Media Oriented Systems Transport (MOST)

Communication Protocols

Media Oriented Systems Transport

- MOST is a standard (ISO 21806-1) for high-bandwidth automotive multimedia networking.
  - Developed by MOST Cooperation
  - Optimized for automotive infotainment and ADAS systems
  - Also supports industrial and home applications
- Supports 25, 50 and 150 Mbps
  - Three versions: MOST25, MOST50 and MOST150
- Uses a single medium and supports different physical layers
- Defines the protocol, hardware and software layers required for
  - An efficient and a low-cost transport of control, real-time and packet data.
  - Streaming of audio/video with an excellent Quality of Service and seamless connectivity
- Defines all the seven layers of the OSI Model for data communication

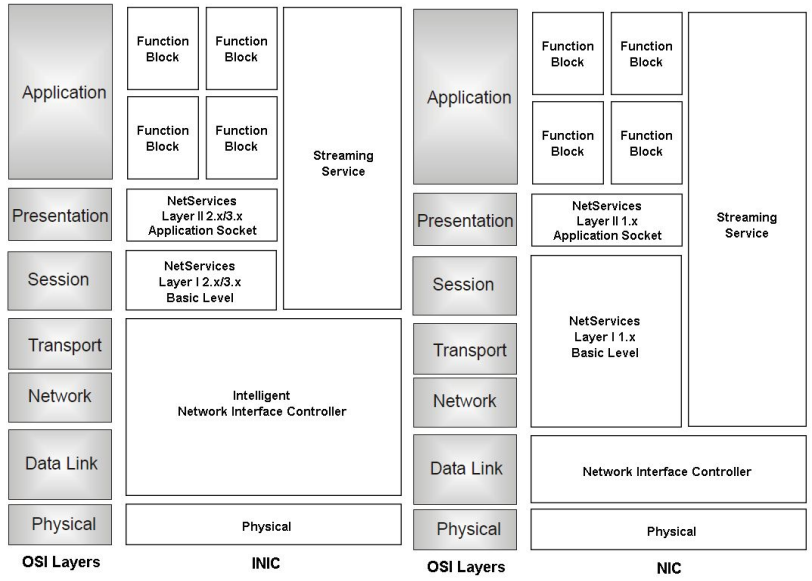
Media Oriented Systems Transport

- Example Applications in a car
  - Classic infotainment system like
    - Audio, video, internet access, navigation and etc.
  - Car maker specific functionalities like
    - Software update, diagnostics, gateway like CAN-MOST and etc.
  - Advanced Driver Assistance System (ADAS) like
    - Advanced camera system used for collision detection

- Supports synchronous, asynchronous and isochronous (MOST150) transmissions
- Supports redundancy for fault-tolerant safety-critical systems
- Provides the TCP/IP stack for internet access
- Supports different types of topology

Media Oriented Systems Transport

- MOST is a function-oriented system
  - In the Application Layer, there are function blocks which are required to control the devices
  - Function blocks have all properties and methods of a MOST device (e.g. a CD player)
  - MOST provides a standardized interface (API) to access device functionality. E.g. CD.1.Track.Set(10)
- Network services layers (NetServices I and II)
  - Are implemented in two layers; the MOST software driver
  - Provide the basic level of the driver and application sockets
  - Include MOST High Protocol which adapts the TCP/IP onto MOST (only MOST25 and MOST50). In MOST150 a pure TCP/IP stack is provided (Ethernet over MOST)



  - Include the control of streaming connections; but not streaming transmissions (sync. & isochronous)

Media Oriented Systems Transport (Application Framework)

- MOST has three types of interaction with the function blocks
  - **HMI (Head Unit)** is the user interface of a MOST system
  - **Controller** is an administration application
    - It uses an application protocol to control function blocks of one or more slaves
  - **Slave** is a MOST device which is controlled by a controller.
    - Provides its functionality by properties and methods in its function block.
    - Can easily be added or removed from a MOST system without modifying the software (plug & play)

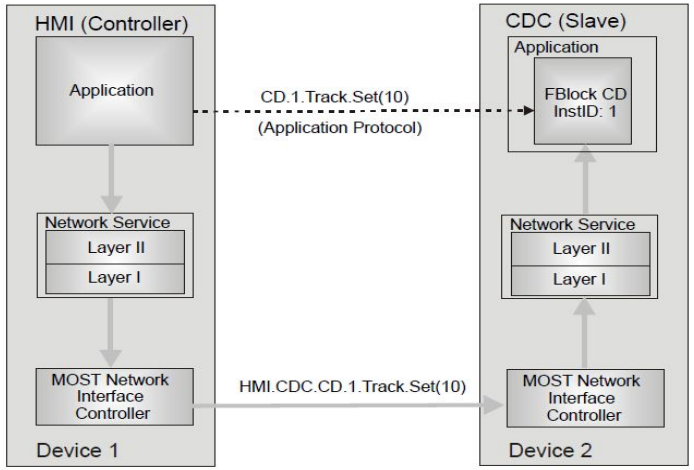


Fig. 2.5: Application protocol

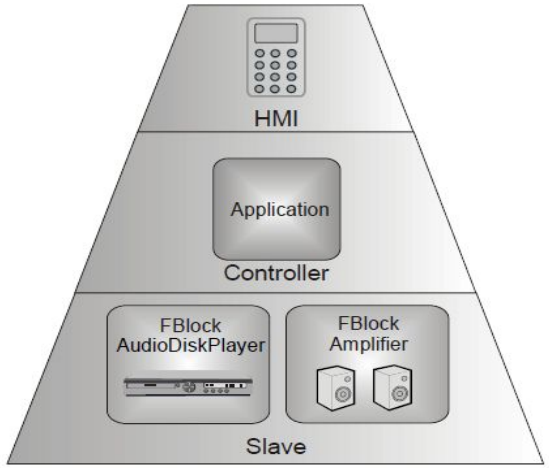


Fig. 2.3: Hierarchy in the MOST system

Media Oriented Systems Transport (Data Types)

- There are four types of data in a MOST network
  - **Control data** which is used in the administration of the system
    - Like commands and status messages
  - **Synchronous data** like digital audio and warnings data which
    - Are transferred with low latency
  - **Packetized data** which is used in client-server communications
    - Like Ethernet packets (standard TCP/IP) used to e.g. software download
  - **Isochronous data** which is the streaming data that
    - Is not synchronous to the network clock. E.g. compressed MPEG video streaming from a DVD
    - This type of data transmission is only support by MOST150
- The key feature of the MOST
  - Supporting of all the data types and transmission methods; including broadcasting

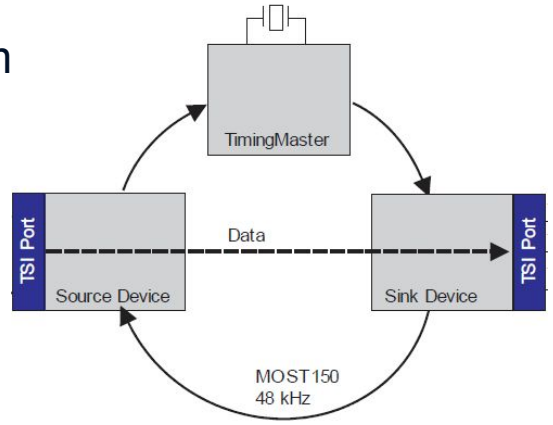
Media Oriented Systems Transport

- Isochronous Transmission
  - Is a transmission method used for transmitting real-time information like video data
  - It combines the features of asynchronous and synchronous data transmission
  - It sends blocks of data asynchronously (data stream can be transferred at any intervals)
  - But the blocks of data is delivered at a fixed rate.
    - E.g. in an MPEG video with 25 fps, every frame should be delivered in 40 ms
  - Data gets packetized and each transmission begins with a start packet.
  - Once the start packet is transmitted, the data must be sent at a constant bit rate
  - If the packet is sent using more than one frame, there should be no delay between the frames
  - There is no error detection and correction mechanism (no acknowledgment of receipt of packet)
  - A new data packet is sent, regardless of the success or failure of the previous packet
  - The entire stream of bits are synchronized

Media Oriented Systems Transport

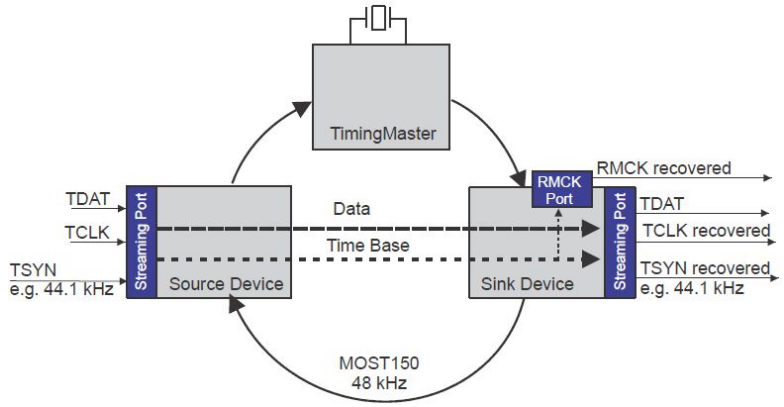
- Isochronous Data in MOST150
  - Isochronous channels are handled in the same way as synchronous channels
    - Channels for isochronous data are preallocated and required bandwidth is reserved

- MOST150 supports three isochronous mechanisms
  - **A/V packetized Isochronous Streaming**
    - Used for video streaming without any reference to the MOST network clock
    - The stream data gets packetized; optionally including a timestam
    - E.g. MPEG video stream from a DVD which is coded with a variable or constant frame rate
      - The MPEG data stream is stuffed with bits in order to have a fixed bit rate



Media Oriented Systems Transport

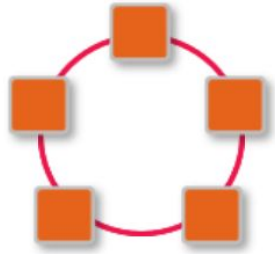
- MOST150 supports three isochronous mechanisms ...
  - **Discrete Frame Isochronous**
    - Used for streaming data containing additional time information in parallel
    - Data is arranged in frames and the frames are not synchronized to the MOST network time
    - E.g. PCM (pulse code modulation) audio with a frame sync signal

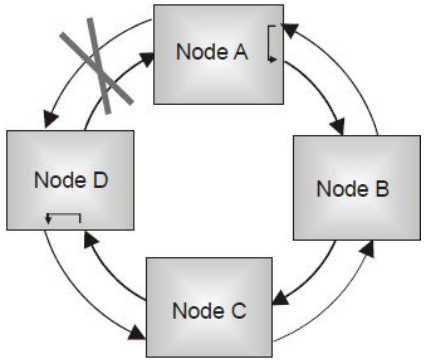


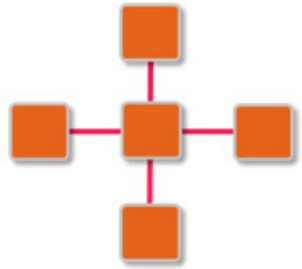
  - **QoS IP (Streaming)**
    - Used for packet transmission for full quality of service requirements
    - E.g. in transporting video data as an IP stream on the MOST Ethernet channel
    - High volume data transfer can lower the bandwidth for the video
    - QoS IP (Streaming) mechanism prevents the data transfer to interfere with the video streaming

Media Oriented Systems Transport (Network Architecture)

- MOST supports different topologies including
  - Point-to-point, ring, daisy chain, star and hybrid
- The basic topology is a P2P network based on ePhy/oPhy/cPhy layer
- Max number of nodes in a ring network
  - Up to 64 nodes; 20 nodes in MOST150
  - A typical automotive ring has 4 to 8 nodes
- Redundancy and double structure is possible
  - Each node must have 2 transmitters and 2 receivers
  - In the case of a problem between two nodes, the ring can be closed via the redundant segment
- MOST supports plug and play; allows devices to be easily attached and removed
- Hubs or switches are also possible; but not well-established in the automotive sector.







Media Oriented Systems Transport (Network Architecture)

- Network Management
  - In addition to function blocks for the application functions, there are
    - **NetBlock** which is responsible for the administration of the device. E.g. node address
    - **PowerMaster** which is responsible for
      - Starting up and shutting down the network and supervising the status of the power supply
      - The network can be woken up by any node
    - **NetworkMaster** which starts the system up and administers the network status
      - All the other nodes in the network are called **NetworkSlaves**
    - **ConnectionMaster** is the function block that
      - Has an interface to the connection manager and is responsible for establishment and disconnection of streaming connections

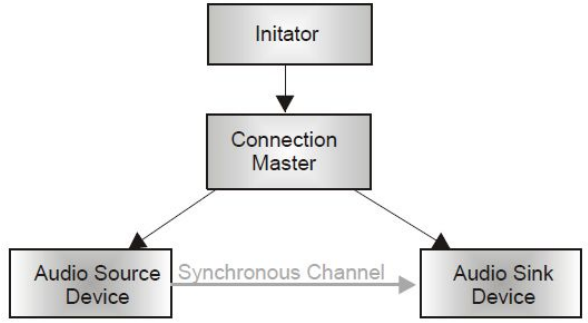
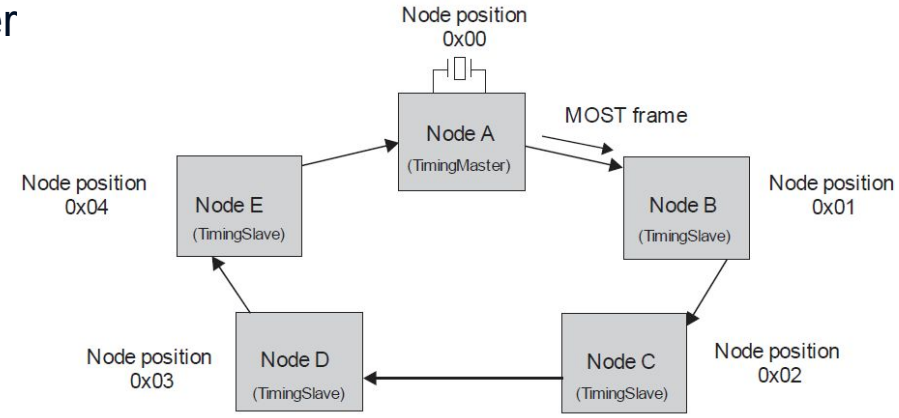


Fig. 2.12: Basic principle of the ConnectionMaster

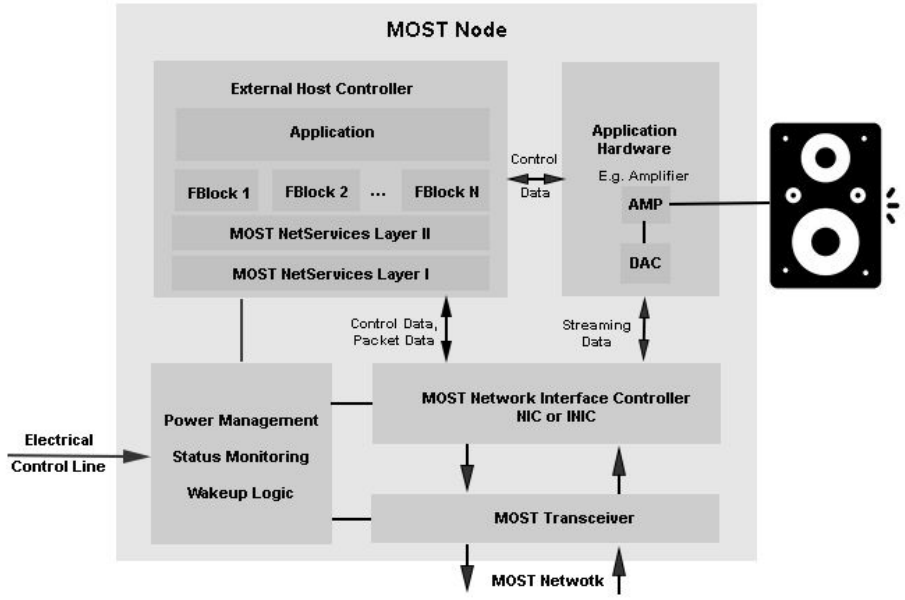
Media Oriented Systems Transport (Node)

- MOST is a point to multipoint synchronous network system
  - Transmission is initiated by a source node and any number of sink nodes can transfer their data
- In a MOST network there are two types of node
  - TimingMaster and TimingSlave
- All nodes share a common system clock which is derived from the data frame
  - The system clock is generated by the TimingMaster
  - Other nodes are synchronized to the system clock
  - In a MOST network there should be only one TimingMaster at a time.
  - In vehicles usually TimingMaster is located in the Head Unit of the infotainment system



Media Oriented Systems Transport (Node)

- MOST Transceiver can be electrical or optical
- The Network controller has different interfaces for exchanging different types of data
  - It exchanges control and packet data with the EHC via **I2C**
  - It uses **I2S** for transmitting of multiple synchronous audio streams
  - **MediaLB** is a serial multiplexed high speed interface which is used for transmitting of control, packet, audio and video data
  - **SPI** for Ethernet packets (TCP/IP)
  - **TSI** (Transport Stream Interface) for video data or **USB** for control, packet and streaming data



General Software and Hardware Architecture

Media Oriented Systems Transport (Physical Layer)

- MOST supports UTP, POF and Coaxial cable in the physical layer
- **Unshielded Twisted Pair** for MOST50
  - Impedance of 100Ω to 140Ω and differential signals ±1.25V
- **Plastic Optical Fiber** for MOST25 and MOST150
  - Red light, total internal reflection
  - No electromagnetic interference
  - Core diameter 0.98mm and min. bending radius 25 mm
  - Temp. range: -40℃ to +80℃
  - Different connectors standardized by MOST
    - E.g. MOST150 FOT (Fiber Optical Transmission unit)
      - Uses low-voltage differential signaling

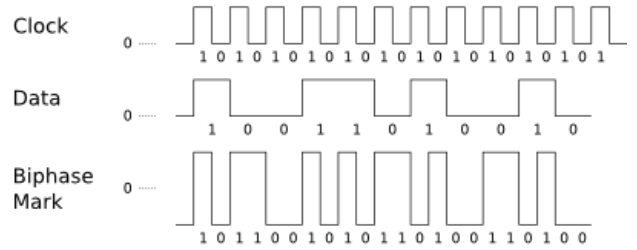
Media Oriented Systems Transport (Physical Layer)

- **Coaxial Cable** for MOST150
  - Impedance of 50Ω to 75Ω, max. distance 100m
  - Bidirectional transmission and power over coax is possible
  - Ideal for connecting camera using just one cable
  - **FAKRA** connectors are used in automotive applications

- Max. distance between two nodes
  - Limited by the speed and number of nodes
    - E.g. 10m in MOST50, using 30 nodes and 15m in MOST150
- **MOST25** max. speed is ~25 Mbps; can transport up to 15 stereo audio channels simultaneously
- **MOST50** max. speed is ~50 Mbps; can transport up to 29 stereo audio channels simultaneously
- **MOST150** max. speed is ~150 Mbps; can transport up to 93 stereo audio channels simultaneously

Media Oriented Systems Transport

- A dedicated TimingMaster generates
  - The clock for the entire network
  - Biphase encoding to encode the line
    - Data and clock signal are combined to form a single 2-level self-synchronizing data stream
    - There is always a transition in the beginning of the bit.
    - "1" forces a transition in the middle of the bit and "0" does nothing.
  - MOST frames at a constant rate which results in a continuous bit stream
  - All TimingSlaves get synchronized to the MOST Frames and adjust their internal clocks
- Data is organized in fixed length MOST frames and sent in constant bit and frame rates
  - MOST25 => bit rate: ~25 Mbps and frame rate: 44.1 kHz
  - MOST50 => bit rate: ~50 Mbps and frame rate: 48 kHz
  - MOST150 => bit rate: ~150 Mbps and frame rate: 48 kHz



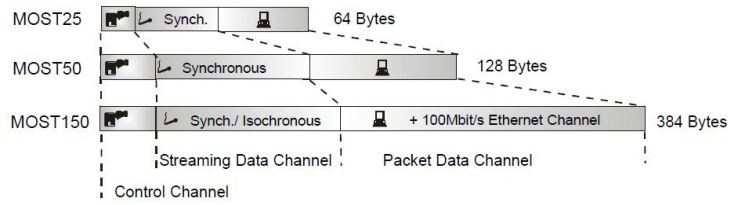


Fig. 2.6: Basic structure of a MOST frame

Media Oriented Systems Transport

- MOST Frame Length
  - In MOST25 is 64 bytes
  - In MOST50 is 128 bytes
  - In MOST150 is 384 bytes

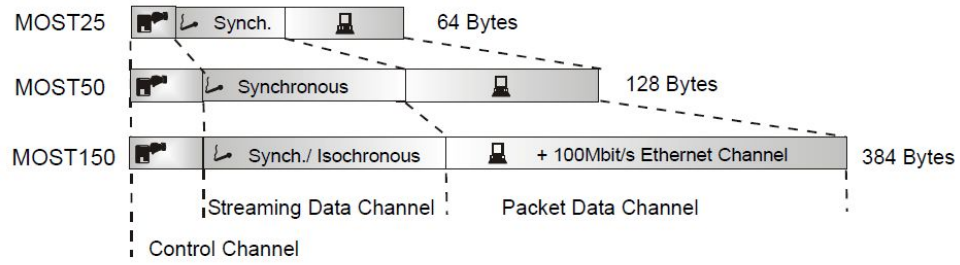


Fig. 2.6: Basic structure of a MOST frame

- Uses TDM, CSMA, Token and Arbitration to allow nodes transfer different types of data.
- A MOST frame contains three types of channel
  - **Control Channel** is used for network and system related administration and control
    - By exchanging commands and status messages using **CSMA**
  - **Streaming Channel** uses **TDM** to transmit multiple audio and video streams
  - **Packet Channel** uses a **token** to transmit Ethernet and MOST data packets asynchronously
    - E.g. Internet traffic, navigation and software update data

Media Oriented Systems Transport

- The frames travels around the network and transports data to/from all devices cyclically
- For example: MOST150 Frame
  - Header is 12 bytes and used to transport the the administration and control messages
    - Preamble and System Lock Flag are used to synchronize the nodes to the bit stream
    - Shutdown flag is used to shutdown the network and Boundary Descriptor is used to specify the boundary of streaming data and packet data
    - 4 bytes of the control data provides data for the **control message**
  - Length of the stream data and the packet data can be 0 - 93 quadlets (0 - 372 bytes)

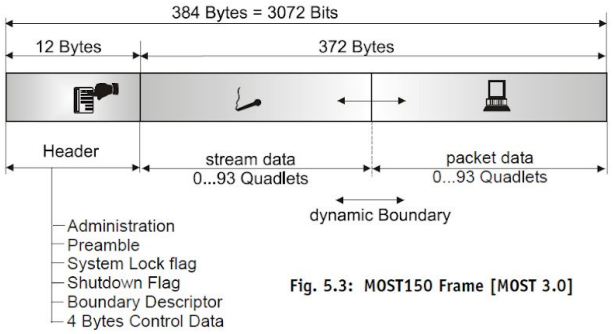


Fig. 5.3: MOST150 Frame [MOST 3.0]

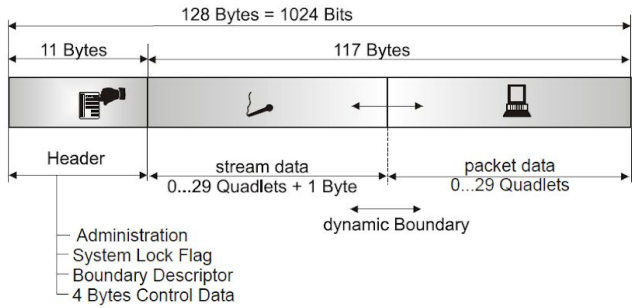


Fig. 5.2: MOST50 Frame [MOST 2.5]

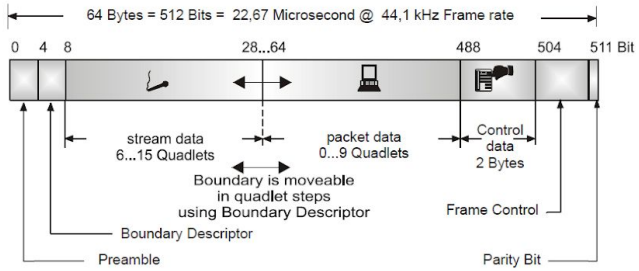
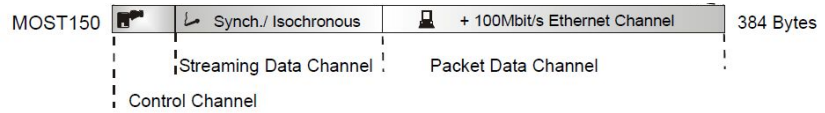


Fig. 5.1: MOST25 frame [MOST 2.4]

Media Oriented Systems Transport (MOST150 Frame)

- Control channel is shared by all devices
  - Since only one device can send a message at a time, all messages are transmitted sequentially



- Control Message
  - A control message is splitted into 4 bytes per frame and sent in consecutive frames
    - 4 bytes per frame for control data within the header
  - If a service needs more than 12 bytes for the parameter (Data Bytes), the message must be segmented into telegrams
  - The length can vary depending on the message
  - **Preemptive Acknowledge** is used for flow control. It is driven by the receiver and indicates if the receiver is ready or not

DeviceID.FBlockID.InstID.FktID.OPType (parameter)

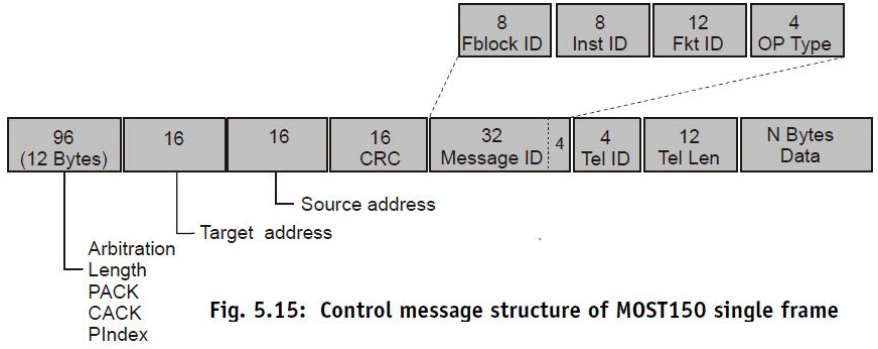


Fig. 5.15: Control message structure of MOST150 single frame

Media Oriented Systems Transport (MOST150 Frame)

- Control Message
  - **Complete Acknowledge** It is driven by the receiver and indicates if the CRC is correct or not
  - **Length** is the length of the message; it can be max. 65535 bytes
  - **Pindex** is a counter and is incremented with each new control message sent by a node
    - It is used for low-level retries in the case of errors
  - **Message ID** covers FBlockID, InstID, FktID and OPType
  - **Arbitration** is used for access control (Carrier Sense Multiple Access)
    - The priority of the message does not depend on the position of the node
  - Target and Source Addresses
    - Address = 0x100 + Node-Position
    - TiminingMaster position is always 0x00

DeviceID.FBlockID.InstID.FktID.OPType (parameter)

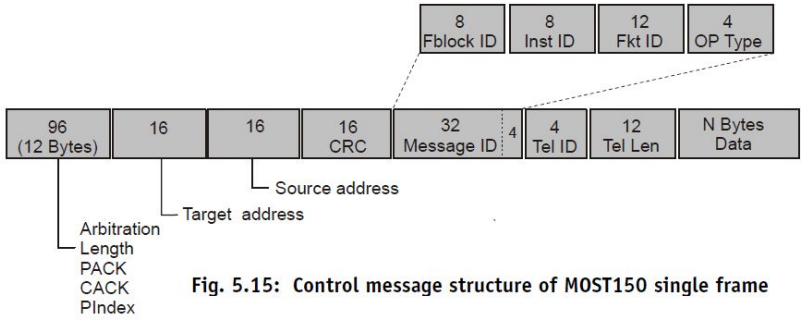
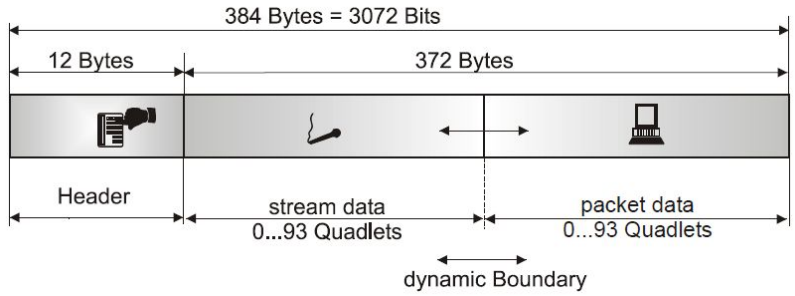


Fig. 5.15: Control message structure of MOST150 single frame

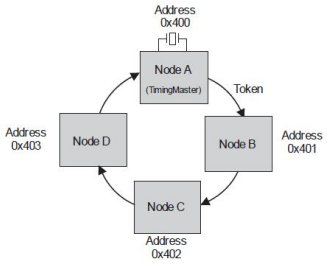
Media Oriented Systems Transport (MOST150 Frame)

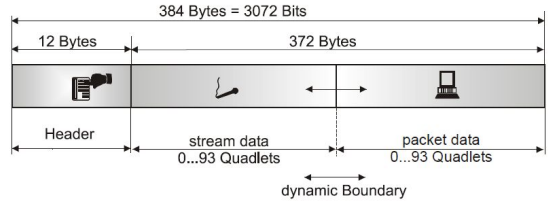
- Streaming Data Channel is shared by all devices
  - Its length depends on the boundary descriptor
  - Synchronous and isochronous data are transferred in this channel.
  - Synchronous data is used for real-time transmission of audio and video.
    - Up to 93 stereo audio connections can be established (4 bytes per sample - L & R)
  - Isochronous data is used for transmission of A/V data with constant frame rate
  - Time Division Multiplexing (**TDM**) is used for access control
  - Dynamic bandwidth allocation & deallocation is done during run time
  - Data is splitted and transported in consecutive frames
  - A connection is established by the connection manager
  - Fixed bandwidth for each data stream. No collision
  - Broadcasting is supported



Media Oriented Systems Transport (MOST150 Frame)

- Packet Data Channel
  - MOST150 provides two types of addressing
    - 16 bit addressing (classic MOST address)
    - 48 bit address (MAC address)





  - Sender **packetizes** the data & splits packets to **segments** with size of the data in the packet channel
  - Sender must wait until the packet channel is idle
  - If the sender takes the control of the bus, it can transfer a complete packet in several consecutive frames in the packet channel without any interrupt
  - Node Prioritization and low-level retries are possible
  - Access control is done by using a **token**.
  - A node must gain the token from the bus and place the token back after sending a single packet.
  - Having the token means exclusive access to the bus.

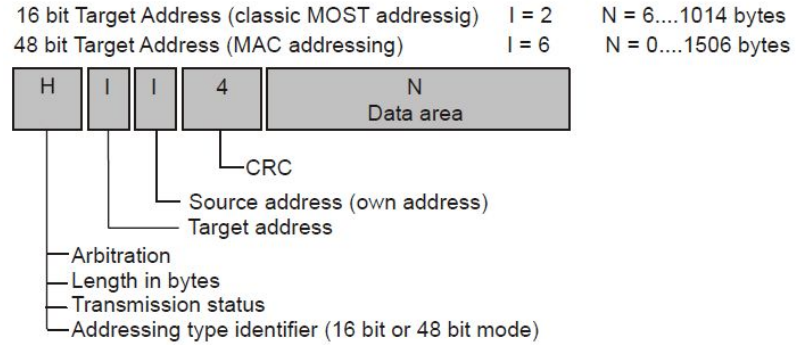


Fig. 5.9: Structure of the data link layer protocols for MOST150

Media Oriented Systems Transport (Application)

- MOST Function Blocks
  - Provide standardized methods and properties to access functionalities of different devices
  - Can be customized for a particular car platform
  - The structure of MOST applications messages follows the related FBlocks specifications.

FBlock	Function	OPType	Parameter
AudioAmplifier (0x22)	Volume (0x400)	Set	Volume
		Get	-
		SetGet	Volume
		Increment	NSteps
		Decrement	NSteps
		Status	Volume
		Error	ErrorCode, ErrorInfo

Parameter

NSteps

Explicit values ranges are specified in the application.

Basis datatype	Exp.	Range of values	Step	Unit
Unsigned Byte	0	1..255	1	not defined

Volume

Explicit values ranges are specified in the application. The value 0 corresponds with mute. High values correspond with high volume.

Basis datatype	Exp.	Range of values	Step	Unit
Unsigned Byte	0	0..255	1	none

- MOST Function Catalog
  - Is a database which holds all function blocks specifications of an infotainment system. Every block has its own document
  - Typically defines several thousands messages in a large infotainment system
  - Is based on the definitions of the MOST Cooperation standard FCat

Media Oriented Systems Transport

- Some useful links
  - MOST Bus
  - MOST Specification
  - MOST Book - MOST Cooperation
  - The MOST Network and Fiber Optic Basics
  - MOST - Introduction
  - MOST - Network
  - MOST - Applications