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A Study on Architecture of CAN over 3GPP Gateway in Vehicle Network

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Abstract. In vehicle, there are many ECU (Electronic Control Unit)s, and ECUs are connected to networks such as CAN(Controller Area Network), LIN(Local Interconnect Network), FlexRay, and so on.
The CAN is the most used technology in automotive network. If the 3GPP technology is used for the purpose of V2I (Vehicle to Infrastructure) in automotive network, it would need an Inter-connection of CAN network and 3GPP to deliver messages. In this paper, we propose the software architecture and functions of CAN over 3GPP gateway to transfer an In-vehicle logging message, automotive diagnostic status or safety-related information, etc to user or server in the internet.

Keywords: 3GPP, CAN, Gateway, Automotive, Vehicle

1 Introduction

Recently, The automotive technology with different state of the art IT technologies have rapid progressed to the Smart Car, Connected Car and V2X(Vehicle to Everything) by active collaboration between IT technologies and industry for a driver's safety and convenience enlargement.

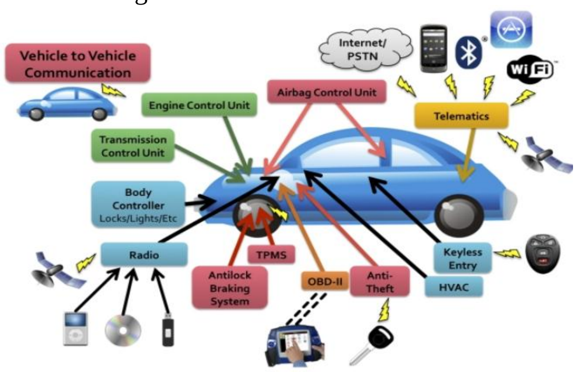

Fig. 1. Automotive internal/external communication

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In this paper, we propose the architecture of automotive CAN over 3GPP gateway which applied the LTE-based communication technologies to transfer the real-time status information of the automotive to user or server on the internet.

2 CAN

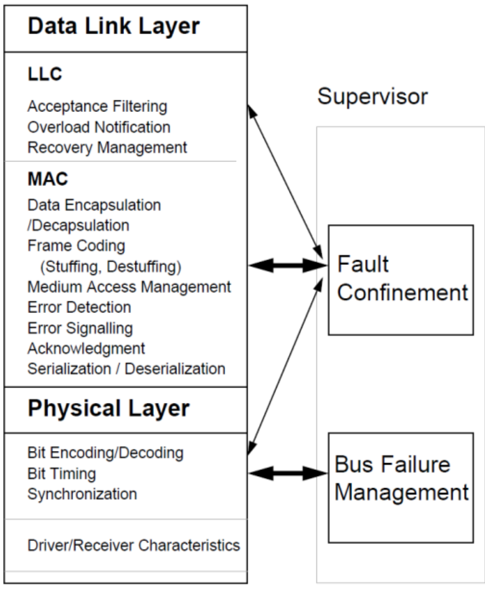

Fig. 2. Layered Architecture of CAN according to the OSI Reference Model [1]

The CAN (Controller Area Network) is a serial communications protocol which efficiently supports distributed real-time control with a very high level of security. It is domain of application ranges from high speed networks to low cost multiplex wiring. In automotive electronics, engine control units, sensors, anti-skid-systems, etc. are connected using CAN with bitrates up to 1 Mbit/s. At the same time it is cost effective to build into vehicle body electronics to replace the wiring harness otherwise required. The intention of this specification is to achieve compatibility between any two CAN implementations. Compatibility, however, has different aspects regarding e.g. electrical features and the interpretation of data to be transferred. To achieve design transparency and implementation flexibility CAN has been subdivided into the Data Link Layer and the Physical Layer according to the ISO/OSI Reference Model. The Data Link Layer are comprised of the Logical Link Control (LLC) sublayer and the Medium Access Control (MAC) sublayer. The scope of the LLC sublayer is to provide services for data transfer and for remote data request, to decide which messages received by the LLC sublayer are actually to be accepted and to provide means for recovery management and overload notifications.

The scope of the MAC sublayer mainly is the transfer protocol, i.e. controlling the Framing, performing Arbitration, Error Checking, Error Signaling and Fault Confinement.

3 3GPP

3.1 3GPP Overview

The high-level network architecture of LTE is comprised of three main components such as User Equipment (UE), Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), Evolved Packet Core (EPC). The LTE standard based on 3GPP specifies an IP-only network supporting data rates up to 150 Mbps. In the 3GPP Long Term Evolution (LTE), UE is any device used directly by an end-user to communicate.

The E-UTRAN (Evolved UTRAN) consists of eNBs, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The EPC is a new, high-performance, high-capacity all-IP core network for LTE. EPC addresses LTE requirements to provide advanced real-time and media-rich services with enhanced Quality of Experience (QoE). EPC improves network performance by the separation of control and data planes and through a flattened IP architecture, which reduces the hierarchy between mobile data elements.

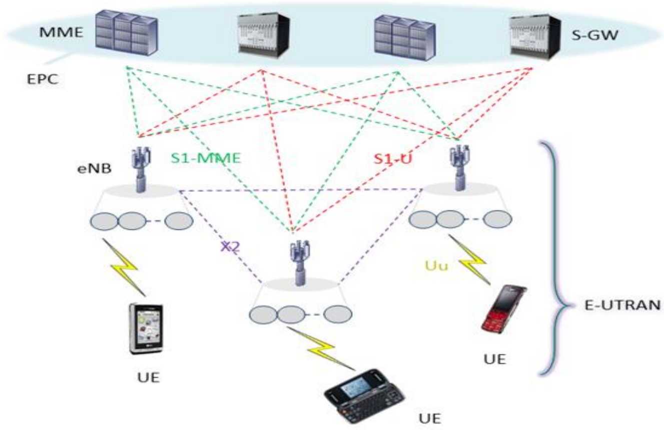

Fig. 3. 3GPP Overall architecture

3.2 3GPP Protocol

The radio interface is layered into three protocol layers: the physical layer (L1), the data link layer (L2), network layer (L3). Layer 2 is comprised of Medium Access Control (MAC), Radio Link Control (RLC), and Packet Data Convergence Protocol

(PDCP) sublayers. Layer 3 and RLC are divided into Control (C-) and User (U-) planes.

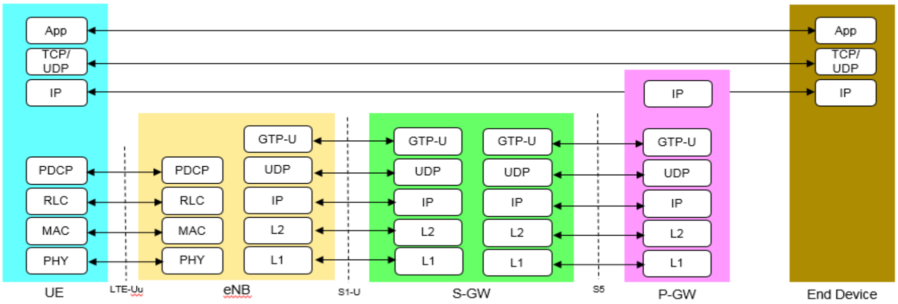

Fig. 4. 3GPP User-Plane Protocol Stack

4 CAN over 3GPP Gateway

4.1 Overview

The proposed method in this paper is to transfer the entire CAN frame to 3GPP platform and distinguish the PDU from CAN Id in the CAN Frame. In other words, 3GPP is used as the means of communication to transmit/receive the CAN Frame.

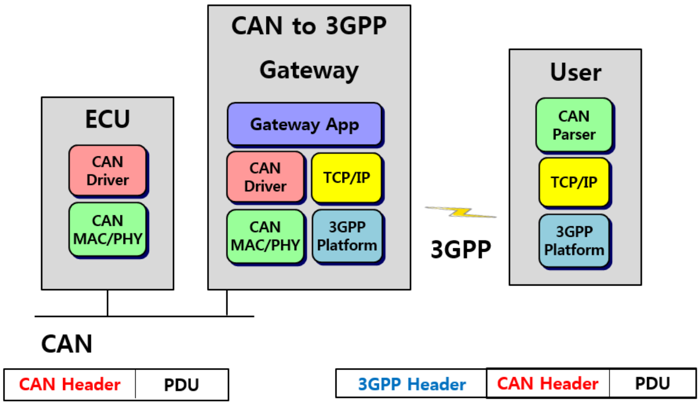

Fig. 5. CAN over 3GPP Gateway Concept

4.2 Operation Principle

The simple modules and operations flow for CAN over 3GPP gateway are represented in Fig.7 below. When the CAN communication module receive the CAN frame from CAN network, CAN Driver transfers the CAN frame to CAN Interface based on CAN Id. The CAN Interface transfers the received CAN frame from CAN Driver to the CAN over 3GPP gateway function. At this time, the CAN over 3GPP gateway searches the PDU management table for the CAN id. If it exist, the CAN over 3GPP gateway function transfers the CAN frame to the TCP/IP protocol stack.

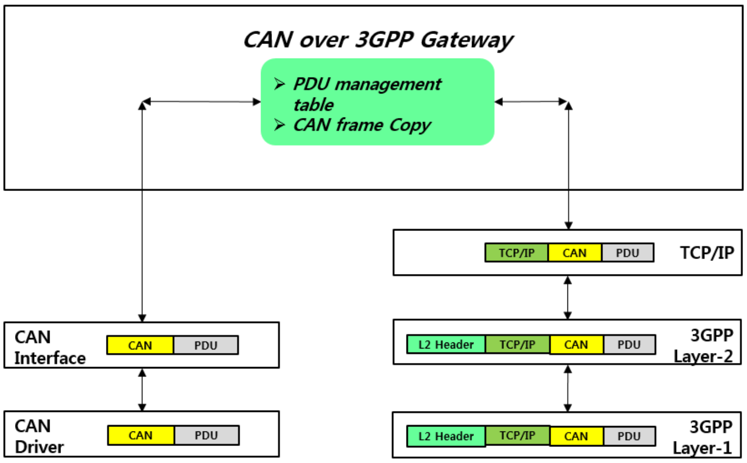

Fig. 6. The flow diagram of the CAN over 3GPP Gateway

The TCP/IP protocol stack makes the IP packet included the CAN frame. In this case, the IP source address is the assigned address form P-GW when 3GPP platform as an UE connect to the 3PPP network and the IP destination address is the address of the place to receive the CAN frame such as user or server on the internet. The generated IP packet is delivered to the 3GPP platform.

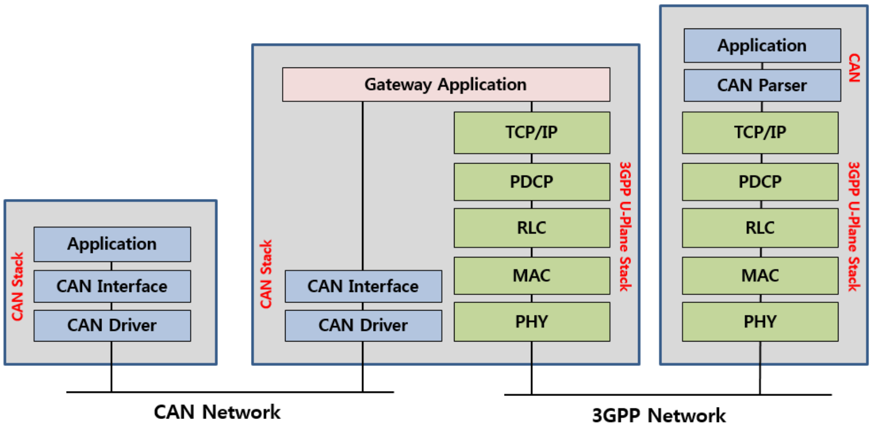

Fig. 7. Protocol Stack of the CAN over 3GPP gateway

The other way, the CAN over 3GPP gateway extracts the CAN Id from the CAN frame that is received from 3GPP platform and searches the PDU management table for the CAN id. The CAN interface transfers the CAN frame to the CAN network.

Namely, the main point is to distinguish the CAN frame from CAN id and transfer the entire CAN frame using the encapsulation/decapsulation such as tunneling.

The CAN frame that is received through the 3GPP network is transferred to the CAN Parser module. The CAN Parser checks the CAN frames for validity and classifies the CAN frame according to the CAN id and the each CAN PDU in the CAN frame transfers to the related application such as for diagnosis, monitoring, control, safety-related information, and so on.

5 Conclusion

In this paper, we propose the new software architecture of CAN over 3GPP gateway based on LTE for automotive network. The method of the new CAN over 3GPP gateway transmits/receives the IP packet included the entire CAN frame. In other words, we expect that the new CAN over 3GPP gateway is a great help to transmit/receive the CAN frames for the purpose of the automotive status information, diagnostic information, and so on.

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