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Introduction to Controller Area Network (CAN)

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Topics

- CAN Protocol Overview
  - What is CAN?
  - CAN Message Structure (Frames)
  - Error Handling
- CAN in Action
  - Sending a Message
  - Receiving a Message
- Additional Resources

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CAN Protocol Overview
What is CAN?

- CAN Stands for Controller Area Network
- CAN is an extremely robust standardized communication protocol.
- CAN protocol was developed by Bosch in the 1980s to create standardization and reduce the cost and weight in vehicle wiring harnesses
- Primary uses today are automotive and Industrial control applications

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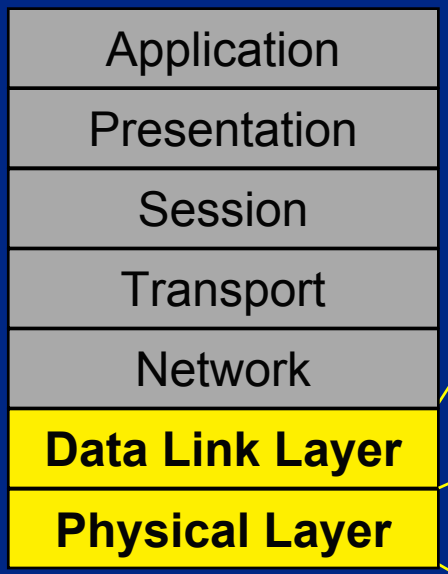
CAN Protocol Overview: CAN Protocol Layers

- CAN only defines portions of the lower 2 layers of the OSI 7- Layer Reference Model

OSI Reference Layers



Logical Link Control (LLC)
- Acceptance Filtering
- Overload Notification

Medium Access Control (MAC)
- Data Encapsulation/Decapsulation
- Frame Coding (stuffing/destuffing)
- Error Detection/Signalling

Physical Signaling (PLS)
- Bit Encoding/Decoding/Timing

Physical Medium Attachment (PMA)
- Driver/Receiver Characteristics

Medium Dependent Interface (MDI)
- Connectors

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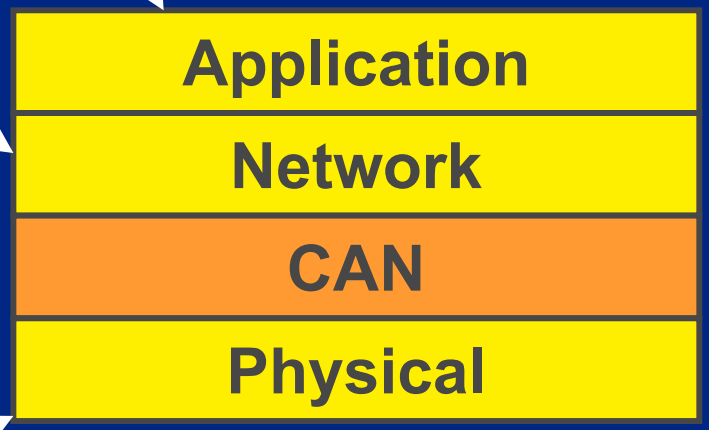
CAN Protocol Overview: CAN Protocol Layers

Node specific application

HLP such as DeviceNet™, J1939, CANopen, CANKingdom™, Proprietary, etc.

CAN layer



Physical medium, transceiver, wires, connectors, etc.

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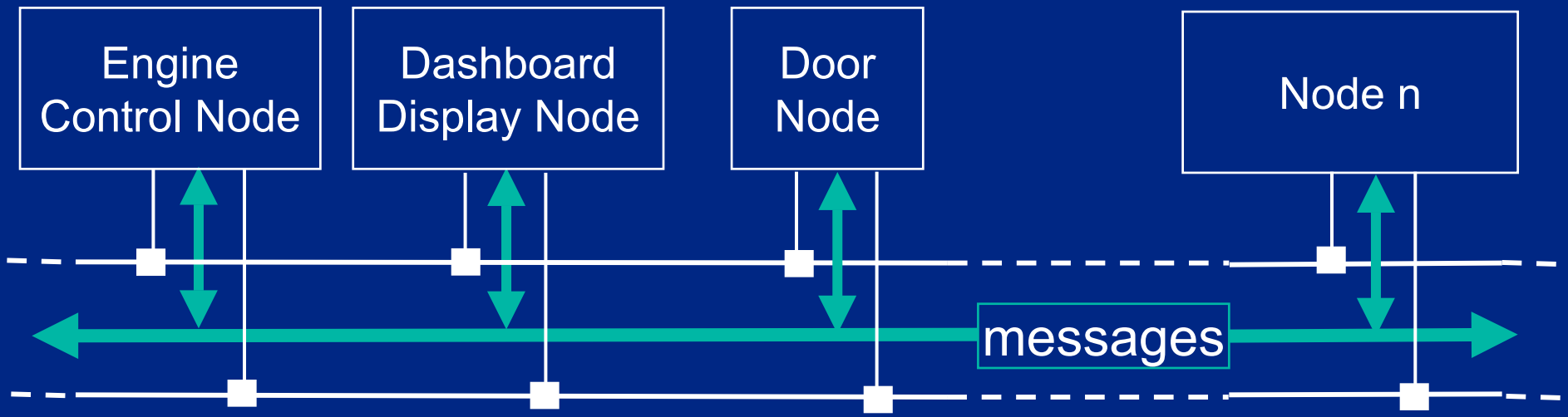
CAN Protocol Overview: CAN Networks

- A CAN network is made up of a group of “Nodes”
- Each node can communicate with any other node
- Communication is handled with extremely robust packets called “Messages”
- Transmission speeds of up to 1 Mbps are defined



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CAN Protocol Overview: What does a CAN 'Node' Do?

- A node is any sub system that is connected to the CAN bus
- A node may be very simple or very complex
- A node may continually send messages, such as a motor speed control node
- A node may only transmit a message when a system failure has occurred, such as a temperature monitoring node
- A node may only take action when another node instructs it to do so, such as an electronic valve control

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CAN Protocol Overview: CSMA/CD-CR

- Carrier Sense (CS) - Every node must monitor bus for a period of no activity before sending a message
- Multiple Access (MA) - Once a period of no activity occurs, every node has an equal opportunity to transmit a message
- Collision Detection (CD) - If 2 nodes transmit at the same time, a collision occurs
- Collision Resolution (CR) - Non-destructive bitwise arbitration to resolve collisions

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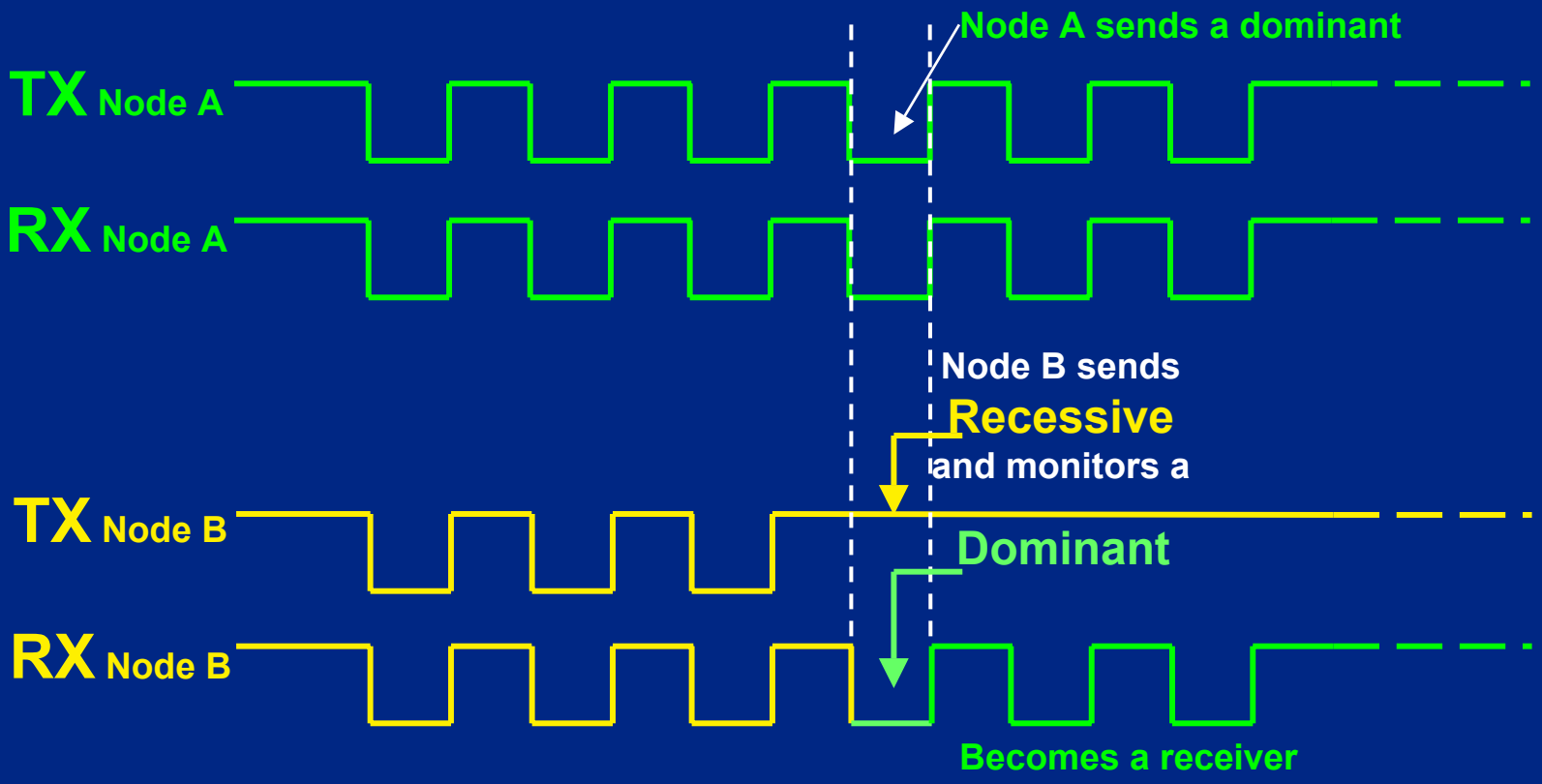
CAN Protocol Overview: Arbitration

- The node(s) losing arbitration become receivers and receive message



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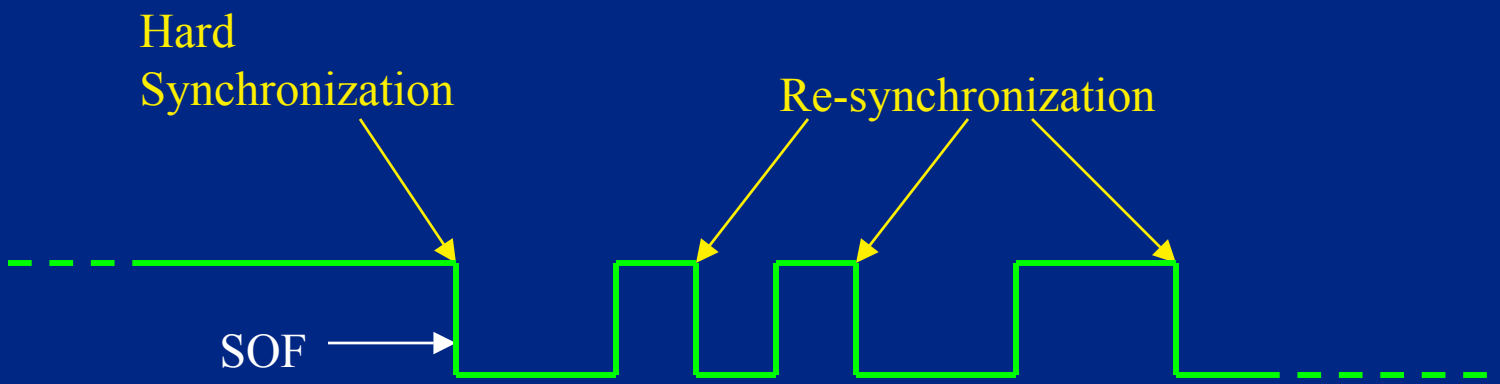
CAN Protocol Overview: Synchronization

- No clock in bit stream
- Receivers synchronize on recessive to dominant transitions



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CAN Protocol Overview: CAN Messages

- There are several types of ‘Messages’ or ‘Frames’ defined
- Data Frame
  - Transmits data from a transmitting node to any or all other nodes
  - Standard and Extended
- Remote Frame
  - Is a request for data from other node(s)
  - Standard and Extended
- Error Frame
  - Signifies bus errors have been detected

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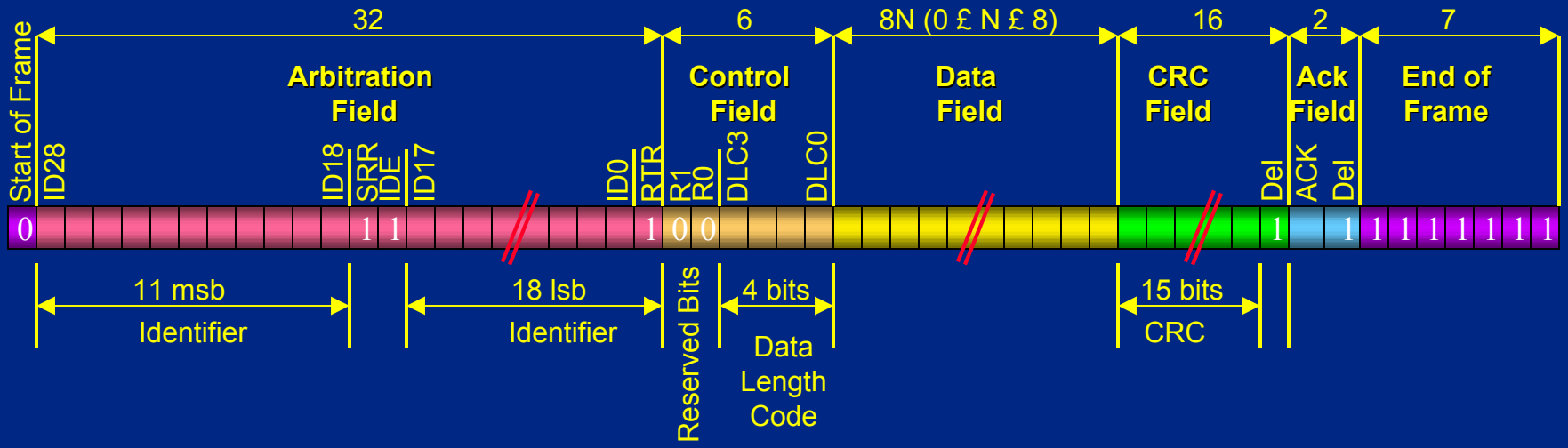
CAN Protocol Overview: Data Frame

- Standard Data Frame has 11-bit identifier
- Extended Data Frame has 29-bit identifier



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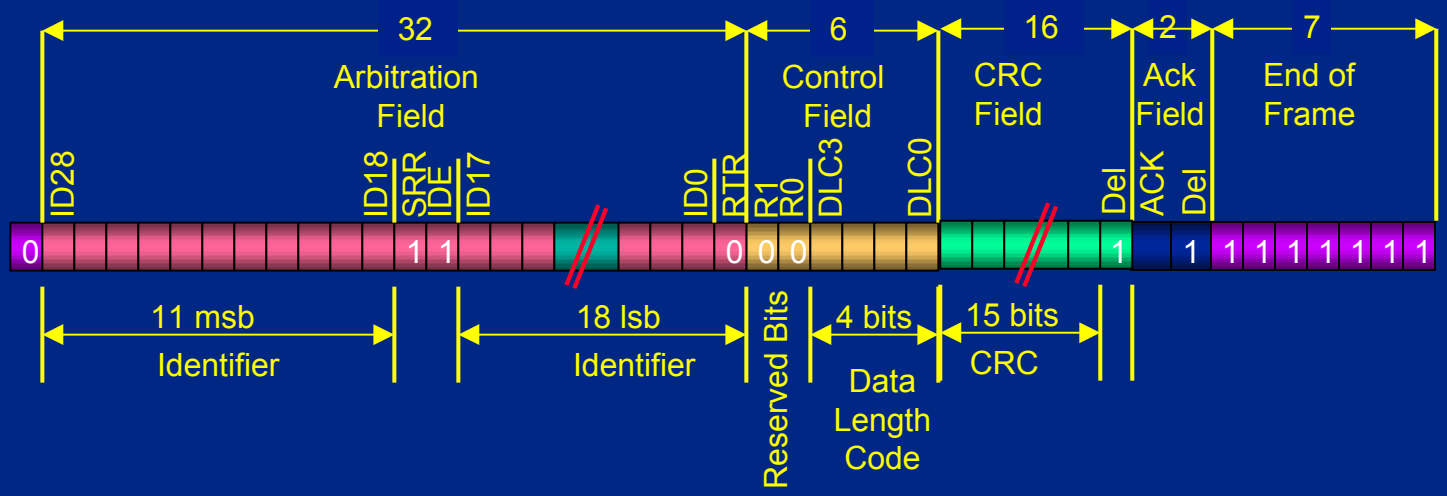
CAN Protocol Overview: Remote Frame

- Two types, standard or extended.
- Identical to the Data Frame, except there is no Data Field and the RTR bit is recessive.



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CAN Protocol Overview: Error Handling

- Several different types of error frames are generated for protocol violations
  - ensures integrity of messages
- Fault Confinement
  - CAN nodes can transition from working normally to being totally disconnected from the network based on fault data
  - Fault Confinement prevents faulty nodes from continuously transmitting and bogging down a network

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CAN Protocol Overview: Error Handling

- Acknowledge Error
  - Transmitting node sends ACK Slot bit as a recessive bit and checks for a dominant bit to verify reception
- CRC Error
  - All nodes receive message, calculate CRC and verify against CRC received
- Form Error
  - Generated when a dominant bit is detected where one should not be (CRC Delimiter, Ack Delimiter, End of Frame (EOF) field or Interframe Space)
- Stuff Error
  - The bit stuffing rule is violated if 6 consecutive bits with the same polarity are detected
- Bit Error
  - Node detects a signal on the bus that is opposite of what it sent

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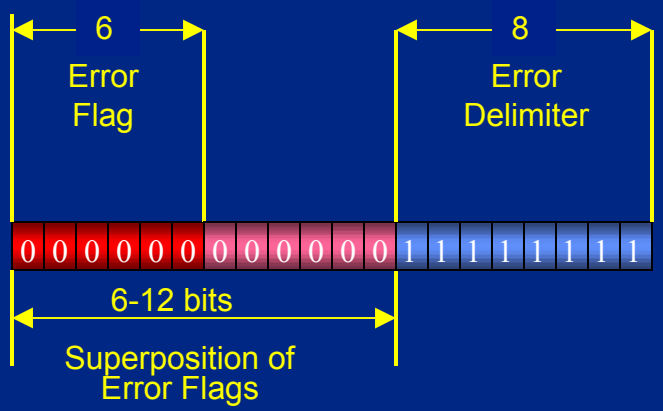
CAN Protocol Overview: Error Frame

- An Error Frame will be generated when a node detects one of the many types of errors defined by CAN



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CAN in Action

Sending and Receiving Messages

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CAN in action: How does a node determine which messages to act on?

- Each node has “Filter” Registers
- Identifier fields of incoming messages are compared to these Filter Registers to determine if an action is required

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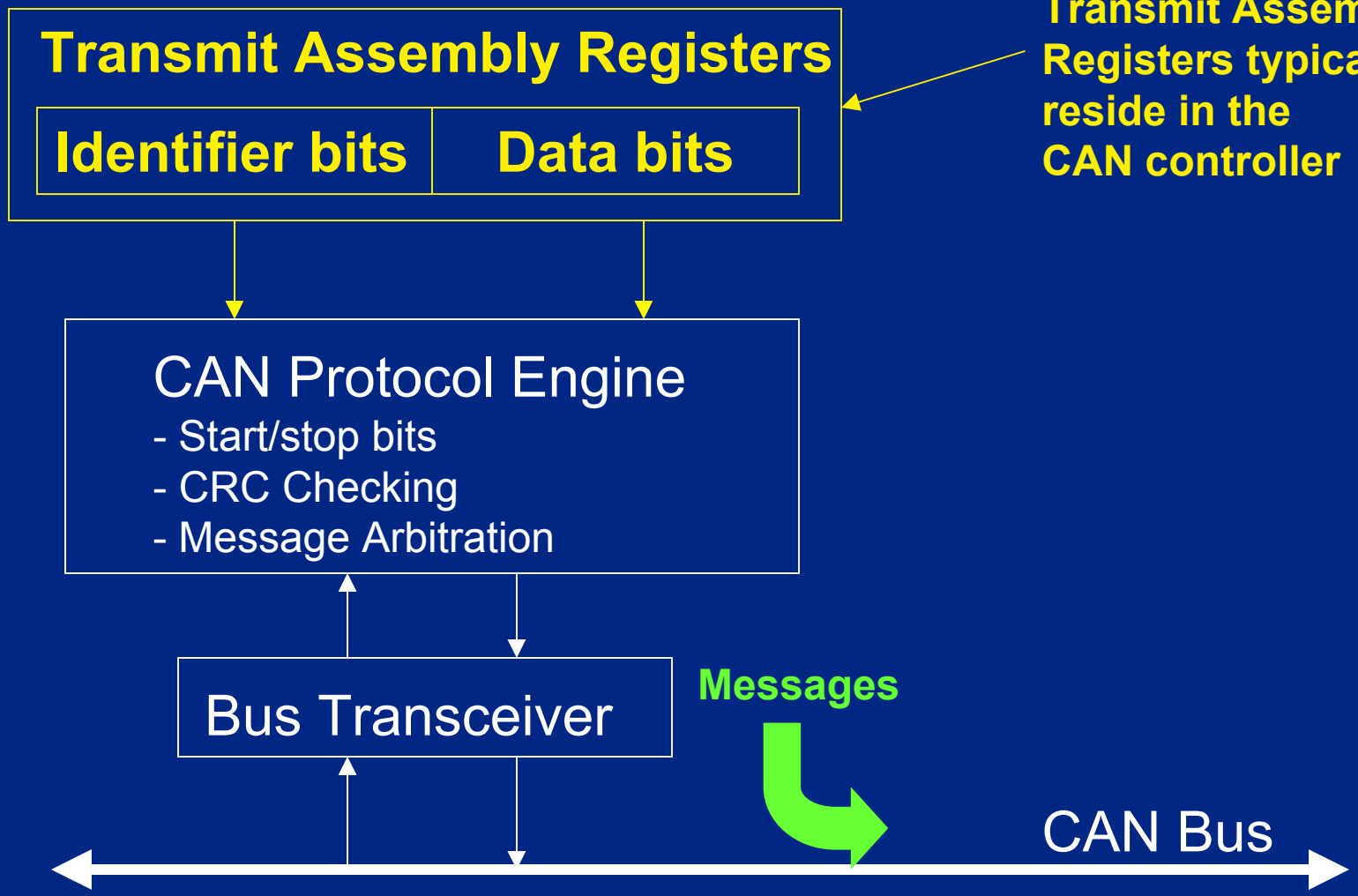
CAN in action: Sending a Message



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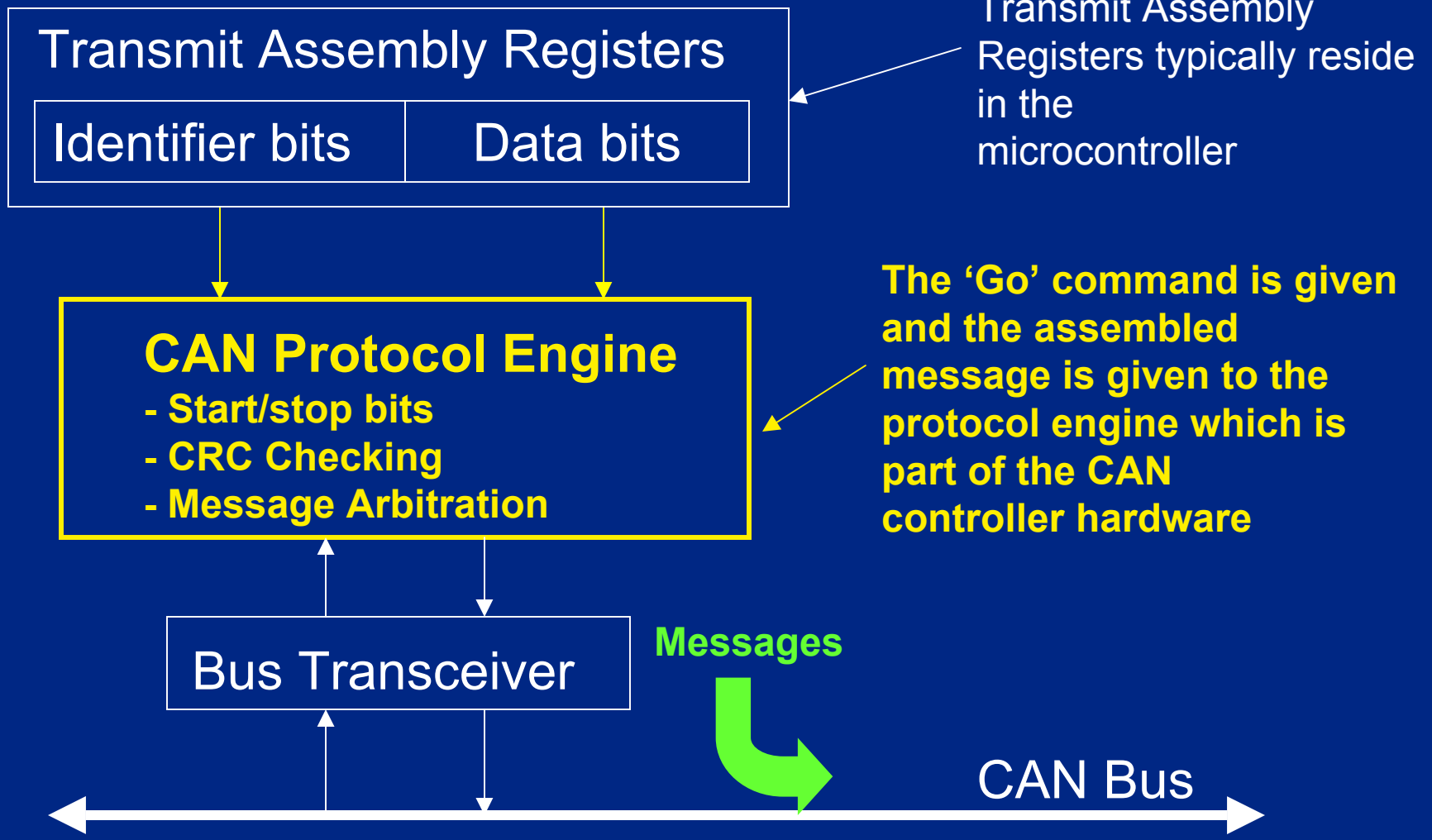
CAN in action: Sending a Message



Transmit Assembly Registers typically reside in the microcontroller

The 'Go' command is given and the assembled message is given to the protocol engine which is part of the CAN controller hardware

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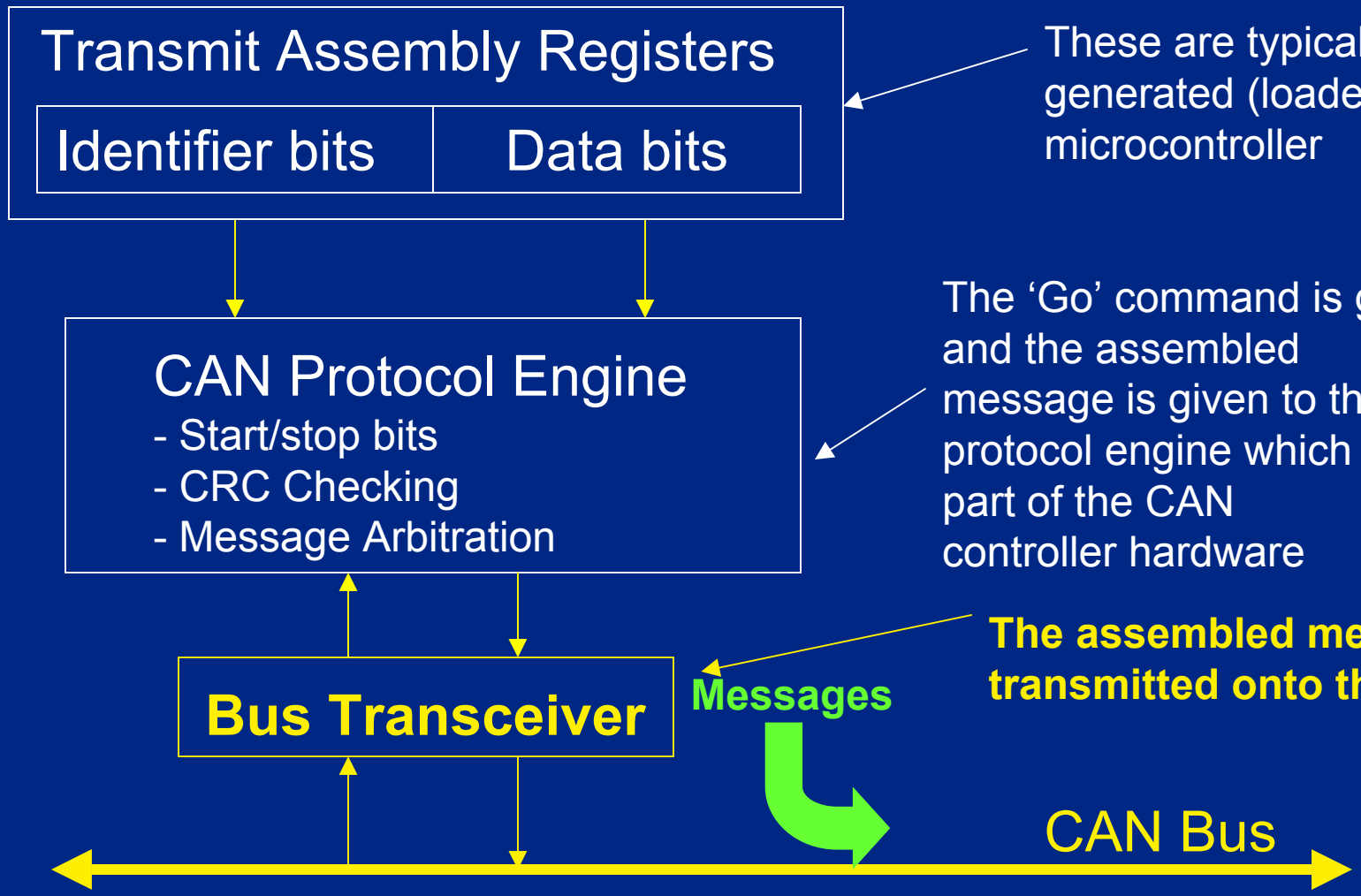
CAN in action: Sending a Message



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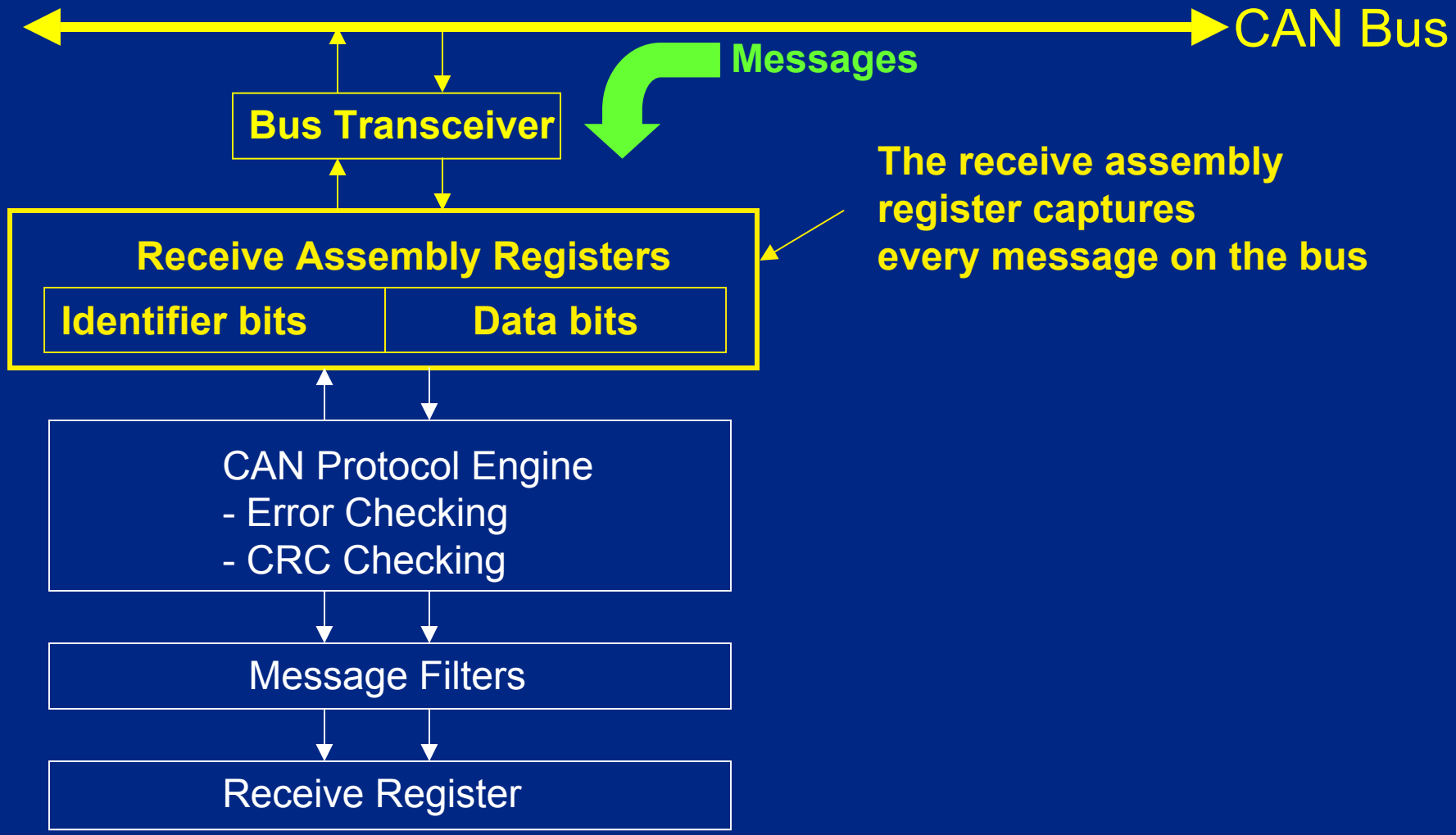
CAN in action: Receiving a Message



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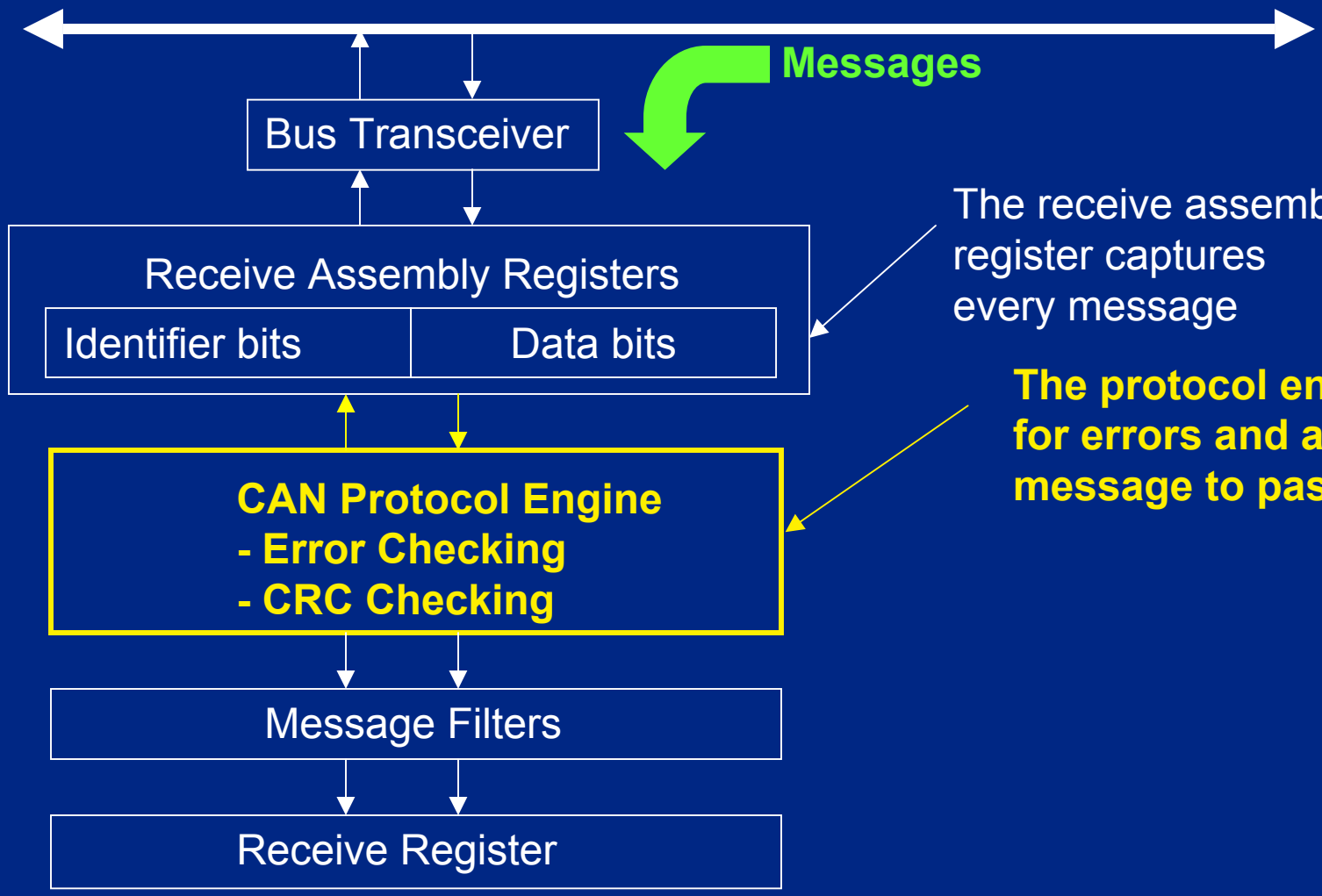
CAN in action: Receiving a Message



The receive assembly register captures every message

The protocol engine checks for errors and allows message to pass if valid

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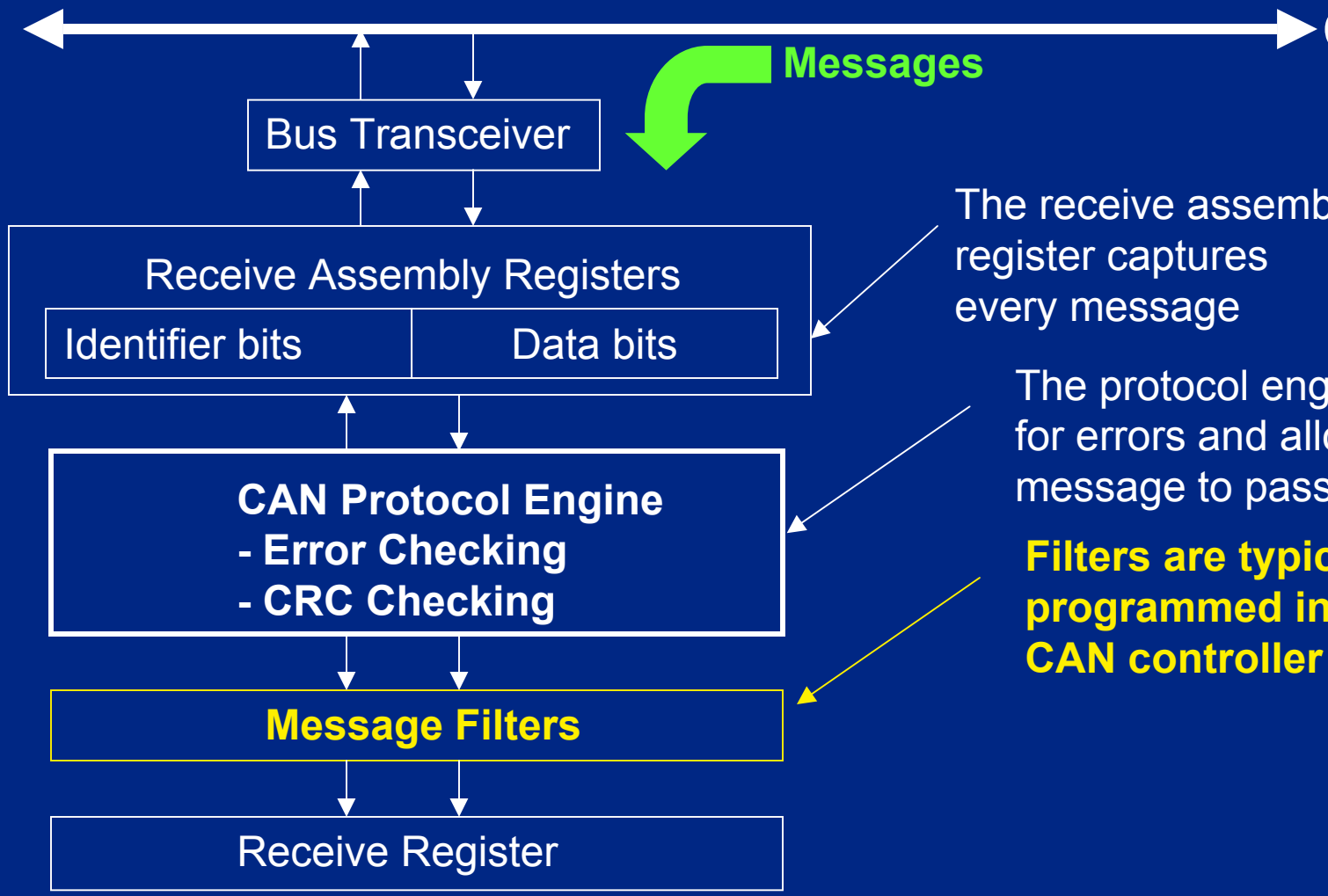
CAN in action: Receiving a Message



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Filters are typically programmed into the CAN controller

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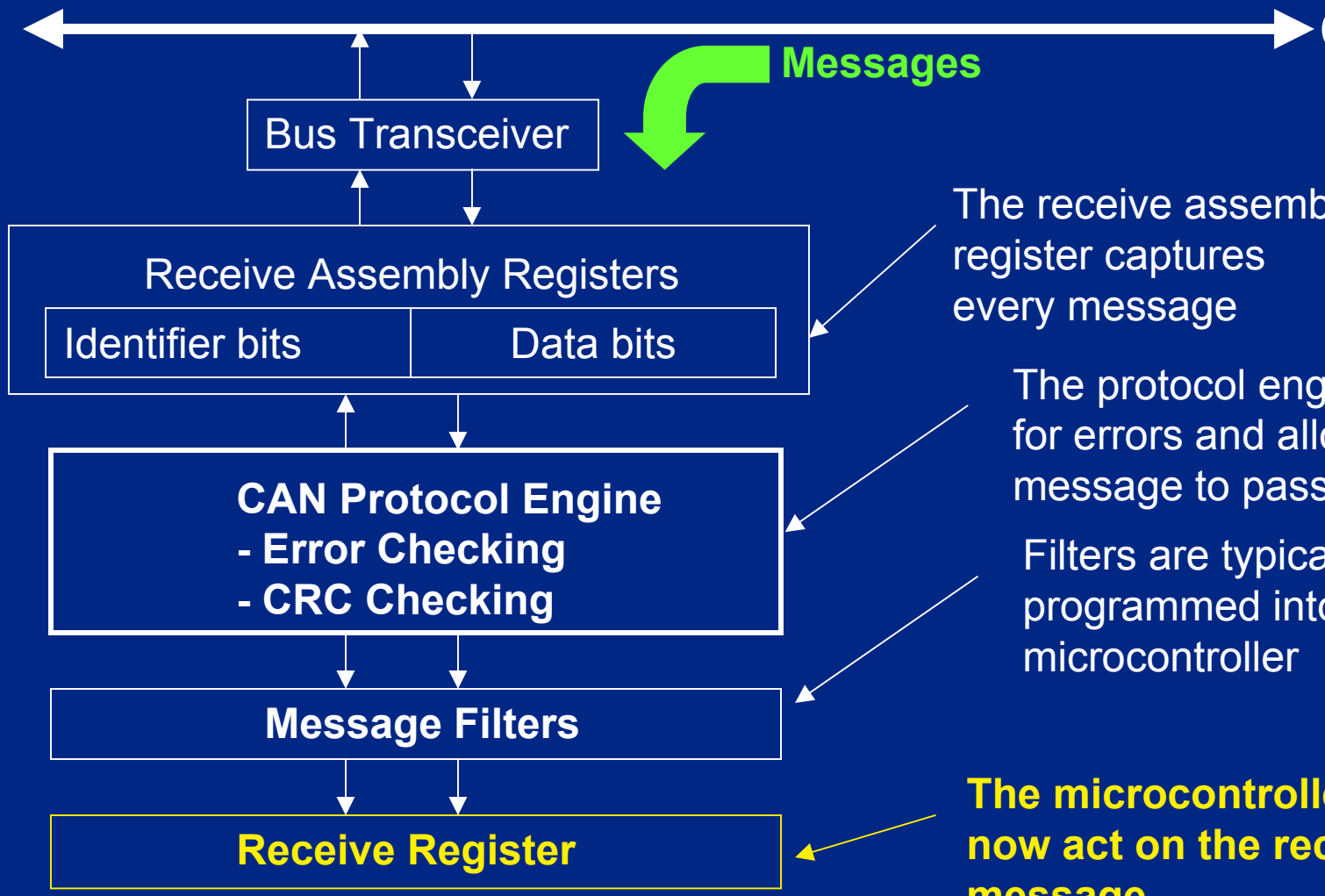
CAN in action: Receiving a Message



The receive assembly register captures every message

The protocol engine checks for errors and allows message to pass if valid

Filters are typically programmed into the microcontroller

The microcontroller can now act on the received message

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CAN in action: Its not as difficult as it looks!

- Most aspects of sending or receiving a message is handled by the protocol engine
- Transmitting a message typically requires only the loading of the identifier and data bytes - then giving the ‘GO’ command
- Receiving a message typically requires monitoring a status byte or interrupt pin and then reading the data that has been received

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Summary

- CAN is a robust data communications protocol which is suitable for:
  - Simple sensor and display applications
  - Distributing control across the network
  - System critical applications in automotive and industrial markets.

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If you would like to learn more…

- Some Industry Groups
  - CAN In Automation (CIA) www.can-cia.de
  - Open DeviceNet™ Vendors Association www.odva.org
  - SAE (e.g., J1939)
- Some Development Tools
  - Kvaser AB www.kvaser.se
  - Diversified Engineering www.diversifiedengineering.net

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Microchip's CAN Products

- MCP2515 Stand-alone CAN controller
- MCP250xx CAN I/O Expander (four devices)
- MCP2551 CAN Transceiver
- PIC18CXX8 8-bit MCU with CAN (two devices)
- PIC18FXX8 8-bit MCU with CAN (four devices)
- PIC18FX680 and PIC18FX585 with ECAN™ technology (four devices)
- dsPIC30F601X 16-bit MCU with CAN

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References

- Application Notes
  - ADN004, *Ease into the Flexible CANbus Network*
  - AN713, *An introduction to the CAN protocol that discusses the basics and key features.*
  - AN212, *Smart Sensor CAN Node using the MCP2510 and PIC16F876*
  - AN215, *A Simple CAN Node using the MCP2510 and PIC12C67X*
  - AN228, *A CAN Physical Layer Discussion*
  - AN754, *Understanding Microchip's CAN Module Bit Timing*
  - *AN815, Understanding the MCP250xx Devices*
  - *AN816, A CAN System Using Multiple MCP25050 CAN I/O Expanders*
  - *AN872, Upgrading from the MCP2510 to the MCP2515*

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