University of Idaho

# ECE 444 / ECE 544 / CS 444 / CS 544 Supervisory Control and Critical Infrastructure Systems

Session 16

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## Communication Network Topologies

- Can be implemented physically or logically
  - Network switches
- Add redundancy - no single points of failure
- Reduce costs
  - performance
  - reliability

Trade-off → cost of failure
- cost of buildout
- cost of maintaining
- probability of failure



1



## Point to point versus bus

- RS-232: better direct connection
- RS-485: supports multidrop (broadcast)
  - Data packet header includes ID
  - Data bus is a more general form of multidrop
    - Common in digital networks



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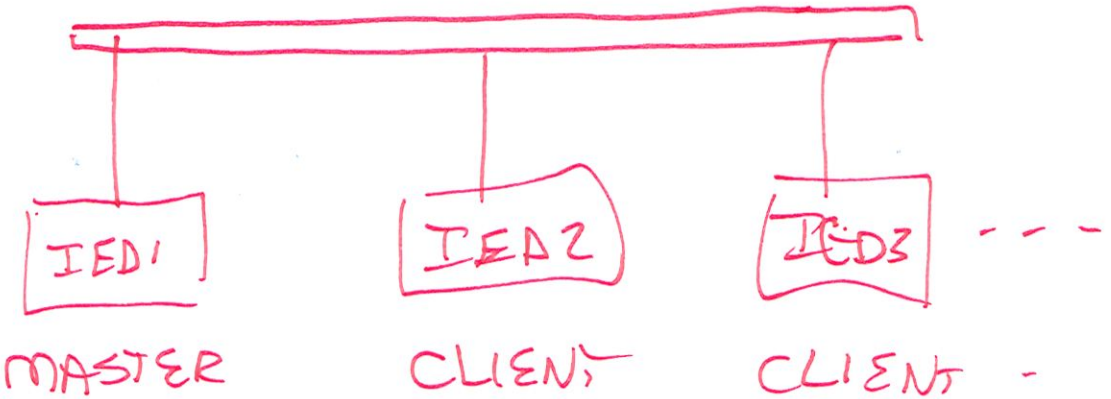
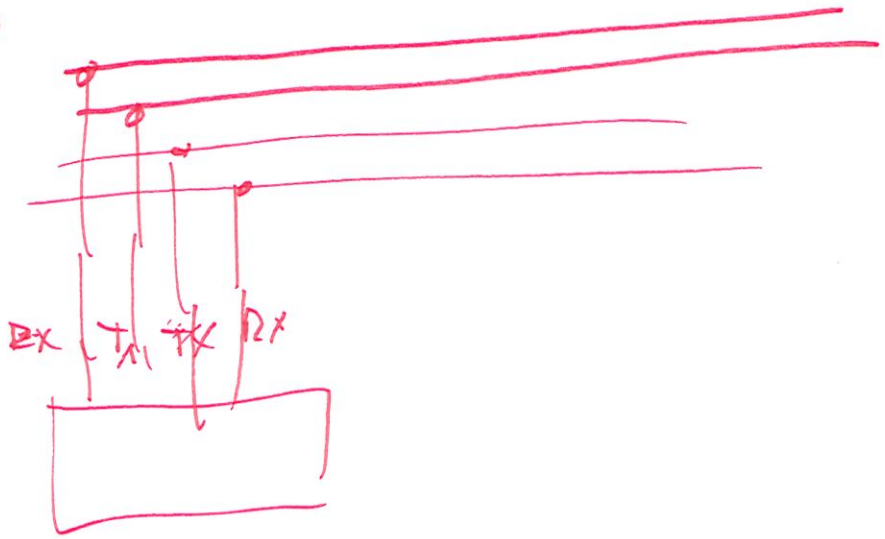


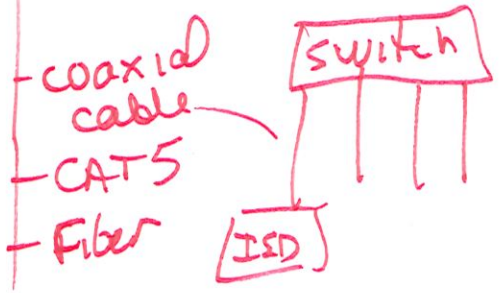

Physically

RS-485




Logically

- hub or switch that makes logical connection



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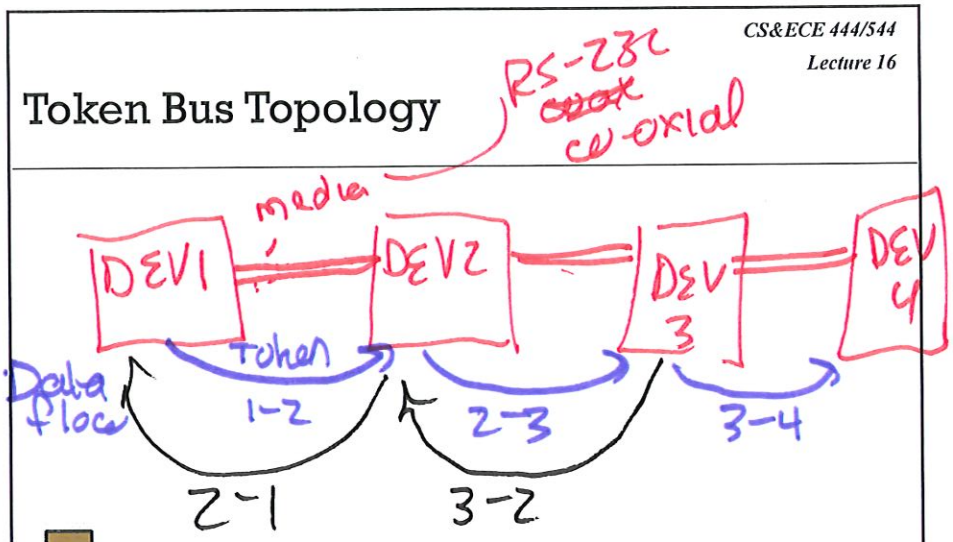
## Token Bus Topology








## Token Bus Topology

- Token (data frame)
  - Passed from device to device
  - Device holding token controls the channel flow (priority)
  - Packets stop at end of the bus if no takers
- Benefits
  - Inexpensive to implement
  - No interrupts
- Drawbacks
  - A bit slower → latency
  - Single point of failure

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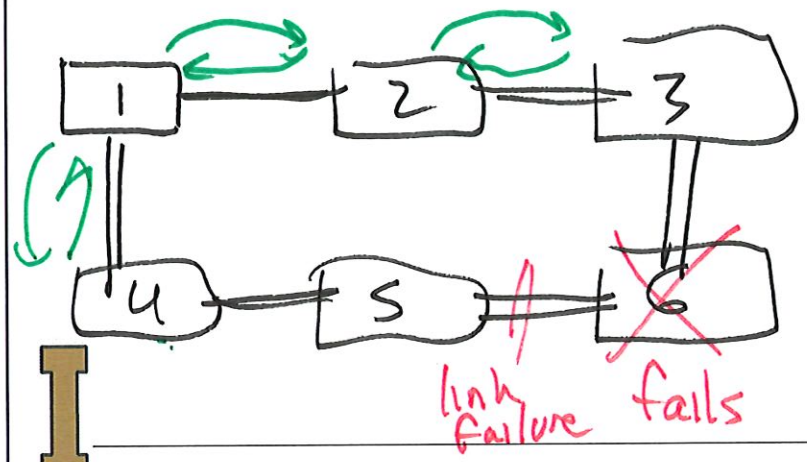
## Token Ring Topology








## Token Ring Topology

- Bidirectional data flow
- Can tolerate failures of devices
  - If device 6 fails can still communicate with 3 and 5
- Variation on topology: Synchronous Optical Network (SONET)
  - Cross-boundary communications – Between different owners
  - Limited number of devices
  - Used in critical infrastructure for – long distance
    - Reliable communications important
    - Time critical communications

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# Logical Network Topologies

- data packets → separate from protocal (DNP3)
  - controlled by communication system

- Transfer element

- Packet switched network
  - logical connections between devices

- flexibility & less wiring

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## Media Access

- Communication Requirements and Considerations
- Media Access Control (MAC) address unique identifier associated with network interface card/device

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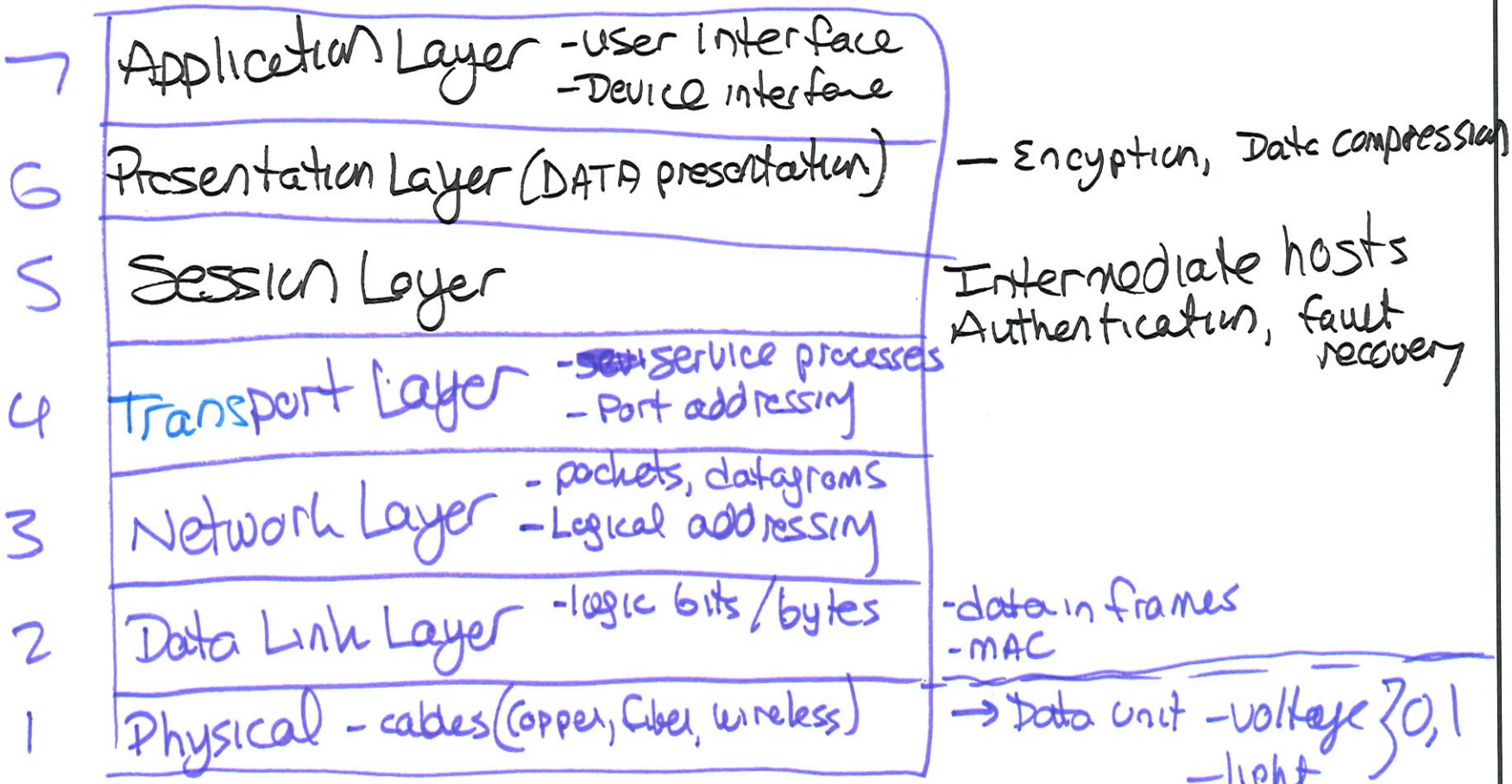
# OSI (Open System Interconnection) 7 Layer Model



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Level 2 includes
- Flow control
- Error checking
- Acknowledgement

Layer 3 - Addressing → routing (switches) [physical, virtual]

example → Internet protocol (IP) address

XXX. XXX. XXX. XXX

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Layer 4

Multiple alternatives
→ design/implementation choices

(1) connections enabled & maintained constantly
- guarantees delivery
- increases requirements for resources (overhead)
- example: Transmission Control Protocol (TCP)

TCP/IP - guarantee delivery not timeliness
└ challenge for industrial control systems

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(2) connections established only as needed

- dynamic network (~~effect~~ introduces its own delay)

example User datagram protocal (UDP)

→ send & forget

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Another Layer 4 topic:

Quality of service measures

- traffic flow level
- message integrity

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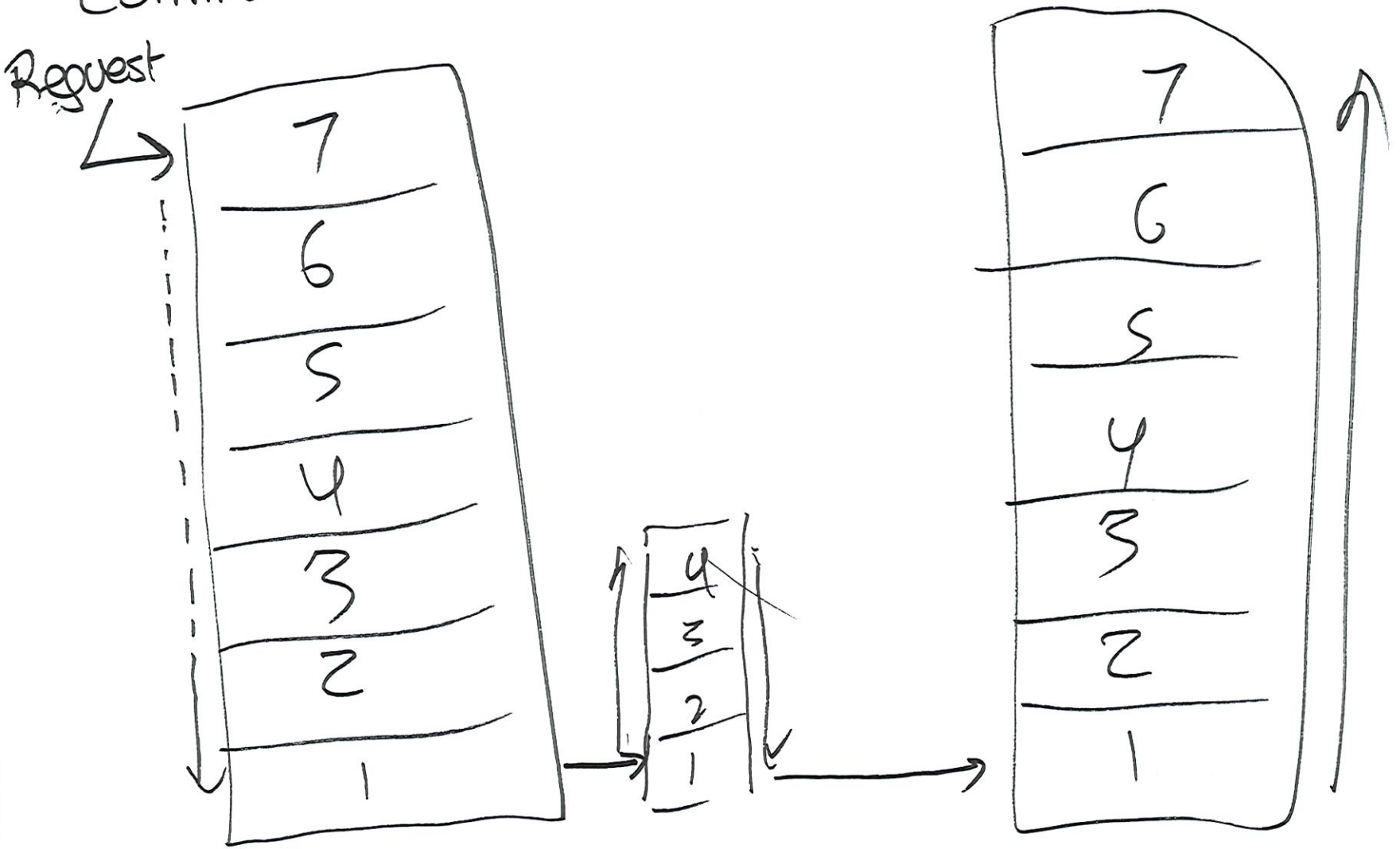
# Communication between devices



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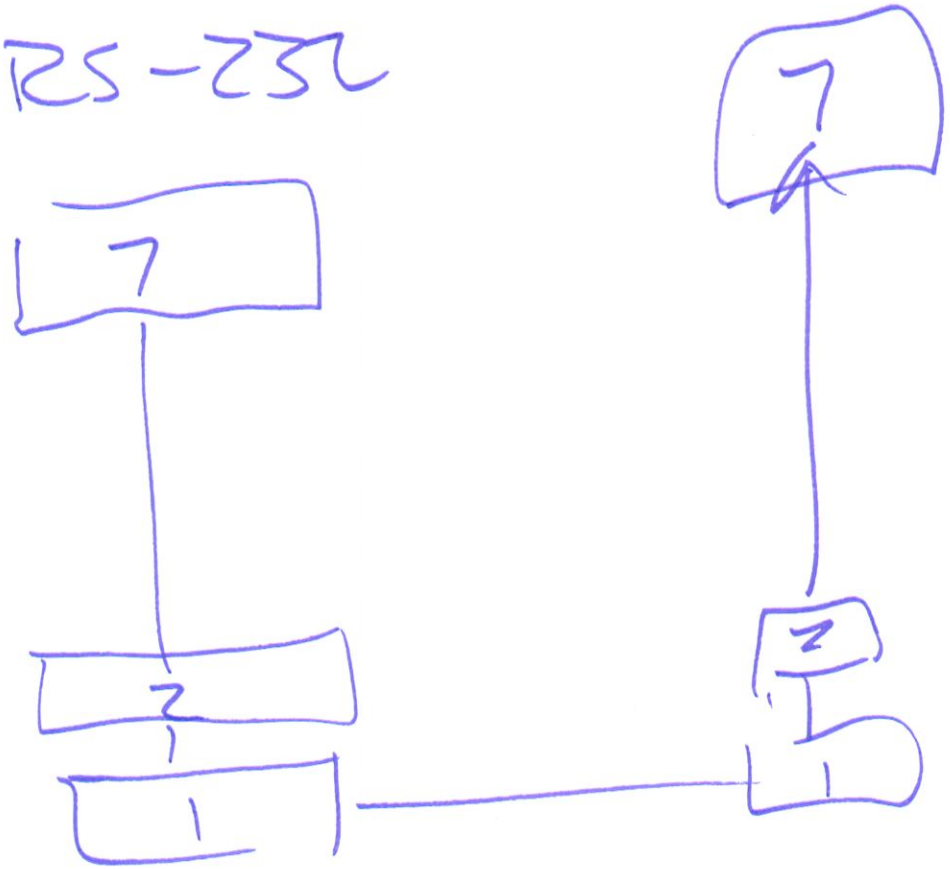
- Reduced set of layers by application

- RS-232



IEC 61850 is designed around use of OSI 7 layer model

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## Network Connectivity Devices

- Hub (repeater hub): hardware device for connecting ethernet devices together
  - Layer 1 device
  - Data received in a port broadcast out all of the other ports
  - Devices depend on identifier in the data packets to choose what to read or respond to
  - Can be used a repeaters
  - For analyzing network traffic, protocol analyzers can be connected to a port on a hub as an alternative to a network tap, span port or port mirror





## Network Connectivity Devices

- Network Switch (switching hub, bridging hub, IEEE MAC bridge)
  - Layer 2 (data link layer) device
    - Uses Media Access Control (MAC) addresses to forward data
    - Layer 2 bridging
    - Data is transmitted only out the port that is addressed
  - Trend for switches to include routing capabilities
    - Adds Layer 3 (network layer capabilities)
    - Might be referred to as layer 3 switches (multilayer switches)
  - Network segmentation to reduce collision domains
  - Can enable/disable ports
  - MAC filtering and other access control