Ethernet in Embedded Systems

Dili Hu, Nicholas Dedenbach, Sinan Gunbay

Presentation Overview

- Basics
- Key Concepts
- Interfacing

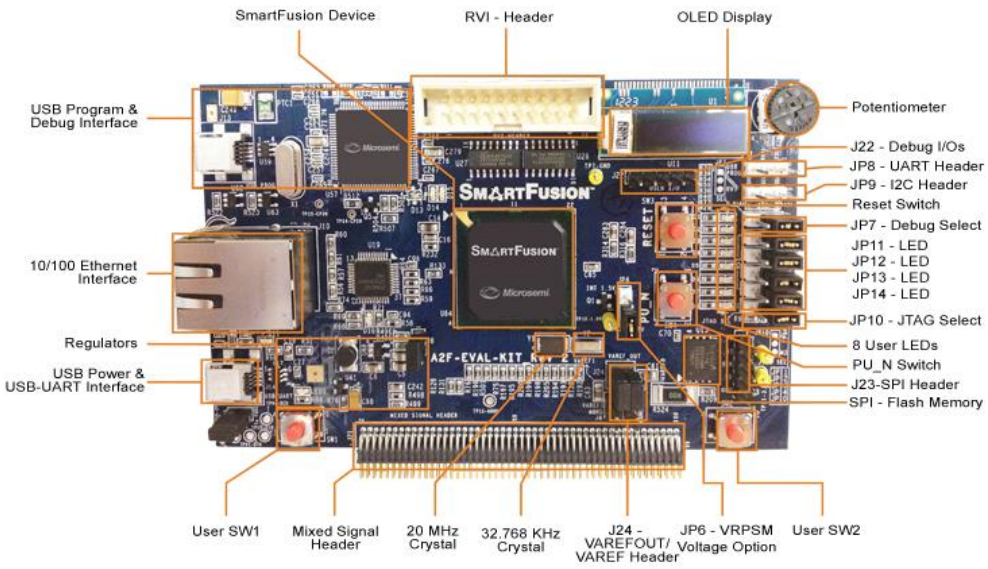
Basics

Ethernet

- The most widely used computer networking communications protocol for local area networks (LANs)
- Based on a standard (IEEE 802.3) that ensures interoperability within a network of devices
- Ethernet networks are scalable from the simple to the immensely complex (up to 2^{48} nodes)

Advantages

- Internet connectivity
- High speed (10 Mbps - 10 Gbps)
- Popularity
- Broadcasting capability
- SmartFusion-friendly



Disadvantages

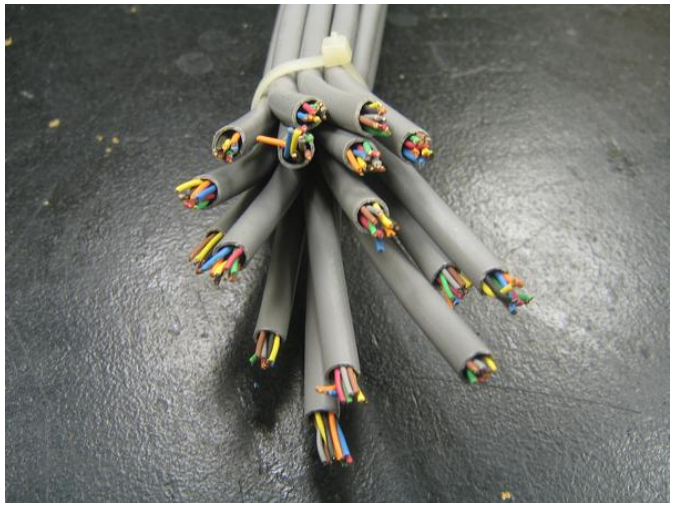
<http://en.wikipedia.org/wiki/File:Ethernet_RJ45_connector_p1160054.jpg>

- Requires physical connection (if not using WiFi)
  - Cable installation
  - Cable protection
- Network diameter limitations (100m for twisted pair cable, 2km for Fiber optic cable)
- Message potentially accessible by all devices on same network
- No guaranteed minimal latency

:(

Transfer Rate

- 10Base5 Ethernet -- 10 Mbps
  - Coaxial cable
  - Only on legacy system
- 100BaseTX Ethernet -- 100 Mbps
  - twisted pair cable
- Gig-E -- 1000 Mbps
  - Fiber-optic or twisted pair cable
- Even above -- 10 Gbps
  - High-end optical networking switches



<http://www.tested.com/tech/2740-how-to-properly-patch-and-repair-your-network-cables>

Embedded Applications

- Remote System Control and Analysis
  - Home Automation
  - Environmental Monitoring
- Utilization of Data from Web
  - Crawl Web Pages

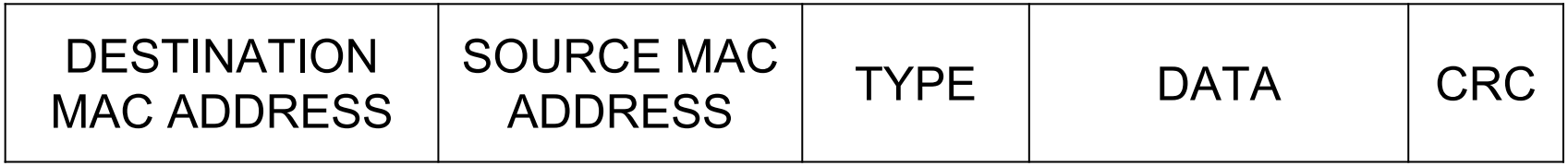
[

<http://99designs.com/mobile-app-design/contests/design-home-automation-app-control-lights-210543/entries/84>

Key Concepts

Ethernet Frame

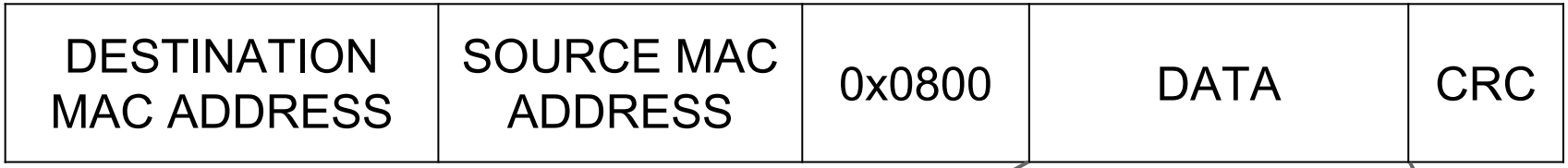
- Ethernet frame



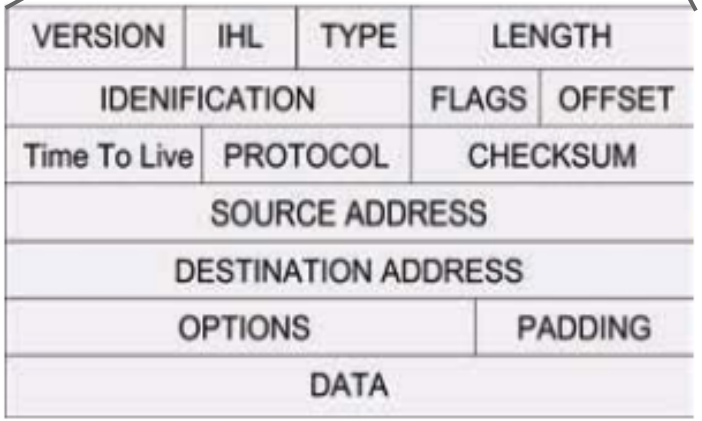
- DATA =
  - IP packet
  - DECnet packet
  - ARP packet

Ethernet Frame

- Ethernet frame



- DATA = IP packet
- DATA =
  - UDP packet
  - TCP packet



<http://www.mikroe.com/downloads/get/1622/ethernet_ew_03_11.pdf>

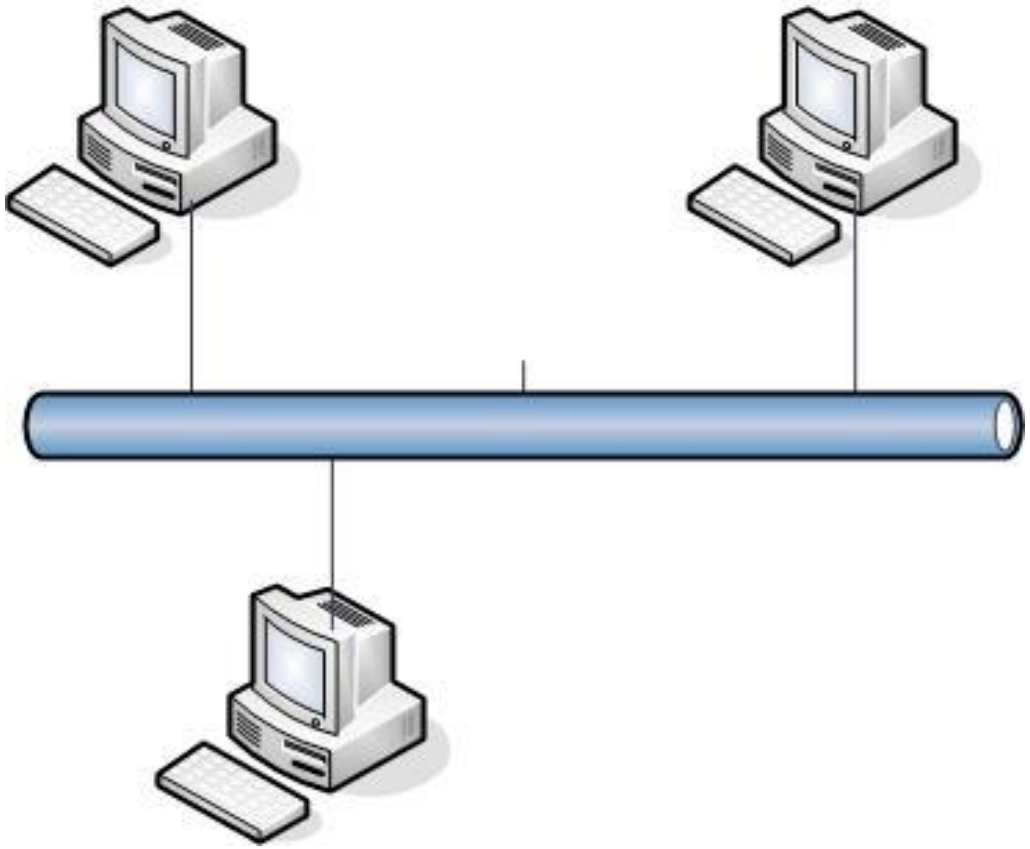
Collision Detection -- CSMA/CD

- Carrier Sense Multiple Access with Collision Detection
  - Multiple access:

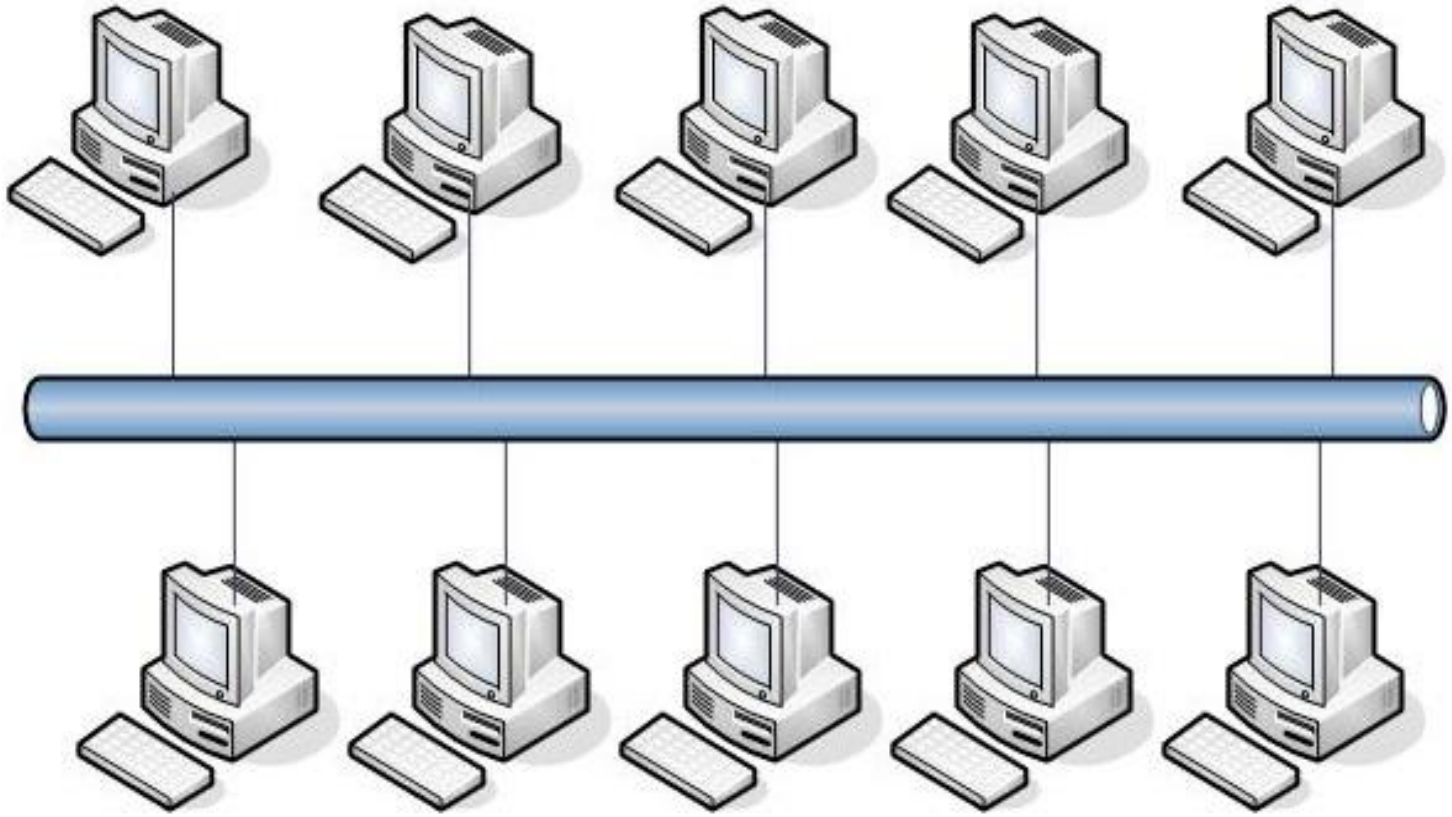
    Message accessible to all devices
  - Carrier sense:

    Check for availability before transmission
  - Collision detection:

    If collide with other devices when start sending, withdraw and wait a random amount of time

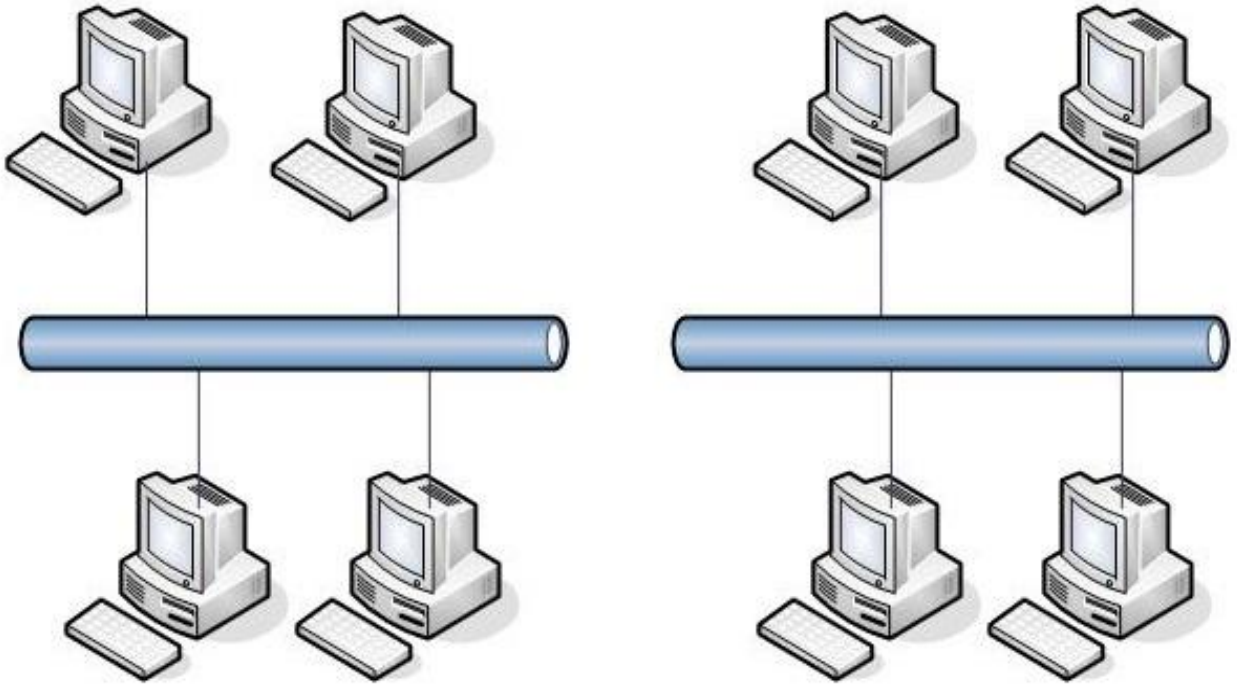


<http://www.thebryantadvantage.com/images/CSMACD.jpg>



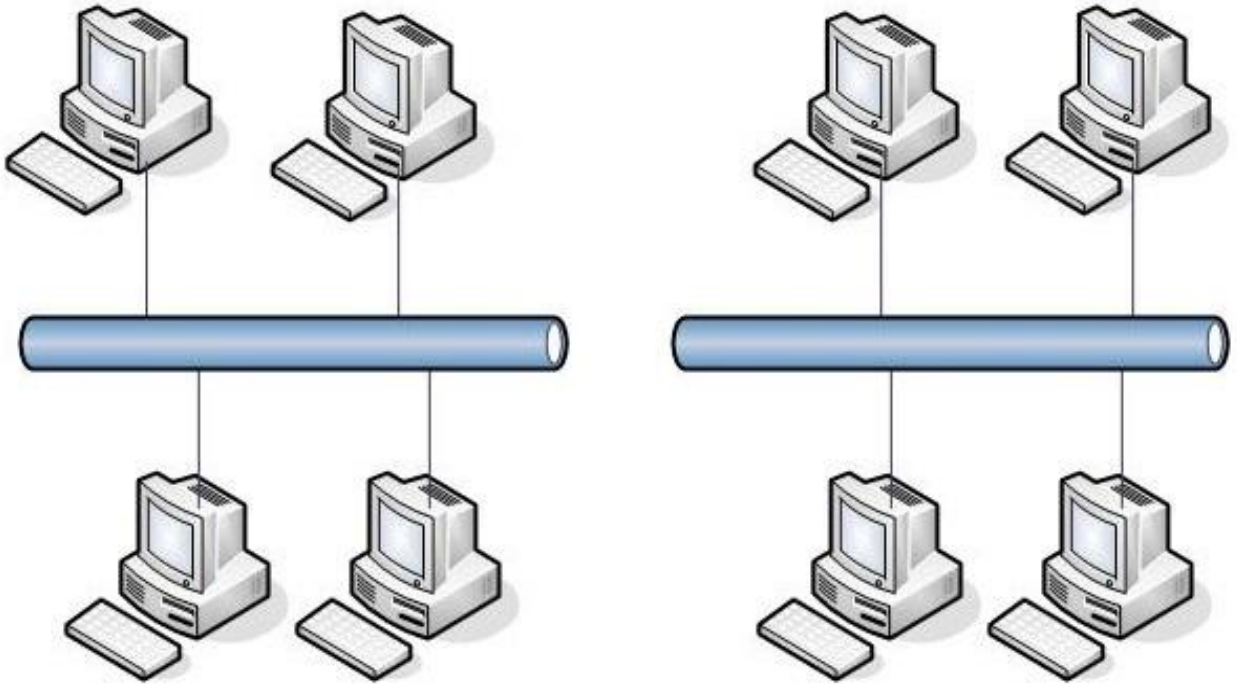
Segmentation

- Separate devices into disconnected segments
- Less device, less collision, less wait



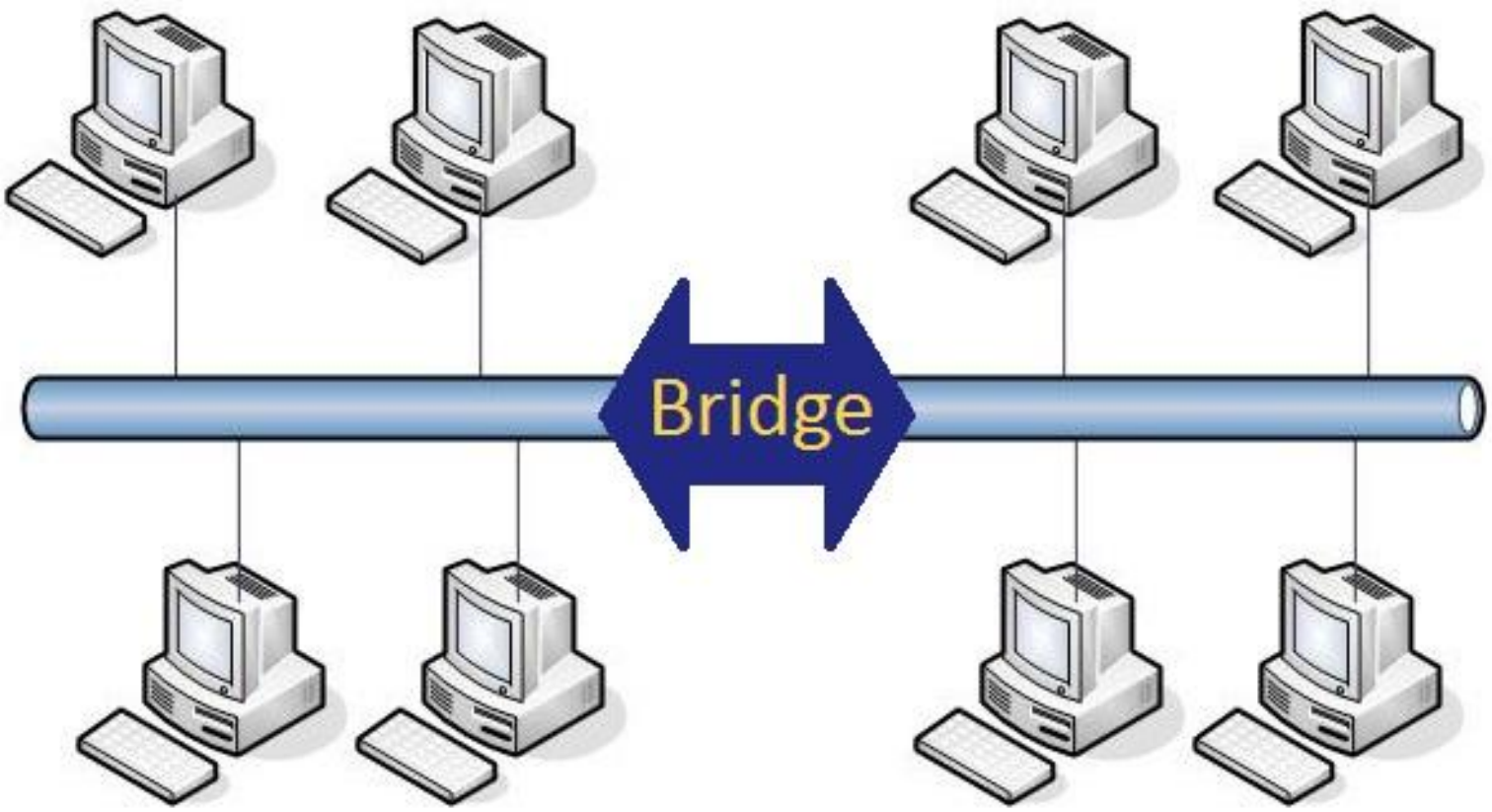
Segmentation

- Separate devices into disconnected segments
- Less device, less collision, less wait
- But, disconnected!



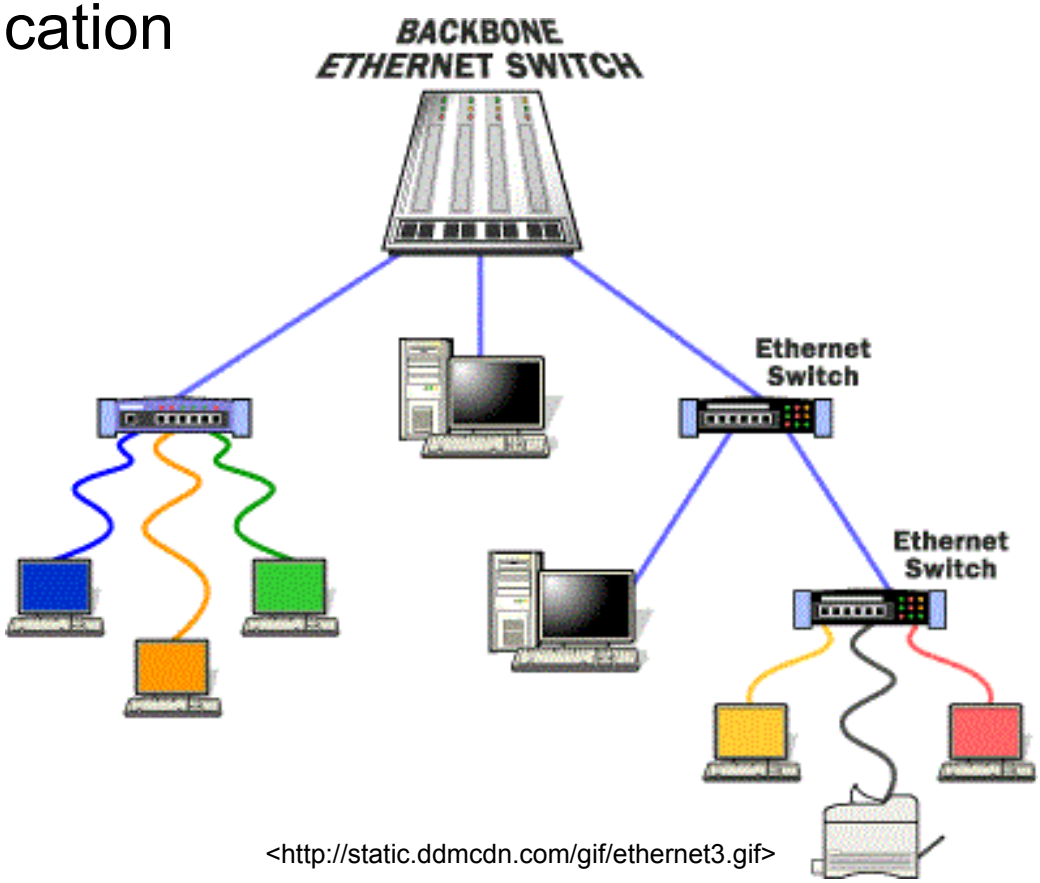
Bridges

- Connect two segments
- Forward information when needed



Ethernet Switches

- Connect an arbitrary number of segments
- One device per segment
- One to one communication
- Collision free!

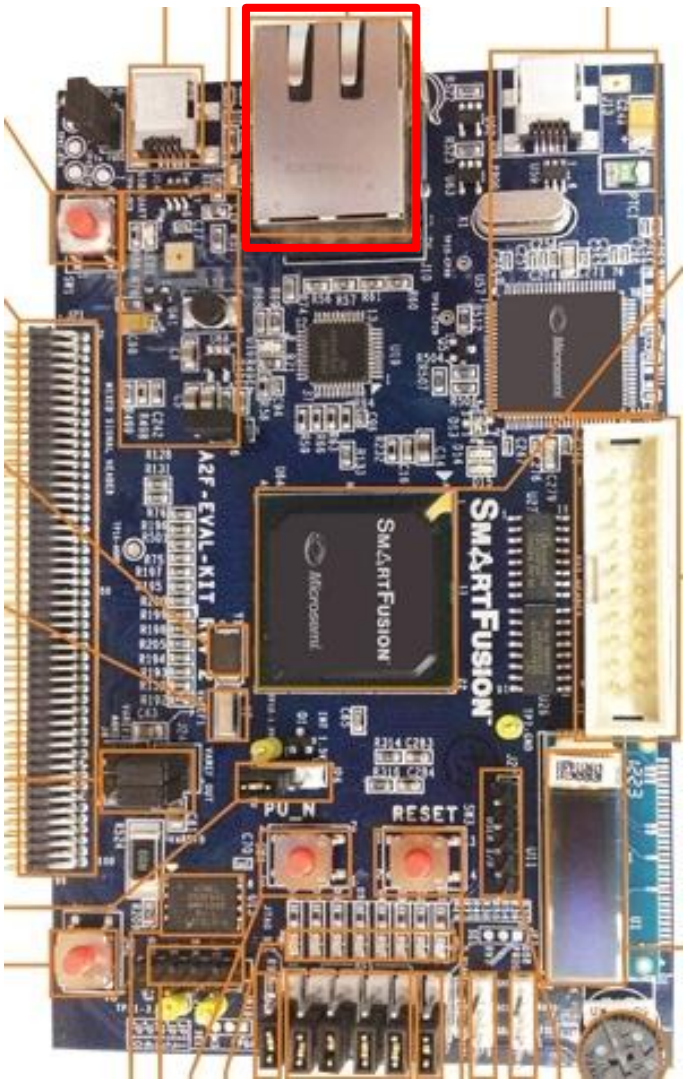


<http://static.ddmcdn.com/gif/ethernet3.gif>

Interfacing

The SmartFusion Ethernet MAC

- High-speed MAC Ethernet controller
- Uses RMII (Reduced Media Independent Interface)
- Controllable through APB slave interface
- Dedicated transmit / receive memory and buffers
- Minimal CPU footprint



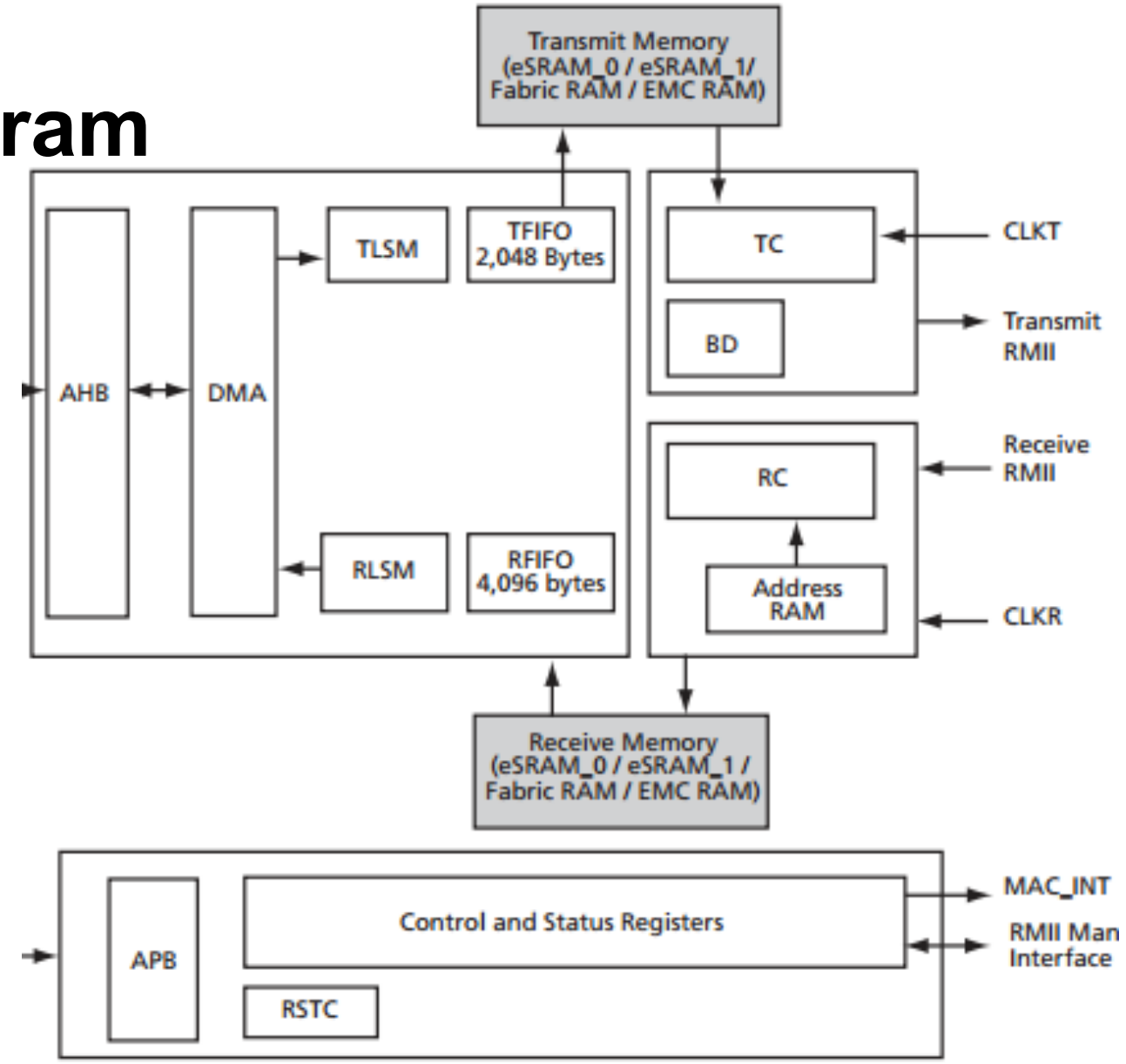
Block Diagram

- DMA: Direct Mem. Access Controller

- TLSM: Transmit Linked List Sate Machine
- TFIFO: Transmit Queue
- TC: Transmit Controller
- BD: Backoff/Deferring

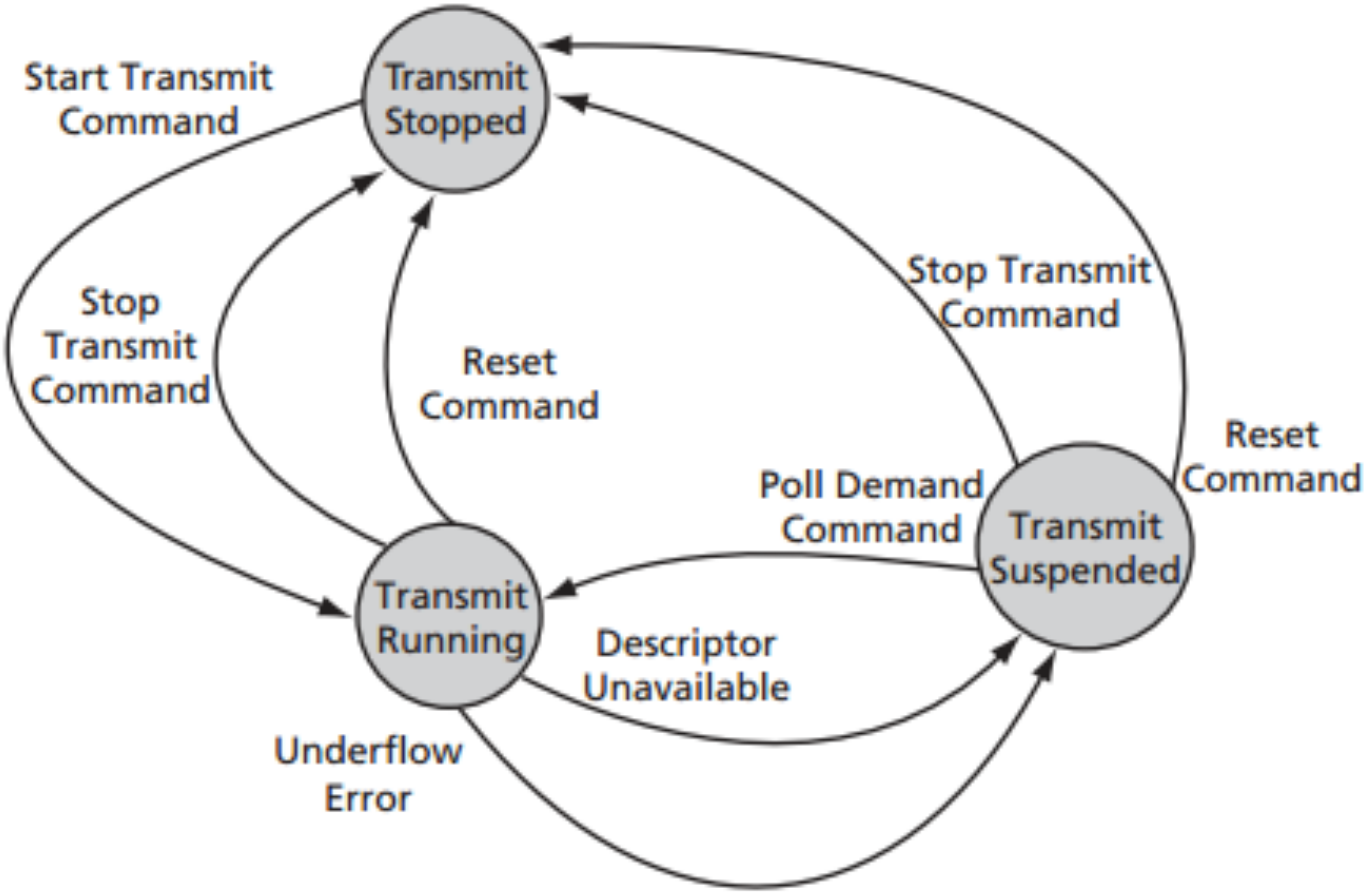
- RLSM: Receive Linked List State Machine
- RFIFO: Receive Queue
- RC: Receive Controller

- RSTC: Reset Controller



<http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf>

The Linked List State Machine



<http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf>

Frame Format

Field	Width (bytes)	Transmit Operation	Receive Operation
PREAMBLE	7	Generated by Ethernet MAC.	Stripped from received data. Not required for proper operation.
SFD	1	Generated by Ethernet MAC.	Stripped from received data.
DA	6	Supplied by host.	Checked by Ethernet MAC according to current address filtering mode and passed to host.
SA	6	Supplied by host.	Passed to host.
LENGTH/ TYPE	6	Supplied by host.	Passed to host.
DATA	0–1500	Supplied by host.	Passed to host.
PAD	0–46	Generated by Ethernet MAC when CSR[23] (DPD) bit is cleared and data supplied by host is less than 64 bytes.	Passed to host.
FCS	4	Generated by Ethernet MAC when CSR[26] bit is cleared.	Checked by Ethernet MAC and passed to host.

<http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf>

Frame Format

Field	Width (bytes)	Transmit Operation	Receive Operation
PREAMBLE	7	Generated by Ethernet MAC.	Stripped from received data. Not required for proper operation.
SFD	1	Generated by Ethernet MAC.	Stripped from received data.
DA	6	Supplied by host.	Checked by Ethernet MAC according to current address filtering mode and passed to host.
SA	6	Supplied by host.	Passed to host.
LENGTH/ TYPE	6	Supplied by host.	Passed to host.
DATA	0–1500	Supplied by host.	Passed to host.
PAD	0–46	Generated by Ethernet MAC when CSR[23] (DPD) bit is cleared and data supplied by host is less than 64 bytes.	Passed to host.
FCS	4	Generated by Ethernet MAC when CSR[26] bit is cleared.	Checked by Ethernet MAC and passed to host.

<http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf>

Frame Format

Field	Width (bytes)	Transmit Operation	Receive Operation
PREAMBLE	7	Generated by Ethernet MAC.	Stripped from received data. Not required for proper operation.
SFD	1	Generated by Ethernet MAC.	Stripped from received data.
DA	6	Supplied by host.	Checked by Ethernet MAC according to current address filtering mode and passed to host.
SA	6	Supplied by host.	Passed to host.
LENGTH/ TYPE	6	Supplied by host.	Passed to host.
DATA	0–1500	Supplied by host.	Passed to host.
PAD	0–46	Generated by Ethernet MAC when CSR[23] (DPD) bit is cleared and data supplied by host is less than 64 bytes.	Passed to host.
FCS	4	Generated by Ethernet MAC when CSR[26] bit is cleared.	Checked by Ethernet MAC and passed to host.

<http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf>

The Library!

- void MSS_MAC_init(uint8_t phy_address);
- void MSS_MAC_configure(uint32_t configurations);
- int32_t MSS_MAC_get_configuration();

- int32_t MSS_MAC_tx_packet(uint8_t *pacData, uint16_t pacLen, uint32_t time_out);
- int32_t MSS_MAC_rx_packet(uint8_t *pacData, uint16_t pacLen, uint32_t time_out);

- int32_t MSS_MAC_rx_packet_ptrset(uint8_t **pacData, uint32_t time_out);
- void MSS_MAC_prepare_rx_descriptor();

Configuration Options

- MSS_MAC_CFG_RECEIVE_ALL
- MSS_MAC_CFG_TRANSMIT_THRESHOLD_MODE
- MSS_MAC_CFG_STORE_AND_FORWARD
- MSS_MAC_CFG_THRESHOLD_CONTROL_[00,01,10,11]
- MSS_MAC_CFG_FULL_DUPLEX_MODE
- MSS_MAC_CFG_PASS_ALL_MULTICAST
- MSS_MAC_CFG_PROMISCUOUS_MODE
- MSS_MAC_CFG_INVERSE_FILTERING
- MSS_MAC_CFG_PASS_BAD_FRAMES
- MSS_MAC_CFG_HASH_ONLY_FILTERING_MODE
- MSS_MAC_CFG_HASH_PERFECT_RECEIVE_FILTERING_MODE

Sources

- http://computer.howstuffworks.com/ethernet.htm
- http://www.sans.edu/research/security-laboratory/article/ethernet-512
- http://www.mikroe.com/downloads/get/1622/ethernet_ew_03_11.pdf
- http://www.microchip.com/stellent/groups/sitecomm_sg/documents/devicedoc/en551260.pdf
- http://www.eecs.umich.edu/eecs/courses/eecs373/readings/Actel_SmartFusion_MSS_UserGuide.pdf
- http://www.actel.com/documents/mss_ethernet_mac_driver_ug.pdf

Questions?