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NETWORK FOR MULTIMEDIA APPLICATION

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Abstract: For the last four decades, the number and sophistication of electronic systems in vehicles have shown an exponential increase. One high-growth area is telematics systems – the convergence of mobile telecommunications and information processing in cars (radios, Web browsers, CD/DVD players, telematics, and infotainment systems). There is the need for a high-speed serial interface for future vehicles, able to share audio-video sources between all passengers and able to connect automotive electronic world with consumer electronic world.

Different networks are available for multimedia automotive applications. Because of their capabilities IDB-1394b and Most are strong candidate.

IDB 1394 is the automotive version of IEEE 1394 version b. It is designed for high-speed multimedia applications that require large amounts of information to be moved quickly in a vehicle. Key features include hot plug capability, compatibility with consumer electronics and the ability to use small, flexible, and inexpensive cables and connectors. Its flexible topology supports both branching and daisy-chaining of nodes. MOST (Media Oriented Systems Transport) is a Multimedia optical fiber system transport that is designed for the automotive environment. This paper presents the main characteristics of these two multimedia protocols. It includes the electrical characteristics, topology, transmission media, software layers...

It includes as well some examples of applications and platform development

Keywords: MOST, IDB1394, DVD player, digital TV, streaming.

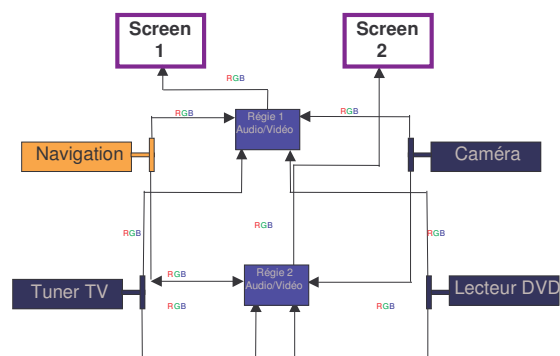
1. Introduction

We have been used for a long time with electronic entertainment and communications in our homes and offices: digital TV receiver, camera, DVD Player, Personal Computer, Game console, MP3 player... But we now expect our infotainment devices to be available any time and anywhere. And, of course, we should have them in our cars too.

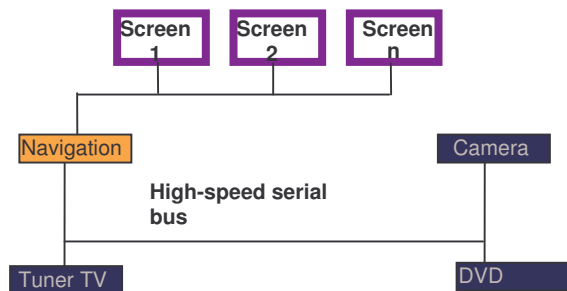
The challenge for the car manufacturers is to integrate these consumer electronic digital devices at a cost compatible with the automotive market

constraints and with a minimum impact on the cable harnesses.

One way to solve issues is to network those devices together through a robust and reliable high-speed serial bus to replace the classical analogue link.



This high-speed bus shall establish a direct link between electronic consumer's world and the automotive world; it shall offer high data rates to support numerous channels video and audio stream. It shall be easily adaptable to any upcoming consumer's digital devices, and must be easy to set up.



Today, two high-speed serial buses can be used for those applications:

- MOST (Media Oriented Systems Transport)
- IDB-1394b (IEEE-1394 or FireWire especially adapted for automotive applications)

The MOST network is already well known by European carmakers, we will limit our paper on an overview of MOST to focus us on the IDB-1394 less known in automotive area.

2. Overview of MOST

The MOST is a multimedia fiber-optic network designed for automotive application.

BMW, DaimlerChrysler, Harman/Becker and Oasis Silicon Systems founded the MOST Cooperation in 1998 to standardize the MOST technology. MOST network is an extension of D2B network and was developed specifically for interconnecting automotive multimedia devices and enable distributing audio, voice, and data in a digital way (targeted devices are navigation unit, phone, active speakers, CD audio player, microphone,...). The first automotive application started in 2001.

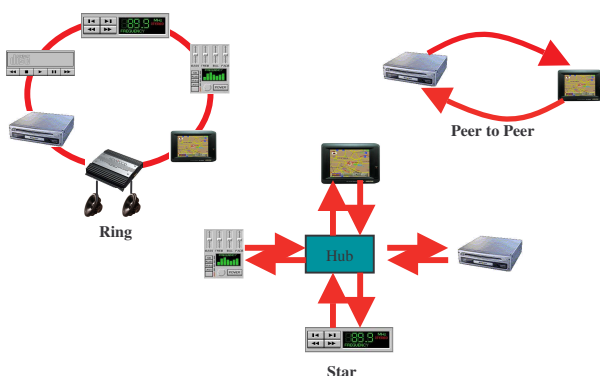
Principal characteristics:

- Data rates up to 24.8 Mbps
- Optimized for use Plastic Optical Fiber (POF)
- Full support for real-time audio and MPEG 1 compressed video
- Asynchronous and synchronous data transfer
- Constant Bit Rate (CBR) data support
- Up to 64 devices
- Simultaneous transmission of multiple data streams such as control, packet and real-time information
- Low overhead due to embedded network management

2.1 Physical layer

Three topologies are possible with MOST:

- Ring
- Star
- Peer to Peer



The specified physical layer requires a Fiber Optical Transceiver (FOT); each node is connected in transmission and in reception to one multi-mode fiber-optic. The signal is coded in Manchester encoded and sent in a continue stream. A bypass system allows to keep the continuity of the network if

a node becomes inactive. With use of LED transmitter, power budget is around 14 dB.

Fiber Optical Transceiver form factor is not part of the standardization and the physical interface consists of the following signal lines:

- RX -receive data line
- TX -transmit data line

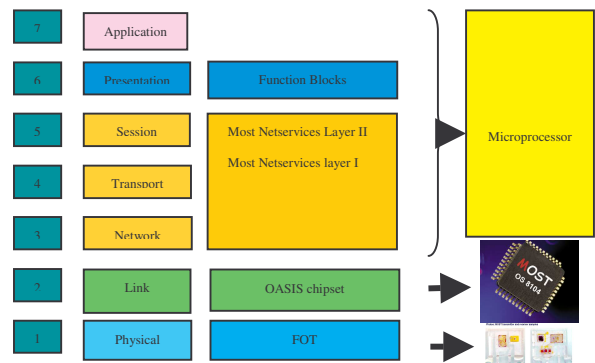
Optional lines could be:

- Power
- Ground
- Wake_up –an optional wake up line for waking up the MOST network

The wake up function in general is derived from sensing activity on the RX line. A receiver device should be able to detect activity and wake up the target device.

2.2 MOST and the OSI model

- Layers 3 to 6 are processed by Netservices software on a microprocessor.
- Layer 2 is realized by a specific OASIS component.
- Layer 1 is realized by a FOT.

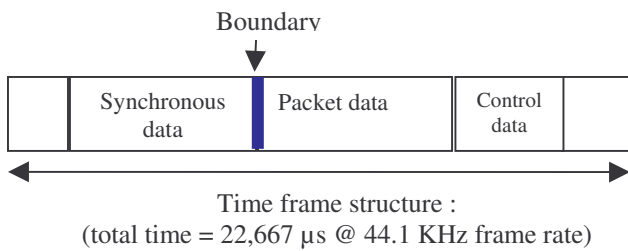


2.3 MOST Protocol

The MOST protocol allows two types of transmission mode:

- Synchronous mode
- Asynchronous mode
 - Control data
 - Packet data

The master node periodically generates a frame shared between time for asynchronous data transfer and time for synchronous data transfer. The frame rate can be fixed at 38 KHz, 44.1 KHz or 48 KHz. Slave nodes can periodically put data or extract data in/from the frame.



At network initialization, the timing master node shall fix the boundary between time for synchronous data transfer and time for packet data transfer. If synchronous data transfer is expected to use maximum of the bandwidth (60 bytes), packet data transfer will not be possible. Following table shows some bit rate combination @ 44.1 KHz frame rate.

	Synchronous data	Packet data
Theoretical bit rate (without protocol)	8.5 Mbit/s.	14.4 Mbit/s
	10.5 Mbit/s	10.5 Mbit/s
	21 Mbit/s	0

Packet data transfer can be used for high frequency burst type application such hard discs transfer, picture or graphic data transfer. Access to this type of data is provided in a token ring manner however low level retry and acknowledgement mechanism are not implemented, user has to implement its own high level protocol following application targeted. Control data is used for commands, status and diagnosis messages between the single nodes of the bus. Protocol on this channel runs in a Carrier Sense Multiple Access (CSMA) manner; low-level retry and acknowledgement are implemented. A control message has a max of 18 bytes payload and the net data rate on this channel is 105 Kbit/s @ 44.1 KHz frame rate.

Synchronous mode is used for CBR data transfer. Accessing this channel is provided by time division multiplexing (TDM) and allocation of a maximum of height bytes at each allocation request. A connection master node administers the synchronous resources and all requests for allocating or establishing connections must be directed to it before any transactions.

If sources and receivers sampling frequencies are identical to the network frame rate there is no need for additional buffering to put and extract data over the network. I.e.: a CD audio player and a stereo active speaker run both at 44.1 Khz sampling frequency, they can communicate through the

network without need of protocol overhead; and buffering with a MOST network frame rate at 44.1 Khz. This system is very cost efficiency. If all the network bandwidth is dedicated to synchronous mode (no packet data transfer), this transmission mode allows to support up to 15 uncompressed CD-quality audio channels (16 bit stereo at 44.1 kHz). However, several sources using different sampling frequencies and mode to output data can be connected over the network, (i.e. DVD audio supports six channels of 24 bits uncompressed audio data at a 48 kHz-sample rate, DVD video signals use compressed with Variable Bit Rate (VBR) at 48 KHz, Digital Video Broadcast use compressed with CBR and 188 bytes packet long at 48 Khz,...), these sources shall be adapted to the MOST network characteristics; transcoding native variable bit rate stream into constant bit rate stream, re-synchronizing data to the clock of the MOST network, segmenting 188 bytes long packet., etc...all in real time. These operations consumes CPU and buffers decreasing the system cost efficiency.

2.4 MOST future evolutions

The MOST Cooperation is working on new specification to increase the data rate up to 150 Mbps. This new specification will define a new physical layer introducing new technologies in vehicle. The coding scheme will change to support higher data rate and VCSEL transmitter will replace LED transmitter. Thus, optical wavelength will change from 650 nm visible to 850 nm infrared and Plastic Optical Fiber couldn't be used any more. It will be replaced with PCS (Plastic Clad Silicon) fiber. Backward compatibility with the 25 Mbit/s version and validation of the new physical layer is the next MOST challenge.

3. IDB-1394

3.1 Introduction

The IDB-1394 specification is a joint initiative of 1394 Trade Association and the IDB Forum to develop an in-vehicle network designed for high-speed multimedia applications that require large amounts of information to be moved quickly within a vehicle. Previously known as IDB-M, IDB-1394 is built on the IEE-1394 technology, which has already gained wide acceptance in the consumer electronics community. The 1394 Trade Association automotive working group adopted the IDB-1394 specification in July 2002.

Apple Computer developed the IEEE 1394, as well as known under the names FireWire or i.Link, in mind 1980s. The first specification was adopted in 1995.

IEEE 1394 provides a serial bus interconnected that allows a wide range of high performance devices to be attached. The primary characteristics of this serial bus include:

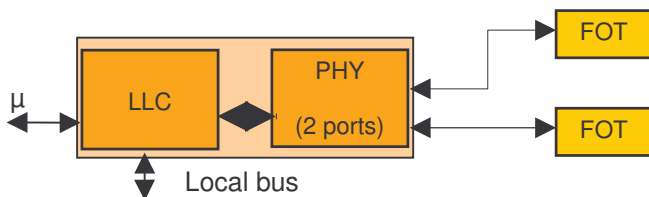
- Data rates up to 800 Mbps
- Optimized for different media : Plastic Optical Fiber (POF), Glass Optical fiber (GOF), Unshielded Twisted Pair (UTP), Shielded Twisted Pair (STP), Coaxial
- Full support for real-time audio and video data and all kind of compressed audio-video formats (MPEG 1, MPEG 2, DV, AC-3, etc...)
- Asynchronous and isochronous data transfer
- CBR and VBR data support
- Up to 64 devices
- Simultaneous transmission of multiple data streams such as control, packet and real-time information Hot plug and play
- Ease to use
- Huge amount of memory mapped address space supported (16 Exabytes)

Typical IEEE1394 domain applications today:

- Mass storage equipment
- Entertainment consumers equipment (DTV, camcorder, DVD recorder-player,...)
- Home networking
- In-flight entertainment
- Industrial application
 - Engine control system
 - Camera
 - Printers
- Military critical applications
- Automotive : Navigation map update

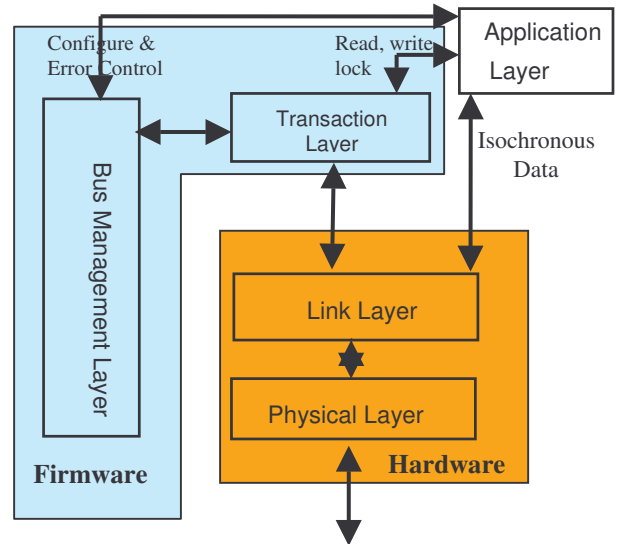
3.2 IDB 1394 model

The typical hardware topology consists of a physical layer (PHY) and a Link Layer controller (LLC). PHY and LLC is often integrated into the same chipset



The PHY layer has physical signaling circuits and logic that are responsible for power-up initialization, arbitration, bus-reset sensing, and data signaling. It can have one to sixteen ports and incoming data signal is automatically repeated to every port. A PHY acts as a repeater.

The IEEE 1394 standard also defines two software layers, a transaction layer and a serial bus management layer, often implemented in firmware and named 1394 stack.



The bus management layer refers to setting up the node on the bus and keeping track of the capabilities and addresses of other nodes on the bus. It can contain all or some of the following functionalities:

- **Isochronous manager** : keeps the budget of bandwidth and isochronous channel
- **Cycle Master**: ensures node synchronization
- **Bus manager** : builds speed and topology maps

The transaction layer provides protocol for asynchronous transfers and can perform bus configuration and management. Application layer is what ever we want the device to accomplish and contains the protocol used to communicate with other device and potentially the user interface.

Based on this model, three kind of link layer chipset exist today on the market:

1. General purpose link controller which has no protocol layers integrated and need an external microcontroller
2. Processor link layer controller which integrates a small microprocessor, some RAM, and the necessary protocol layer(s); This link layer can have standard interface, like I2S, I2C, SPDIF, BT 656, etc... and doesn't need any external microcontroller

3. OHCI link layer which has direct mapping connection to a PCI interface

The cost-effective solution, for automotive application is a processor Link Layer with an integrated PHYb.

3.3 IDB 1394 Topology

The physical topology for a typical IDB 1394 network is a tree structure. Typically, a node will have a least two ports which enables multiple nodes to be daisy chained together. If a node has more than two ports, multiple branches can be created. During initialization, one node is defined to be the root node with all nodes extending down different branches. The topology can have any number of branches.

A root node is re-elected after each bus reset (bus reset is the consequence of device connection/disconnection, device resuming from sleep mode to active mode or network initialization). Root node shall contain cycle master and bus manager. In the automotive implementation it is required to force one specific node to be the root node in order to control the network management.

3.6 IDB 1394 Physical layer

IDB 1394 physical layer consists of two optical fibers. The transmission is full duplex and optical links are unidirectional. The 8B/10B coding scheme used allows transporting clock and data in the same bit stream. Transmitter periodically inserts K28.5 symbol in data to allow receiver synchronization. When neither node is sending data, they always continue to exchange periodic K28.5 symbol to keep the synchronization. With LED transmitter, the power budget is around 14.5 dB.

POWER MODE

IDB 1394 PHY component implements three power consumption modes

- Full power : all port are powered and active
- Sleep : all ports are in sleep state and able to be awoken by network activity (port is still listening for tone)
- Ultra low power; all ports are disabled, only event from internal microcontroller can awake the PHY

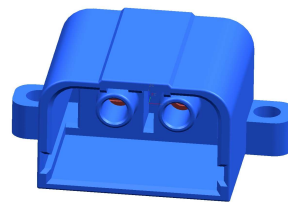
FOT power modes	Consumption (3,3 V)
Full	140 mA (max)
Sleep	40 µA (max)
Ultra low (if optical activity is detected RX transmits a wake signal that can be used to wake up the node's microcontroller)	20 µA (max)

FIBER OPTIC TRANSCEIVER

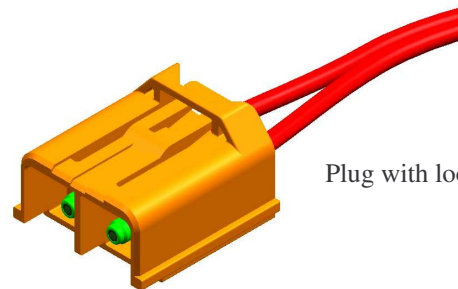
IEEE TA2004024 PMD for wake up on LAN document defines FOT dimensions and electrical-optical characteristics for S100, S200 and S400 bit rate in order to guarantee all connectors and FOT's interoperability.

CONNECTOR

IDB 1394 specification defines the interface and latch of an optical connector for the embedded network. This connector is adapted from the consumer PN07 connector and the FOT is directly integrated into the header (without pigtail). Three coding are specified to avoid incorrect mating. Plug designs for fixed ferule and loose ferule are provided

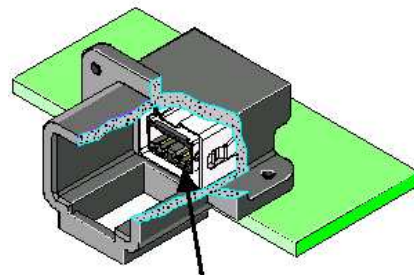


Header with FOT



Plug with loose ferule

IDB 1394 defines the copper connector used to interconnect portable devices to the automotive embedded network. The CCP socket inter mate with both IEEE 1394b-2002 bilingual type 2 and type 3. This connector can provide power to the connected node. The connector is already standardized with multiple manufacturers. The design was optimized for EMI/RFI protection.

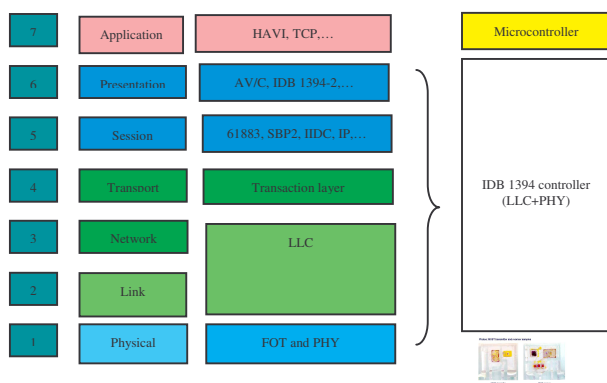


CCP IDB-1394B CONNECTOR

CLOCK SYTEM

Each Physical Layer's node requires a 49.152 MHz system clock, which can be derived from either an external crystal oscillator or an external clock. The clock drives an internal phase-locked loop (PLL), which generates the required reference signal. This reference signal provides the clock signals that control transmission of the outbound encoded information. A 98.304 MHz clock signal is supplied by the PHY to the associated LLC for synchronization of the two devices when operating the PHY-link interface in compliance with the IEEE 1394b-2002 standard.

3.5 IDB 1394 and the OSI model



Physical, data and network layers are standardized in IEEE 1394a and 1394b specification

Session layers and presentation layers used to communicate are standardized by IEC and IEEE organization to ensure devices interoperability. Some examples:

- IEC 61883-2 to 8 protocols handle isochronous streaming data like video and audio (compressed video : DV, MPEG2 TS, compressed and uncompressed audio)
- IEC 61883-1 protocol is utilized to send command and control between nodes on the network.
- ANSI SBP-2/3 protocols are currently defined to send/receive asynchronous data blocks between nodes on the network (hard disk, DVD-ROM player,...).
- IEEE TA1999023 IIDC protocol handles uncompressed video data for camera.
- "IP over 1394" standardizes how to transfer IP packets across a FireWire interface.

3.6 IDB 1394 protocol

The 1394 protocol supports both asynchronous and isochronous data transfers. Isochronous transfers are always broadcast in a one to one or one to many fashion. There is no error correction or

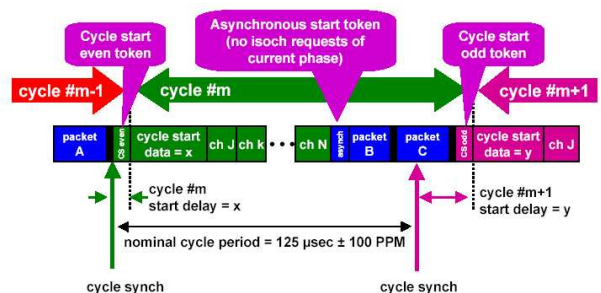
retransmission available for isochronous transfers. The maximum amount of bandwidth an isochronous device can obtain is only limited by the other isochronous devices that have already obtained bandwidth from the isochronous resource manager. Asynchronous transfers are acknowledged and responded to. This allows error checking and retransmission mechanisms to take place.

CONTROL COMMAND

Control commands are defined in specific AV/C sub-unit specification document (i.e. AV/C sub-unit CD changer, AV/C sub-unit disc,...) An AV/C command frame can be up to 512 payload bytes. Maximum effective bit rate on the control channel is 93 Mbit/s @S100.

ISOCHRONOUS TRANSACTIONS

Isochronous channel guarantee bandwidth to applications like real time audio, video and voice. When an application is allocated an isochronous channel, it is guaranteed to send isochronous packets at regular intervals. The cycle master (in the root) broadcasts every 125 μ s an isochronous «cycle start». Once all nodes have received this message, an isochronous communication window opens. All nodes waiting with pending isochronous messages will then send. Once all isochronous messages have been transferred using a maximum of 100 μ s (80% of the bandwidth), the isochronous communication closes, and asynchronous communication are allowed to take place, until the next 125 μ s cycle begins.



Isochronous communication uses a channel scheme where nodes transmit over a numbered channel and receive by listening on the receiver channel. Talker needs to allocate the necessary bandwidth and a channel number at the isochronous resource manager (IRM) before sending data.

Isochronous transactions are packed based and the overhead consists of 4 bytes of header and 8 bytes of checksum for data and header. DATA can be up to 4800 bytes at S400.

automotive display as low as possible (no decompression, no video scaler).

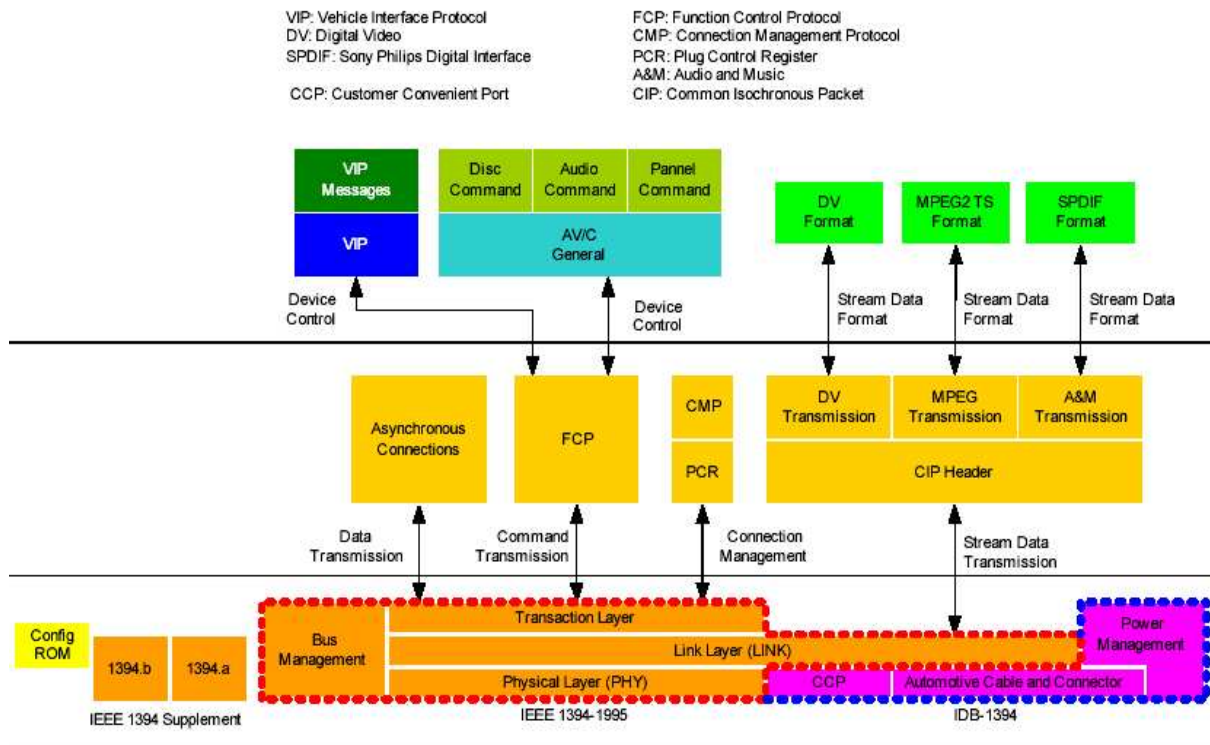
AMI/C

The Automotive Multimedia Interface Collaboration (AMI-C) is a non-profit corporation comprised of motor vehicle manufacturers from around the world as members. It was established to facilitate the development, promotion and standardization of automotive information and entertainment system interfaces to motor vehicle communication networks. AMI-C produces a set AMI-C Technical Documents (requirement, specification and reference documents) concerning automotive information and entertainment.

For example, AMI-C defines the Vehicle Interface Protocol for 1394. This specification describes the protocol and messages to control and manage vehicle information over 1394 networks.

3.7 IDB 1394 future evolutions

IDB forum and 1394-trade association are working on new specification extension to use UTP, STP and wireless over Ultra Wide Band in automotive.



4. Conclusion

Most is well implanted in vehicles today but could be limited. On the other hand, IDB-1394, even if it is a new network in the automobile field could take advantage from already existing products coming from consumer world. It enables a cost-effective introduction of consumers electronics devices (such as CD players, DVDs, Digital TV receiver,..) in vehicles.

Due to the work done by organizations like IDB, AMI-C... and including now automotive requirements IDB-1394 is completely ready, including automotive requirements to be used as an automotive high-speed bus multimedia backbone.

Products as navigation are already available by Toyota and some global projects like rear seat entertainment with IDB-1394 as multimedia backbone are on the way and will equip vehicles in 2009 in vehicles.

5. References

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6. Glossary

AMII/C	: Automotive Multimedia Interface collaboration	PCS	: Plastic Optical Silicon
ANSI	: American National Standards Institute	PLL	: Phase-Locked Loop
API	: Application Programming Interface	PHY	: Physical Layer
CBR	: Constant Bit Rate	POF	: Plastic Optical Fiber
CCP	: Consumer Convenience Port	STP	: Shielded Twisted Pair
CSMA/CD	: Carrier Sense Multiple Access Collision Detection	TDM	: Time Division Multiplexing
IDB	: ITS Data Bus	UTP	: Unshielded Twisted Pair
IEC	: International Electrotechnical Commission	VBR	: Variable Bit Rate
IEEE	: Institute of Electrical and Electronics Engineers	VCEL	: Vertical Cavity Emitting Laser
IRM	: Isochronous Resource Manager		
FOT	: Fiber Optical Transceiver		
GOF	: Glass Optical Fiber		
LLC	: Link Layer Controller		
MOST	: Media Oriented Transport		