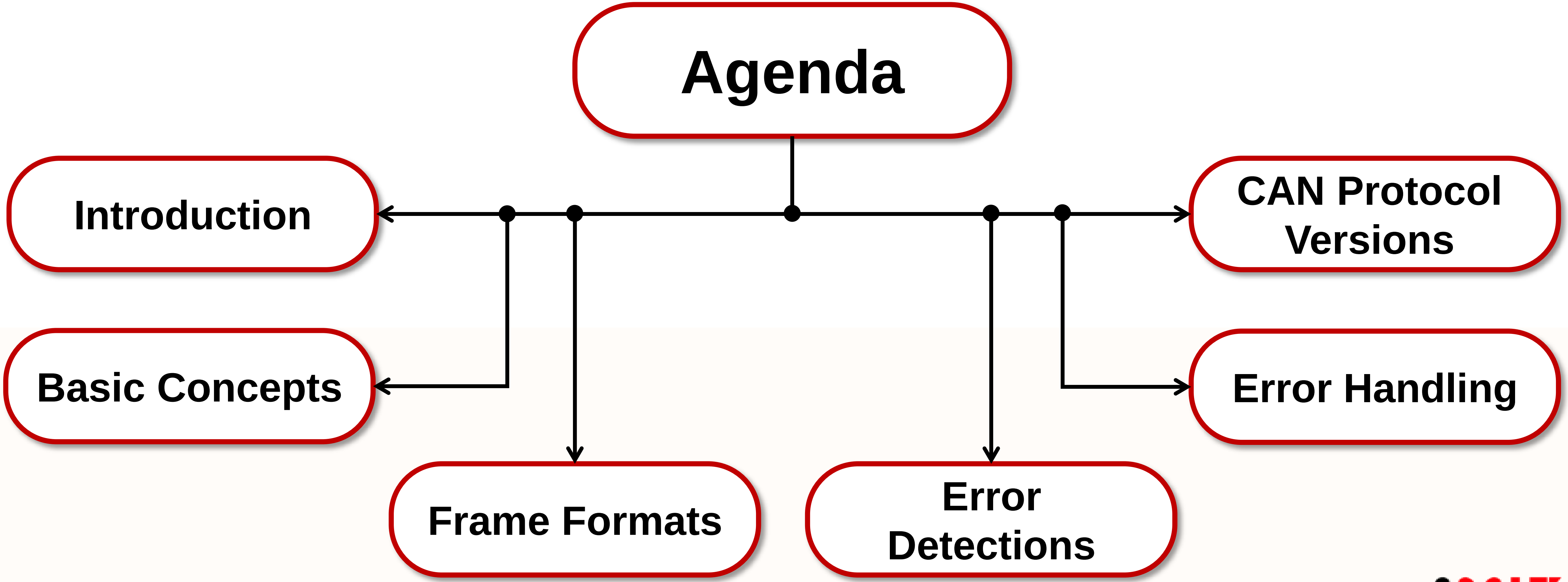
Learn Automotive Bus Technology

Prepared By: AMIT Learning

Agenda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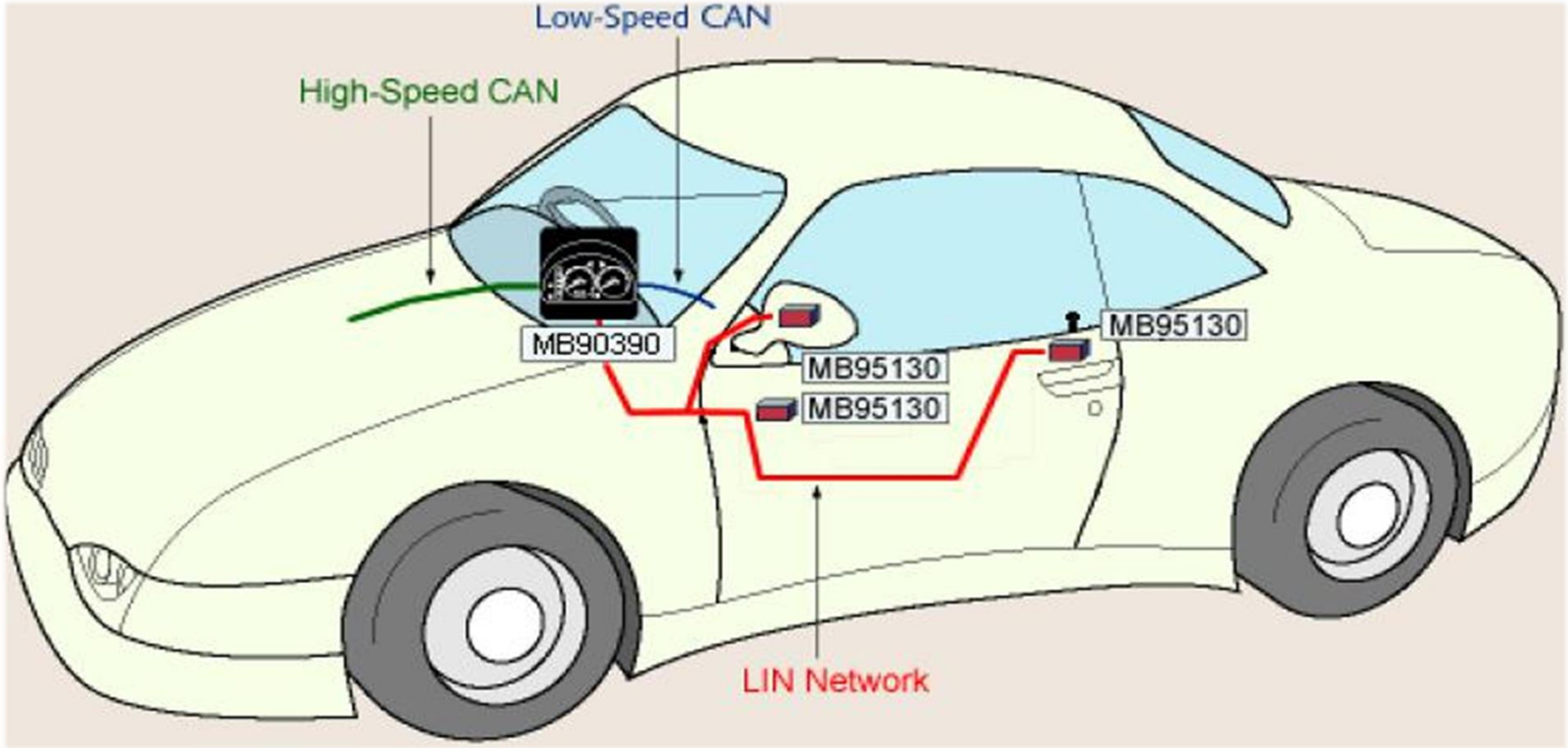
Introduction
Basic Concepts
Frame Formats
Error Detections
Error Handling
CAN Protocol Versions

➢ Introduction

- **How it began ...**



Introduction

Each type requires specific features:

- Conventional body and powertrain applications use protocols with known real-time properties
  - **CAN**

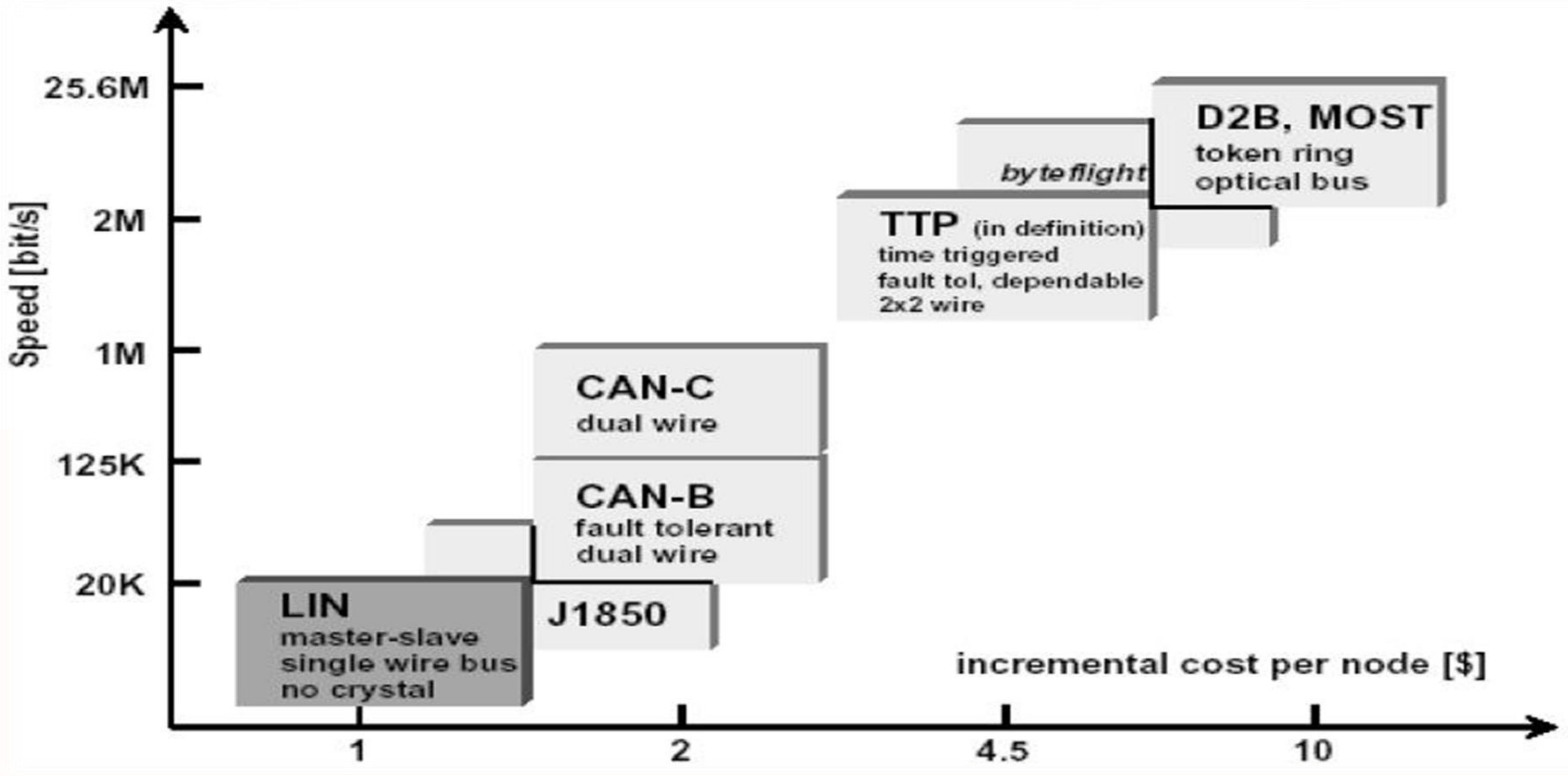
- Multimedia applications, calling for protocols that should provide high bandwidth and speed and even wireless interconnection.
  - **Bluetooth**
  - **MOST**
  - **Firewire**

➢ Introduction

- Safety critical applications, needing protocols that are fault tolerant and reliable. X-by-wire is an emerging market that calls for protocols like
  - **TPIC (Time-Triggered Protocol classified as a SAE type C network)**
  - **FlexRay**
  - **TT-CAN (Time Triggered CAN).**

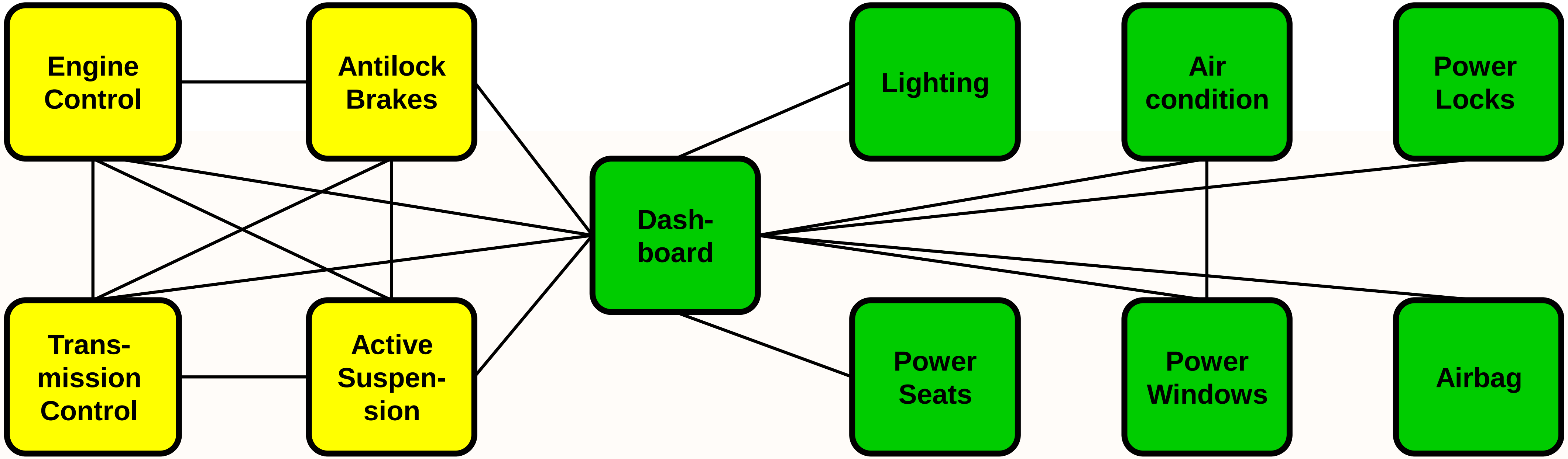
- Mechatronic type applications such as smart sensors and actuators, or even complex ECUs with simple communication needs. These applications are addressed by protocols like
  - **LIN**
  - **TTP/A**
  - **other OEM (Original Equipment Manufacturer) specific protocols**.

➢ Introduction



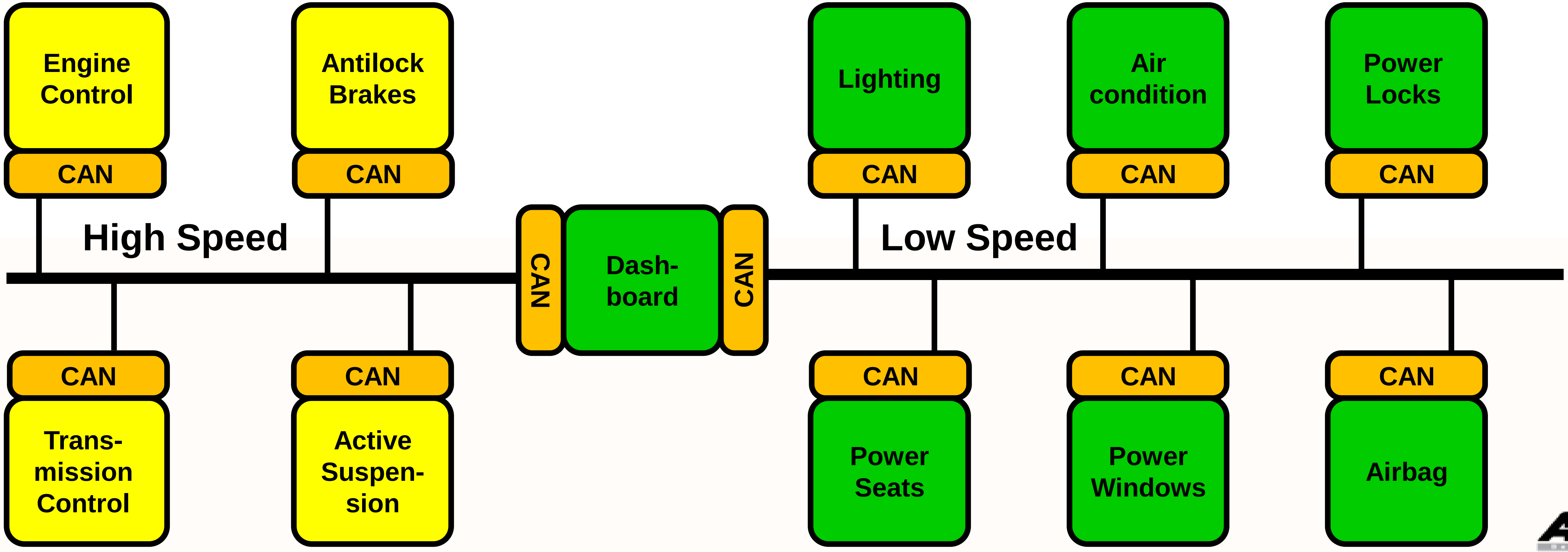
Introduction

- **How it all began ...**
  - Discrete Interconnection of different systems (point to point wiring)
  - Network cable with a length of up to several miles and many connectors was required !!



Introduction

How it all began ...



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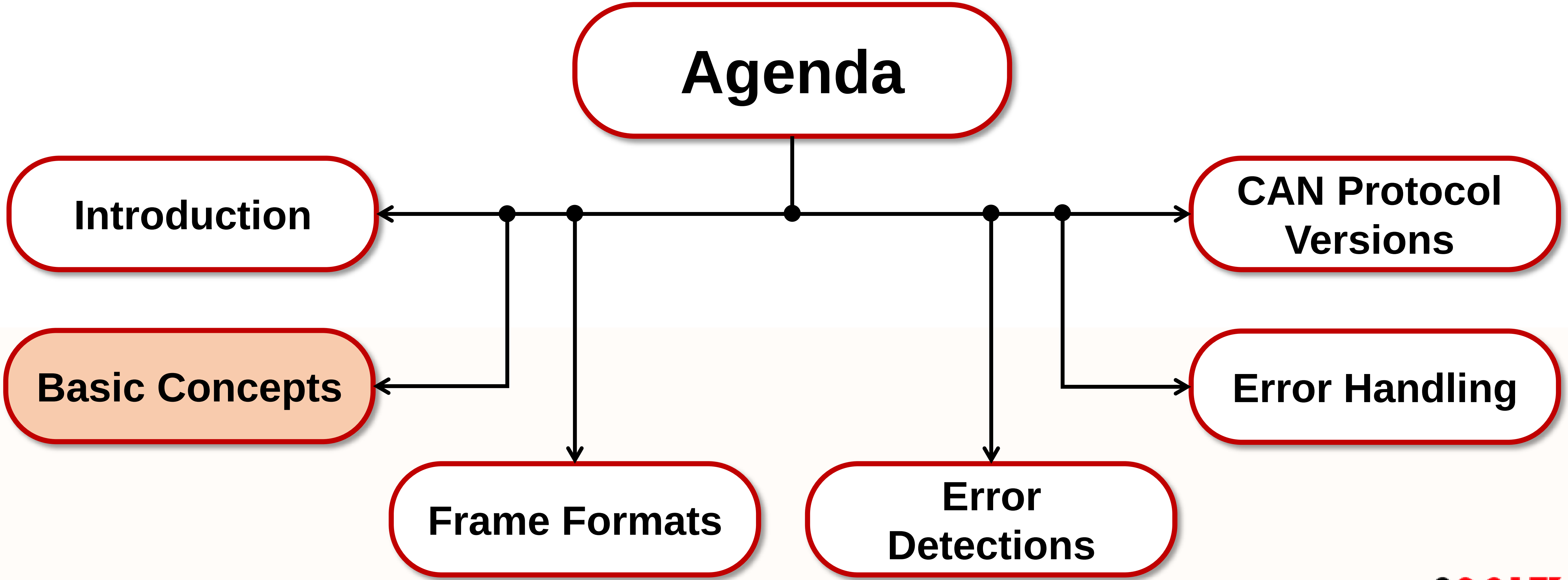
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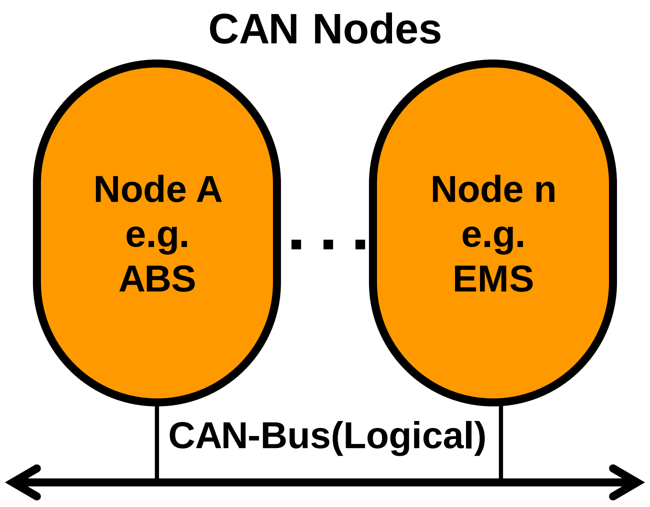
➢ Basic Concepts

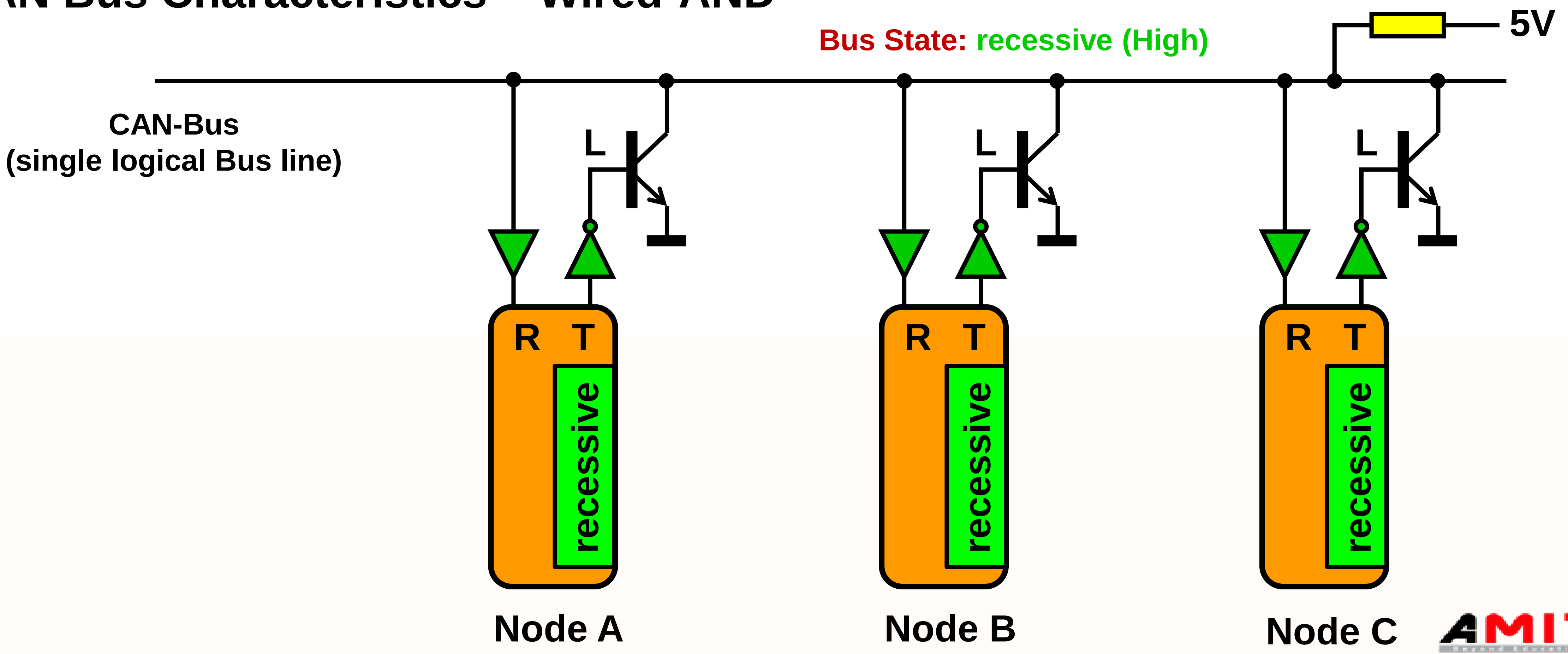
- Multi-Master Concept.
- Number of Nodes is not limited by protocol
- No Node addressing
  - **Message ID specifies contents and priority.**

- Easy connection/disconnection of nodes.
- Broadcast/Multicast capability.
- CAN Network Speed:
  - **LOW Speed CAN: baud rates from 40Kbtis/s to 125Kbits/sec**
  - **High Speed CAN: baud rates from 40Kbtis/s to 1Mbits/sec, depending on Cable length**



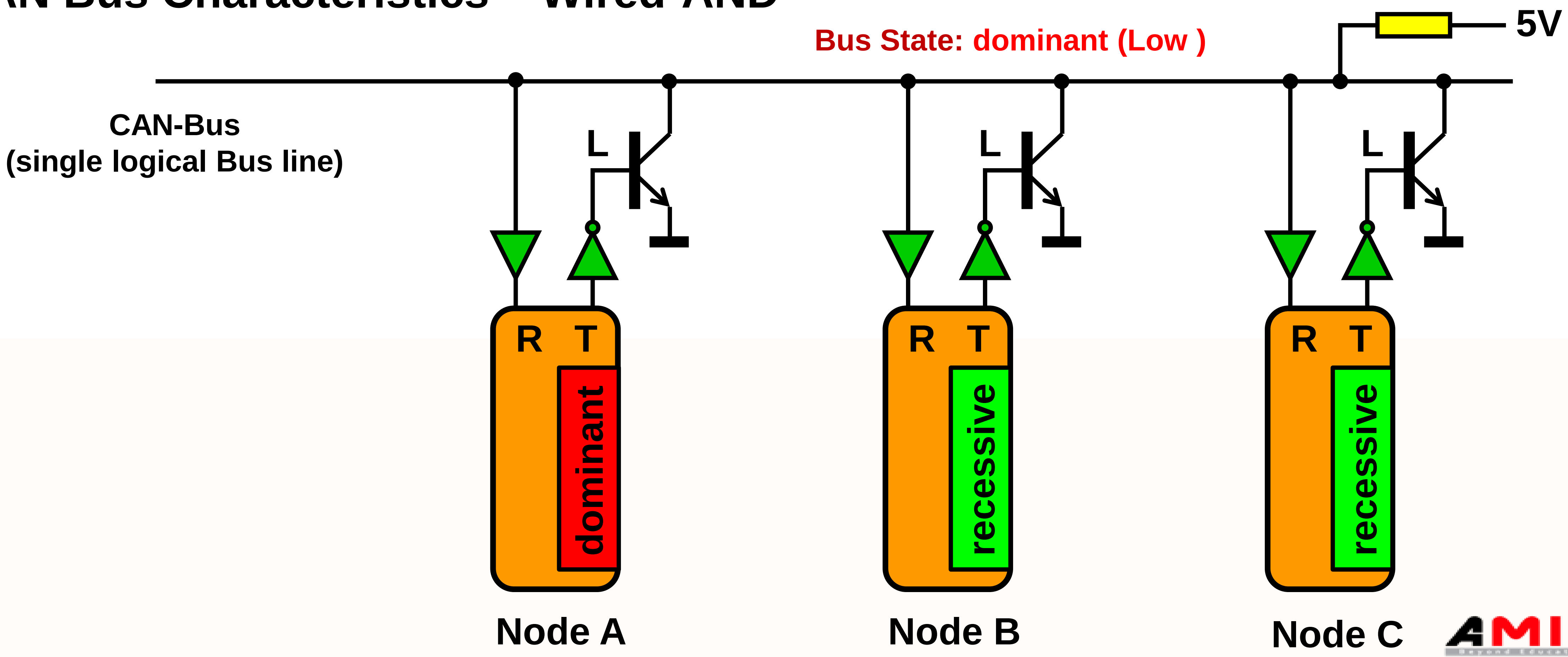
➢ Basic Concepts

➢ CAN Bus Characteristics – Wired-AND



➢ Basic Concepts

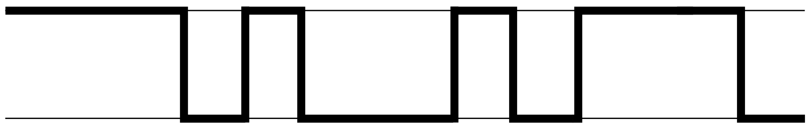
➢ CAN Bus Characteristics – Wired-AND



Basic Concepts

CAN Bus Characteristics – Wired-AND

Recessive Vs Dominant



“1” = recessive

“0” = dominant

Two logic states possible on The bus.

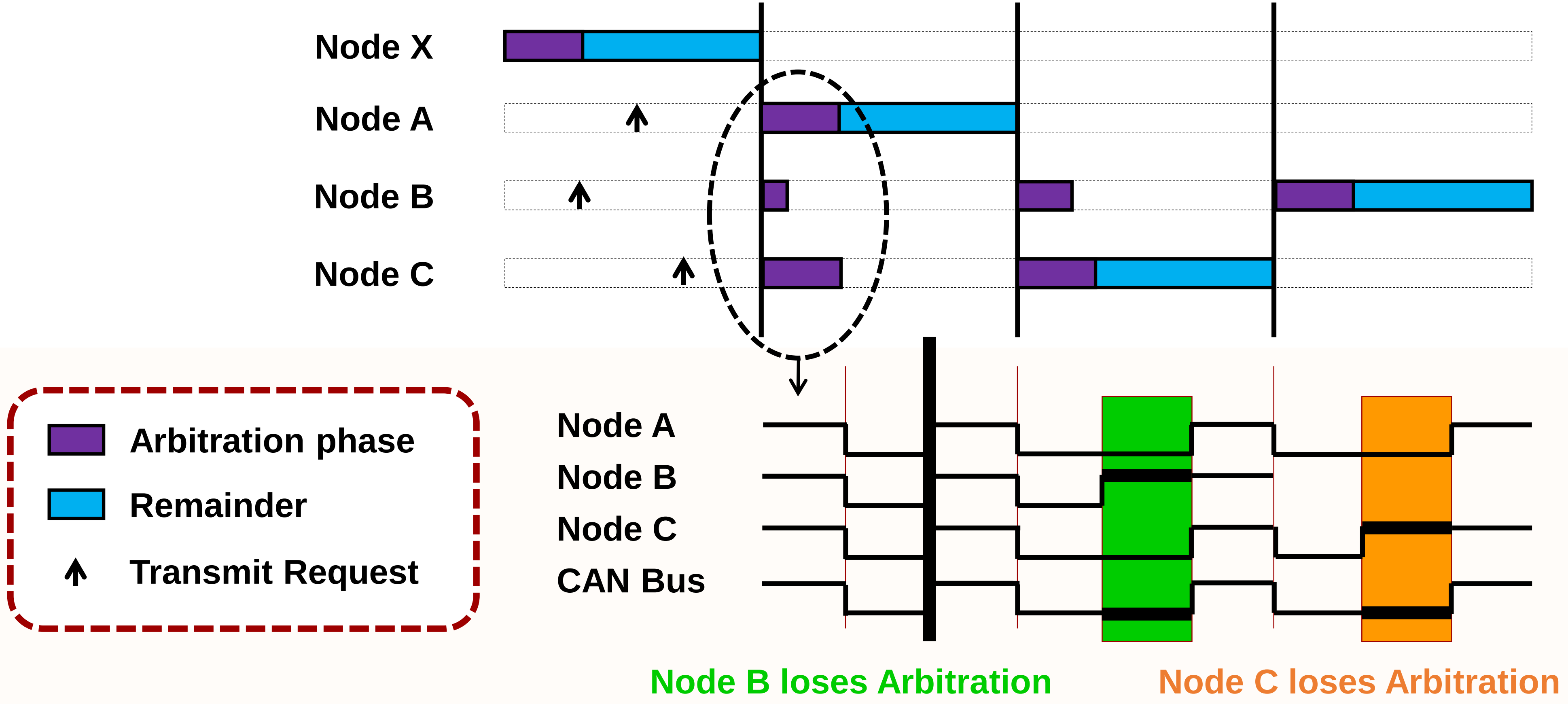
A	B	C	BUS
D	D	D	D
D	D	R	D
D	R	D	D
R	R	R	D
R	D	D	D
R	D	R	D
R	R	D	D
R	R	R	R

As soon as one node nodes transmits
a dominant bit (zero):
Bus is in the dominant state

Only if all nodes transmit
recessive bit (ones):
Bus is in the recessive state

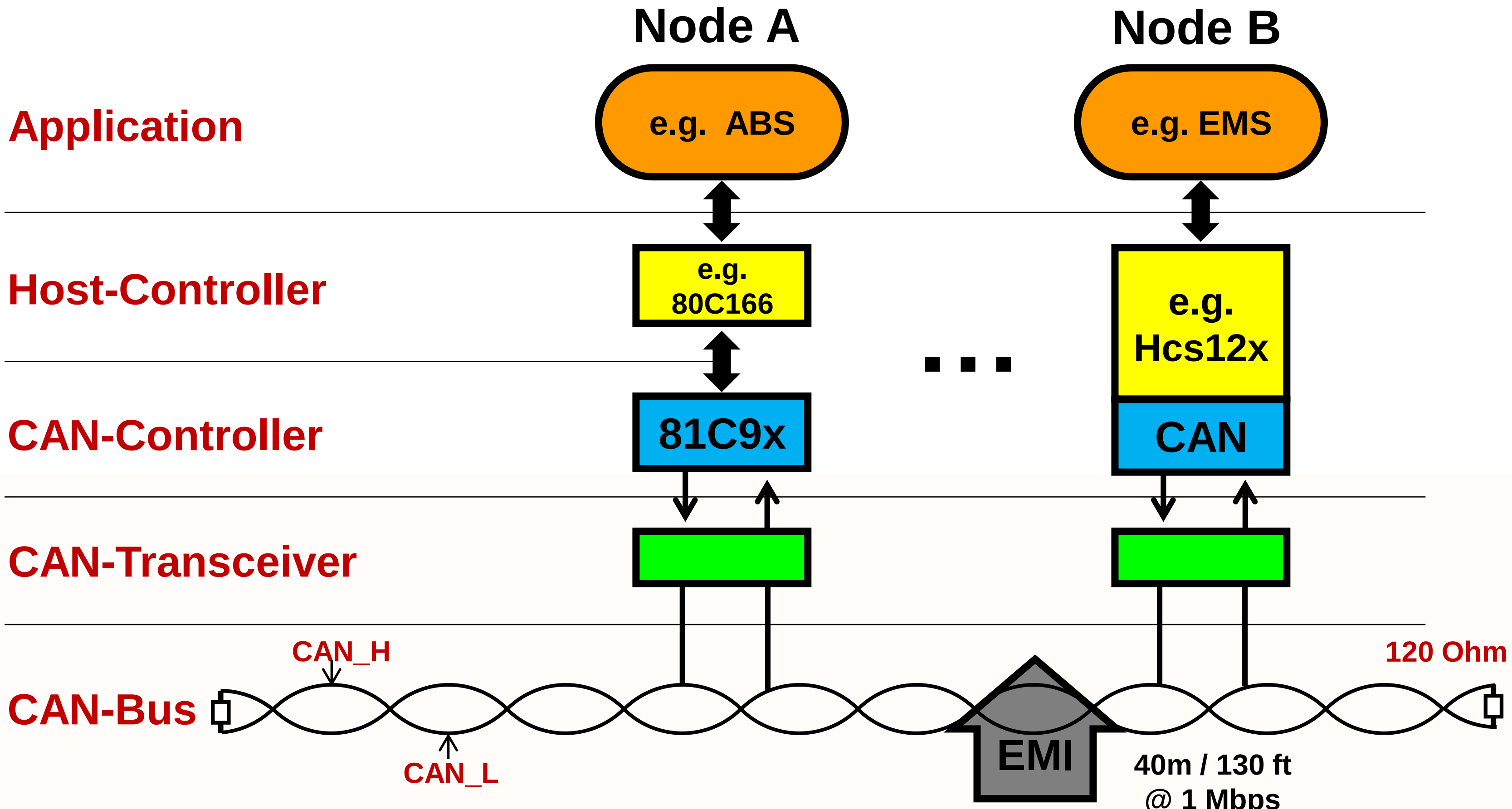
Basic Concepts

Bus Access and Arbitration



➢ Basic Concepts

- **Sophisticated Error Detection/ Handling**
- **NRZ and Bit Stuffing for Synchronization**
- **Bus Access via CSMA/CD**

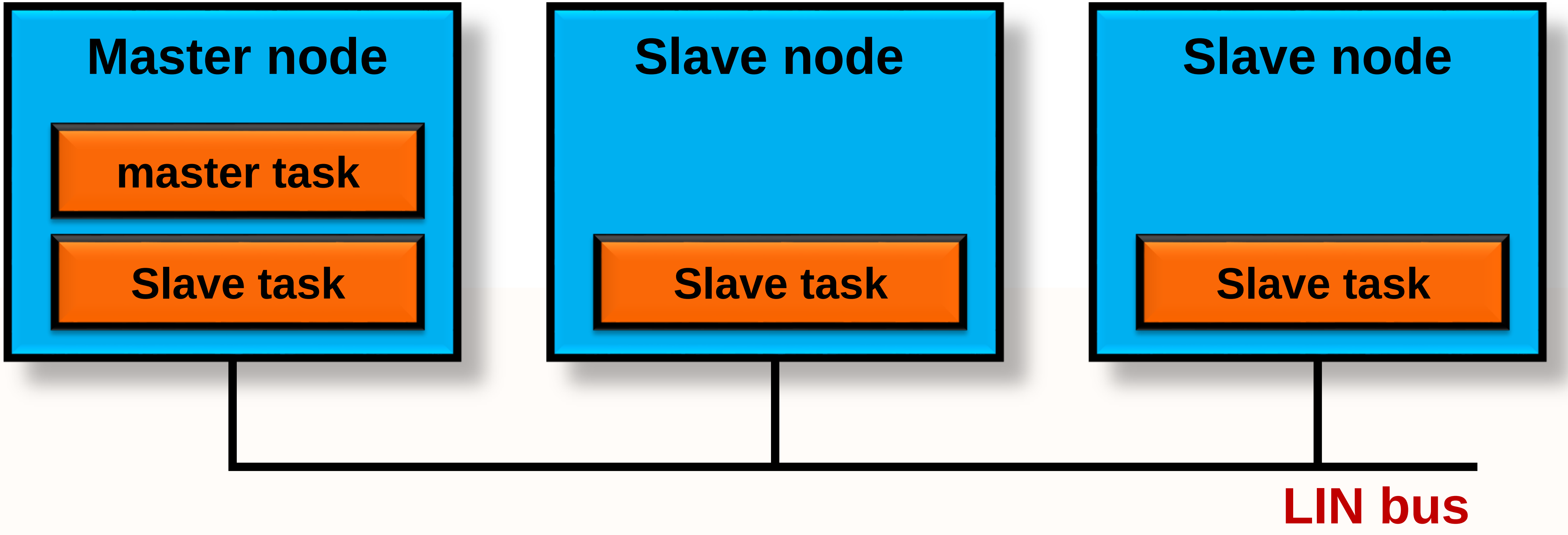


CSMA/CD → Carrier Sense Multiple Access / Collision Detection

Basic Concepts

- The LIN is a SCI/UART-based serial
- Single-Master / Multi Slave Concept.
- Number of Nodes is limited up to 16 slaves
- No Node addressing
  - **Message ID specifies Contents and priority**
- Broadcast / Multicast capability.
- LIN Network Speed**.**
  - **LIN baud rates up to 20 Kbit/s**

➢ Basic Concepts



Basic Concepts

- LIN is a Time Triggered communication protocol designed to support automotive networks in conjunction with Controller Area Network (CAN)

- No collision detection exists in LIN, therefore all messages are initiated by the master with at most one slave replying for a given message identifier

➢ Basic Concepts

- The LIN bus is connected between smart sensor or actuators and an Electronic Control Unit (ECU) which is often a gateway With CAN bus.

- Enables cost-effective communication with sensors and actuators when all the features of CAN are not required.

- The main features of this protocol (compared to CAN) are low cost and low speed and used for short distance networks.

➢ Basic Concepts

- The master is typically a moderately powerful microcontroller, whereas the slaves can be less powerful, cheaper microcontrollers or dedicated ASICs.
- The LIN is a single wire 12V bus connection, in which the communication protocol is based upon ISO9141 NRZ- standard.
- An important feature of LIN is the synchronization mechanism that allows the clock recover by slave nodes without quartz or ceramics resonator.
- Only the master node will be using the oscillating device. Nodes can be added to the LIN network Without requiring hardware or software changes in other slave nodes.

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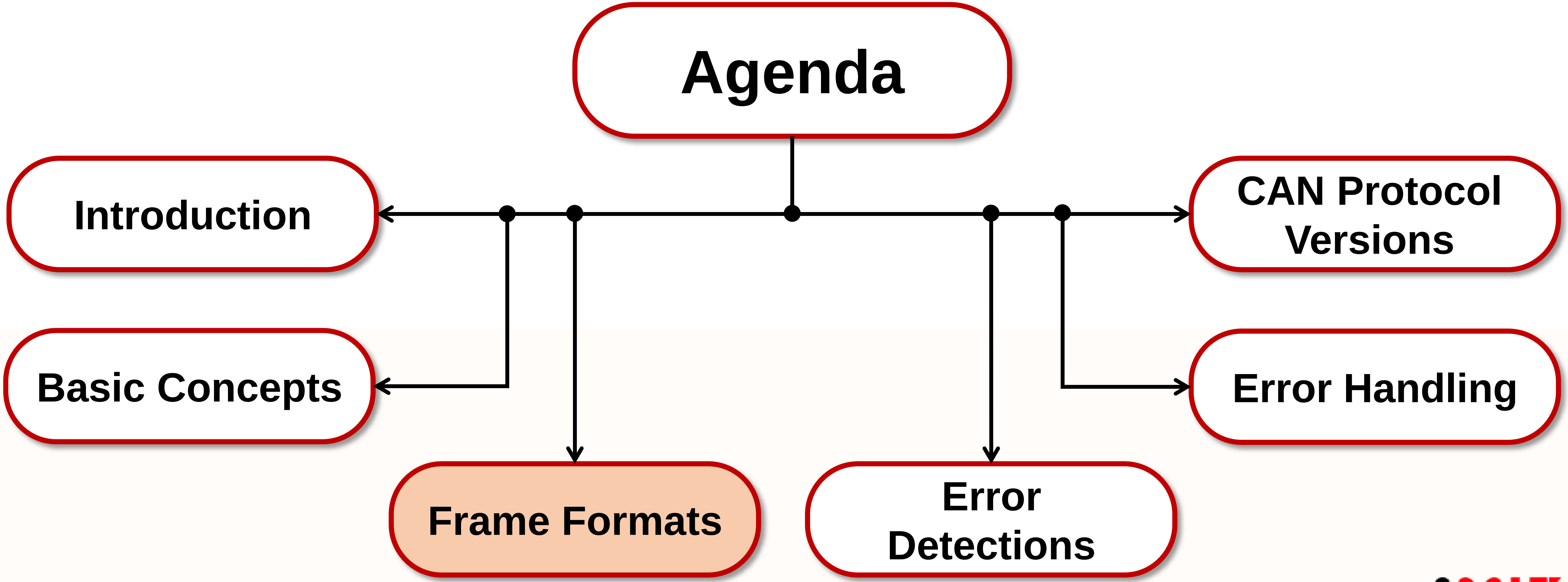
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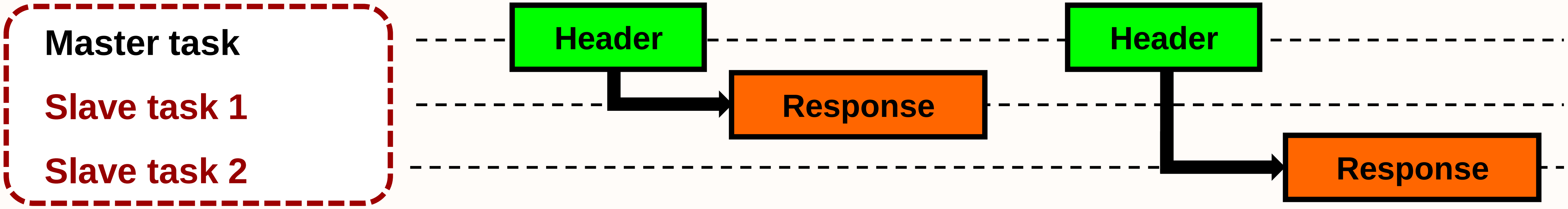
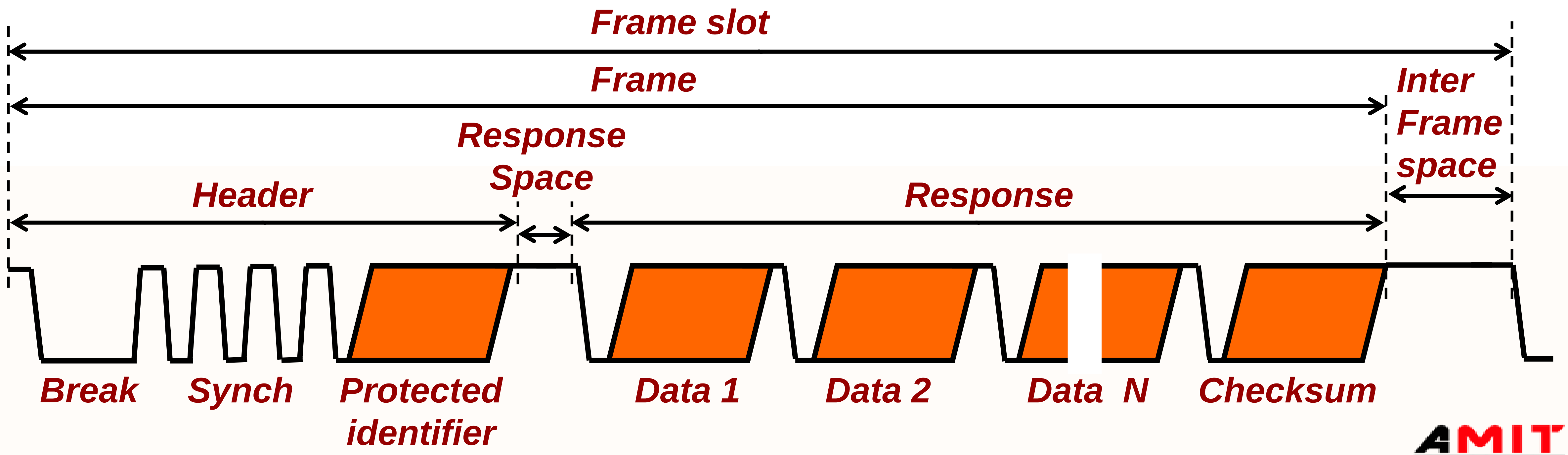
➢ Frame Formats

- A frame consists of a header (provided by the master task) and a response (provided by a slave task)
- The slave tasks interested in the data associated with the identifier receives the response, verifies the checksum and uses the data transported



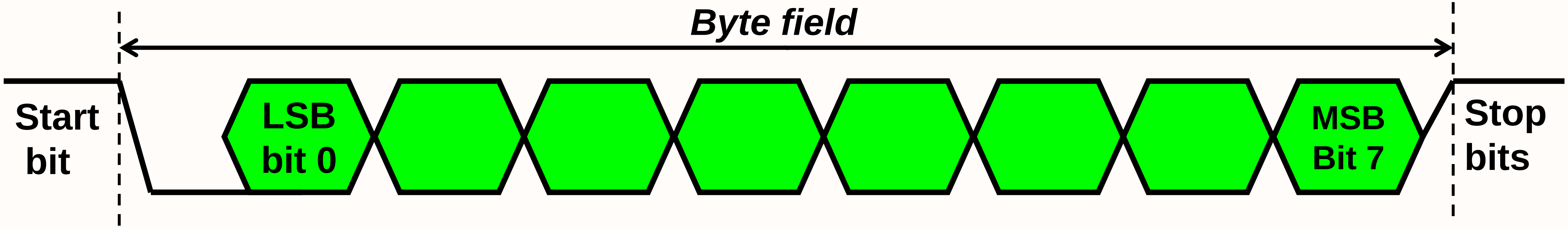
➢ Frame Formats

➢ Frame Structure



➢ Frame Formats

- Frame Structure
- Structure od a Byte field
  - **The LSB of data is sent first and the MSB last.**
  - **The start bit is encoded as a bit with value zero (dominant) and the stop bit is encoded as a bit with value one (recessive)**

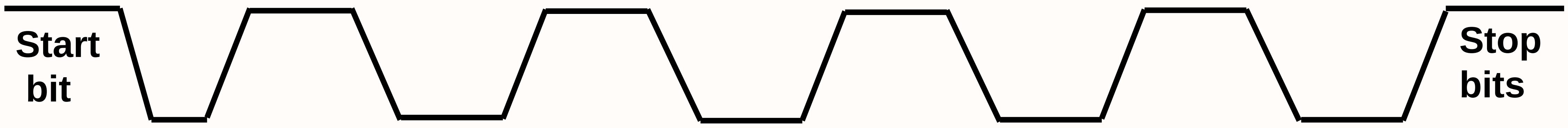


Frame Formats

- Break:
  - **The break symbol is used to signal the beginning of a new frame**
  - **A break is always generated by the master task and it shall be at least 3 bits of dominant value, including the start bit, followed by a break delimiter**

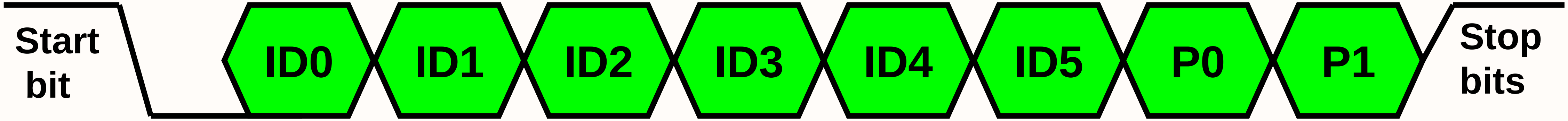
Frame Formats

- Synch Byte:
  - **Synch is a byte field with data value 0x55**
  - **A slave task shell always be able to detect the break/synch symbol sequence**



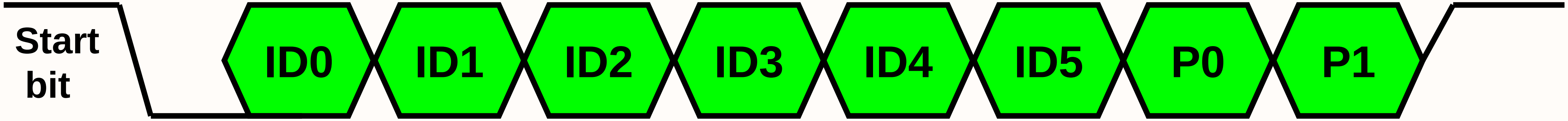
Frame Formats

- Protected Identifier
- Identifier
  - **Six bits are reserved for the identifier (ID), values in the range 0 to 63 can be used**
  - **The identifiers are split in four categories:**
  - **Values 0 to 59 (0x3b) are used for signal-carrying frames**
  - **60 (0x3c) and (0x3d) are used to carry diagnostic data**
  - **62 (0x3e) is reserved for user-defined extensions**
  - **63 (0x30) is reserved for future protocol enhancements**



Frame Formats

- **Parity:**
  - **The parity is calculated on the identifier bits**
  - **PO = ID0 $\oplus$ ID1 $\oplus$ ID2 $\oplus$ ID4**
  - **P1 = (ID1 $\oplus$ ID3 $\oplus$ ID4 $\oplus$ ID5)**



Frame Formats

- Data:
  - **A frame carries between one and eight bytes of data**
  - **A data byte is transmitted in a byte field**
  - **For data entities longer than one byte, the entity LSB is contained in the byte sent first and the entity MSB in the byte sent last (little-endian)**

Frame Formats

- Checksum:
  - The checksum contains the inverted eight bit sum with carry 6 over all data bytes or all data bytes and the protected identifier
  - Checksum calculation over the data bytes only is called classic checksum and it is used for communication with LIN 1.3 slaves
  - Checksum calculation over the data bytes and the protected identifier byte is called enhanced checksum and it is used for communication with LIN 2.0 slaves
  - Identifiers 60 (0x3c) to 63 (0x3f) shall always use classic checksum

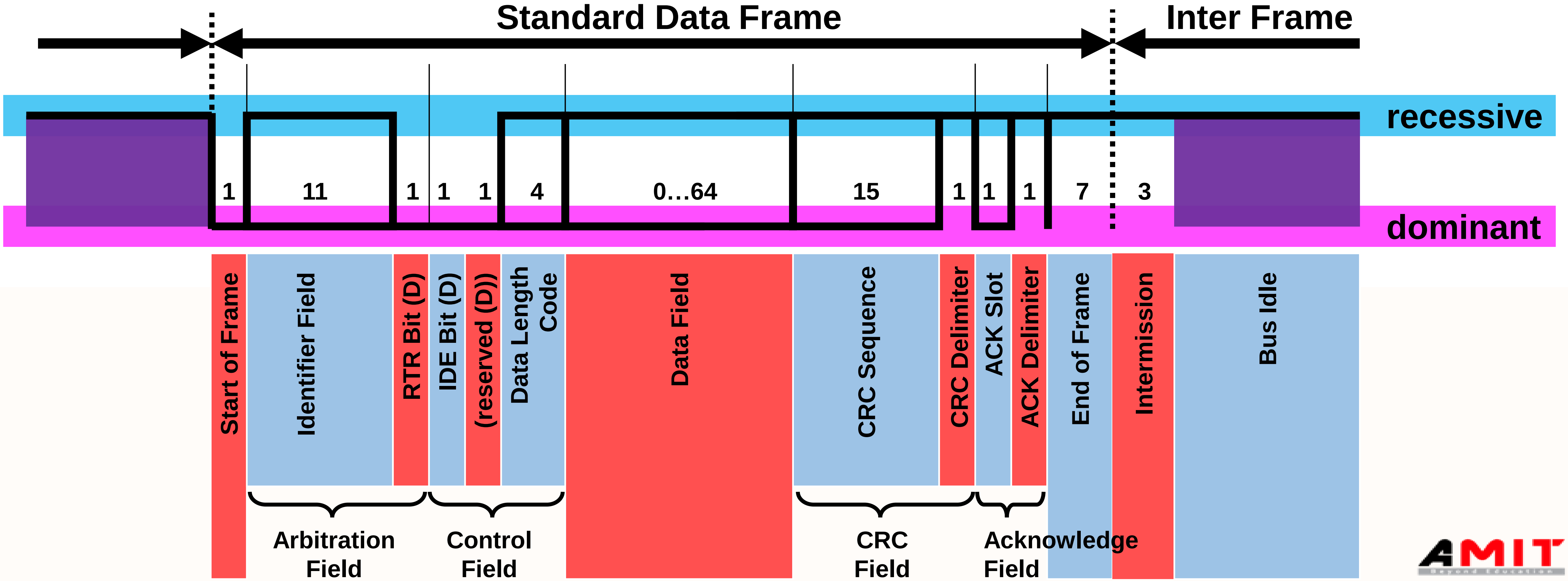
➤ Frame Formats

Frame Formats

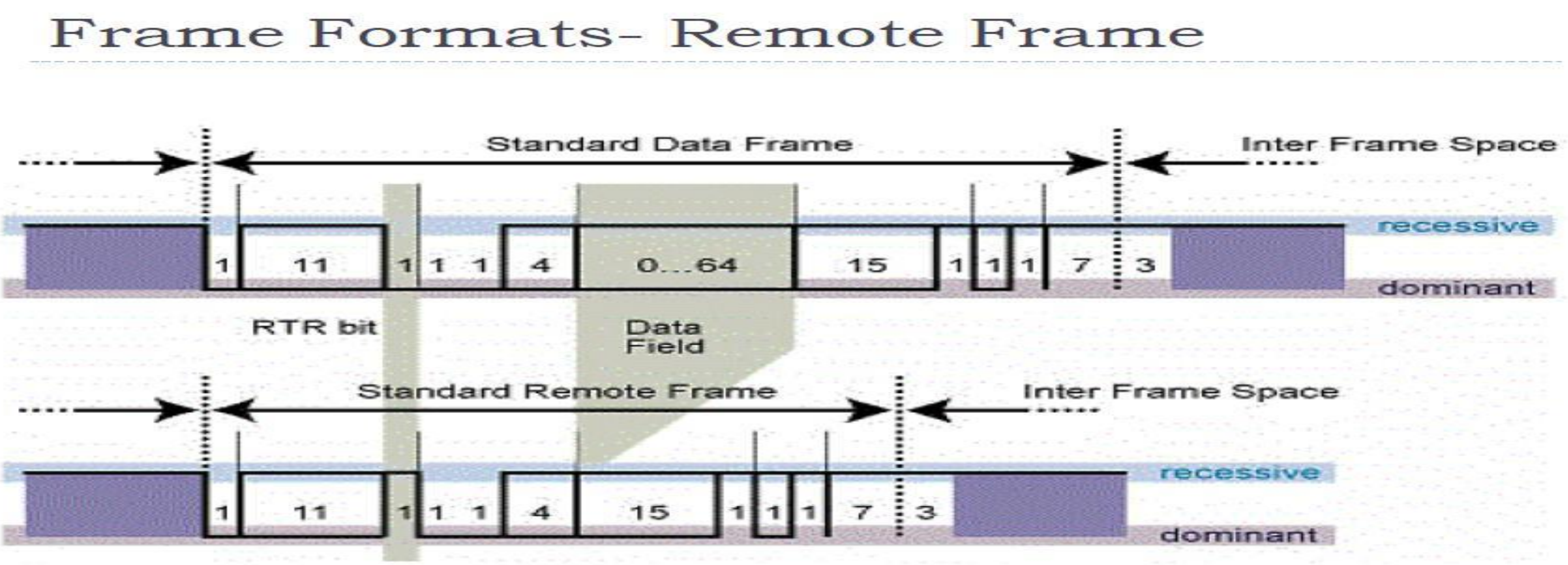
- Data Frame
- Remote Frame
- Error Frame
- Message vs. Signal
- Inter- Frame Space
- Overload Frame

➢ Frame Formats

➢ Data Frame



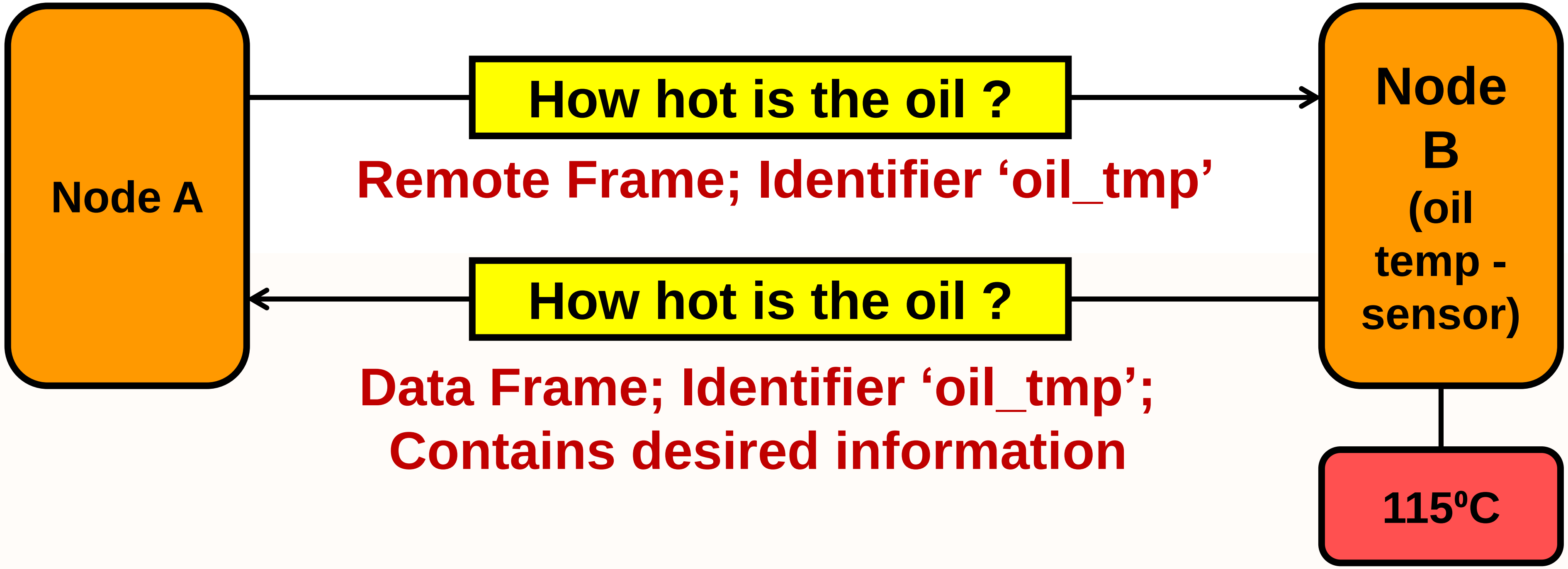
➢ Frame Formats



Frame Formats

Remote Frame

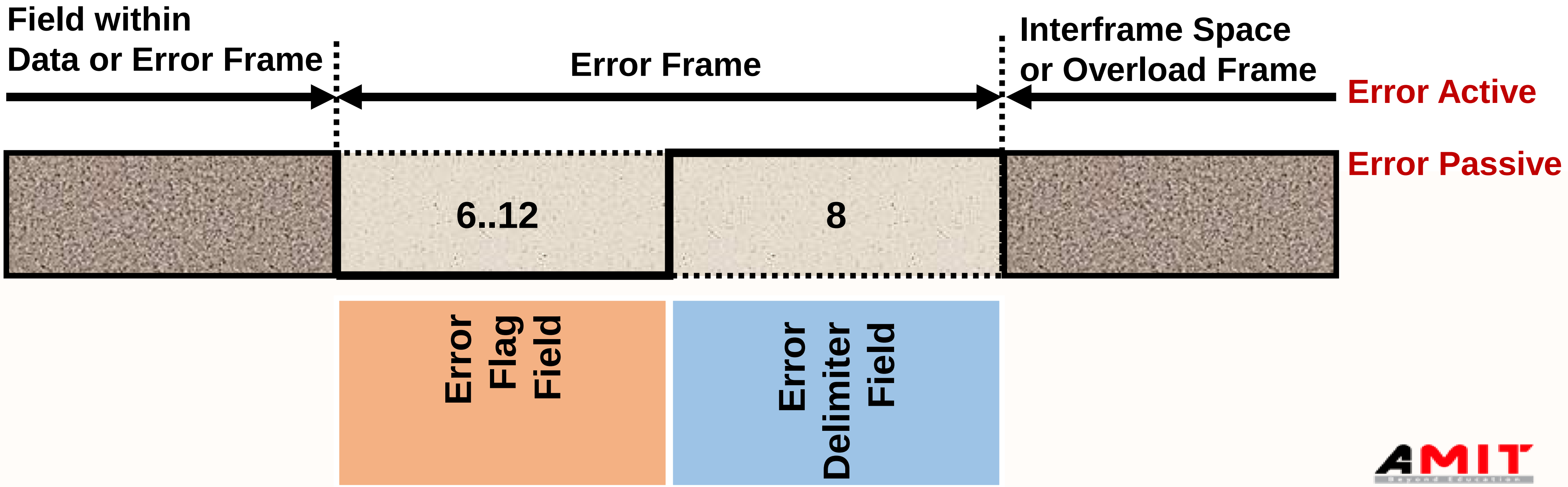
Remote Frame Scenario



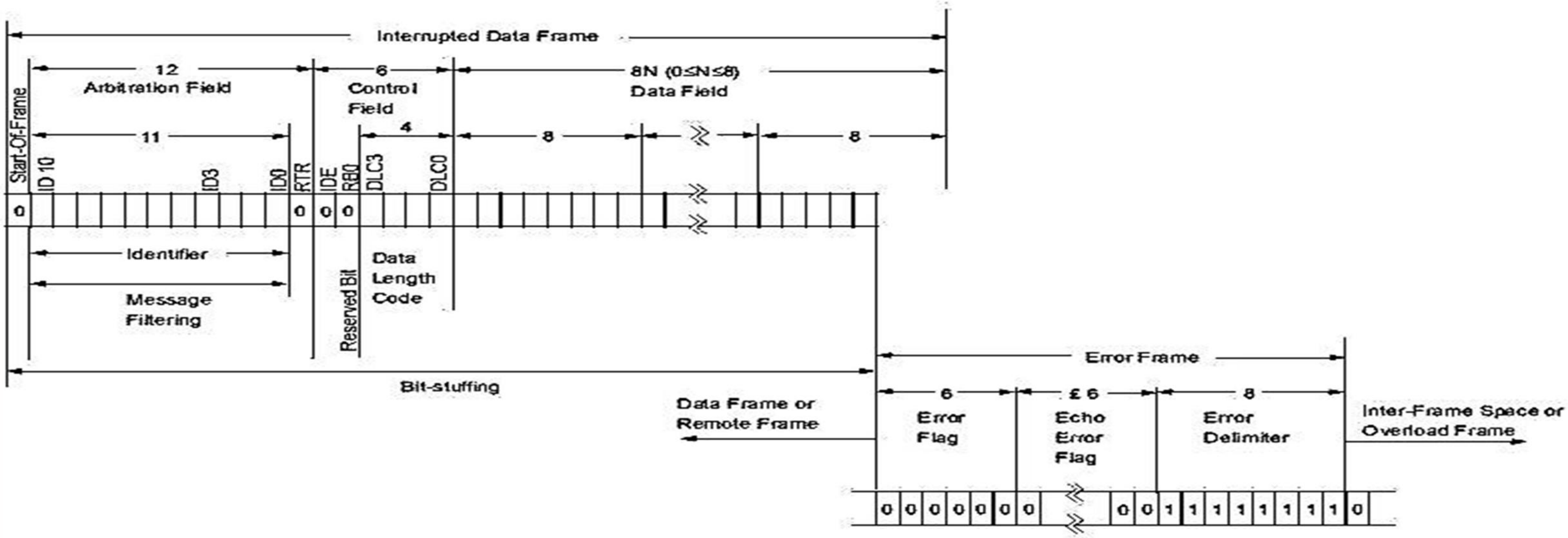
Frame Formats

Error Frame

Active Error Frame



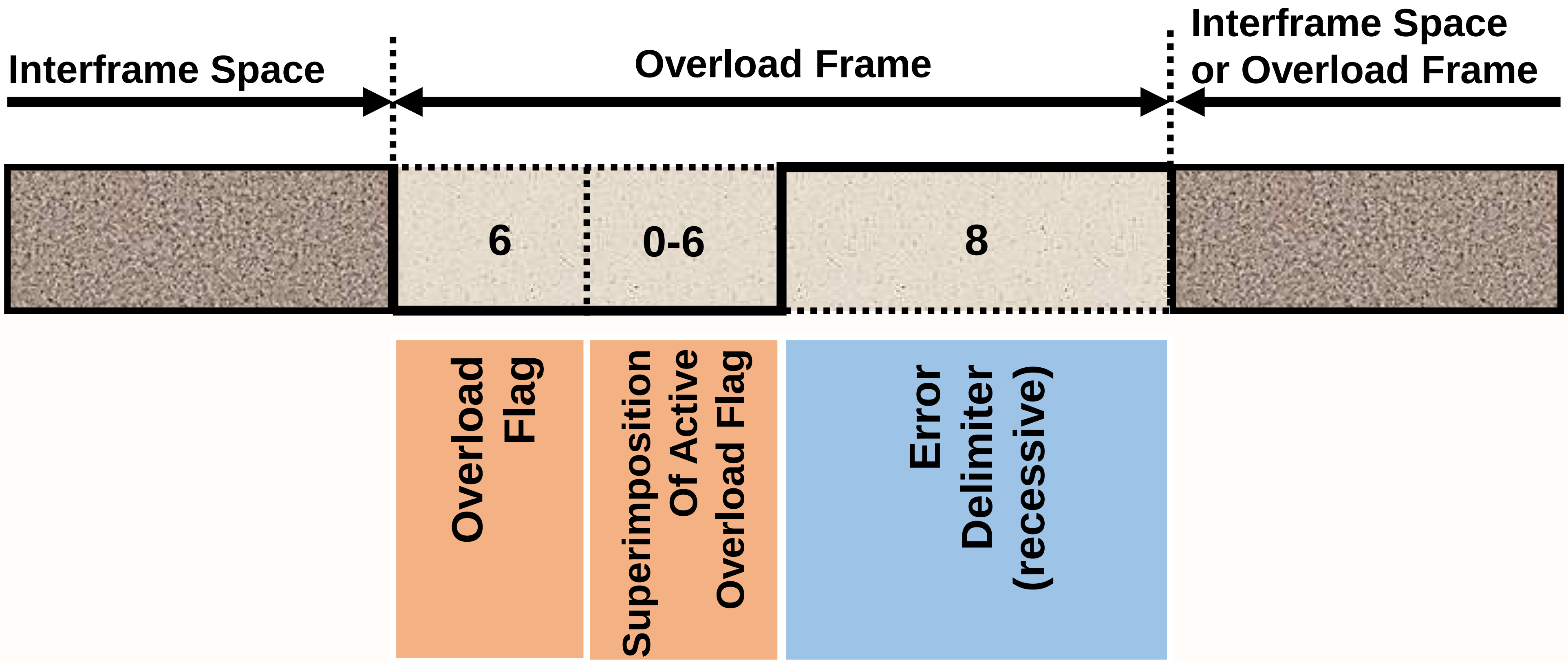
➢ Frame Formats



Frame Formats

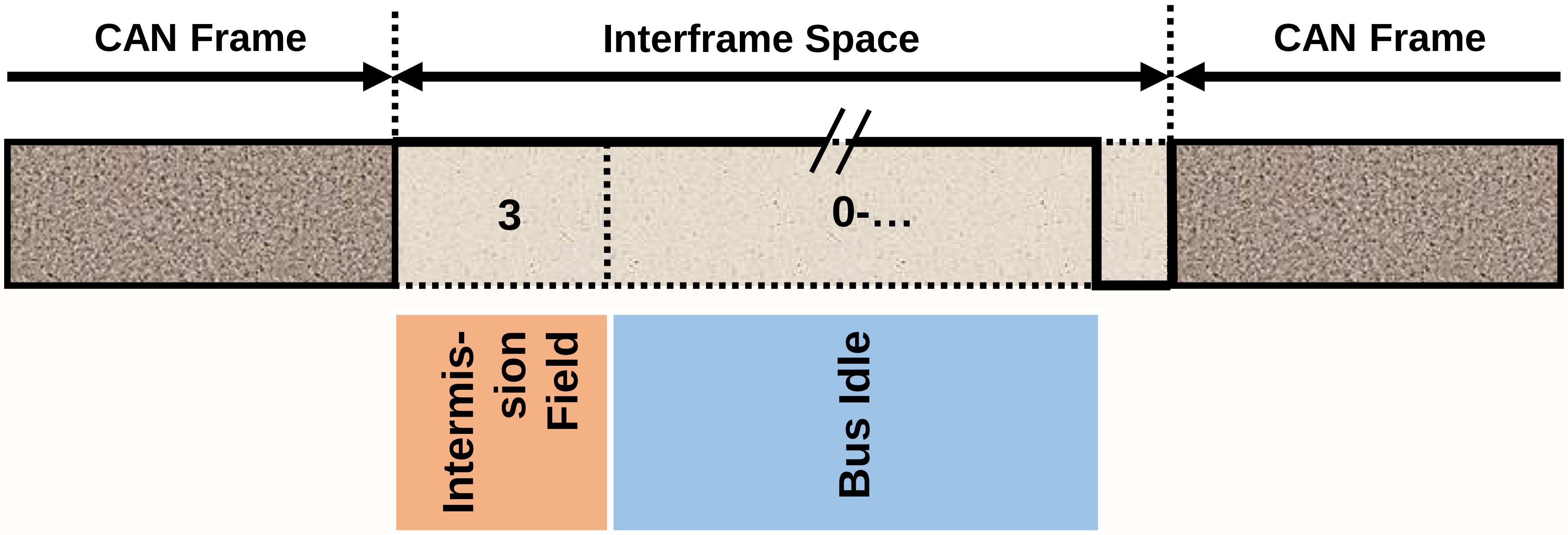
Overload Frame

- **Overload Frame used to delay next CAN message**



Frame Formats

- **Inter- Frame Space**
  - **Separates a frame (of whatever type) from a following Data or Remote frame**



➢ Frame Formats

Message vs. Signal

- ➢ Messages are transmitted between Network Nodes over the bus

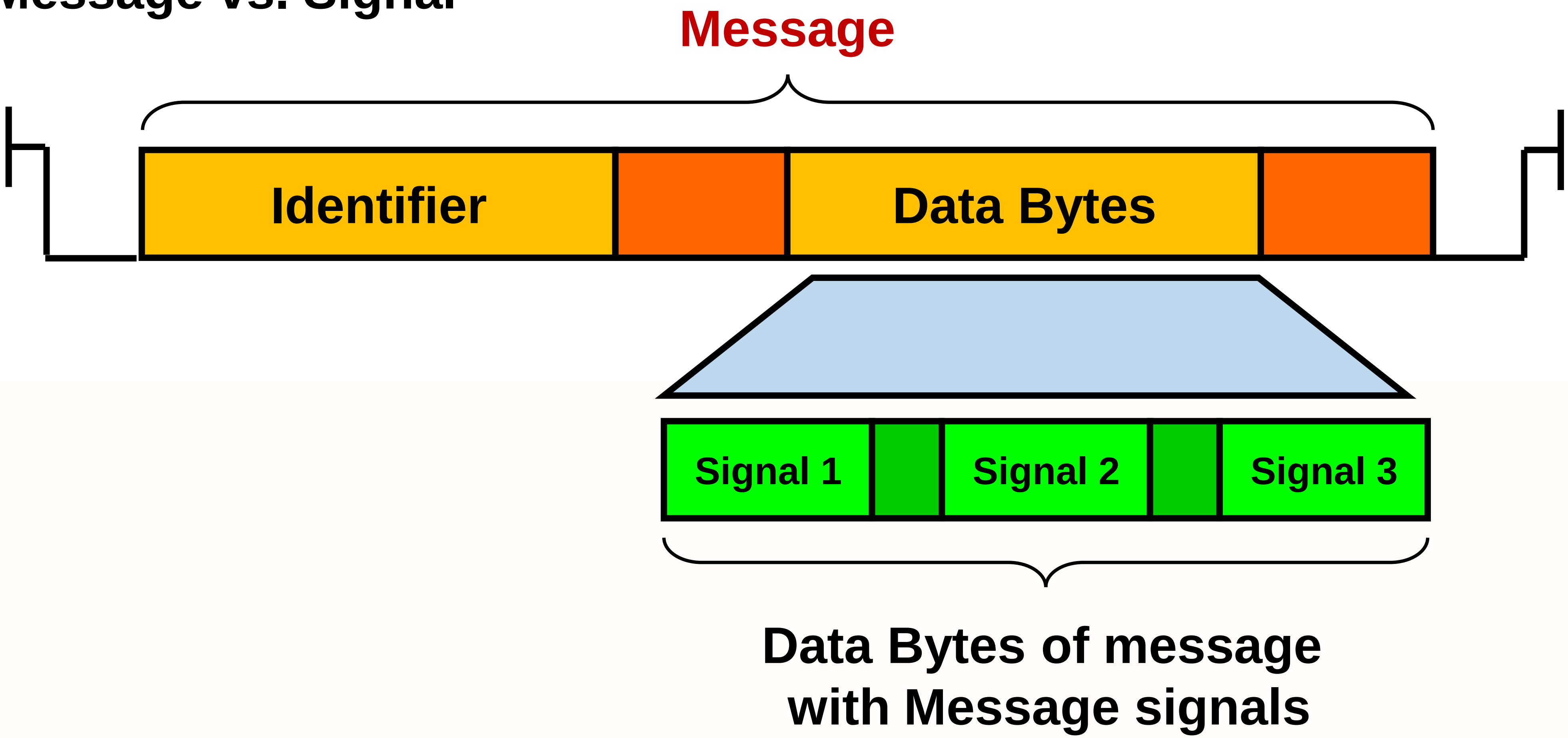
- ➢ The data bytes of any message is divided into Signals

- ➢ Signals represent a physical value

- ➢ For example, one data byte could be divided into 3 Signals as:
  - ➢ **4 bits that represent the vehicle speed => e.g: Named SpeedSig**
  - ➢ **2 bits that represent the gear speed => e.g: Named GearPosSig**
  - ➢ **2 bits that represent the light speed => e.g: Named LightStaSig**

➢ Frame Formats

➢ **Message vs. Signal**



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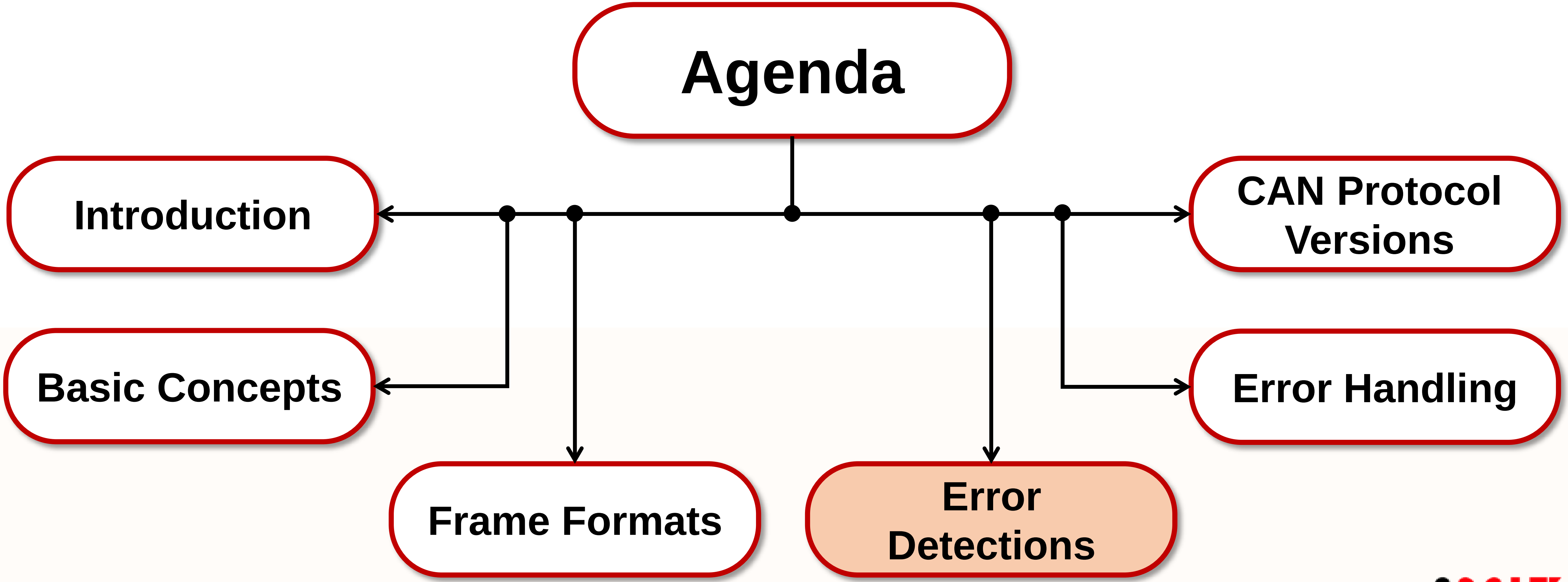
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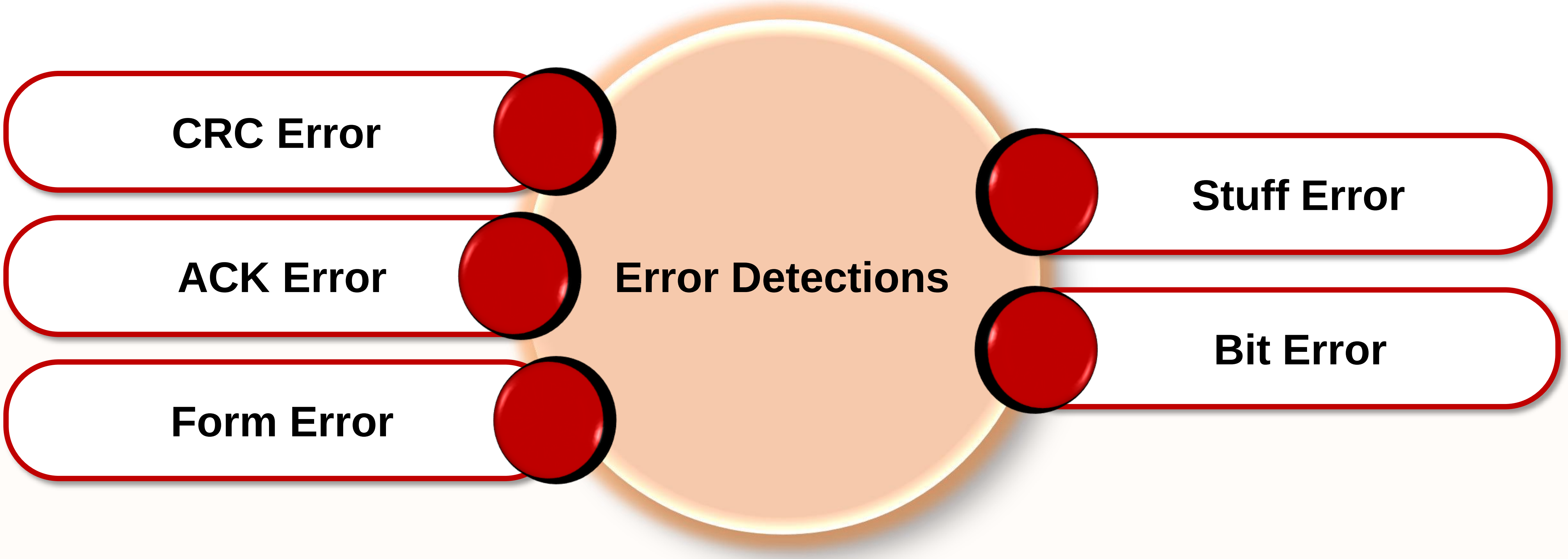
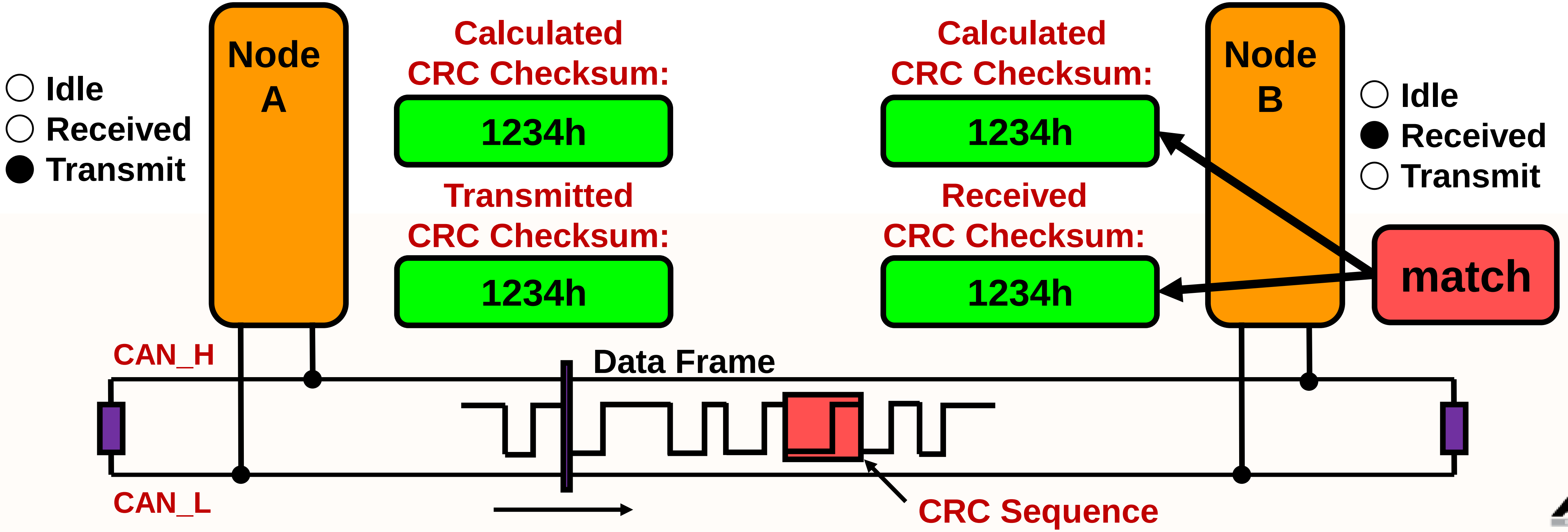
Error Detections



Error Detections

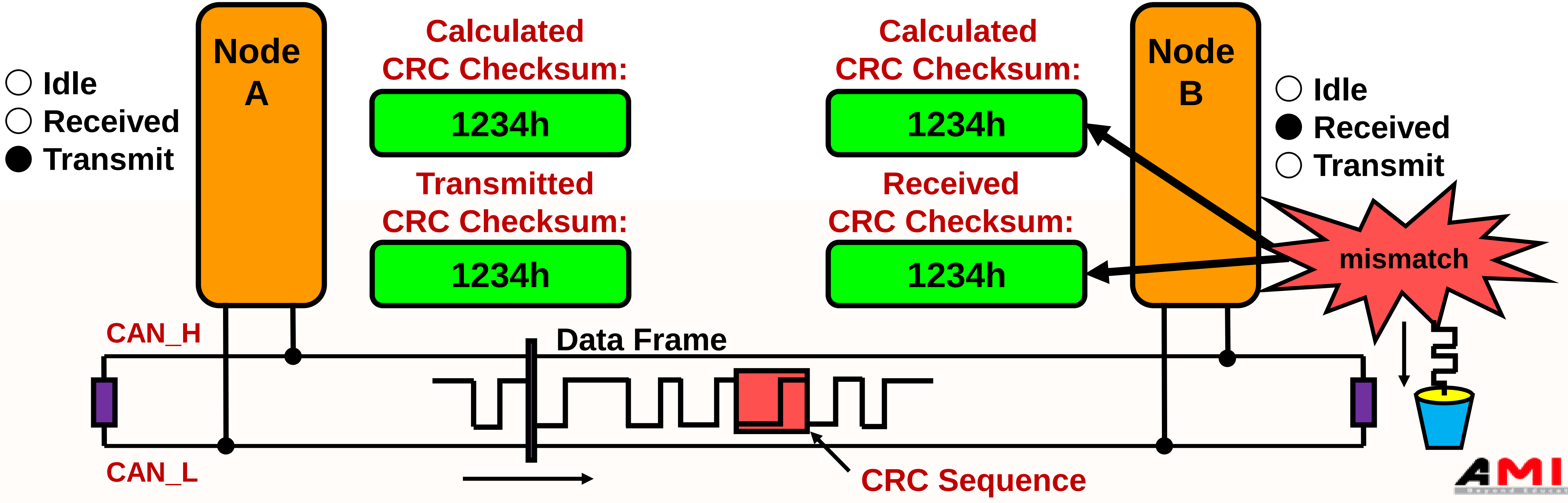
CRC Error

- **Calculated and Received checksum must match**



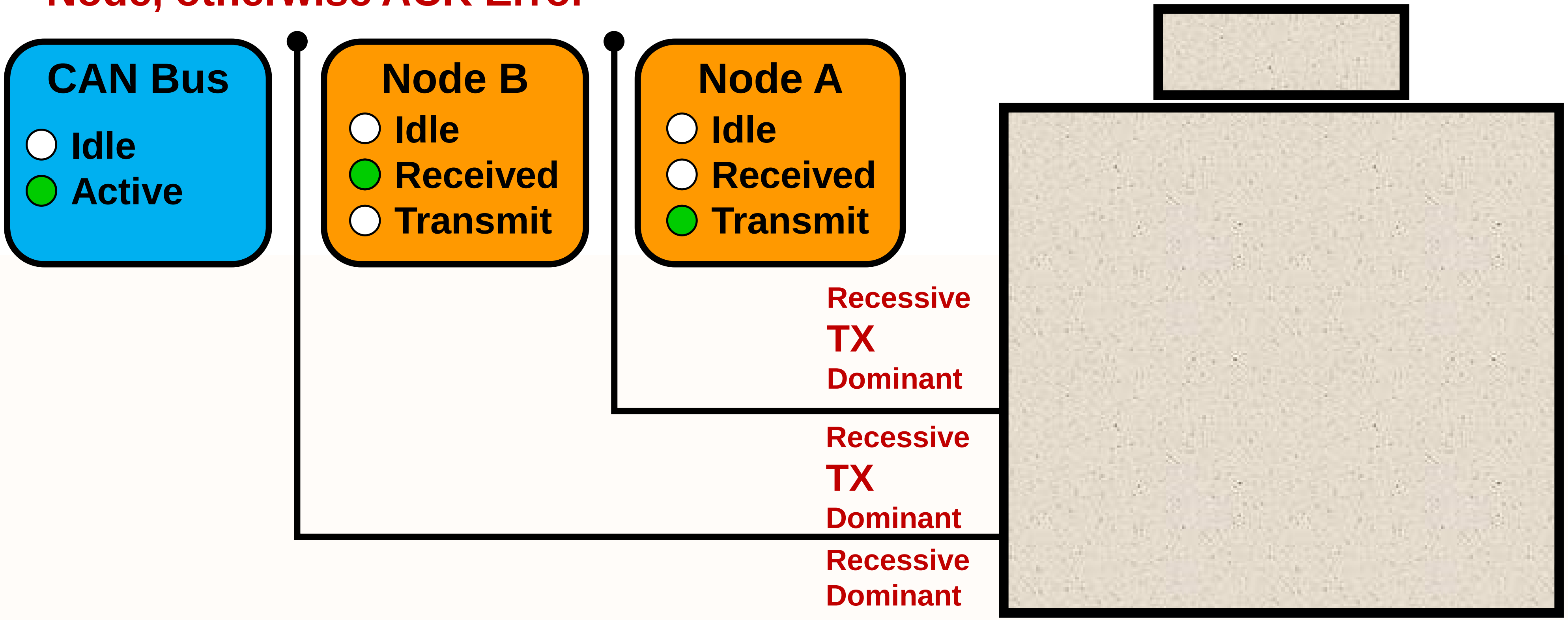
- **Agenda**
  - Error Detections

- **CRC Error**
  - Otherwise frame wasn't received correctly (CRC Error)



Error Detections

- **Acknowledge**
  - **A frame must be Acknowledged by at least one other Node, otherwise ACK Error**



➢ Error Detections

Frame Check

- No Dominant Bits allowed in
  - **CRC Delimiter**
  - **ACK Delimiter**
  - **End of Frame**
  - **Inter-frame space**

Otherwise Form Error is generated

Error Detections

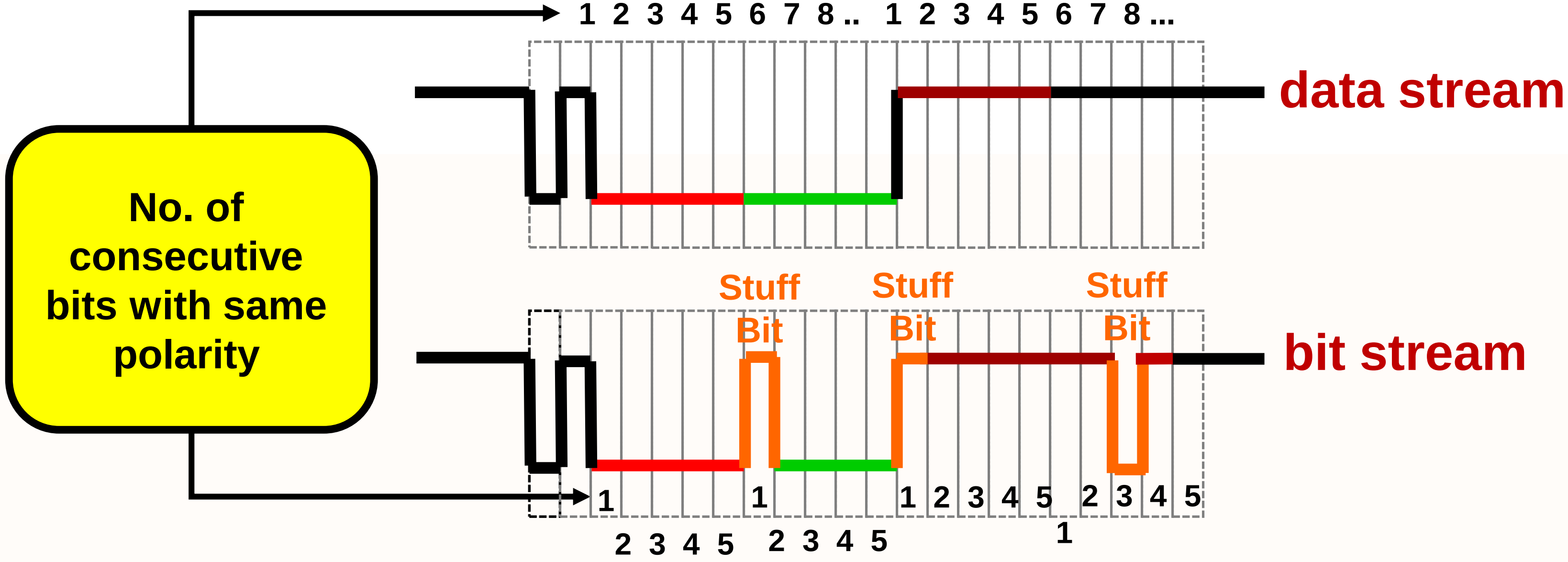
- **Bit Monitoring**
  - **A transmitted bit must be correctly read back from CAN Bus, otherwise Bit Error**
  - **Dominant bits may overwrite recessive bits only in the Arbitration field and in the Acknowledge slot.**

Error Detections

Bit Stuffing

- **Six consecutive bits with same polarity are not allowed between start of frame and CRC Delimiter**

Otherwise Bit Stuffing Error



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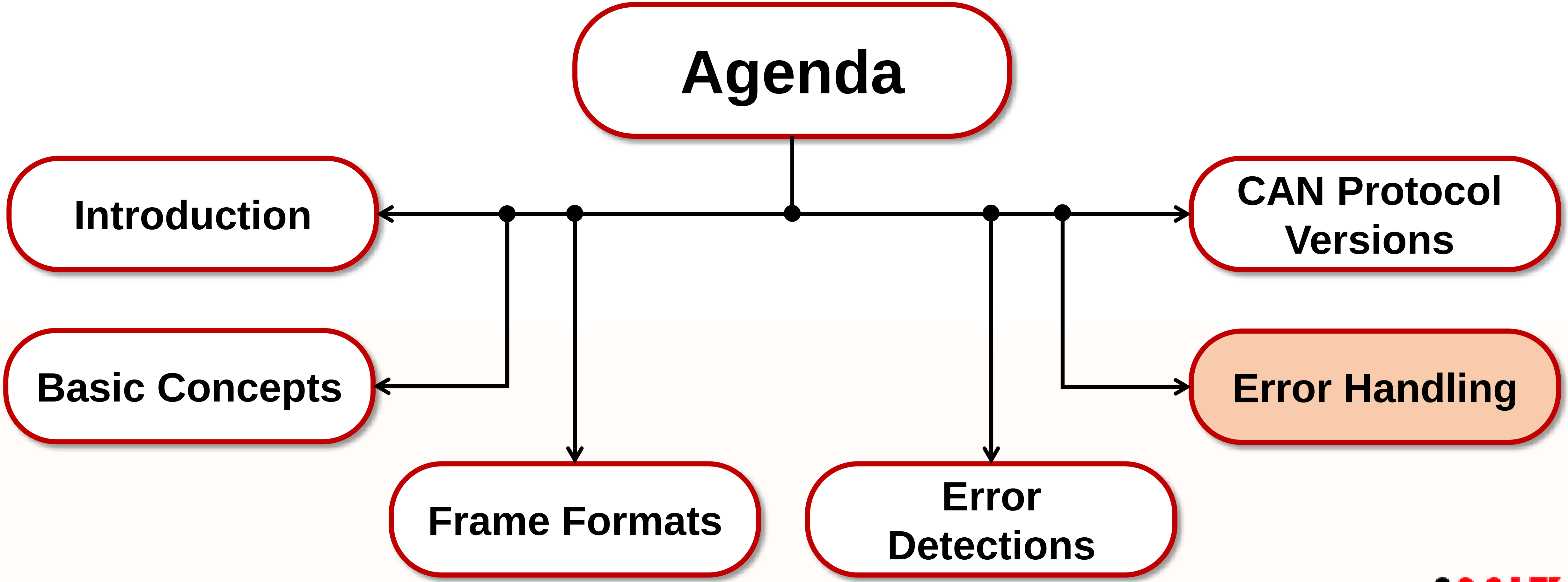
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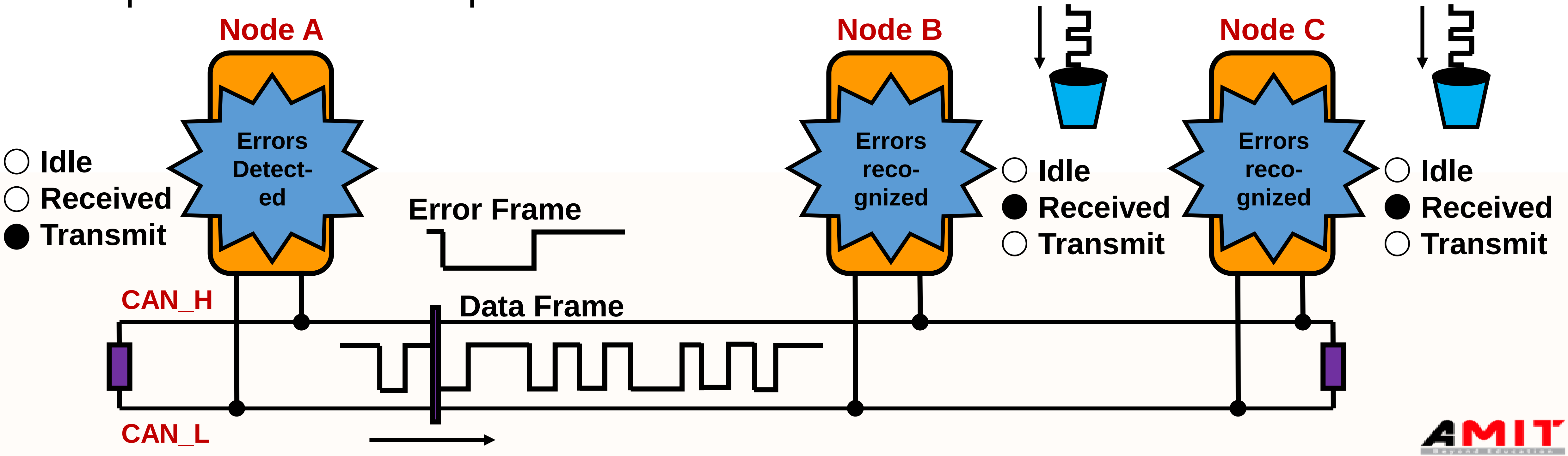
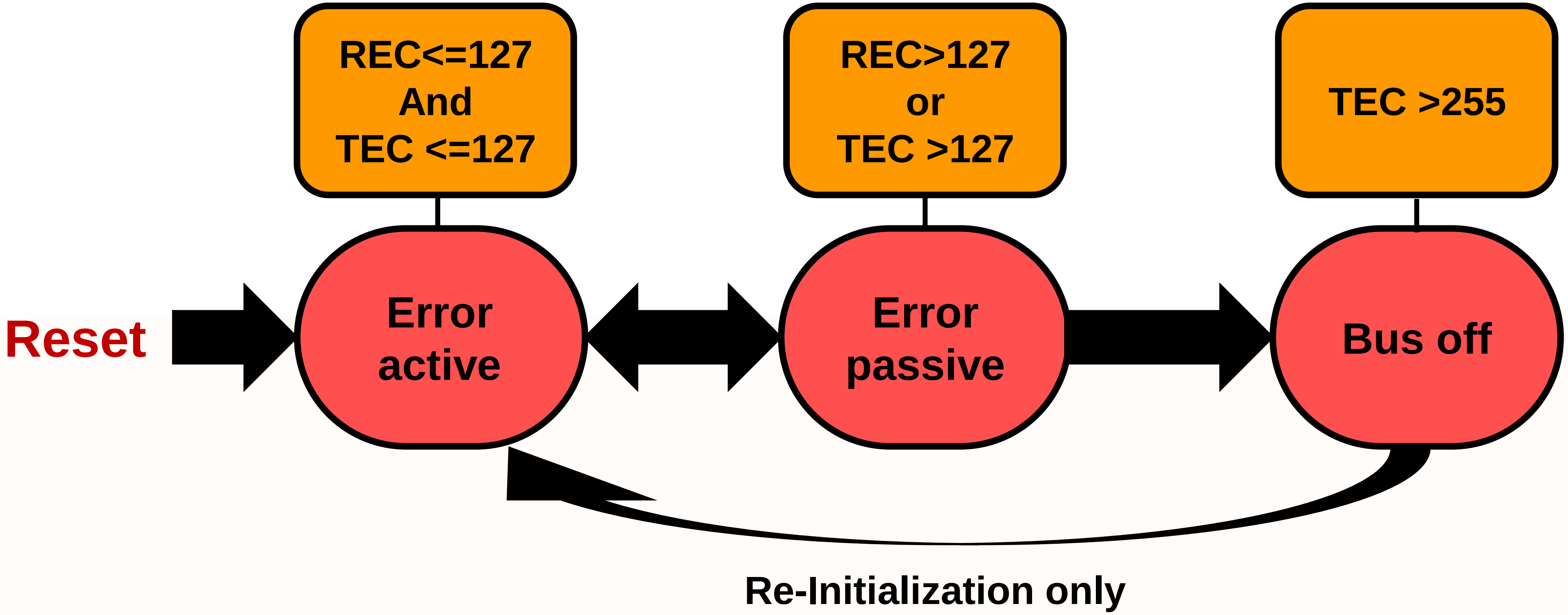
➢ Error Handling

- ➢ Detected Errors are made public to all other nodes via Error Frames.
- ➢ The transmission of the erroneous message is aborted and the frame is repeated as soon as possible.



Error Handling

- **Each Node is either in Error Active, Error Passive or off state.**



faulty nodes withdraw from the bus automatically (Bus off State)

Error Handling

Undetected Errors

- **Imagine a vehicle equipped with CAN**
  - **Running 2000hr/year**
  - **At CAN bus speed of 500 Kbps**
  - **With 25% bus load**

=> will result in I undetected errors every 2000 years!!

Agenda

- **Agenda**
  - Introduction
  - Basic Concepts
  - Frame Formats
  - Error Detections
  - Error Handling
  - CAN Protocol Versions

CAN Protocol Versions

- Two CAN protocol versions available:
  - V2.0A (Standard) – I I bit Massage ID's – 2048 ID's available

Start of Frame	Identifier 11 bits	Control Field	Data Field (0..8 Bytes)	CRC Field	ACK Field	End of Frame

  - V2.0B (Extended) – 29 bit Massage ID's – more than 536 Million ID's available

Start of Frame	Identifier 29 bits	Control Field	Data Field (0..8 Bytes)	CRC Field	ACK Field	End of Frame

CAN Protocol Versions

- **Three types of CAN modules available (all handles I I bit ID’s)**
  - **2.0A – Considers 29 bit ID as an error.**
  - **2.0B Passive – Ignores 29 bi ID message**
  - **2.0B Active – Handles both I I and 29 bit ID Message**

	Frame with 11 bit ID	Frame with 29 bit ID
V2.0B Active CAN Module	Tx/Rx OK	Tx/Rx OK
V2.0B Passive CAN Module	Tx/Rx OK	Tolerated
V2.0A CAN Module	Tx/Rx OK	Bus ERROP

THANK YOU!

AMIT
Beyond Education