CS698T
Wireless Networks: Principles and Practice

Topic 16
IEEE 802.11 (WLAN/WiFi)

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http://www.cse.iitk.ac.in/users/braman/courses/wless-spring2007/

IEEE 802.11 (WiFi)

- Part of 802.x series
  - 802.3 is Ethernet
- 802.11a, 802.11b, 802.11g specify three different PHY layers
  - MAC is the same
- 802.11a: 5.2 to 5.7GHz
- 802.11b/g: 2.4 to 2.4835GHz

802.11: What does it specify?

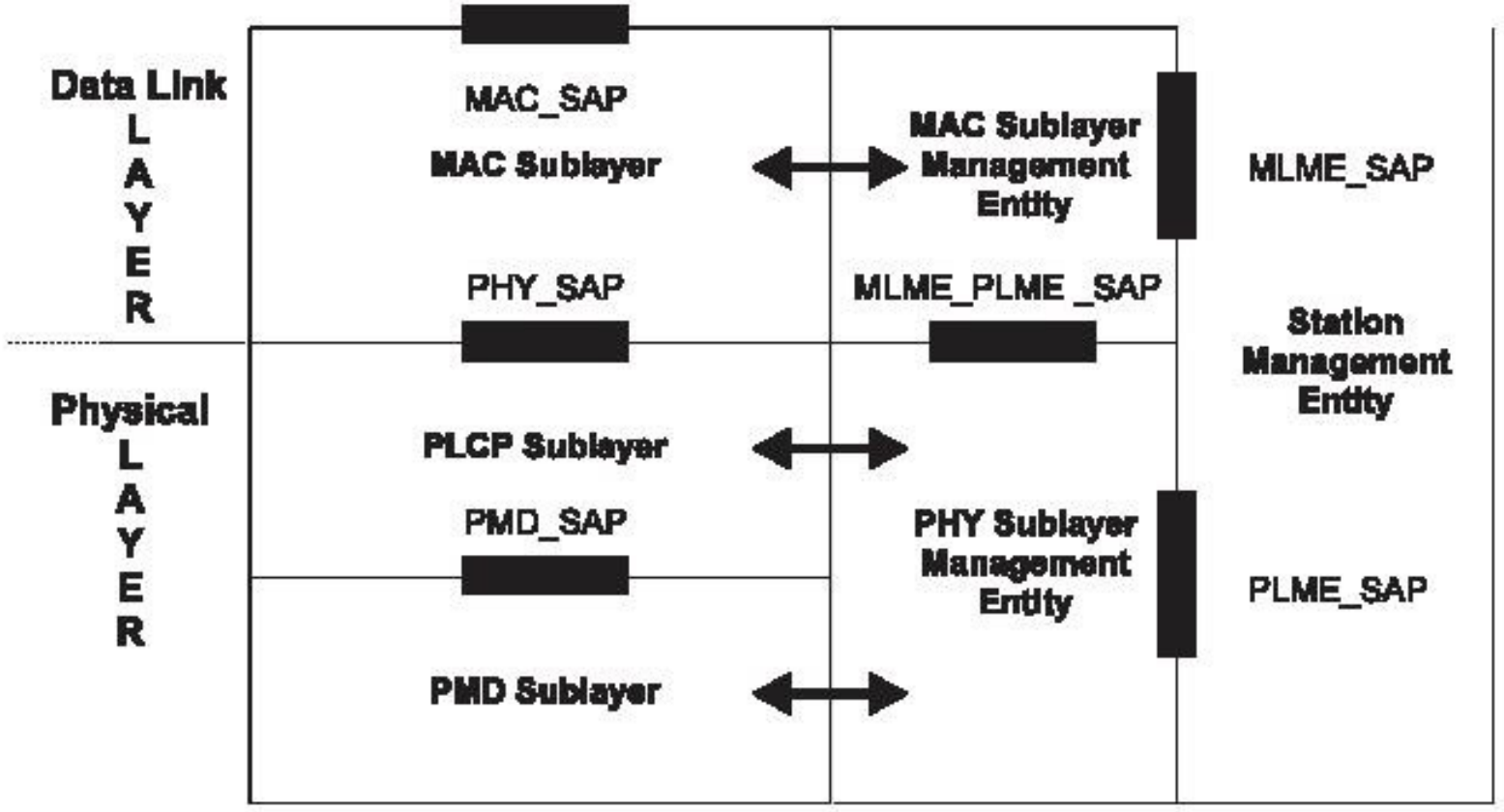


Figure 11—Portion of the ISO/IEC basic reference model covered in this standard

Source: IEEE 802.11 specification

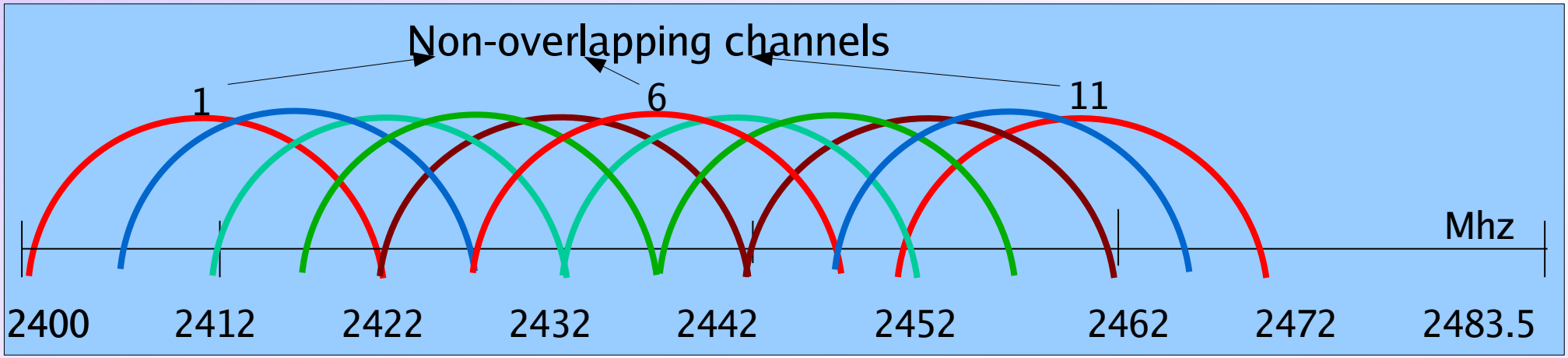
802.11: What does it Specify?

- PHY sub-layer
  - 802.11a, 802.11b, 802.11g
- MAC sub-layer
  - Independent of the PHY
  - DCF (Distributed Coodrination Function)
    - CSMA/CA
  - PCF (Point Coordination Function)
- MAC management

802.11 PHY

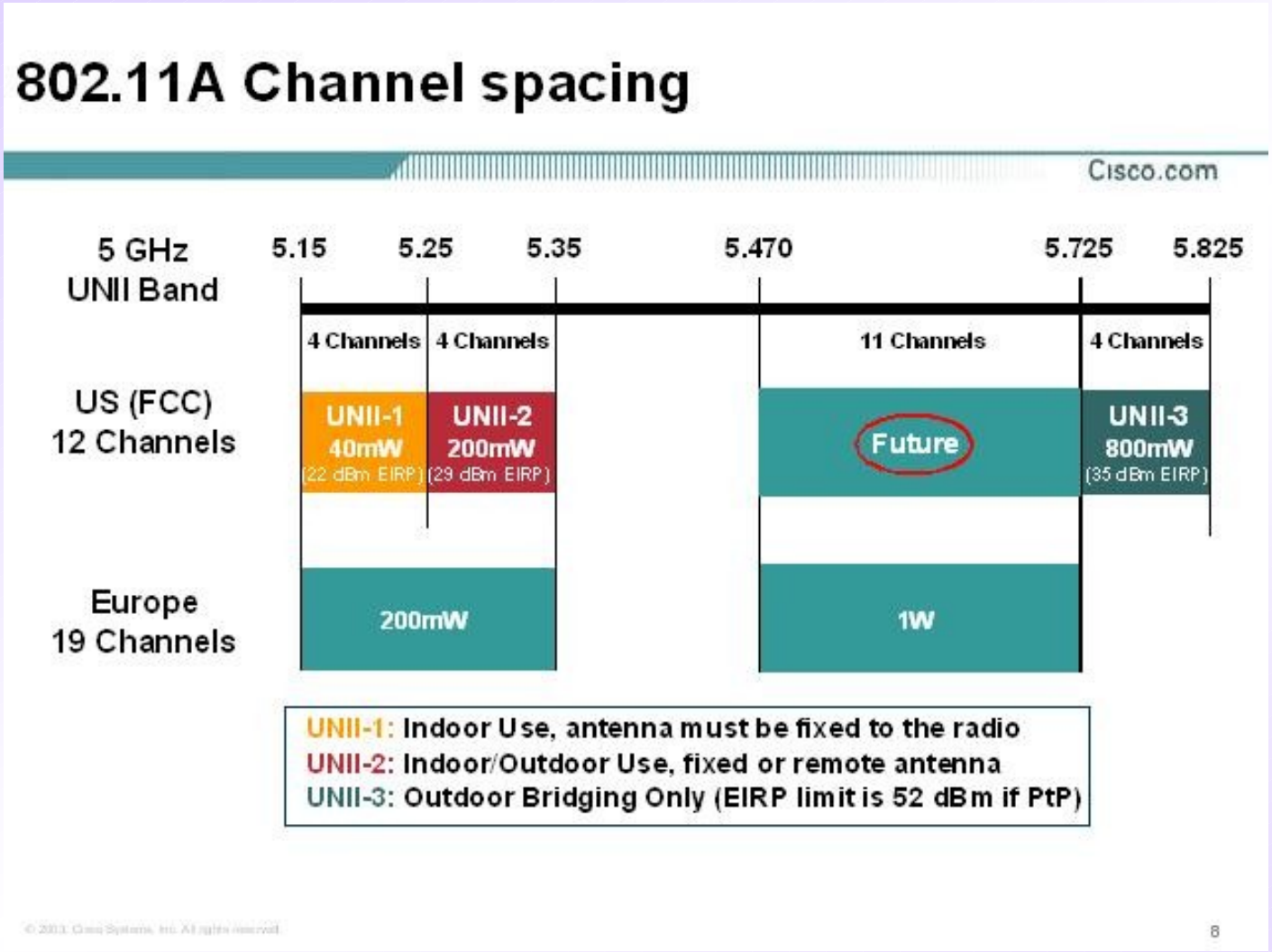
- 802.11b data-rates (modulation schemes):
  - 1Mbps (BPSK), 2Mbps (QPSK), 5.5Mbps (CCK), 11Mbps (CCK)
- 802.11a and 802.11g data-rates:
  - 6, 9, 12, 18, 24, 36, 48, 54 Mbps
  - OFDM + BPSK/QPSK/16QAM/64QAM
  - 802.11g also supports 802.11b data-rates and modulations (backwards compatible)

802.11b Channels



- Each channel is 22MHz wide
- Adjacent channels overlap
- Non-overlapping channels: 1, 6, 11
- Band recently delicensed in India for indoor, outdoor usage

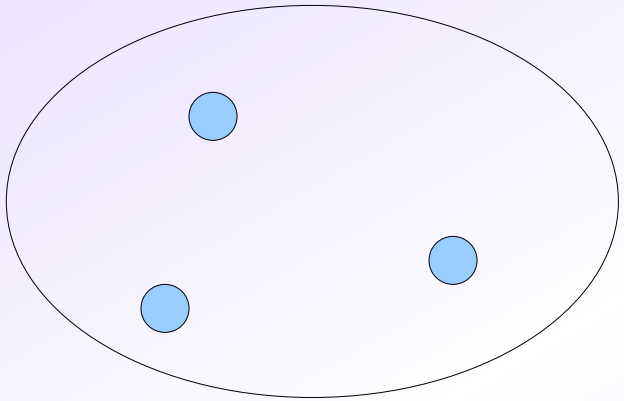
802.11a Channels



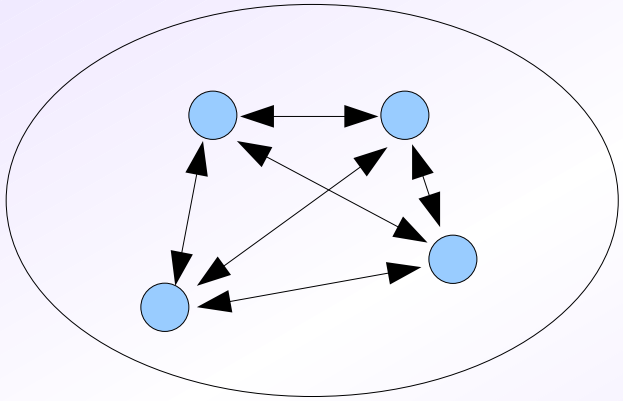
- Each channel is 20MHz wide
- As of now, band is not free in India for outdoor use

Source: Cisco presentation

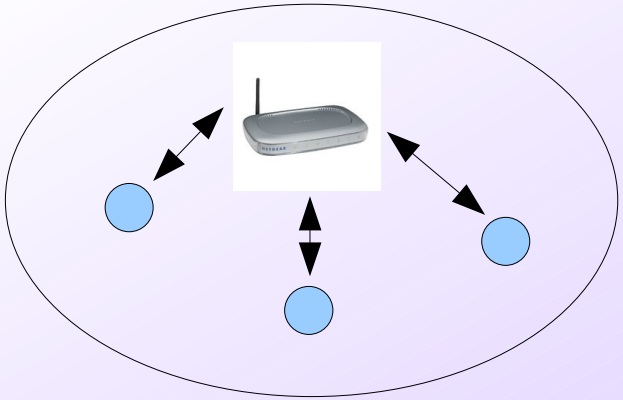
802.11 Service Sets



Basic Service Set: set of STAs in a region

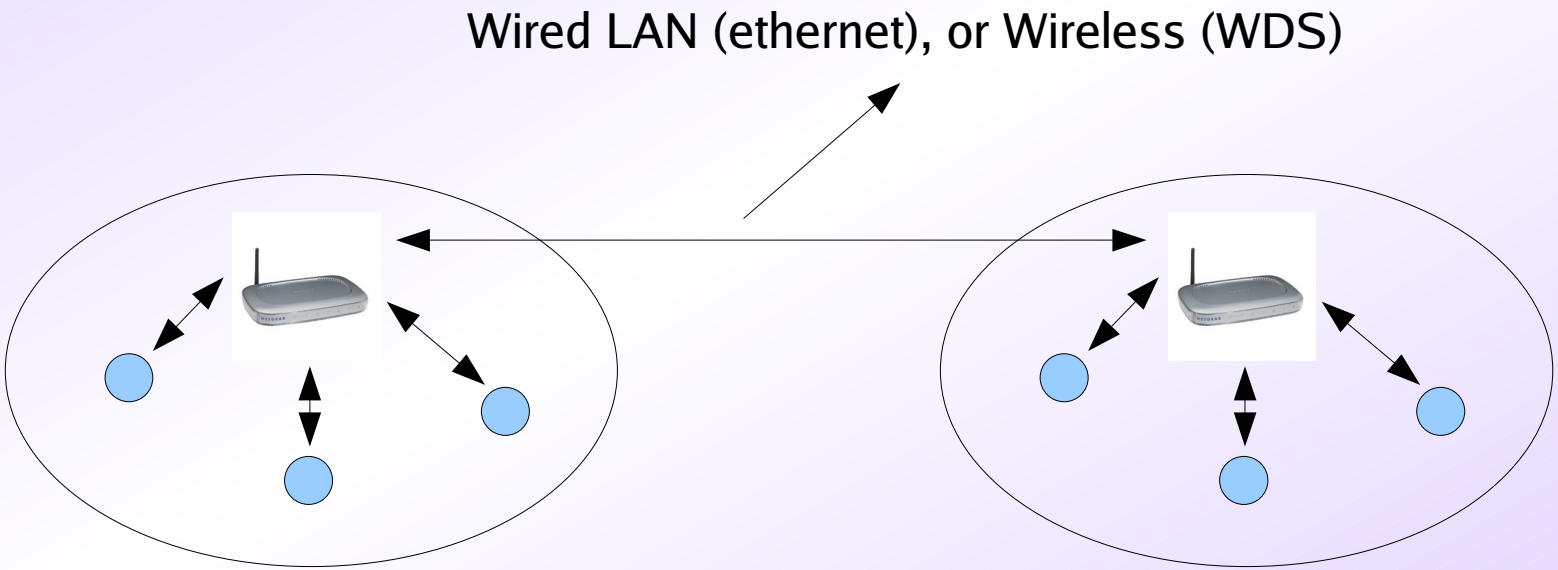


IBSS: Independent Basic Service Set



Infrastructure Basic Service Set

802.11 Extended Service Set (ESS)



MAC Classification

- Based on what dimension is used for multiplexing:
  - SDMA, TDMA, FDMA, CDMA
- Based on how control is achieved:
  - Central
    - (+) Easy to design/implement
    - (-) Single point of failure, bottleneck
  - Distributed
    - (+) Natural when there is no central information
- 802.11 specifies DCF (Distributed Coordination Function), PCF (Point Coordination Function)
  - PCF uses central control

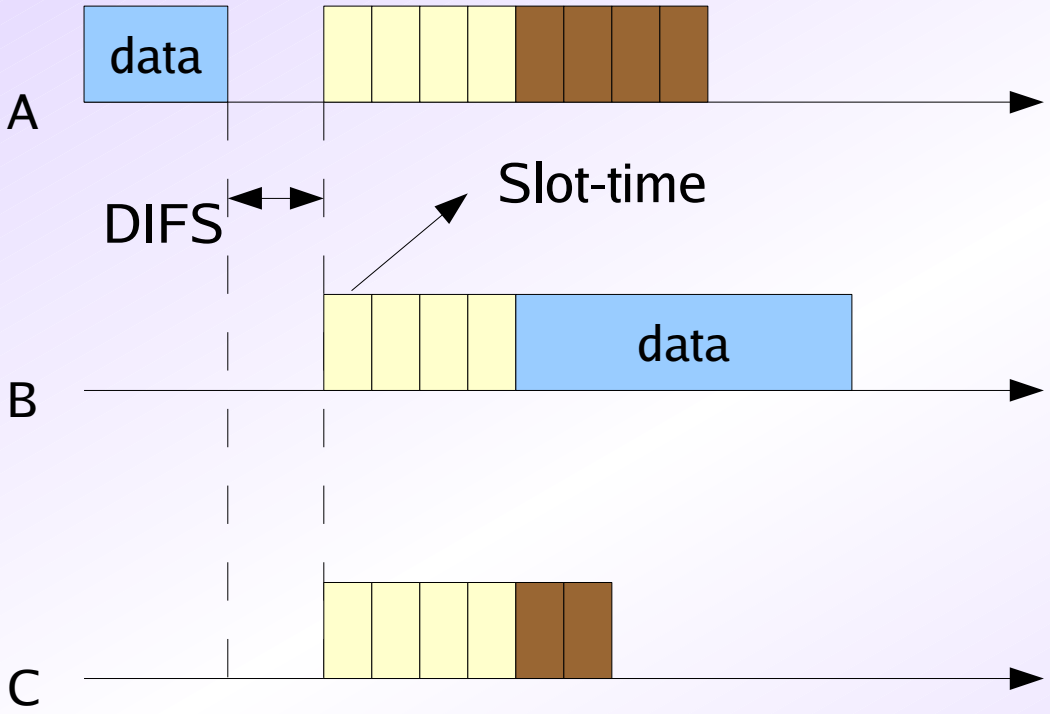
Ethernet CSMA/CD: Prelude to 802.11 CSMA/CA

- CSMA/CD: Carrier-Sense Multiple Access with Collision Detection
  - Listen before transmit (CS)
  - Tx when (as soon as) medium is free (1-persistent)
  - Collision Detection (CD)
  - Backoff (exponential) on collision

802.11 CSMA/CA

- Collision detection impossible in wireless
  - Tx power is relatively very high near the transmitter
- Conceptual name is CSMA/CA: Carrier-Sense Multiple Access with Collision Avoidance
  - 802.11 calls it DCF (Distributed Coordination Function)
- Collision Avoidance:
  - Back-off before tx (even when no collision)
  - **Contention Window (CW)** in terms of number **slots**

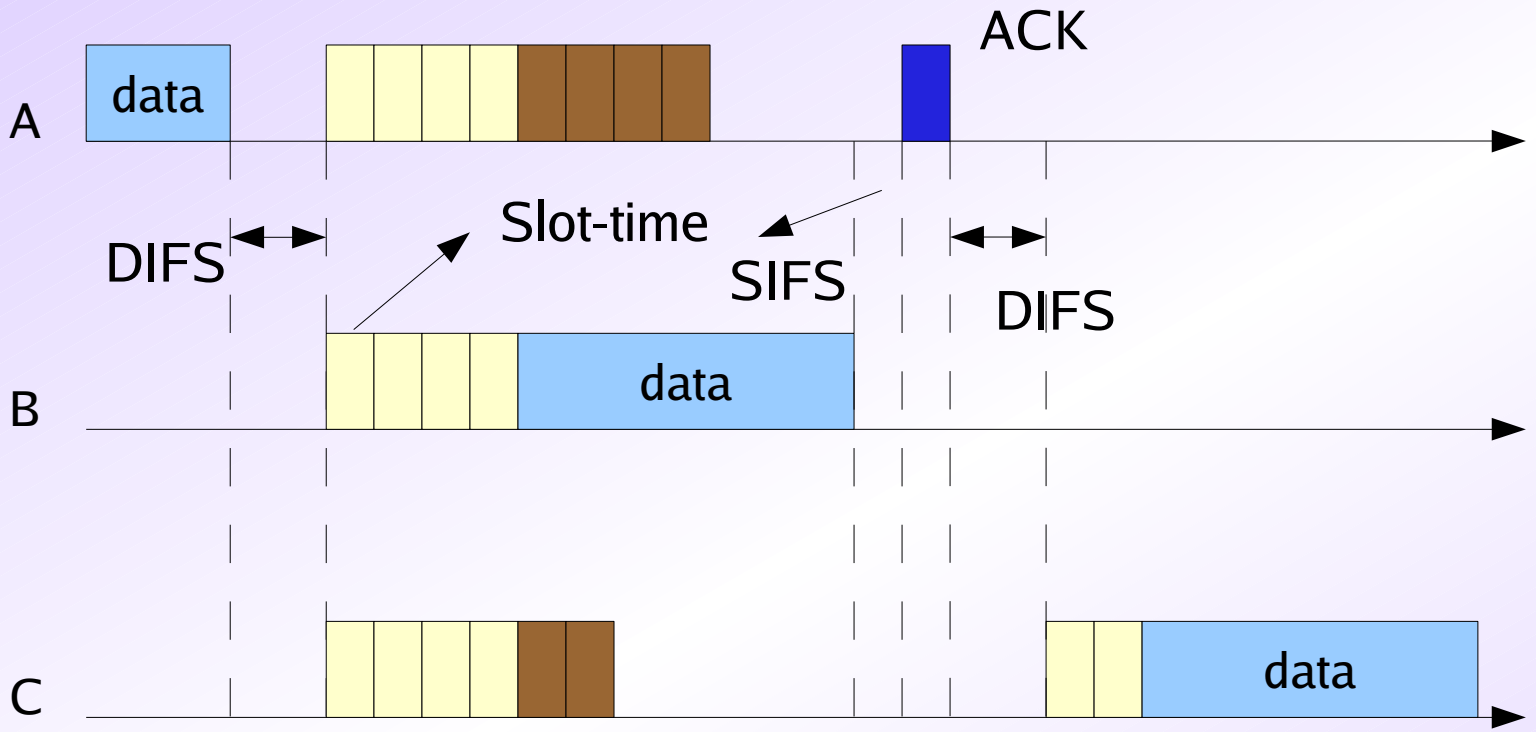
The Backoff Procedure



Contention window:
Num slots = Random[0, CW)
CW = 32, 64, 128, 256, 512, 1024
Double CW on collision

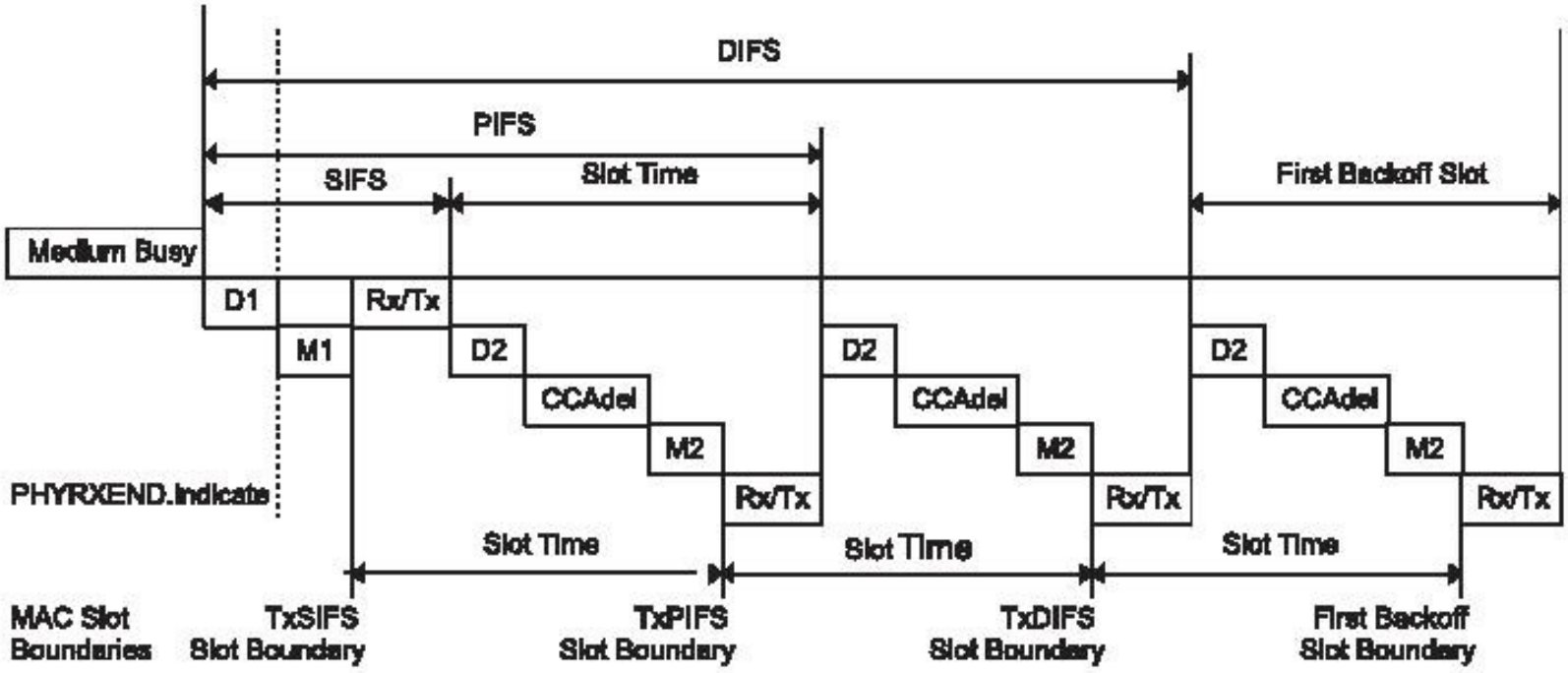
Question: Why DIFS?

CSMA/CA + ACK



- ACK missing ==> Deduce collision
  - Retransmit (have to content anew)
- SIFS should be < DIFS
  - Else, ACK timeout may occur unnecessarily

DCF Timing Relations

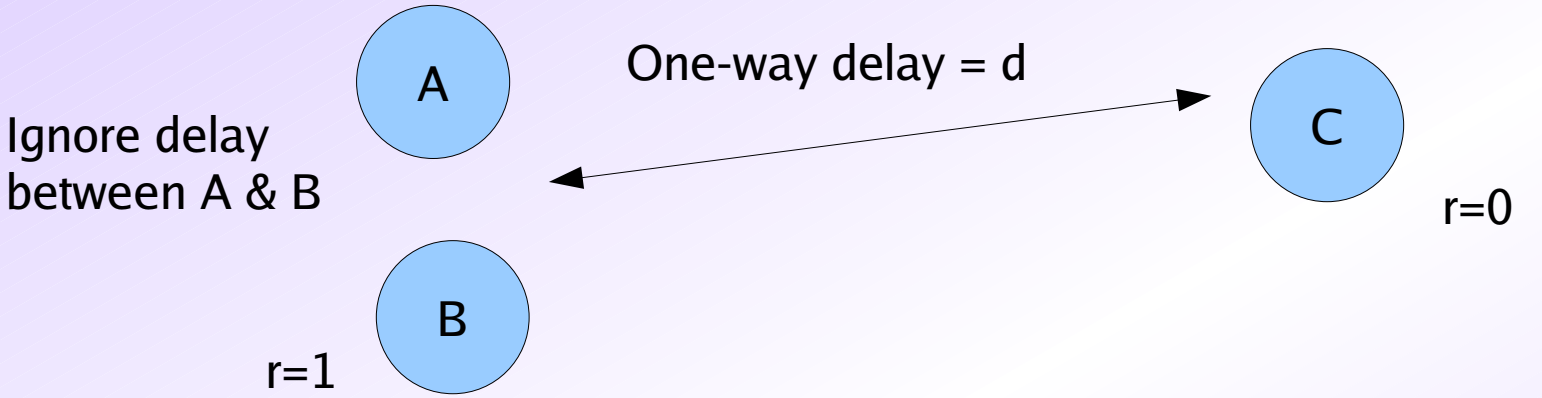


D1 = aRxRFDelay + aRxPLCPDelay (referenced from the end of the last symbol of a frame on the medium)
D2 = D1 + Air Propagation Time
Rx/Tx = aRXTXTurnaroundTime (begins with a PHYTXSTART.request)
M1 = M2 = aMACPrcDelay
CCAdel = aCCA Time - D1

Figure 58—DCF timing relationships

Source: IEEE 802.11 Specifications

Propagation Time is Important



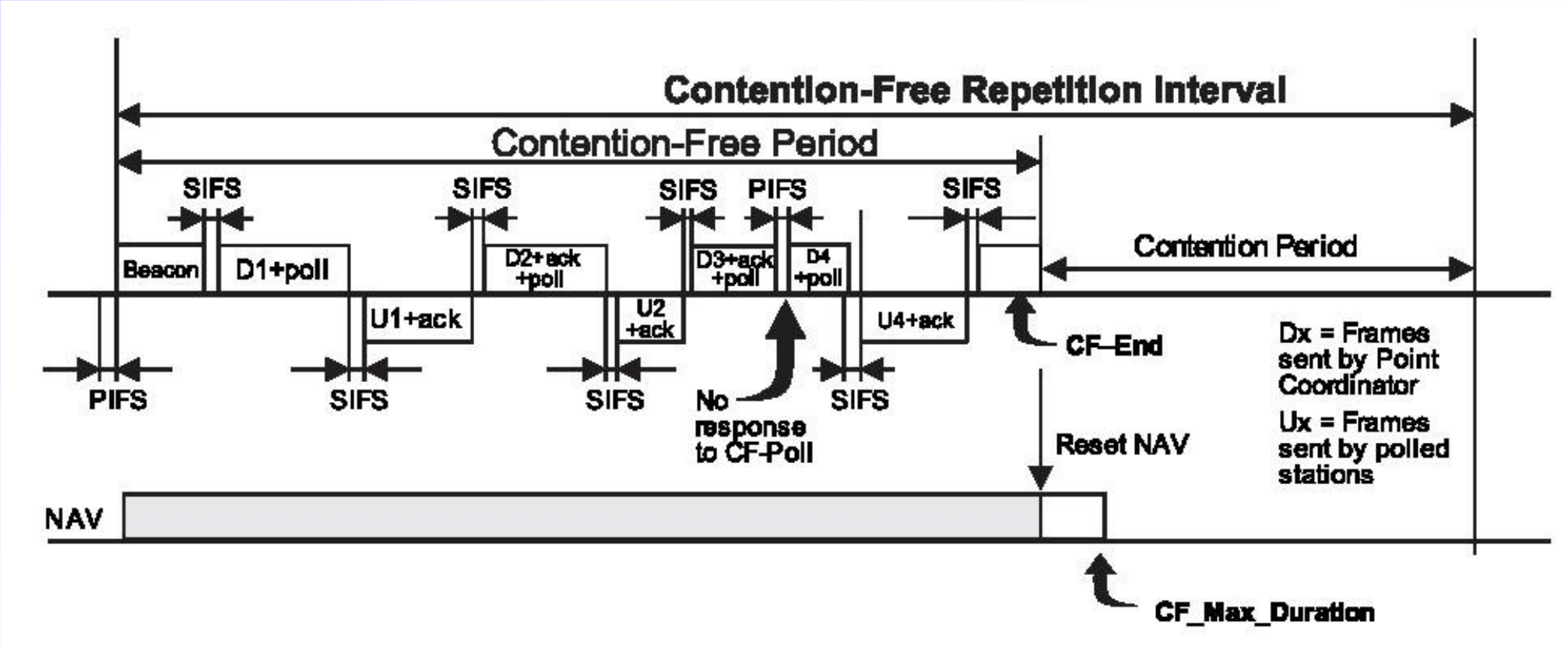
(1)A finishes tx at time t

(2)B senses the channel to be free at t, C senses the channel to be free at t+d

(3)C starts sending at t+d+DIFS, this reaches B at t+d+DIFS+d

(4)B should not have started tx by then ==> slot-time should be < 2d

802.11 PCF Mode of Operation



Source: IEEE 802.11 Specification

IFS Relations

aSIFSTime and aSlotTime are fixed per PHY.

aSIFSTime is: aRxRFDelay + aRxPLCPDelay + aMACProcessingDelay + aRxTxTurnaroundTime.

aSlotTime is: aCCATime + aRxTxTurnaroundTime + aAirPropagationTime + aMACProcessingDelay.

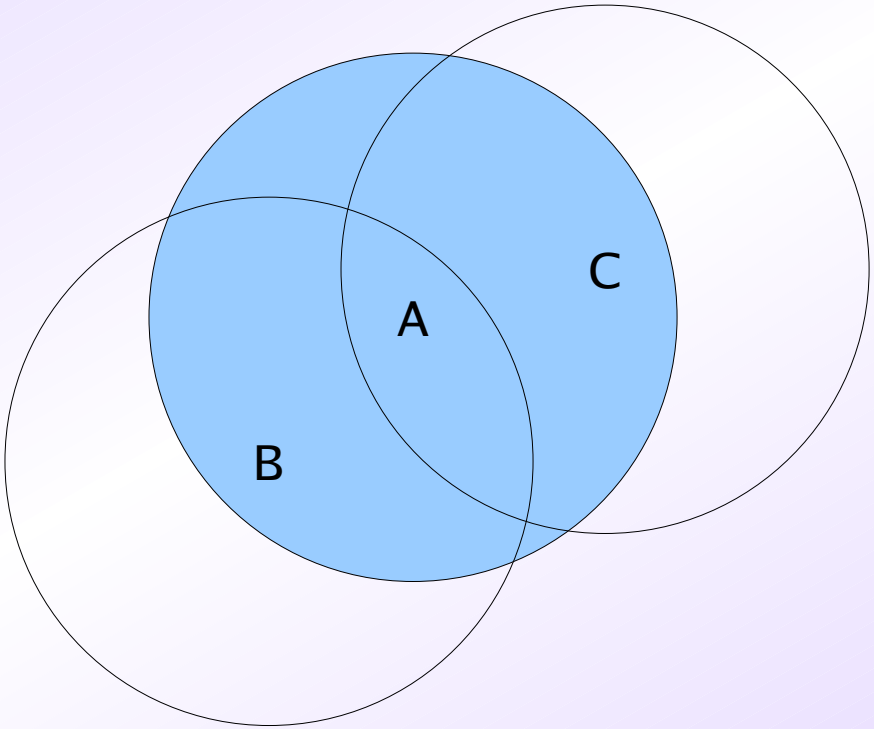
The PIFS and DIFS are derived by the following equations, as illustrated in Figure 58.

PIFS = aSIFSTime + aSlotTime

DIFS = aSIFSTime + 2 × aSlotTime

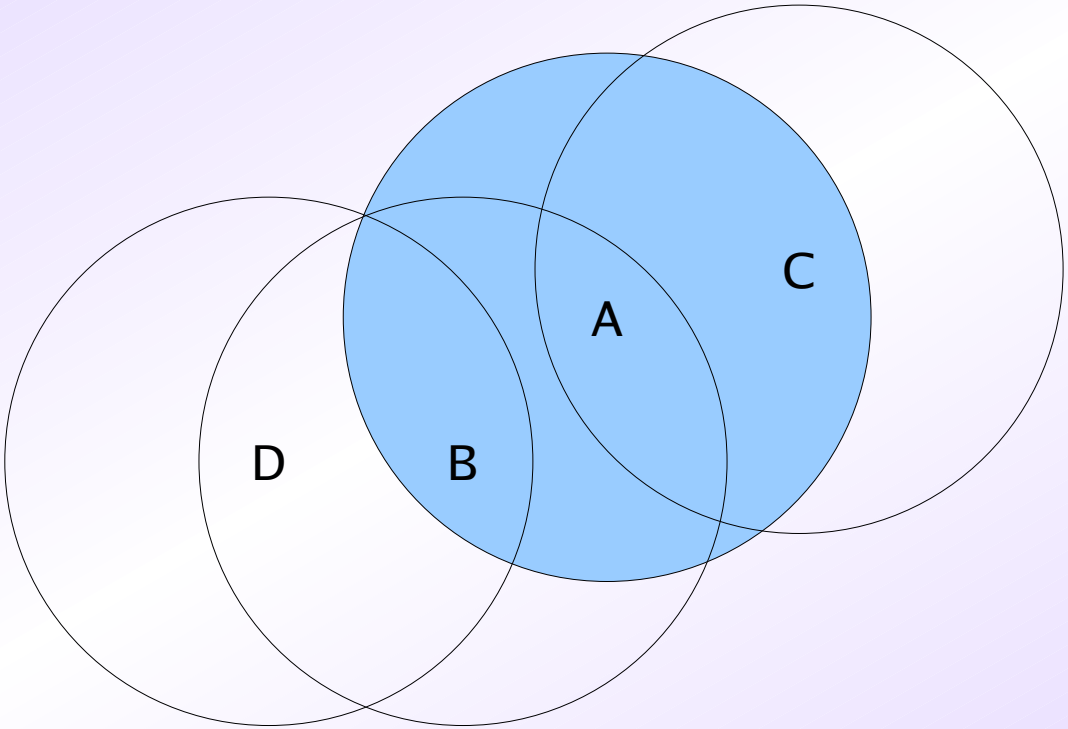
Source: IEEE 802.11 Specification

The Hidden Node Problem



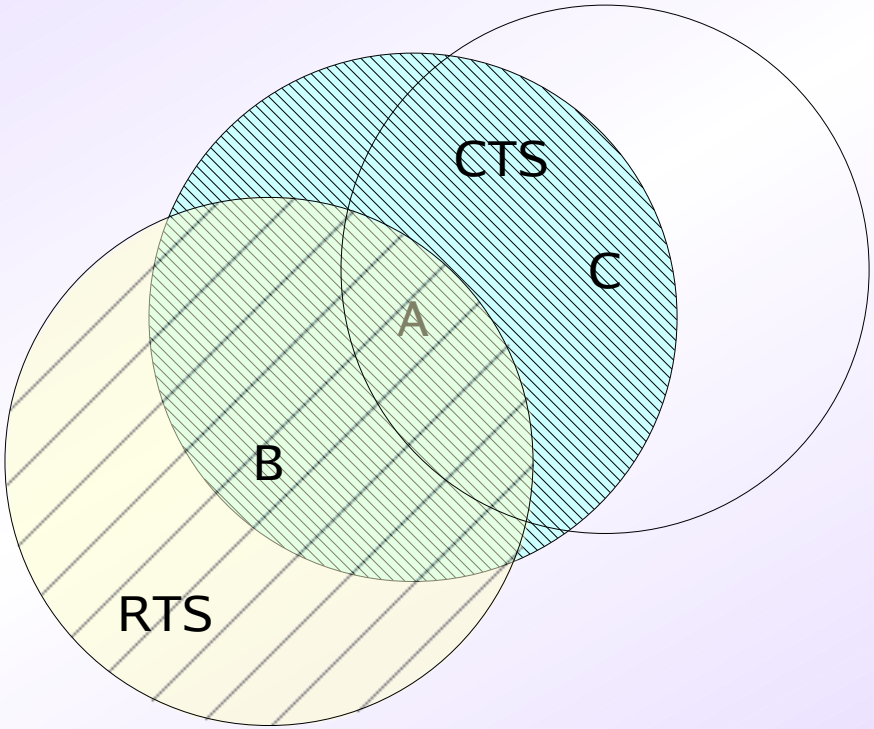
Medium is free DOES NOT IMPLY ok-to-transmit

The Exposed Node Problem

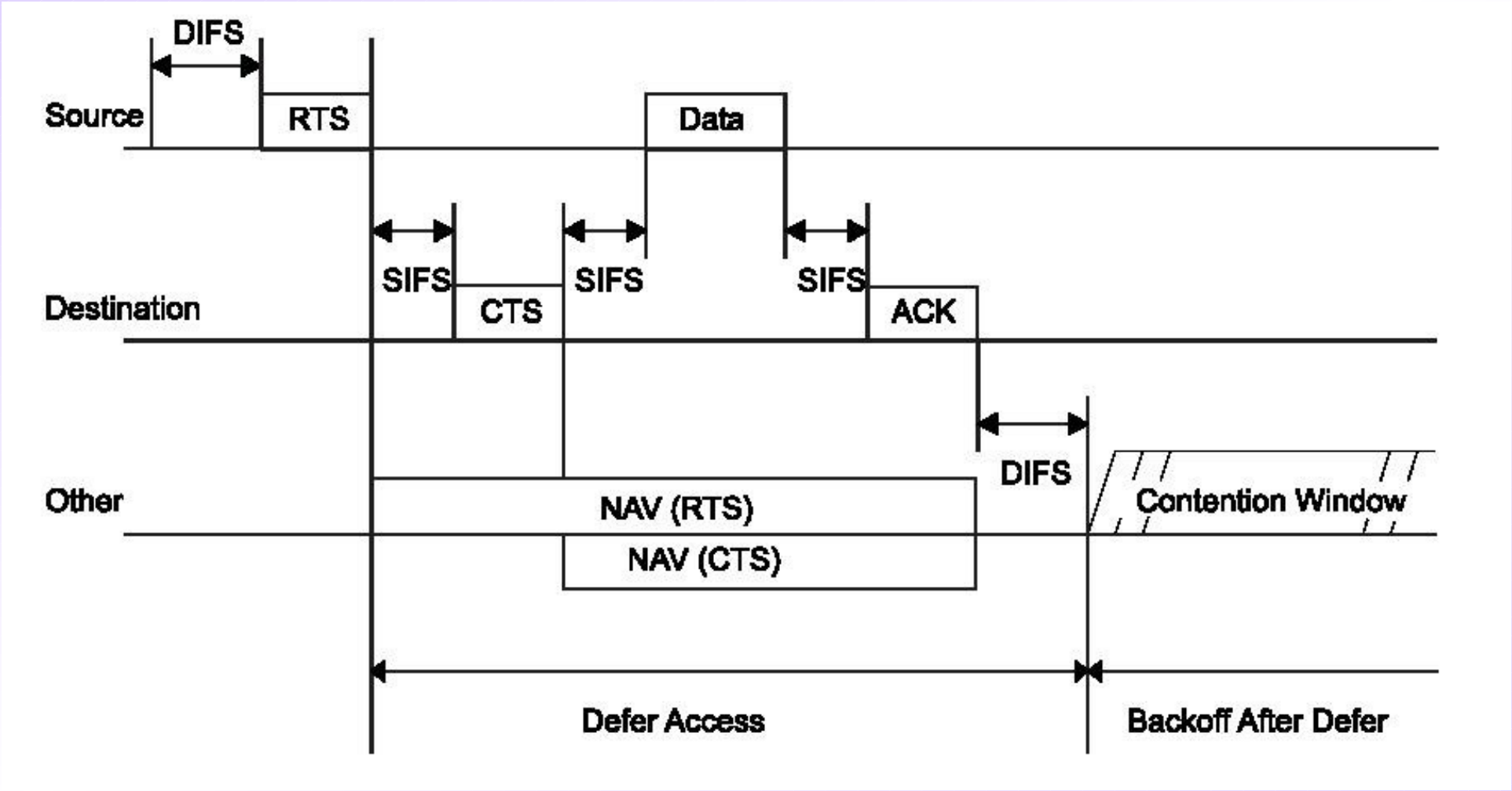


Medium is busy DOES NOT IMPLY not-ok-to-transmit

Hidden Node Solution: RTS/CTS

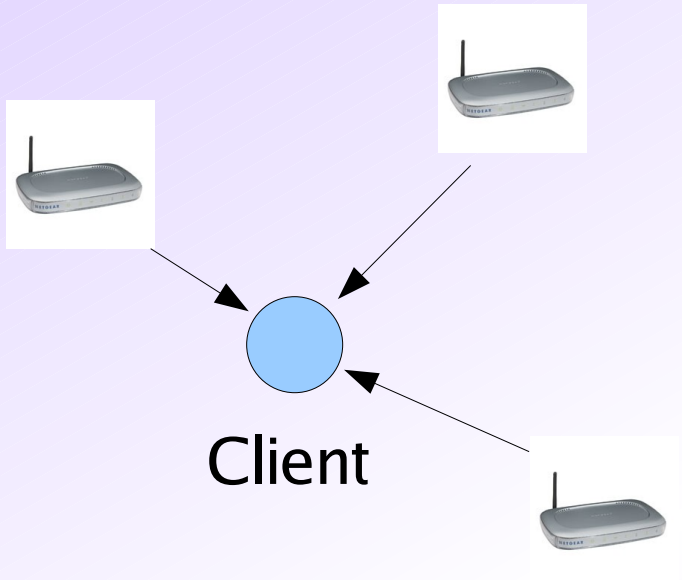


RTS/CTS Exchange Example



Source: IEEE 802.11 Specification

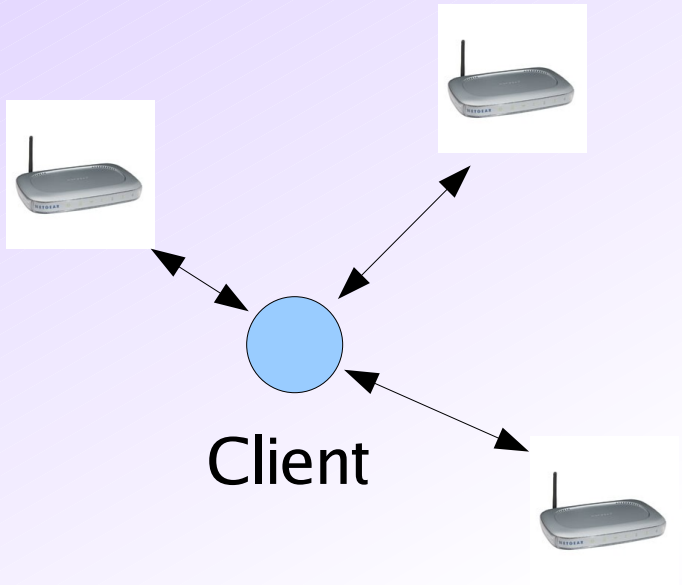
Beacons and Probes



Beacon has: AP capabilities, beacon period, SSID, Traffic Indication Map (TIM)

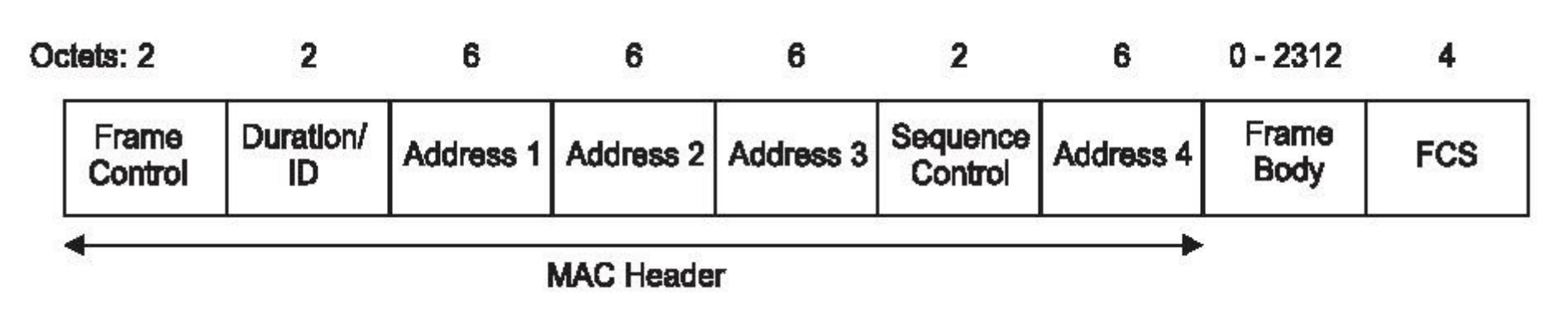
- A client may be in the coverage area of many APs
- APs send periodic beacons
- Client may passively scan these
- Or, probe-response for active scanning

Authentication and Association

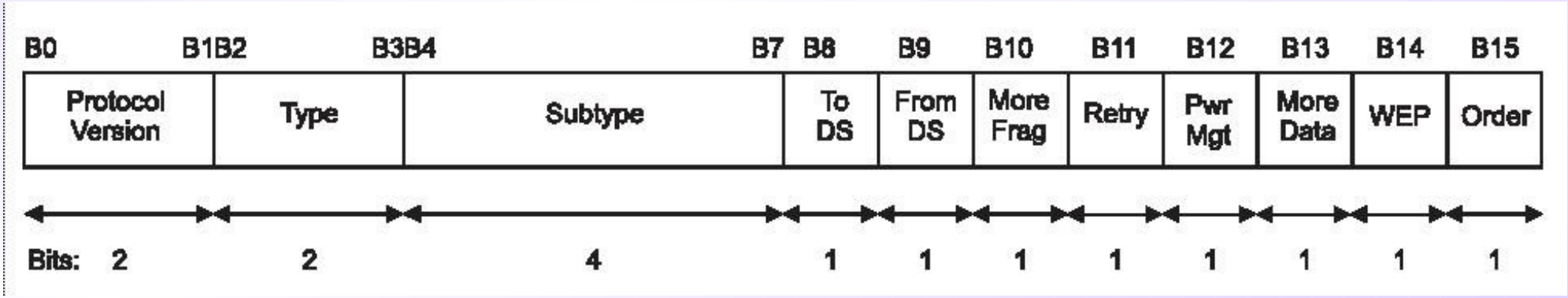


- A client has to
  - Authenticate itself to an AP
  - Then Associate itself
- A client may authenticate itself to many APs to speed-up roaming

802.11 Frame Format



Source: IEEE 802.11 Specification



Source: IEEE 802.11 Specification

Throughput estimation in 802.11

- PLCP preamble + header: 24 bytes
- RTS: 20 bytes, CTS: 14 bytes
- MAC header: 28 or 34 bytes
- IP header: 20 bytes
- TCP header: 20 bytes
- UDP header: 8 bytes
- Bottomline: too much per-packet overhead!

802.11 Alphabet Soup

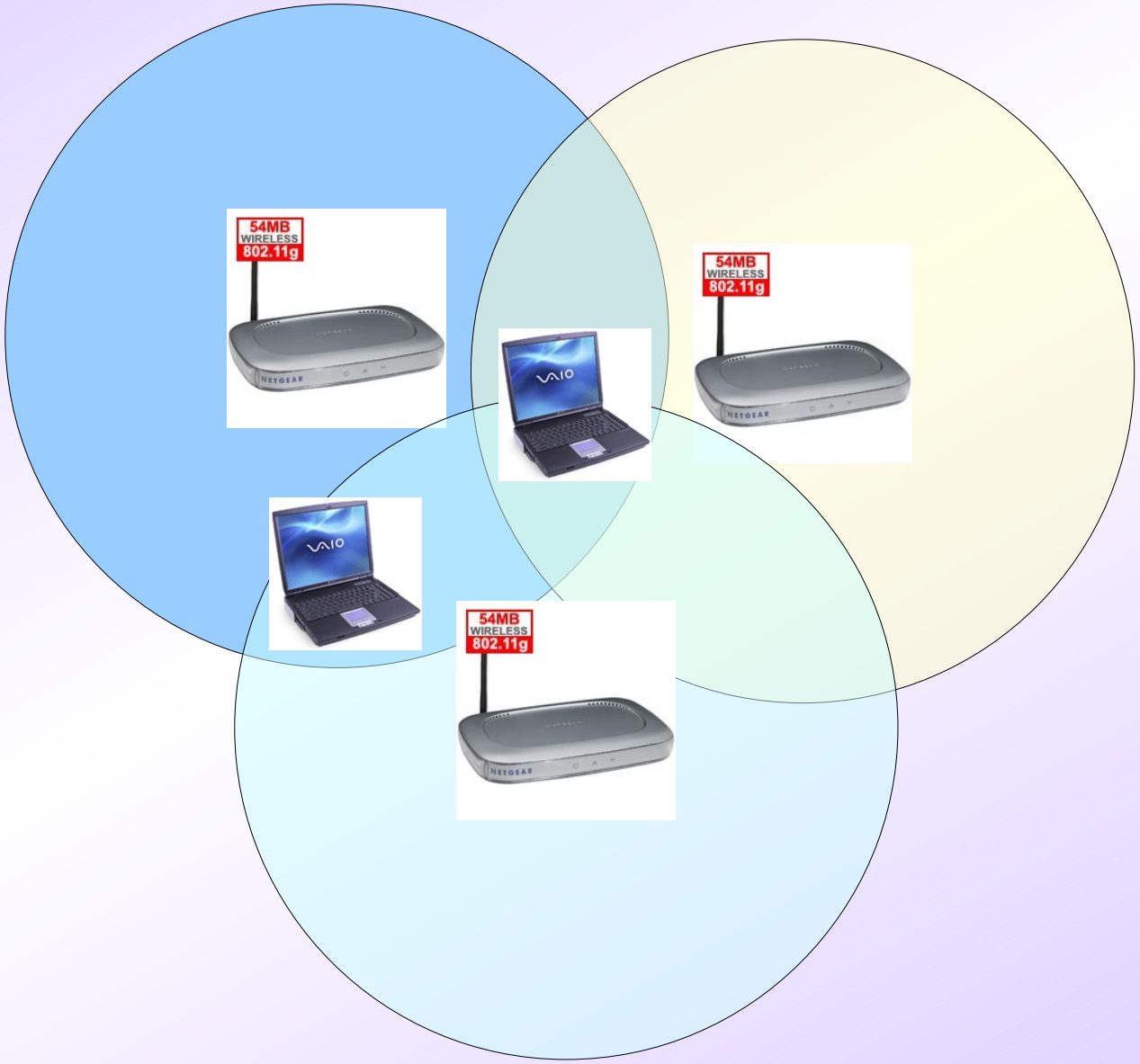
WLAN "Alphabet Soup": IEEE 802.11 Standards Activities

Cisco.com

- 802.11a: 5 GHz, 54 Mbps
- 802.11b: 2.4 GHz, 11 Mbps
- 802.11d: Multiple regulatory domains
- 802.11e: Quality of Service (QoS)
- 802.11f: Inter-Access Point Protocol (IAPP)
- 802.11g: 2.4 GHz, 54 Mbps
- 802.11h: Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC)
- 802.11i: Security
- 802.11j: Japan 5 GHz Channels (4.9-5.1 GHz)
- 802.11k: Measurement
- 802.11m: Maintenance
- 802.11n: High-Speed

Source: Cisco presentation

802.11 Enterprise Deployment



Community Networks

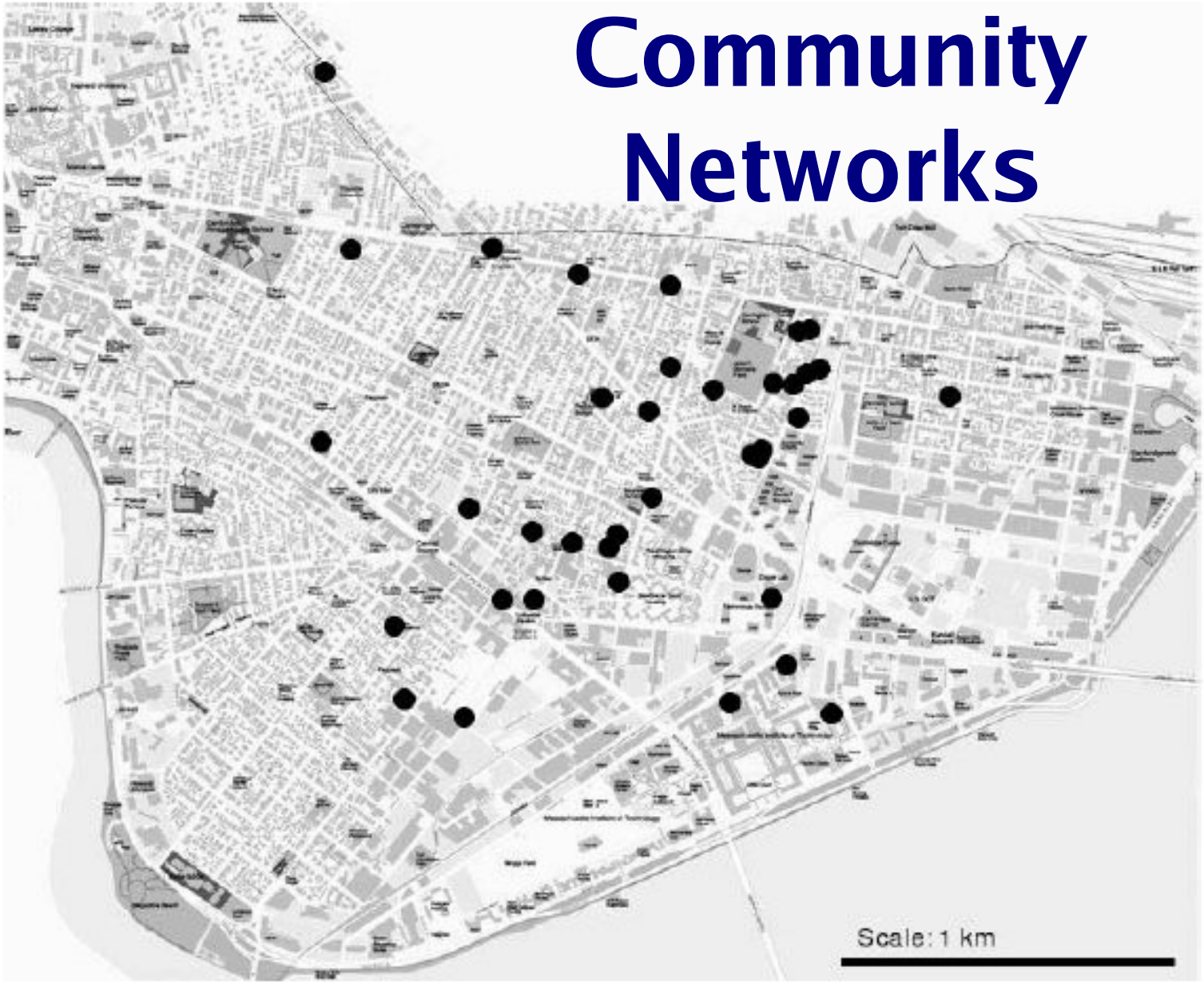
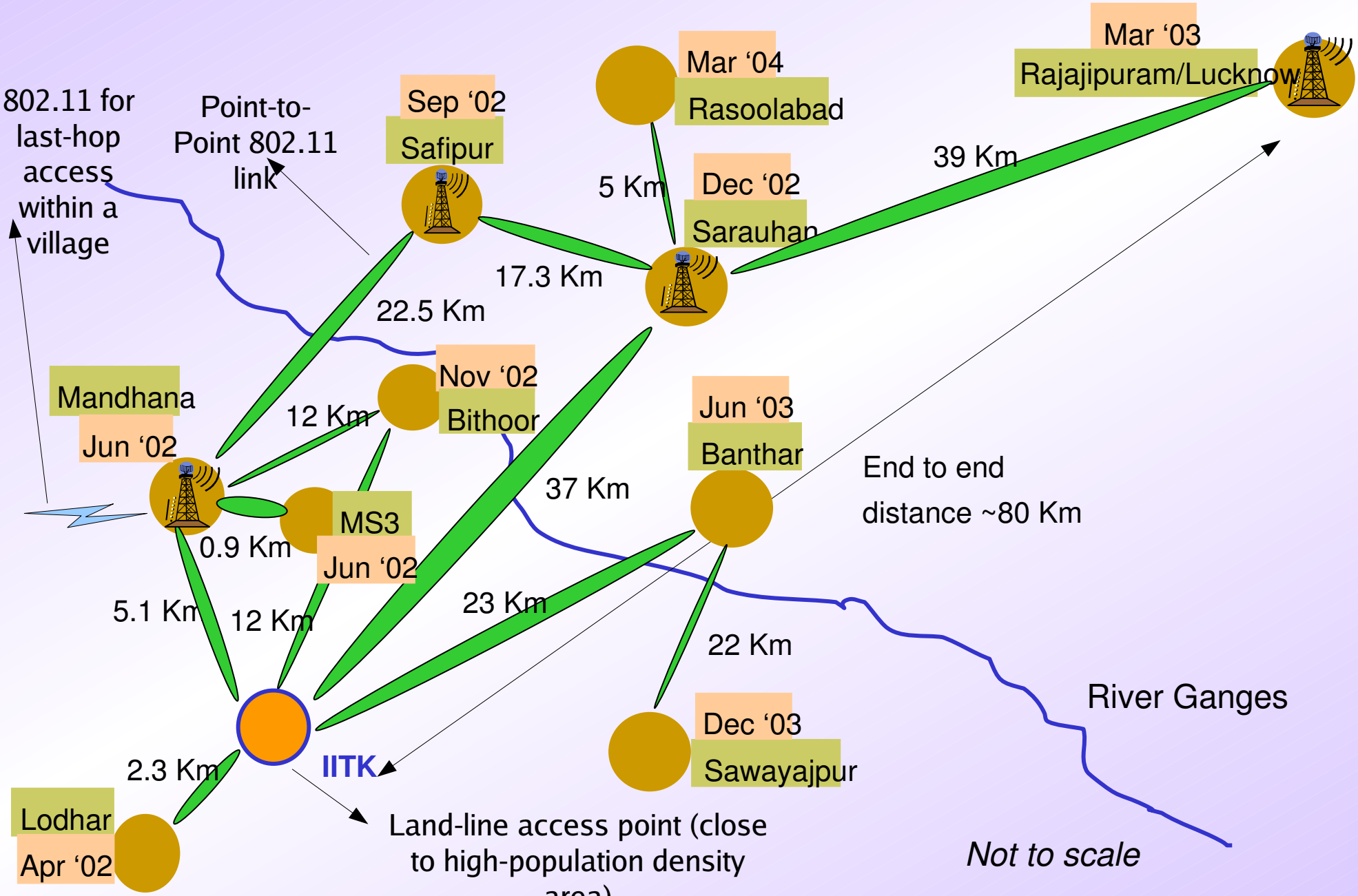


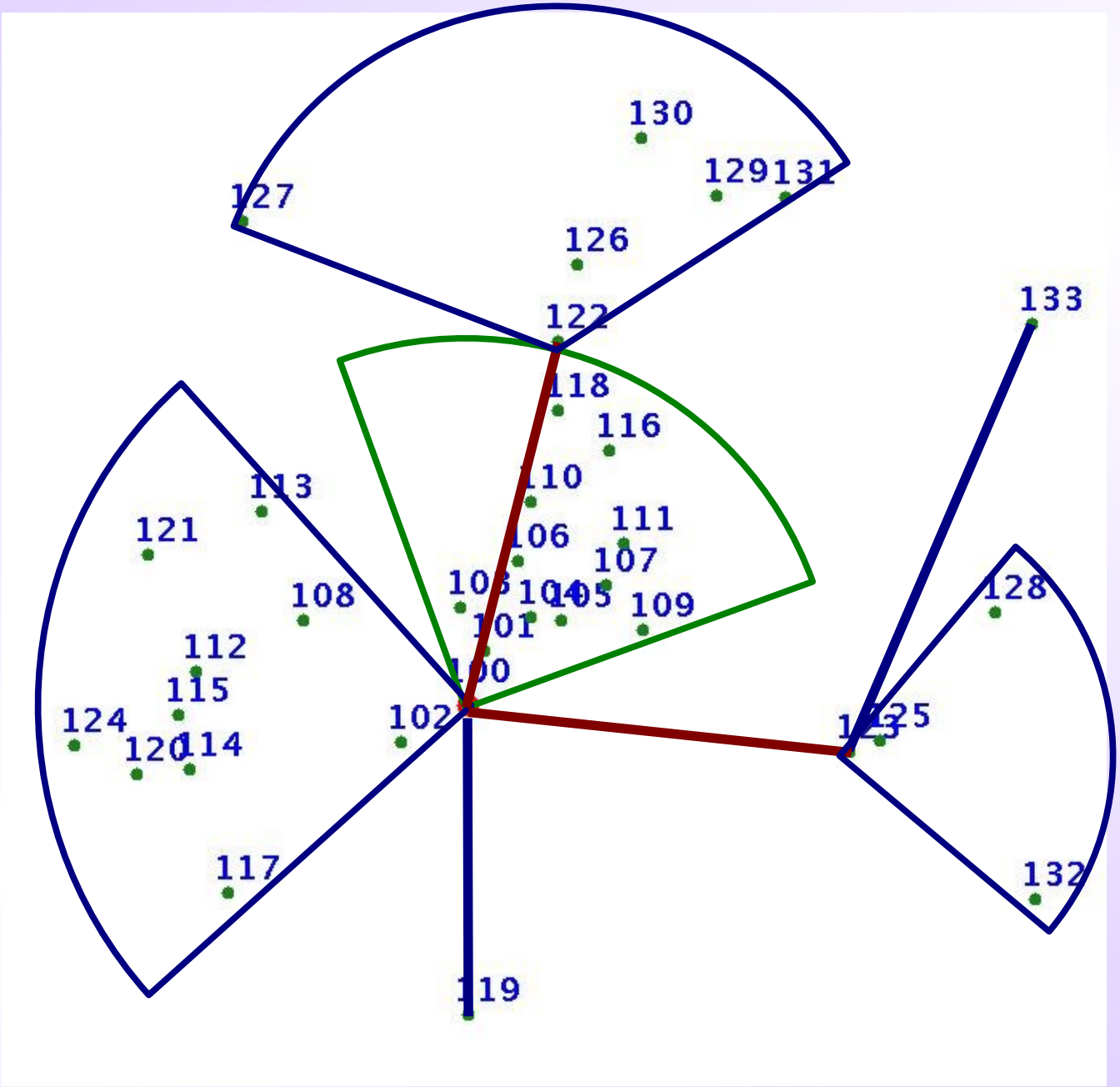
Figure 2: A map of Roofnet, with a black dot for each of the 38 nodes that participated in the experiments presented in this paper.

Source: Roofnet SIGCOMM04 paper

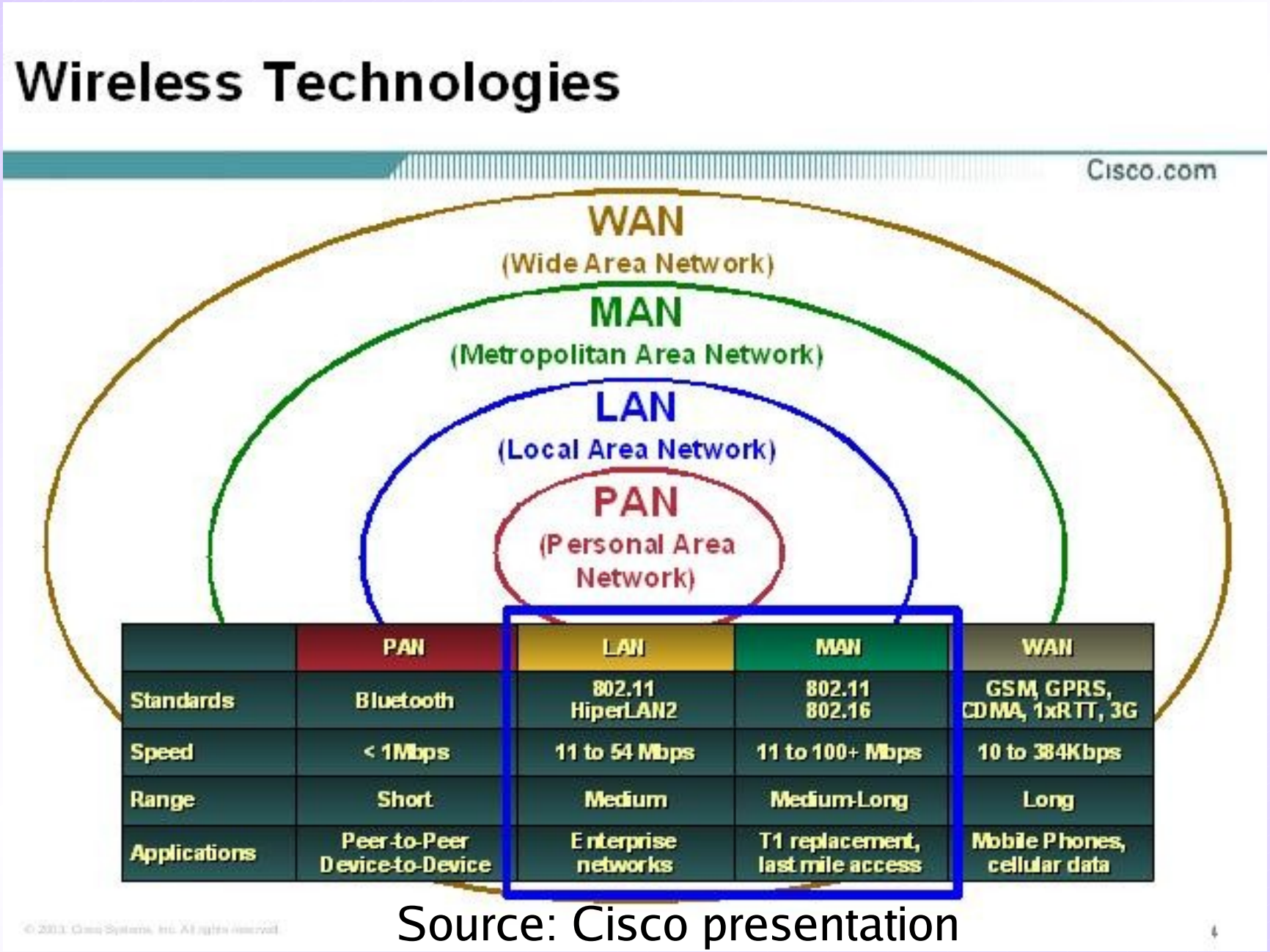
Long-Dist.: Digital Gangetic Plains



The Ashwini Network



Wireless Technologies



Source: Cisco presentation