Embedded Systems Architecture

Session #10

Communications

- Topologies
- Signaling standards
- Error detection
- Error Detection & correction
- Network basics

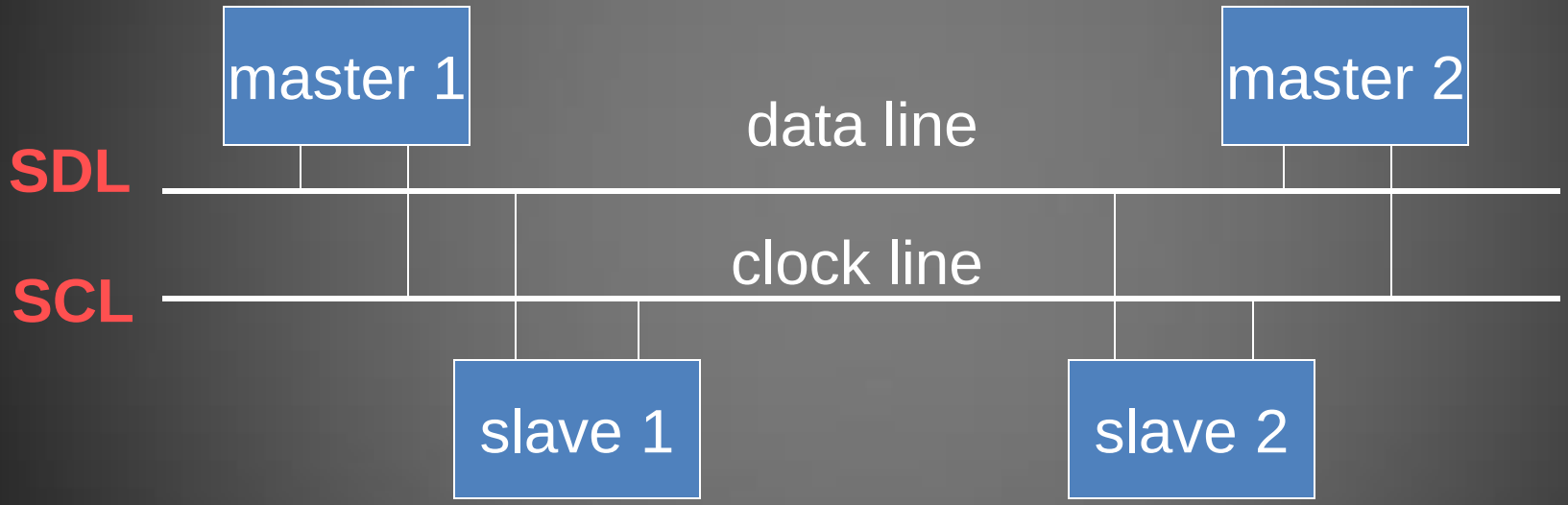
Point to Point Communications

- Parallel
- Serial
  - Synchronous
  - Asynchronous

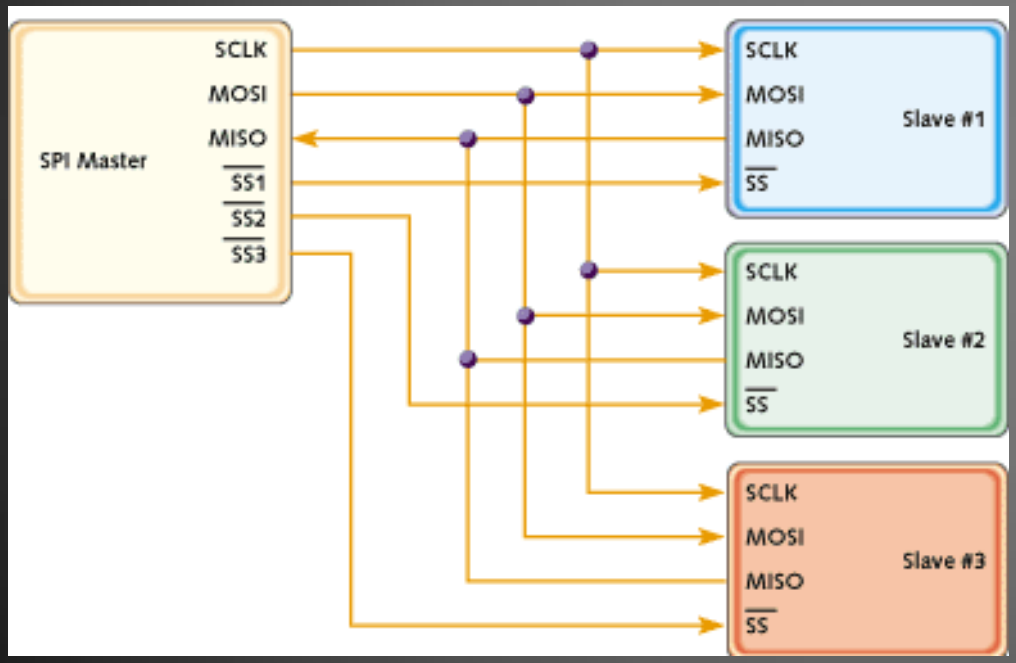
Synchronous Serial

- I^2C (Inter-Integrated Circuit)
- SPI (Serial Peripheral Interface)

I²C



SPI



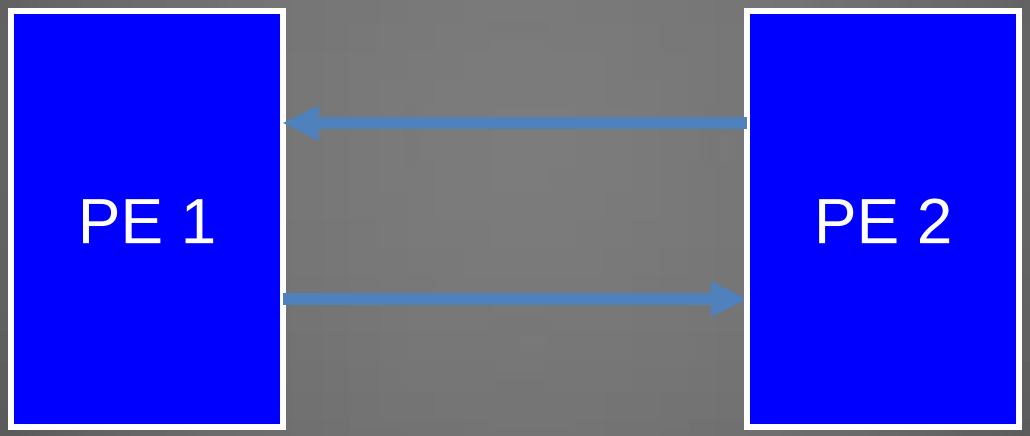
- MISO: Master In - Slave Out data.
- MOSI: Master Out - Slave In data.
- SCLK: Serial Clock.
- SS: Slave Select.

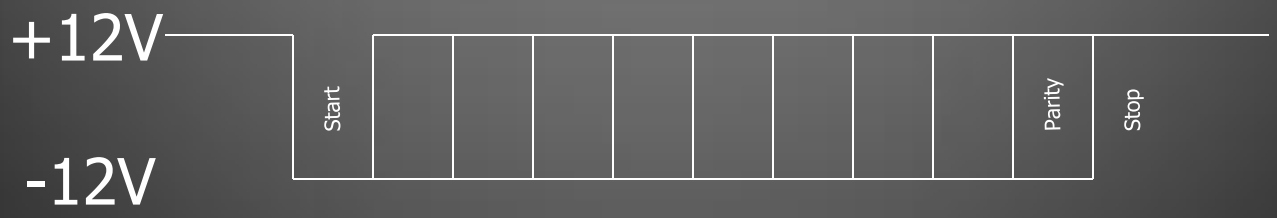
Asynchronous Serial

- Single ended
- Differential
- Encoding

Single Ended

- RS-232 (full duplex)



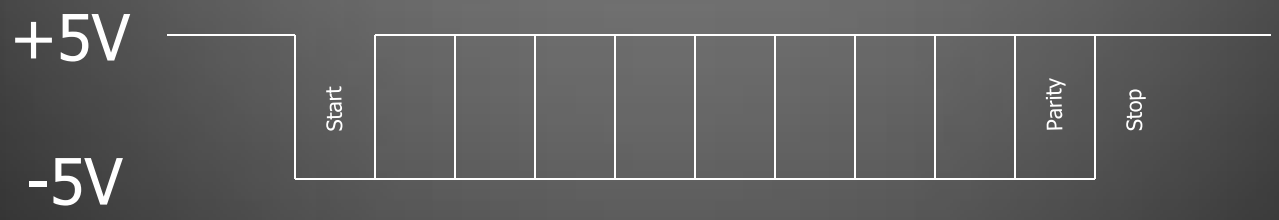


Differential

- RS-422
- RS-485
- LVDS

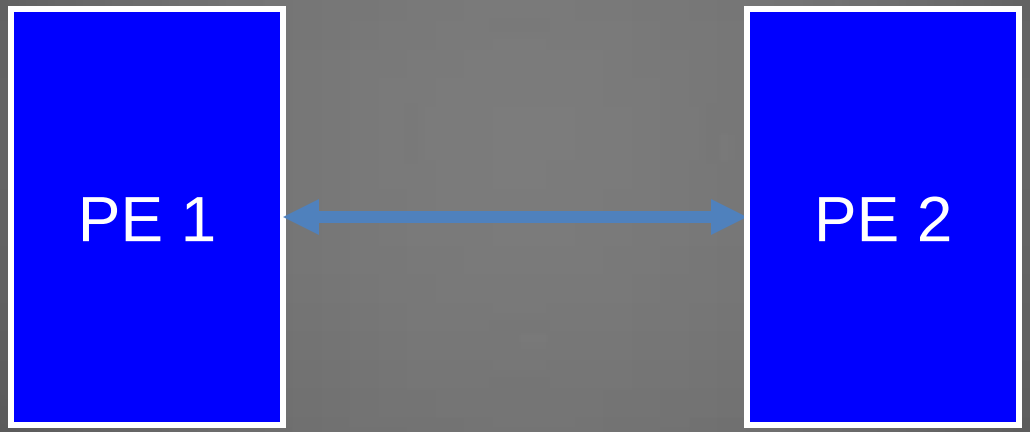
RS-422

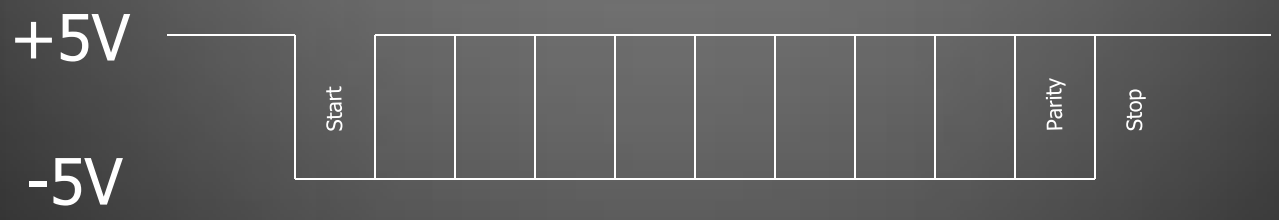
- (full duplex)



RS-485

- (half duplex)





LVDS

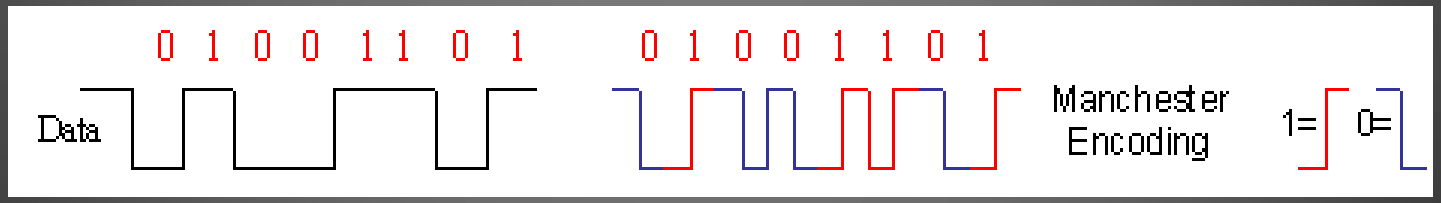
- Low Voltage Differential Signaling.
- <1 volt swing.
- High speed (gigabits per second).
- Low EMI susceptibility or radiation.
- Can be configured as point to point, multidrop, or multipoint.

Encoding

- Manchester
- Non-return-to-zero (NRZ)
- Non-return-to-zero, inverted (NRZI)

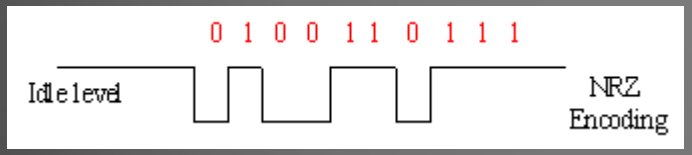
Manchester code

- DC balanced.
- Also called Bi-Phase encoding.
- Used in Ethernet 10BaseT & 100BaseT.



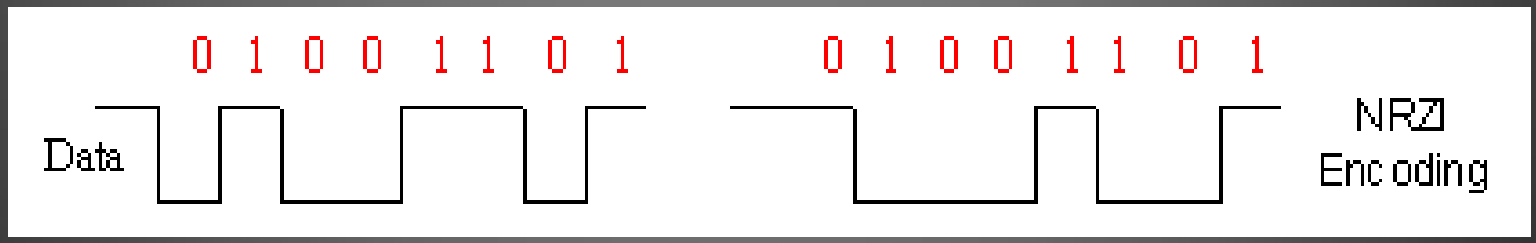
Non-return-to-zero (NRZ)

- A ‘1’ is a high and a ‘0’ is a low.
- Used in RS-232 & CANbus.



Non-return-to-zero, inverted (NRZI)

- A ‘1’ is a change (high to low or low to high) and a ‘0’ is no change.
- Used in FDDI and USB.



Symbol Coding

- 4B/5B
- 5B/6B
- 8B/10B
  - Used with Fibre Channel, Gigabit Ethernet, 10 Gigabit Ethernet, & ATM interfaces.

Symbol Coding Example

Hex Digit	Symbol	Hex Digit	Symbol	Hex Digit	Symbol	Hex Digit	Symbol
0000	011010	0100	001101	1000	001011	1100	001110
0001	101001	0101	101100	1001	100011	1101	100110
0010	011001	0110	011100	1010	010011	1110	010110
0011	110001	0111	110100	1011	110010	1111	100101

Framing

- *How do we know where the beginning and ending are for bytes, words, frames, or packets?*
- We use signaling that cannot appear within the data stream itself.
- Symbols that are not used for data are handy for this purpose.

Error Detection

- Parity
- Checksum
- Longitudinal Checksum
- Cyclic Redundancy Check
- Illegal Symbol

Parity

- Used on small packets of data bits.
- The parity bit is added to the data by the sender and checked by the receiver.
- Even parity maintains an even number of ‘1’s in the data and an odd parity maintains an odd number of ‘1’s in the data.

Checksum

- Used on multiple words of data.
- Each word is numerically summed to determine the checksum.
- Overflow bits, if any, are removed.
- Checksum size can vary from application to application.

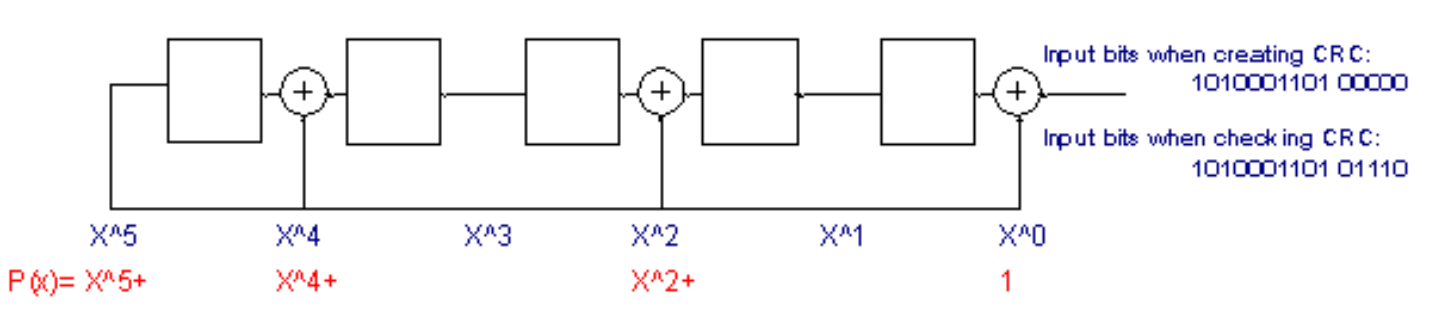
Longitudinal Checksum

- Used on multiple words of data.
- Calculated by performing a boolean exclusive OR operation on all words on a bit position basis.
- The longitudinal checksum will be be the same size as the data words.
- Also called Longitudinal Parity.

Cyclic Redundancy Check

- Used on multiple words of data.
- Data is fed serially into the CRC polynomial.
- CRC size is polynomial specific.

Cyclic Redundancy Check



- CRC-12: X^12+X^11+X^3+X^2+X+1
- CRC-16: X^16+X^15+X^2+1
- CRC-CCITT: X^16+X^12+X^5+1
- CRC-32: X^32+X^26+X^23+X^22+X^16+X^12+X^11+X^10+X^8+X^7+X^5+X^4+X^2+X+1

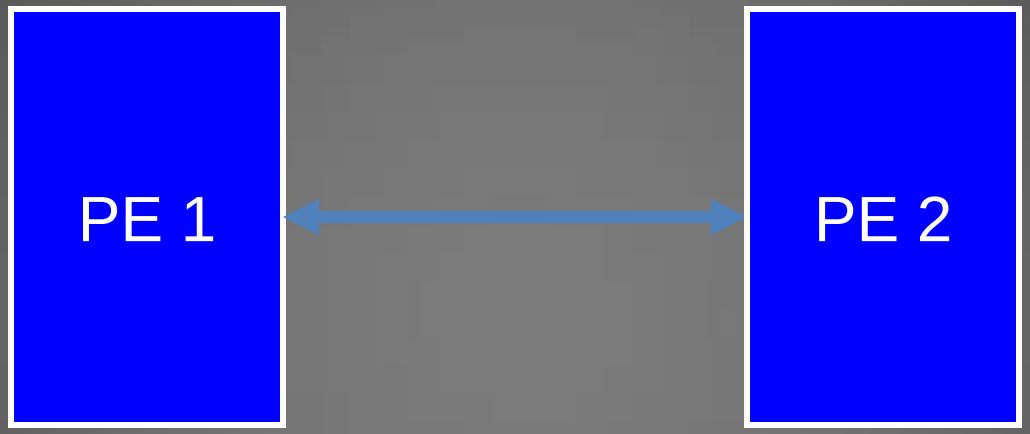
Illegal Symbol

- Illegal symbols (symbols that are not assign to data or signaling) can also be used to detect errors.

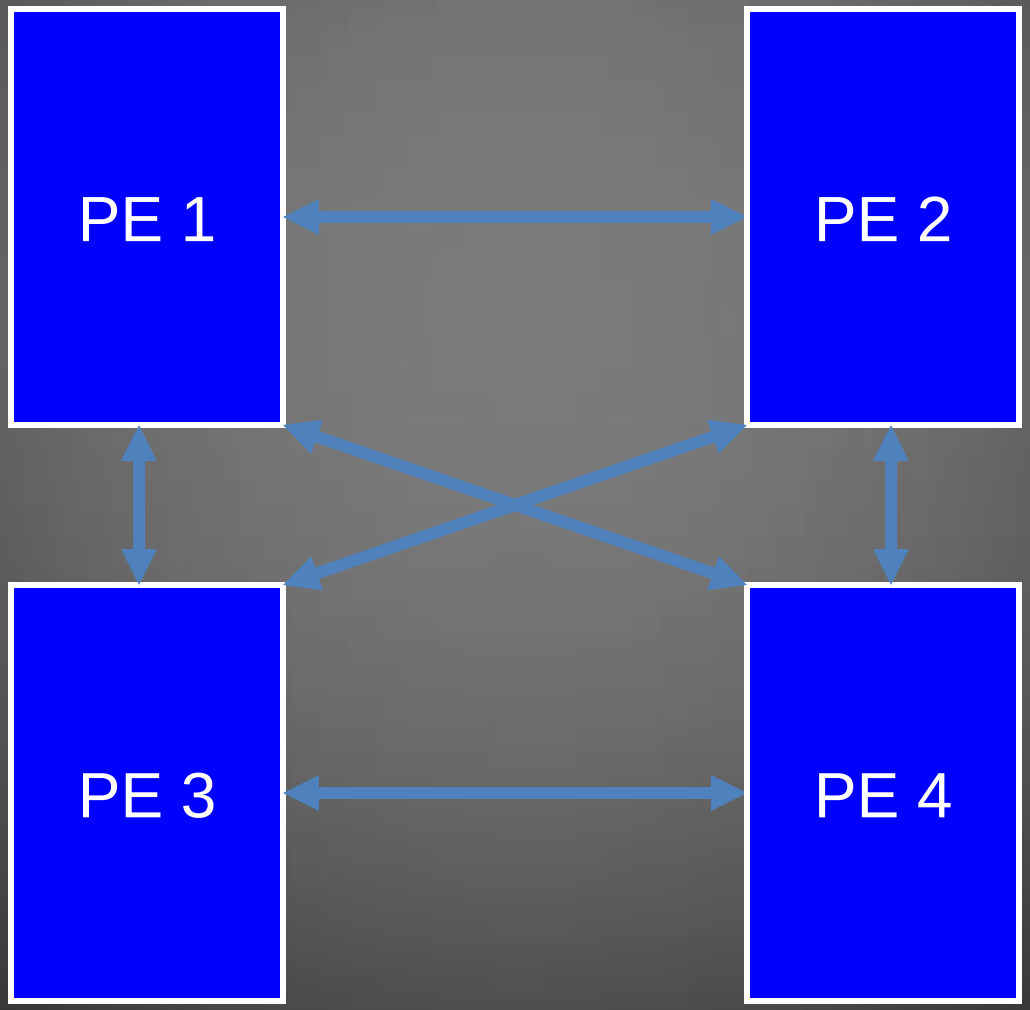
Error Detection & Correction

- Reed-Solomon
- ECC: Error-Correcting Code
- EDAC: Error Detection And Correction
- FEC: Forward Error Correction

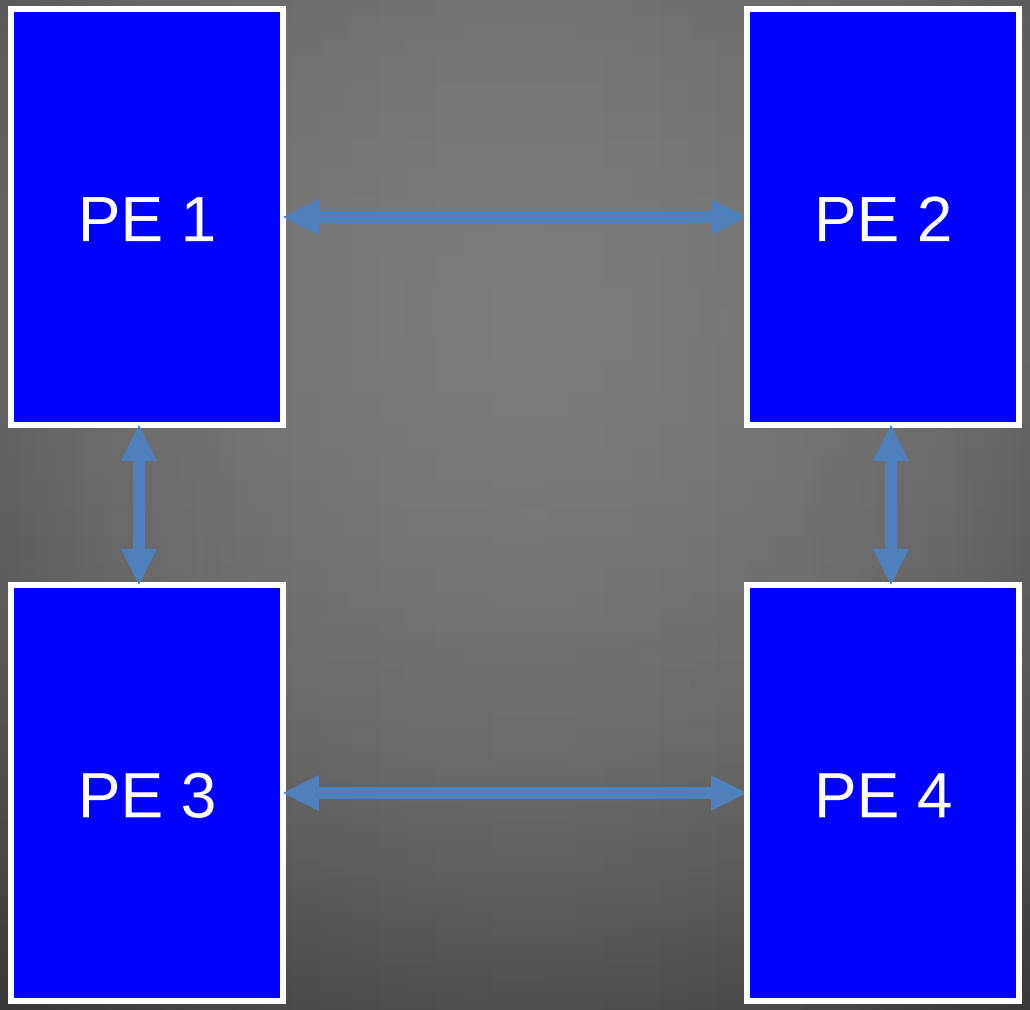
Networks



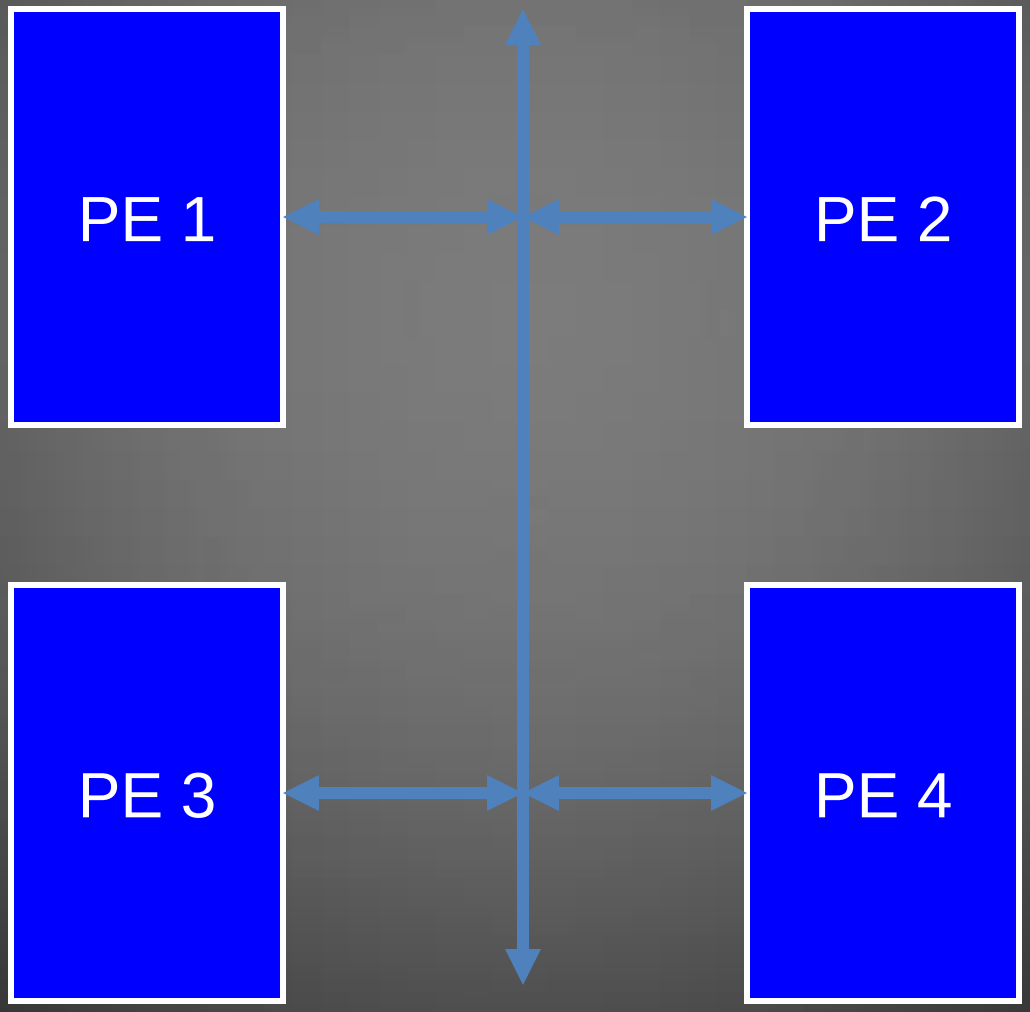
Networks



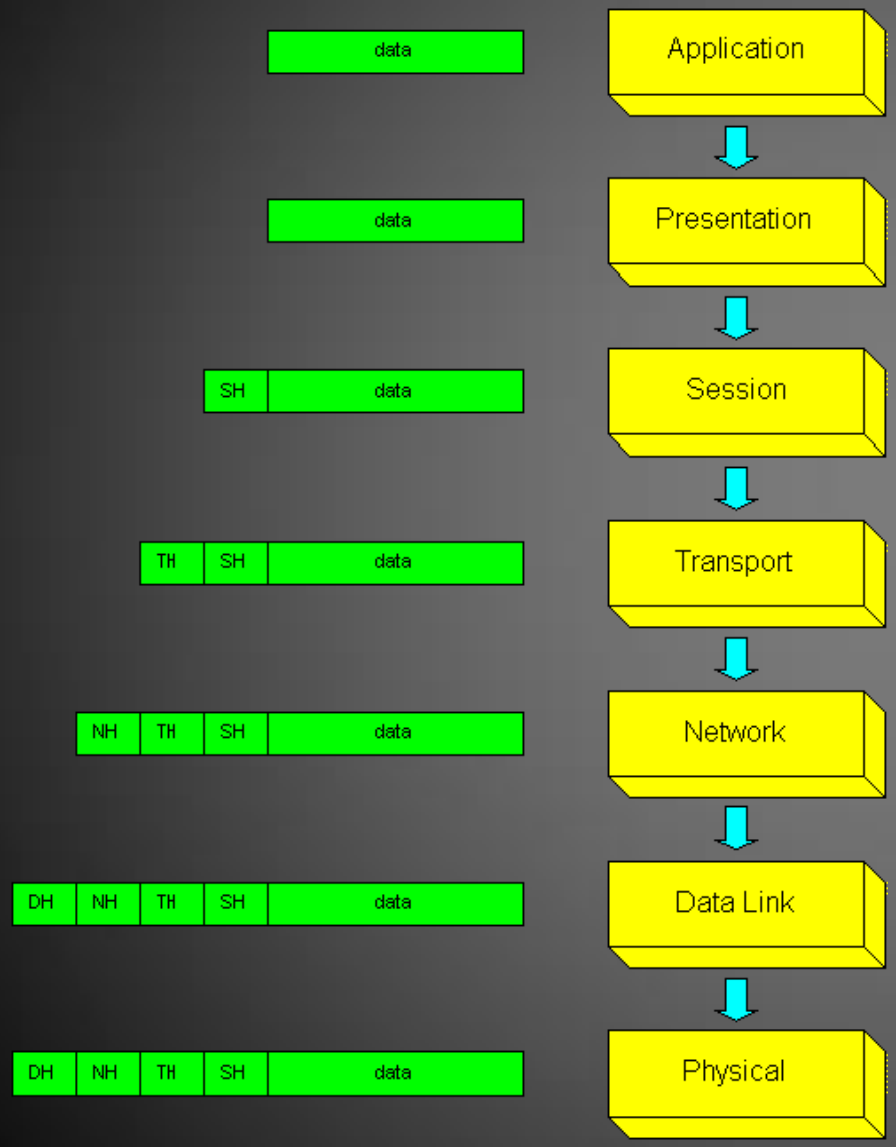
Networks



Networks

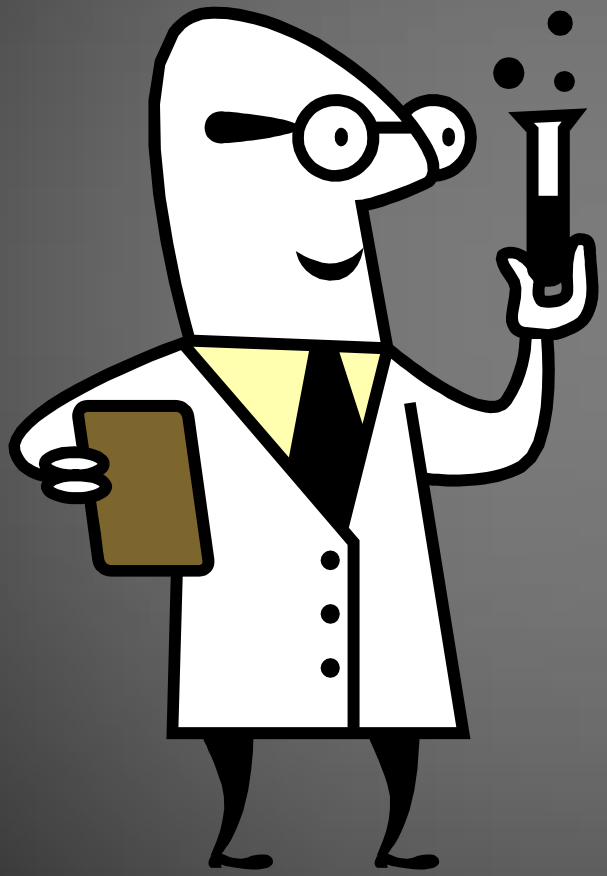


Layer Description



- Application – Uses the data.
- Presentation – Present data in a common format.
- Session – Includes some special functions (i.e., chaining). Rarely used.
- Transport – Ensures reliable communication. Handles errors, high-level fragmentation and reassembly, etc.
- Network – Allows a pair of systems to talk to each other. Route calculation, congestion control, fragmentation and reassembly, etc.
- Data Link – Transmits information across a local link. Addressing next hop, checksum calculation, coordinating shared media, etc.
- Physical – Transmits bits of information across a physical link. Deals with specific technology. Bit-level issues, such as synchronization and pin assignment.

Lab Session #10



- Design Project Presentation