**Data Link Layer Data Link Layer**

Router 1

Router 2

1

2

3

Access Point

**Routing Table of Router 1**

Destination IP Address Out Port

B 2

Date segmentation

**Van Allan Belt (Electro Magnetic Field surrounding Earth**

**Bit Timing**

Bit Timing

Bit Timing

**Modulation**

**Modem = Modulation + DeModulation**

**Base Band Base Band**

Base Band + Carrier Base Band + Carrier

Network

Modulator

De-Modulator

De-Modulator

Carrier Frequency Carrier Frequency

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**San Jose San Francisco**

**Using multiple sub-carriers**

**Modulation (Packing) Demodulation (Unpacking)**

Base Band

Boxes Truck-1 (Carrier-1) Truck-1 (Carrier-1) Boxes

Truck-2 (Carrier-2) Truck-2 (Carrier-2)

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**OFDM (Orthogonal Frequency Division Multiplexing)**

Guard Band

Max MaxMax

`F1 F2 F3 Frequency

**Bit Timing**

Signal

Bit Timing

Bit Timing

**Non Self Clocking Code**

Information

Clock

**Information**

**Clock**

**++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++**

**Self Clocking Code**

Information + Clock

**Clock Pulses**

**TX**

**RX**

**++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++**

**bps (Bit Per Second) =** **100 symbols rate per sec \* 8 (No. of bits per character) =800**

**Baud = 100 symbol rate per sec**

**++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++**

**QAM (Quadrature Amplitude Modulation)**

1000

Amplitude

Phase

Server

First Mile

Last Mile

Middle Mile

IXC

8 bits 64 Kbps

8 bits 64 Kbps

**T1-**Time Slots 1 2 3 4 24

**E1-**Time Slots 1 32

Bits 0 7

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**Codec (Analog-to-Digital and Digital-to-Digital Conversion)**

Source

TX

Receive

RX

Analog Signal

Analog

Digital

3 Volts

2 Volts

Analog Signal

Digital

Analog

|  |  |
| --- | --- |
| Digital | Analog |
| 0010 | 2 Volts |
| 0011 | 3 Volts |

|  |  |
| --- | --- |
| Analog | Digital |
| 2 Volts | 0010 |
| 3 Volts | 0011 |

**Signaling Methods in the Networking**

1. **Out-of-Band Signaling**

Signaling

Information

Information + Signaling

1. **In-Band Signaling**

**+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++**

**λ = c/f C speed of light 300.000 KM/sec**

**f frequency**

**++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++**

**Mobile Communication**

Base Station

Downlink F1

Uplink F2

F3

Base Station

**RFID operation**

Electromagnetics

Object

CPU

Memory

ROM

Antenna

RFID Reader

**Analog Bandwidth**

Frequency

[Hz]

Time [Sec]

FMax

FMin

**Analog Bandwidth = F Max – F** Min

**Digital Bandwidth**

Bit Per Second = bps

**Metal, Fiber Optics, Radio Frequency**

**Simplex**

**Half Duplex**

**(WalkiTalki)**

**Full Diplex**

From A to B or From B to A

From A to B and From B to

At the same time A

AnalogSignal

Digital Signal

50 Ohm prevents reflection of analog signal

50 Ohm

Resistor

Reflection

75 Ohm

Resistor

75 Ohm prevents reflection of analog signal

Reflection

**Chip Sequence C**

**Chip Sequence B**

**Chip Sequence A**

Payload

Payload

Payload

**Frequency**

**CDMA (Code Division Multiple Access)**

Frequency F1

Freq Frequency F1

Frequency F1

120o

120o

120o

**Sectorized Antenna**

**ESCAPE Characters 7F** AB567321

End Flag 7F

Start Flag **7F**

**Escape Character**

**Switch (Bridge)**

**Switch**

**(Bridge)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| In Port | Out Port | Destination MAC Address | Expiration Time(min) | VLAN-ID |
| 1 | 3 | C | 10 | 100 |
| 3 | 2 | B | 5 | 200 |
|  | 3 | C | 15 | 300 |

VLAN Concept

B2

B1

|  |  |
| --- | --- |
| Ip Address | Label |
| 10.12.5.3 | 100 |
| 100.4.8.22 | 200 |

3 bits Priority

1 bit CFI

Little Endian

Big Endian

12 bits VLAN-ID

**VLAN ID Fields**

**Little Endian**

**Big Endian**

Data 5643

Memory location 8021 8022

56 43 <<<<< Big Endian (Motorola Micro Processors)

43 56 <<<<<< Little Endian (Intel Micro Processors)

**CSMA/CD**

**Ethernet Standards:**

10 Mbps Ethernet

100 Mbps Fast Ethernet

1000 Mbps Giga bit Ethernet

10BASET

!0 Mbps BasebandTwisted pair

**Ethernet Frame Format**

FCS (Frame Check Sequence)

4 Bytes

Payload, Maximum

1500 Bytes

ETYPE (Ethernet Type )or Length

2 Bytes

Source MAC Address

6 Bytes

Destination MAC Address

6 Bytes

If Etype/Length field > 1500 then is Etype

If Etype/Length field <= 1500 then is Length

**Variable Length Text**

3456DAT Pass word

567H

221

HASH Module

**Fix Length Text**4321

5562

4311

**Fix Length Text**4321

5562

4311

Re-HASH Module

**Variable Length Text**

3456DAT

567H

221

User ID (Not Hashed)

John.Mayer

Hashed Value of Pass Word **4321**

User ID Rehashed Value

John.Mayer3456DAT

Compare values If correct then provide service

**Hash and Re-Hash**

**CSMA/CD (Collision Sense Media Access with Collision Detection)**

**CSMA/CA (Collision Sense Media Access with Collision Avoidance)**

2-CTS

1-RTS

3-User Date

RTS from B

Contention Free End + ACK

Contention Period

Time

Poll +ACK

**F1, N( S= 1, R= 0+1=1)**

**S1 N( S= 1, R = 1+1=2)**

**F2 N( S=2, R = 1 +1=2)**

**S2 N( S=2, R =2+1=3)**

F1

F2

F3

**N sub of S, N sub of R**

**N(S,R)**

S… Send

R… Frame expected to receive

R= Received Frame No. +1 = Expected frame number

**Note: If User B doesn’t have data to transmit the**

**ACK will be sent o user A for each frame received.**

S1

S2

S3

**Infrastructure Network (Point Coordination Function)**

ACK-1

Frame-1

**Non-Infrastructure Network (Distributed Network)**

Timer=10msec

Counter =2

++++++++++++++++++++++++++++++++++++++++++++++++++++

F1 M= 1

F1 M=1

F2 M=1

F3 M=0

10 msec

Counter= 2

F1 M= 1 Retry=1

10 msec

**If no ACK received after the second time, then send Error message to Manager**

No ACK was sent

No ACK was received, User A will send again the F1, M=1 with Retry bit set to 1

Ethernet

S3 Higher Layer Data

S2 Higher Layer Data

S1 Higher Layer Data

S1 F1 M=1

S1 F2 M=0

S1 Higher Layer Data

S1 F1 M=1

S1 F2 M=0

S2 Higher Layer Data

S2 F1 M=1

S2 F2 M=0

S1 Higher Layer Data

S2 F1 M=1

S2 F2 M=0

**Segmentation and fragmentation of higher layer packets in IEEE 802.11**

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**Address 1: final receiver (destination)**

**Address 4: Switch address connected to Access point 1**

**Address 2: origination or source of frame**

Switch-1

(Bridge)

Switch-2

(Bridge)

**Address 3: Wireless end station**

**(Access Point)**

**sends to address 1 (final address).**

**Addressing in IEEE802.100**

S3 Higher Layer Data

S2 Higher Layer Data

S1 Higher Layer Data

S1 F1 M=1

S1 F2 M=0

S1 Higher Layer Data

S1 F1 M=1

S1 F2 M=0

S2 Higher Layer Data

S2 F1 M=1

S2 F2 M=0

S2Higher Layer Data

S2 F1 M=1

S2 F2 M=0

**Segmentation and fragmentation of higher layer packets in IEEE 802.11**

Server

First Mile

Last Mile

Middle Mile

Channel ID =220 Service ID =50

Channel ID =240 Service ID =80

Channel ID =230 Service ID =60

Piconet-1

Piconet-2

Switch

(Bridge)

Scatter Net

Bluetooth

**TX**

**Time Slots** 1 2 3 4 5

Time Slots 1 2 3 4 5

**RX**

**Circuit Switching Networks**

Router 1

Router 2

Access Point-1

Access Point-2

Router 3

Router 4

**Fragmentation Link Layer**

1 2 3

**Packet Switching Networks**

**Data Segmentation and Fragmentation**

CAC

SLA ( Service Level Agreement)

Jitter, when t1 != t2 t2 t1

**Routing Table**

1 GByte

800 MByte

Buffer

TTL (Time-to-Leave) in decremented

If TTL=0 and IP Add. Of node is equal to Add. of dest. In packet the packet will be processed, else will be dropped.

Scheduler Buffer

|  |  |  |  |
| --- | --- | --- | --- |
| Ip Address | Out Port | Expiration Time | Priority of IP Header |
| 10.12.5.3 | 2 | 10 min | 7 |
| 100.4.8.22 | 1 | 6 min |  |

Label out port

100 2

200 3

**Virtual Circuit: concept**

Physical Layer, Metal, Fiber glass

**Token Bucket**

t1

t2

Credit 500 Bytes

1000 Bytes

Old Credit 500 Bytes + new cedit 500 Bytes = 1000 Bytes

1000 Bytes

1000 Bytes

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**Packet arrival**

Old

New

**FIFO (First In First Out**

**Memory buffer**

3 Subscribe

4 Content

3 Subscribe

4 Content

3 Subscribe

4 Content

Netflix Server

Multicast Router

List of subscribers A, B, C

2Content

**Multicast**

|  |
| --- |
| Application |
| Presentation |
| Session |
| Transport |
| Network |
| Data Link |
| Physical |

Security in WiMax (Using encryption Key and integrity key)

0110111

Encryption Key

1001000

Encrypted Frame

FCS

1001000

**IPV4 Address Fields**

|  |  |  |  |
| --- | --- | --- | --- |
| 8 bits  1 2 3 4 5 6 7 8  0 , leading bit set 0 | 8 bits | 8 bits | 8 bits |

Prefix (Network Address) Host Address

IP Address 100.22.33.44

IP-Add-Tunnel-Begin IP-Add-Tunnel-End

100.10.12.33 100.10.12.34

De-capsulation

Encapsulation

IP-Add-Tunnel-Begin

IP-Add-Tunnel-End

Tunnels Provides:

1. Security
2. Bandwidth

DestinationAdd. IP-B

Source Add. IP-A

Payload

**IPV6 Address compression:**

**E2c0 : 0 : 0 : Ac21: 0 : 0 : 0 : AAAA**

**Wrong, not permitted 🡪 E2c0 :: Ac21:: AAAA**

**E2c0 : 0 : 0 : 0 : 0 : 0 : 0 : AAAA**

**Correct compression (Only one time )E2C0 : : AAAA**

RTP (using UDP)

Port no 6020

RTCP (using UDP) Port no 6020+1

Port no 8020

Port no 8020+1

Packet 1

Packet 1 retransmitted

Packet 1 retransmitted

Packet 2, time stamp =10 AM, 10 msec

Audio

Packet 2, time stamp =10 AM, 10 msec

Video

Packet 2, time stamp =10 AM, 10 msec

Subtitle

ACK counter =2

Repeat every 10 msec if no ACK was received

**ECN (Explicit Congestion Notification)**

1. When congestion happens Router-1 will set ECN flag =11
2. Ip Layer at destination informs TCP layer about congestion in the net work
3. TCP layer will delay the ACK for received packet, set ECE, CWR and sends to source of traffic
4. Source of traffic will decrease the No. of Bytes in the transmitted packet
5. if the network is still congested the router 1 will set again the ECN flag in IP header to 11
6. The steps 2, 3, and 4 will be repeated
7. If congestion in the network disappears then the ECN flag will be set to 10, or 01
8. The receiver of packet will inform TCP layer about the congestion relief
9. TCP layer will set ECE =0 and CWR =0 and sends this packet to source of traffic
10. Source will increase additive the number of Bytes, not multiplicative

1000 Bytes before congestion was the payload

ECE = 11, reduce the payload **multiplicative decrease** (in case below we divide by 2)

500 Bytes will be sent

ECE =11 >> again divided by 2 >>>> 250

ECE =01 Increase the No. of Bytes additive >>> 250 +100 =350

ECE =10>>> 350+100=450

Phy

Data Link

Network

ort

Session

Presentation

Application

Router 1

Router 2

Access Point-1

Access Point-2

Router 3

Router 3

**TCP/IP Protocol Characteristics**

Phy

Data Link

Network

Transport

Session

Presentation

Application

|  |  |  |
| --- | --- | --- |
| **Routing Table** | |  |
| Destination IP Address | Out Port (Interface) | QoS Mbps |
| B | 2 | 100 |
| C | 3 | 500 |

**Additive Increase Multiplicative Decrease**

Source Destination

100 Bytes sent ACK 100+1

100+50=150 ACK 150+1

150+50=200 ACK 200+1

Congestion

Multiplicative Decrease:

200:2=100 ACK 100+1

Congestion

100:2=50 ACK 50+1

Congestion

50:2=25 ACK 25+1

Congestion is gone

Additive increase

25+20=75 ACK 75+1

75+20=95 ACK 95+1

95+20=115 ACK 115+1

**Packet loss in the network**

Source Destination

100 ACK 100+1

100+1 lost in network

200+1 ACK 100+1

Retransmit 100+1 ACK 100+1

ACK 200+1

If ACK 200+1 was not received

Then retransmit the packet

after ACK 200+1 timer expiration

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**DOM (Document Object Model)**

Server

Text

Font Color

Bold

Parity Packet

4

3

2

1

1 XOR Parity Packet