensors or monitoring devices such as traffic cameras. The second stage is to develop a pre-processing algorithm that process the acquired data and convert it to a proper format for cloud storage and transmission. The final stage is represented by cloud operations and services which include big-data analytics that ultimately delivers valuable information to the system which can manage or predict traffic congestions and queues. Inevitably, the system is put into testing stage to evaluate the results and how it conforms to the objectives of this research**.**

Keywords: *Self-Sustainable, Intelligent, Transportation System*

1. Introduction

Savvy transportation framework enhances data innovation to transportation foundation and vehicles, meaning to oversee vehicles, heaps and courses to enhance wellbeing and lessen vehicle wear, transportation times and fuel costs. These frameworks, depend on broad correspondence and brought together data preparing, they are capital serious, inclined to disappointments and require the executives of the correspondence arrange.

Also, continuous traffic observing and early line discovery is of noteworthy significance in any ITS which is executed by utilizing dispersed traffic checking on a vast scale, in view of non-nosy arrangements that are exceedingly attractive for traffic checking. In this manner, such frameworks will be mind boggling, requiring vast capacity, higher correspondence data transfer capacity and bigger preparing time which requires immense capital speculations and upkeep costs.

Ordinary traffic observation frameworks make utilization of meddlesome sensors, for example, inductive circle identifiers or weight sensors for their high precision in vehicle location. Nonetheless, these sensors upset traffic amid establishment and fix, and thusly have high establishment and upkeep costs. These restrictions have pushed towards the advancement of non-meddlesome traffic observing innovations including laser radars, latent infrareds, ultrasonic, aloof acoustic clusters and camcorders (Kher, et al., 2002).

ITS information gathering innovations have created monstrous measures of information to enhance transportation framework execution. Numerous arrangements were informed in regards to the administration and capacity with respect to the information produced by the ITS, for instance information pressure, none the less these arrangements are viewed as not proficient while considering expansive scale organization of ITS gadgets and the tremendous development of information volume, assortment and speed.

These measures of gathered ITS information has made deterrents for compelling information stockpiling, transmission and recovery. The vast majority of ITS circle finders or sensors gather traffic speed, volume and inhabitance information more than once at a short successive interims, for example, 25 or 30 seconds (Turner, 2001), thinking about the immense number of indicators and their day in and day out consistent activity, notwithstanding the live video streams from reconnaissance cameras, these information will surge into traffic the executives focuses (TMC) at a high rate then the information should be handled and arranged for online remote access or ongoing administration by clients not working in the TMC's themselves.

Enormous information examination requires uncommon advances to viably process expansive amounts of information with bearable passed times. Innovations being connected to enormous information incorporate hugely parallel handling databases, information mining matrices, conveyed document frameworks, disseminated databases, distributed computing stages, and versatile stockpiling frameworks

(Hurwitz, et al., 2013).Reasonably, real-time information delivery is one of the defining characteristics of big data analytics. Latency is therefore avoided whenever possible (Zhang, et al., 2007). Cloud servers on the other hand, basically offer big data processing services that are designed to create data pipelines that ingest, transform and analyze this data. This form of distributed processing minimizes the cost and time of data processing and transmission at large scale transportation systems.

This research proposes the design and development of distributed big-data ready traffic monitoring system using wireless cameras as a non-intrusive traffic processing units, which will be equipped with on-board applications that process and transmit the acquired data securely to a cloud server while considering the objectives of the research including distributed processing to maintain sustainability, maintain secure transmission at all nodes and to focus on real-time big data recovery and delivery.

The main concern regarding the design of a real-time traffic monitoring system is the efficient performance of the system when it involves large cumulated data received from the underlying sensing and monitoring devices.

To transmit the aforementioned big data in a communicating network it will require state of the art technologies that can handle communication load and error recovery as well as system sustainability.

This big data, is transmitted simultaneously from different traffic monitoring devices, cameras for instance, to a central storage location which can be identified as the traffic management center (TMC).

Henceforth real time video monitoring of traffic whether on highways or urban areas requires transmission of large data streams back and forth to TMC's which will probably overload the traffic communication network.

The cost of installation of the above required network devices and technologies are very high when considering the size of the data being transferred, reliability and security of transmission medium, as that latter is considered to be an error prone, more advanced security protocols and encryption algorithms are needed.

This work aims to design or integrate a self-sustainable traffic monitoring system capable of continuous operation with auto failure recovery adapted in a distributed environment. And additionally, to develop a software algorithm capable of processing large data acquired from traffic cameras, stand-alone or built in within the cameras which will tremendously minimize the data being transmitted to the traffic monitoring center. This is achieved by the development of a secure transmission protocol that includes an encryption and decryption algorithms for the transmitted data. The encryption of smaller data is much faster than the big data acquired by traffic cameras.

2. Related Work

Enormous information is definitely not another innovation that has been developed starting with no outside help, it is somewhat a creative methodology developed on past information the executives advancements to offer a superior information control administrations to clients and organizations. To see huge information, it is commonly portrayed as the information created by everything around us consistently, each computerized procedure and internet based life trade produces it. Frameworks, sensors and cell phones transmit it. Enormous information is touching base from various sources at a high rate, volume and assortment. To remove important incentive from enormous information, ideal preparing power, examination abilities and aptitudes are required.

For an increasingly exhaustive meaning of huge information, it tends to be characterized as the ability to oversee immense volume of divergent information, at the correct speed and inside the perfect time allotment to permit ongoing investigation and response.

For the motivations behind this exploration, information should initially be caught from various kinds of sources, for example, traffic sensors or cameras then these information must be composed, and incorporated then it very well may be investigated and controlled to create the ideal results. Fig.1 exhibits the cycle of huge information the executives (Hurwitz, et al., 2013).

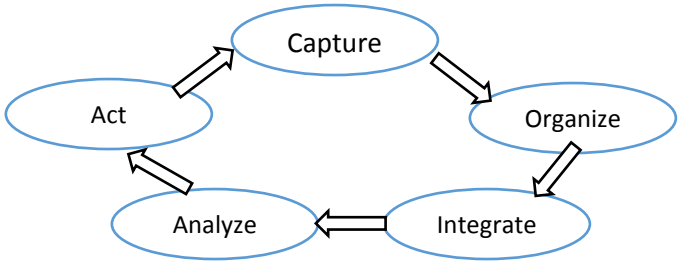

Fig. 1: The Cycle of Big Data Management

2.1.Big Data and Cloud Platforms

Enormous information and cloud innovation is weaved with regards to offering administrations. Enormous information needs bunches of servers for preparing, which mists can promptly give, what is consistently called "cloud" is basically virtualized servers which are fundamentally processing assets that presents itself as a standard server, rentable per utilization. This is for the most part called framework as an administration (IaaS), and is offered by various stages, for example, Rackspace Cloud or Amazon ECto 2. These administrations are accessible to be utilized, and designed by utilizing exceptional programming, for example, a Hadoop bunch or NoSQL database (Hurwitz, et al., 2013).

The Apache Hadoop programming library is a system that offers disseminated preparing of huge informational collections crosswise over bunches of PCs utilizing fundamental programming models. It was intended to be adaptable which can be utilized inside single server to a large number of machines, each offering neighborhood calculation and capacity. Rather than depending on equipment to convey high-accessibility, it was intended to identify and deal with disappointments at the application layer, so as to convey an exceedingly accessible administrations over a group of PCs, which might be inclined to disappointments (Ji, et al., 2012).

With connection to enormous information, a few design instruments as of now utilizing Hadoop expressly, among them Dell's (Crowbar, 2013), which intends to make conveying and arranging bunches straightforward, and Apache (Whirr, 2013), which is specific for running Hadoop administrations and other grouped information preparing frameworks.

Past (IaaS), a few cloud administrations convey application layer bolster for huge information work. Which is known as oversaw arrangements, or stage as an administration (PaaS), these administrations annihilate the need to design or scale things, for example, databases, lessening the outstanding burden and upkeep over load. Moreover, PaaS suppliers can understand extraordinary efficiencies by facilitating at the application level, and pass those funds on to the client (Ji, et al., 2012).

The present real suppliers of such huge information stage administrations are Amazon, Google and Microsoft, Table-1 beneath frameworks the administrations and abilities of every stage. Both Amazon Web Services and Microsoft's Azure have a blend use between framework as an administration and stage. On the other hand, Google's view point is to concentrate just on the idea of the application with no thought of utilizing servers.

2.1.1.Amazon Web Services

Amazon has a critical involvement in facilitating huge information preparing. Utilization of Amazon EC2 for Hadoop was a famous for some early huge information adopters, on account of Amazon's expandable supply of process control. As a result, Amazon propelled Elastic Map Reduce in 2009, giving a facilitated, adaptable Hadoop benefit (Hurwitz, et al., 2013). Notwithstanding Elastic Map Reduce, Amazon offers a few different administrations important to enormous information, for example, the Simple Queue Service for organizing circulated registering, and a facilitated social database benefit (Amazon, 2013). At the expert end of enormous information, Amazon's High Performance Computing arrangements are tuned for low-idleness bunch processing, of the sort required by logical and building applications.

2.1.2.Google Cloud Platform

Google's cloud stage has taken an alternate track for its innovation from its rivals. Rather than virtualization, it furnishes an application holder with characterized APIs and administrations. Engineers don't should be comfortable with the idea of machines, as applications execute in the cloud, gaining admittance to as much preparing force as they require, inside characterized asset utilization limits.
All things considered, to utilize Google's stage, it must be inside the limitations of its APIs, to have the advantages of its security, tuning and execution enhancements (Shakeel PM, et al., 2018), as it has been the manner in which Google builds up the majority of its administrations.

One of the applications, AppEngine, which is a facilitating administration inside Google's cloud, offers a MapReduce office for parallel calculation over information, however this is to a greater extent a component for use as a major aspect of complex applications instead of for explanatory purposes (Hurwitz, et al., 2013). Rather, BigQuery and the Prediction API shape the center of Google's enormous information offering, individually offering examination and machine learning offices (Google, 2014).

2.1.3.Microsoft Big Data Solutions

The Microsoft way to deal with enormous information has sponsored up the utilization of web applications under its Windows stage, and guaranteed its cloud benefits as a focused decision for information focused ventures. For extreme down to earth arrangement Microsoft approach is worried about interoperability instead of planning another structure for huge information, as recommended by different contenders, Microsoft is concentrating intensely on coordination.
Absorbed by Windows Azure notwithstanding Windows Server, Microsoft is giving its information stages to make either on preface or cloud-based improvements similarly practical with its innovation. Sky blue equivalents Amazon's web benefit contributions from multiple points of view, which is a blend of IaaS administrations with oversaw applications, for example, SQL Server.
Microsoft's settled on the decision to work with the Apache Hadoop people group, empowering the movement of new apparatuses and talented engineers to its stage (Jorgensen, et al., 2014). Hadoop is the center tech of Microsoft's huge information approach, encompassed by the biological community of its own database and business insight devices. Purplish blue will speak to the smoothest course to coordinate huge information into the activity. Sky blue itself is pragmatic about dialect decision, supporting distinctive dialects, for example, Java, and PHP notwithstanding Microsoft's own (Jorgensen, et al., 2014).

2.2. Real-time Traffic Prediction

With the wide utilization of traffic cameras, roadway sensors and GPS gadgets like cellphones, transportation offices are presently battling with a surge of huge information accessible to screen the status of vehicles' development.

The traffic information obtained by thruway specialists, can be imparted to voyagers through radio alarms, dashboard route frameworks, Web destinations and electronic street signs. This regularly called (Real-time) traffic refreshes used to pass on the direness of this data stream. The truth of the matter is, as a rule continuous traffic refreshes are simply not quick enough.

The proficient control of traffic on urban zones or turnpikes can give numerous advantages, including quicker voyage times, less toxin emanations, and diminished driver push. Moderately, to precisely anticipate the up and coming condition of traffic on a road, courses of action could be taken to predict blockage and its related negative effects.

Traffic estimation and forecast frameworks can possibly enhance traffic conditions and diminish travel delays by encouraging better usage of accessible limit. These frameworks misuse at present accessible and rising PC, correspondence, and control advancements to screen, oversee, and control the transportation framework. They likewise give different dimensions of traffic data and trek warning to framework clients, including numerous ITS specialist co-ops, with the goal that explorers can settle on convenient and educated travel choices.

2.2.1. IBM Traffic Prediction Tool

In thick urban territories, with regards to expansive limit roads, conventional development of new limit is cost-restrictive and frequently physically incomprehensible. The IBM traffic forecast device can give extraordinary esteem administrations to regions battling with traffic clog by conveying exact traffic expectations that can be utilized for enhancing transport tasks and arranging (IBM, 2013).

The traffic predication apparatus offers the way to create inventive traffic frameworks that utilizes verifiable traffic information and continuous traffic contribution from existing transport framework to conjecture traffic streams over pre-set lengths, for instance at regular intervals. It uses ongoing transportation information created by individuals traveling through the city utilizing their vehicles, trains and on transports. By incorporating the majority of this data, it very well may be dissected and utilized in better approaches to fabricate a more astute transportation framework.

Obtaining constant traffic information and utilizing it to enhance existing transportation frameworks can result in shorter travel times, better consumer loyalty and increment utilization of open travel frameworks, which at last can lessen carbon emanations.

This forecast instrument is viewed as exceptionally effective and can keep running on a medium-to vast size system continuously (IBM, 2013).

2.2.2. Singapore Intelligent Traffic Prediction System

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3. Method

This section presents the suggested framework and methods for this research, listing the design stages and the development of the software needed to integrate big data analysis and storage in addition to the implementation phase and testing of the obtained results. The research focuses on integrating the use of big data and cloud computing into intelligent transport system within distributed environment.

3.1. Framework and Methodology

The first step in the research would be to establish a framework for the ITS big-data acquirement which will be carried out using distributed infrastructure of sensing or monitoring nodes preferably wireless cameras, consequently the data is analyzed locally by performing pre-processing stage at each node. This amounts of processed data is then converted to another format to meet the requirements of size and security to be prepared for transmission to distributed cloud servers for storage and recovery. Accordingly, the cloud servers holding the stored data (Sridhar KP, et al., 2018) provides many services including analysis, manipulation and retrieval of this data at high speeds or in real-time which can be accessed from local site or traffic management centers TMC's. Figure-1 below demonstrates the block diagram of the proposed system.

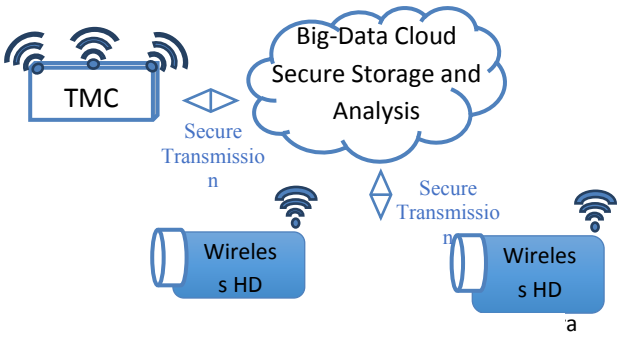

Fig. 2: Block Diagram of the Proposed System

3.2. Software Development and Integration

A software program is to be developed and designed to carry out and formulate the steps of the framework. The basic function of the program is to provide the algorithms needed to process the acquired data and convert it to a common format by using proper security ciphering to ensure reliability. Users should be able to input the ITS data file such as those acquired from traffic cameras, then the data are stored on a cloud server for further processing, analysis and recovery. The software need to embed big-data support within each system node for fast processing and streaming of the data. The cloud server may be designed from scratch or integrated to accommodate the research requirements.

3.3.Testing and Results Evaluation

To evaluate the proposed system as a whole and to test the corresponding developed software, operational test of all or part of the system is required (Shakeel PM, et al., 2018). A proper big-data source needs to be identified as it will feed the data in to the system for example real-time traffic camera. The acquired data will go through the system different stages, big-data analysis, pre-processing of the data and converting the data to a different common format before storing to the cloud servers. Subsequently, the results will be evaluated according to specific performance metrics required including storage and retrieval speed this requires the system to operate at real-time on near real-time basis, thus low latency is a merit. Additionally, secure transmission through the links is required, hence reliability is the second metric for evaluation. And above all distribution of the acquired data (Shakeel PM, et al., 2018) provides sustainability. Hence, the error recovery and data safety is of high importance as well.

4.Preliminary Work and Expected Results

In this section, all the work required to be carried out first is listed in addition to the expected outcomes of this research are stated.

4.1. Preliminary Work

The early stages of this research shall identify the required infrastructure including network topology, transmission protocols, and communication devices used. Additionally, on the virtual side, the distributed cloud shall be designed or integrated by using existing cloud servers' providers to meet all the requirements of the services needed to carry out the objectives of this research. The final data stored (P. Mohamed Shakeel, et al., 2018) in the cloud will be retrieved and analyzed by traffic management centers, traffic conditions are often simulated by using traffic simulators. The interface between sensors or event-triggered devices are developed

and ready to be integrated with the system.

4.2. Expected Results

The expected outcomes includes a software integration capable of processing big-data received from sensing nodes such as traffic cameras, which ultimately converted to a common data format for security and minimizing size purposes. The data will be receive from connected nodes in different location which support distribution and sustainability, this means the failure of one sensing device will not impact on the system as a whole but rather the node itself. The first two research objectives is attained at this point, as far the last objective a sophisticated ciphering algorithm is applied to the data being transmitted to ensure security and reliability.

5. Conclusion and Summary

This research is focusing on integrating big-data and cloud computing into intelligent transportation systems. Current ITS's are deployed on large-scale basis, it exists in various locations of the city whether on highways, freeways and high density urban areas. The amount of data acquired is very large and includes valuable information to help traffic management such as volume, speed and road capacity. This large amount of information is applied to big-data solutions which basically use every piece of information and process to deliver end user services that can help predict and handle traffic congestions in real-time or even before it happens.
As for cloud computing, it actually works best with big-data analysis as it provides the required services at very high speeds with minimum latency and maximum accuracy, and since cloud servers operates virtually in a distributed environment, it actually delivers self-sustainability to the system. Additionally, cloud servers minimizes the need for sophisticated network infrastructure, in which the ITS data will flood and over load the entire network. By designing an encrypted data storing facility which provides data integrity the acquired data is safely stored into and retrieved from the cloud servers.

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