Communication Architectures

for ICS

- Because of legacy systems
- Some systems are using outdated schemes
- Mix of setups within a larger system
- Also mix of media
Master - Slave

Respond to Request

Command

Slave

Master
Peer to Peer

- Neither is master
  - either can take control

- One is normally master
  - Get the slave can initiate comm if an event happens
Broadcast / multicast

- everyone sees messages broadcast onto the network
Network Topologies

Bus
- RS 485 multidrop

Token Bus
- Point-to-point through each device
- Data frame (token) - the device holding token controls comm. channel

Single point of failure

- No interrupts
- Low cost
- Less cable
Token Ring

If Failure

- Can communicate in either direction
- Gets rid of single point of failure problem

Still used in SCADA system

- SONET - synchronous optical network
- Some critical systems have parallel SONET
Star Topology

- at control station
- single point of failure
- needs more cable
- clients can send requests (repeat requests)
Physical Topology

- older systems very tied to physical topology

Virtual Topology

- star with hub versus switch
  - repeats everything
  - breaf costs
  - different levels of management in the switch
  - selectivity
  - control data flow

Filter
- Mesh network

- Ad Hoc network
  - configuration changed dynamically
  - wireless

- Can most easily handle loss of devices
- Highest cost
- More common with wireless types
Data Transmission Analog Versus Digital

Broadband - analog signal encoded with modulation techniques

- Amplitude modulator
- Frequency modulator
- Phase modulation

→ good for long distances with microwave freq
"Base band" - digital transmission of data.

- On/off keying (OOK)
- Electrical signals above/below threshold (1/0)
- Light signals in fiber

Threshold

Logic levels

5V
0V
Digital Data Transmission

- **Serial**: Transmit single bit each clock cycle
- **Parallel**: Transmit multiple bits each clock cycle

8-bit
Ethernet is a serial protocol.

- New techniques for speed
- Longer distances
- Serial, less cable

- Common cables vs wireless
- Network obsolete in wireless

- Needs more infrastructure (length limits)
  Clock rate
  Parallel is more efficient at lower...
Synchronous -serial communication

- Clock signal transmitted with data

- Adds another wire
IRIG-B

Clock

- Don't need to transmit extra data bits
- Extra hardware needed for synchronization
A synchronous

- No extra wiring needed
- Data frames at start and end of message
- Extra start bits
- Provide the reference
- Extra data bits
- Get low added cost

More common in newer installations/upgrade
Error Correction (error detection)

Options:
- Parity Bits
  - Odd \( \Rightarrow \) total number is in data packet plus error but is odd
  - Even
  - None
Checksum
- add up numbers of ones in data packet
  - send that number
    - provides increased reliability

CRC - cyclical redundancy check
  - additional calculation on the message
    53 32 on 16 bit CRC