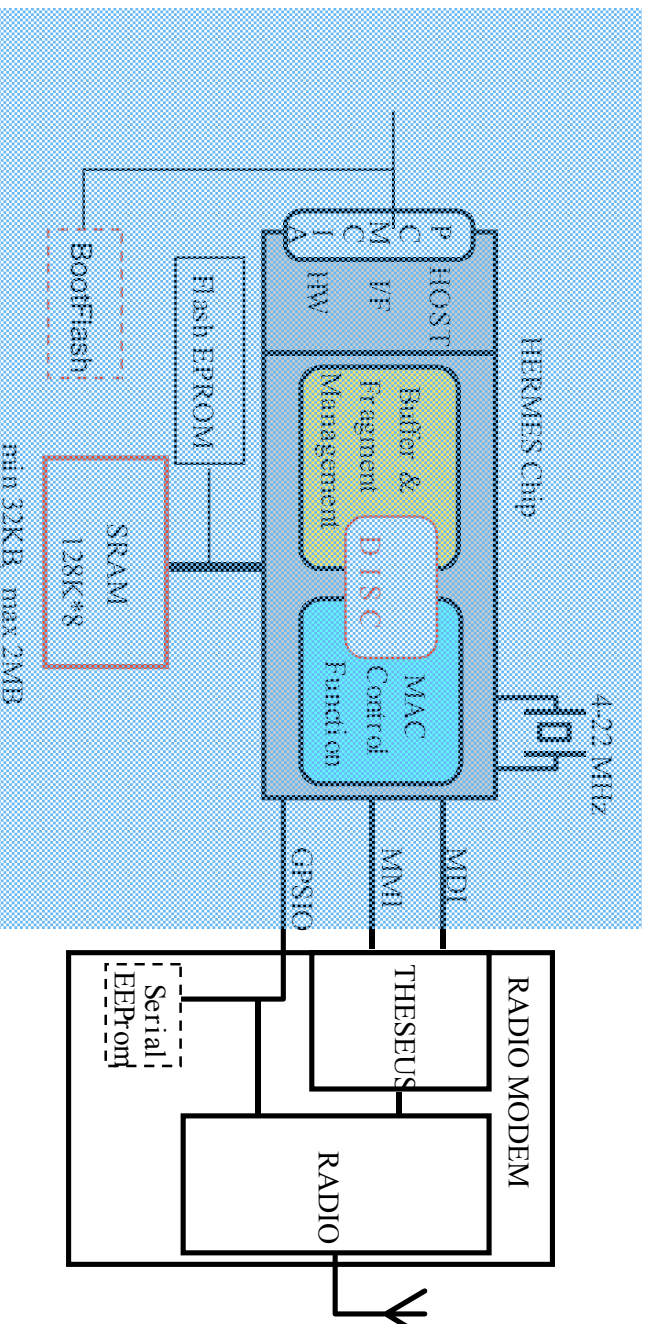


IEEE 802.11 MAC Functionality

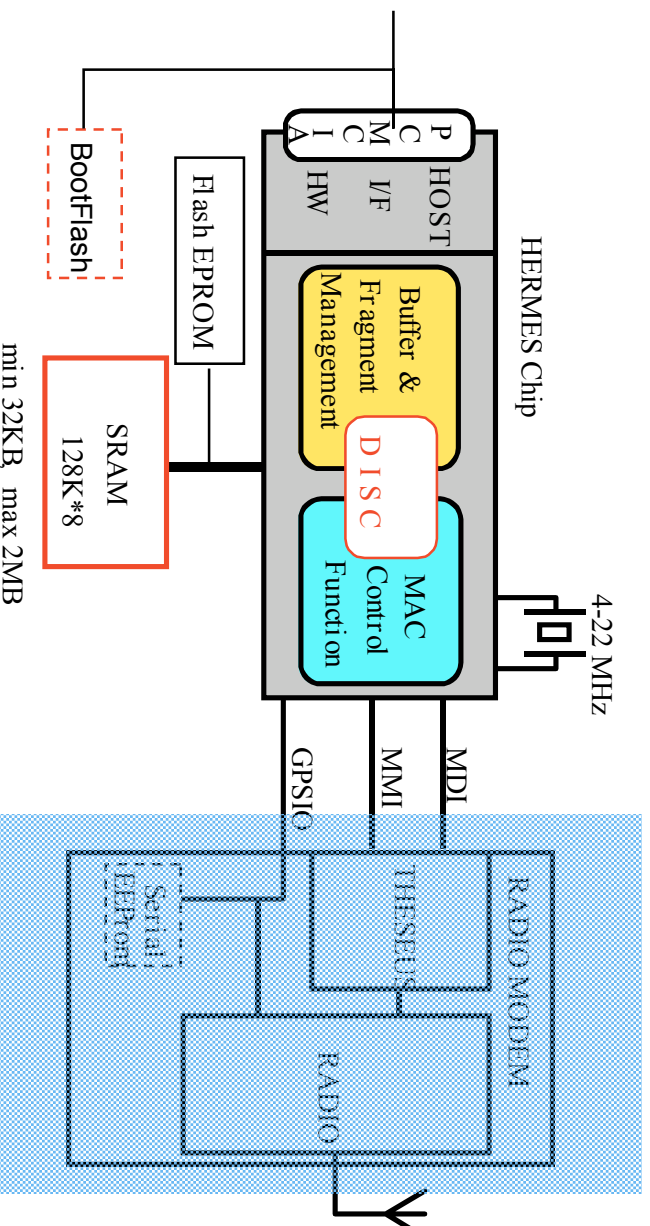
Avaya Wireless implementation of IEEE 802.11

- ★ Digital Signal Processor (Theseus)
- ★ IEEE 802.11 MAC chip (Hermes)



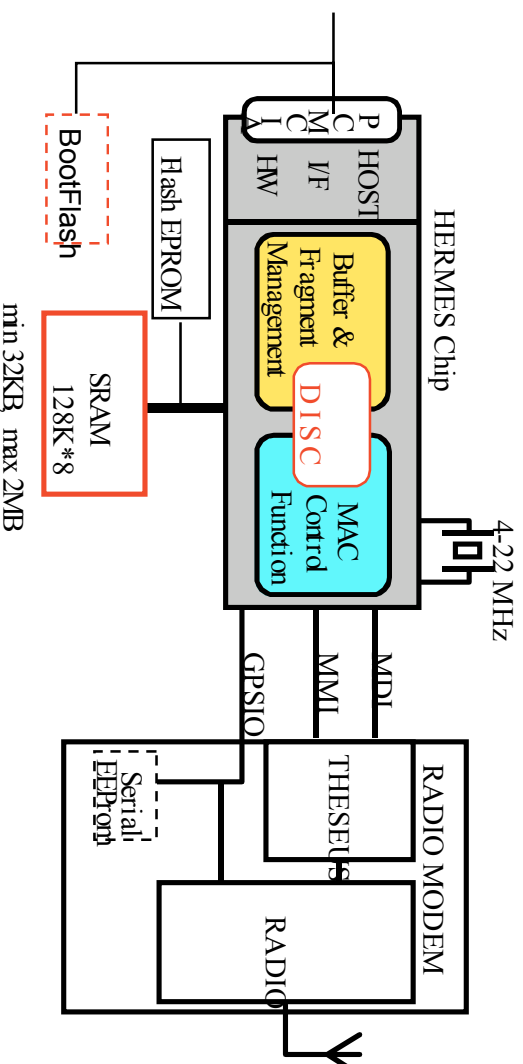
Avaya Wireless implementation of IEEE 802.11

- ★ Digital Signal Processor (Theseus)
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Avaya Wireless implementation of IEEE 802.11

- ★ Protocol functions programmed in FW, so flexible.
- ★ For use in station and access points (additional FW loaded when operating as access point)
- ★ Functions can be added over time, via upgrade utilities



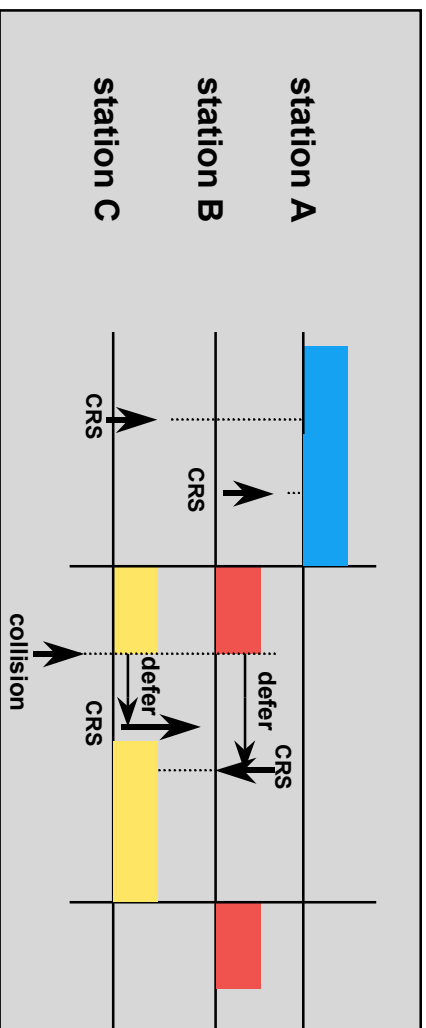


IEEE 802.11 features

★ ACK protocol

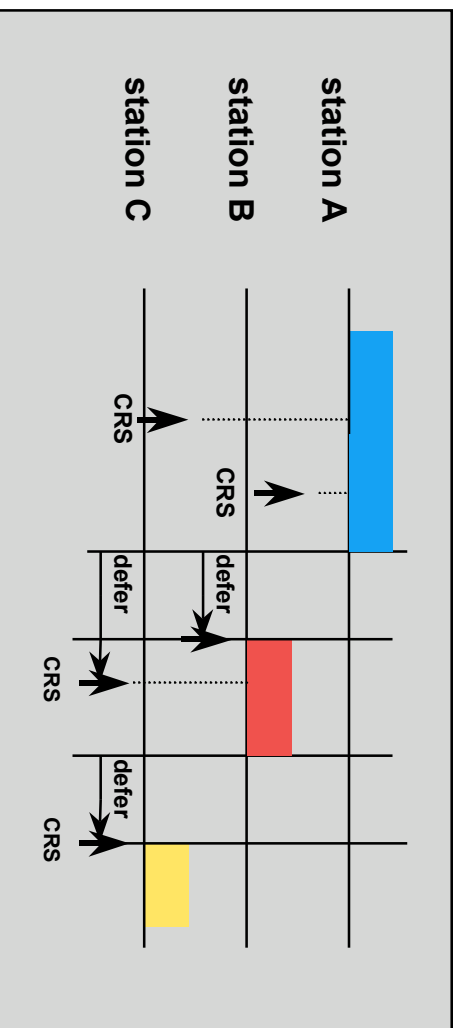
- ★ Medium reservation (RTS/CTS)
- ★ Fragmentation
- ★ Multi-channel roaming
- ★ Automatic data-rate fall-back
- ★ Cell size / Multi-rate applications
- ★ In-cell relay
- ★ Power Management
- ★ Wired Equivalent Privacy (WEP)
- ★ Wireless Distribution System (WDS)

Accessing the medium CSMA/CD



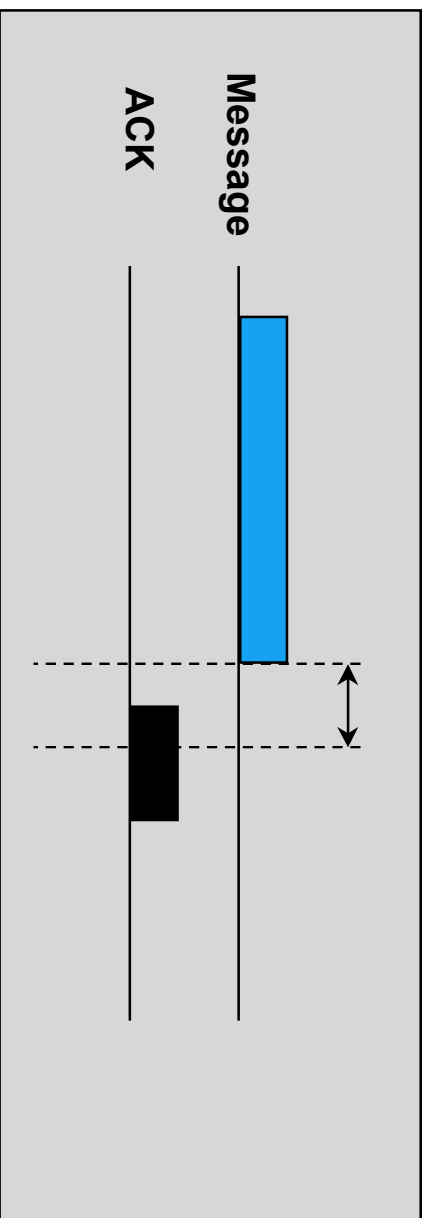
- ★ Adapters that can detect collisions (e.g. Ethernet adapters)
 - ★ Carrier Sensing: listen to the media to determine if it is free
 - ★ Initiate transmission as soon as carrier drops
 - ★ When collision is detected station defers
 - ★ When defer timer expires: repeat carrier sensing and start transmission

Accessing the medium CSMA/CA




- ★ Wireless LAN adapters cannot detect collisions:
- ★ Carrier Sensing - listen to the media to determine if it is free
- ★ Collision Avoidance - minimize chance for collision by starting (random) back-off timer, when medium is sensed free, and prior to transmission

CSMA/CA with MAC - level Acknowledgment



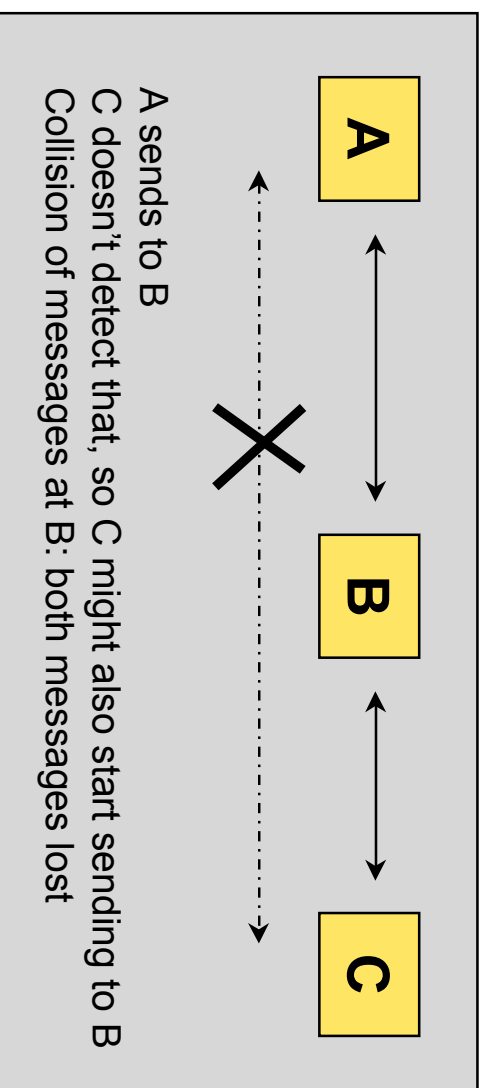
- ★ Collisions still can occur (interference; incapability of sensing other carrier)
- ★ IEEE 802.11 defines “low-level” ACK protocol
- ★ Provides faster error recovery
- ★ Makes presence of high level error recovery less critical




IEEE 802.11 features

- ★ ACK protocol
- ★ **Medium reservation (RTS/CTS)**
- ★ Fragmentation
- ★ Multi-channel roaming
- ★ Automatic data-rate fall-back
- ★ Cell size / Multi-rate applications
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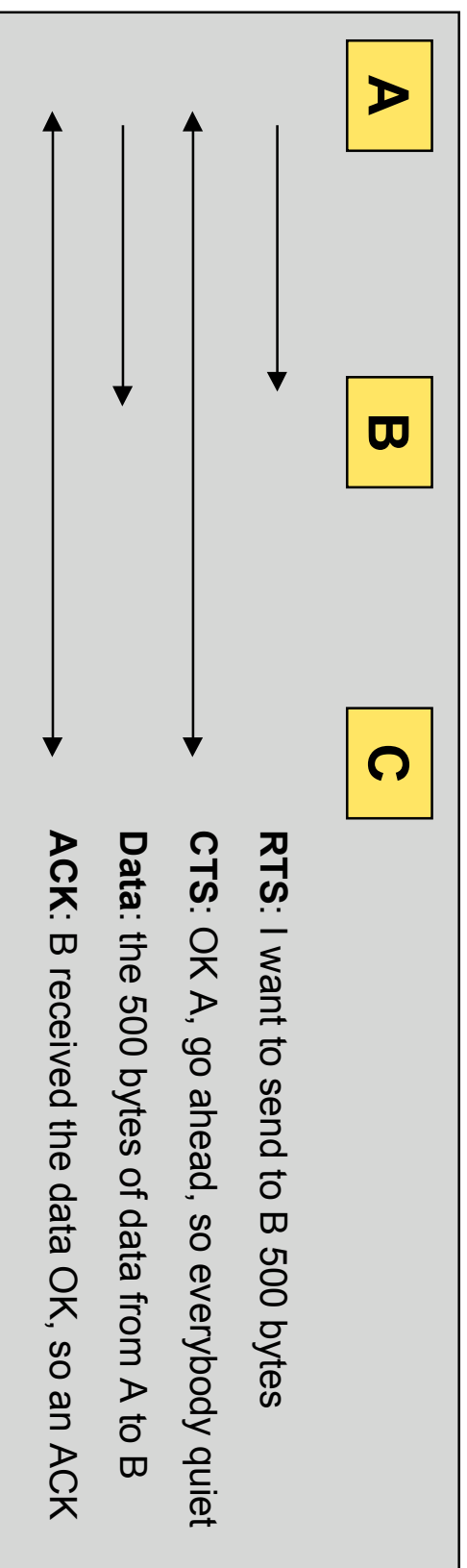
“Hidden stations” the problem



- ★ Situation that occurs in larger cells (typical outdoor)
- ★ Loss of performance
- ★ Error recovery required



“Hidden stations” the solution



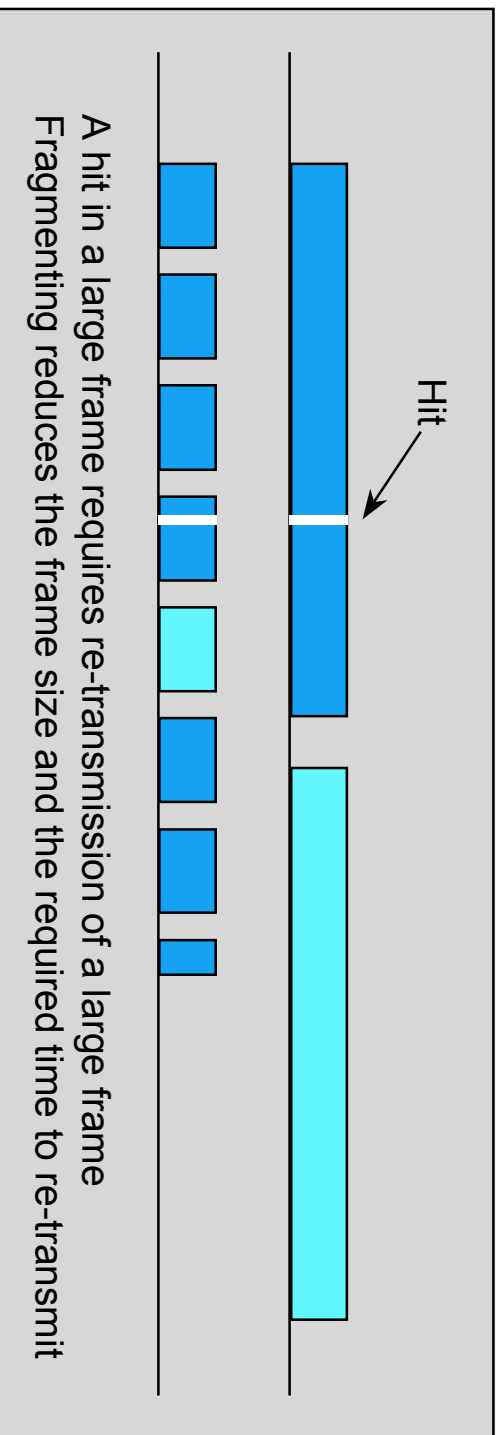
- ★ IEEE 802.11 defines:
 - ★ MAC level RTS/CTS protocol (Request to Send / Clear to Send)
 - ★ Can be switched off to reduce overhead (when no hidden nodes exist)
 - ★ More robustness, and increased reliability
 - ★ No interruptions when large files are transmitted



IEEE 802.11 features

- ★ ACK protocol
- ★ Medium reservation (RTS/CTS)
- ★ **Fragmentation**
- ★ Multi-channel roaming
- ★ Automatic data-rate fall-back
- ★ Cell size / Multi-rate applications
- ★ In-cell relay
- ★ Power Management
- ★ Wired Equivalent Privacy (WEP)
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Message fragmentation



- ★ IEEE 802.11 defines:
 - ★ MAC level function to transmit large messages as smaller frames (user definable)
 - ★ Improves performance in RF polluted environments
 - ★ Can be switched off to avoid the overhead in RF clean environments



IEEE 802.11 features

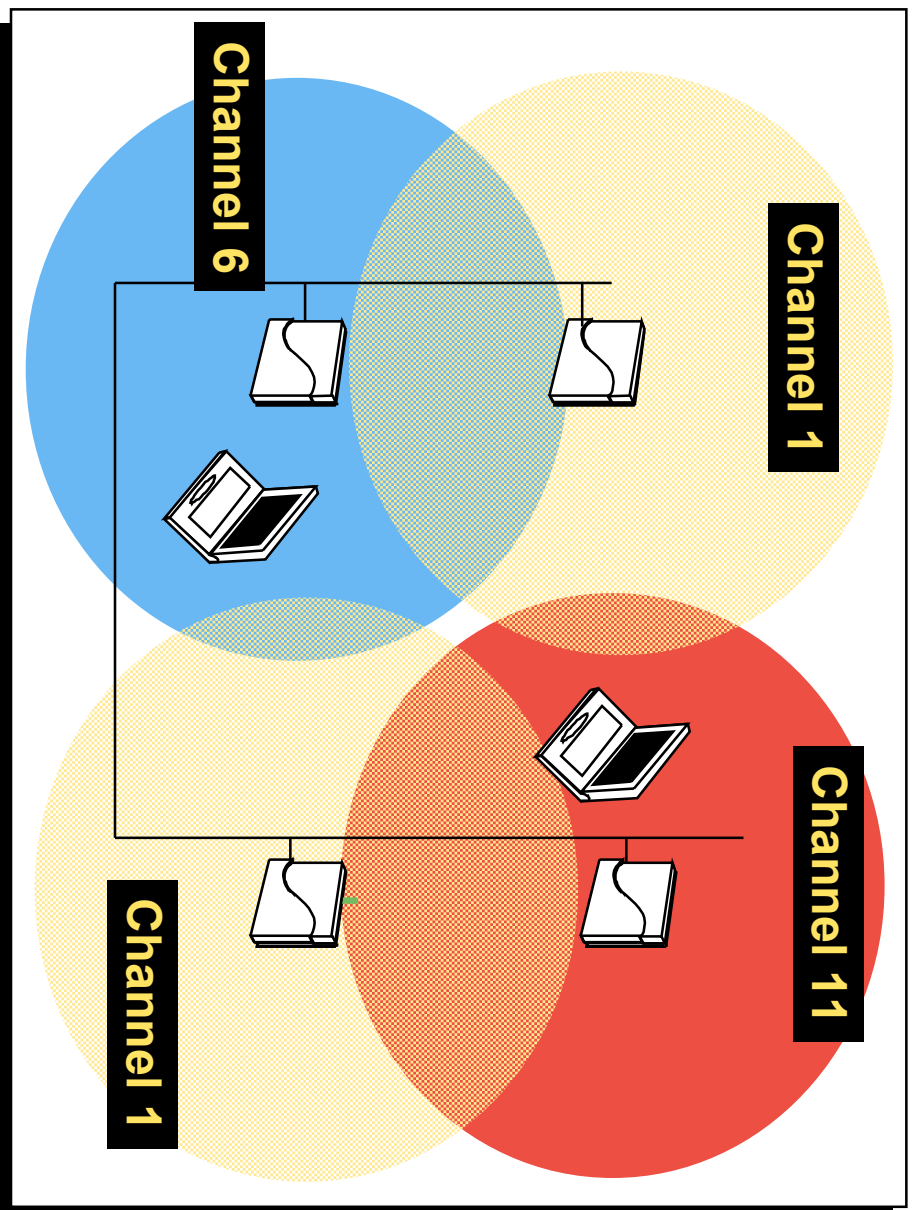
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- ★ **Multi-channel roaming**
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- ★ Power Management
- ★ Wired Equivalent Privacy (WEP)
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Multi-channel roaming

- ★ Avaya Wireless IEEE 802.11 systems, support multi-channel roaming
 - ★ Access points are set to a fixed frequency
 - ★ Stations do not need to be configured for a fixed frequency
 - ★ Stations switch frequency when roaming between access points
 - ★ Stations “associate” dynamically to the access point with best signal, on power on
- ★ This implies
 - ★ Easier configuration
 - ★ Faster installation

Multi-channel roaming





IEEE 802.11 features

- ★ ACK protocol
- ★ Medium reservation (RTS/CTS)
- ★ Fragmentation
- ★ Multi-channel roaming
- ★ **Automatic data-rate fall-back**
- ★ Cell size / Multi-rate applications
- ★ In-cell relay
- ★ Power Management
- ★ Wired Equivalent Privacy (WEP)
- ★ Wireless Distribution System (WDS)



Automatic rate select

- ★ **Avaya Wireless PC Card, dynamically switches data-rate**
 - ★ Fall back to lower data-rate when communications quality decreases
 - out of range situations
 - Interference
 - ★ Fall-back scheme:
 - 11 Mbps, 5.5 Mbps, 2 Mbps, 1 Mbps
- ★ **This implies**
 - ★ Operating at larger distances
 - ★ Robustness in RF polluted areas



Automatic rate select

- ★ **Avaya Wireless PC Card in AP-1000 and AP-500 is capable of supporting different data-rates “simultaneously”:**
 - ★ e.g. operates at “High” speed in communication to nearby station and at “Low” speed to station that is further away.
- ★ **Data rate capability is maintained in “station association table”**
- ★ **Speed of IEEE Management - and Control frames use fixed speed determined as “IEEE Basic Rates”, and controlled by “Multi-cast Rate parameter”.**



IEEE 802.11 features

- ★ ACK protocol
- ★ Medium reservation (RTS/CTS)
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- ★ **Cell size / Multi-rate applications**
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Cell size / Multi Rate applications

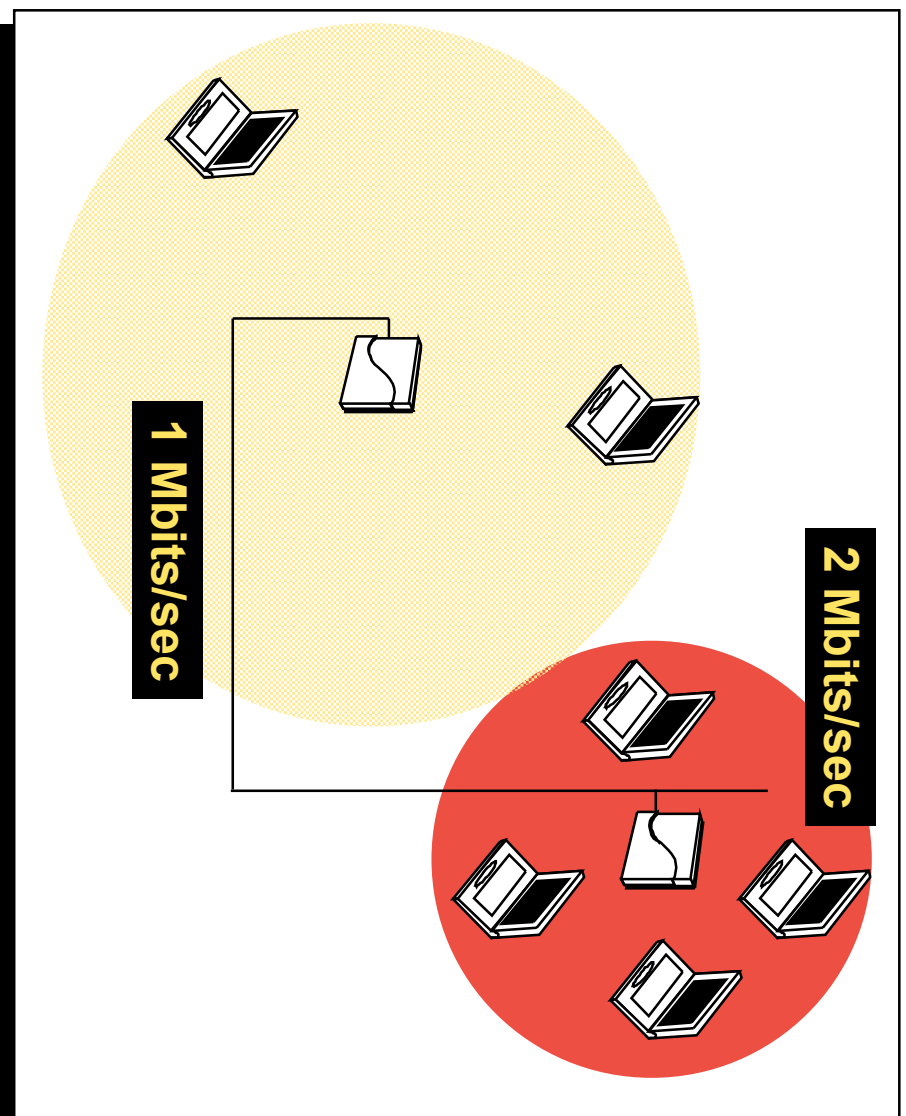
- ★ Cell-size can be influenced by “Distance between APs” parameter:
 - ★ Distance between APs = Large -> large cell
 - ★ Distance between APs = Medium -> medium size cell
 - ★ Distance between APs = Small -> small cell
- ★ Cell-size influences capacity per station in the cell
 - ★ small cell physically accommodates smaller number of stations than large cell
 - ★ bandwidth per station in small cell greater than in large cell
- ★ Cell size influences data-rate
 - ★ larger distance between station and access-point may lead to lower data-rate



Cell size / Multi Rate applications

- ★ Mixture of cell-sizes accommodate mixed applications:
 - ★ Office workers:
 - High physical station density
 - High bandwidth requirement
 - Small cell operating at high data rate
 - Distance between APs is small
 - ★ Warehouse operations (such as forklift truck)
 - Low physical station density
 - Low bandwidth requirement (transaction processing)
 - Large cell operating at low data rate
 - Distance between APs is large

Multi Rate applications





IEEE 802.11 features

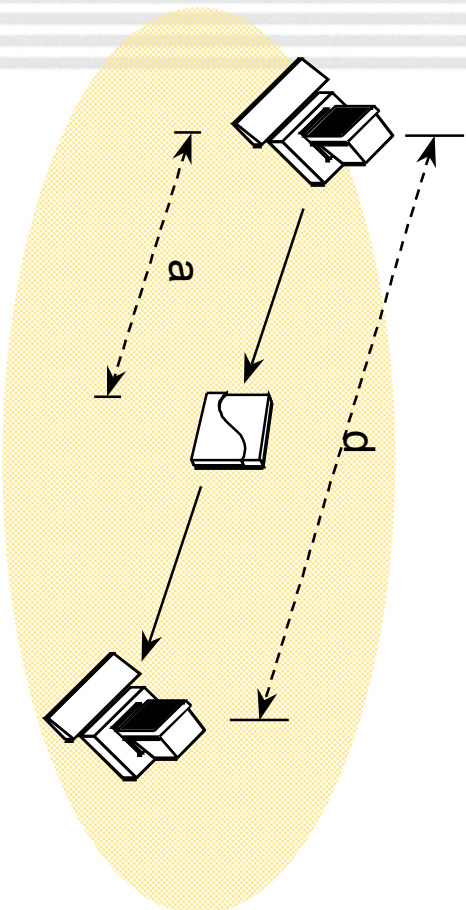
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In-cell Relay

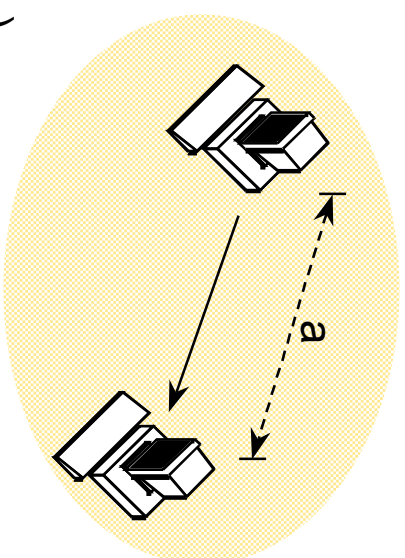
- ★ IEEE 802.11, in-cell relay:
 - ★ Single radio module when used in the AP-1000 or AP-500 acts as repeater
 - ★ Provides cells that are app. twice as large as with pre-IEEE wireless systems
 - ★ Communication flows via access-point so overall transmission time increases relative to pre-IEEE 802.11 (or direct station to station communication)
- ★ This implies:
 - ★ Larger cell size and consequently less need for access points and interconnecting infrastructure
 - ★ Reduced performance in peer to peer communication within one cell compared to pre-IEEE 802.11

In-cell Relay




In-cell relay:

Larger cell (diameter = $d > a$)
Lower throughput (data travels through air twice)



No in-cell relay:

Smaller cell (diameter = $a < d$)
Higher throughput (data travels through air once)



IEEE 802.11 features

- ★ ACK protocol
- ★ Medium reservation (RTS/CTS)
- ★ Fragmentation
- ★ Multi-channel roaming
- ★ Automatic data-rate fall-back
- ★ Cell size / Multi-rate applications
- ★ In-cell relay
- ★ **Power Management**
- ★ Wired Equivalent Privacy (WEP)
- ★ Wireless Distribution System (WDS)



Power Management

- ★ IEEE 802.11, supports power management:
 - ★ nothing to send: station in sleep mode
 - ★ out-bound traffic stored in Access Point (out-bound = from AP to STA)
 - ★ station wake up only for Traffic Information Map (TIM)
 - ★ if messages: stay awake to receive them
- ★ This implies:
 - ★ Prolonged battery life
 - ★ Increase usability in hand-held equipment
 - ★ Works best in application that have limited bandwidth requirements (transaction processing)



IEEE 802.11 features

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- ★ Power Management
- ★ **Wired Equivalent Privacy (WEP)**
- ★ Wireless Distribution System (WDS)



Wired Equivalent Privacy

- ★ Optional security functionality (factory “installed”)
- ★ Encryption based on RC4 (1988 RSA algorithm)
- ★ Stream cipher 64 or 128 bits key
- ★ Used by Netscape, Microsoft, Oracle and Lotus (80 million users)
- ★ Used for data encryption
- ★ Used for shared key station authentication



IEEE 802.11 features

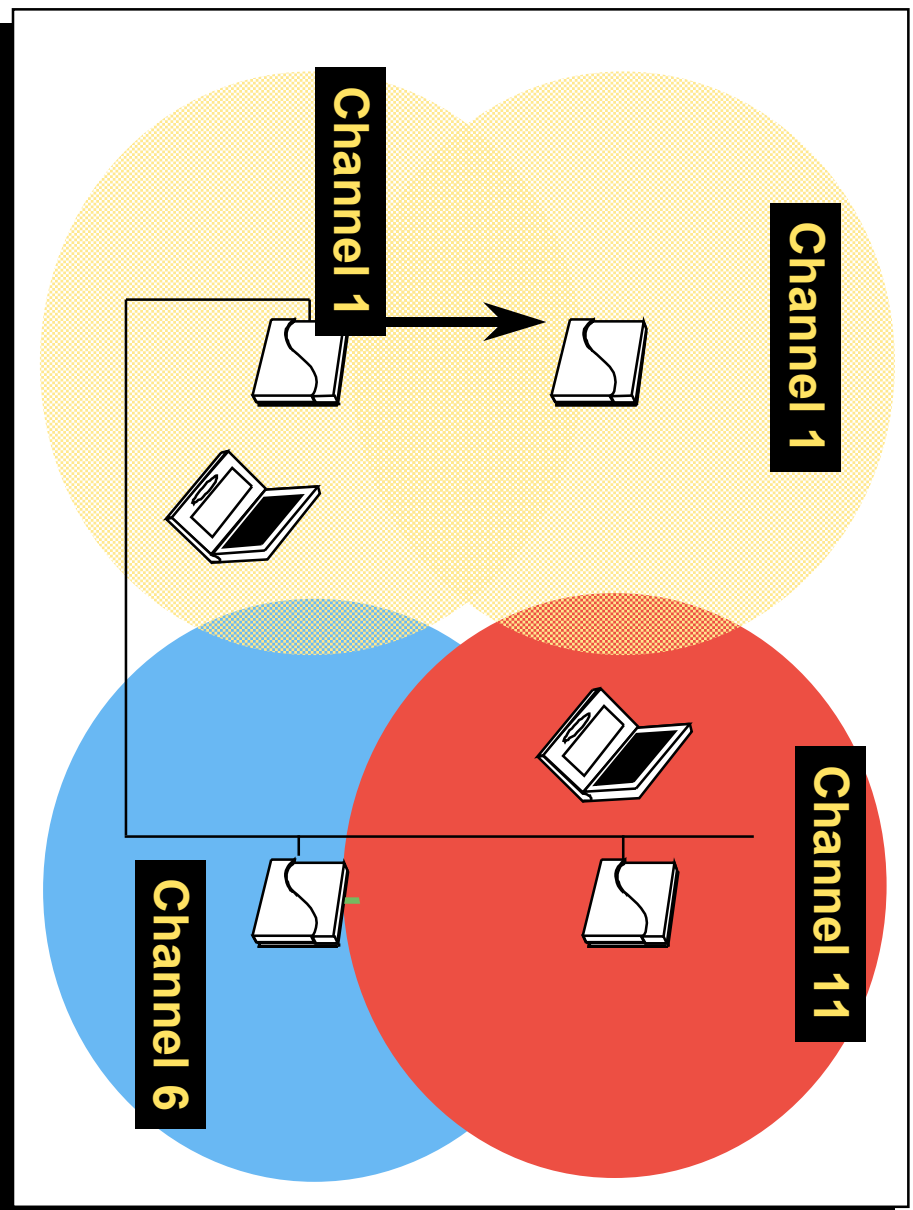
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- ★ Power Management
- ★ Wired Equivalent Privacy (WEP)
- ★ **Wireless Distribution System (WDS)**



Wireless Distribution System

- ★ IEEE 802.11, WDS means
 - ★ Multiple wireless “ports” inside the access-point, to wirelessly interconnect cells (access-points connecting to other access-points)
- ★ pre-IEEE 802.11, did not support WDS:
 - ★ Three ports exist in one access-point (one Ethernet, and two wireless cells)
 - ★ One wireless backbone extension can be made (using two radio modules in the access-point)
- ★ WDS allows:
 - ★ Extending the existing infrastructure with wireless backbone links
 - ★ Totally wireless system without any wired backbones, needed in locations where large areas are to be covered and wiring is not possible

Wireless Distribution System





IEEE 802.11 features

Module summary

- ★ ACK protocol
- ★ Medium reservation (RTS/CTS)
- ★ Fragmentation
- ★ Multi-channel roaming
- ★ Automatic data-rate fall-back
- ★ Cell size / Multi-rate applications
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