A Prospective Cloud-Connected Vehicle Information System for C-ITS Application Services in Connected Vehicle Environment

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Abstract. In the era of the Internet of Things (IoT), various applications providing people with utilities are rapidly emerging by the needs for people. Recently, combining cloud computing, IoT technologies, and vehicular applications promotes Intelligent Transportation System (ITS). In other words, this is for safety of vehicles and drivers as well as convenience of the drivers. Vehicular Ad-hoc Network (VANET) is an application of Mobile Ad-hoc Network (MANET), which is a networking technology including vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) using wireless communications. In real life, vehicles and infrastructures which have a lot of sensors generate various data for Cooperative-Intelligent Transportation System (C-ITS) application services according to each sensor type. Therefore, collecting, processing, and storing a number of data generated from various sensors built in vehicles and infrastructures require a great computing capacity and storage resources. In this paper, we propose an architecture of prospective cloud-connected vehicle information system for C-ITS application services in connected vehicle environment and describe the procedure of our local and global vehicle information system concerned with case scenario.

Keywords: IoT · ITS · C-ITS · Vehicular network · VANET · V2V · V2I · Cloud computing · Connected car · LDM

1 Introduction

With advanced IT technologies in the cloud computing era, Internet of Things (IoT) allows to design and devise a wide range of applications in a number of different ways. Recently, this flow meets increasing interests in amazing future vehicle system so that a wide variety of vehicular applications is used for Intelligent Transportation System (ITS) such as automatic driving. This allows ITS to guarantee safety for vehicles and drivers or convenience on driving for drivers, ease traffic congestion, and mitigate environmental pollution, which can be realized by implementing IoT framework in the vehicular cloud environments [1].

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Various sensors mounted in vehicles show the characteristics of the dynamic node topology in accordance with the movement of the vehicles on road, which is different from traditional static Wireless Sensor Network (WSN). Very dynamic changing topology of sensors in the circumstance of rapidly moving vehicle nodes creates a network topology that cannot be predicted. This can cause data loss and deliver distorted information while the data packets are passing between network nodes [2]. VANET which is an application of MANET is a networking technology that provides wireless communications between a plurality of rapidly moving vehicles and with Infrastructures (e.g. RodeSide Unit) such as V2V or V2I respectively. Saif Al-Sultan [3] describes a comprehensive VANET communication. Li [4] classifies and summarizes the most well-known routing protocols for VANET as follow: Topology-based, Position-based, Cluster-based, Infrastructure-based, and broadcast [4]. A vehicle information system is really needed in local automotive environment as well as global cloud environment through this network.

Cooperative-Intelligent Transportation System (C-ITS) application services relating to traffic safety and efficiency use the meaningful information of the data obtained from the ego-vehicle, other vehicles, and infrastructures on roads. One of characteristics of vehicles in C-ITS applications is to have a huge chuck of sensors that are pouring so much data, which have much interest in even field with big data as the automotive industry. Precise analysis of vehicle information on driving and vehicle behaviors provide objective information on vehicles or roads and help to make data-driven decisions. Therefore, we need appropriate vehicle information system for C-ITS application services to realize amazing future vehicle system for storing, managing and transmitting data used for the C-ITS application services in connected vehicle environment and computing resource or storage capacity to handle a large scale information for realizing actual models in the real world. It means that cloud-connected vehicle information system can be one solution.

Ericssion [5] proposes open Connected Vehicle Cloud (CVC) which supports various business models and application development needed in automotive ecosystem providing vehicle and device data connector, cloud management functions as open API. T-System [6] also proposes open CVC supporting development and deployment of C-ITS application services on OEM, Telco Provider, and 3rd party with Embedded Connected Car Platform (ECCP), M2M Platform, and Central Connected Car Platform (CCCP). However, many automotive platforms and systems still are static on cloud resource management operation in accordance with the application requirements.

In this paper, we propose an architecture of prospective cloud-connected vehicle information system for C-ITS application services in connected vehicle environment and describe the procedure of our local and global vehicle information system concerned with case scenario (Fig. 1).

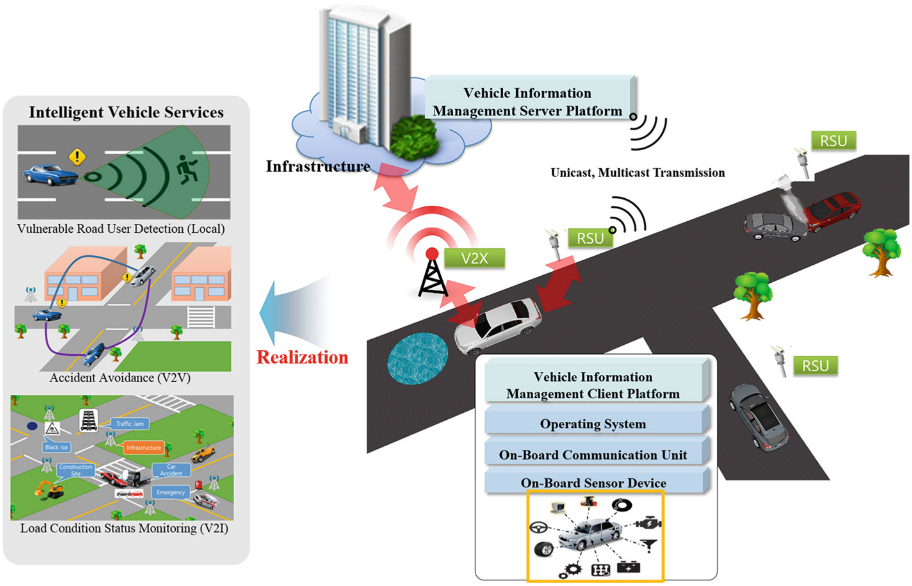

Fig. 1. Overall real model for proposed vehicle information system [7, 8]

2 Proposed Architecture of Prospective Cloud-Connected Vehicle Information System for C-ITS Application Services in Connected Vehicle Environment

We propose an architecture of prospective cloud-connected vehicle information system for C-ITS application services in connected vehicle environment. Advanced Driver Assistance System (ADAS) which is an application of our proposing system recognizes or judges the set of circumstances of ego-vehicle or road state, and provides drivers with analysis contents on surroundings area through visualization. This information used for applications such as ADAS is not limited to a single-node. A vehicle information system generates a real-time traffic information through crowdsourcing method. In other words, it is utilized to multiple-node for a wide range of applications through V2X based communications to perform the exchange of information between our local vehicle information systems in mobile devices and our global vehicle information systems in cloud infrastructures. The architecture of the vehicle information system we propose in mobile devices and cloud infrastructures is as follows (Fig. 2).

Proposed our mobile vehicle information system is composed of next-generation high-speed wireless networks based V2X communication units between other vehicles and roadside infrastructures. Our mobile vehicle information system in mobile devices analyzes the status of the vehicles in real time using a built-in sensor data collected in the mobile vehicle information database. When an accident of driver's vehicle occurs, the system can automatically provide C-ITS application services such as sending the current position and state information of the vehicle to the vehicle information system

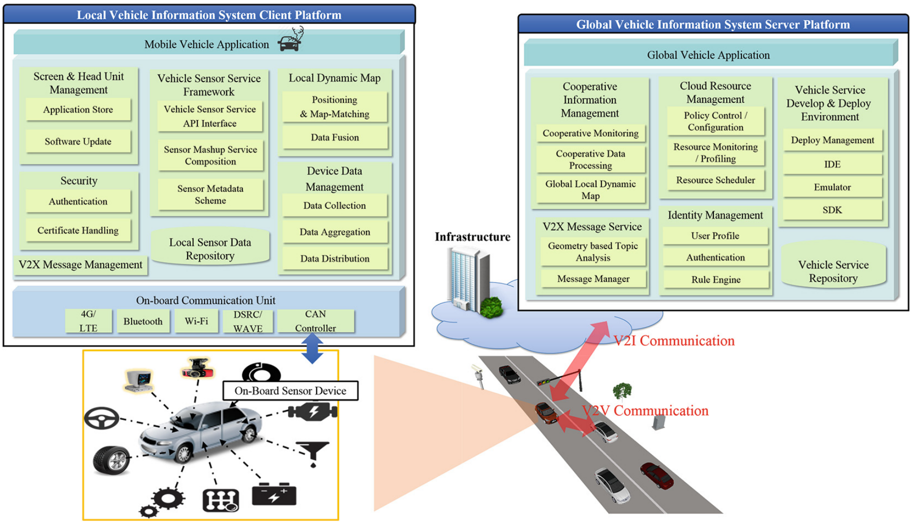

Fig. 2. Overall architecture of prospective cloud-connected vehicle information system for C-ITS application services in connected vehicle environment

of other mobile terminals in other vehicles and the central control center in cloud. Our mobile system continuously shares and exchanges useful information between roadside infrastructures and the other vehicles, but not limited to information acquired form a single node. The drivers who are linked to a central control center of the vehicle information system through the networks provide an integrated information and utilize C-ITS application services such as a critical alarm and safety precaution. Functions of our mobile vehicle information system in a mobile terminal of a vehicle are as follows.

On-Board Communication Unit: Integrated communication network management of the automotive environment of connected vehicle within the mobile devices. It constitutes In-vehicle network, V2V, and V2I and determines to use what on-board communication unit such as Bluetooth, Controller Area Network (CAN), DSRC/WAVE, Wi-Fi, and 4G/LTE by configuration to scenario.

Screen & Head Unit Management: Deployment of developed C-ITS application services via application store and management of the application services via software update function.

Security: Security manager of the personalized system using authentication by login interface of an individual user who uses the vehicle application services and management of certificate repository of the user.

V2X Message Management: Message manager of management, transition, and reception of collected, processed, and managed data to apply for various application services using V2X Message Interface.

Vehicle Sensor Service Framework: Framework on processing the sensor data generated in the vehicle, which objectifies sensors in vehicles based on metadata of sensors and provides sensor mashup composition and vehicle sensor service API interface.

Local Sensor Data Repository: Central repository for holding the contents of the local vehicles such as ego-vehicle and others in the vicinity for particular application services using V2X communication.

Device Data Management: General device data management, which actually collect, aggregate, and distribute sensor data the system will use for C-ITS application services.

Local Dynamic Map (LDM): Conceptual data storage for information relating to operate Cooperative-ITS (C-ITS) applications for road traffic safety and efficiency. The LDM database reflects the road traffic information and the road status information around vehicles on a fixed map information. This idea helps communicate among various applications via LDM, which shortens the response time on the request for information in the database and improves C-ITS application performance, as well as reduces the data traffic.

Vehicle Application: Mobile application services provided by the in-vehicle mobile devices.

The large amounts of data collected by infrastructures and vehicles is transmitted to the central control center of big data processing system to process it. The central control center provides comprehensive information for smooth traffic flow and safe driving to the driver of each vehicle generating information after various data processing. Our global vehicle information system in cloud environment performs complex processing by the event by combining data from multiple sources. The global traffic information being produced continuously over the cloud computing resources in real-time is collected and processed. Our system can construct the environment for analysis of big data by extracting meaningful information from it, which ensures the reliability of data, seeks the scalability of the data analysis, and makes the effect of reducing the time and costs for traffic analysis through a distributed application such as Hadoop running on secure computer clusters. Functions of the vehicle information system of the physical infrastructure in the cloud is shown below.

Global Vehicle Application: Global C-ITS application services provided by global cloud environment.

Cooperative Information Management: Global integrated information management by monitoring, processing, and storing information as global LDM in global cloud environment.

V2X Message Service: V2X message service management as a mobile vehicle information system as well as topic analysis interested in particular local area based on geometry.

Cloud Resource Management: Cloud resource management, which controls policy for using cloud resource dynamically, monitors, profiles, and schedules the cloud resources.

Identity Management: Security manager which is linked security in mobile vehicle information system giving functions such as profiling user information, authentication determined by rule engine.

Vehicle Service Repository: Storage for the global vehicle application services.

Vehicle Service Develop & Deploy Environment: Development environment which allows to develop global and local vehicle application services in cloud and deploys the application linking Screen & Head Unit Management in client vehicle system.

3 Scenario Case: Procedure of Local and Global Vehicle Information System

The mobile vehicle information system in mobile terminals collects and analyzes sensor data from in-vehicle and surrounding other vehicles or infrastructures in real-time using V2X communication units within the vehicle on-board communication unit. Objectifying sensor devices is to make a variety of things such as devices objects using profile which is information of a variety of things and devices in order to provide the web service of the vehicle environment, which is a phase as sensor metadata scheme. A combination of sensor objects using a sensor mashup composition makes it possible to provide a newly-configured service. Collected data from sensor devices is managed as object catalog, meta-database, local area database, and global area database. This managed data is used in various applications through networks via V2X message management which has V2X message manager, message transmitter, and message receiver functions, and these data builds and constitutes LDM environment through the positioning of the vehicle and map-matching in a fixed map information database via the data fusion. LDM includes information of the real world which comprise a conceptual information on objects that affects with respect to the traffic flow. Data depicting objects in the real world is defined by layering and expressing in the flowing categories (permanent static data, transient static data, transient dynamic data, and highly dynamic data) [9]. Monitoring road traffic information and road status information in real time to detect and diagnose a particular event occurring for each event is set to enforce action decided by established automation of analysis of the big data collected from sensors using a machine learning. C-ITS application services such as detection of vulnerable road user and accident avoidance guarantee the safety and convenience of the driver by recognizing the road conditions or circumstances such as roadside. C-ITS application is determined whether it exercise in local mobile devices or global cloud resources according to requirements of application services. The collected data through the cloud resource-linked offloading via a network which contains the information of the node by using a global LDM vehicle cloud-based collection, storage, through a process step to the relational information for the entire single road conditions processing to build a databases. Through Complex Event Processing (CEP) analysis with the resource pattern matching and filtering on provided cloud computing resources linked to a central control center, when we build an integrated environment of the vehicle information system that responds to detect changes, implementing C-ITS in the real world can be operated more easily and efficiently (Fig. 3).

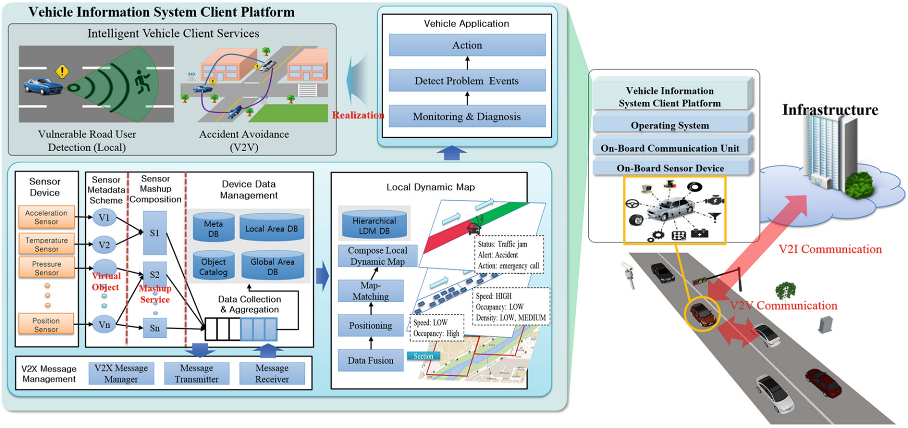

Fig. 3. Procedure of proposed local and global system concerned with case scenario

4 Conclusion

In this paper, we propose an architecture of prospective cloud-connected vehicle information system for C-ITS application services in connected vehicle environment and describe the procedure of our local and global vehicle information system concerned with case scenario. Data generated from a variety of sensors in infrastructure on road or vehicles in the real world is the big data requiring more computing resources to process it efficiently. Processing a number of data generated from various sensors built in vehicles and infrastructures requires a great computing capacity and storage resources. The information by the respective vehicle nodes using the VANET network access is aggregated in global vehicle information system of central control center to manage the data acquisition process according to the definition of the data type of LDM. Therefore our local and global vehicle information system to process or manage efficiently transportation relational big data enhance a quality of C-ITS application services using various functions. In addition, we need to study more related-research on greater access to vehicle information in cloud which can improve C-ITS application service such as autonomous driving [10].

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