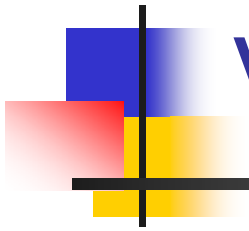
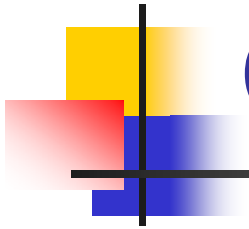
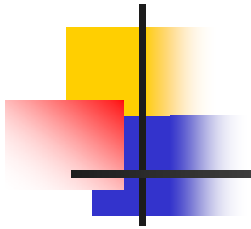


Voice over Wireless LAN



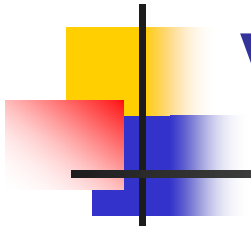
Outline

- Introduction to VoWLAN
- Wireless LAN Technology
- Why VoWLAN?
- VoWLAN Requirement
- VoWLAN Challenge
- Summary



Introduction to VoWLAN

- VoWLAN or Voice over Wireless Local Area Network expands the capability of WLANs or Wireless LANs
- VoWLAN is a natural extension of VoIP
- VoWLAN is the added feature that will enable you to make phone calls using this mobile Internet access

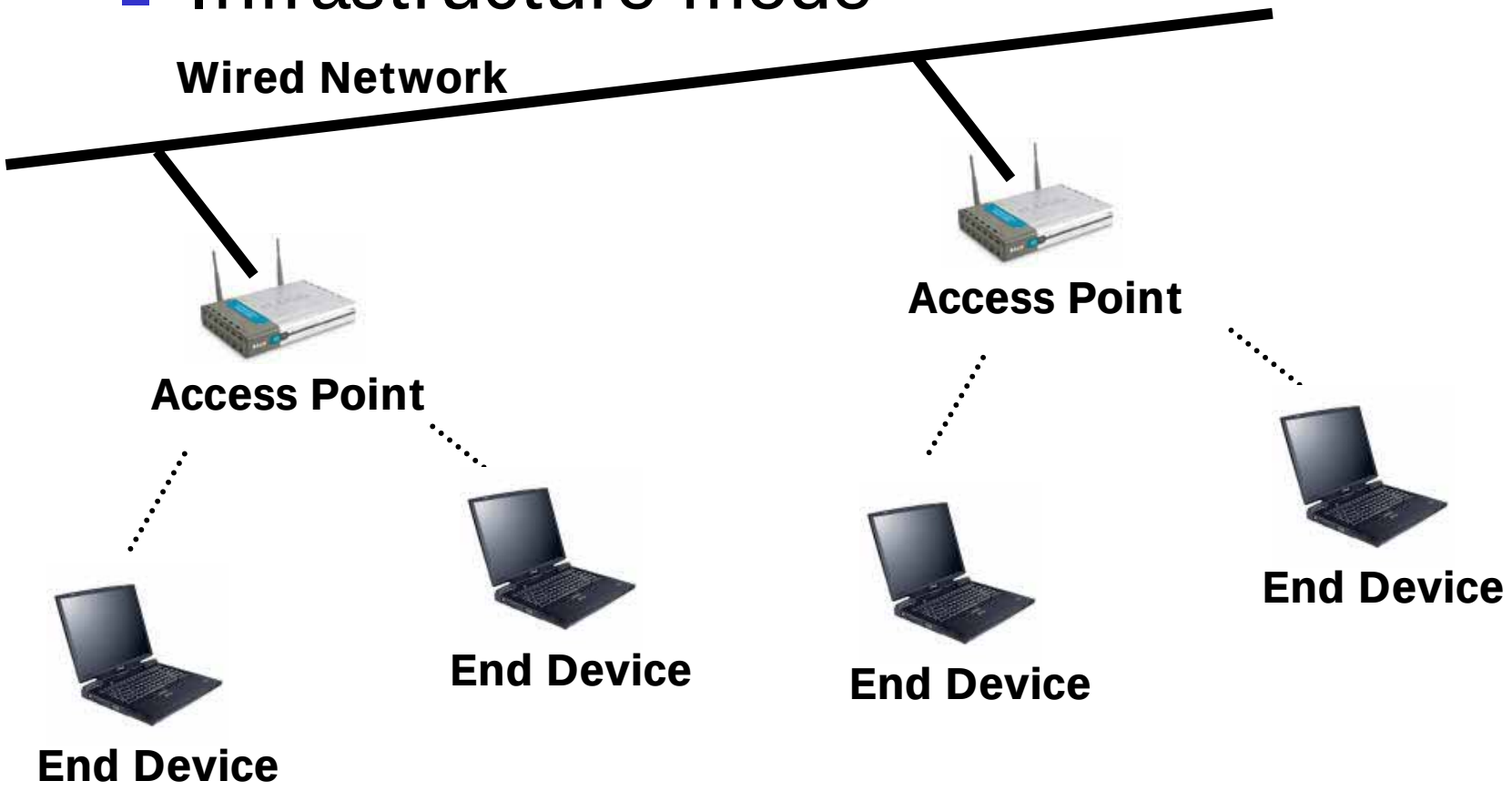


VoWLAN Technology

- VoIP + Wireless LAN
- VoIP
  - SIP, RTP, H.323
- Wireless LAN
  - WiFi : 802.11a/b/g
  - WiMAX : 802.16

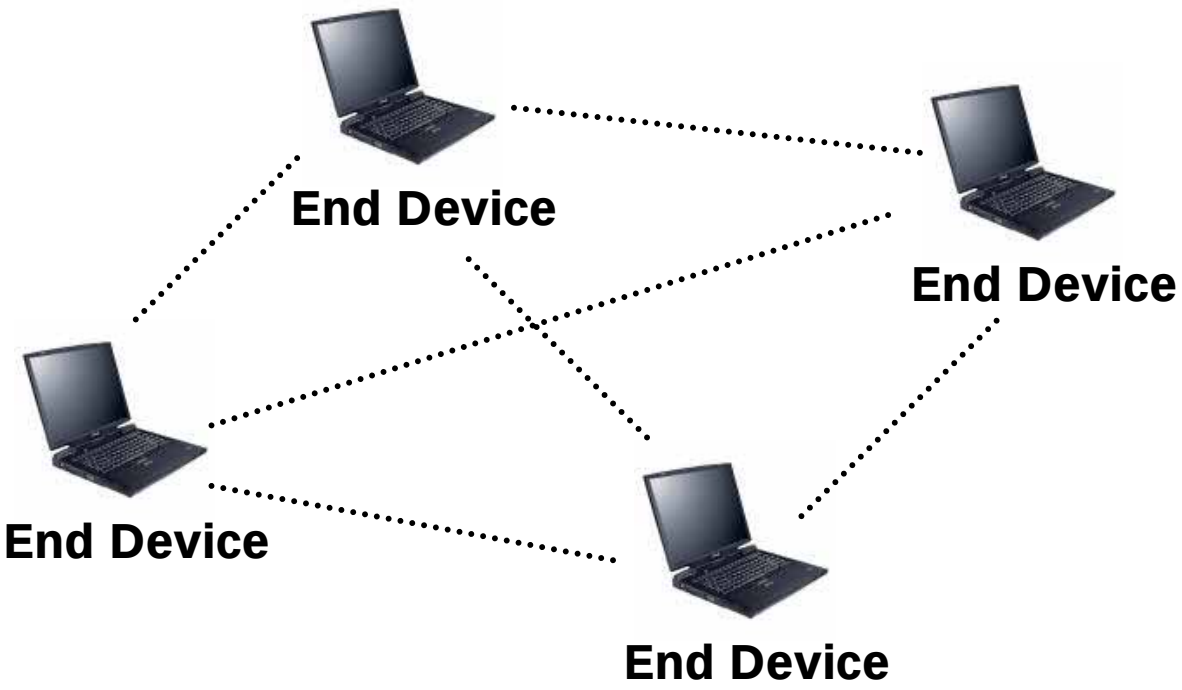
802.11 Overview

- Infrastructure mode



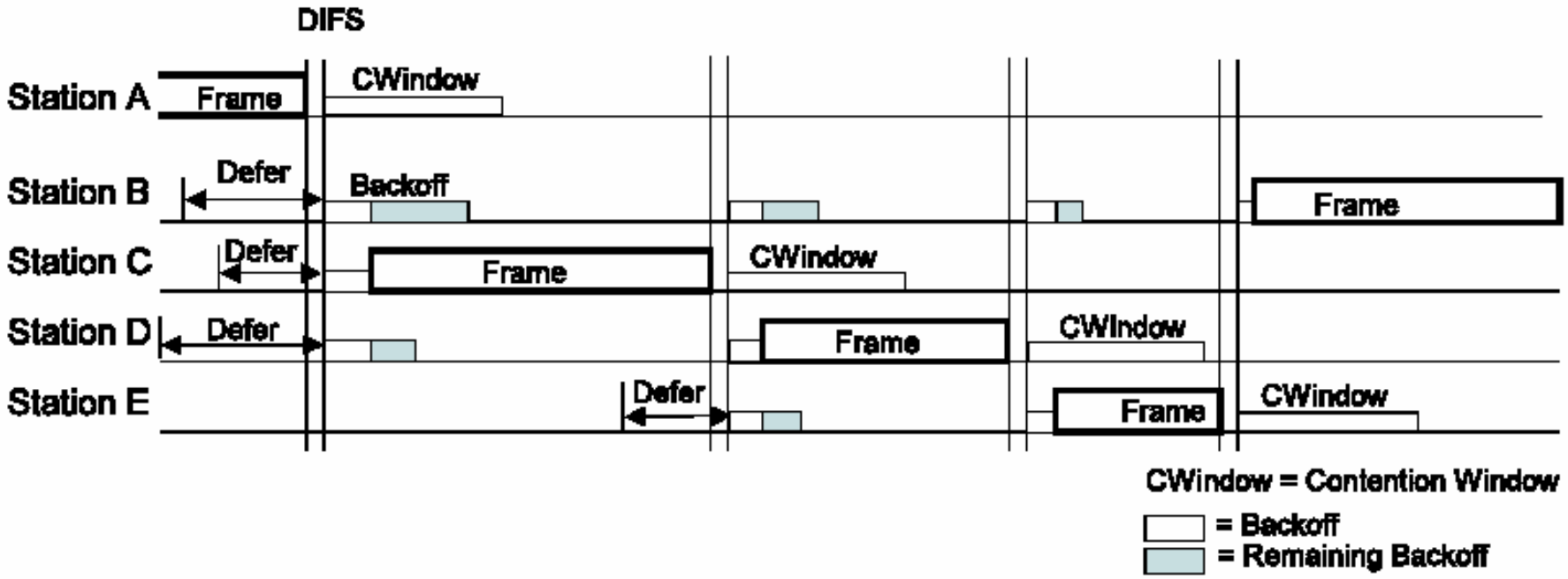
802.11 Overview

- adhoc mode



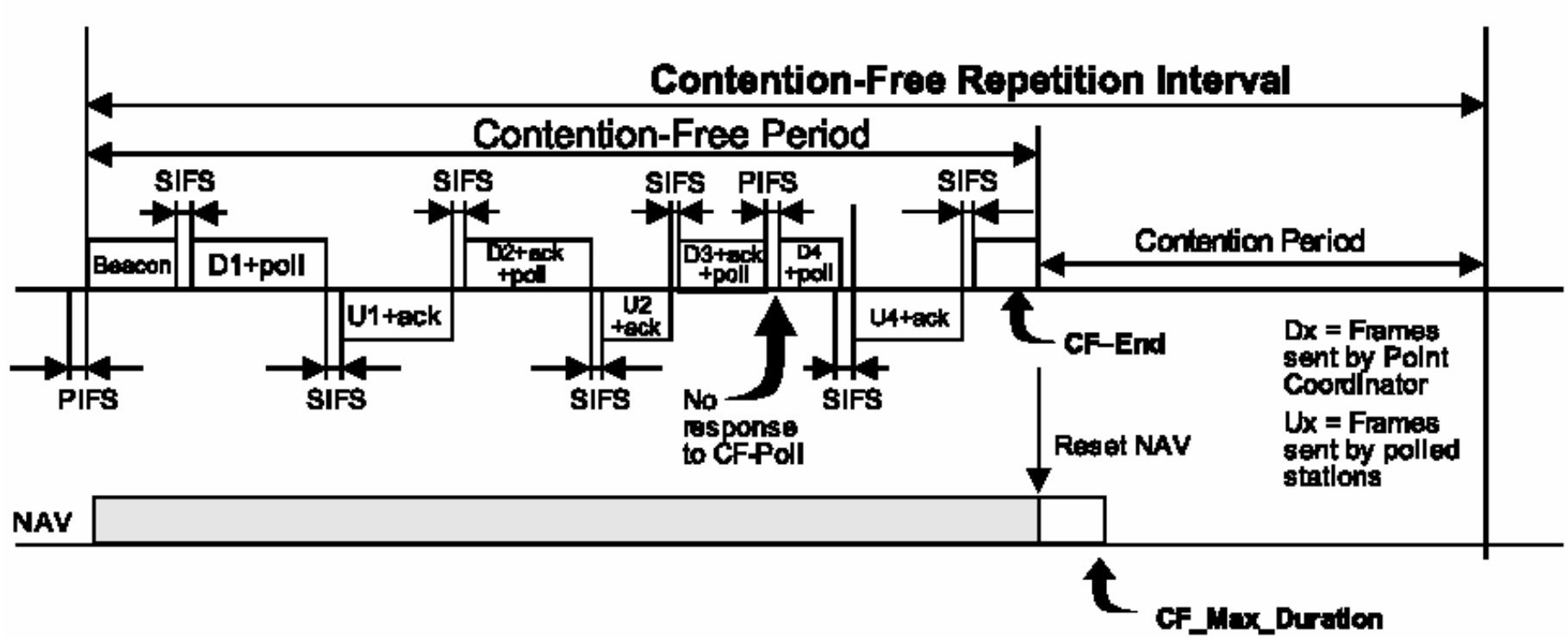
802.11 Overview

- DCF : Distributed Coordination Function
  - Contention-based MAC function



802.11 Overview

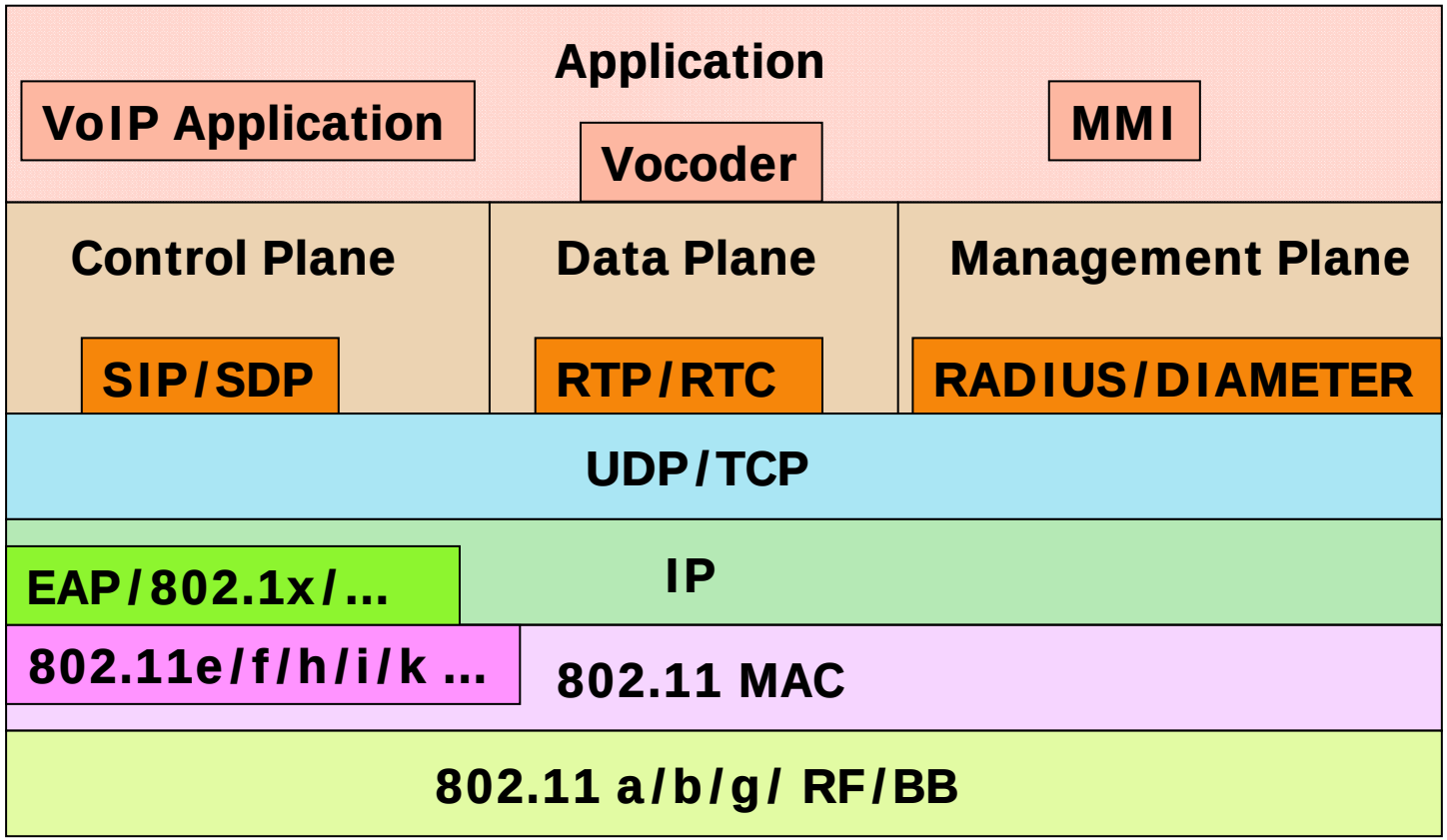
- PCF : Point Coordination Function
  - Contention-free MAC function

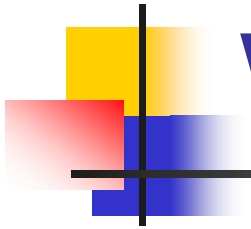


802.11 Overview

	802.11b	802.11a	802.11g	802.11b +
Raw Data Rates	11Mbps	54Mbps	54Mbps	22/44Mbps
Average Actual throughput	4~5Mbps	27Mbps	20~25Mbps	6 Mbps
Frequency	2.4GHz	5GHz	2.4GHz	2.4GHz
Available Spectrum	83.5MHz	300MHz	83.5MHz	83.5MHz
Modulation Encoding	DSSS/CCK	OFDM	OFDM	PBCC
Channels/non-overlapping	11/3	12/8	11/3	11/3

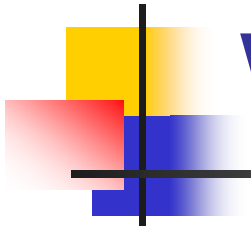
WiFi Phone protocol stack





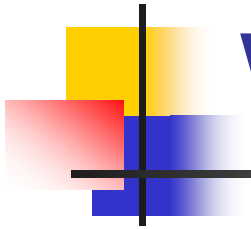
Why VoWLAN

- Low cost
  - Free Charge of ISM Band
    - ISM band : free (2.4-2.4835 GHz)
    - 3G band : NTD 10 Billion
  - Inexpensive network deployment
    - Reuse of existing network, easy to setup
    - Low cost of Access Point VS. High cost of Base Station



Why VoWLAN

- Low complexity
  - Centralized architecture in cellular network
    - PBX contains most intelligence of the network
    - Typically hard to maintain the proprietary system
  - Decentralized architecture in VoIP network
    - Intelligence are implemented in User Agent
    - Easy for maintenance

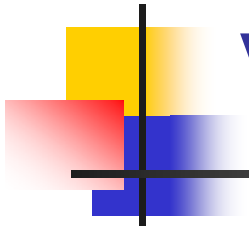


Why VoWLAN

- Low transmission power
  - Small coverage of the AP, small transmission power needed
  - GSM: 500mW ~ 2W
  - WLAN: < 100mW
- Easy for providing value-added service
  - Voice and data service is integrated into VoIP
  - Flexibility of SIP protocol

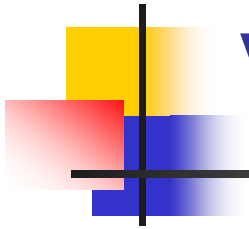
Why VoWLAN

- Market trend
  - VoWLAN market will reach $507 million (end user revenue) by 2007 *(In Stat/MDR)*
  - VoWLAN handset will grow by more than 89 percent annually until 2007 when there will be more than 653,000 *(On world)*



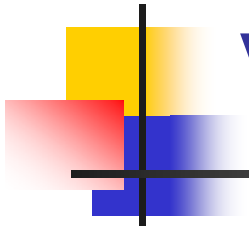
VoWLAN Requirement

- Performance
  - Voice quality must be as good as wired network
    - Delay >100 ms is typically sensible by human
    - Low latency : <50 ms latency is recommended
  - Reliable transmission over wireless channel
    - Low packet lost rate
- User mobility management
  - Support roaming between wireless network



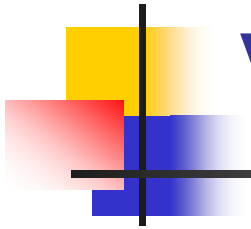
VoWLAN Requirement

- Capacity management
  - Heavy traffic load increase packet lost rate and latency
  - Number of Users must be controlled
- Channel assignment
  - 11 channels in 802.11b
  - Manage operating channel among adjacent Access Point



VoWLAN Requirement

- Security
  - Data ciphering
    - Wireless channel is insecure
    - Data over wireless should be protected
  - AAA
    - Authentication : legal user identification
    - Authorization : service level differentiation
    - Accounting : statistics for billing
- Location Tracking



VoWLAN Challenge

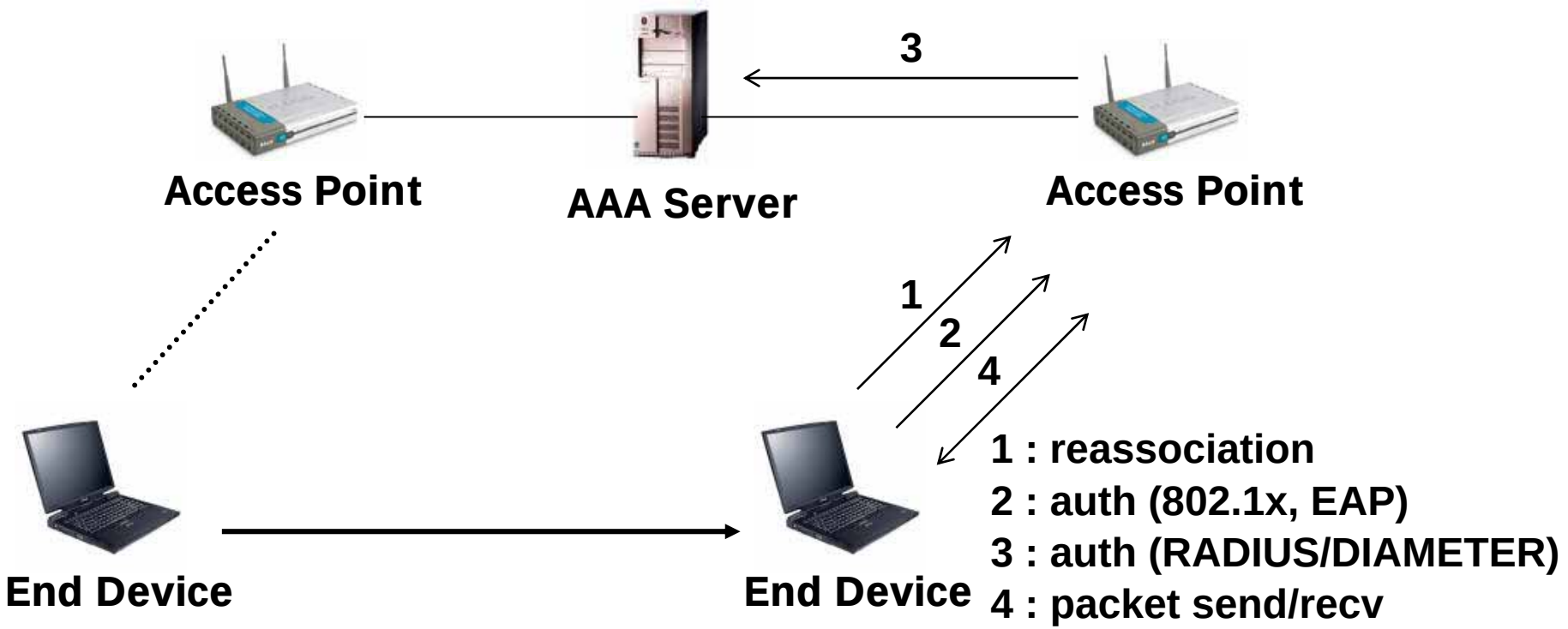
- Due to the requirements of VoWLAN, several issue should be solved
- User Mobility Issue
- Power Consumption Issue
- Security Issue
- QoS Issue
- Capacity Issue
- Other Related Issue

User Mobility Issue

- Supporting user mobility is an important feature of VoWLAN
- Typically concern about two factors
  - Handoff latency
  - Packet lost rate
- Seamless handoff
  - Fast handover : focus on reducing handoff latency
  - Smooth handover : focus on reducing packet loss during handoff

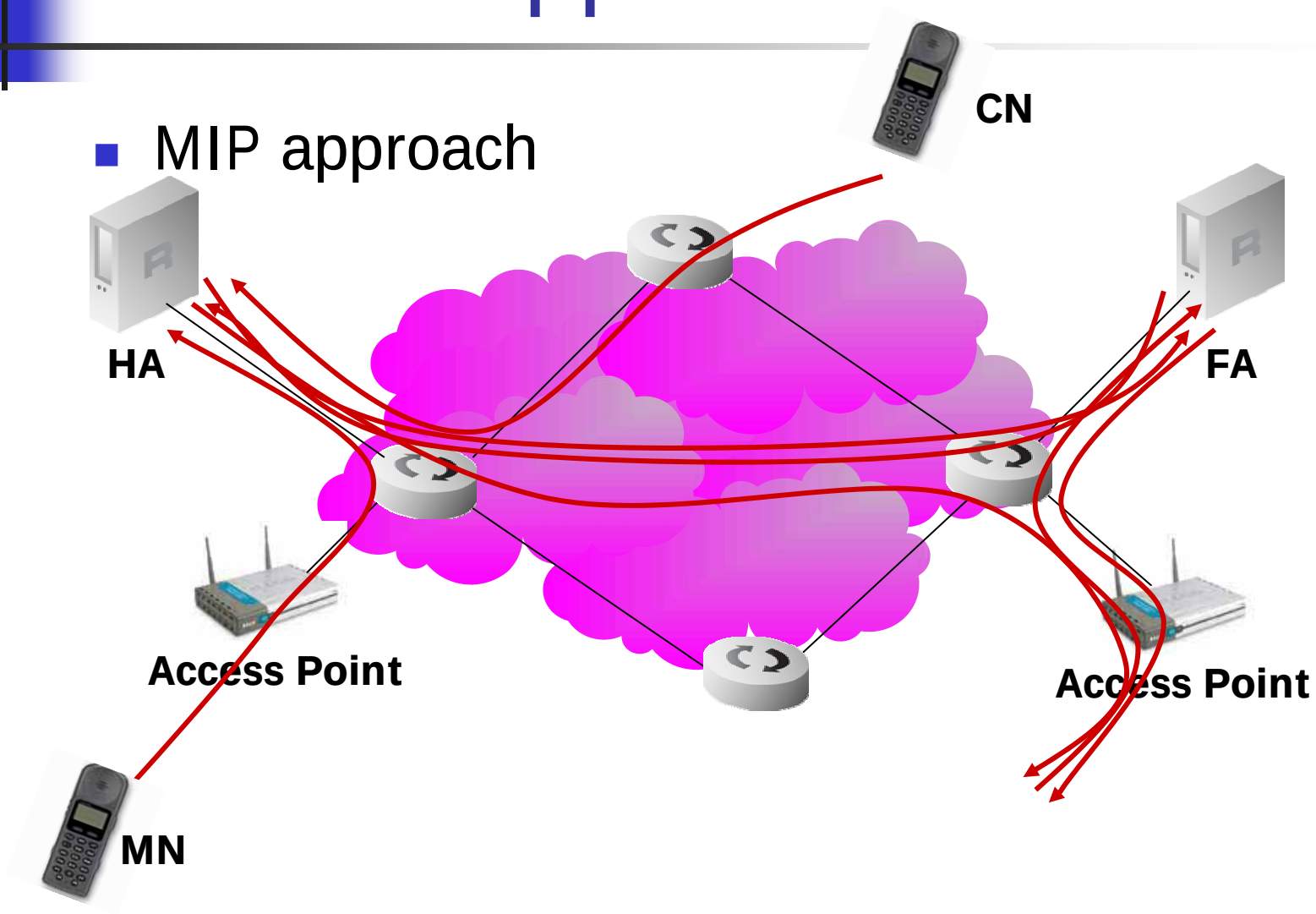
Handoff Approach

- Layer 2 approach



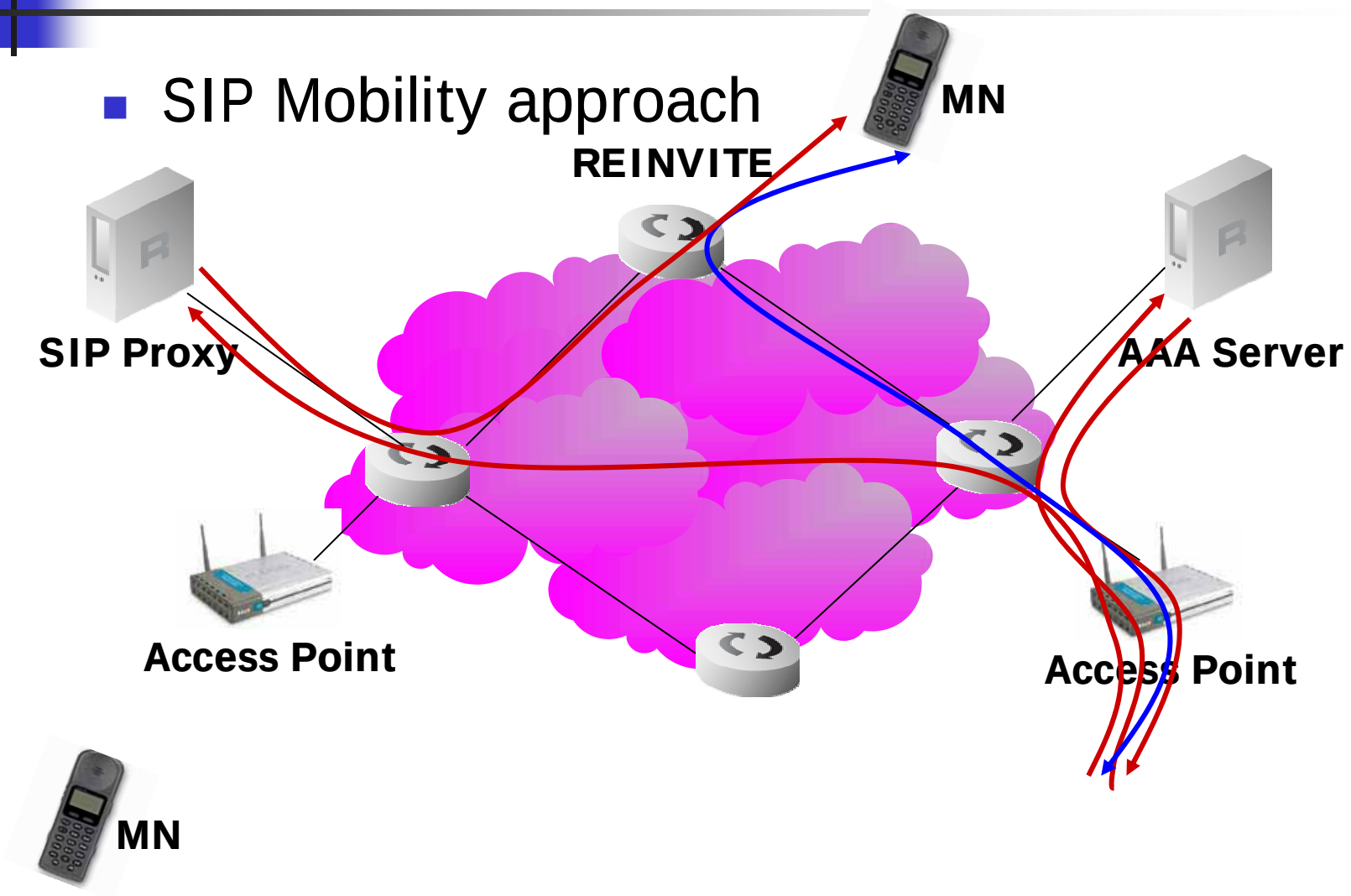
Handoff Approach

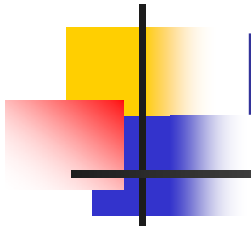
- MIP approach



Handoff Approach

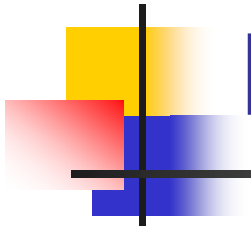
- SIP Mobility approach





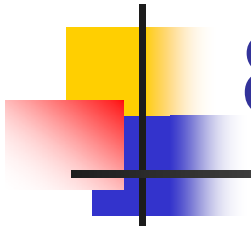
Handoff Approach

- Intra ESS
  - L2 approach with/without authentication
- Inter ESS
  - DHCP + MIP
  - DHCP + SIP Mobility
- Inter Domain
  - Same as Inter ESS, but business policy should be concerned



Power Consumption Issue

- Always be a problem since only limited battery power available at mobile device
- System
  - CPU, Memory, LCD, DSP/Codec
- WLAN
  - Physical Layer: RF
  - MAC Layer: 802.11a/b/g
  - Network Layer: TCP/IP

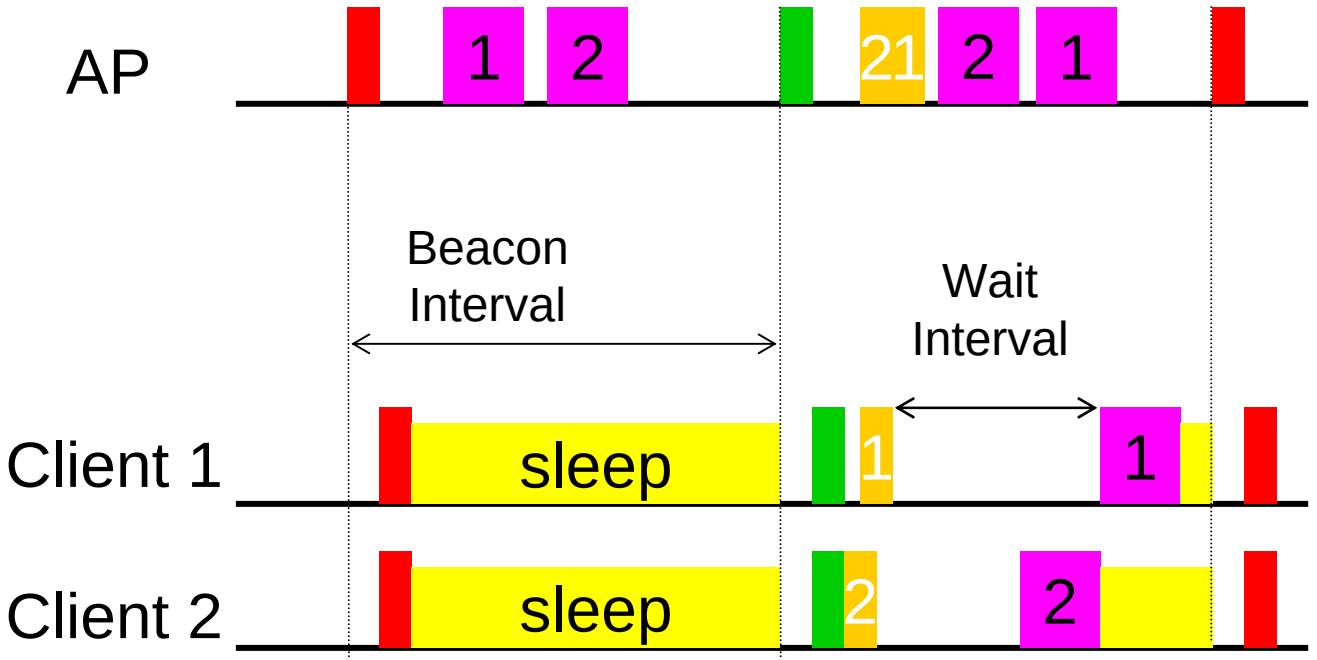


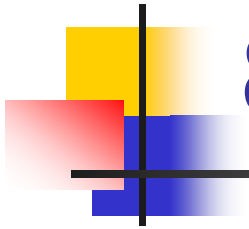
802.11 Power Saving Mode

- Reduce power consumption of transceiver when mobile device is idle
- AP buffers data packet for the mobile device which is in PSM, and inform it to receive by sending beacon
- Mobile device in PSM periodically wake up to receive data packet buffered in AP

802.11 Power Saving Mode

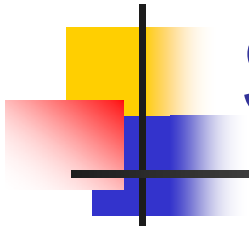
beacon | beacon with data | PS poll | PS data





802.11h

- Supplementary to 802.11a (5GHz)
- TPC (Transmission Power Control)
  - Keeps signal strength efficient, using only enough power to reach active users rather than using a uniform power output
- DFS (Dynamic Frequency Selection)
  - Selects the radio channel at the access point to minimize interference with other systems

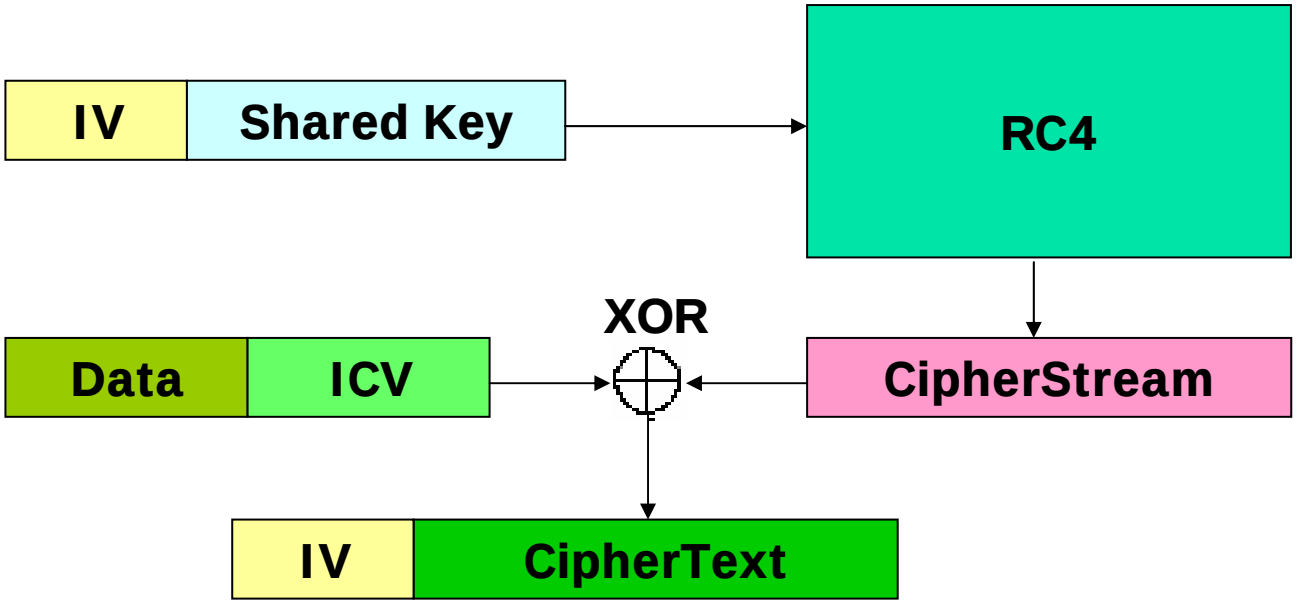


Security Issue

- Data ciphering
  - WEP, 802.11i
- AAA (Authentication, Authorization, Accounting)
  - 802.1x, RADIUS, DIAMETER

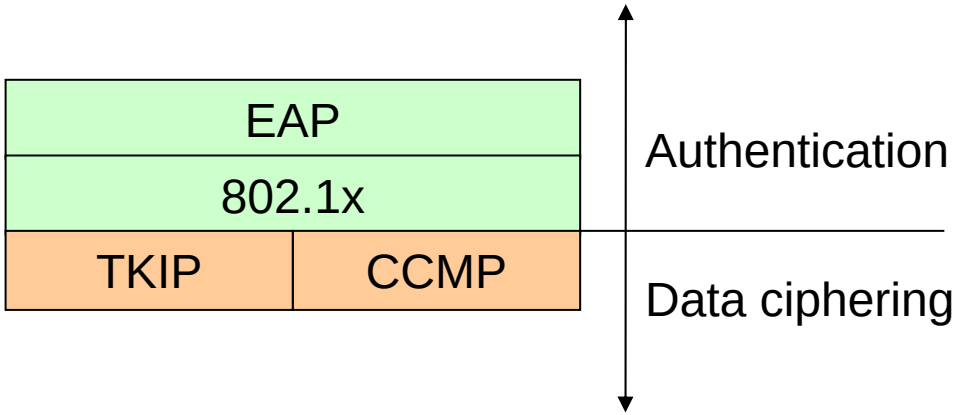
WEP

- WEP use RC4 to encrypt data which is dependent on the IV (Initialization Vector) and Shared Key

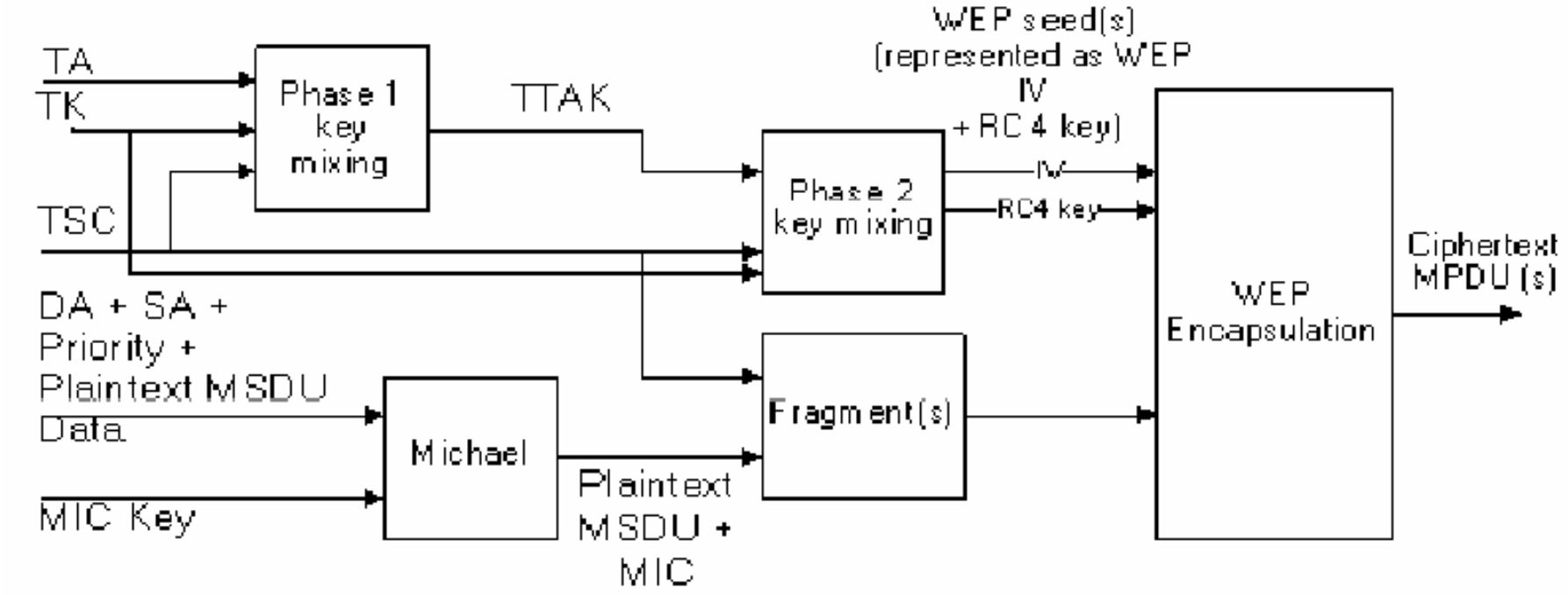


802.11i

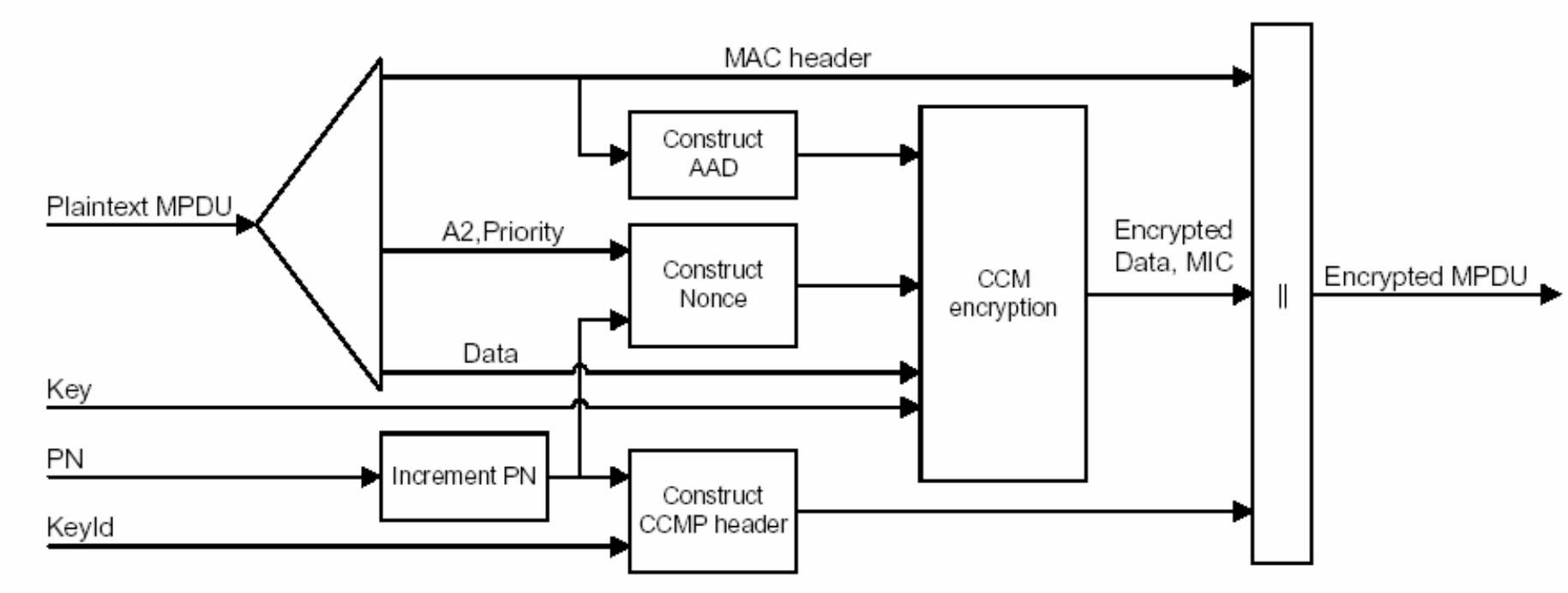
- Data transfer protection
  - TKIP : based on RC4
  - CCMP : import AES algorithm with better security
- Authentication
  - 802.1x, EAP

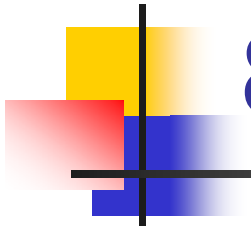


TKIP


TA
TK
TSC
DA + SA +
Priority +
Plaintext MSDU
Data
MIC Key
Phase 1
key
mixing
TTAK
Michael
Plaintext
MSDU +
MIC
WEP seed(s)
(represented as WEP
IV
+ RC4 key)
Phase 2
key mixing
IV
RC4 key
Fragment(s)
WEP
Encapsulation
Ciphertext
MPDU(s)

CCMP

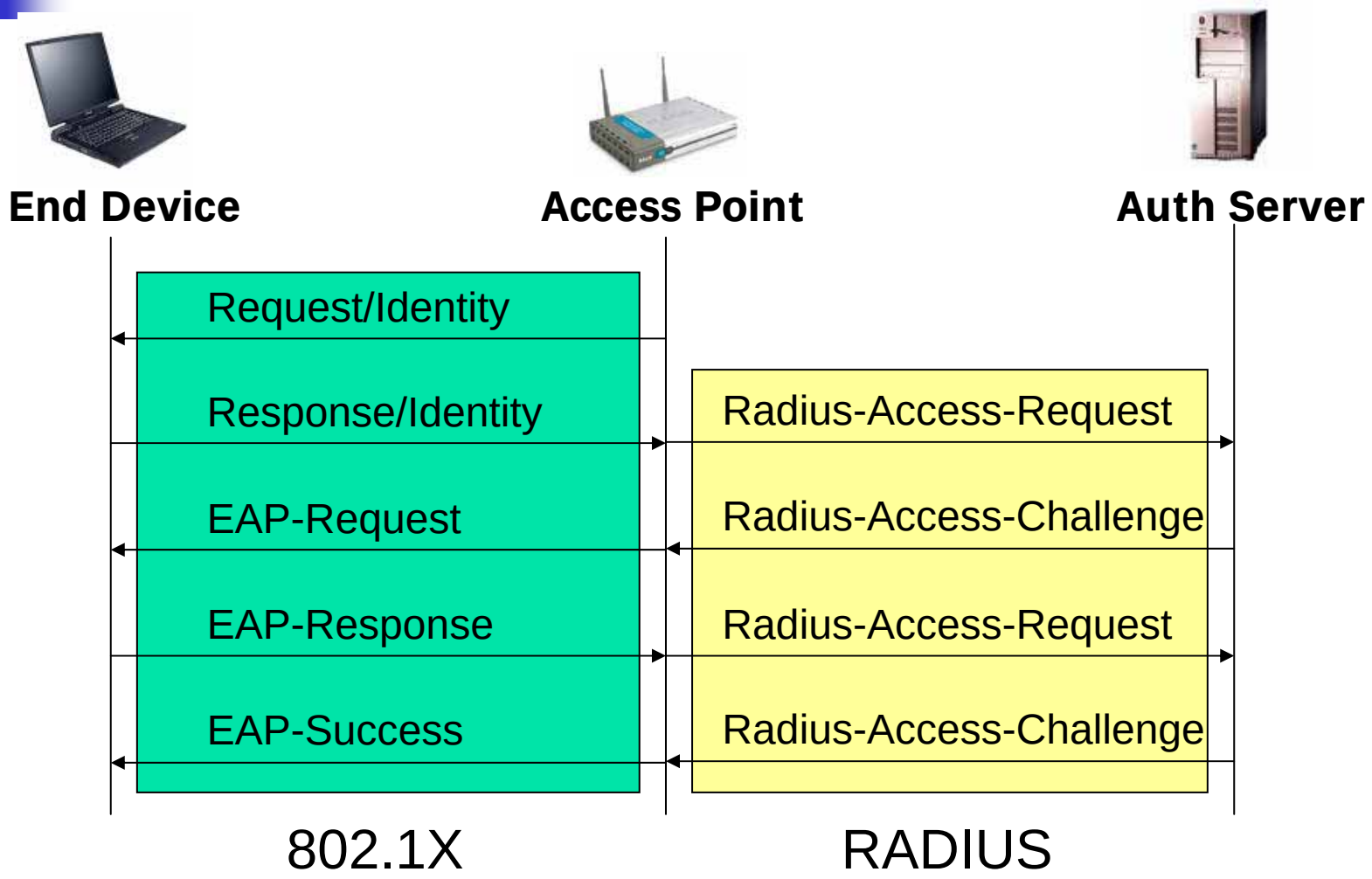

MAC header
Plaintext MPDU
Construct AAD
A2,Priority
Construct Nonce
Data
CCM encryption
Encrypted Data, MIC
||
Encrypted MPDU
Key
PN
Increment PN
Construct CCMP header
KeyId

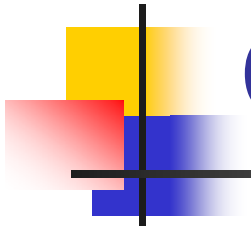


802.1x

- General-purpose, port-based network access control mechanism for any 802 technology
- Enables mutual authentication of devices
- Provides service for exchange of 802.11 session keys
- Leverages existing AAA infrastructure
- Extensible protocol to support future authentication methods (RFC 2284)

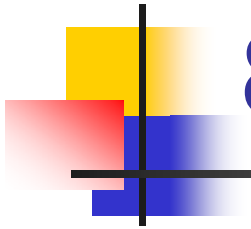
802.1x – EAP Authentication





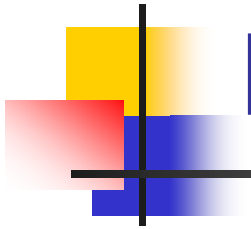
QoS Issue

- Typically, voice quality is depend on the delay and loss rate of packets
- No QoS guarantee in legacy 802.11 DCF, since each mobile device contends for the channel by using CSMA/CA
- There are some proprietary QoS schemes proposed, but QoS is still an open issue



802.11e

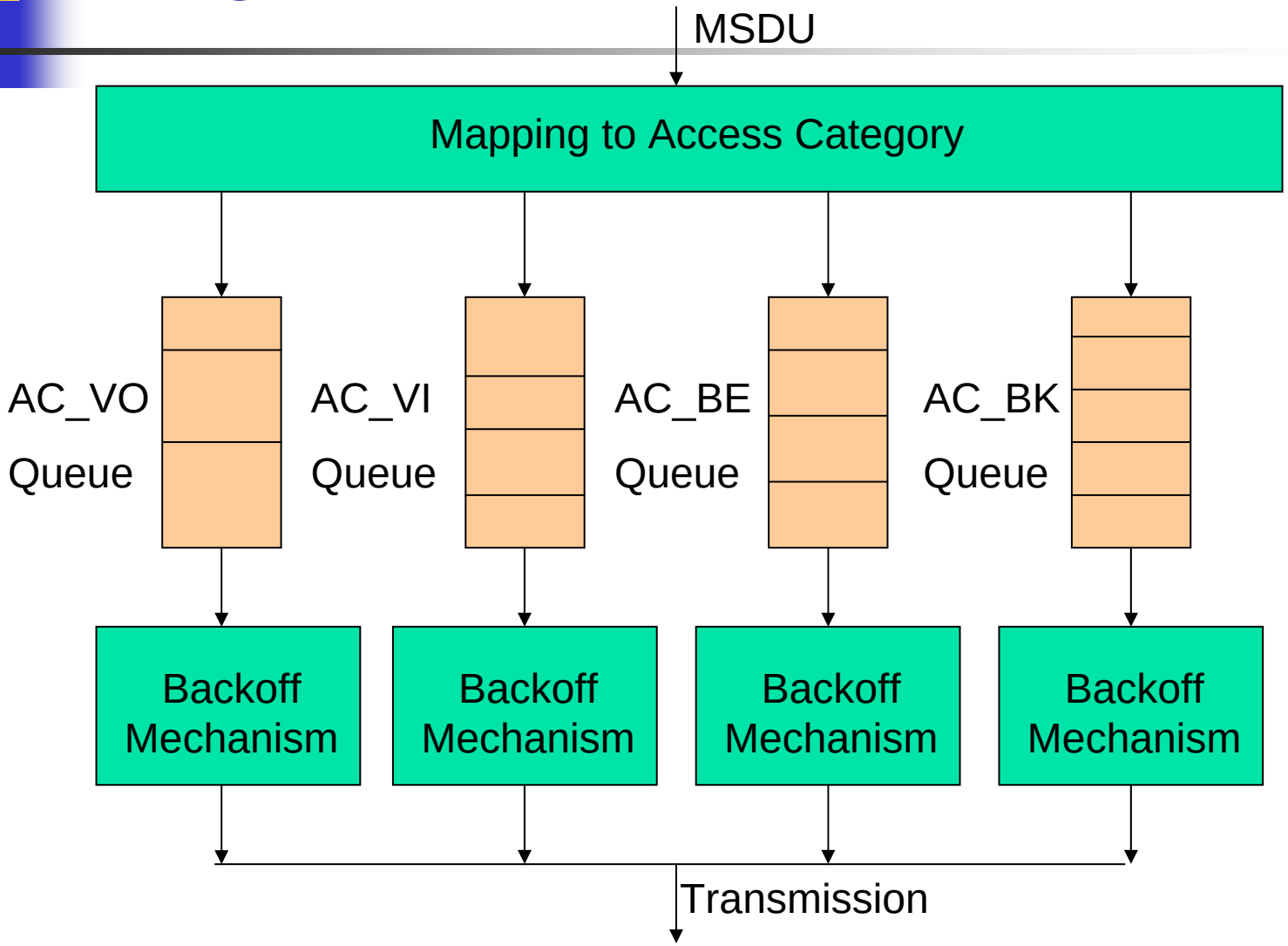
- Promise to bring QoS capabilities WLAN system need for streaming applications
- Introduce HCF (Hybrid Coordination Function) to provide some QoS facilities
  - EDCA : Enhanced Distributed Cannel Access
  - HCCA : Hybrid coordination function Controlled Channel Access

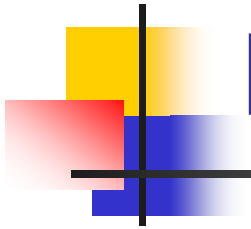


EDCA

- Contention-based channel access
- Four backoff entities within one station
- Each backoff entities represents one Access Category (AC) and has different contention window size
  - AC_VO (voice), AC_VI (video) , AC_BE (best effort) , AC_BK (background)

EDCA

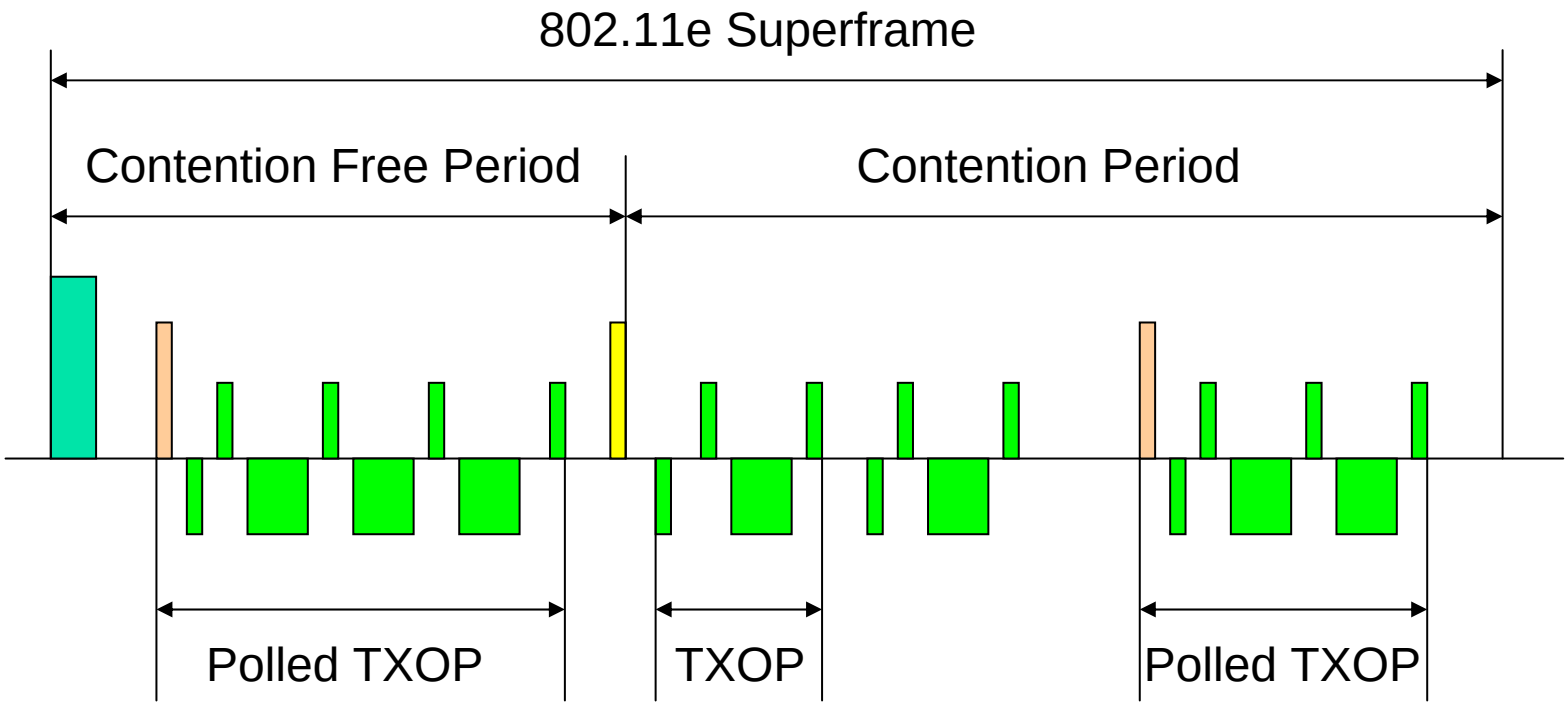

MSDU
Mapping to Access Category
AC_VO
Queue
AC_VI
Queue
AC_BE
Queue
AC_BK
Queue
Backoff
Mechanism
Backoff
Mechanism
Backoff
Mechanism
Backoff
Mechanism
Transmission

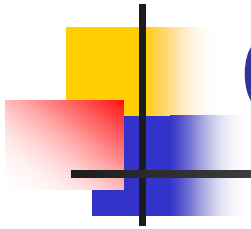


HCCA

- Controlled channel access
- HC can allocate TXOP (Transmission Opportunity) during CFP or CP by transmitting QoS CF-Poll frame
- During CFP, this mechanism is the same as legacy 802.11
- During CP, it will allocate the medium after detecting the channel being idle for PIFS

HCCA


802.11e Superframe
Contention Free Period
Contention Period
Polled TXOP
TXOP
Polled TXOP



Capacity Issue

- Voice quality is a key component of voice service (real-time, high throughput)
- CSMA/CA mechanism limits the max # of subscribers under the AP
  - A VoIP streams typically requires less than 10Kbps
  - Ideally, the number of simultaneously VoWLAN sessions is
    - 11M / (10K * 2) = 550
  - However, the maximum number of VoIP sessions is about 12 if GSM 6.10 (13.2Kbps) is used

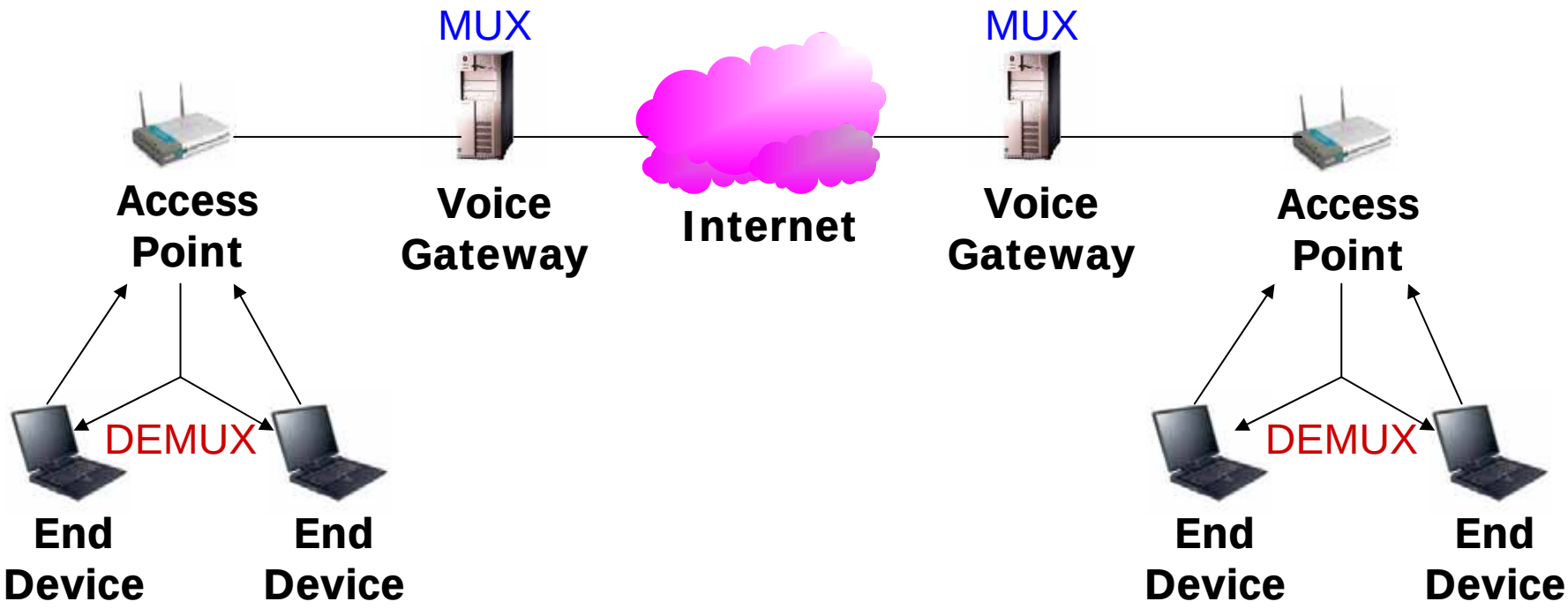
Capacity Issue

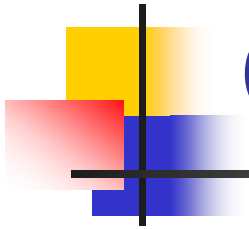
- An analysis result from “W. Wang et al, Solution to Performance Problems in VoIP over 802.11 Wireless LAN”

Codec	Max # of user
GSM 6.10	11.2
G.711	10.2
G.732.1	17.2
G.726-32	10.8
G.729	11.4

Multiplex-Multicast Scheme

- Multiplex : Combine several downlink data into one
- Multicast : Multicast the packet to all destination
- De-Multiplex : Retrieving the corresponding payload



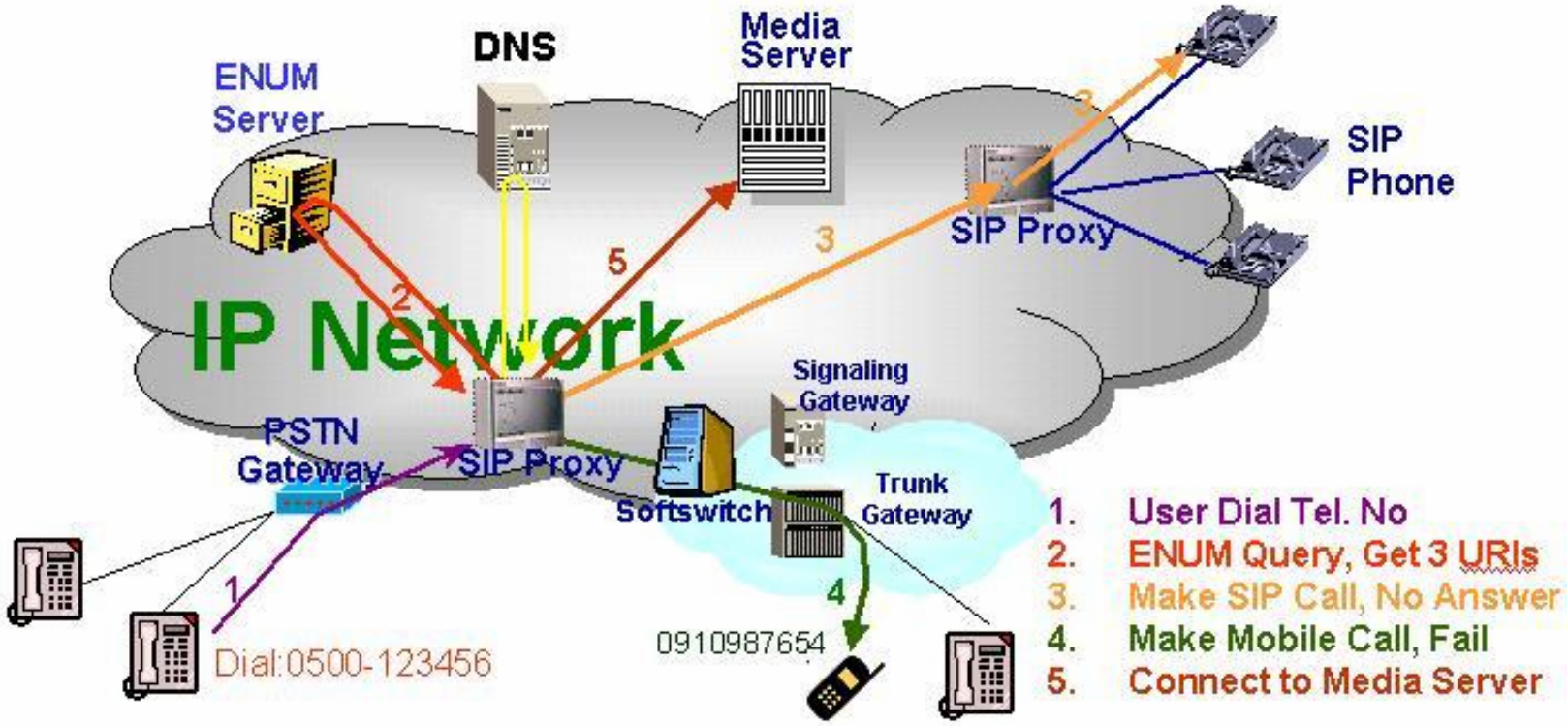


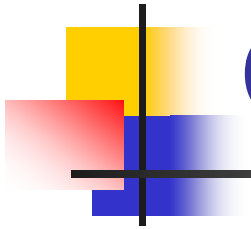
Other Related Issue

- Codec Compression
  - The ability to maximize the wireless bandwidth for voice, intelligent use of compression codec is important.
  - Often require hardware assist, the target device is hardware dependent and needs to be specially designed
- PBX Integration
  - Provide the PSTN access, often a gateway solution
  - SIP ENUM

SIP ENUM

```
$ORIGIN 6.5.4.3.2.1.0.0.5.0.e164.arpa.
        IN NAPTR 100 10 "u" "sip+E2U"      "!^.*$!sip:user@itri-sip-proxy.org.tw!"
        IN NAPTR 102 10 "u" "tel+E2U"      "!^.*$!tel:+886910987654!"
        IN NAPTR 102 10 "u" "mailto+E2U"   "!^.*$!mailto:user@itri.org.tw!"
```

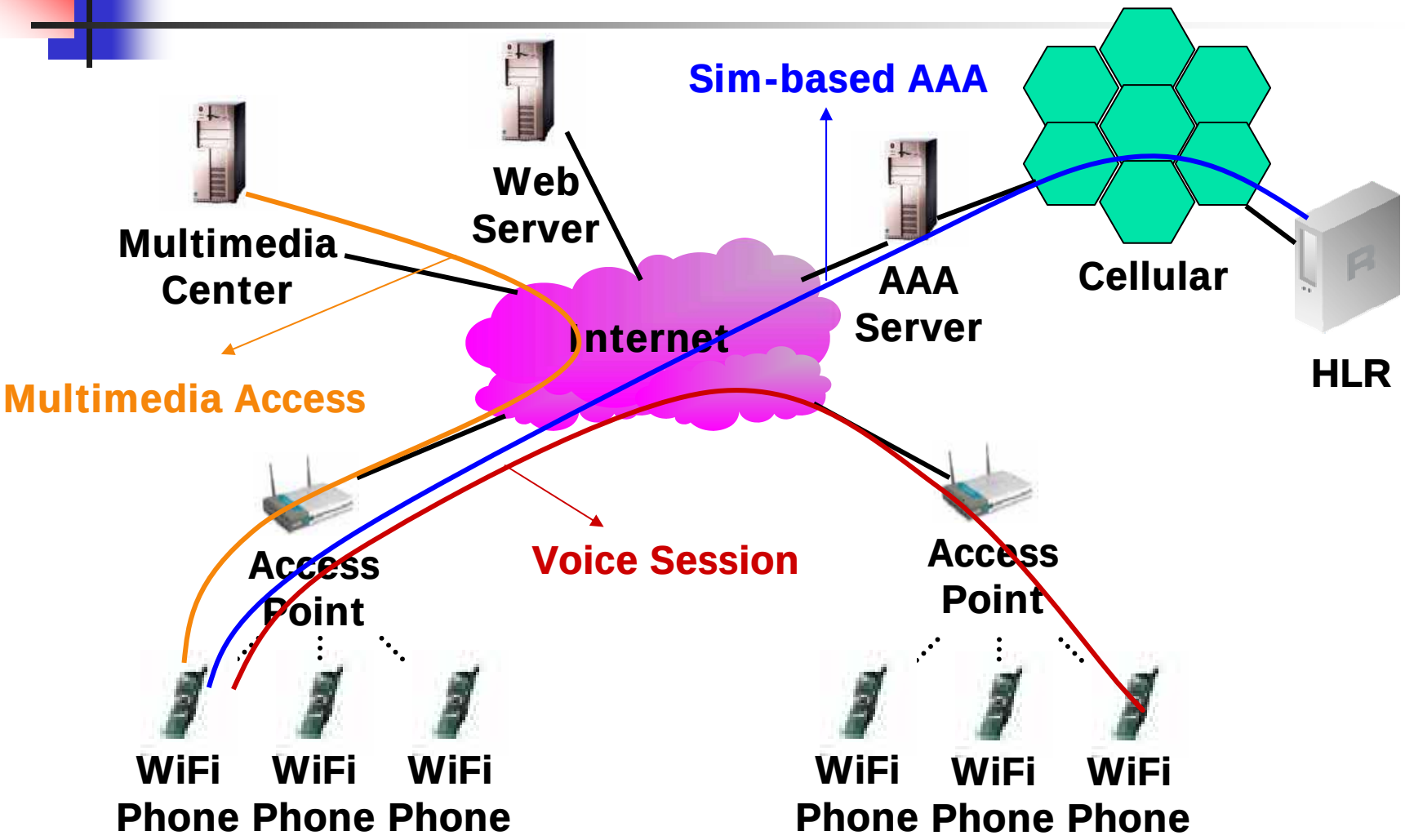


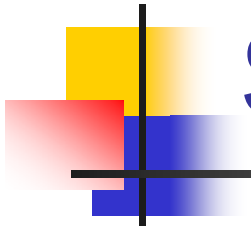


Other Related Issue

- Combine WLAN and Cellular
- WLAN
  - High bandwidth, Low Cost, Multimedia Service, Video Phone
- Cellular
  - Large Coverage, High Mobility, Mature Billing System, Popularity

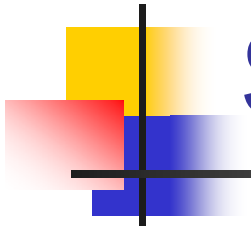
WLAN + Cellular





Summary

- The existing VoWLAN solutions may not be robust and reliable enough to support deployment for a large base of users
- QoS of VoWLAN is always an open issue
  - it may or may not have a good solution
- Security and Capabilities for fast handoff between APs still needs some improvement



Summary

- RF management and MAC layer mechanism affect power consumption of mobile device
- Voice over WLAN is a trend
  - Many cellular operators have devoted to the development of VoWLAN
  - Government promotes the combination of WLAN and Cellular network
  - VoWLAN may just be the next big thing in mobile telephony