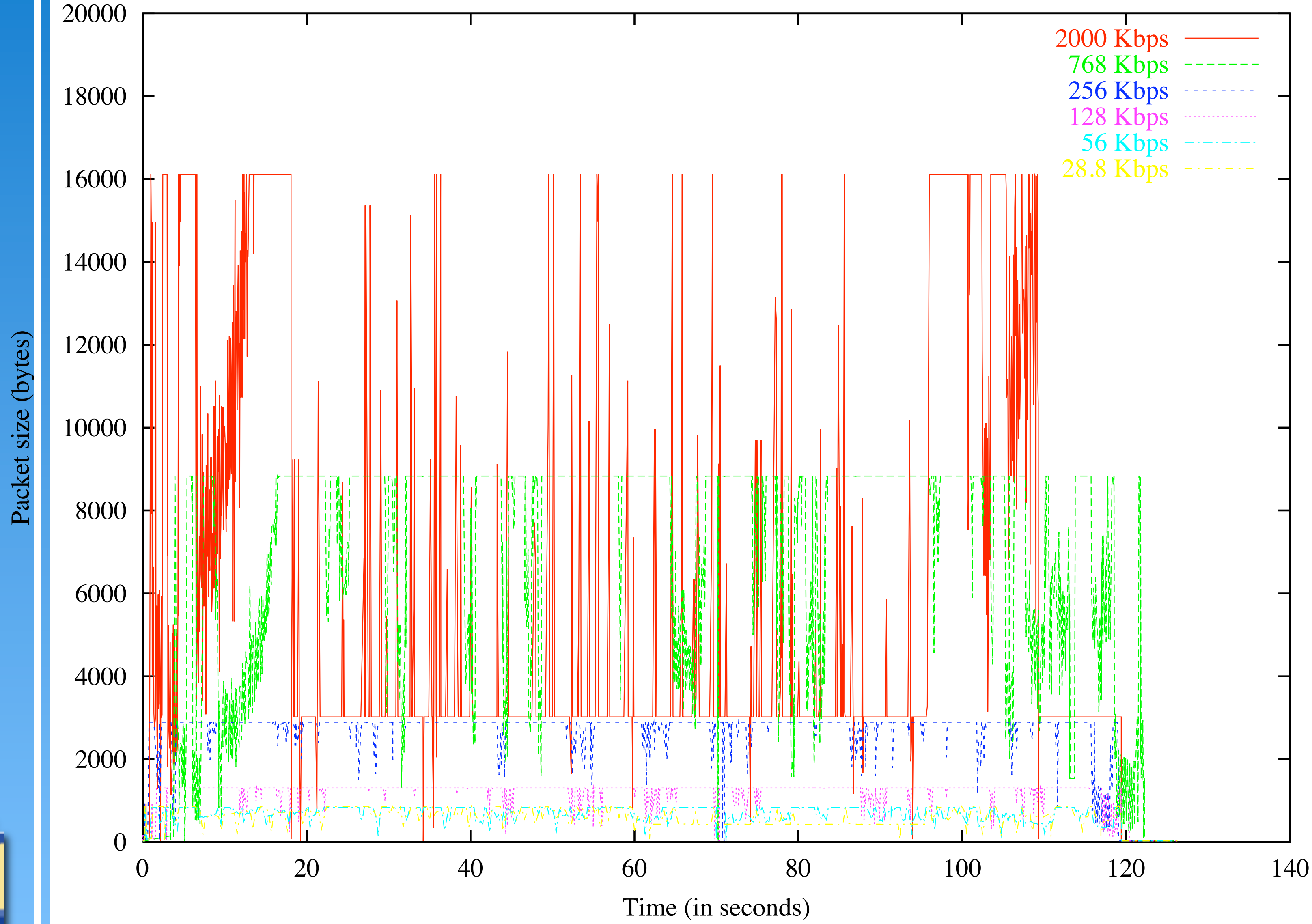
Networks strive for fairness

- Assuming we want to support 'n' network flows over a network link of capacity 'm'
  - Approach 1: reserve equally, say n/m per flow or proportional to flow requirements
    - Wasteful if flow doesn't use a particular allocation
      - Sharing can help customers even though ISP get paid
  - Approach 2: Best effort
    - Each flow can be aggressive and pump as much as they possibly can. Network will experience congestion and drop packets. You will get the best of what can be supported
    - Each flow can be "nice". One form of niceness is TCP friendly. TCP internally probes the network bandwidth using additive increase multiplicative decrease (AIMD) scheme. It increases the amount of data slowly in additive fashion till it experiences congestion (packet drop). At that point, it drops quickly and tries again to calculate the bottle neck bandwidth in a distributed fashion

Multimedia traffic

- Isochronous traffic: somewhere between synchronous (constant traffic) and asynchronous (unpredictable). Sort of predictable, sort of bursty
  - Peak burst not necessarily equal to the network capacity (unlike for file transfer application which can use as much bandwidth as you can throw at it).
  - Traffic bursty and will interact with TCP traffic that are competing for resources
  -

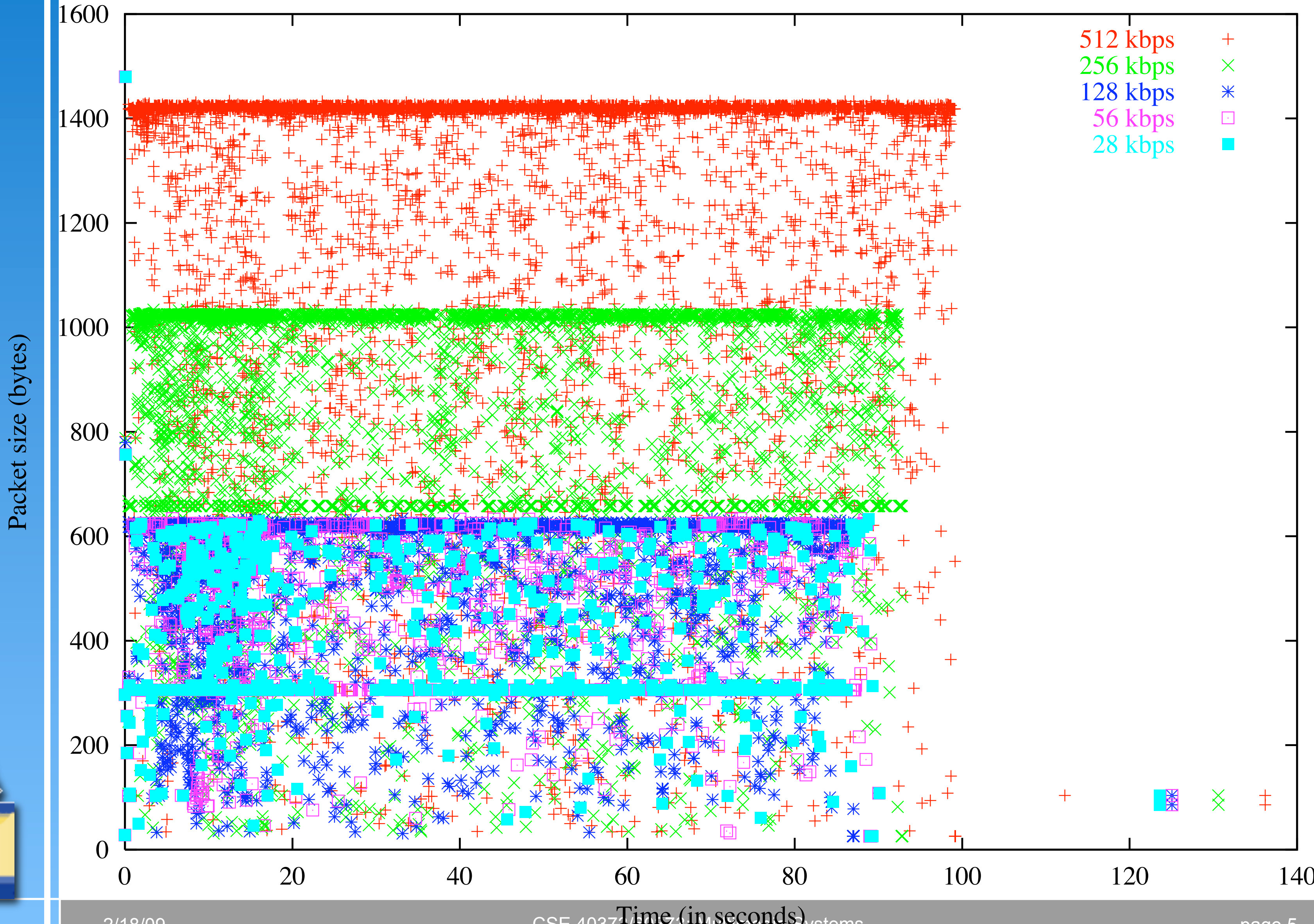
Microsoft media for various networks



Microsoft Media

- Packets arrive at fairly regular intervals
- Large packets (up to 16 KB): Uses network fragmentation
  - Losing one fragment loses the entire packet
  - Fragments arrive back to back
    - can assist adaptation policy
- Lossy network - adapts to a low quality stream
  - fragmentation makes this effect worse

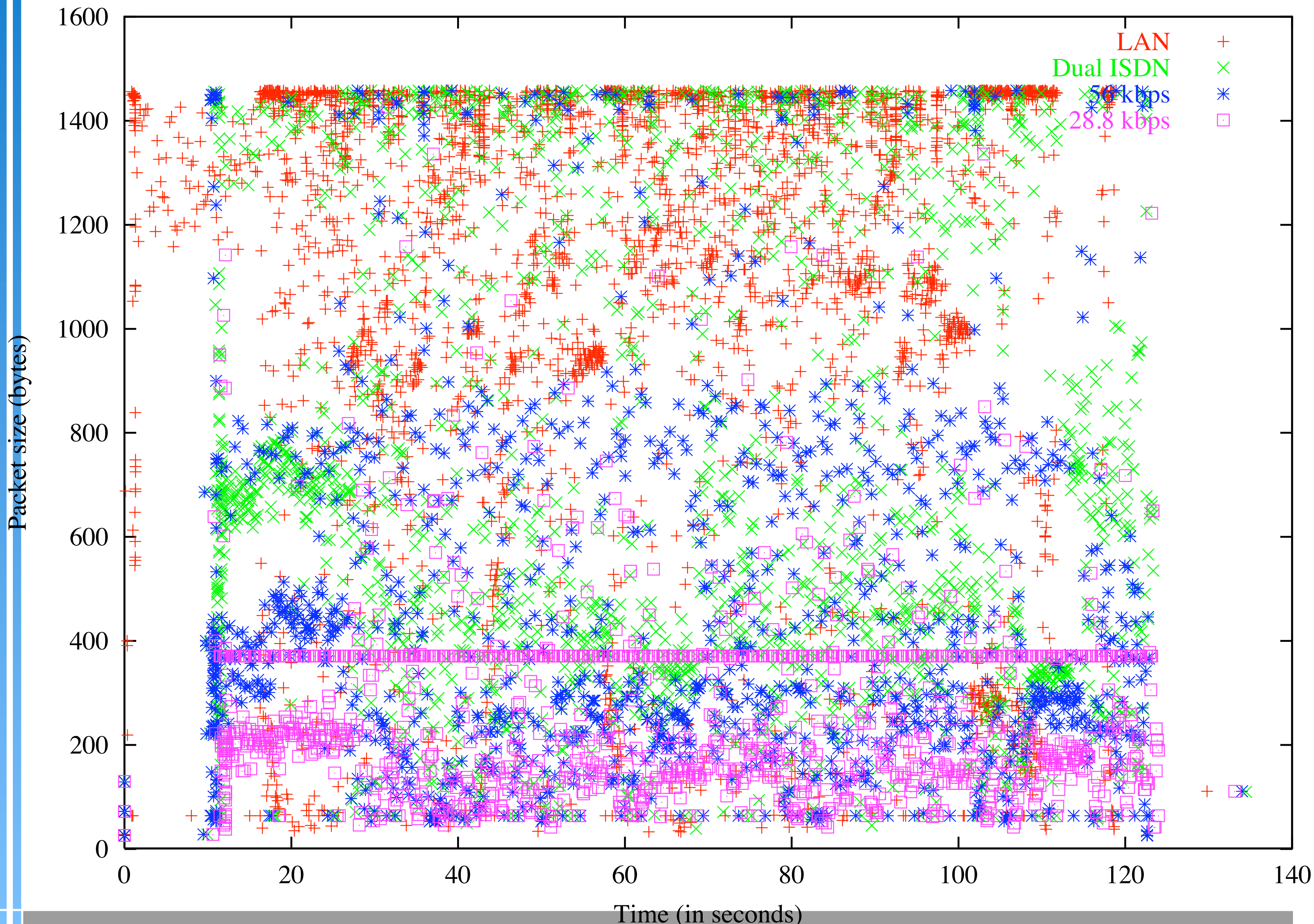
Real video for various networks



Real

- Variable packet size (50-1500 bytes)
  - Packet arrivals almost regular
  - Packets sent closer to each other
- Packet size less than MTU
  - No network level fragmentation
- Lossy networks - lower quality video

Quicktime video for various networks



Quicktime

- Variable packet size
  - Packets sent in “clusters” – burst and extended idle
    - Application level fragmentation?
- Packet size less than MTU
  - No network fragmentation
- Lossy networks – lower quality video

Networking technologies - wired

- Ethernet: modern Ethernet 100 Mbps or 1 Gbps
  - Switched, full duplex and so no congestion
  - No notion of bandwidth reservation
  - Network is bounded by the packet processing duration, small packets require more per packet overhead (not amortized over the size of the packet)

Network technologies

- ATM – allows for bandwidth reservation. ISPs love technology but for the most part, relegated to fringe networks.
- Wide area networks
  - Iptv topology – courtesy **Misha Rabinovich @CWRU**

Wireless - broadband

- 3G wireless – higher bandwidth, clients use bandwidth allocated by cellular provider, no competition
- WiMAX – broadband metro area broadband

Wireless LANs

- IEEE 802.11
  - Bandwidth: 1 or 2 Mbps
  - 802.11b - 11 Mbps (2.4 GHz)
  - 802.11g - 54 Mbps (2.4 GHz)
  - 802.11a - 54 Mbps (5 GHz)
  - 802.11n – up to 300 Mbps
- Physical Media
  - spread spectrum radio (2.4 GHz)
  - diffused infrared (10 m)

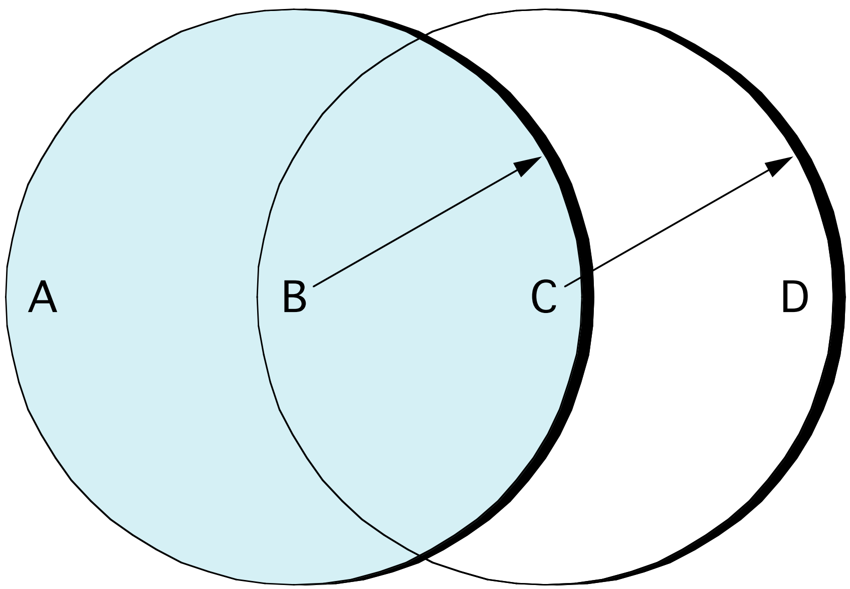
- Wireless LAN
- irDA
- Bluetooth

Spread Spectrum

- Idea
  - spread signal over wider frequency band than required
  - originally designed to thwart jamming
- Frequency Hopping
  - transmit over random sequence of frequencies
  - sender and receiver share…
    - pseudorandom number generator
    - seed
  - 802.11 uses 79 x 1MHz-wide frequency bands

Collisions Avoidance

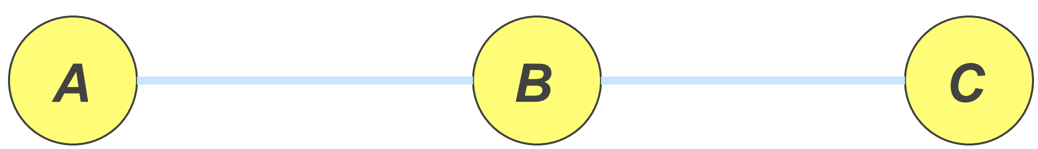
- Similar to Ethernet - CSMA
- Problem: hidden and exposed nodes



Hidden Terminal Problem

- Node B can communicate with A and C both
- A and C cannot hear each other

- When A transmits to B, C cannot detect the transmission using the *carrier sense* mechanism
- If C transmits, collision will occur at node B



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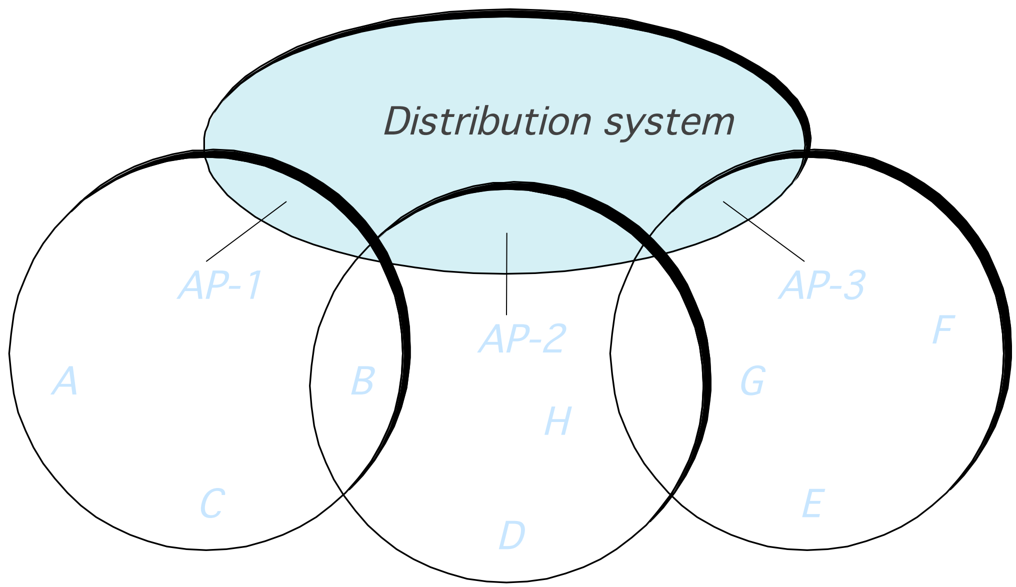
Supporting Mobility

- Case 1: ad hoc networking
- Case 2: access points (AP)
  - tethered
  - each mobile node associates with an AP



Challenges

- Limited wireless transmission range
- Broadcast nature of the wireless medium
  - Hidden terminal problem
- Packet losses due to transmission errors
- Mobility-induced route changes
- Mobility-induced packet losses
- Battery constraints
- Potentially frequent network partitions
- Ease of snooping on wireless transmissions (security hazard)

Nitin Vaidya @ UIUC

Bluetooth

Pravin Bhagwat
@ AT&T Labs

- A cable replacement technology
- 1 Mb/s symbol rate
- Range 10+ meters
- Single chip radio + baseband
  - at low power & low price point

Why not use Wireless LANs?
- power
- cost

Cordless Headset

- User benefits
- Multiple device access
- Cordless phone benefits
- Hands free operation

Pravin Bhagwat @ AT&T Labs