Lecture 2.c

Networking 1
Physical and Link Layers

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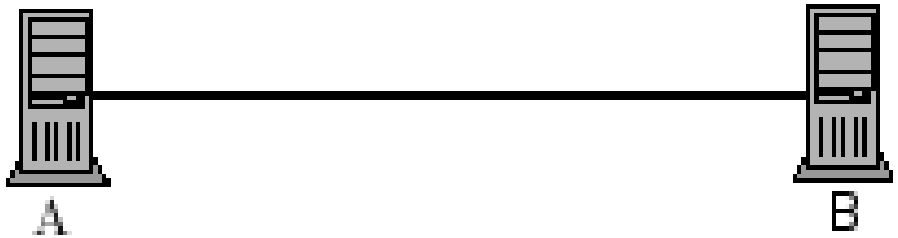
The Physical Layer

- The lowest layer of our protocol stack is the Physical Layer
- This layer is concerned with actually placing data onto a physical connection.

The Physical Layer (Example)

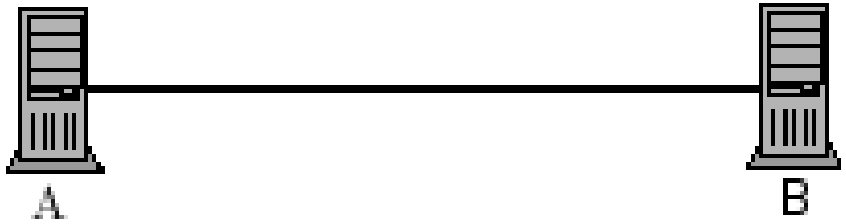
- The simplest network configuration we can have is two machines connected by a communication channel.
- We shall assume that this is a single piece of cable.

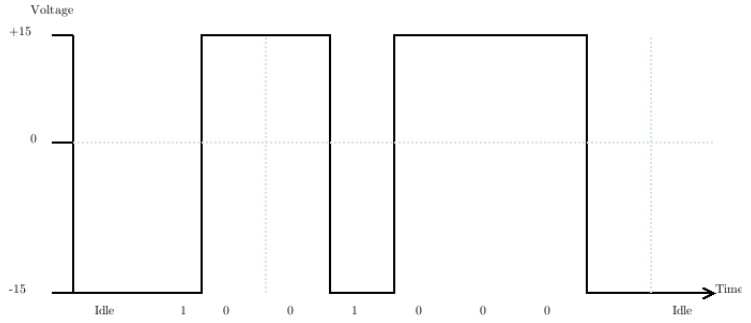


- The task is to allow machine A to send the message “Hello B" to machine B.
- The issues are:
  - Encoding
  - Synchronisation
  - Transmission Speed

The Link Layer

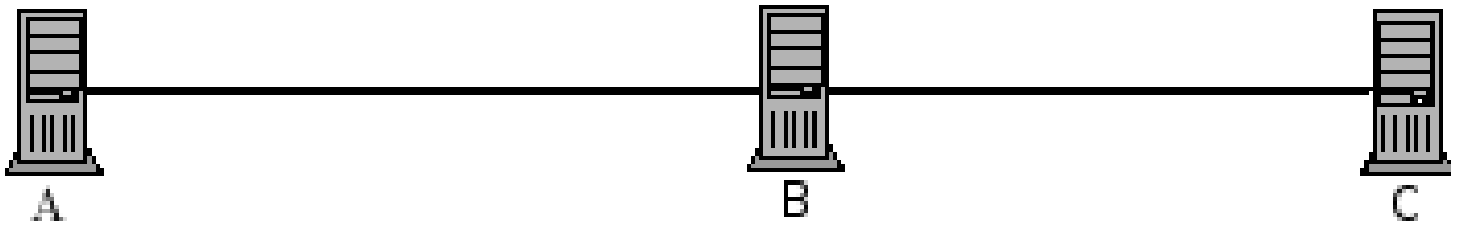
- We have already looked at the simple network configuration where we have two machines connected by a communication channel.
- We used a simple protocol like RS-232 to send character data between one machine and the other





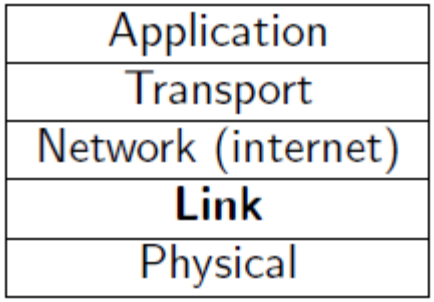
What if we are more than two ?

- However, what are the issues we have to deal with when we add more computers to the scenario?
- Consider a small office with three machines: How does machine A communicate with Machine C when machine B is in the way?



The link layer

- Concerned with achieving reliable, efficient communication between adjacent machines
- Adjacent: Machines are physically connected by a communications channel.
- We do not care about details of physical channel this is the business of the physical layer
- Reliable: Try to detect and correct errors
- Efficient: Try to achieve maximum use of the communication channel



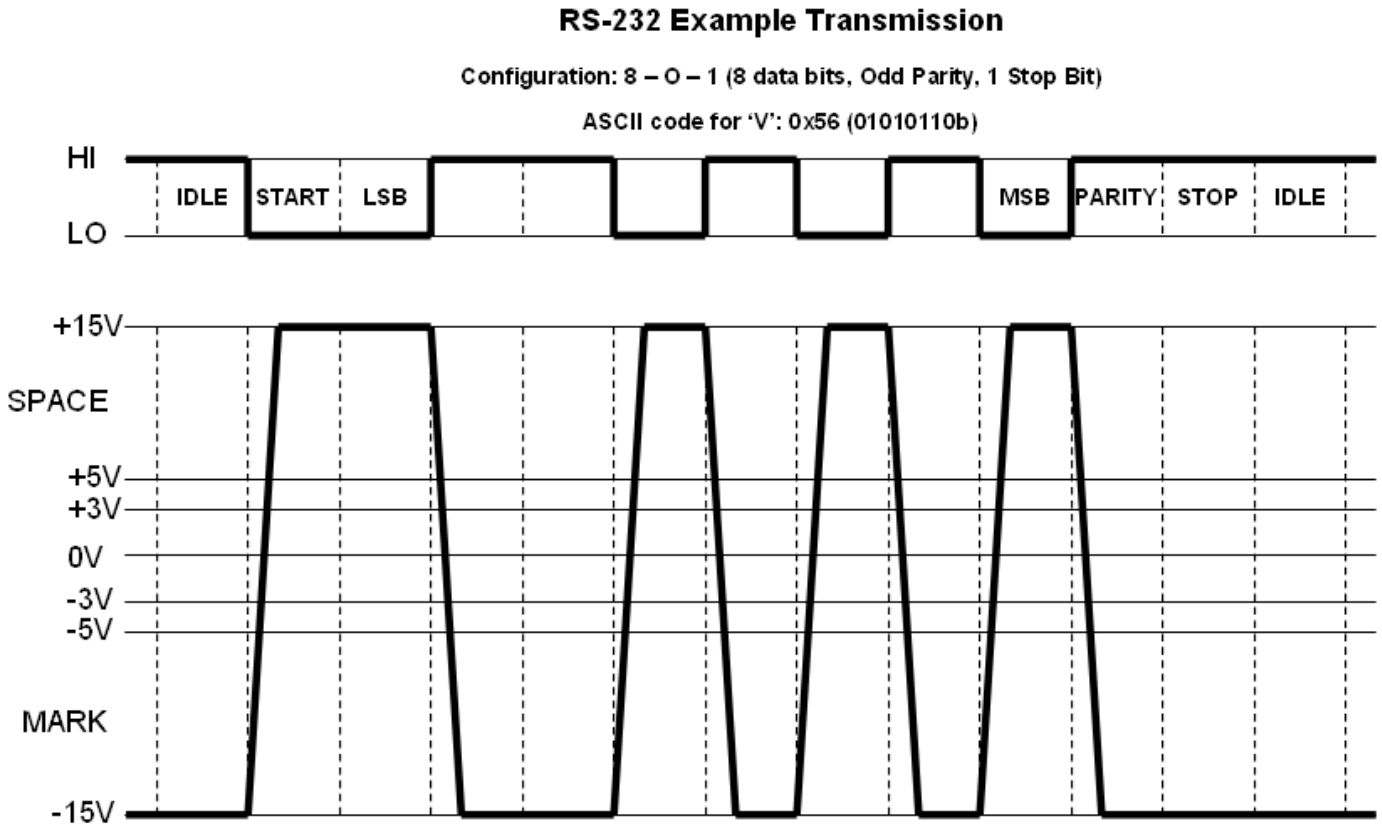
Packets and Checksums

- Remember that at the physical layer data is sent as a continuous bit stream.
  - Not guaranteed to be error free
  - The number of bits received by the destination machine may be less than or more than those sent
- Link layer breaks continuous data stream up into packets of bits (called Frames):
  - We can perform computations on the data in a packet to determine whether it is the same as the one that was sent
  - The checksum is sent with every frame and can be queried to see if errors have occurred

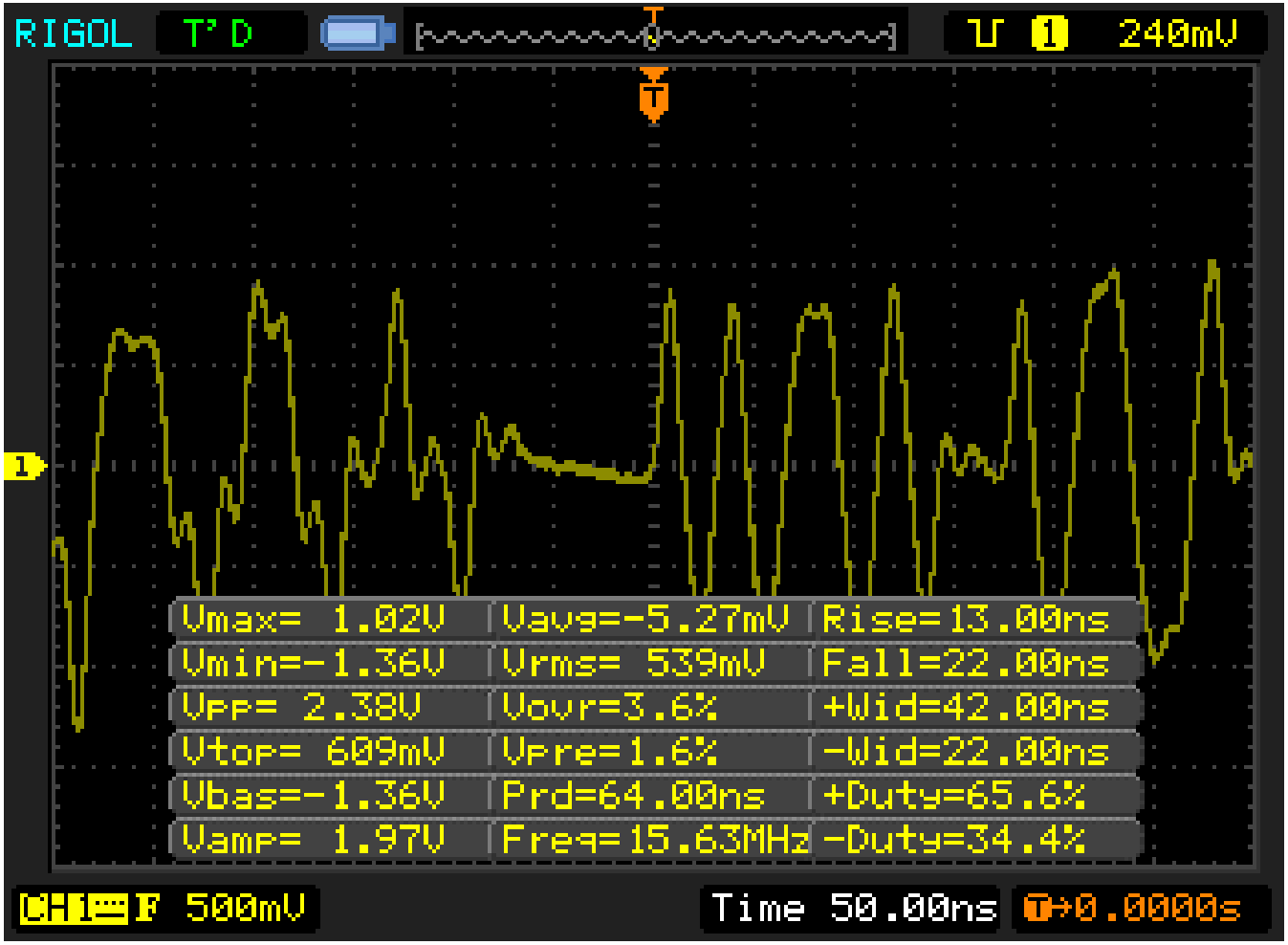
Error Detection

- A very simple error detection scheme is the use of a parity bit. We will append a single extra bit to the end of a data packet for this. Even parity works like this:
  - Sender sets the parity bit to 0 or 1 which ever will make the total number of 1 bits (including the parity bit) an even number.
  - If the number of 1 bits in the data packet is even, append parity bit set to 0
  - If the number of 1 bits in the data packet is odd, append parity bit set to 1
- Examples:
  - Original data packet: 0100101
  - Number of ones is odd so append 1 parity bit - to make it even.
  - Data packet with parity bit: 01001011
- Original data packet: 1110010
  - Number of ones is even so append 0 parity bit -to keep it even.
  - Data packet with parity bit: 11100100

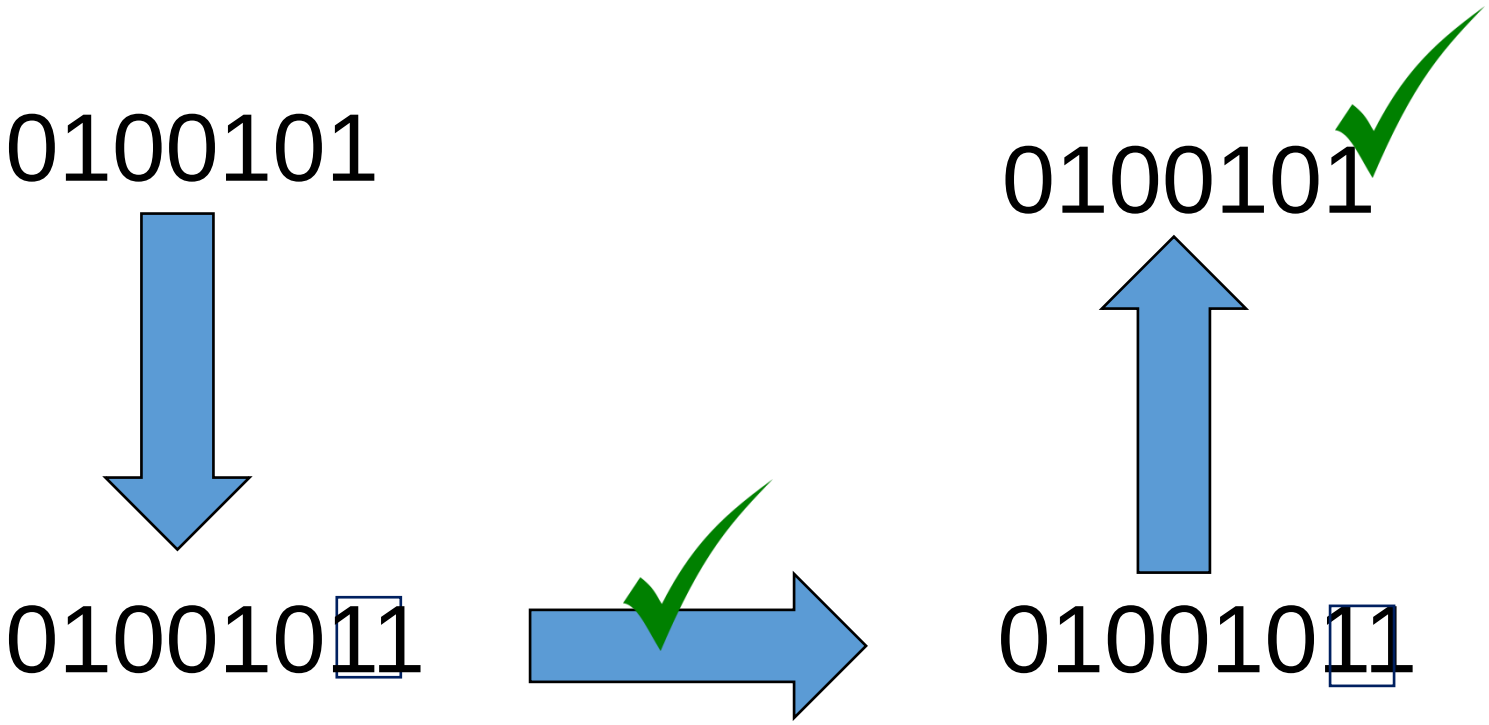
Why Errors ?


RS-232 Example Transmission
Configuration: 8 – O – 1 (8 data bits, Odd Parity, 1 Stop Bit)
ASCII code for 'V': 0x56 (01010110b)
HI
LO
IDLE
START
LSB
MSB
PARITY
STOP
IDLE
+15V
SPACE
+5V
+3V
0V
-3V
-5V
MARK
-15V

Why Errors ?

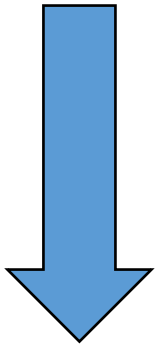

RIGOL
T' D
240mV
Vmax= 1.02V
Vavg=-5.27mV
Rise=13.00ns
Vmin=-1.36V
Vrms= 539mV
Fall=22.00ns
Vpp= 2.38V
Vovr=3.6%
+Wid=42.00ns
Vtop= 609mV
Vpre=1.6%
-Wid=22.00ns
Vbas=-1.36V
Prd=64.00ns
+Duty=65.6%
Vamp= 1.97V
Freq=15.63MHz
-Duty=34.4%
CH1 F 500mV
Time 50.00ns
T→0.0000s

Error Detection – All is ok !



Error Detection – Error !

0100101



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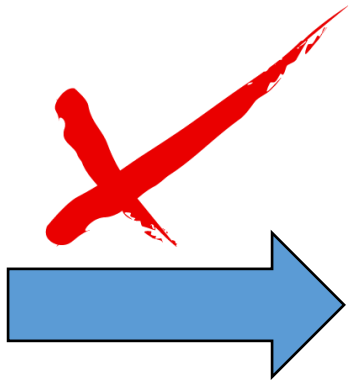

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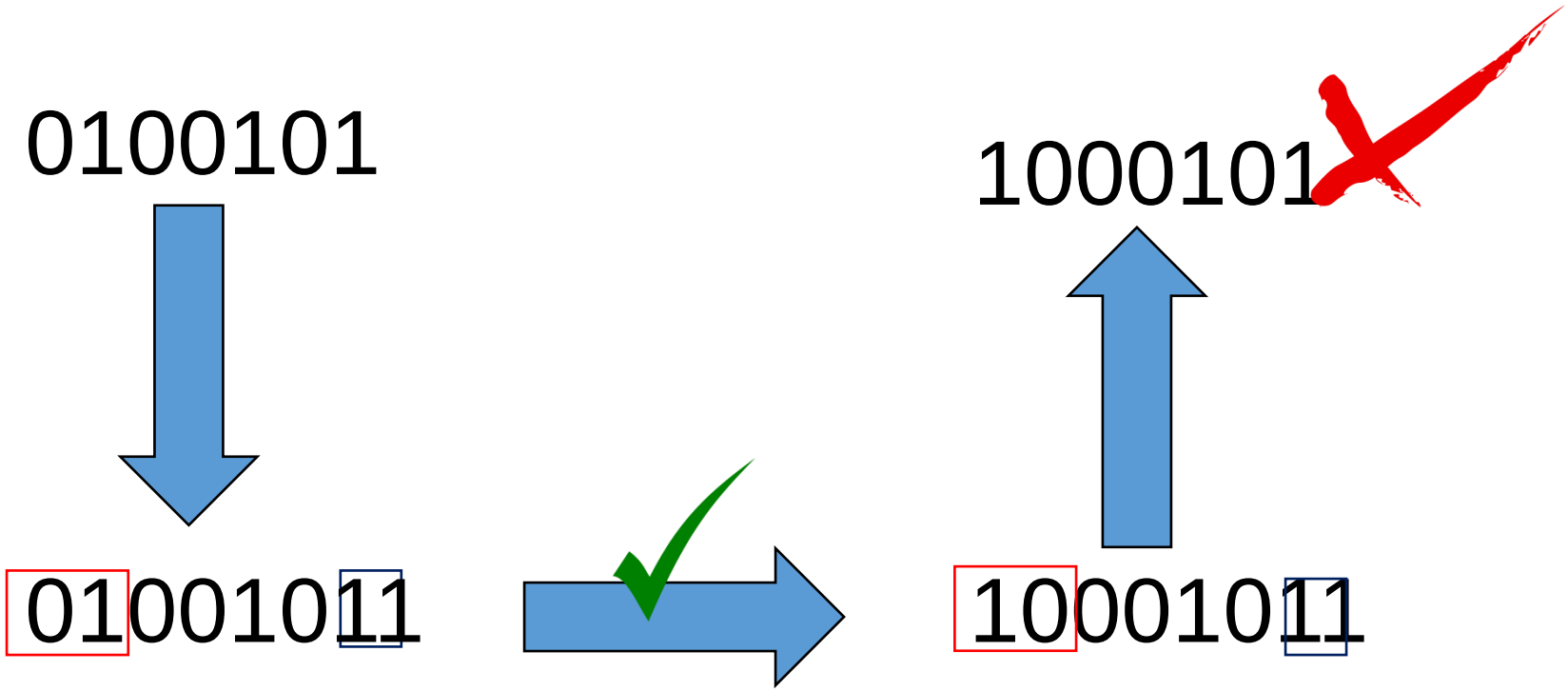
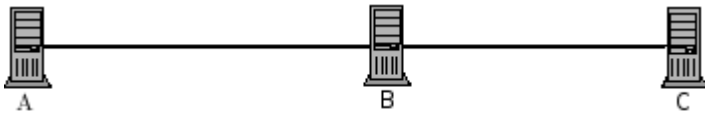
Error Detection – All is ok !
Is it really ?



Multiple Machines

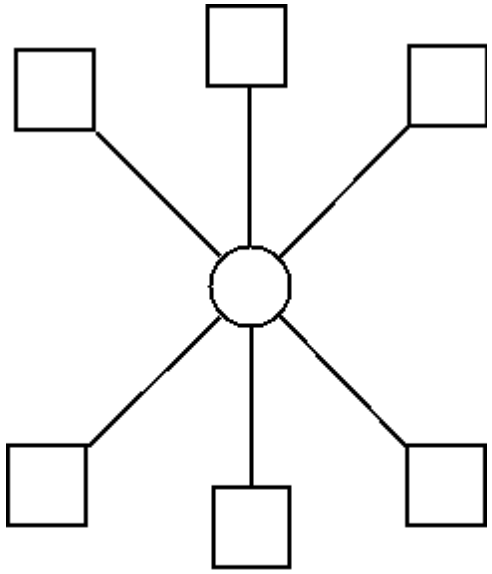
- We have a single communication channel shared by all connected machines
  - How do the machines share the channel without interfering with each other?
    - If they send at the same time their messages will interfere with each other
    - How do they make the best use of the channel bandwidth
  - How do the machines address each other?
    - Each machine is going to need a unique address
    - Each machine is going to need to know the address of the other machines



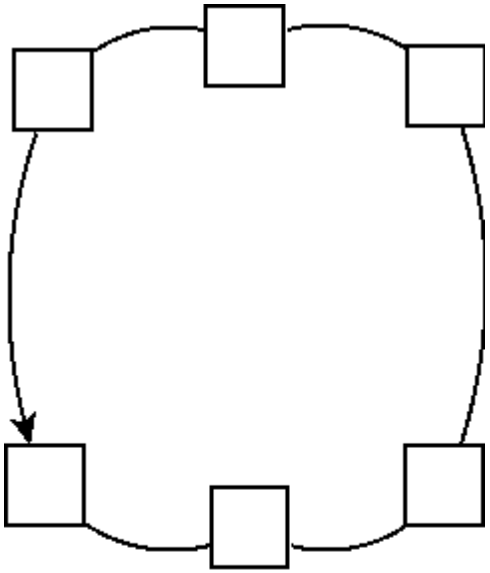
Local Area Networks

- These issues need to be addressed in Local Area Networks (LANS)
- LAN Key features:
  - Computers linked together in close proximity (There will be a physical limit to the total length of the LAN
  - High throughput
  - Relatively low cost
  - Relies on a shared communication channel
- We can class LANs by shape (“Topology"). Here are the three most popular:

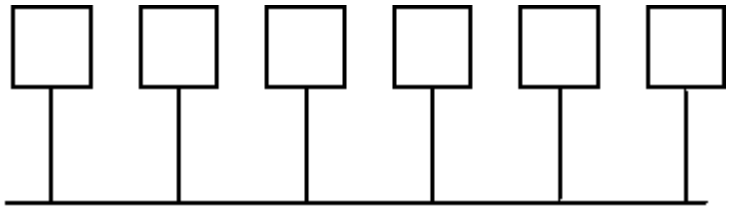
Topologies



Star



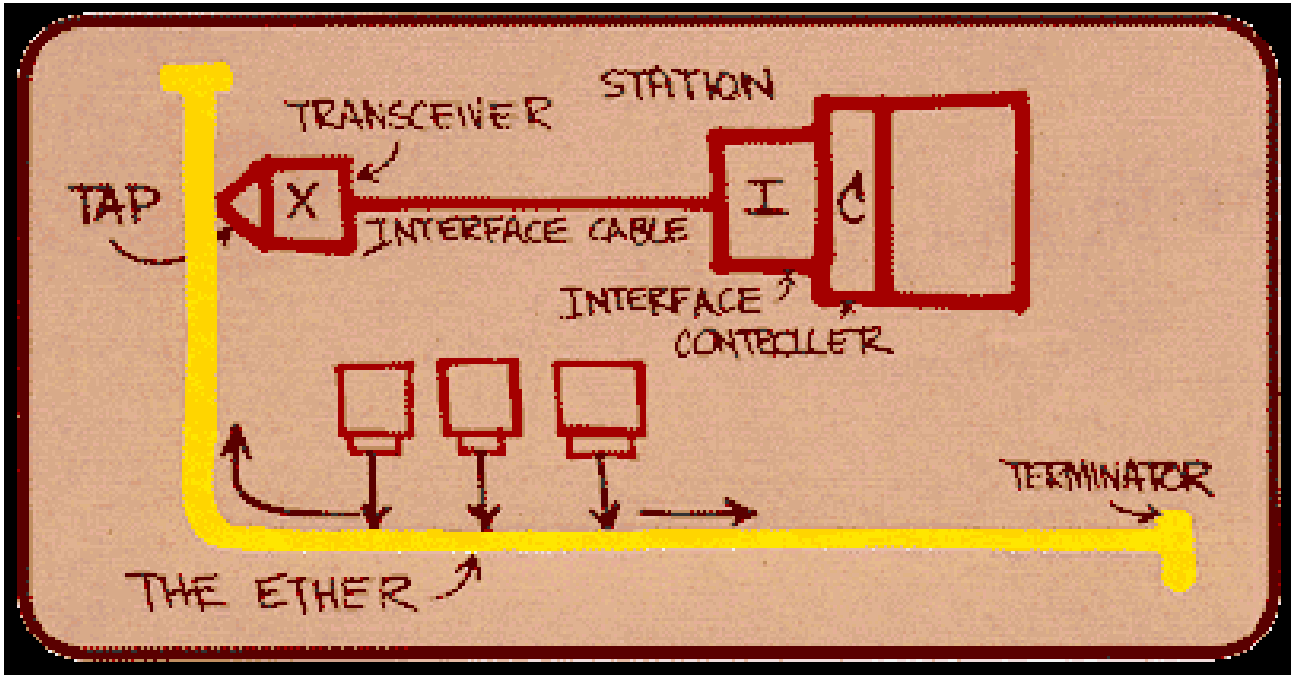
Ring



Bus

Ethernet

- The most popular LAN technology today. It can have a bus topology or a star topology.
- The first Ethernet was outlined Bob Metcalfe (Xerox PARC) in the 1970s it had a bus shape



Basic Concepts

- One computer transmits at a time
- Signal propagates from transmitter in both directions along the length of cable
- Every message is broadcast on the shared medium: Every attached computer receives the signal, only the one to which it is addressed will reply.

Multiple Access Problem

- Computers on the Ethernet do not synchronize their messages sending times. At any time several computers may have messages to send yet they do not negotiate who can send first
- Yet only one machine at a time can have the use of the channel
- If more than one machine uses the channel simultaneously one or more message collisions occur
- Essentially this means that each message is contaminated with noise (from the colliding message). Colliding messages are entirely useless!

Ethernet Big Idea

- The defining idea behind Ethernet is to allow computers share a single communication channel without interfering with each other
- We require a distributed algorithm that determines how stations share channel i.e., determine when a station can transmit
- Conundrum: Communication about channel sharing must use channel itself!
- How to resolve this?

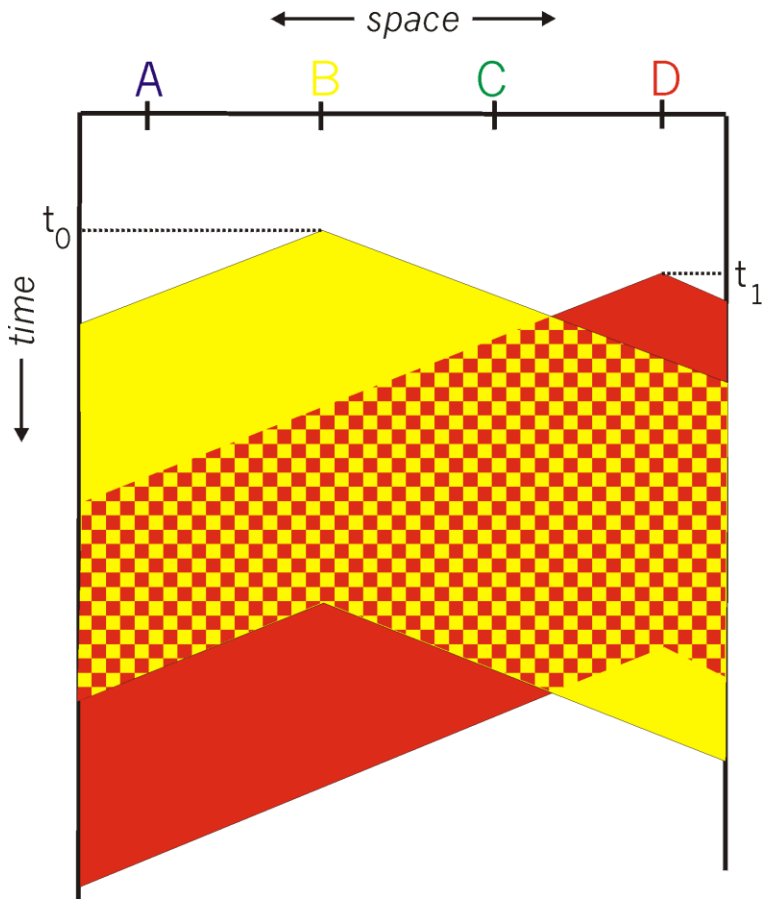
CSMA - Carrier Sense on Multiple Access networks

- CSMA:
  - Distributed coordination scheme
  - Uses electrical activity on the channel to determine status of channel (busy or not)
- The basic idea is to listen before transmitting:
  - If channel sensed idle: transmit entire frame
  - If channel sensed busy, defer transmission
- Non-persistent CSMA: retry after random interval
- Human analogy: be polite, do not interrupt.

Carrier Sensing

- The length of the cable is vitally important here
- An electrical signal takes time to travel from one point to another – propagation delay. If the cable is very long then the propagation delay from one end of the cable to the other may be considerable.
- What does this mean?
- Well, it means that a machine at one end of the cable may transmit a signal thinking the cable is free
- In fact the signal sent by another machine may just not have reached it yet
- When a collision occurs what happens?
- Even while sensing the channel collisions can still occur: propagation delay means two nodes may not hear each other's transmission

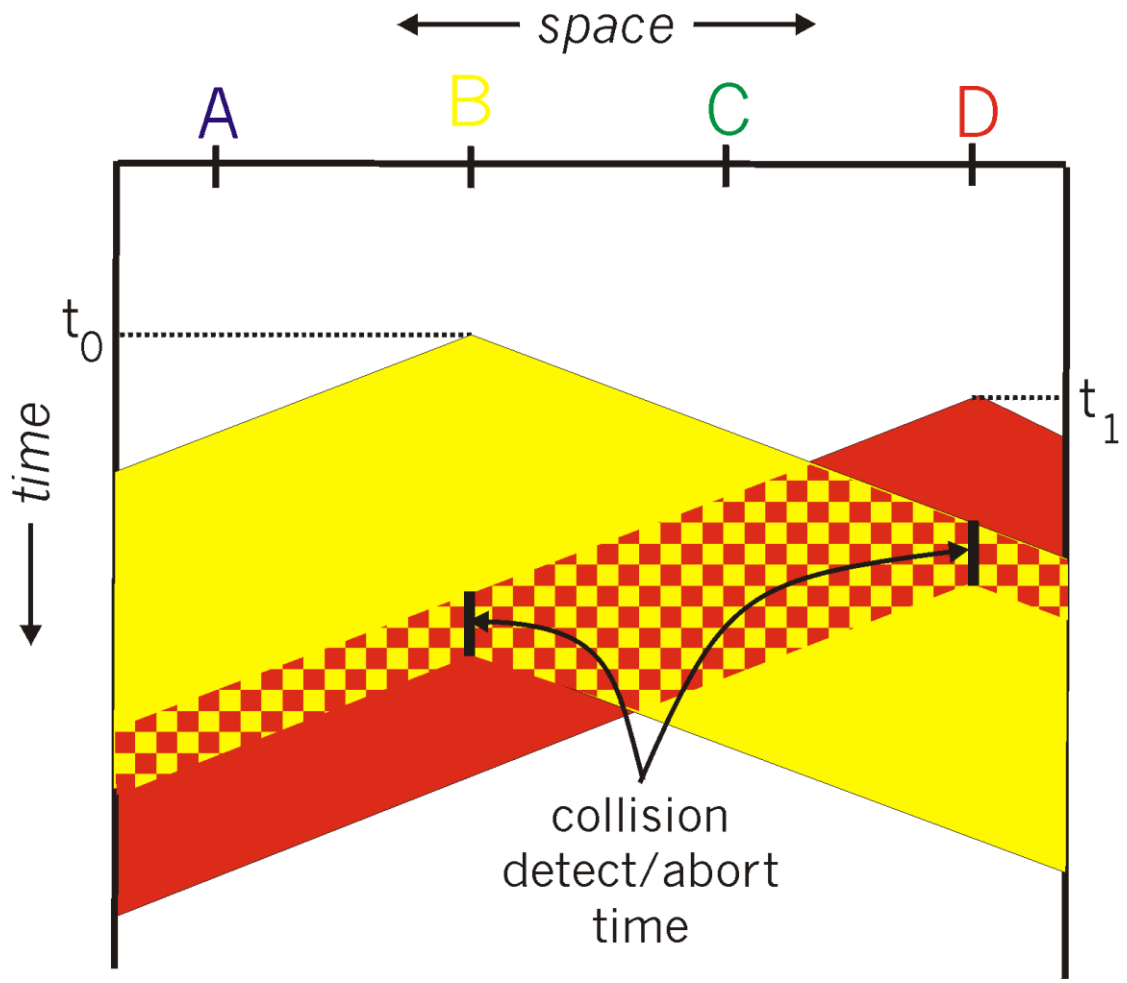
Collision



Collision Detection

- CSMA with collision detection (CD):
  - key idea listen for collisions while talking (easy in wired LANs: measure signal strengths, compare transmitted, received signals)
  - immediately abort transmission when a collision is detected (therefore channel wastage reduced)
- Wait random time before attempting to re-send
- Worst case time to detect a collision?
- 2 times propagation delay (well explain why in a moment)
- Performance depends (as in CSMA) on channel length

CSMA Collision Detection



Carrier Sensing

- Performance will depend on channel length
  - Large propagation delays: poor performance (High probability that someone else is transmitting)
- Length of Ethernet must be limited. The Ethernet standard species:
  - A maximum cable size
  - A minimum spacing between connections
  - A minimum frame size

Ethernet Packet

- The Ethernet protocol operates at the LINK layer of our protocol stack.
- To be accurate, we should refer to these packets as FRAMES
  - The data part of the frame encapsulates the packet from the network layer
  - Destination address: address of machine that should receive this message
  - Source address: address of sending machine

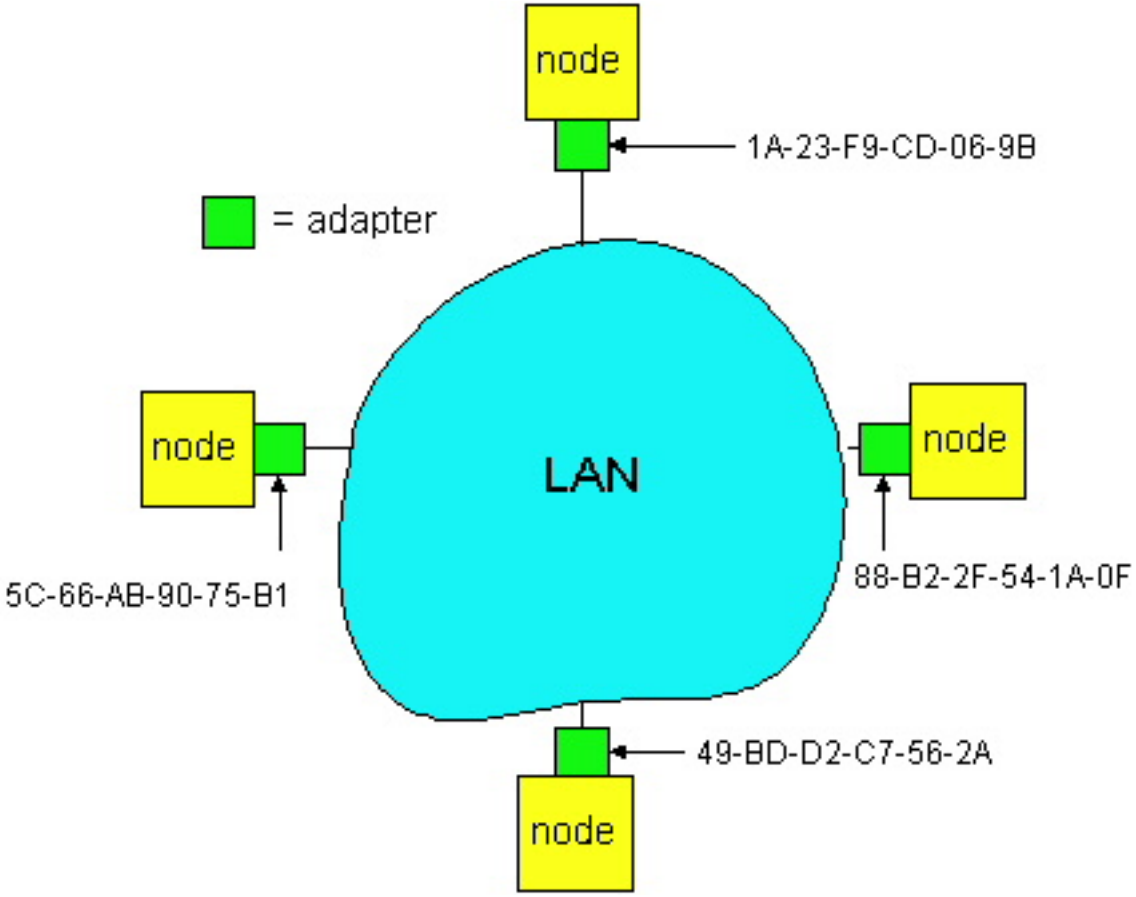
Preamble	Dest. Address	Source Type	Frame	Data in Frame	CRC
8	6	6	2	46–1500	4

Addressing

- We know that Ethernet is a broadcast protocol
  - All the network cards on the cable get a copy of the message
  - Only the network card to whom the message is addressed replies
- What type of addressing are we talking about?
- LAN Addresses and ARP: LAN { also known as the MAC (Media Access Controller), Ethernet or physical { address:
  - Used to get a frame from one machine to another physically-connected machine (same network)
  - 48 bit MAC address (for most LANs)
  - physically burned in to the network card ROM
- These are different from IP addresses you may have heard about well discuss these later on

LAN Addresses and ARP

- Each network card on LAN has unique LAN address:



LAN Addresses

- LAN address allocation administered by IEEE
- Network card manufacturer buys portion of LAN address space (to ensure uniqueness)
- Analogy:
  - LAN address: like a social security number
  - IP address: like postal address
- LAN at address => portability (can move LAN card from one LAN to another)
- IP hierarchical address NOT portable (depends on network to which one attaches)

Address Resolution Protocol

- Every machine on the Ethernet has a table of addresses
- These addresses relate IP addresses (which we will see next week) to LAN addresses
- These are constantly being updated by means of ARP messages
- ARP messages are means by which machines tell each other their address information

IP Address	LAN address	Time To Live
222.222.222.222	49-BD-D2-C7-56-2A	11.43:00
222.222.222.221	88-B2-2F-54-1A-0F	12.54:00