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Developing Data Cloud Services in Various Environments

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ABSTRACT:

The advances in cloud computing and internet of things (IoT) have provided a promising opportunity to resolve the challenges caused by the increasing transportation issues. We present a novel multilayered vehicular data cloud platform by using cloud computing and IoT technologies. Two innovative vehicular data cloud services, an intelligent parking cloud service and a vehicular data mining cloud service, for vehicle warranty analysis in the IoT environment are also presented. Two modified data mining models for the vehicular data mining cloud service, a Naïve Bayes model and a Logistic Regression model, are presented in detail. Challenges and directions for future work are also provided.

Index Terms:

Automobile service, cloud computing, internet of things (IoT), intelligent transportation systems (ITSs), service-oriented architecture (SOA).

INTRODUCTION:

MODERN VEHICLES are increasingly equipped with a large amount of sensors, actuators, and communication devices (mobile devices,GPS devices, and embedded computers). In particular, numerous vehicles have possessed powerful sensing, networking, communication, and data processing capabilities, and can communicate with other vehicles or exchange information with the external environments over various protocols, including HTTP, TCP/IP, SMTP, WAP, and Next Generation Telematics Protocol (NGTP) [1].

As a result, many innovative telematics services [2], such as remote security for disabling engine and remote diagnosis, have been developed to enhance drivers' safety, convenience, and enjoyment. The advances in cloud computing and internet of things (IoT)have provided a promising opportunity to further address the increasing transportation issues, such as heavy traffic, congestion, and vehicle safety. In the past few years, researchers have proposed a few models that use cloud computing for implementing intelligent transportation systems (ITSs). For example, a new vehicular cloud architecture called ITS-Cloud was proposed to improve vehicle-to-vehicle communication and road safety [3].

Existing System:

A cloud-based urban traffic control system was proposed to optimize traffic control [4]. Based on a service-oriented architecture (SOA), this system uses a number of software services (SaaS), such as intersection control services, area management service, cloud service discovery service, and sensor service, to perform different tasks. These services also interact with each other to exchange information and provide a solid basis forbuilding a collaborative traffic control and processing system in a distributed cloud environment. As an emerging technology caused by rapid advances in modern wireless telecommunication, IoT has received a lot of attention and is expected to bring benefits to numerous application areas including health care, manufacturing, and transportation [5]–[8].

Proposed System:

Currently, the use of IoT in transportation is still in its early stage and most research on ITSs has not leveraged the IoT technology as a solution or an enabling infrastructure. To this end, we propose to use both cloud computing and IoT as an enabling infrastructure for developing a vehicular data cloud platform where transportation-related information, such as traffic control and management, car location tracking and monitoring, road condition, car warranty, and maintenance information, can be intelligently connected and made available to drivers, automakers, part-manufacturer, vehicle quality controller, safety authorities, and regional transportation division. An experiment of using data mining models to analyze vehicular data clouds in the IoT environment was also conducted to demonstrate the feasibility of vehicular data mining service.

RELATED WORK:
Vehicular Networks:

Wireless technology leads to the development of vehicular networks in the past decades. The original idea is that the roadside infrastructure and the radio-equipped vehicles could communicate using wireless networks. To make networking operations such as routing more effective, researchers had developed a dynamic inter-vehicle network called vehicular ad-hoc networks (VANET). VANETs were primarily designed to support the communication between different vehicles (V2 V) and the communication between vehicles and the roadside infrastructures (V2I) [9]. VANETs possess hybrid architecture and integrate ad hoc networks, wireless LAN, and cellular technology [10] for ITS. Furthermore, many VANET applications were developed by numerous vehicle manufacturers, government agencies, and industrial organizations. Initially, most VANET applications were focused on improving drivers' safety and offered functions such as traffic monitoring and update, emergency warning, and road assistance [11]. In recent years, many nonsafety-related VANET applications, such as entertainment and gaming applications, have been developed.

Cloud Computing in the Automotive Domain:

Cloud computing has been proposed to reshape vehicular software and services in the automotive domain. As more and more cars are equipped with devices that can access the internet, Olariu et al. [11] propose to integrate existing vehicular networks, various sensors, on-board devices in vehicles, and cloud computing to create vehicular clouds. They suggest that vehicular clouds are technologically feasible and will have a significant impact on the society once they are built. Thus, both existing automobile software and a variety of information resources are being virtualized and packaged as services to build vehicular clouds. Different vehicular services are often combined and used to implement the mapping, encapsulation, aggregation, and composition and allow vehicles to interact with various hosted services outside the vehicles. Currently, using the modular approach, multilayer and SOAs to integrate various vehicular resources and services appears to be the most promising model and framework for building vehicular cloud service platforms. By using the modular approach to decompose a complex system into smaller subsystems according to their functions, we can divide a vehicular cloud service platform into a number of functional services and subsystems such as traffic administration, service routing, information processing, vehicle warranty analysis and mining, etc.

As cloud computing includes three distinct services—platform as a service (PaaS), infrastructure as a service (IaaS) as well as the popular software as a service (SaaS), a compound of SaaS, PaaS, and IaaS should be leveraged for building vehicular cloud service platforms. Furthermore, clouds can also be divided into private, public, and hybrid clouds. Thus, vehicular cloud service platforms can also be designed to be a hybrid cloud where some services, such as user information query, can be hosted on public cloud platforms and other missing-critical services, such as traffic administration, should be hosted on private cloud platforms [12]. A taxonomy was developed to classify VANET-related clouds into the followingthree types: 1) vehicles using clouds; 2) vehicular clouds; and 3) hybrid clouds [13].

IoT in the Automotive Domain:

The integration of sensors and communication technologies provides a way for us to track the changing status of an object through the Internet. IoT explains a future in which a variety of physical objects and devices around us, such as various sensors, radio frequency identification (RFID) tags, GPS devices, and mobile devices, will be associated to the Internet and allows these objects and devices to connect, cooperate, and communicate within social, environmental, and user contexts to reach common goals [24], [25]. As an emerging technology, the IoT is expected to offer promising

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solutions to transform transportation systems and automobile services in the automobile industry. Speed and Shingleton [26] propose an idea to use the "unique identifying properties of car registration plates" to connect various things. As vehicles have increasingly powerful sensing, networking, communication, and data processing capabilities, IoT technologies can be used to harness these capabilities and share under-utilized resources among vehicles in the parking space or on the road. For example, IoT technologies make it possible to track each vehicle's existing location, monitor its movement, and predict its future location.

PROPOSED VEHICULAR DATA CLOUD PLATFORM IN THE IOT ENVIRONMENT:

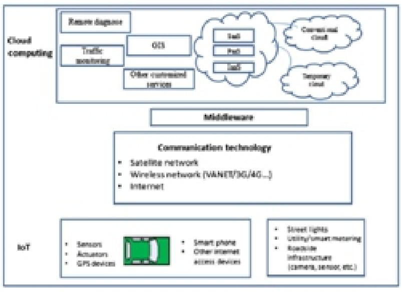

Fig. 1. Architecture for IoT-based vehicular data clouds.

Fig. 1 shows the layered architecture of our proposed IoT-based vehicular data cloud platform. By integrating various devices such as sensors, actuators, controllers, GPS devices, mobile phones, and other Internet access equipments, and employing networking technologies (wireless sensor network, cellular network, satellite network, and others), cloud computing, IOT, and middleware, this platform supports V2 V and V2I communication mechanisms and is able to collect and exchange data among the drivers, vehicles, and roadside infrastructure such as cameras and street lights. The goal of this platform is to provide real-time, economic, secure, and on-demand services to customers through the associated clouds including a conventional cloud and a temporary cloud (vehicular cloud) [3]. The conventional cloud is composed of virtualized computers and provides SaaS, PaaS, and IaaS to interested customers. For example, cloud management services and many traffic administration applications can be hosted on the conventional cloud.The temporary cloud is typically formed on demand and is composed of under-utilized computing, networking, and storage facilities of vehicles and is designed to expand the conventional cloud in order to increase the whole cloud's computing, processing, and storing capabilities. The temporary cloud supports a compound of SaaS, PaaS, and IaaS and primarily hosts highly dynamic vehicular applications which may have issues running on the conventional clouds [26]. For example, traffic-related applications and smart parking applications are suitable for the temporary cloud. The temporary cloud often needs to communicate with the conventional clouds and there is a frequent exchange of data and services between the two clouds [13]. Based on the layered architecture in Fig. 1, heterogeneous IoT-related devices, network, community technologies, and cloud-based services on different layers can be integrated to exchange information, share resources, and collaborate on the clouds.

VEHICULAR DATA CLOUD SERVICES:
Intelligent Parking Cloud Service:

Finding available parking space is challenging in many cities and often leads to issues such as congestion, road accidents, and psychological frustration. To make it easier to find available parking space, an intelligent parking cloud service that collects and analyzes geographic location information, parking availability information, parking space reservation and order information, traffic information and vehicle information through sensor detection and the clouds is needed. Using a modular approach, a software architecture [31] for implementing the intelligent parking cloud service is proposed in Fig. 2.

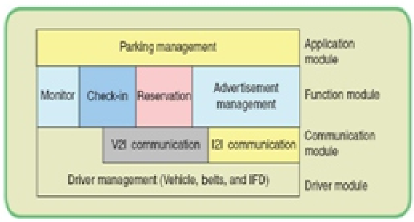

Fig. 2. Software architecture for intelligent parking cloud service.

Each vehicle is pre-enlisted with a transceiver with short transmission range (about 1 m) and a processor with simple computing capacity. The transceiver can be common devices, such as zigbee, bluetooth devices, and infrared devices, with low cost. Both the processor and the wireless transceiver are enlisted into an event data recorder (EDR).Wedesigned a parking lot with WIFI network, infrared devices, and parking belts to detect misparked cars. When a car enters the parking lot and heads to the reserved parking slot, the entrance booth will validate the reservation.

If the parking spot is validated, a direction-related guidance will be uploaded to the car for finding the reserved spot. The infrared device, lights, and parking belt will work together to detect and prevent misparking.

Mining Vehicular Maintenance Data Service:

Another application that we are interested in the proposed vehicular data cloud is to mine maintenance data. Maintenance of vehicles are frustrated and heavily loaded for drivers. More importantly, auto-manufacturers and auto-parts designer and manufacturers also desperately seek feedback from end users to improve the quality of producers and enhance competition capability to the foreign auto-makers. We can merge maintenance data from both users and repair people.The merged data are nature language text descriptions of maintenance. We place these texts into main files. To dig out auto-parts warranty information, we adopt nature language text mining technologies to these merged texts. As an emerging research area, currently limited studies have been published regarding how data mining techniques could be applied to vehicular networks or clouds. Few models were developed and tested for mining vehicular data collected from vehicular networks or data clouds.

CHALLENGES AND DIRECTIONS FOR FUTURE WORK:

IoT-based vehicular data clouds must be efficient, scalable, secure, and reliable before they could be deployed at a large scale. Existing algorithms and mechanisms are unsatisfactory to meet all these requirements at the same time. Below is a description of some of these challenges. 1) Scalability and technology integration: The effectiveness of a vehicular cloud depends on its scalability to handle a dynamically changing number of vehicles. In addition to handling regular traffic, vehicular clouds must be able to handle traffic spikes or sudden demands caused by special events or situations, such as sport games or emergencies. More development on optimization algorithms that coordinate virtual machines, storage space, and network bandwidth to balance server workload and improve computing resource utilization on the vehicular clouds is needed [39]. As new devices and technologies are coming out each year, developing effective IoT Middleware that supports integration of these new technologies and devices [40] with existing in-vehicle technologies from automobile manufacturers will be a challenge.

2) Performance, reliability and quality of service: As vehicles are often on the move, the vehicular networking and communication is often intermittent or unreliable. More new mechanisms are needed to enhance the communication reliability with reduced traffic overhead. For example, Chen et al. [41] developed a new transmission protocol to make the conventional Zigbee protocol more reliable.Cross layer data synchronization mechanisms should also be designed to minimize the traffic overhead between layers. Acceleration data compression algorithms for resource-constrained sensors, actuators, and other Internet-access devices need improvement to be able to effectively and efficiently compress a large amount of raw data generated. Multiple processing units and support in different cloud data centers are needed to minimize the service response time, improve availability and stability of the service, and increase cloud reliability and fault tolerance. Real-time evaluation mechanisms regarding the performance, reliability, and service quality on vehicular data clouds will have to be further developed.

3) Security and privacy: There are some security and privacy concerns with vehicular data clouds due to a lack of established infrastructure for authentication and authorization [39]. A low security level of vehicular data clouds is unacceptable for vehicular services regarding transportation safety. For example, roadside attackers may maliciously send many fake requests to the parking cloud service and reserve many parking spaces. They can also send misleading parking availability information or wrong location information to the parking cloud service to cause chaos. Trust relationships are hard to be built in vehicular clouds because of the large and dynamically changing number of vehicles on the road. Balanced security measures are needed to enhance the security and trust of cloud services without limiting the flexibility of the system. In addition, many drivers do not want their vehicle locations to be tracked or monitored due to the worries about their privacy.

Reasonable efforts in technology [42], law, and regulation are needed to secure the vehicular data clouds and prevent unauthorized access to or disclosure of the privacy data. For example, implementing security authentication in vehicular data clouds is required security countermeasure.4) Lack of global standards for device and service integration, security, privacy, architecture, and communications:Global standards are essential to avoid conflicts between locally developed vehicular data clouds [27].

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However, as there are a number of stakeholders involved in vehicular data clouds, and complex dependencies among these stakeholders also exist, it is challenging to establish global standards to lower the complexity and make vehicular data clouds more compatible and cost effective. Further efforts on standardization are needed to coordinate various efforts and resources for implementing vehicular data clouds.

CONCLUSIONS:

In this paper, we present a novel modular and multilayered vehicular data cloud platform based on cloud computing and IoT technologies. We also discuss how cloud services could be developed to make the vehicular data clouds useful. This study makes contributions by proposing a novel software architecture for the vehicular data clouds in the IoT environment, which has the capabilities to integrate numerous devices available within vehicles and devices in the road infrastructure. IoT-based vehicular data clouds are expected to be the backbone of future ITSs with the ultimate goal of making driving safer and more enjoyable. However, research on integrating IoT with the vehicular data clouds is still in its infancy and existing study on this topic is highly insufficient. To make vehicular data clouds useful, numerous services, such as road navigation, traffic management, remote monitoring, urban surveillance, information and entertainment, and business intelligence [43]–[47], need to be developed and deployed on vehicular data clouds. A number of challenges such as security, privacy, scalability, reliability, quality of service, and lack of global standards still exist. Due to the complexity involved in implementing vehicular clouds and integrating various devices and systems with vehicular clouds [48]–[51], a systematic approach and collaboration among academia, the automobile companies, law enforcement, government authorities, standardization groups, and cloud service providers are needed to address these challenges. Though with many challenges, IoT and cloud computing provide tremendous opportunities for technology innovation in the automobileindustry [52], [53] and will serve as enabling infrastructures for developing vehicular data clouds.

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