Data Communication and Computer Network

BLM3051

Dr. Öğr. Üyesi Furkan ÇAKMAK

Lecture Information Form - Weekly Subjects

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Hafta	Tarih	Konular
1	20.02.2024	Introduction to Data Communication Standards Used on Data Communication, Architectural models
2	27.02.2024	OSI Reference Model , Layers and Their Functions, Signaling and Signal Encoding
3	05.03.2024	Parallel and Serial Transmission, Communication Media and Their Technical Specs., Multiplexing (TDM, FDM)
4	12.03.2024	Error Detection and Error Correction Techniques, Data Link Control Techniques, Flow Control
5	19.03.2024	Asynchronous and Synchronous Data Link Protocols (BSC, HDLC)
6	26.03.2024	LAN Technologies Continued, IEEE 802.4, 802.5, 802.11
7	02.04.2024	Connectionless and Connection Oriented Services, Switching
8	09.04.2024	Tatil - Ramazan Bayramı Arifesi
9	16.04.2024	1. Ara Sınav
10	23.04.2024	Tatil - 23 Nisan Ulusal Egemenlik ve Çocuk Bayramı
11	30.04.2024	Static and Dynamic Routing, Congestion in the Network Layer, Its Causes and Solutions
12	07.05.2024	IP (Internetworking Protocol), ICMP, BOOTP, DHCP
13	14.05.2024	2. Ara Sınav
14	21.05.2024	UDP (User Datagram Protocol), TCP (Transmisson Control Protocol)

LAN – Local Area Networks

- Multi-point mode
- Basic models:
  - Ethernet - IEEE 802
  - Token Bus - IEEE 802
  - Token Ring - IEEE 802
  - FDDI/CDDI (Fiber/Copper Distributed Data Interface) - ANSI
  - WLAN (Wireless LAN) - IEEE 802
- Data Link Layer is consist of HDLC
- 3 types of Media Access:
  - Fixed Based
    - TDMA, FDMA veya CDMA (Time/Frequency/Code Division Multiple Access)
  - Contention Based
    - Aloha, CMSA
  - Token/Reservation Based
    - Token Ring

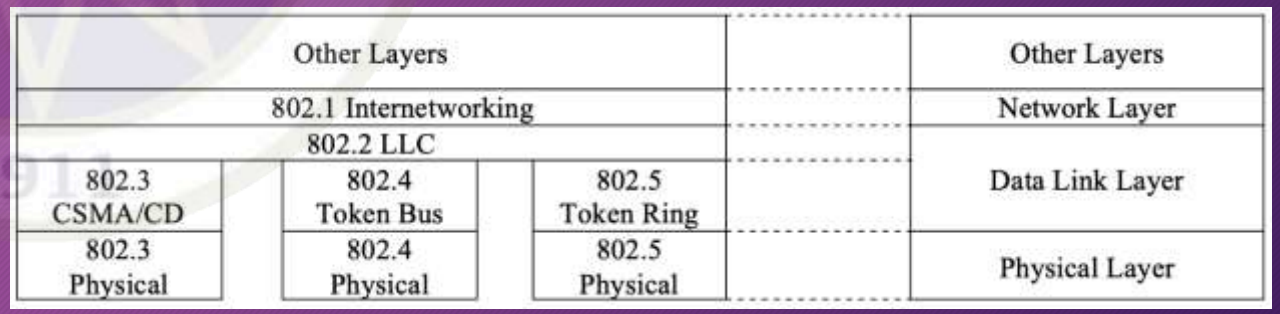
IEEE 802 Project

- LANs
  - 802.3 Ethernet
  - 802.4 Token Bus
  - 802.5 Token Ring
- Wireless LANs
  - 802.11 Wi-Fi
- Wireless PANs
  - 802.15 WPAN
  - 802.15.1 BlueTooth
  - 802.15.4 Zigbee
- WANs
  - 802.16 Wi-Max

IEEE 802 Project – Con't

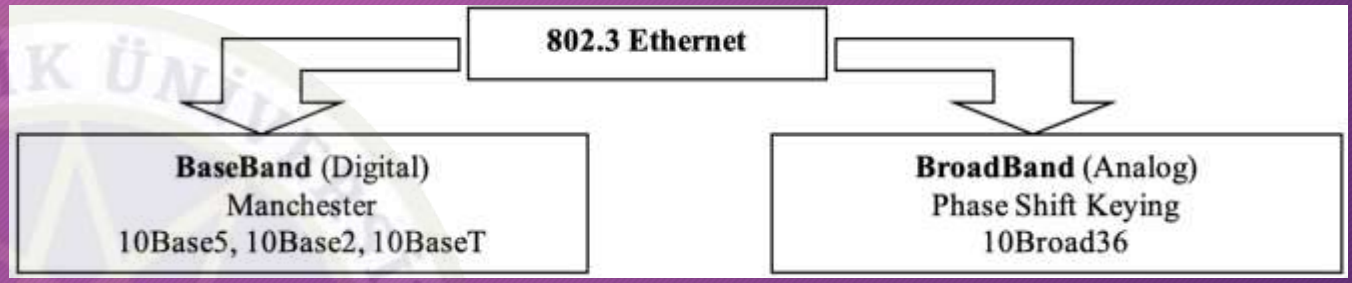
- to ensure compatibility between protocols used in LANs
- MAC (Media Access Control)
- LLC (Logical Link Control)
  - Un-ack connectionless service
  - Connection mode sevice
  - Ack connectionless service
- PDU (Protocol Data Unit)
  - in LLC
  - DSAP (Destination Service Access Point)
  - SSAP (Source Service Access Point)
  - Control Field
  - Information Field

DSAP	SSAP	Control	Information



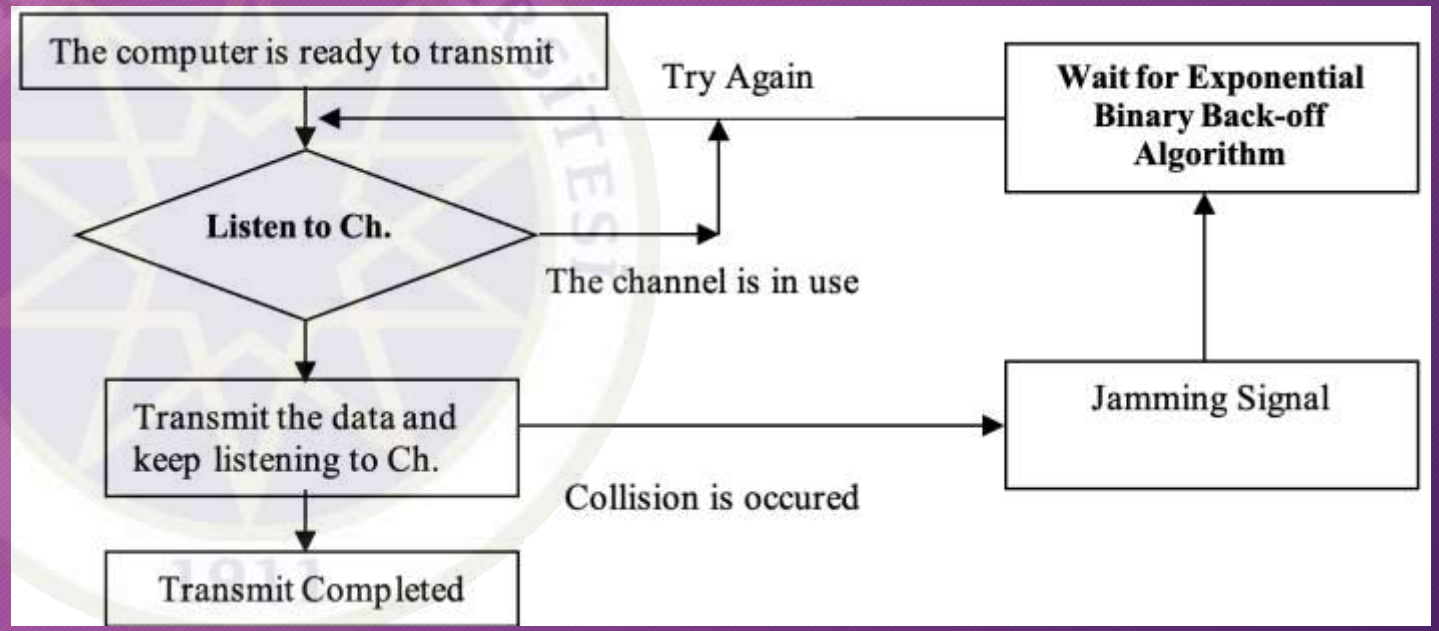
IEEE 802.3 Ethernet

- 1972
- Xerox Corp.
- Aloha
  - Bob Metcalfe
  - 1973
  - Hawaii Islands
    - Radio network
  - Collision?
  - Utility Rate: 18%
- Slotted Aloha
  - Utility Rate: 37%



CSMA (Carrier Sense Multiple Access)

- The goal is to improve the Slotted Aloha.
- Nonpersistent CSMA
- 1-Persistent CSMA
- p-Persistent CSMA
- CSMA/CD (Collision Detect)



IEEE 802.3 Ethernet - Framing

7 byte	1byte	2-6 byte	2-6 byte	2 byte	46-1500	4byte
Preemble	SFD	Dest.Addr	Src.Addr.	Length	Data. Unit	CRC

- Preemble: **10101010**
  - for sync.
- SFD (Start of Frame Delimitter): **10101011**

- Shared and Switched Ethernet

IEEE 802.3 Ethernet Variations

- **IEEE 802.3u - IEEE 802.3y - Fast Ethernet**
  - 10 Mbps -> 100 Mbps
  - Auto Negotiation
- **IEEE 802.3z - IEEE 802.3ab Gigabit Ethernet**
  - Cat5/5e/6/7/8
  - 100 Mbps -> 1000 Mbps
  - Auto Negotiation
- **IEEE 802.3ae - IEEE 802.3ak - IEEE 802.3an - IEEE 802.3aq - 10 GigE**
  - 1 Gbps -> 10 Gbps
- **IEEE 802.3ba - 40/100G Ethernet**
  - 40-100 Gbps

Metro Ethernet, *Power over Ethernet (PoE)*

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IEEE 802.4-Token Bus

- In worst case scenarios, some computers seem to wait too long to transmit.
  - General Motors
  - 1980s
- Bus and Tree Topology
- Each computer recognizes the computers on its right and left.
- After the logical ring is established, the computer with the highest number will transmit
- Gives the control frame (Token) to its neighbor
- Collision is impossible
- New computers can be added or removed.
- IEEE 802.4 MAC protocol is quite complex
  - Each computer included in the system must keep up to 10 different time information and
  - Evaluate approximately 24 status information.
- 75Ω Coaxial Cable
- 3 Different Modulation Techniques are used
  - Phase continious frequency shift keying
  - Phase coherent frequency shift keying
  - Multilevel duobinary amplitude modulated shift keying
- Max speeds: 1,5 ve 10 Mbps

IEEE 802.4-Token Bus - Framing

- SD: Starting Delimitter
- FC: Frame Control
- ED: Ending Delimitter
- Frame size is almost 5 times bigger than 802.3.
- Priority mechanism:
  - 4 levels priority: 0, 2, 4, 6

1 byte	1byte	1byte	2-6 byte	2-6 byte	0-8182	4byte.	1byte
Preemble	SD	FC	Dest.Addr	Src.Addr.	Data. Unit	CRC	ED

IEEE 802.5-Token Ring

- It uses a technique based on the principle that the computers to be transmitted send their data sequentially.
- Token size: 3 bytes (even if the line is empty)
- Token Re-Sizing
- Physical Length of a Bit

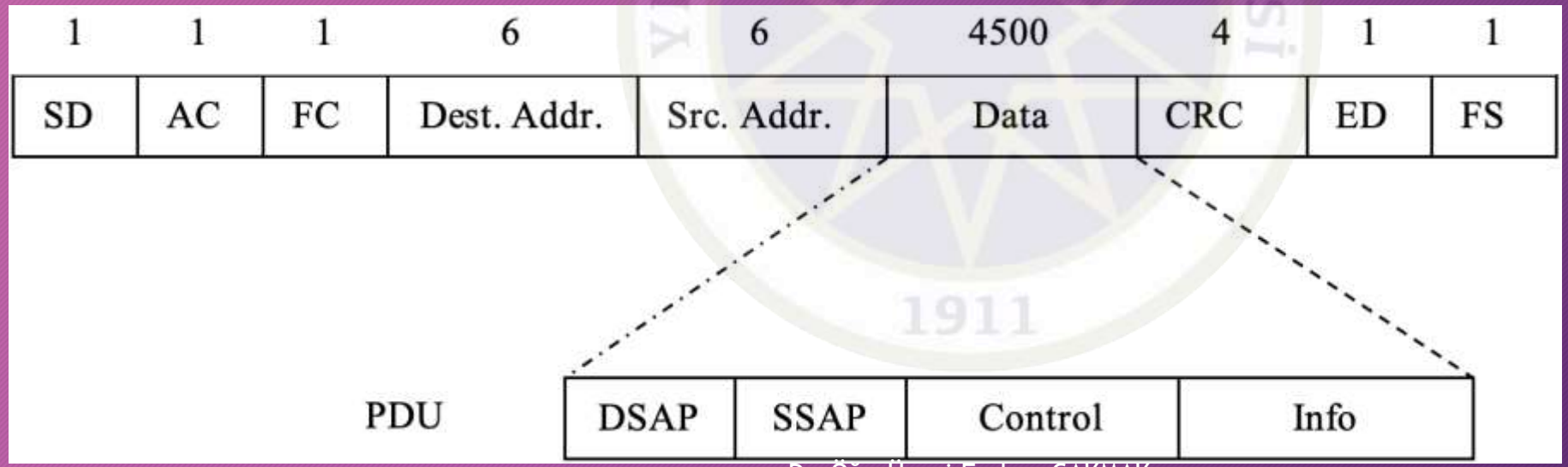
- Example: Transmission speed: R Mbps
- Bit extraction rate: 1/R μsec
- Signal propagation rate: SP m/μsec
- Every bit occupies on ring: SP/R m
- What is the number of bits (b) that can be simultaneously on an L-meter ring?
- $b = L * R / SP$

IEEE 802.5-Token Ring - Priority and Reservation

- For reservation: AC (Access Control) is used.
- Time Limitation
- Monitor Station
  - No Token Frame
  - Orphan Frame

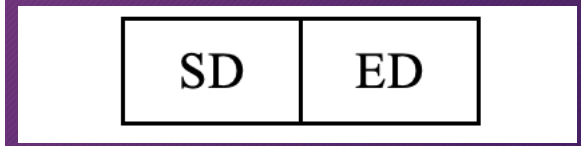
IEEE 802.5-Token Ring - Framing

- NIC (Network Interface Card) Addresses (6-byte)
- Differential Manchester Coding
- Max speeds are 4 and 16 Mbps (IEEE 802.5t: 100 Mbps, IEEE 802.5v: 1 Gbps)
- First sending bit is MSB (different from 802.3 and 802.4)



Token

Abort



FDDI (Fiber Distributed Data Interface)

- ANSI and ITU-U standart
- Fiber optics: 100 Mbps
- Token
- S-Frame (Synchronous Frame) - priority
- A-Frame (Asynchronous Frame)
- Timing Register
  - SA (Synch. Allocation)
  - TTRT (Target Token Rotation Time)
  - AMT (Absolute Maximum Time)

  - TRT (Token Rotation Timer)
  - THT (Token Holding Time)

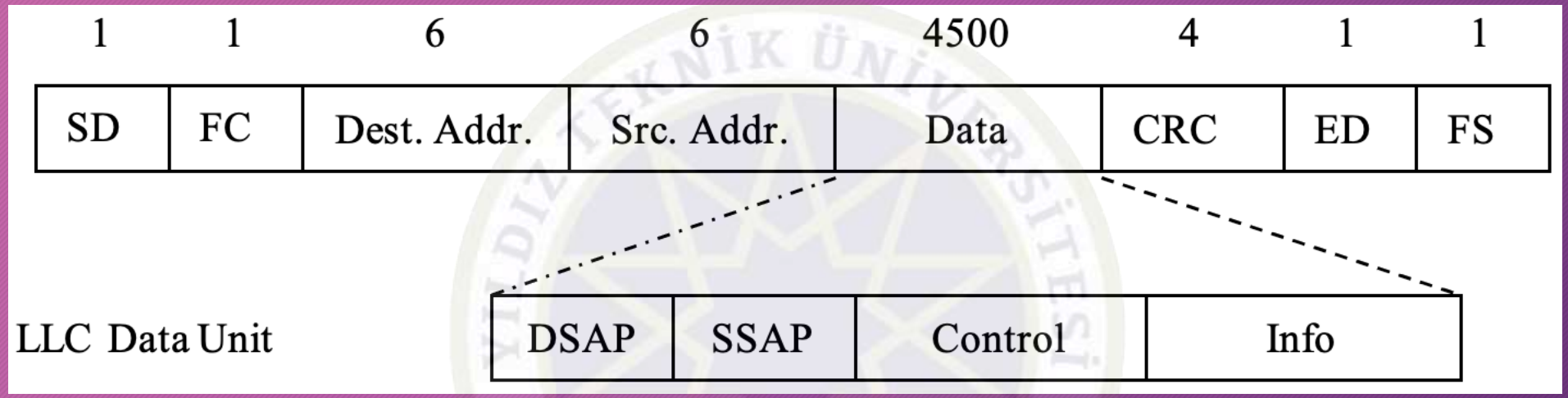
FDDI (Fiber Distributed Data Interface) – Con't

- 4B/5B Coding
  - Using NRZ-I

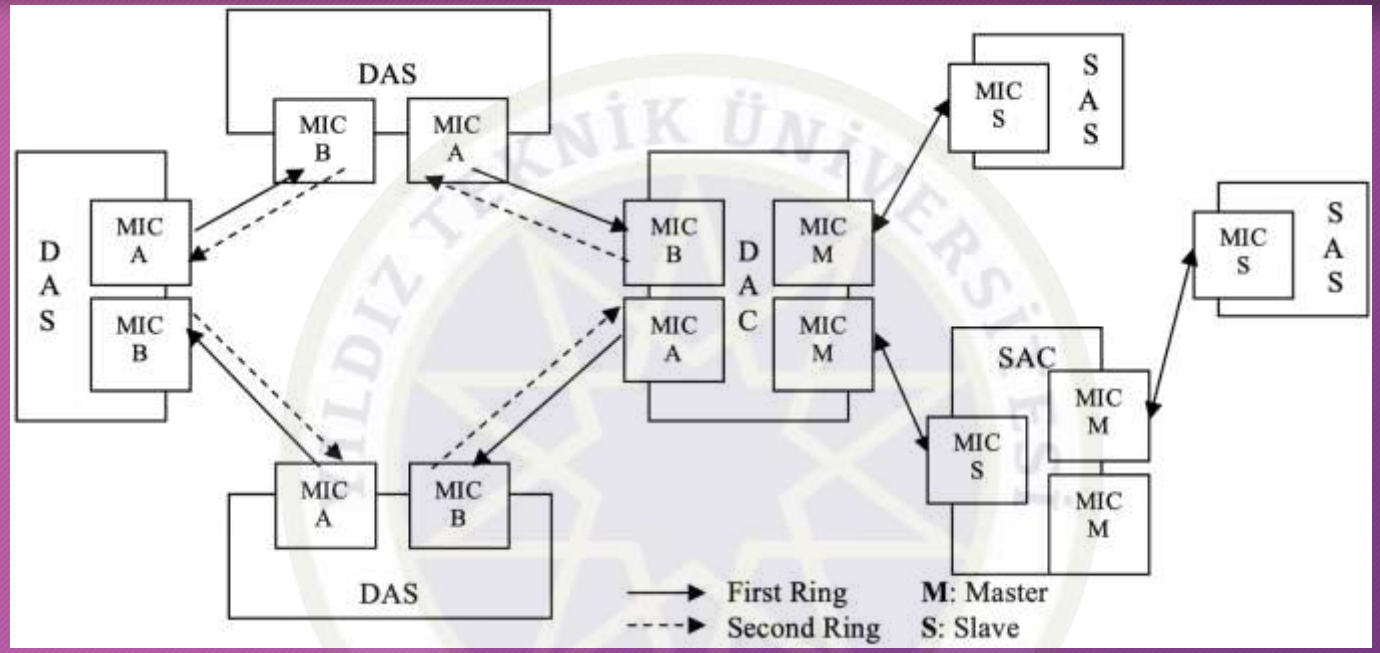
5 Bit	Explanation
00000	Q (Quit)
11111	I (Idle)
00100	H (Halt)
11000	J (Used as a starting marker)
10001	K (Used as a starting marker)
01101	T (Used as a ending marker)
11001	S (Set)
00111	R (Reset)

4 Bit	5 Bit	4 Bit	5 Bit
0000	11110	1000	10010
0001	01001	1001	10011
0010	10100	1010	10110
0011	10101	1011	10111
0100	01010	1100	11010
0101	01011	1101	11011
0110	01110	1110	11100
0111	01111	1111	11101

FDDI – Framing



FDDI – Mechanism



IEEE 802.11 - WiFi

- RF
- Infrared
- Static
- Mobile, Nomadic
  - Roaming
- Carrier
- Non-Line-of-Sight Propagation (NLSP)

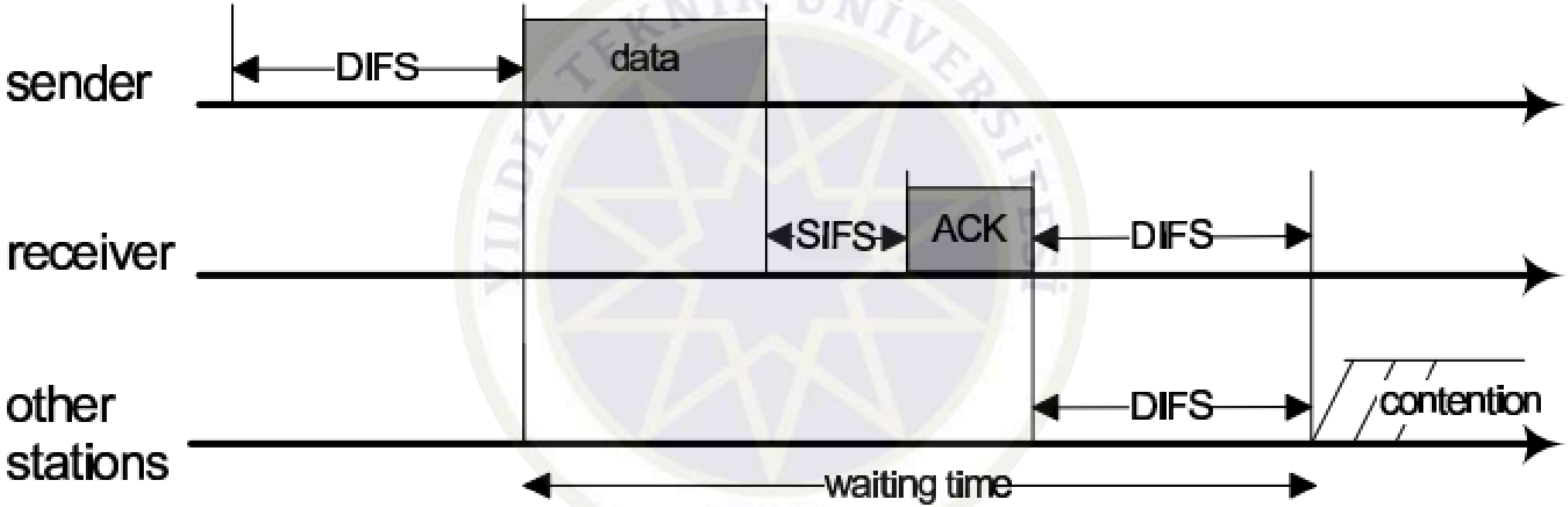
IEEE 802.11 – WiFi – Con't

- Continuation of the Ethernet
- CSMA/CD -> CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance)
  - Antenna type: half-duplex
  - Fading
    - The signal decreases inversely with the square of the distance
  - Noise
  - Detecting collisions is almost impossible
- IEEE 802.11 MAC
  - DCF (Distributed Coordination Function)
    - CMSA/CA
  - PCF (Point Coordination Function)
    - Polling

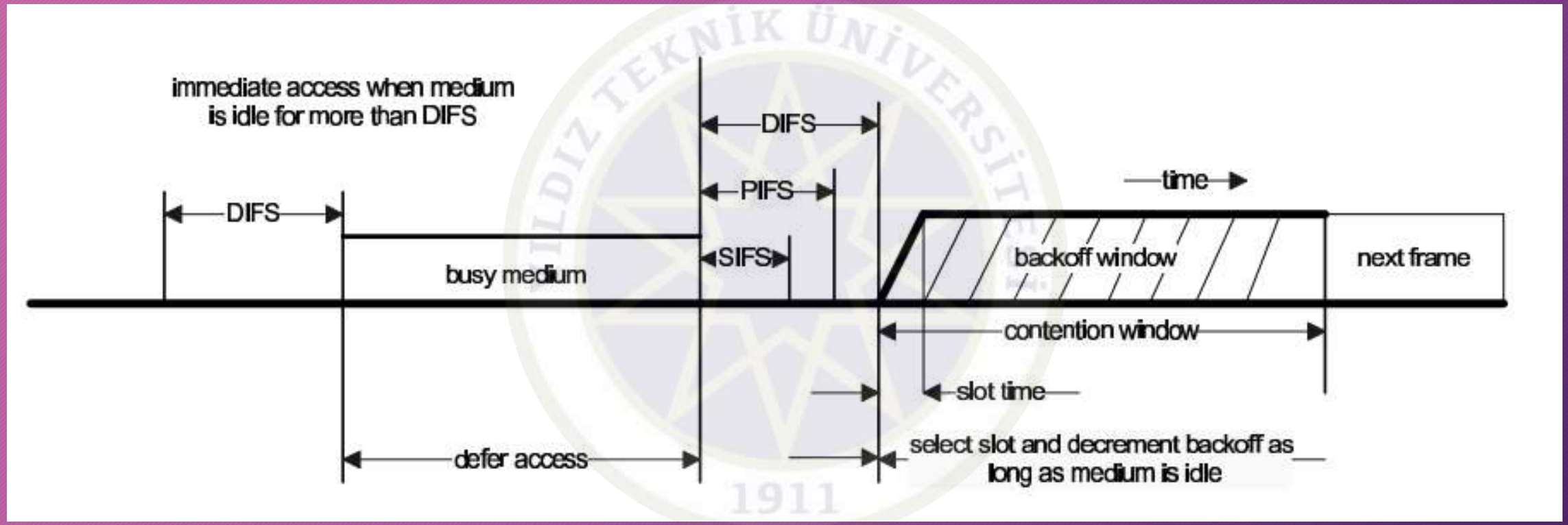
IEEE 802.11 – DCF-Distributed Coordination Function

- DCF basic access method
  - Checks if the line is empty
  - If it sees that the line is empty for DIFS (DCF Inter-Frame Space) time, it switches to transmission.
  - If the line is busy, it delays its own transmission until the transmission is finished.
    - Waits until DIFS (back-off) times is up
  - The back-off timer starts to decrease (DIFS)
  - It transmits when the back-off time value is 0.
  - Timing slots
  - Receiving node sends acknowledgment (ACK) after waiting the time specified by SIFS (Short Inter Frame Space).
    - SIFS<DIFS
  - In case a collision;
    - EIFS (Extended Inter Frame Space)

IEEE 802.11 – DCF-Distributed Coordination Function – Con't



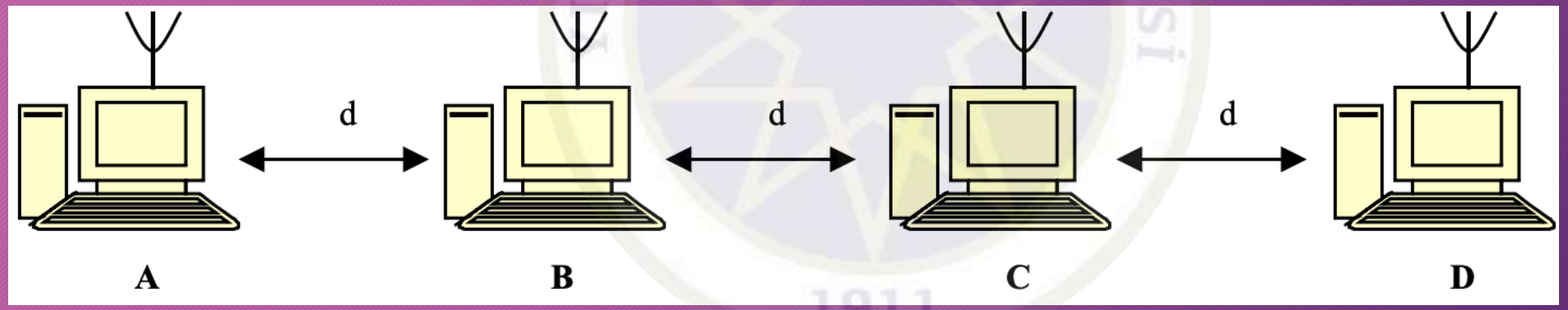
IEEE 802.11 – DCF-Distributed Coordination Function – Con't



IEEE 802.11 – DCF-Distributed Coordination Function – Con't

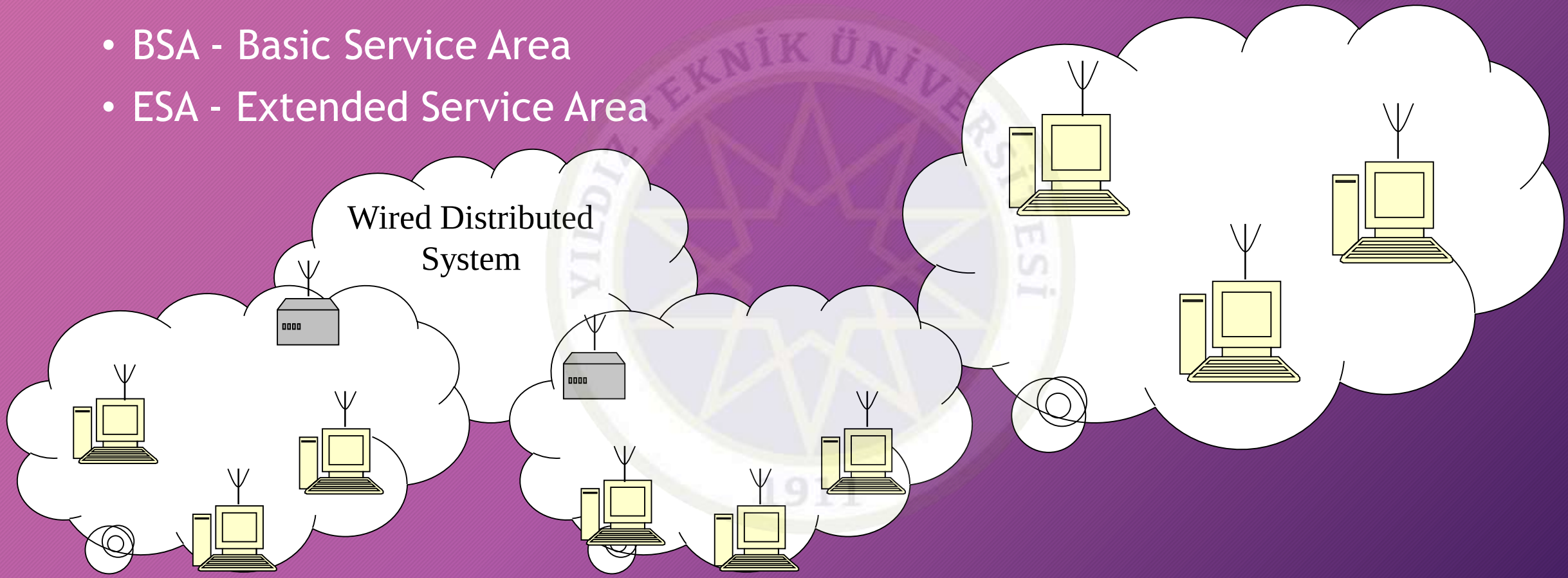
IEEE 802.11 – DCF-Distributed Coordination Function – Con't

- RTS (Request To Send) / CTS (Clear To Send)
  - NAV (Network Allocation Vector)
- Hidden Node
- Exposed Node



Service Area

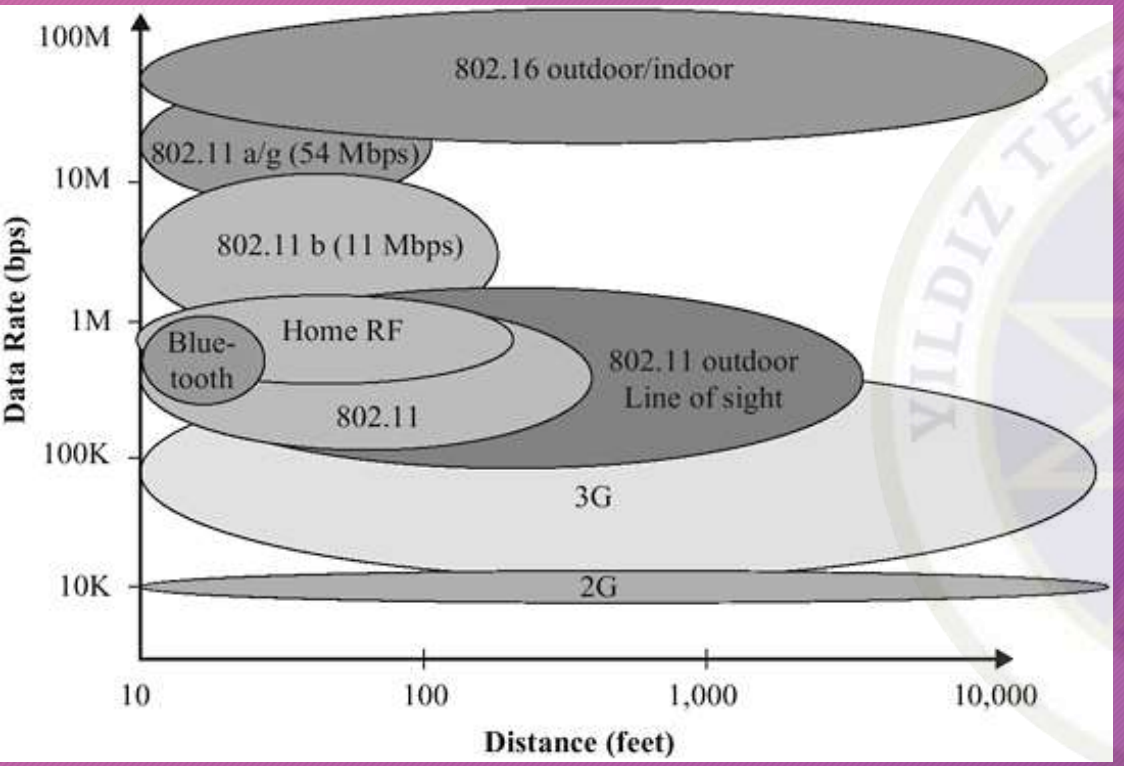
- BSA - Basic Service Area
- ESA - Extended Service Area

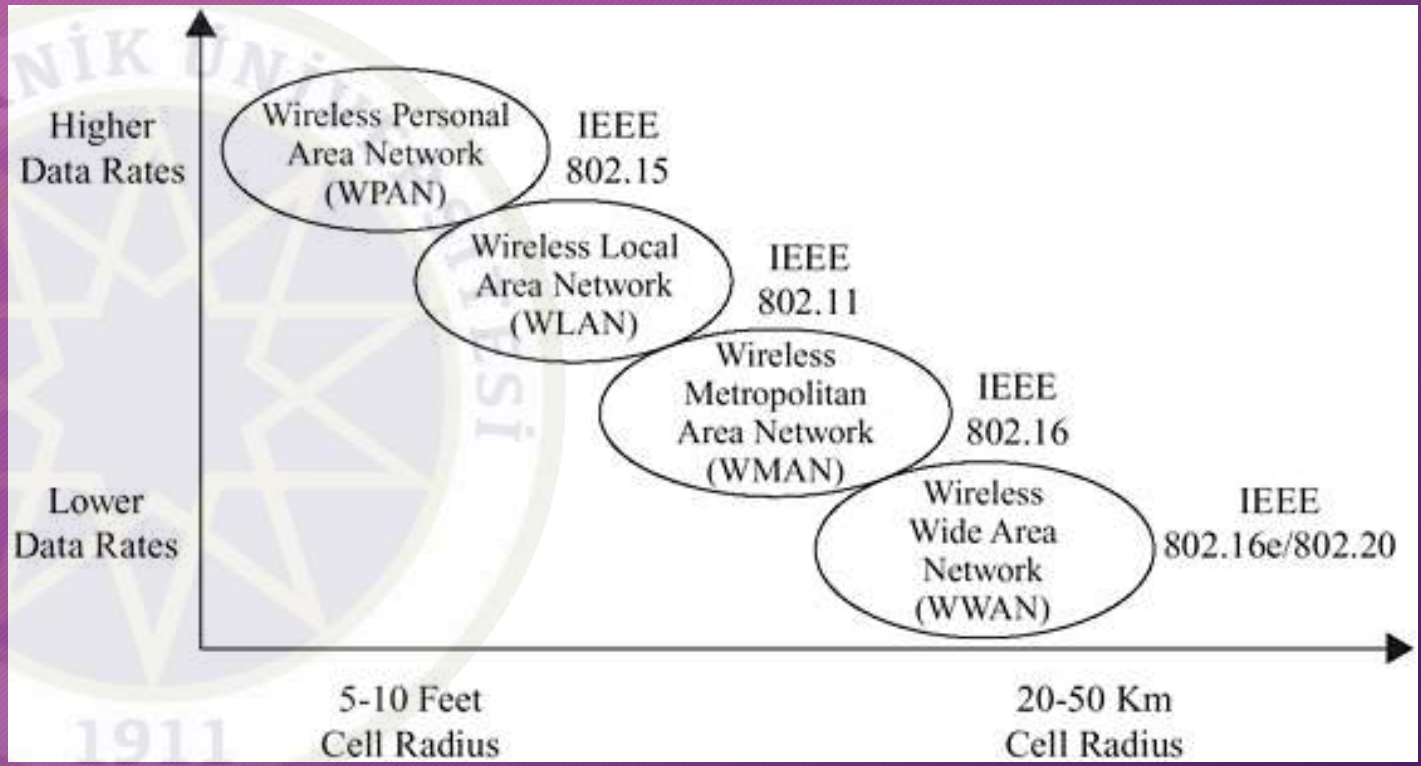


Channel Usage

Standart	Bant Genişliği	Veri Hızı	Modülasyon	Örtüşmeyen Kanal	İç Ortam	Dış Ortam
IEEE 802.11	20 MHz	≤ 2Mbps @ 2.4GHz	FHSS, DSSS		20m	100m
IEEE 802.11a	20 MHz	≤ 54Mbps @ 5GHz	OFDM	11	35m	120m
IEEE 802.11b	20 MHz	≤ 11Mbps @ 2.4GHz	DSSS (CCK)	3	35m	140m
IEEE 802.11g	20 MHz	≤ 54Mbps @ 2.4GHz	OFDM (>20Mbps) DSSS (<20Mbps)	3	38m	140m
IEEE 802.11n	20 MHz 40 MHz	≤ 72Mbps @ 2.4GHz ≤ 150Mbps @ 5GHz	OFDM (MIMO – 4 stream)	3/11	70m	250m
IEEE 802.11ac	20 MHz 40 MHz 80 MHz 1600 MHz	≤ 87.6Mbps @ 5GHz ≤ 200Mbps @ 5GHz ≤ 433Mbps @ 5GHz ≤ 866Mbps @ 5GHz	OFDM (MIMO – 8 stream)			
Bluetooth	Ver 3.0	≤ 24Mbps @ 2.4GHz	FHSS	79		100m
HomeRF		≤ 10Mbps @ 2.4GHz	FHSS			
HiperLAN/1		≤ 20Mbps @ 5GHz	CSMA/CA			
HiperLAN/2		≤ 54Mbps @ 5GHz	OFDM			

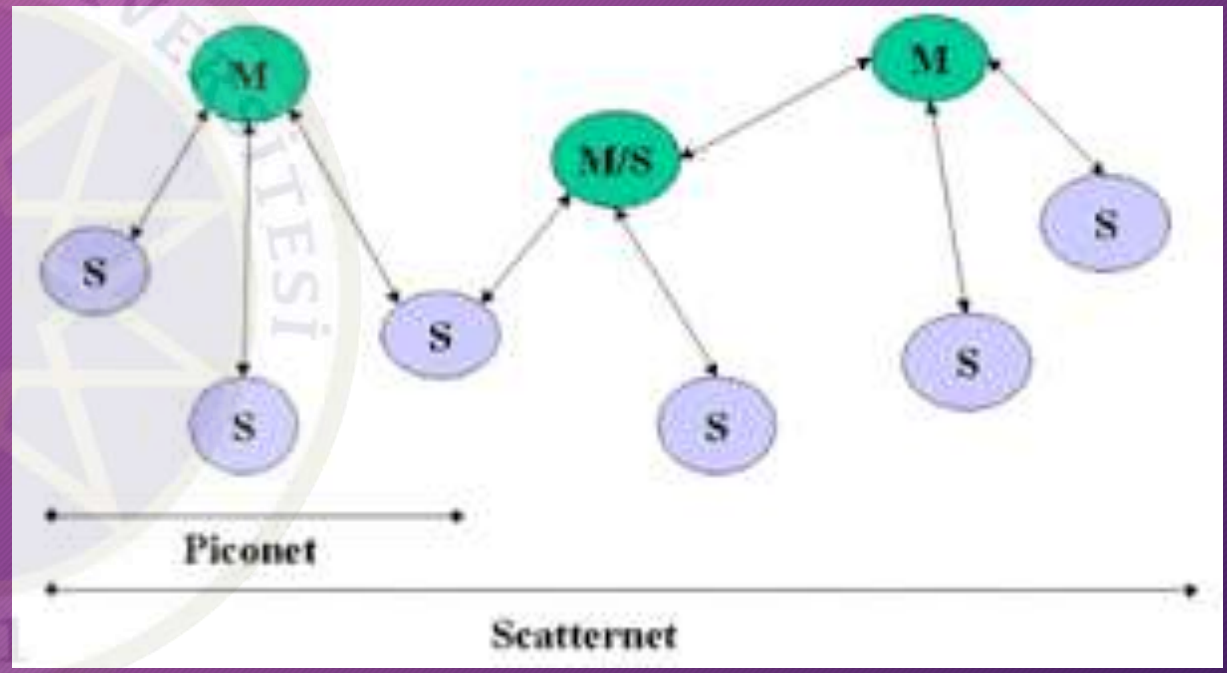
Channel Usage – Con't





Other WiFi Standarts

- BT (Bluetooth) – IEEE 802.15.1
  - 1994
  - Ericsson
  - Bluetooth Special Interest Group (SIG)
  - 2.45 GHz (2.402-2.480 GHz)
  - SSFH (Spread-Spectrum Frequency Hopping)
  - 10-100m
  - 24 Mbps
- Piconet
- Scatternet
- Zigbee – IEEE 802.15.4
- HomeRF
- HiperLAN



Threats for Wireless Networks

- Eavesdropping
- Unauthorization Access
  - Intruder
    - Sending message
    - Receiving message
    - Changing message
    - Forging message
  - Compromised
  - Authentication
    - Credential
    - Intrusion detection
- Interference, Jamming
  - Denial of service attack
- Physical threats

Security in Wireless Networks

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- Authentication
- Encryption
- Security types
  - Wired Equivalent Privacy (WEP)
    - Encryption only for data, not for header
    - RC4
    - Encryption key is too weak.
  - Wi-Fi Protected Access (WPA)
    - >= 2003
    - Temporal Key Integrity Protocol (TKIP)
      - Authentication
    - WPA2 (2010)
      - Advanced Encryption Standard (AES)
      - Extensible Authentication Protocol (EAP)
    - 2008 -> TKIP is unreliable

802.3 Ethernet	+	Yaygın kullanım, sahip olunmuş deneyim
	+	Basit algoritma
	+	Basit kurulum. Yıldız ilingesinde yeni bir bilgisayar eklemek ağın çalışmasını etkilemez.
	+	Sayısal işaretleşme (Manchester) LSB öncelikli veri iletimi
	+	Düşük yüklerde gecikme sıfıra yakındır
	–	CD donanımı örneksel
	–	Yüklü çalışma durumunda veri bozulması (collision) olasılığı artar
	–	Non deterministic (Gerçek zamanlı uygulamalar için ideal değil)
	–	Öncelik mekanizması mevcut değil
	–	En az 64'byte'lik çerçeveler
	–	Sınırlı çerçeve büyüklüğü
802.4 Token Bus	+	Deterministic
	+	Öncelik mekanizması (garanti edilmiş bant genişliği)
	+	Yüklü çalışmada mükemmel sonuç
	+	Birden fazla kanal üzerinden iletim imkânı (örneksel)
	–	Örneksel yapı (modem, amplifier vs.)
	–	Son derece karmaşık protokol yapısı
	–	Düşük yüklerde gecikmeler artıyor
	–	Fiber kullanımına müsait değil
802.5 Token Ring	+	Sayısal işaretleşme (Differential Manchester) MSB öncelikli veri transferi
	+	Öncelik mekanizması ve 8 seviye
	+	Rezervasyon imkânı
	+	Yüklü çalışmada yüksek verim
	+	İletim ortamındaki çeşitlilik
	+	Kısa ve uzun çerçeve yapıları kullanabilir.
	+	Deterministic
	–	Monitör fonksiyonu
	–	Düşük yüklerde jeton iletiminde yaşanan gecikmeler
FDDI	+	Zamana duyarlı veri iletimine öncelik verilmiştir.
	+	Çift halka kullanımı dolayısıyla çalışma süreklilik vardır.
	+	Fiber kullanımı ile kapsadığı mesafe arttırılmıştır
	–	Hız olarak ihtiyaçların gerisinde kalmak üzeredir.
WLAN	+	Mobil olma kavramını getirmiştir
	+	Fiziksel olarak kablo çekmenin mümkün olmadığı yerlerde son derece tatminkâr sonuçlar üretir.
	–	Sınırlı mesafe içinde çalışmaktadır.
	–	Kablolu ağlara nazaran iletişim hızları düşüktür.

Thank you for your listening.

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