Comparison of CAN, LIN, FLEX RAY and MOST In-vehicle bus protocols

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Abstract: The components inside the vehicle are interconnected through the vehicle bus. The electronic modules like Engine Control Units (ECU), Transmission Control Unit (TCU), Anti-lock Braking System (ABS), and Body Control Module (BCM) need to be interconnected and they must communicate with each other over a complex in-vehicle network (IVN). The IVN are heterogeneous also the rapid increase of electronics in the automotive has made the networking and intercommunication between the heterogeneous network more complex. Thus, OEMs stepped forward to figure out and make use of vehicle bus protocols that are universally accepted. This paper mainly focusing on the IVN protocols that are most commonly used in the vehicle network architecture and many other important features like baud rate, payload, access control, range and also the application field where they can implemented in an automobile.

Index Terms: CAN, LIN, MOST, In-vehicle network (IVN).

I. INTRODUCTION

The In-Vehicle communication network is becoming more complex as the demand for drive by wire, telematics, pre-crash warning, remote diagnostics and software updates are increasing. Based on the locality and the functionality of the modules the network modules are divided for the diagnostics. Various electronic modules are incorporated in today's vehicle. The serial buses are being used for the in connection of the electric modules. The vehicle buses like CAN, LIN, MOST etc. are interconnected via a gateway network which is a bridge network that facilitates the undisturbed intercommunication between the heterogeneous bus protocols. Automakers today, looking towards the performance analysis of the in-vehicle network through simulation models. By doing the realistic simulations a cost effective comparison of advantages and disadvantages of various protocols and the network topologies is done. The simulation analysis will help the automakers to achieve cost reduction and time to market targets.

II. IN-VEHICLE BUS PROTOCOLS

The multiple computing devices are linked by networking which helps in sharing the data and communicate with each other. The same or similar networking protocols are used in both wired and wireless technologies [1]. The recent technologies like ADAS are achieved through the most advanced microcontrollers. The intercommunication between the controllers is achieved by the in-vehicle bus network like CAN, LIN, Flex Ray, MOST etc. hence the bus network must be prone enough to any of the attacks by intruders [2]. The communication between the multimedia bus and the wireless communication interfaces will be achieved soon. The care should be taken to prevent the lower bus like LIN or MOST from sending the messages to the highly safe bus systems like CAN or Flex RAY [3]. In this paper specifically we have discussed CAN, LIN, MOST, Flex Ray bus protocols technologies in brief.

A. Controlled Area Network (CAN)

Controlled area network (CAN) is the powerful MultiMaster serial Vehicle bus. The CAN devices on bus are known as the nodes. The nodes are connected each other via two wires bus and the wires are 120 ohms twisted pair. By making use of CAN the microcontroller and the devices are allowed to communicate with each other in any application without the host computer.

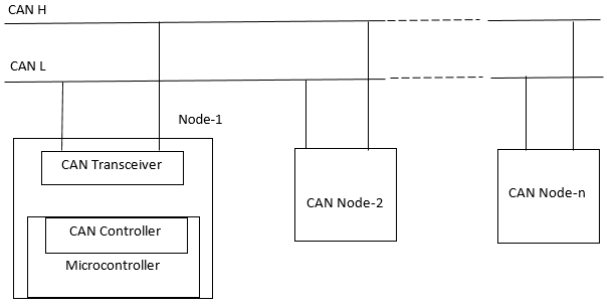

Fig-1: CAN bus structure

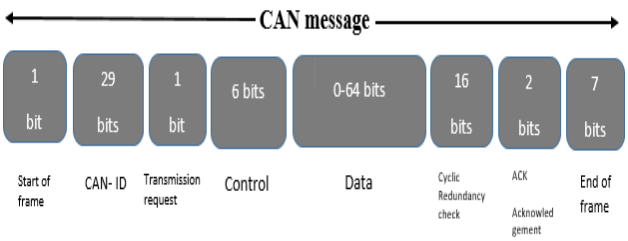

Fig-2: CAN message frame

The Robert Bosch Gmbh developed the Controlled Area Network (CAN) bus and released in the year 1986 and Mercedes Benz W140 was the first vehicle to feature the CAN based wiring in 1991. The CAN standard ISO 11898 was released in 1993. The ISO 11898 later again redefined as 1) ISO 11898-1: For data link layer standards, 2) ISO 11898-2: For physical layer standards and 3) ISO 11898-3: For physical layer for lower speed, fault tolerant CAN standards. The CAN protocol and its interfaces will run around 40 times the speed of OBDII/EOBD protocols which were using earlier. In present scenario, CAN bus is one of the most affordable network systems. Also, its being one of the most reliable, it is the main cost-effective choice of automobile manufacturers around the world.

Pros and Cons of CAN in automotive domain.

Pros:

- CAN can used in the different electrical environment and also noise free transmission is ensured.
- Since CAN is a distributed control network It reduces wiring and thus the system performance enhancing is ensured.
- If the CAN systems are not directly related then failure of one system will not affect the other this makes the entire system safe as the healthy modules continue to function properly.
- CAN bus will provide error free transmission. Here, each node can check for errors during the transmission of the message and send the error frame.

Cons:

- CAN bus sometimes will have undesirable interaction between the nodes.
- Whenever a node is removed a termination resistor of 120 ohm at the proper place is mandatory on the bus.
- CAN bus needs more expenditure on the software and also the maintenance.

B. Local Interconnect Network (LIN)

The Local Interconnect Network (LIN) I a serial bus that is used for the communication between the components in the vehicle. The LIN is comparatively less expensive protocol for serial communication which supports applications within a car's network. It is mainly used for the mechatronics nodes of the automotive applications. The LIN bus is the single master and the multi slaves bus architecture network where master polls the each slave. LIN has a feature mechanism which allow the devices to enter the sleep mode when they are in the idle mode and thereby power conservation is achieved potentially.

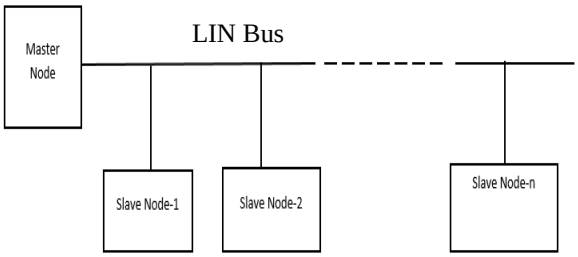

Fig-3: LIN bus structure

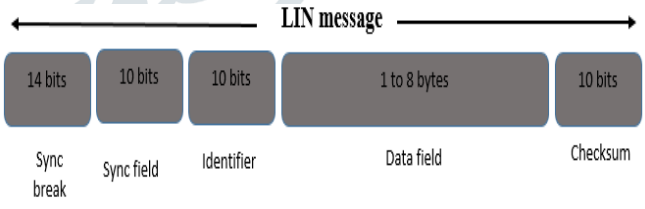

Fig-4: LIN message frame

The Local Interconnect Network (LIN) was first developed by the Volcano communications technology (VCT) and it is based on the Volcano Lite technology and it was released in the middle of 1999. The LIN mainly concentrating on the body electronics applications of the automobile such as window lifter, mirror, wiper etc. The most updated LIN standard was defined in the year 2010 and then later it was accepted by the ISO as ISO 17897 standard which was released in the year 2016. The number of LIN nodes that are connected through a physical cable is known as the LIN cluster. A single cluster can have only one master node and the multiple slave nodes (max Upto 16 nodes). Today LIN being a safe, cheap and efficient protocol it is present in almost all the automobiles. Though LIN is not a replacement for the CAN bus but it is a good alternative where the bandwidth, speed is not a major concern.

Pros and Cons of LIN in automotive domain.

Pros;

- LIN is the simple, low cost interface that could be implement and use in relative to the CAN bus.
- As the LIN is single wire based wiring method it reduces the cost and the implementation complexity. Also it is self-synchronized hence there is no need of external oscillator.
- LIN bus cannot replace the CAN bus but it is considered as the best alternative to the CAN where the low cost, bandwidth/speed are not the major concern.

Cons:

- Because of its low speed LIN is not ideal for safety or other important application systems in the vehicle.
- In LIN bus is the communication is initiated by the master thus if in case the master fails then the whole bus gets fail which is the major drawback.

C. Flex Ray

Flex ray is the most reliable network communication protocol in the automotive. The Flex ray is designed in such a way that it is more reliable than CAN and the TTP. The Flex ray bus will operate on time signal that divided into two parts i.e dynamic and the static segments. The first production vehicle to have the Flex ray bus was BMW X5 (E70) at the end of the year 2006. The Flex ray nodes are interconnected by using the twisted pair of wires. The bus has the cabling impedance of 80 and 110 ohms.

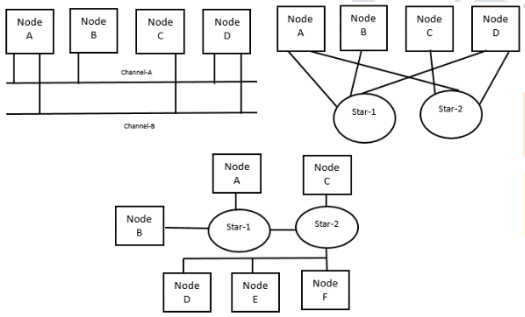

Fig-5: Flex Ray bus structure

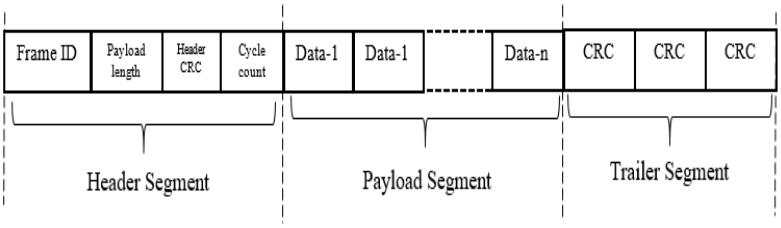

Fig-6: Flex Ray message frame

Flex ray is a automotive network communication protocol for governing the onboard automotive computing. It was developed by Flex ray consortium in 2009. The consortium was made up of Free-scale semiconductors, BMW AG, Robert Bosch Gmbh, NXP Semiconductors, Volkswagen AG, Daimler AG and General AG. ISO 17458-1 to 17458-5 is the ISO Flex Ray standard. The Flex Ray always try to deliver the deterministic, fault tolerant and high speed bus which are the required for the next generation of the automotive.

Pros and Cons of Ray in automotive domain.

Pros:

- Flex Ray has an unique ability to sync up node on a network without an external synchronous clock.
- The star topology helps in reducing the exposed wire for the segment and also helps in increasing the noise immunity.
- The use of hybrid leads to the ease of use and also cost advantages.
- By using multibus drop network topology the installation has become simplified and thereby reducing the wiring complexity in the vehicle.

Cons:

- Because of its low speed LIN is not ideal for safety or other important application systems in the vehicle.
- In LIN bus is the communication is initiated by the master thus if in case the master fails then the whole bus gets fail which is the major drawback.

D. Media Oriented Stream Transfer (MOST)

Media Oriented Stream Transfer (MOST) is the high speed serial communication system network topology mainly optimized for towards the automotive industry. The uncompressed audio stream channels and multichannel of audio and video streams are supported by the MOST technology. MOST supports different physical layers like fiber Optics, Unshielded twisted Pair (UTP), and Ethernet with the variable baud rate transmission. In 1998 the MOST Corporation was founded. The companies like BMW, Audi, Daimler, Harman and microchip technology being core partners worked to standardizing the MOST technology as a global standard for multimedia network.

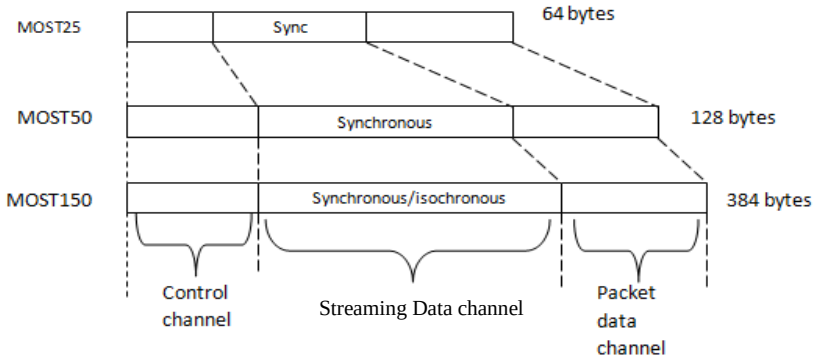

Fig-7: MOST protocol Frame structure

Based on the transmission speed the MOST is again redefined in three ways:

1) MOST25
2) MOST50
3) MOST150 the features of these bus are summarized in the below table

	Baud rate	**Physical layer**	**Message transfer type**	**Frame length**	**Application**
MOST25	25Mbps	Fiber Optics	Asynchronous Synchronous	64 bytes	Transmission of audio, video, voice, data
MOST50	50Mbps	UTP	Asynchronous Synchronous	124 bytes	
MOST150	150Mbps	Ethernet	Asynchronous Synchronous Isochronous	384 bytes	Electrical conducts

Table-1: Features of different MOST bus

Pros:

- The MOST protocol provides a single interconnect for the audio, video, data and information transmission
- It supports physical layer such as fibre optic, Unshielded Twisted Pair (UTP) and Ethernet.
- The variable baud rate of range 25Mbps, 50 Mbps, 150Mbps is supported by the MOST
- It provides plug and play functionality due to which the adding or removing a MOST device is made easy and user friendly.

Cons:

- Being the most flexible and high speed protocol MOST is the expensive bus.

III. COMPARISSION OF IN—VEHICLE BUS PROTOCOLS

Here we have tried to summarize the comparison of in-vehicle serial bus protocols. In specific we have taken CAN, LIN, Flex Ray and the MOST protocols for discussion in this paper.

Attribute	CAN	LIN	Flex-Ray	MOST
Range	1-5kms	40mts	10mts	5mts
Baud rate	Fast- 1Mbps Slow- 500kbps (variable with distance)	Upto 20kbps (variable with distance)	10mbps (variable with distance)	150mbps
Payload	8 bytes	8 bytes	256 bytes	60 bytes
Physical Layer	2 wire bus	1 wire bus	2 or 4 wire bus	Dual wire based fiber optic
Cabling Impedance	120 ohms	1k ohms	Between 80 and 110 ohms	50 ohms (Varies with physical layer)
Duration of cycle	~ 240µs	52µs	1-5 ms	2.7ms
Network Topology	MultiMaster	SingleMaster	Multidrop bus, Star, Hybrid	Peer to Peer (MultiMaster)
ISO standard	ISO 11898	ISO 189141/ ISO 17897	ISO 17458-1:2013	ISO 7498-1
Operating Voltage	3.3v	8v to 9v	Differential voltage of +2.0v	3.3v
Duplex mode	Half	Half	Full	Data stream
Bandwidth	125kbps max	10kbps (variable)	10Mbps	1130Mbps
Communication	Event-triggered	Event-triggered	Event-triggered and Time triggered	Event-triggered and Time triggered
Cost	Medium	Low	High	Very high
Identifier ID	11/29 bits	6 bits	11 bits	16 bits
Communication Nodes (max)	16	16	Bus drop- 22 Star- 22/64 Hybrid- 64	64
Message transfer type	Asynchronous	Synchronous	Asynchronous and Synchronous	Asynchronous Synchronous Isochronous
Access control	Polling	CSMA/CA	TDMA	TDMA , CSMA/CA
Applications	Powertrain (Chassis, engine, ABS)	Body electronics (mirror, power seat, accessories)	High performance powertrain safety (Active suspension, Adaptive cruiser control)	Transmit audio, video, data and control info.

Table-2: Comparison of In-vehicle bus protocols

IV. CONCLUSION

The components inside the vehicle are interconnected by the vehicle bus. Most of the requirements like message delivery, data transmission period, noise resilience, routing informations etc. are all sent through the specialized inert communication networks like. In this paper specifically we have discussed CAN, LIN, MOST, Flex Ray bus protocols technologies in brief. Also we have evaluated the capabilities of these bus protocols with respect to their network architecture and many other important features like baud rate, payload, access control, range and also the application field where they can implemented in an automobile. Even though they all have their own network architectures and frame structures to have the better performance and to reach the today's market demands in the automotive field they need to be communicate with each other. Achieving the uninterrupted intercommunication between two different bus architectures is really a challenging task. The one of the best solutions to this is adopting the software adoption method rather depending on the component adoption where the software development and maintenance is focused irrespective of the components being used in any applications.

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