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New elements in vehicle communication "media oriented systems transport" protocol

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Summary. Until recently, no significant breakthroughs have occurred in the area of functional efficiency of automotive vehicle communication protocols. The transmission speed for "high-speed" communications busses and protocols is still much slower than those of a typical computer network. Neither the High-Speed CAN (1 Mbps bandwidth) nor TTP protocol (10 Mbps bandwidth), can be compared to the 1 Gbps bandwidth that is typical for widely used computer networks. Other difficulties are that these vehicle communication networks are nonstandard and frequently use proprietary protocols (e.g., communication methods, communication medium and data formats). In contrast, computer networks have much more advanced capabilities. They are capable of a range of functions, from sending simple serial messages to maintaining sessions based on multi-media data. These functions remain lacking in the automotive vehicle communication protocols. One of the protocols in which functionality and bandwidth has reached much higher levels than competitive protocols is the Media Oriented System Transport. The purpose of this publication is to review new functions introduced in its latest version.

Key words: Media Oriented Systems Transport, Vehicle Information Network.

INTRODUCTION

Communication protocols and buses used in automotive vehicles went through a different development process than typical solutions used in computer communication. The main focus of automotive communication interfaces was initially the exchange of simple diagnostic messages. The function of such systems was to monitor and regulate the amount of pollution emitted by the vehicle. The second step of the evolution of the buses was to limit the number of failures by limiting the number of connections and the length of the wiring [19]. The next developmental step was to increase the safety and functionality of the vehicle by increasing the bandwidth between the larger number of communication ports. At this point, two major development trends of communication buses can be identified. The first of them was to replace the mechanical connection with connections between multiple devices using buses (Drive-by-Wire, X-by-Wire) [14]. The main concern with such a solution is limiting the failure rate. The second development direction was to increase the user comfort by integrating multi-media subsystems. A simple user interface is frequently implemented to manage complex automotive multimedia systems. The integration of various dedicated devices (e.g., telephone, DVD player, MP3 player) into a single system is difficult.

One of the key solutions to solving the problem of communication between various devices is the bus and protocol Media Oriented Systems Transport (MOST). The Media Oriented Systems Transport bus was created as a result of experience with the previous bus, Domestic Digital Bus (D2B) [10].

Similar to the previous D2B, the MOST bus uses an optic fiber link as the primary communication medium. This optical solution allows for even the slowest version to achieve the throughput similar to the highest speed rated in other communication networks, such as FlexRay (10-20 Mbps) [2].

EVOLUTION OF „MOST" BUS

As mentioned before, the MOST evolved directly from the D2B. The D2B was developed with the sole focus of supporting multimedia devices. Similarly, the main functions of MOST are multi-media and telematics [21]. As a result, the MOST bus is located at the boundary of the vehicle control subsystems (Fig. 1)). Safety mechanisms implemented in MOST protocols (checksum, ability to create a redundant interconnecting ring, from 25 to 150 Mbps bandwidth, error rate in the range of 10^{-10} [21]) allow utilization of MOST for almost any configuration.

The protocol of data exchange in MOST25 is much more complex than other protocols (e.g., CAN, LIN) [12, 15]. The basic communication unit of the protocol is created with 16 frames (Fig. 2). A single frame can be up to 64 bytes long and can be used to send data as synchronous, asynchronous, or control (Fig. 2). The most typical data type is synchronous, which represents multimedia data and occupies the largest configurable portion of the frame. Asynchronous data is used to support multi-media information such as GPS systems, information about accessed files, and data of capsulated protocols within the MOST system. The control data is responsible for managing communication between the network ports. Due to this fact, the data frame is 32 bytes long, and the frame has to be divided into 16 sub-frames by each individual communication unit (Fig. 2).

Later versions of the MOST protocol implemented increased transfer speeds. The basic MOST25 (25 Mbps) works with a sampling rate of 44.1 or 48 kHz, maintained in a 64 byte frame. The doubling of the throughput is achieved in MOST50 by increasing the size of the frame from 64 to 128 bytes (Fig. 2, 3). Further increase of the frame size results in achieving throughput of 150 Mbps in the protocol MOST150 (Fig. 3) [6, 7, 9].

In addition to a continuous increase of the bus throughput, frame modifications are introduced. Control data is sent as a set of four byte packets. Also, typical synchronous data types have been complemented with the addition of an isochronous type. For the isochronous data type, a feature reserving a required portion of the bus throughput is introduced. This feature is introduced in spite of the fact that the bus frequency is different from the data sampling rate. Handing of this new data

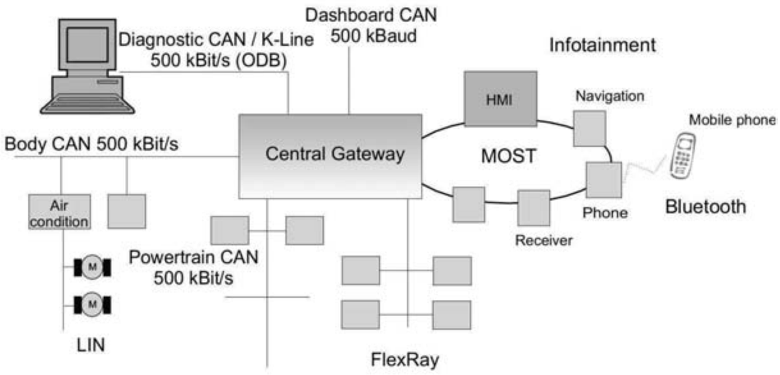

Fig. 1. Vehicle network with a ring of MOST bus [5]

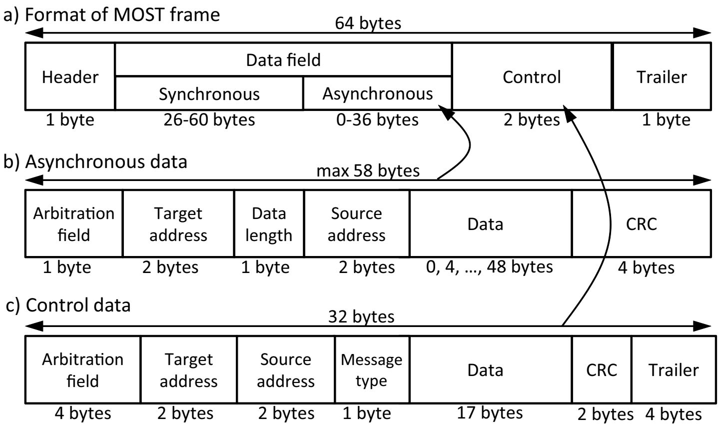

Fig. 2. MOST protocol - data format [5, 20, 19, 21, 16]

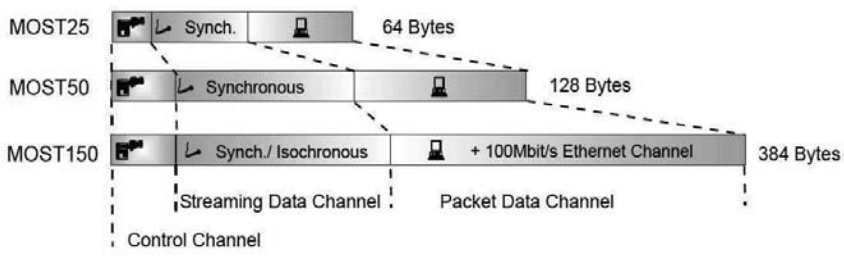

Fig. 3. Structure of MOST frame [6]

type is managed by three isochronous channel servicing protocols.

Undoubtedly the most significant changes were introduced in the area of handling digital data, which were typically managed by computer devices. The first of these types is QoS Isochronous IP (streaming), which is mainly used for transmitting audio/video data from application servers with a guaranteed bandwidth allocation [7, 9].

A second change is the way the asynchronous channel is handled. This channel can now share the bandwidth with a synchronous one, and sending 372 bytes in a single frame is possible. Under this MOST protocol, the asynchronous channel was renamed Packet or Ethernet.

Another key change was the elimination of an adaptive layer MAMAC (MOST Asynchronous Medium Access Control). In the previous MOST versions, MOST25 and MOST50, the MAMAC layer was responsible for the TCP/IP transmissions, which were performed within the asynchronous channel. The MAMAC layer was replaced with MHP (MOST High Protocol). The MHP layer allows use of the asynchronous channel to address the MDP data packets using 16-bit addresses or the MEP Ethernet data using 48-bit addresses. It is even possible to perform parallel addressing using both methods at the same time. MOST Ethernet Packets allow addressing methods identical to the Ethernet network [6].

NEW CAPABILITIES OF MOST150

Advanced driver assistance systems such as: collision warning, traffic sign monitoring, lane departure warning, lane guidance, pedestrian warning, night vision, adaptive cruise control or pre-crash warning require integration with a wide variety of vehicle subsystems. A typical application of the MOST protocol falls under the Infotainment network category (Fig. 1), which does not require as low a failure rate as that of advanced applications.

Fig. 4. Safety layer concept [3]

The MOST protocol appears to contain characteristics allowing for easy integration of existing multimedia networks with driver assistance network. Key characteristics of bus that allow this integration include [3]:

– high throughput – "driver assistance" systems are required to interface with a larger variety of sensors and actuators. MOST is equipped with synchronous/isochronous channels and asynchronous/packet channels capable of allocating a portion of the bandwidth to each of the required services. Having packet communication and IP protocol available allows for easy introduction of car-to-car, car-to-infrastructure communication. It also allows for communication with peripherals such as a fuel distribution, a GSM module or a garage/house control equipment [1, 4, 13];
– deterministic-function - the necessity to provide safety requires implementation of protocols based on stiff time bounded rules guaranteeing small and predictable delays. Additionally, all required parameters must be fulfilled over a wide temperature range (-40 C to 95 °C). The ability to simultaneously define a portion of bandwidth for multiple synchronous channels gives an ability to control both throughput and delays;
– high safety margin - communication cannot be susceptible to errors caused by: failure of network nodes, frame failures, and message delays. Even on the basic communication layer (Fig. 2), it is possible to monitor communication quality through cyclic redundancy check, sequence counter, message length, and timeout detection. An additional application layer gives additional functions of monitoring correctness of exchanged data (Fig. 4).

The features mentioned above confirm that MOST150 can function as a safe system within its own nodes or nodes of other networks. Based on these characteristics, MOST150 shows optimal fit as a network for the Advanced Driver Assistance Systems (ADAS).

The throughput in the range of 150 Mbps, introduced by MOST150, is the highest within any of the vehicle communication networks. This performance dates back to the year 2000 (Fig. 5). In spite of that, even faster solutions are being pursued with designers attempting to take advantage of the physical layer of the optic fibers. Such solutions are characterized by low weight, low sensitivity to interference, and relatively low cost.

Tests performed on increasing communication speed have been conducted in the Fraunhofer Institute. The POF-Plus (Plastic Optical Fiber), implemented within the MOST layer, demonstrated the ability to achieve a throughput of 1.25 Gbps. At the same time, the results indicated that the optical fiber connection solution functioned properly with lengths up to 11.2 meters and an absolute loss coefficient of 0.4 dB/m [17].

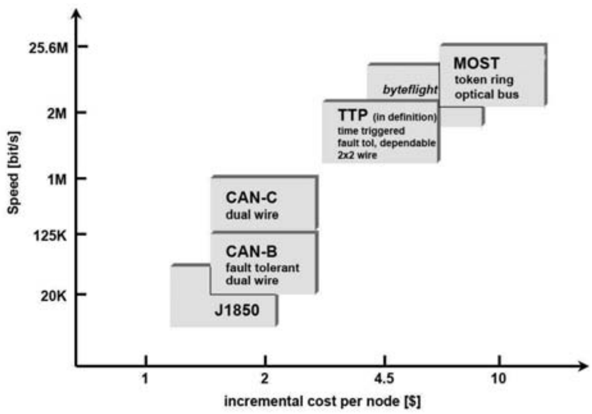

Fig. 5. Data rate of vehicle buses in 2000 [18]

Multimedia content frequently requires protection from unauthorized access or duplication. Two primary mechanisms of data protections are: DTCP (Digital Transport Content Protection) and HDCP (High-Bandwidth Digital Content Protection). Both of these were implemented in the MOST protocol. Version 3 of the DTCP protection is covered by Supplement B (M6 cipher), and protection DTCP-IP version 1 is covered by Supplement E (AES-128 cipher). Difficulties might arise in the case of HDCP protection, which exists under two versions. Version 1 is common for synchronous and uncompressed content, while Version 2 is dedicated to compressed and protected content (interface independent adaptation-IIA).

MOST utilizes two schemes of DTCP deciphering such that a synchronous channel is used for multimedia, audio, and video transport stream, and an additional synchronous channel is used for supplemental data required for the deciphering process (e.g., the cipher key inside of the Synchronous Added Data - SAD, Fig. 6). The HDCP IIA transport stream is protected such that audio requires additional deciphering from an elementary stream. This requires simultaneous transfer of the stream and the cipher key with the utilization of the isochronous channel. A difficulty might arise when accessing two sets of data which are protected using different methods. This circumstance could lead to exceeding the throughput of the packet channel [8].

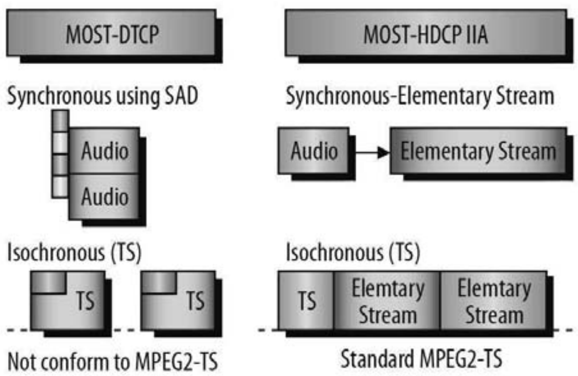

Fig. 6. Two transport mechanisms for protected content [8]

Internet access has become a necessity for people who require continuous access to real/time data. The internet also serves as a source of multimedia data and allows users to connect other mobile devices.

Due to the implementation of the Ethernet channel introduced in MOST150, the driver and passengers have access to functions based on: IP (internet protocol), TCP (Transmission Control Protocol), or HTTP (Hypertext Transfer Protocol). Physical access to the network is achieved by making a connection to the head unit (HU), which functions as a central router independent of the connection type (wire or wireless). The head unit can also act as a hot spot for WLAN devices such as a smart phone or tablet PC (Fig. 7). Due to the vehicle mobility, it is important to be able to utilize wireless networks protection such as ciphering.

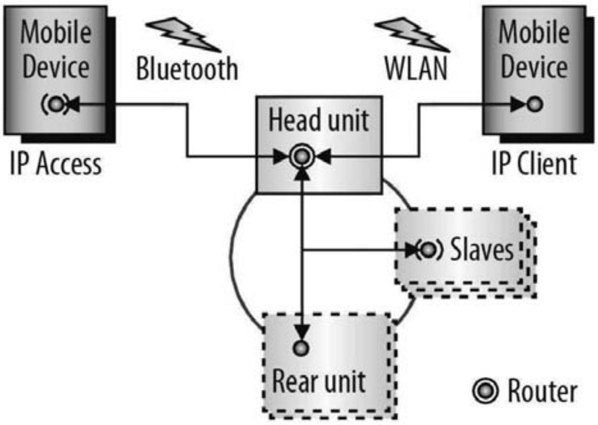

Fig. 7. Model of IP architecture of a vehicle infotainment system [11]

For communication between devices utilizing the IP protocol, the MOST150 Ethernet Packet Channel is used. Practical tests of the efficiency of packet type communication were conducted by Daimler. The results indicated the ability to achieve theoretical throughput of 142.8 Mb/s, with 107 Mb/s under practical conditions. This represents 75% utilization of the throughput capability. Introduction of the limitation of available throughput to 43.75 Mb/s resulted in achieving utilization of the throughput up to 82%. The future design direction of IP for the MOST network focuses on more effective utilization of higher level layers of the OSI model [11].

CONCLUSIONS

Years of development of the MOST network/protocol resulted in achieving a very mature solution capable of servicing a large variety of data types. To date, the use of MOST has moved beyond infotainment applications. The features of this network, as described in the article, lead to the following conclusions:

- The advanced communication frame fulfils requirements of both diagnostic and multimedia communication.
- The high throughput and the predictable behaviour of the protocol allows implementation or utilization of this protocol in future applications for advanced driver assistance systems.
- The protocol contains features allowing access to protected content, allowing compliance with copyright laws.
- The maximum throughput of 150 Mbps does not even approach the possible boundaries of the communication speed of the MOST protocol.

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NOWE ELEMENTY PROTOKOŁU KOMUNIKACYJNEGO POJAZDÓW „MEDIA ORIENTED SYSTEMS TRANSPORT"

Streszczenie. Długotrwały rozwój protokołów komunikacyjnych pojazdów samochodowych nie zaowocował dotychczas nadzwyczajną wydajnością i funkcjonalnością rozwiązań. Prędkości transmisji osiągane przez protokoły i magistrale określane „high-speed" są niskie w porównaniu z przeciętnymi przepustowościami sieci komputerowych. Przepustowość rzędu 1 Mbps protokołu High Speed CAN lub 10 Mbps protokołu TTP jest znacząco mniejsza niż przepustowość 1 Gbps typowa dla kablowych sieci komputerowych. Kolejnym czynnikiem, który należy brać pod uwagę, jest zróżnicowanie metod komunikacji i formatów danych. O ile sieci komputerowe mogą przesyłać zarówno proste komunikaty szeregowe jak i prowadzić sesje oparte o dane multimedialne, to protokoły komunikacji pojazdów dopiero rozwijają takie uniwersalnej funkcje. Protokół, którego funkcjonalność i przepustowość jest bardziej rozwinięta niż u konkurencji to protokół i magistrala Media Oriented Systems Transport. Niniejsza publikacja ma za zadanie przybliżyć funkcje wprowadzone w jego ostatniej wersji.

Słowa kluczowe: Media Oriented Systems Transport, Vehicle Information Network.