Wireless LAN Technology and the IEEE 802.11 Wireless LAN Standard

CS-1699 Wireless Networks
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INTRODUCTION

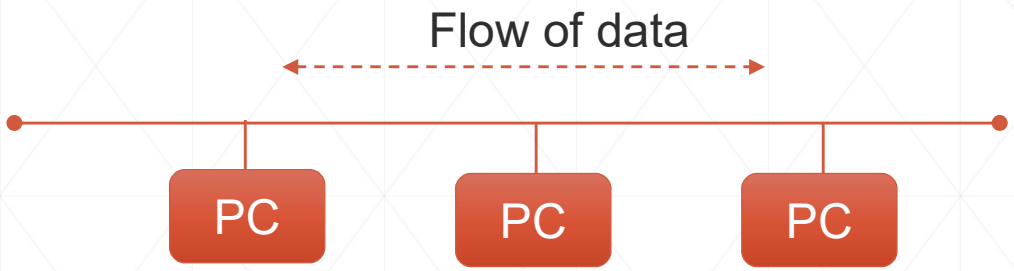
- Local Area Network
  - Consists of a shared transmission medium and a set of hardware, software for interfacing devices to the medium and regulating the orderly access to the medium
  - Variety of applications for LANs is very wide
    - Personal Computer LANs
      - Interconnecting low cost devices, such personal computer to exchange data
      - Sharing expensive resources within organization

LAN applications

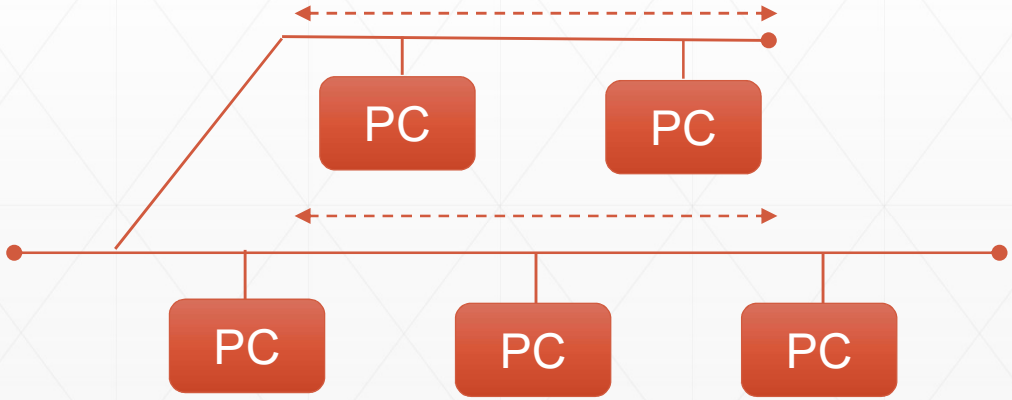
- Backend networks
  - To interconnect large systems such as mainframes, supercomputers and mass storage devices
  - Typical characteristics : High data rate, high-speed interface, distributed access, limited distance and limited number of devices
- Backbone LANs
  - Sometime, developing LANs into cluster of smaller LANs gives some advantages
    - Higher reliability compared to single LAN
    - Capacity of single LAN could saturated as the number of devices to the network grows
    - Each cluster of LAN can be optimized for diverse requirements of interconnection and communication

LAN topologies

- Bus topologies

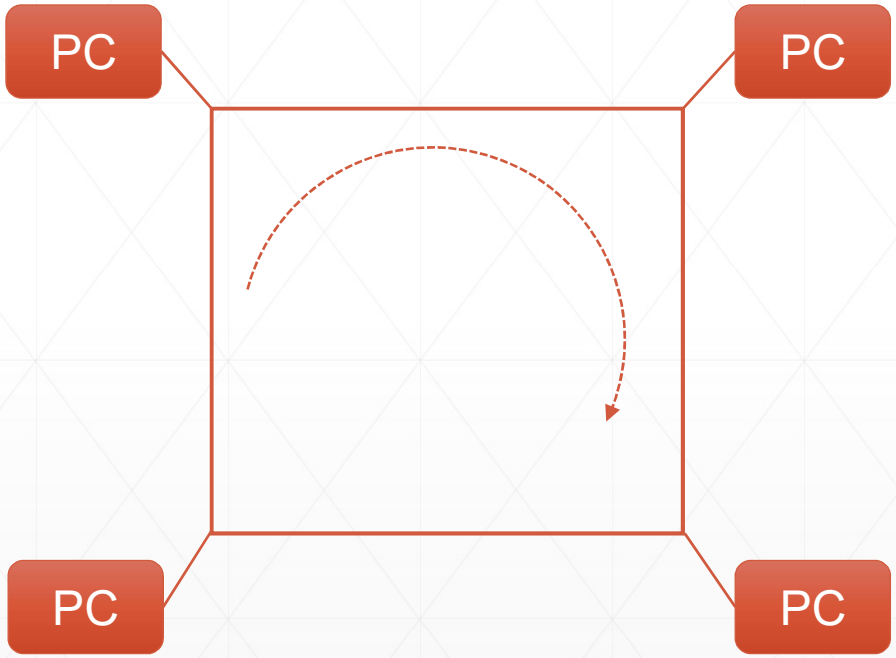


- Tree topology is a generalization of the bus topology



Lan topologies

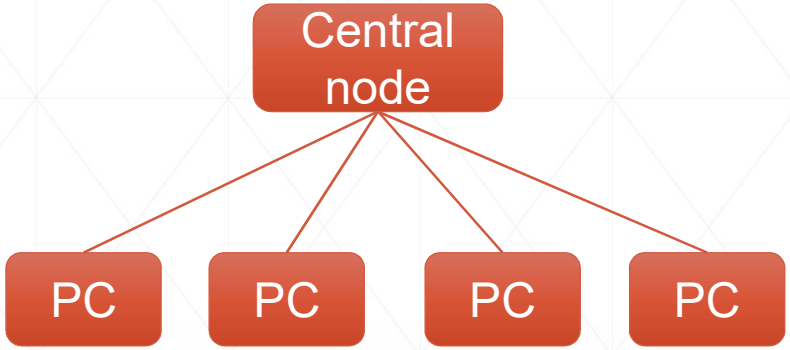
- Ring topology



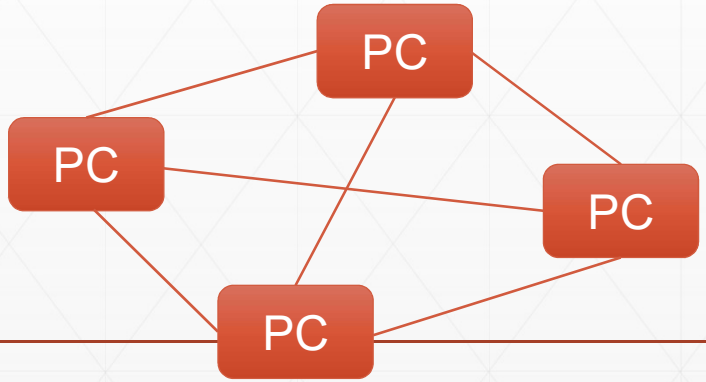
Data flow generally unidirectional

LAN TOPOLOGIES

- Star topology



- Mesh topology

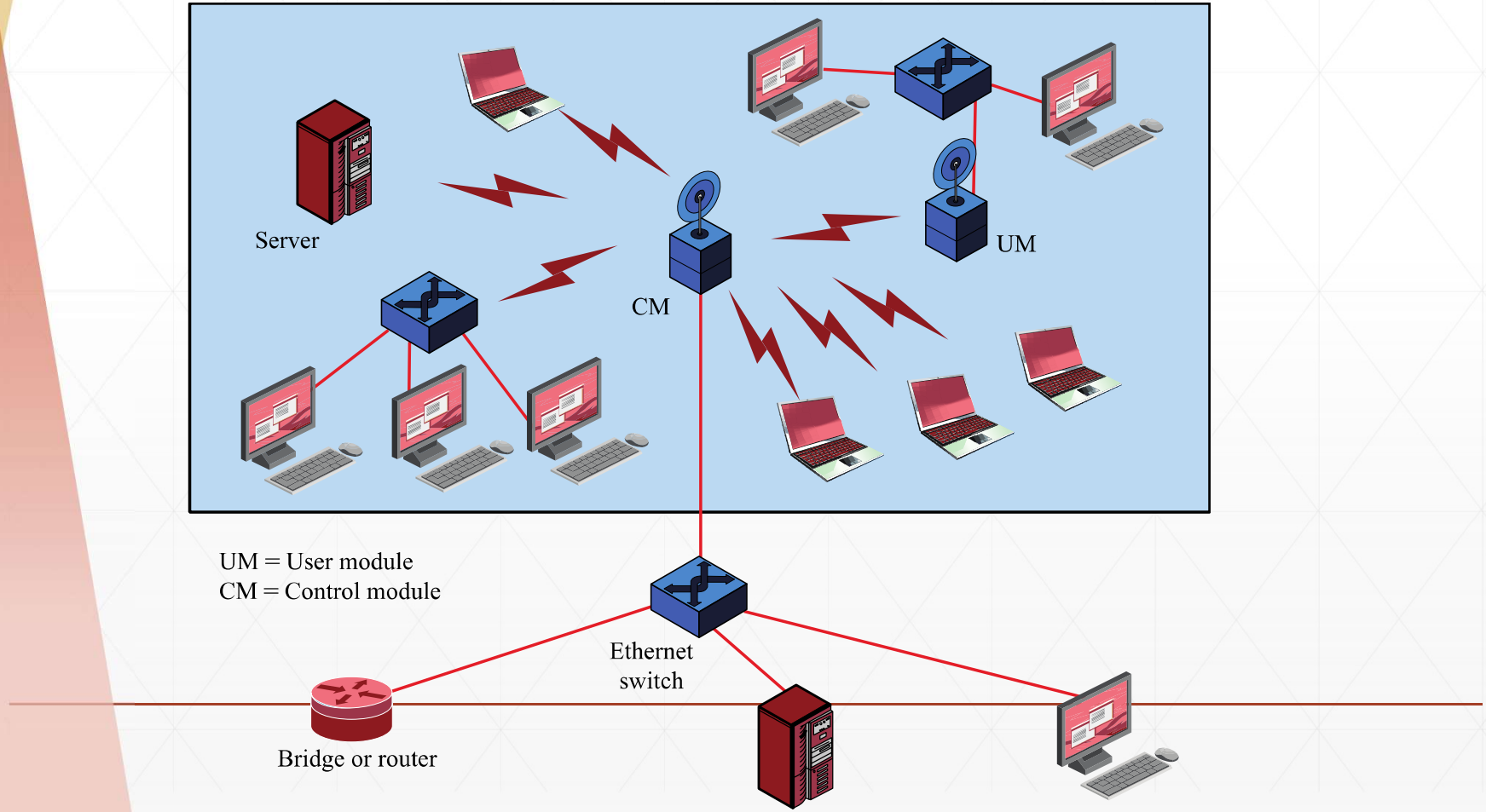


Wireless Lan

- Wireless LANs (WLAN) become indispensable adjunct to wired LANs
  - LAN extension
  - Cross building interconnect
  - Nomadic environment
    - To support limited mobility of communicating device.
  - Ad Hoc Networking
    - Peer to peer network
    - Set up temporarily to meet immediate need

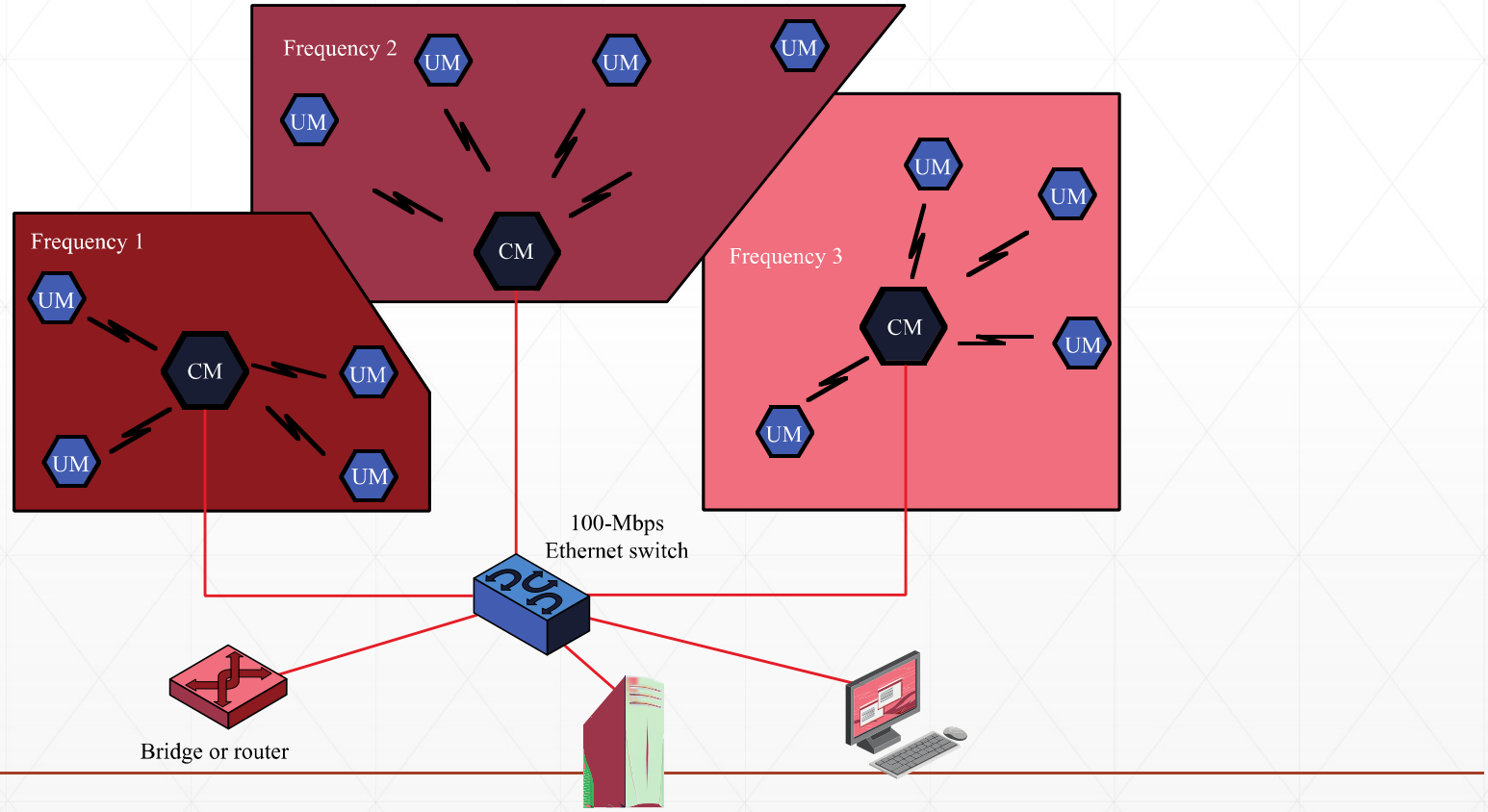
Wireless LAN configuration

- Single cell wireless LAN



Wireless lan configuration

- Multiple-cell wireless LAN configuration



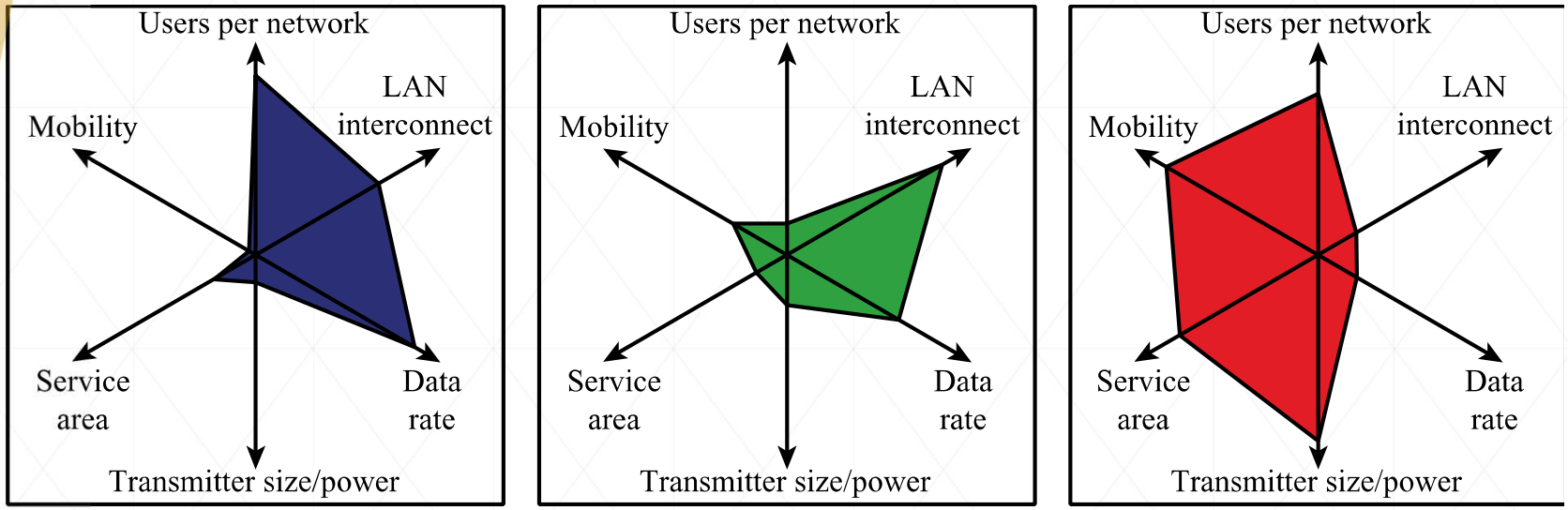
Wireless Lan configuration

- Ad Hoc Wireless LAN Configuration

- The previous two configurations are known as infrastructure wireless LAN, while the later one is infrastructureless

Wireless LAN Requirements

- Throughput
- Number of nodes
- Connection to backbone LAN
- Service area
- Battery power consumption
- Transmission robustness and security
- License-free operation
- Handoff/roaming
- Dynamic configuration



(a) Wired LANs **(b) Wireless LANs** **(c) Mobile data networks**

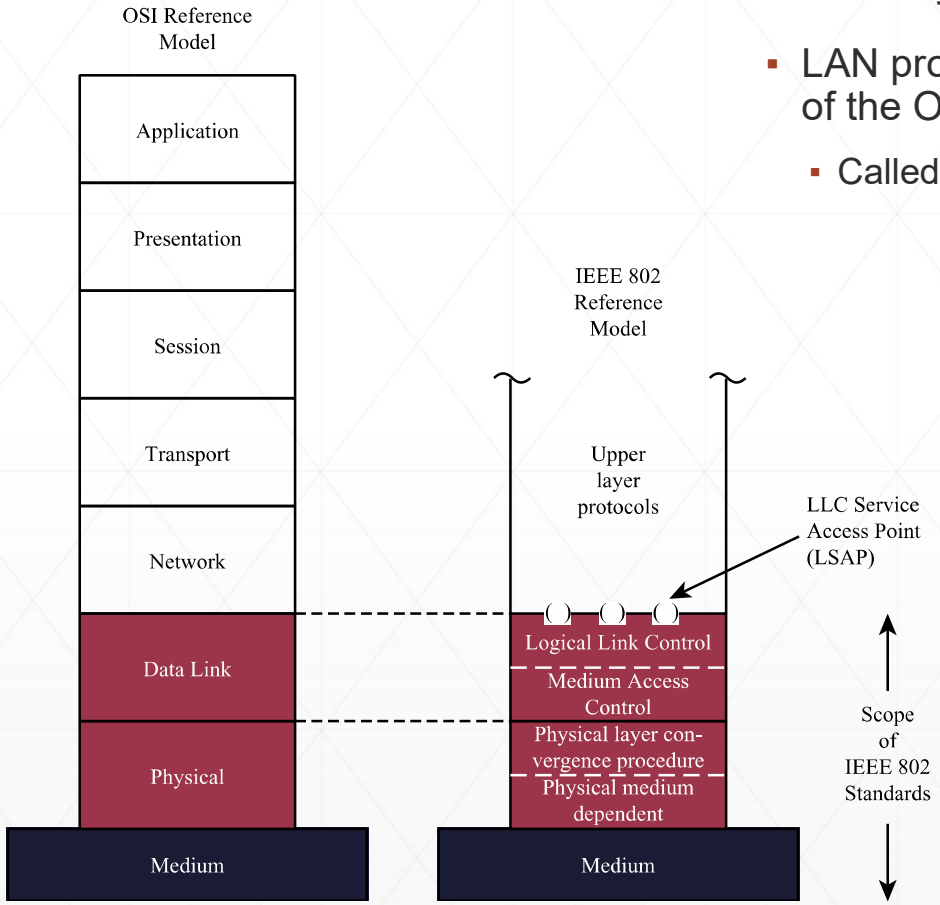
- Comparisons between WLANs, wired LANs, and mobile data networks can be visualized with Kiviat graphs.

Wireless LAN physical layer

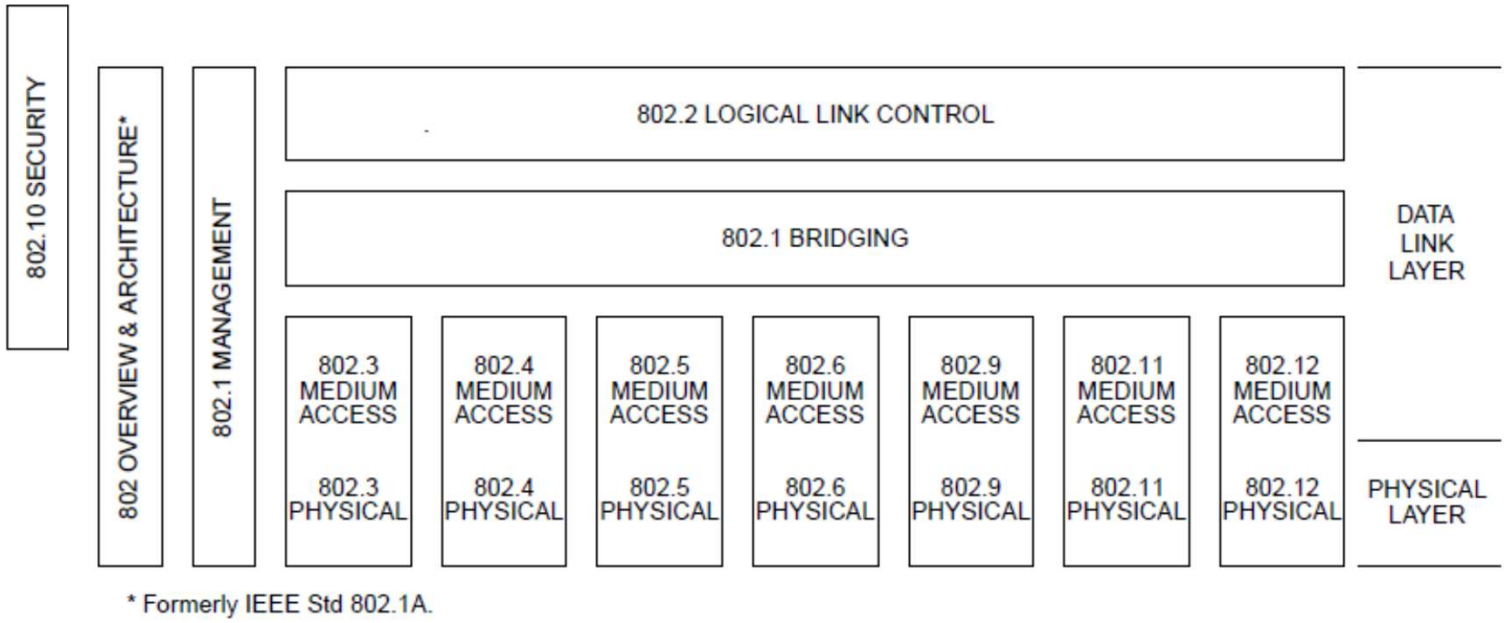
- Multi-cell arrangement
- Transmission Issues
  - No licensing needed – Four microwave bands
    - 902-928 MHz
    - 2.4-2.5 GHz
    - 5.725-5.875 GHz
    - 58-64 GHz (60-GHz mm Wave bands)
      - Higher capacity
      - Less competition
      - More expensive equipment
  - Spread spectrum
    - DSSS CDMA or OFDM
    - Over 1 Gbps possible with OFDM, channel bonding, and MIMO

IEEE 802 Protocol architecture

- Uses layering of protocols
- LAN protocols focus on the lower layers of the OSI model
  - Called the IEEE 802 reference model



IEEE 802 Logical Link control

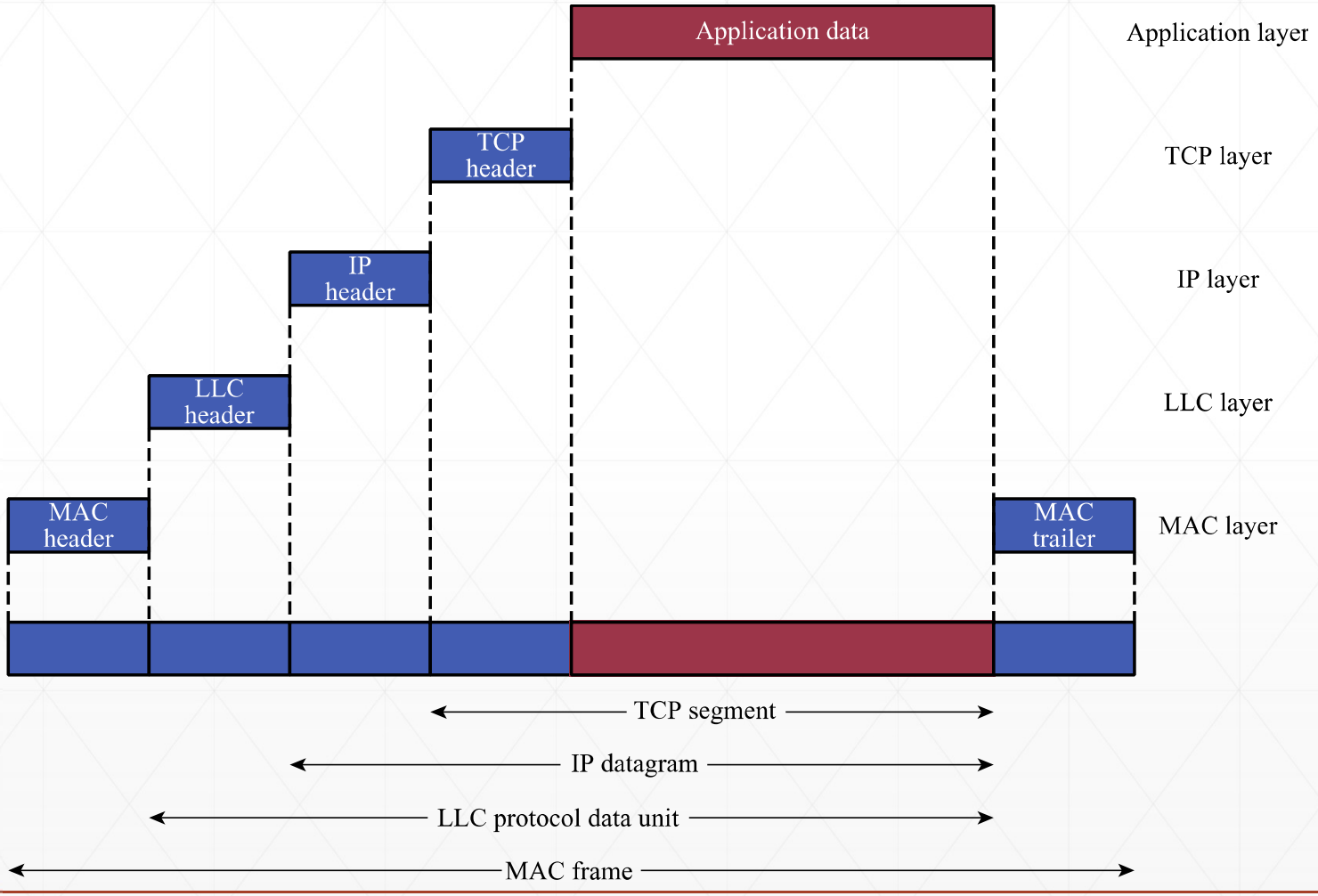


Based on document ISO/IEC 8802-2:1998

IEEE 802 Protocol Architecture

- Functions of physical layer :
  - Encoding/decoding of signals
  - Preamble generation/removal (for synchronization)
  - Bit transmission/reception
  - Includes specification of the transmission medium
- In case of IEEE 802.11, sublayers are:
  - Physical medium dependent sublayer (PMD)
    - Transmitting and receiving user data through a wireless medium
  - Physical layer convergence procedure (PLCP)
    - Mapping 802.11 MAC layer protocol data units (MPDUs) into a framing format
    - Sending and receiving between stations using same PMD sublayer

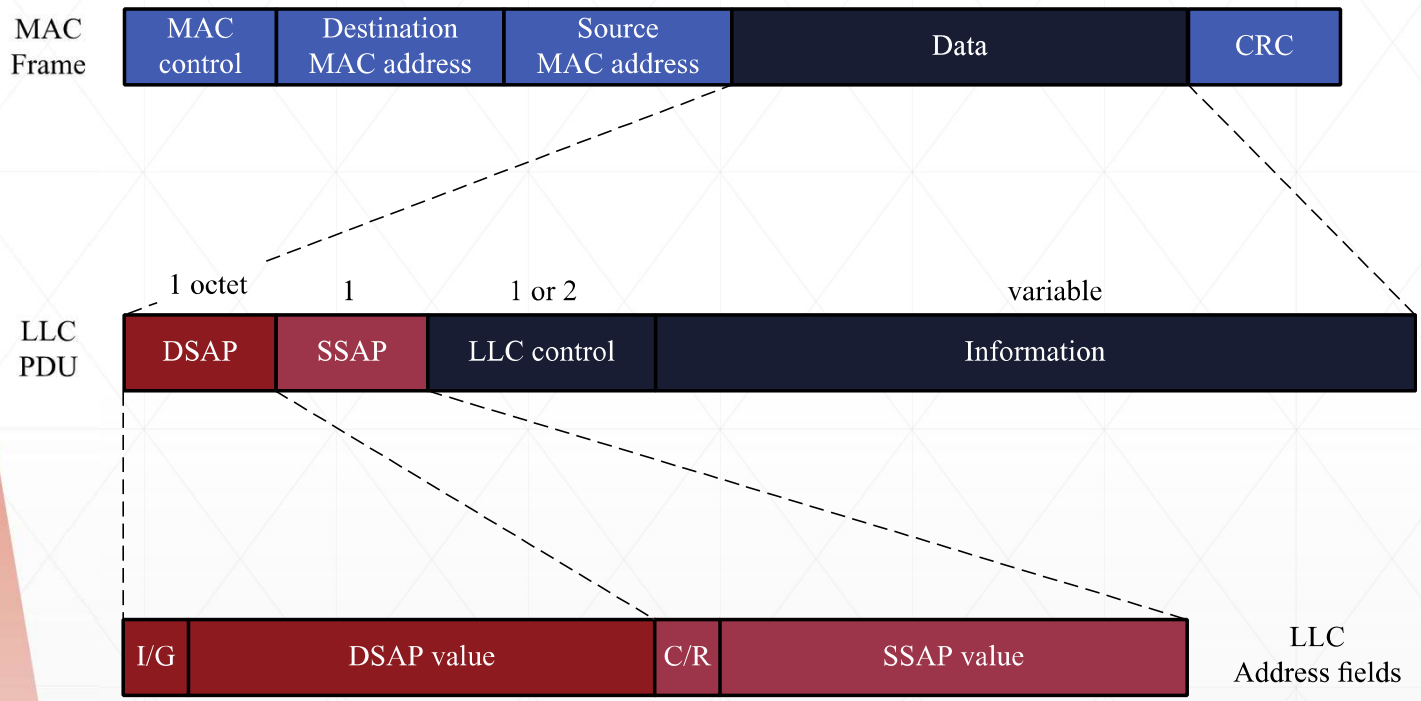
IEEE 802 Protocols in Context



IEEE 802 Logical Link Control and MAC

- Characteristics of LLC not shared by other control protocols:
  - Must support multi-access, shared-medium nature of the link
  - Relieved of some details of link access by MAC layer
- MAC Layer
  - The logic required to manage access to a shared-access medium not found in traditional layer 2 data link control
  - For the same LLC, several MAC options may be provided
  - MAC Format
    - MAC control
      - Contains Mac protocol information
    - Destination MAC address
      - Destination physical attachment point
    - Source MAC address
      - Source physical attachment point
    - CRC
      - Cyclic redundancy check

LLC PDU in Generic MAC Frame Format



I/G = individual/group
C/R = command/response

DSAP = destination service access point
SSAP = source service access point

LLC Services

- Unacknowledged connectionless service
  - No flow- and error-control mechanisms
  - Data delivery not guaranteed
- Connection-mode service
  - Logical connection set up between two users
  - Flow- and error-control provided
- Acknowledged connectionless service
  - Cross between previous two
  - Datagrams acknowledged
  - No prior logical setup

IEEE 802.11

- Started in 1990
  - MAC and physical medium specifications
- Wi-Fi Alliance
  - Industry consortium, initially was Wireless Ethernet Compatibility Alliance
  - Creates test suites to certify interoperability of products
    - May identify a subset of the standard for certification
  - Concerned with a range of market areas for WLANs
- IEEE 802.11 has an ever expanding list of standards

IEEE 802.11 Standards

Standard	Date	Scope
IEEE 802.11	1997	Medium access control (MAC): One common MAC for WLAN applications
		Physical layer: Infrared at 1 and 2 Mbps
		Physical layer: 2.4-GHz FHSS at 1 and 2 Mbps
		Physical layer: 2.4-GHz DSSS at 1 and 2 Mbps
IEEE 802.11a	1999	Physical layer: 5-GHz OFDM at rates from 6 to 54 Mbps
IEEE 802.11b	1999	Physical layer: 2.4-GHz DSSS at 5.5 and 11 Mbps
IEEE 802.11c	2003	Bridge operation at 802.11 MAC layer
IEEE 802.11d	2001	Physical layer: Extend operation of 802.11 WLANs to new regulatory domains (countries)
IEEE 802.11e	2007	MAC: Enhance to improve quality of service and enhance security mechanisms
IEEE 802.11f	2003	Recommended practices for multivendor access point interoperability
IEEE 802.11g	2003	Physical layer: Extend 802.11b to data rates >20 Mbps
IEEE 802.11h	2003	Physical/MAC: Enhance IEEE 802.11a to add indoor and outdoor channel selection and to improve spectrum and transmit power management
IEEE 802.11i	2007	MAC: Enhance security and authentication mechanisms
IEEE 802.11j	2007	Physical: Enhance IEEE 802.11a to conform to Japanese requirements
IEEE 802.11k	2008	Radio Resource Measurement enhancements to provide interface to higher layers for radio and network measurements

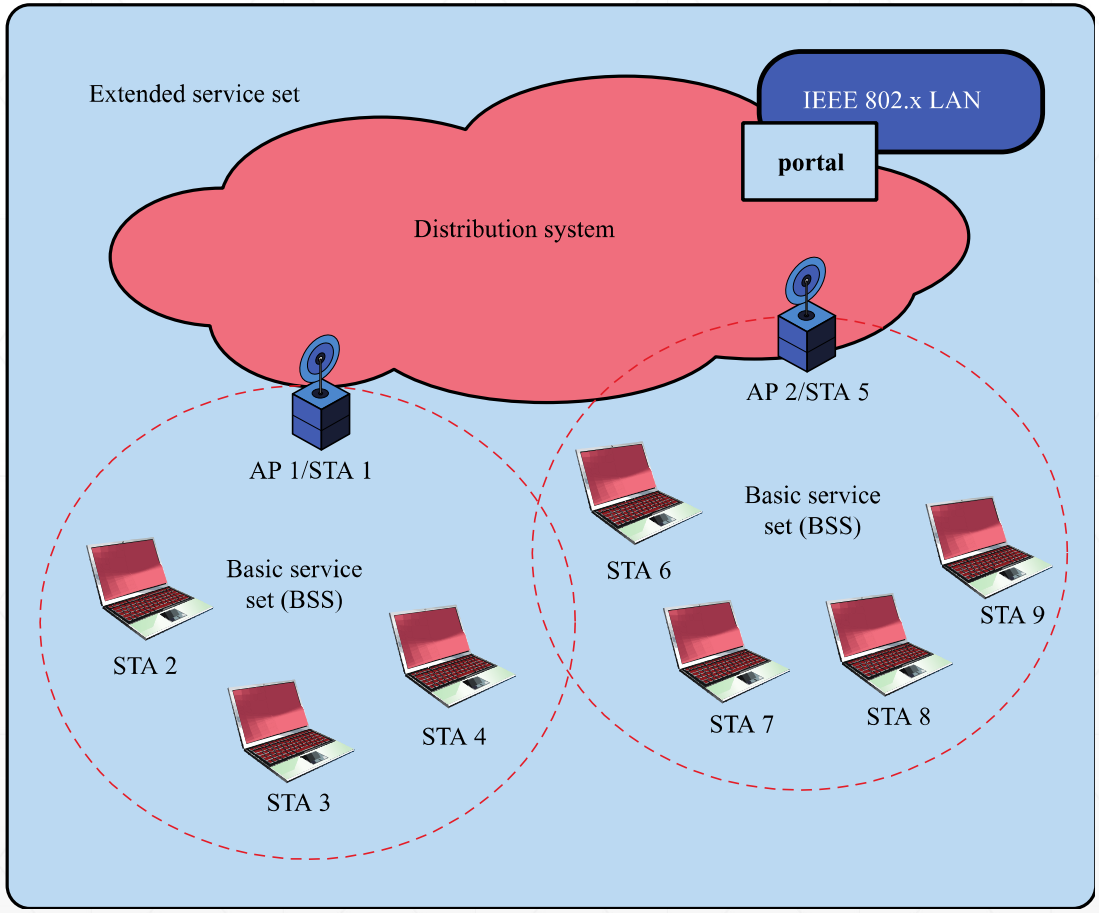
IEEE 802.11 Standards

Standard	Date	Scope
IEEE 802.11m	Ongoing	This group provides maintenance of the IEEE 802.11 standard by rolling published amendments into revisions of the 802.11 standard.
IEEE 802.11n	2009	Physical/MAC: Enhancements to enable higher throughput
IEEE 802.11p	2010	Wireless Access in Vehicular Environments (WAVE)
IEEE 802.11r	2008	Fast Roaming/Fast BSS Transition
IEEE 802.11s	2011	Mesh Networking
IEEE 802.11T	Abandoned	Recommended Practice for Evaluation of 802.11 Wireless Performance
IEEE 802.11u	2011	Interworking with External Networks
IEEE 802.11v	2011	Wireless Network Management
IEEE 802.11w	2009	Protected Management Frames
IEEE 802.11y	2008	Contention Based Protocol
IEEE 802.11z	2010	Extensions to Direct Link Setup
IEEE 802.11aa	2012	Video Transport Stream
IEEE 802.11ac	Ongoing	Very High Throughput <6Ghz
IEEE 802.11ad	2012	Very High Throughput in 60 GHz
IEEE 802.11ae	2012	Prioritization of Management Frames
IEEE 802.11af	Ongoing	Wireless LAN in the TV White Space
IEEE 802.11ah	Ongoing	Sub 1GHz
IEEE 802.11ai	Ongoing	Fast Initial Link Set-up
IEEE 802.11aj	Ongoing	China Milli-Meter Wave (CMMW)
IEEE 802.11ak	Ongoing	Enhancements For Transit Links Within Bridged Networks
IEEE 802.11aq	Ongoing	Pre-Association Discovery (PAD)
IEEE 802.11ax	Ongoing	High Efficiency WLAN (HEW)

IEEE 802.11 Architecture

- Distribution system (DS)
- Access point (AP)
- Basic service set (BSS)
  - Stations competing for access to shared wireless medium
  - Isolated or connected to backbone DS through AP
  - BSSID ➔ The ID of BSS, uses MAC Address of AP
- Extended service set (ESS)
  - Two or more basic service sets interconnected by DS
  - Generally, the ID of this service is known as SSID

IEEE 802.11 Architecture



IEEE 802.11 Services

Service	Provider	Used to Support
Association	Distribution system	MSDU delivery
Authentication	Station	LAN Access and security
Deauthentication	Station	LAN Access and security
Disassociation	Distribution system	MSDU delivery
Distribution	Distribution system	MSDU delivery
Integration	Distribution system	MSDU delivery
MSDU delivery	Station	MSDU delivery
Privacy	Station	LAN Access and security
Reassociation	Distribution System	MSDU delivery

Distribution of Messages Within a DS

- Distribution service
  - Used to exchange MAC frames from station in one BSS to station in another BSS
- Integration service
  - Transfer of data between station on IEEE 802.11 LAN and station on integrated IEEE 802.x LAN

Transition Types Based On Mobility

- No transition
  - Stationary or moves only within BSS
- BSS transition
  - Station moving from one BSS to another BSS in same ESS
- ESS transition
  - Station moving from BSS in one ESS to BSS within another ESS

Association-Related Services

- Association
  - Establishes initial association between station and AP
- Reassociation
  - Enables transfer of association from one AP to another, allowing station to move from one BSS to another
- Disassociation
  - Association termination notice from station or AP