Networking Issues for Mobile Computing

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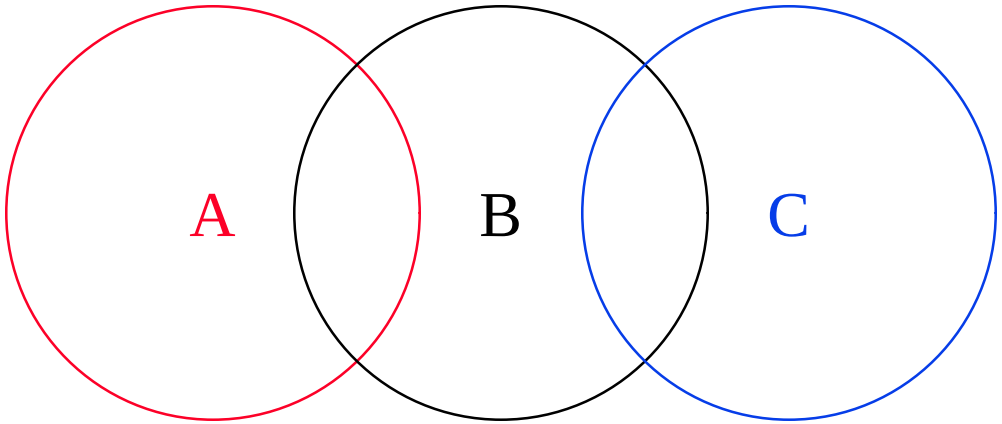
- Wireless LAN standards: IEEE 802.11
- Wireless ATM
- Mobile IP
- Mobility and TCP
- Mobile computing: Disconnected Operation

Wireless LAN Standards

- IEEE 802.11: Media access protocol. Similar to Ethernet.
- HIPERLAN: LAN standard developed by European Telecommunications Standards Institute (ETSI)'s RES10. Uses 5.2 and 17.1 GHz bands.
- WINFORUM: Started by Apple to get Spectrum for data PCS. Developing Spectrum Etiquette.

Hidden Node Problem

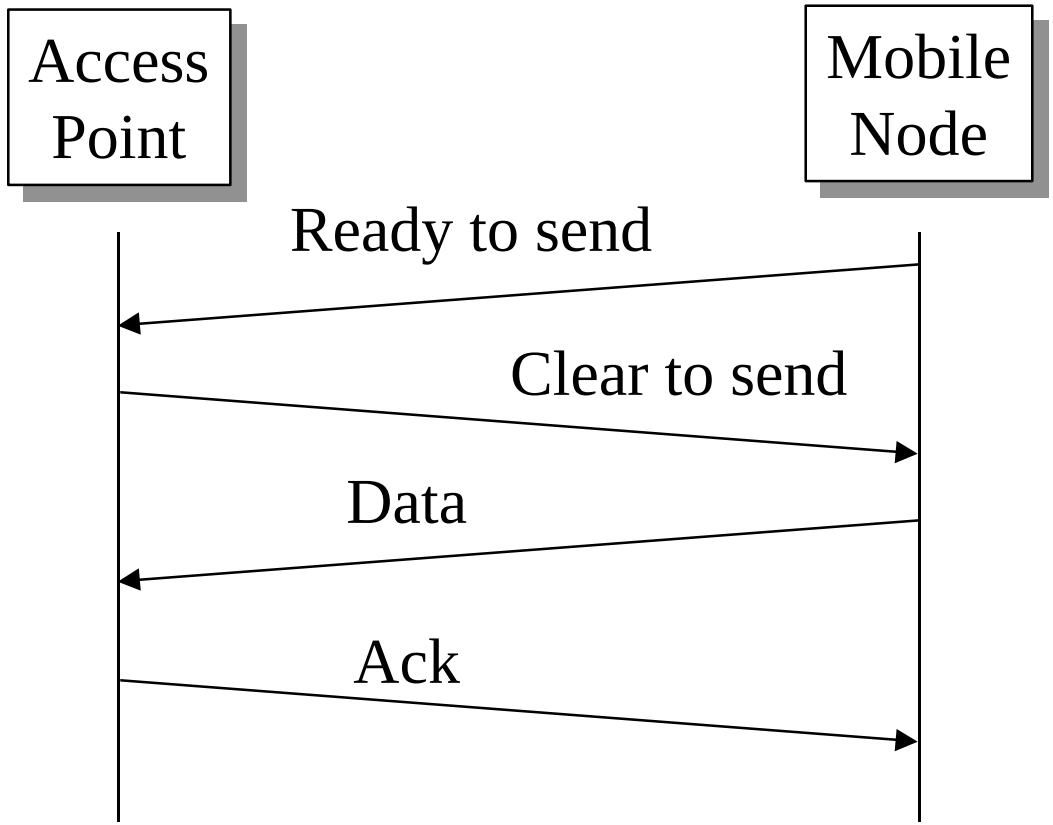


- C cannot hear A.
  It may start transmitting while A is also transmitting
  $\Rightarrow$ Can't detect collision.

IEEE 802.11 MAC: CSMA/CA

- Carrier Sense Multiple Access with Collision Avoidance
- Listen before you talk.
- If the medium is busy, the transmitter backs off for a random period.
- Avoids collision by sending a short message:
  Ready to send (RTS)
  RTS contains destination address and duration of message.
  Tells everyone that they should backoff for the duration.
- Destination sends: Clear to send (CTS)
- Can not detect collision ⇒ Each packet is acked.
- MAC level retransmission if not acked.

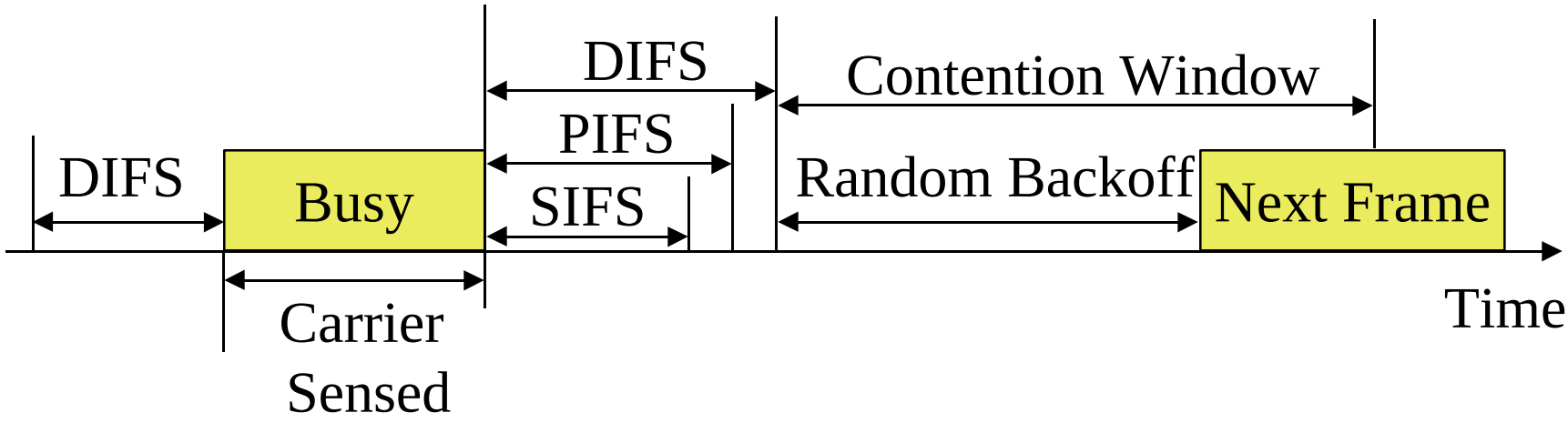
4-Way Handshake



Peer-to-Peer or Base Stations?

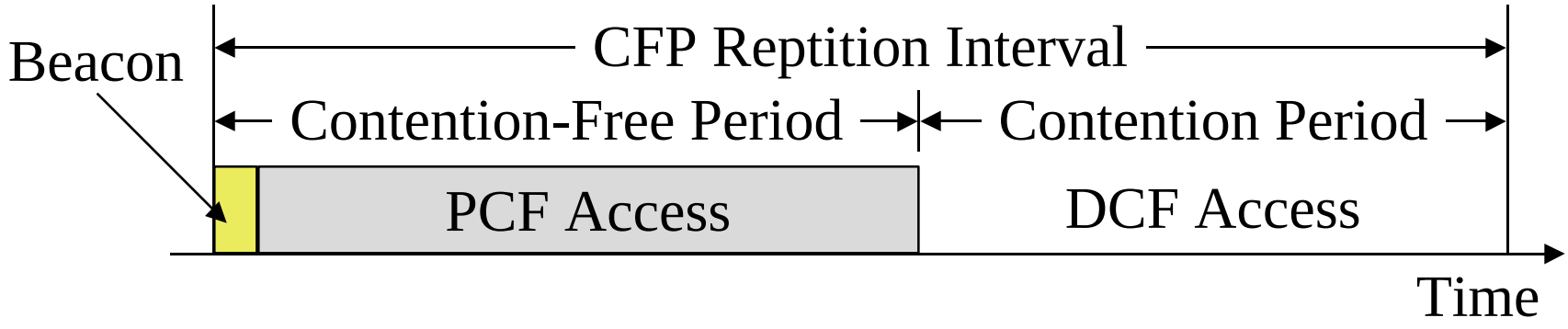
- Ad-hoc (Autonomous) Group:
  - Two stations can communicate
  - All stations have the same logic
  - No infrastructure
  - Suitable for small area
- Infrastructure Based: Access points (base units)
  - Stations can be simpler than bases.
  - Base provide connection for off-network traffic
  - Base provide Location tracking, directory, authentication
  - Scalable to large networks
- IEEE 802.11 provides both.

IEEE 802.11 MAC: Priorities



- Initial interframe space (IFS)
- Highest priority frames, e.g., Acks, use short IFS (SIFS)
- Medium priority time-critical frames use "Point Coordination Function IFS" (PIFS)
- Asynchronous data frames use "Distributed coordination function IFS" (DIFS)

Time Critical Services

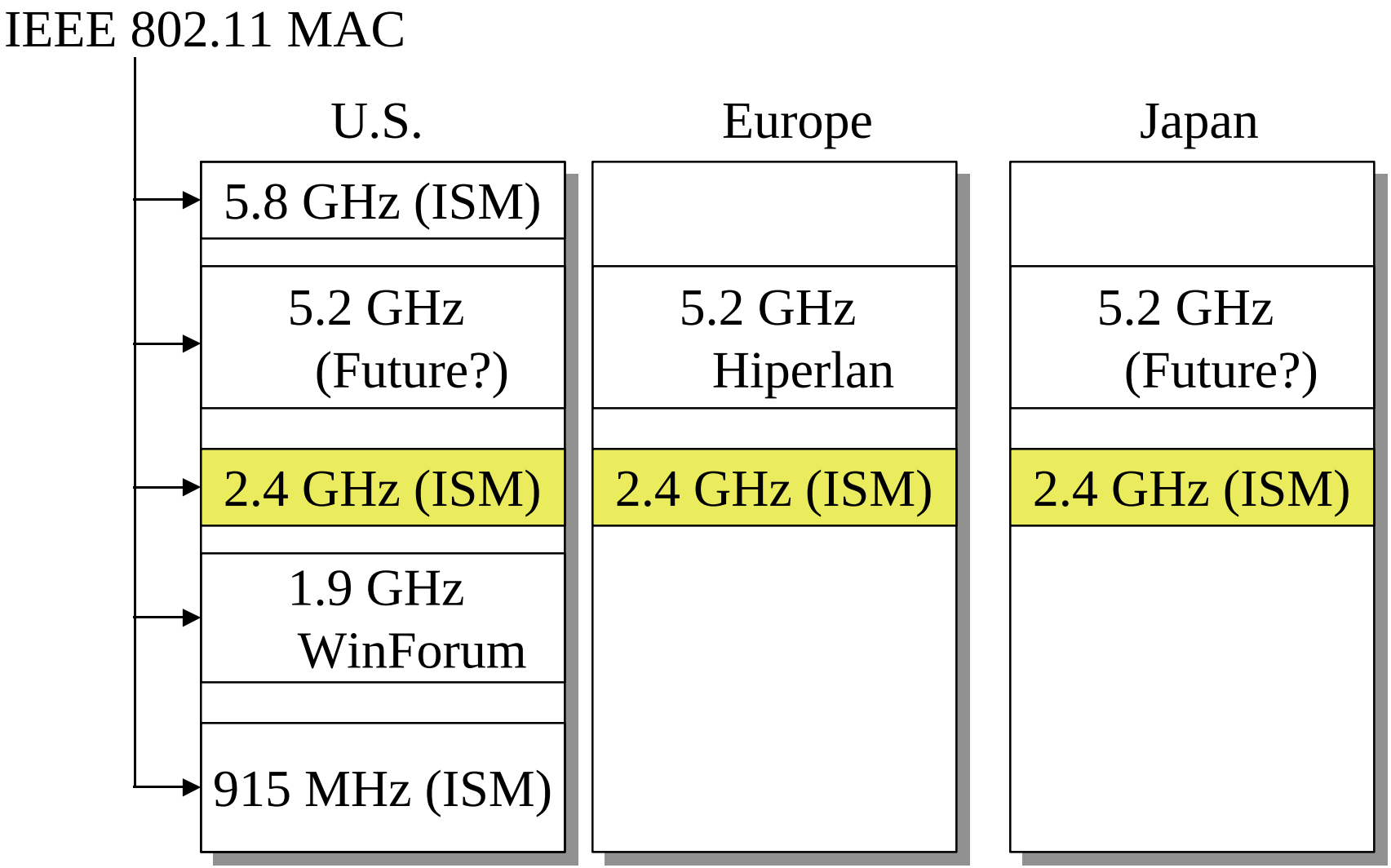


- Timer critical services use Point Coordination Function (PCF)
- The point coordinator (PCF station) allows only one station to access
- PCF station sends a beacon frame to inform all stations. Then uses a polling frame to allow a particular station to have contention-free access
- Length of Contention Free Period (CFP) varies with the load.
- Implementation of PCF is optional

IEEE 802.11 Physical Layer

- Three Phys specified:
  - Direct Sequence Spread Spectrum (DSSS)
  - Frequency Hopping Spread Spectrum (FHSS)
  - Diffused Infrared (DFIR): Wide angle
- DSSS and FHSS operate in 2.4-2.4835 GHz Industrial, Scientific, and Medical (ISM) band
  Some early systems use 902-928 MHz band.
  ISM band is available in many countries.
- Different PHY specifications for 915-MHz, 2.4-, 5.2 GHz, and Infrared (850-900 nm) bands.
- SS at 1 or 2 Mbps. DFIR at 1 Mbps.
- Different Phys $\Rightarrow$ Interoperability issues

Why 2.4 GHz?


IEEE 802.11 MAC
U.S.
Europe
Japan
5.8 GHz (ISM)
5.2 GHz (Future?)
5.2 GHz Hiperlan
5.2 GHz (Future?)
2.4 GHz (ISM)
2.4 GHz (ISM)
2.4 GHz (ISM)
1.9 GHz WinForum
915 MHz (ISM)

IEEE 802.11 Security

- Authentication:
  - New nodes issue a "request for authentication"
  - Network sends a block of random text.
  - The node encrypts it with network password and returns.
- Currently, *one* shared secret key (password) per network.
- The same encryption algorithm is used for privacy. Wired Equivalency Privacy (WEP) Algorithm is based on RC4 PRNT algorithm developed by RSA Data Security, Inc.

Power Management

- A station can be in one of three states:
  - Transmitter on
  - Receiver only on
  - Dozing: Both transmitter and receivers off.
- Access point buffers traffic for dozing stations.
- Traffic indication map included in each beacon.
- Dozing stations wake up to listen to the beacon.
  If there is data waiting for it, the station sends a poll frame to get the data.

FHSS Phy

- 2.4 GHz ISM Band. (Only 2.471-2.497 MHz in Japan)
- 1 and 2 Mbps
- Three sets of frequency hopping patterns. Each set has 22 hopping sequences (22 Channels). Total 66 channels. 12 in Japan.
- Consecutive frequencies in each sequence are at least 6 MHz apart to avoid a narrowband interferer.
- Adjacent or overlapping cells use different patterns.
- Many channels $\Rightarrow$ FH systems better than DS in dense (overlapping cells) environment.

DSSS Phy

- 2.4 GHz band
- 11 chip spreading factor
- 11 DS center frequencies (11 Channels)
- Only 3 channels without overlap.
- 10 mW to 100 mW transmitted power
- 1 and 2 Mbps
- DBPSK for 1 Mbps. DQPSK for 2 Mbps.

Infrared Phy

- Baseband transmission
- 850 to 950 nm range of IR
- 1 Mbps or 2 Mbps
- Diffuse IR
- Up to 10 m in typical offices
  Could be 20 m with better receivers.
- For 1 Mbps, 4-bits are mapped to 16 ppm symbol
- For 2 Mbps, 2 bits are mapped to 4 ppm symbol

Status and Future

- Current Status: To be final by Spring 1996
  - MAC has been fine-tuned.
  - FH Phy layer to be resolved in July 95 meeting
  - IR, DS Phys almost complete.
- More bandwidth in future by:
  1. Better encoding: Multilevel modulation $\Rightarrow$ 8 Mbps
  2. Fewer channels with more bandwidth $\Rightarrow$ 4 MHz channels.
     Or Entire ISM band for one channel.
  3. Find another band.
     May get 150 MHz band in 5-GHz band.
     Fifteen 10-MHz channels with 15-20 Mb/s.

Wireless ATM

- ATM cell size designed for 64 kbps
  May be too big for some wireless LANs
- Wireless LANs may use 16 or 24 byte payload
- Compress ATM header (12 bit VPI/VCI not 28 bits)
  Expanded to standard ATM at the base station
- Add wireless data-link header
  - Service Type: CBR, VBR, ABR
  - Error control: 10-bit sequence numbers, 16-bit CRC, HDLC style retransmissions
  - Segmentation and reassembly of small payload units
  - Handoff support: Bits in header indicate PDUs before and after handoff

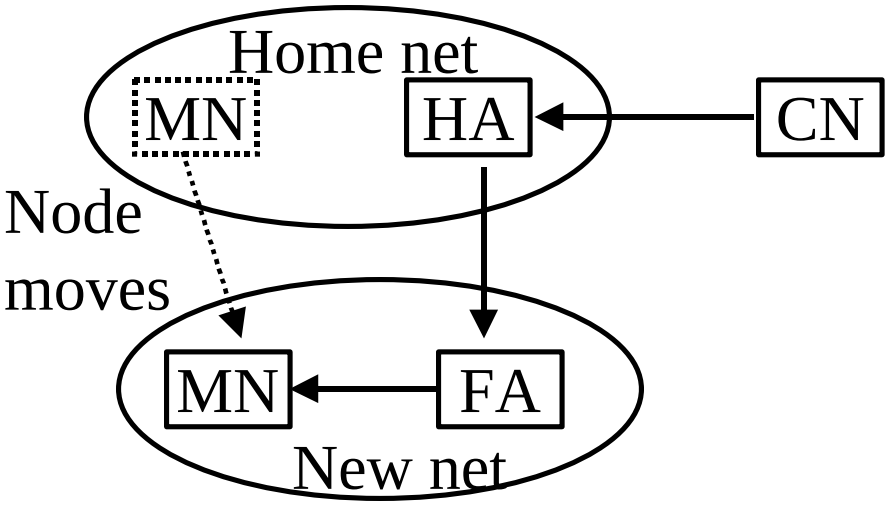
Mobile IP: Features

- You can take you notebook to any location
- Finds nearby IP routers and connects *automatically*
  You don't even have to find a phone jack
- Only "Mobility Aware" routers and mobile units need new s/w
- Other routers and hosts can use current IP
- No new IP addresses or address formats
- Secure: Allows authentication
- Also supports mobile networks
  (whole airplane/car load of mobile units)

Impact

- Your Email is continuously delivered
- You can start a telnet or x-window session as if local
- Continuous access to your home resources
- Access to local resources: Printers
- You wouldn't miss a mail even during meetings
- Airports, Hotels, Hospitals will provide "Mobile IP connectivity"
- Better connectivity
  $\Rightarrow$ More productive meetings and conferences
- Cities will feature "Mobile IP Accessways"
- You can compute while driving

Mobile IP: Terminology



- Mobile Node (MN)
- Home Agent (HA), Foreign Agent (FA)
- Care-of-address (COA): Address of the end-of-tunnel towards the mobile node
- Correspondent Node (CN):
- Home Address: Mobile node's permanent IP address

Mobile IP: Processes

- Agent Discovery: To find agents
  - Home agents and foreign agents advertise periodically on network layer and optionally on datalink
  - They also respond to solicitation from mobile node
  - Mobile selects an agent and gets/uses care-of-address
- Registration
  - Mobile registers its care-of-address with home agent
  - Either directly or through foreign agent
  - Home agent sends a reply to the mobile node via FA
  - Each "Mobility binding" has a negotiated lifetime limit
  - To continue, reregister within lifetime

Processes (Cont)

- Return to Home:
  - Mobile node deregisters with home agent
    sets care-of-address to its permanent IP address
  - Lifetime = 0 $\Rightarrow$ Deregistration
- Deregistration with foreign agents is not required.
  Expires automatically
- Simultaneous registrations with more than one COA allowed (for handoff)

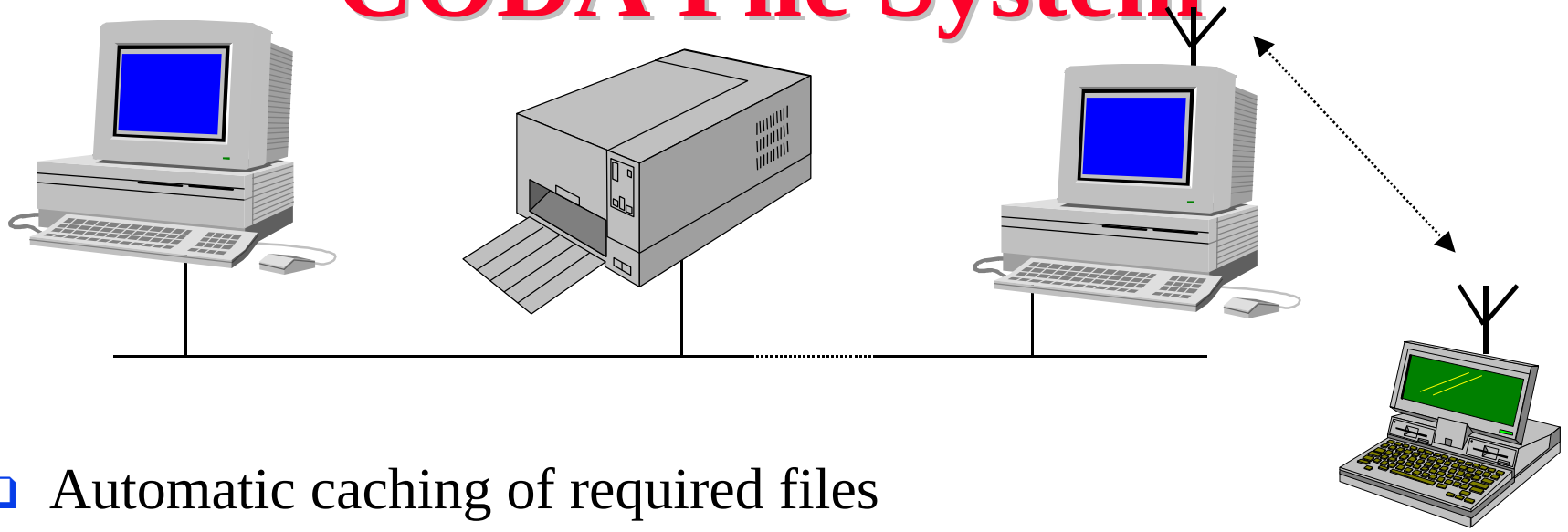
Encaptulation/Tunneling

- Home agent intercepts mobile node's datagrams and forwards them to care-of-address
- Home agent tells local nodes and routers to send mobile node's datagrams to it
- Decaptulation: Datagram is extracted and sent to mobile node

TCP Mobility Considerations

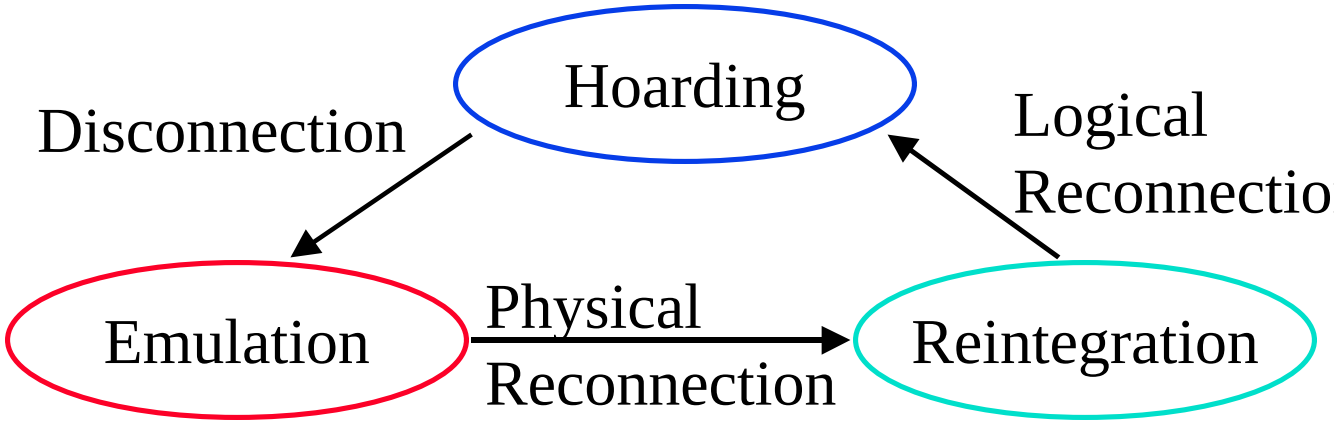
- TCP Timers: Uses delays for timeouts and retransmission
  - Handoffs ⇒ Larger variation in delays
    ⇒ Unnecessary retransmission
- Congestion Management: Uses loss as congestion indication
  ⇒ Decreases windows on retransmissions (Slow start)
  - Handoffs and frequent errors
    ⇒ False congestion signals ⇒ Low throughput
- One Solution: Split the connection: Wired and wireless.
  No TCP on wireless hop.

CODA File System



- Automatic caching of required files
- Automatic resynchronization upon connection
- Conflict ⇒ copies marked inconsistent ⇒ Manual repair
- Allows volume replication at multiple servers
- Allows partial network failures
- Voluntary and involuntary disconnections are treated similarly.

Disconnected Operation in CODA



- Optimistic replication ⇒ Hope no conflict
  ⇒ Allow modification even when all copies are not accessible.
- Conflicts resolved later using logs and manual repair
- Maintains log during emulation
- Integration: Replay log is shipped to all servers
- Allows possibility of low bandwidth reconnection

Hoarding

- Prioritized cache management: Implicit and Explicit information.
- User can specify a prioritized list of files and directories
- Highest priority ⇒ Sticky ⇒ Retain at all times
- The system can monitor file access while user performs specified operations.
- All ancestors of objects should also be cached, e.g., c:\windows\system
- Walks every 10 minutes or on user request
  ⇒ Update versions. Purge lower priority items.
  Get all higher priority items.
- 50 MB sufficient for a day

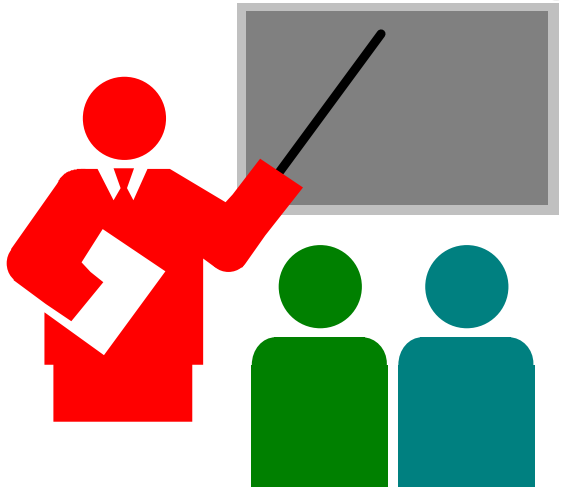
Hoarding (Cont)

- If the server copy is modified ,
  The client cache is not immediately updated.
  Update only when needed or next hoard walk.
  If something is modified, it will be modified again soon.

Emulation

- All update activities are logged.
- Log is optimized to conserve disk space.
  E.g., File overwritten twice $\Rightarrow$ discard previous log entry
- To survive crashes, cache and logs are kept in non-volatile storage (disk).
- If disk becomes full with cache or log, compress log, write to floppy, or reintegrate.

Summary



- IEEE 802.11: 1 to 2 Mbps, CSMA/CA
- ATM: Per-hop error control and recovery.
- IP: Provides transparent mobility via home/foreign agents
- TCP: Varying delays and errors ⇒ More adaptive algorithms
- Mobile Computing: Transparent disconnected operation

Products

- **Mobile IP :**
  - DEC: RoamAbout Mobile IP (V.2.0)
  - Novell: Mobile IPX
- **Disconnected Operation**:
  - AnyPlace by Symmetrical Technologies, Amherst, NH
  - Allows user to create, retrieve, modify, delete and rename files while disconnected from server.

IEEE 802.11: References

- K. Pahlavan, et al, "Trends in Local Wireless Networks," IEEE Communications Magazine, March 1995, pp. 88-95.
- C. Links, et al, "Universal Wireless LANs," Byte, May 1994, pp. 99-108.
- L. Goldberg, "Wireless LANs: Mobile-Computing's Second Wave," Electronic Design, June 26, 1995.
- IEEE 802.11 standard committee archive (encrypted standard) file://atg.apple.com/pub/802.11/

Wireless ATM: References

- D. Raychaudhuri and N.D. Wilson, "ATM-Based Transport Architecture for Multiservices Wireless Personal Communication Networks," IEEE JSAC, October 1992, pp. 1401-1413.

Mobile IP: Internet Drafts

- Internet Draft, "IP Mobility Support," 07/07/1995, <draft-ietf-mobileip-protocol-11.txt>
- Internet Draft, "Route Optimization in Mobile IP," 07/07/1995, <draft-ietf-mobileip-optim-02.txt>
- Internet Draft, "Minimal Encapsulation within IP," 07/07/1995, <draft-ietf-mobileip-minenc-00.txt>
- Internet Draft, "IP Encapsulation within IP," 07/07/1995, <draft-ietf-mobileip-ip4inip4-00.txt>
- RFC1688, "IPng Mobility Considerations" by W. Simpson, 08/11/1994, 9 pp.

Mobile IP: References

- Mobile-IP working group homepage, http://www.ietf.cnri.reston.va.us/html.charters/mobileip-charter.html
- E. Amir, et al, "Efficient TCP over Networks with Wireless Links," Available on-line via http:\\www.berkeley.edu\ (?)
- C.K. Kantarjiev, et al, "Experiences with X in a Wireless Environment," Proc. USENIX Mobile and Location Independent Computing Symposium, 1993, pp. 117-28.

Mobile Computing: References

- G.H. Forman and J. Zahorjan, "The Challenges of Mobile Computing," IEEE Computer, April 1994, pp. 38-47.
- T. Imielinski, and B.R. Badrinath, "Mobile Wireless Computing: Challenges in Data Management," Available on-line via http://winwww.rutgers.edu/
- M. Satyanarayanan, "Scalable, Secure, and Highly Available Distributed File Access," IEEE Computer, May 1990, pp. 9-20.
- J.J. Kistler and M. Satyanarayanan, "Disconnected Operation in the Coda File System," ACM Transactions on Computer Systems, Vol. 10, No. 1, February 1992, pp. 3-25.
- Mobile Computing Bibliography, http://www.ira.uka.de/ftp/ira/bibliography/Distributed/mobile.html

Recent Advances in Networking and Telecommunications Seminar Series 1995

Last Tuesday of the month (mostly), 3:45-5:15 PM

- January 31: High Speed Networks: Trends and Issues
- February 21: ATM Networks: Introduction
- March 28: ATM Networks: Advanced Issues
- April 25: Multimedia Networks
- May 30: Multimedia Networks
- June 27: Wireless Networks (Denny 352, 164 West 17th Ave)
- July 25: Mobile Computing (Denny 352, 164 West 17th Ave)
- September 19: Congestion Control or High Speed LANs?
- October 31: Signaling or New Telecom Data Services?
- November 28: All-Optical Networks