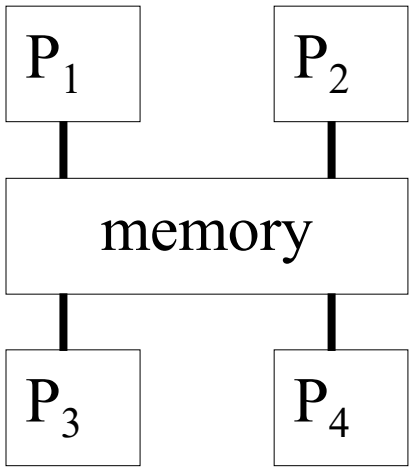
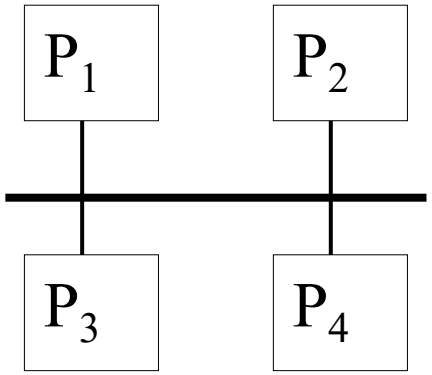
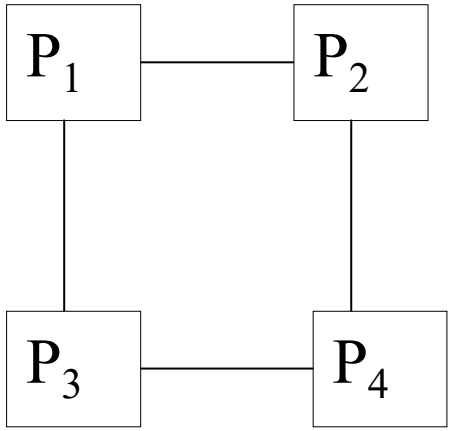
Communication

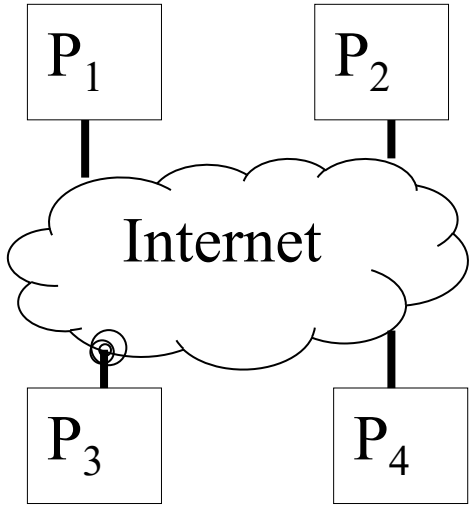
ICT 2203 Computer Architecture

Basic network architectures









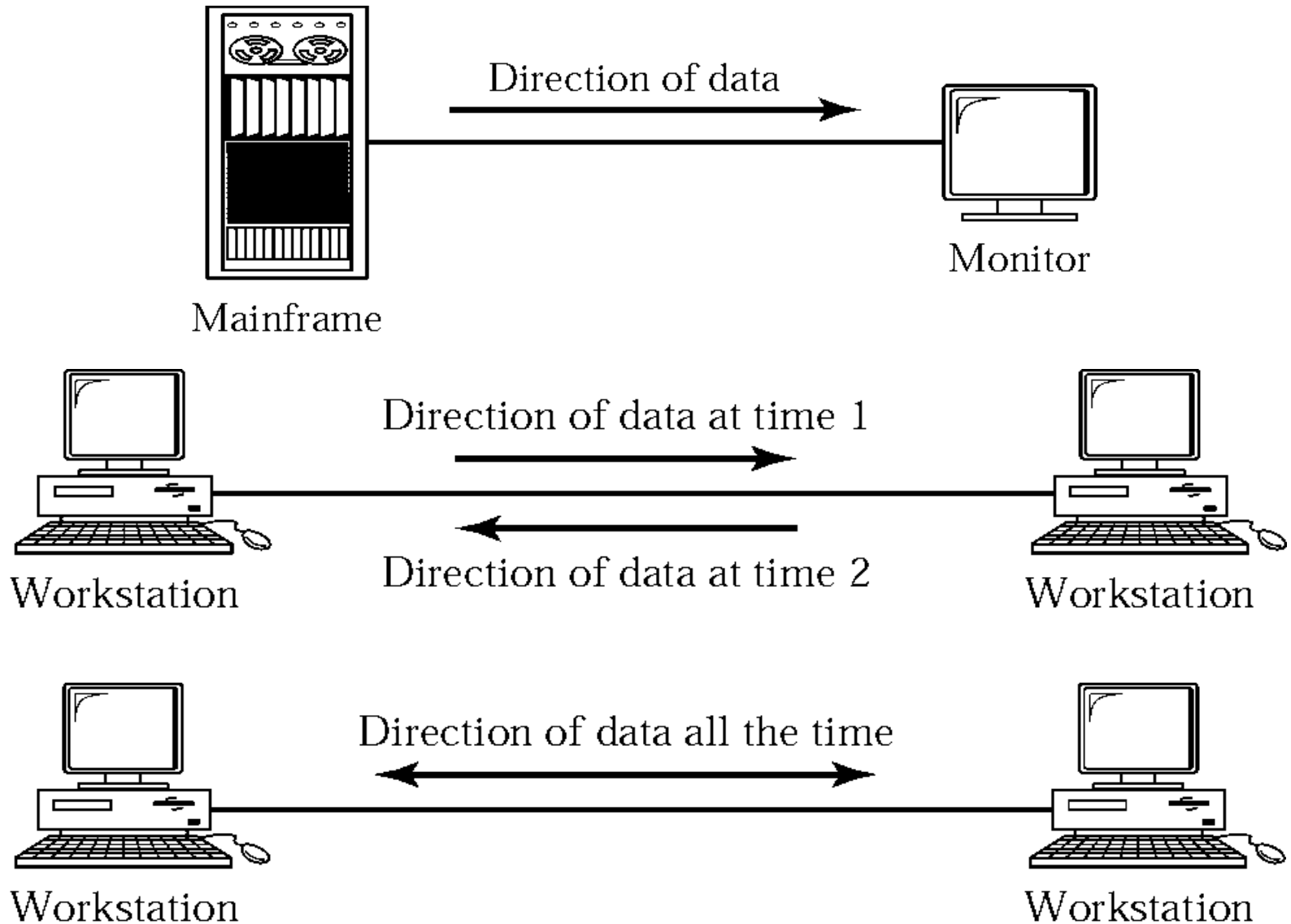
Basic network architectures

- Point-to-point networks
  - Each node connected to every node
  - Simple and reliable
  - Dedicated links make it easy to meet real-time deadlines
  - Costly due to many wires required
- Shared media networks
  - Nodes are connected via bus or other topologies
  - Less wiring and hence cheaper
  - Easily extendable by adding new nodes to network
  - Complex network protocol

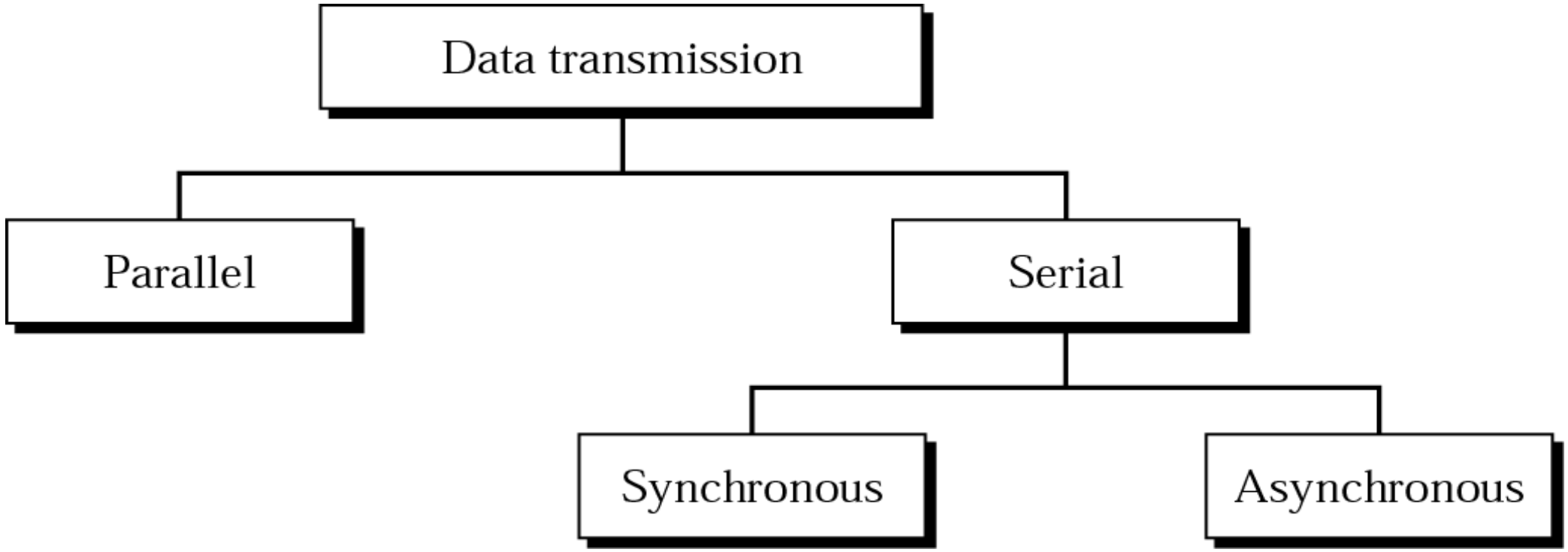
Basic communication methods

- It is essential to understand some of the basic communication methods that can be used to interconnect control systems.
- Characteristics of communication methods:
  - Simplex, Duplex & Semi Duplex
  - Serial Vs Parallel
  - Synchronous Vs Asynchronous
  - Data Throughput

Simplex, Half-duplex, Full-duplex

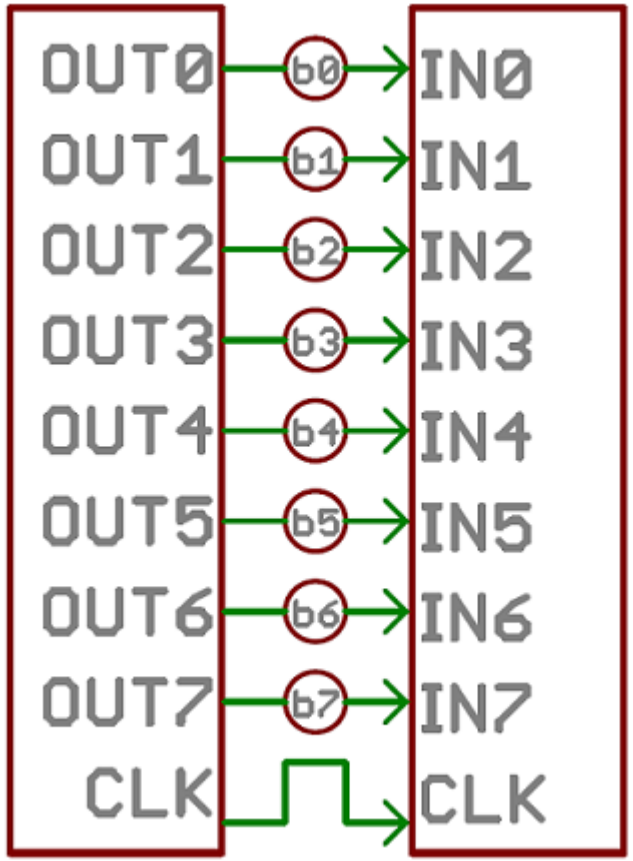


Types of data transfer



Parallel communication

- Parallel interfaces transfer multiple bits at the same time.
- They usually require buses of data - transmitting across eight, sixteen, or more wires.
- It’s fast, straightforward, and relatively easy to implement.
- But it requires many more input/output (I/O) lines.

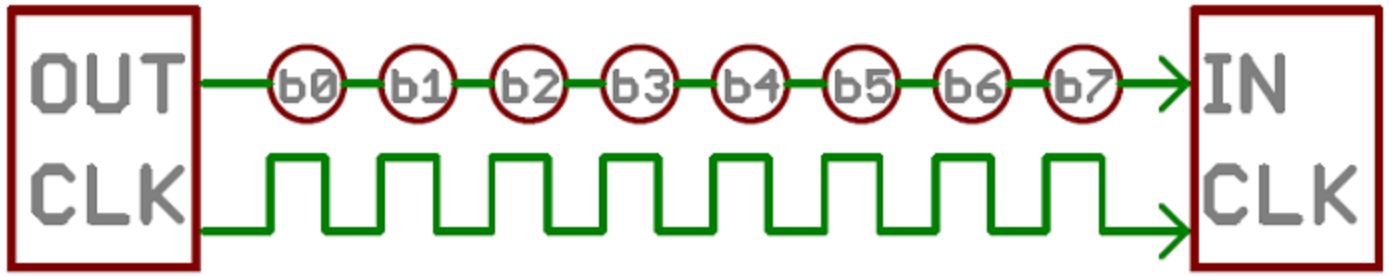


Parallel communication

- Multiple data, control, and possibly power wires
  - One bit per wire
- High data throughput with short distances
- Typically used when connecting devices on same IC or same circuit board
  - Bus must be kept short, because long parallel wires result in high capacitance values which requires more time to charge/discharge, and data misalignment between wires increases as length increases
- Higher cost, bulky

Serial Communication

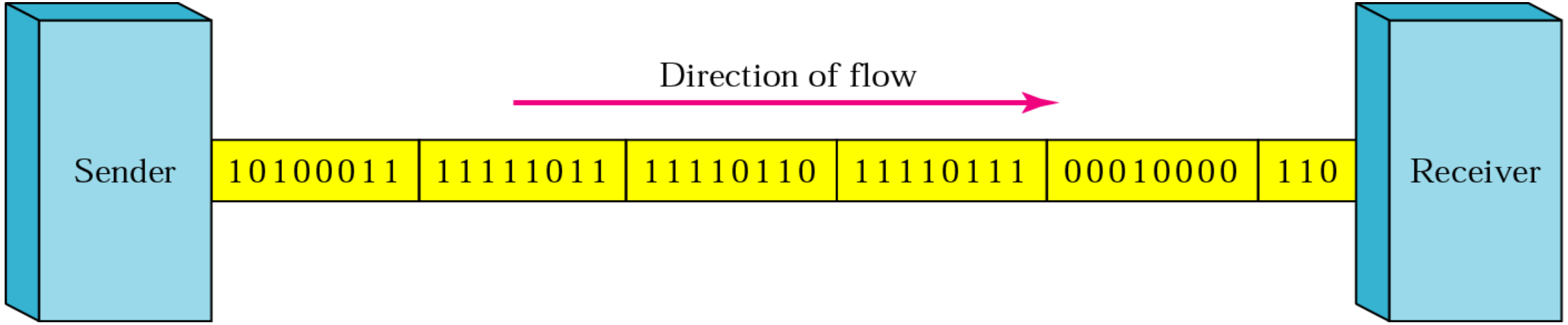
- Serial communication is the process of sending/receiving data in one bit at a time.
- Serial interfaces stream their data, one single bit at a time.
- These interfaces can operate on as little as one wire, usually never more than four.



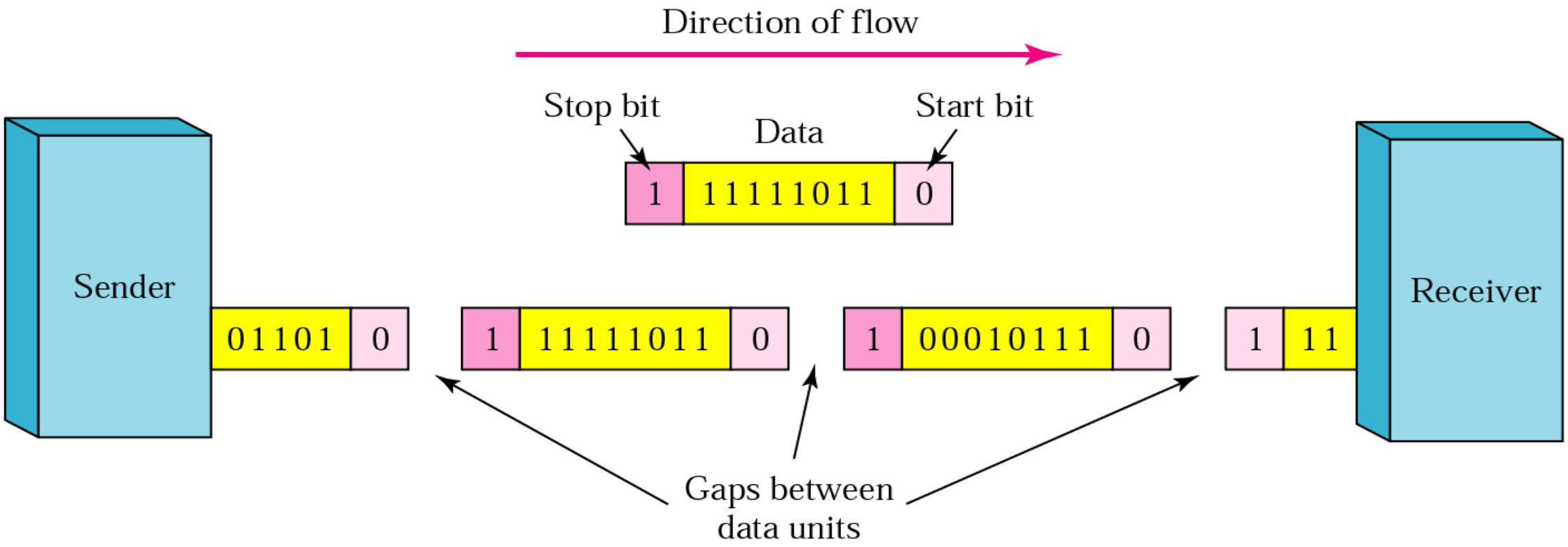
Serial communication

- Single data wire, possibly also control and power wires
- Words transmitted one bit at a time
- Higher data throughput with long distances
  - Less average capacitance, so more bits per unit of time
- Cheaper, less bulky
- More complex interfacing logic and communication protocol
  - Sender needs to decompose word into bits
  - Receiver needs to recompose bits into word
  - Control signals often sent on same wire as data increasing protocol complexity

Synchronous serial transfer



Asynchronous serial transfer



Advantages of serial over parallel

- A serial connection requires fewer interconnecting cables and hence occupies less space.
  - The extra space allows for better isolation of the channel from its surroundings.
  - Crosstalk is not a much significant issue, because there are fewer conductors in proximity.
- In many cases, serial is a better option because it is cheaper to implement.
  - Many devices and sensors relevant to control systems have serial interfaces, as opposed to parallel ones, so that they have fewer pins and are therefore less expensive.

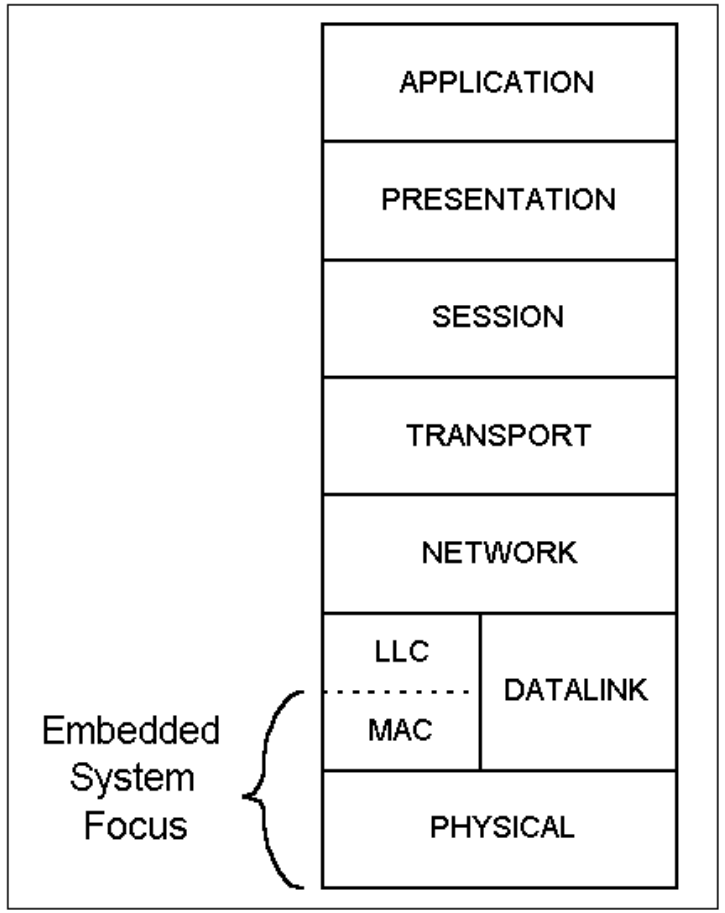
Serial communication protocols

- There are various protocols that can be used with digital control systems for serial communication.
  - UART (Universal Asynchronous Receiver/Transmitter)
  - SPI (Serial Peripheral Interface)
  - I2C (Inter-Integrated Circuits)
  - CAN (Controller Area Network)
  - USB (Universal Serial Bus)
  - 1-wire
- https://www.deviceplus.com/how-tos/arduino-guide/arduino-communication-protocols-tutorial/
- https://www.embedded.com/design/connectivity/4023975/Serial-Protocols-Compared

Advanced communication principles

- Layering
  - Break complexity of communication protocol into pieces easier to design and understand
  - Lower levels provide services to higher level
    - Lower level might work with bits while higher level might work with packets of data
  - Physical layer
    - Lowest level in hierarchy
    - Medium to carry data from one actor (device or node) to another
- Parallel communication
  - Physical layer capable of transporting multiple bits of data
- Serial communication
  - Physical layer transports one bit of data at a time
- Wireless communication
  - No physical connection needed for transport at physical layer

Open System Interconnection



- Intended for computers
- Designed to solve compatibility problem
- Layers provide standard interface and services
- Embedded systems use some standardisation ideas
- Higher layers require lower layers to work

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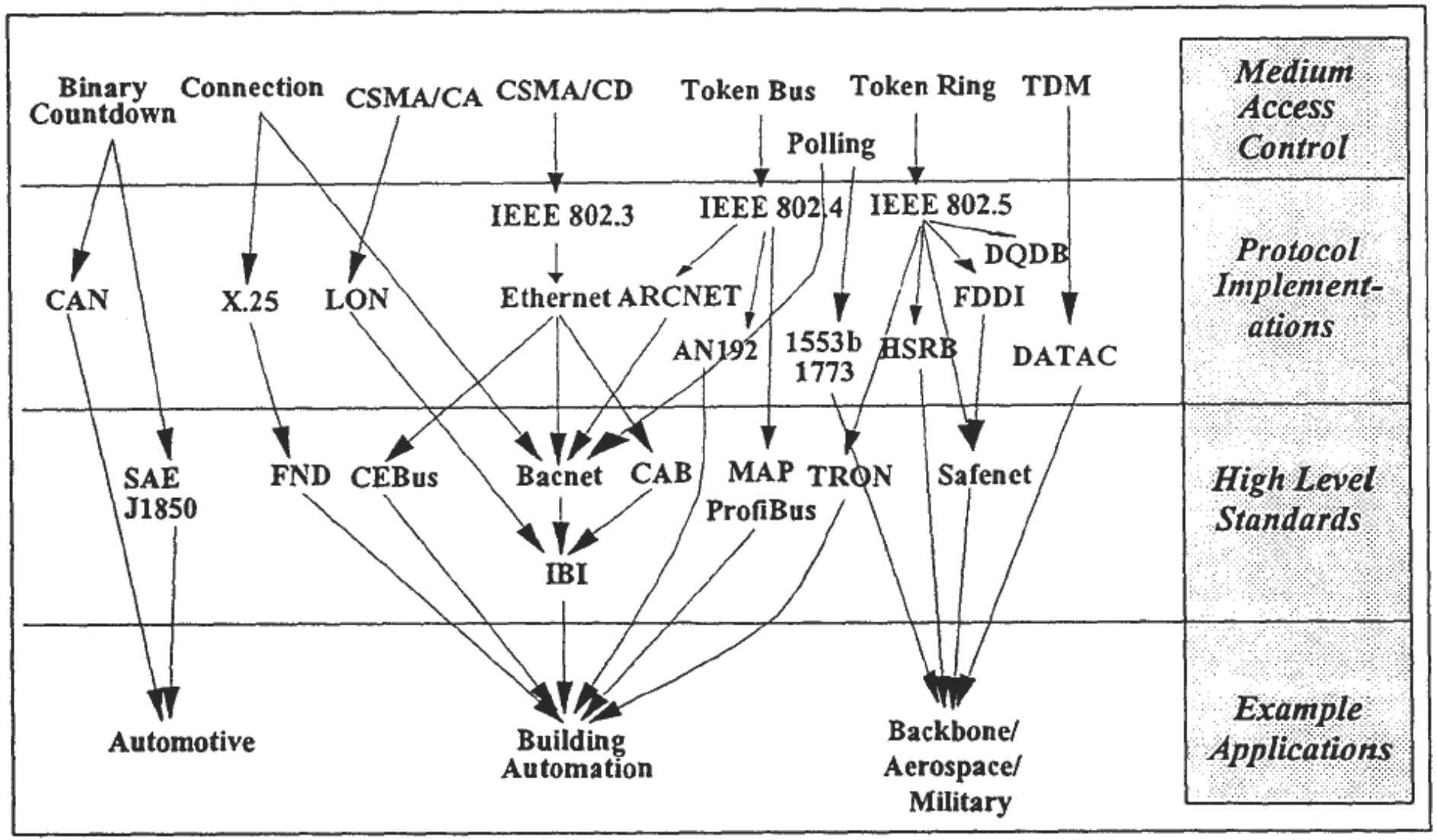
Wireless communication

- Infrared (IR)
  - Electronic wave frequencies just below visible light spectrum
  - Diode emits infrared light to generate signal
  - Infrared transistor detects signal, conducts when exposed to infrared light
  - Cheap to build
  - Need line of sight, limited range
- Radio frequency (RF)
  - Electromagnetic wave frequencies in radio spectrum
  - Analog circuitry and antenna needed on both sides of transmission
  - Line of sight not needed, transmitter power determines range

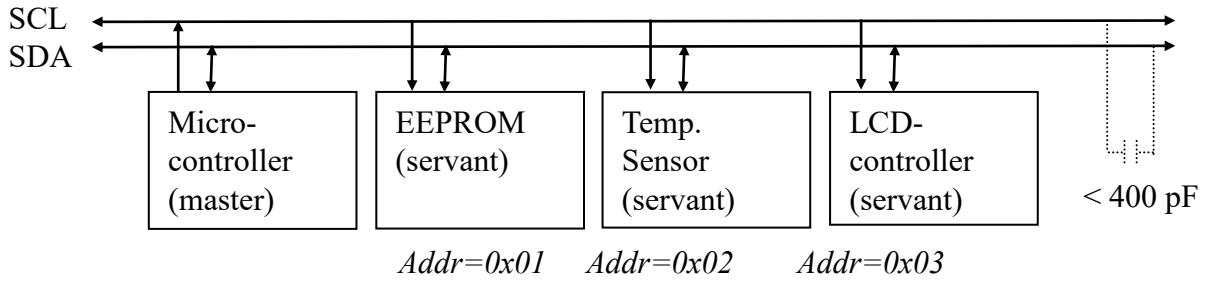
Communication protocols

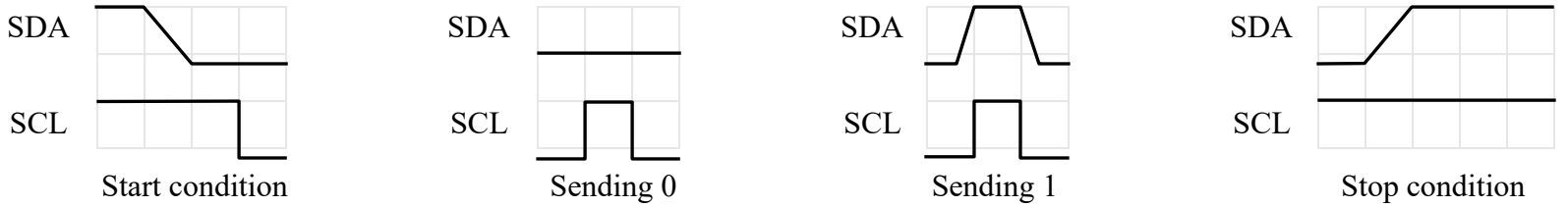


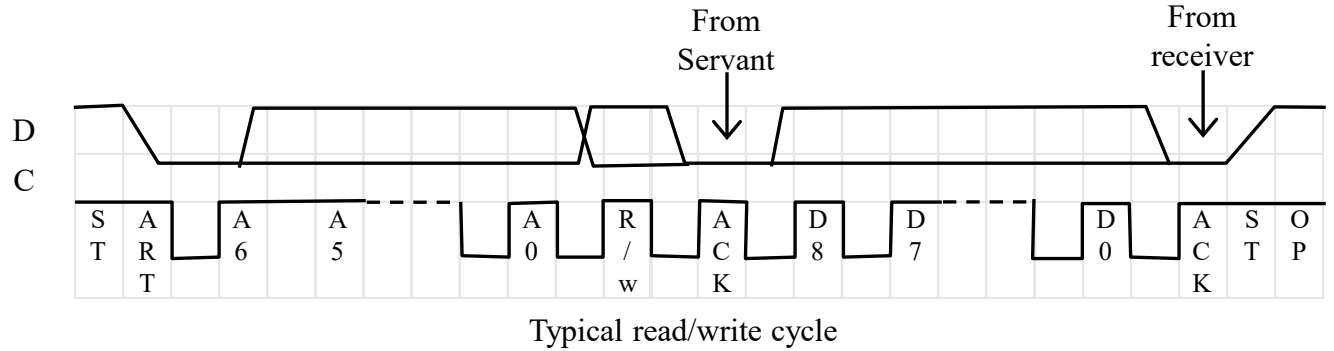
Serial protocols: I^2C

- I^2C
  - Two-wire serial bus protocol developed by Philips Semiconductors nearly 20 years ago
  - Enables peripheral ICs to communicate using simple communication hardware
  - Data transfer rates up to 100 kbits/s and 7-bit addressing possible in normal mode
  - 3.4 Mbits/s and 10-bit addressing in fast-mode
  - Common devices capable of interfacing to I^2C bus:
    - EPROMS, Flash, and some RAM memory, real-time clocks, watchdog timers, and microcontrollers

I²C bus structure







Typical read/write cycle

Serial protocols: CAN

- Controller Area Network
- Protocol for real-time applications
- Originally for communication among components of cars
  - developed by Robert Bosch GmbH
- Applications now using CAN include:
  - elevator controllers, copiers, telescopes, production-line control systems, and medical instruments
- Data transfer rates up to 1 Mbit/s and 11-bit addressing
- Common devices interfacing with CAN:
  - 8051-compatible 8592 processor and standalone CAN controllers

Serial protocols: USB

- USB (Universal Serial Bus)
  - Easier connection between PC and monitors, printers, digital speakers, modems, scanners, digital cameras, joysticks, multimedia game equipment
  - 2 data rates:
    - 12 Mbps for increased bandwidth devices
    - 1.5 Mbps for lower-speed devices (joysticks, game pads)
  - Tiered star topology can be used
    - One USB device (hub) connected to PC
      - hub can be embedded in devices like monitor, printer, or keyboard or can be standalone
    - Multiple USB devices can be connected to hub
    - Up to 127 devices can be connected like this
  - USB host controller
    - Manages and controls bandwidth and driver software required by each peripheral
    - Dynamically allocates power downstream according to devices connected/disconnected

Parallel protocols: PCI Bus

- Peripheral Component Interconnect (PCI) Bus
- High performance bus originated at Intel in the early 1990's
- Standard adopted by industry and administered by PCISIG (PCI Special Interest Group)
- Interconnects chips, expansion boards, processor memory subsystems
- Data transfer rates of 127.2 to 508.6 Mbits/s and 32-bit addressing
  - Later extended to 64-bit while maintaining compatibility with 32-bit schemes
- Synchronous bus architecture
- Multiplexed data/address lines

Parallel protocols: ARM Bus

- Designed and used internally by ARM Corporation
- Interfaces with ARM line of processors
- Many IC design companies have own bus protocol
- Data transfer rate is a function of clock speed
  - If clock speed of bus is X, transfer rate = 16 x X bits/s
- 32-bit addressing

Wireless protocols: IrDA

- Protocol suite that supports short-range point-to-point infrared data transmission
- Created and promoted by the Infrared Data Association (IrDA)
- Data transfer rate of 9.6 kbps and 4 Mbps
- IrDA hardware deployed in notebook computers, printers, PDAs, digital cameras, public phones, cell phones
- Supported on popular embedded OS's

Wireless protocols: Bluetooth

- Based on low-cost, short-range radio link
- Connection established when within 10 meters of each other
- No line-of-sight required
- New, global standard for wireless connectivity
- Bluetooth was invented in 1994 by Ericsson.

Wireless Protocols: IEEE 802.11

- Standard for wireless LANs
- Specifies parameters for PHY and MAC layers of network
- PHY layer - physical layer
  - handles transmission of data between nodes
  - provisions for data transfer rates of 1 or 2 Mbps
  - operates in 2.4 to 2.4835 GHz frequency band (RF)
  - or 300 to 428,000 GHz (IR)
- MAC layer - medium access control layer
  - protocol responsible for maintaining order in shared medium
  - collision avoidance/detection

Next:

Instruction Set Architecture