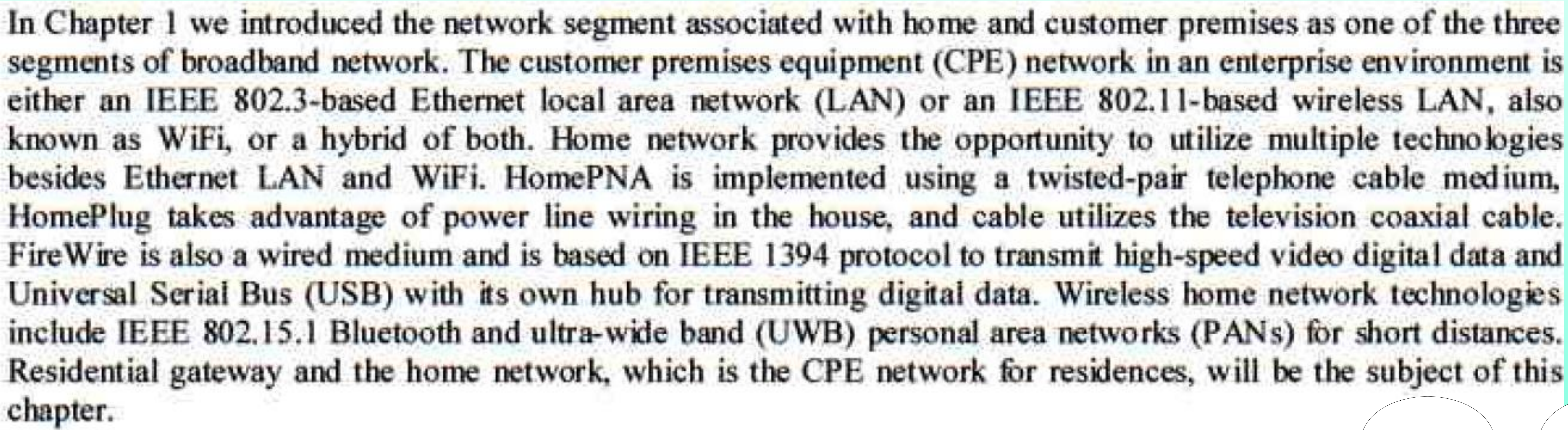
Chapter 15

Broadband Home Networks

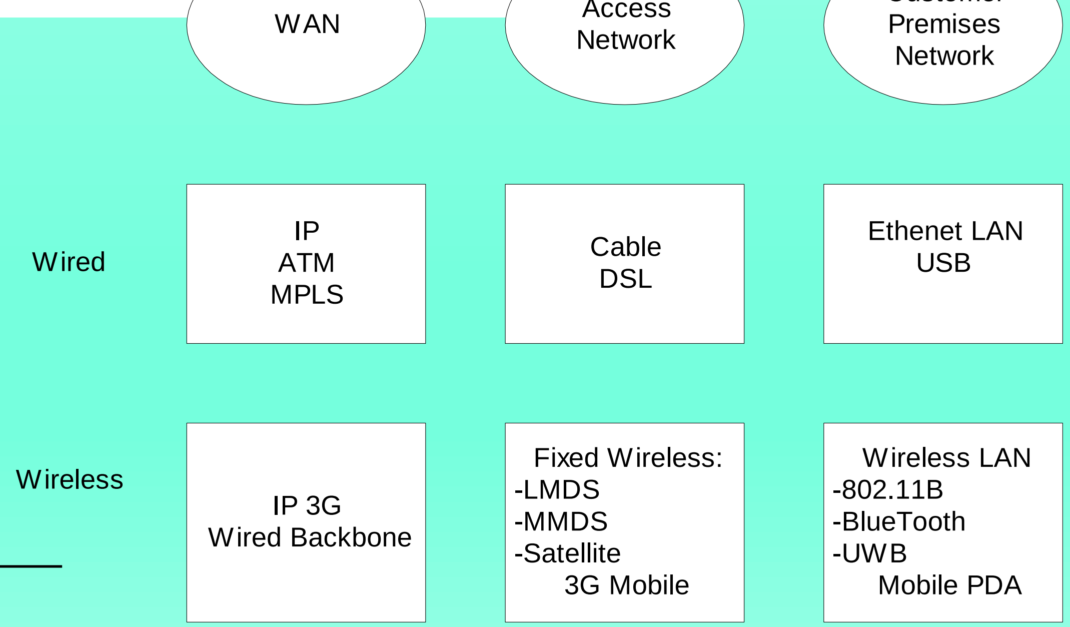
A **home network** or **home area network** (**HAN**) is a type of local area network with the purpose to facilitate communication among digital devices present inside or within the close vicinity of a home. Devices capable of participating in this network, for example, smart devicessuch as network printers and handheld mobile computers, often gain enhanced emergent capabilities through their ability to interact.

Chapter 15

Broadband Home Networks



In Chapter 1 we introduced the network segment associated with home and customer premises as one of the three segments of broadband network. The customer premises equipment (CPE) network in an enterprise environment is either an IEEE 802.3-based Ethernet local area network (LAN) or an IEEE 802.11-based wireless LAN, also known as WiFi, or a hybrid of both. Home network provides the opportunity to utilize multiple technologies besides Ethernet LAN and WiFi. HomePNA is implemented using a twisted-pair telephone cable medium, HomePlug takes advantage of power line wiring in the house, and cable utilizes the television coaxial cable. FireWire is also a wired medium and is based on IEEE 1394 protocol to transmit high-speed video digital data and Universal Serial Bus (USB) with its own hub for transmitting digital data. Wireless home network technologies include IEEE 802.15.1 Bluetooth and ultra-wide band (UWB) personal area networks (PANs) for short distances. Residential gateway and the home network, which is the CPE network for residences, will be the subject of this chapter.



	WAN	Access Network	Customer Premises Network
Wired	IP ATM MPLS	Cable DSL	Ethenet LAN USB
Wireless	IP 3G Wired Backbone	Fixed Wireless: -LMDS -MMDS -Satellite 3G Mobile	Wireless LAN -802.11B -BlueTooth -UWB Mobile PDA

Analogous Wired and Wireless Broadband Network Segments

Objectives

- Broadband home networks overview
- Applications and application protocols
- Middleware between applications and transports
- Transport technologies
- Wired home networks
  - Comprehensive view
  - Lower layer protocols
  - Ethernet-like protocols and management
  - Power Ethernet
- Wireless home network
  - WiFi (802.11a/b/g) wireless LAN
  - 802.11 standards and amendments
  - Hierarchical network using access point
  - Basic service set (BSS)
  - MAC protocols: DCF, PCF, and hybrid
- Special network management considerations
  - Security management
  - QoS management
  - Centralized management
  - WLAN MIBs

Home Networks

- **Three access networks and modems**
- **Four types of distribution networks**

Notes

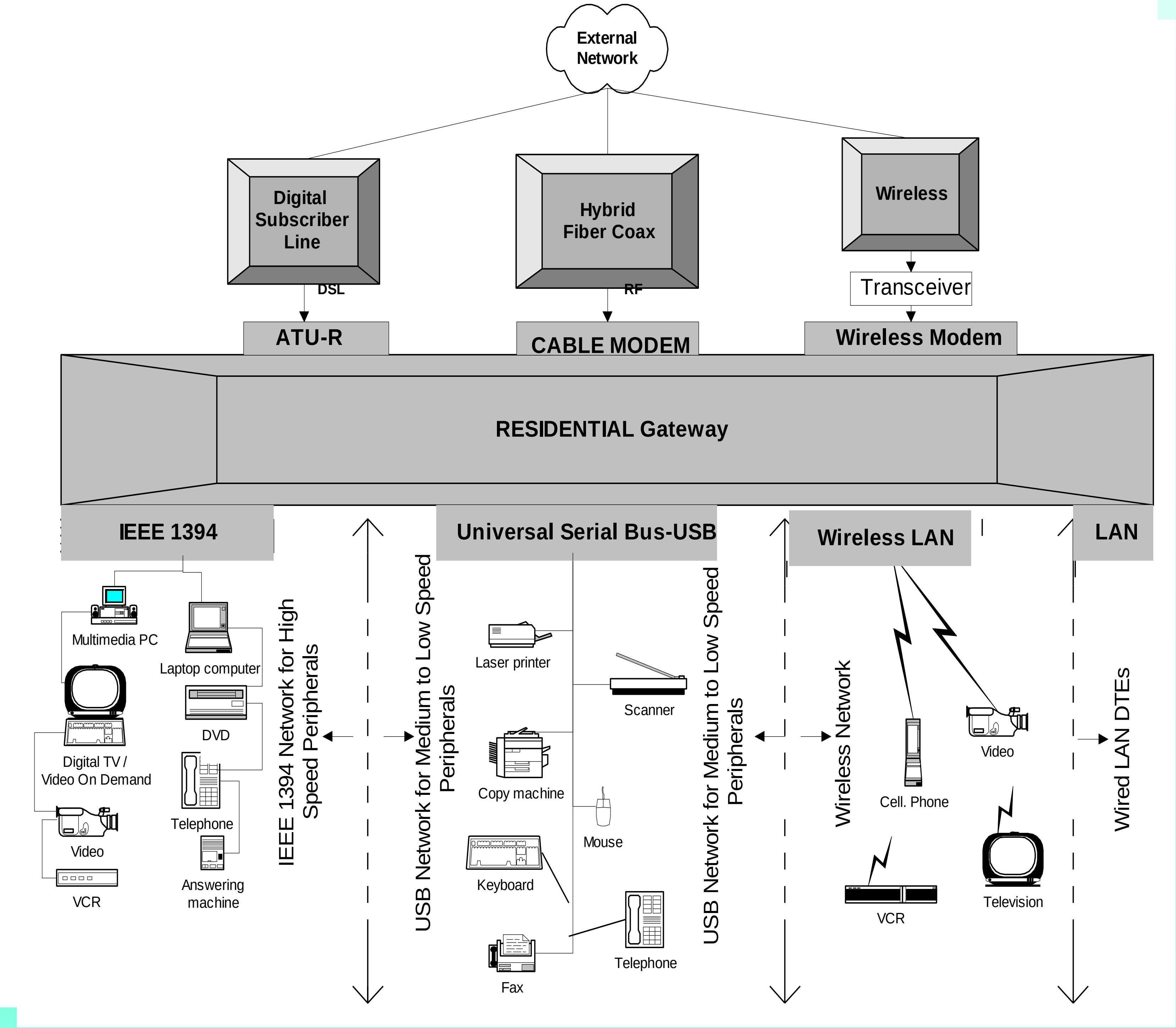


Figure 15.2 Home Networks

•Figure 15.2 shows a comprehensive view of the home network. The access network is one of three choices, namely DSL, HFC, or wireless. Each feed terminates in the respective modem, whose output is connected to a residential gateway. In Figure 15.2 **the residential gateway has four types of distribution networks connected to** it. The USB network has low- and high-speed digital data devices connected to it. The very high-speed digital triple play devices comprise IEEE 1394 network, also known as FireWire® branded by Apple. The third type of network is LAN, the predominant one being wired Ethernet network. Other less popular types of LANs are HomePNA using telephone cable or HomePlug using power line. They could be based on the above-mentioned schemes of either. The fourth home distribution network shown in Figure 15.2 is WiFi, wireless LAN network based on IEEE 802.11. We will next address wired and wireless technologies based on various physical media

Home Network Protocol Architecture

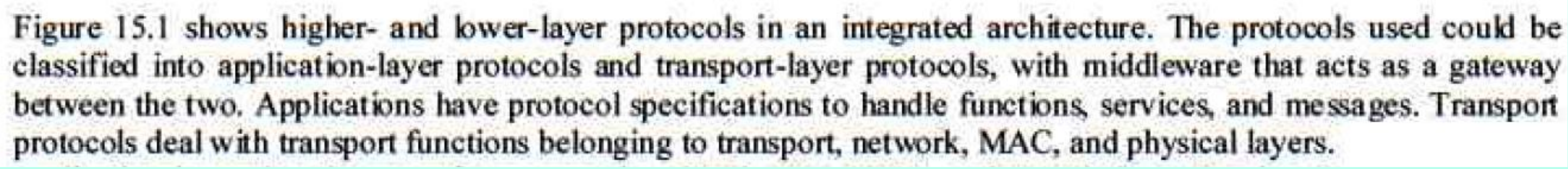
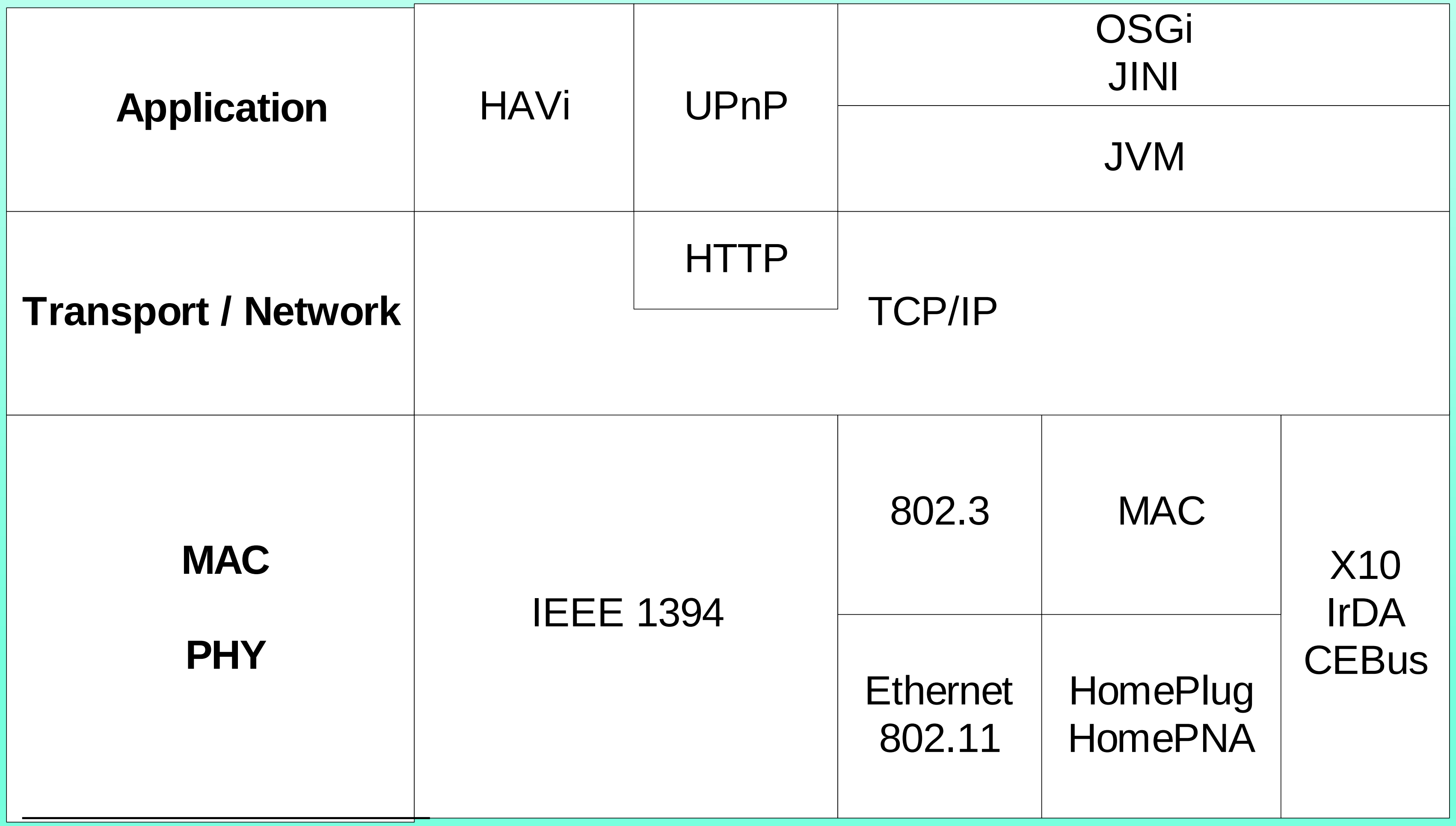


Figure 15.1 shows higher- and lower-layer protocols in an integrated architecture. The protocols used could be classified into application-layer protocols and transport-layer protocols, with middleware that acts as a gateway between the two. Applications have protocol specifications to handle functions, services, and messages. Transport protocols deal with transport functions belonging to transport, network, MAC, and physical layers.



Application	HAVi	UPnP	OSGi JINI JVM		
Transport / Network		HTTP TCP/IP			
MAC **PHY**	IEEE 1394		802.3 Ethernet 802.11	MAC HomePlug HomePNA	X10 IrDA CEBus

Figure 15.1 Home Network Protocol Architecture

Home Networking Technologies

- Middleware and higher layer protocol networks
  - HAVi (Home Audio-Video interoperability)
  - Jini (Java-based middleware/network)
  - UPnP (Universal Plug and Play)
  - OSGi (Open Service Gateway initiative)
- Lower Layer wired protocol based networks
  - IEEE 802.3 Ethernet
  - VHN (Versatile Home Network)
  - IEEE 1394 (FireWire)
  - Cable
  - HomePNA (Home Phoneline Network Alliance)
  - HomePlug (Power Line Communication, PLC)
- Wireless LANs (Local Area Networks)
  - IEEE 802.11 WLAN
  - HomeRF
- Wireless PANs (Personal Area Networks)
  - IEEE 802.15.1 Bluetooth
  - IEEE 802.15.3a UWB (Ultra Wideband)
  - IEEE 802.15.4 Low data rate PAN

<table>
<tr><td rowspan="2"><b>Application</b></td><td rowspan="2">HAVi</td><td rowspan="2">UPnP</td><td colspan="3">OSGi
JINI</td></tr>
<tr><td colspan="3">JVM</td></tr>
<tr><td><b>Transport / Network</b></td><td></td><td>HTTP</td><td colspan="3">TCP/IP</td></tr>
<tr><td rowspan="2"><b>MAC</b>
<b>PHY</b></td><td colspan="2" rowspan="2">IEEE 1394</td><td>802.3</td><td>MAC</td><td rowspan="2">X10
IrDA
CEBus</td></tr>
<tr><td>Ethernet
802.11</td><td>HomePlug
HomePNA</td></tr>
</table>

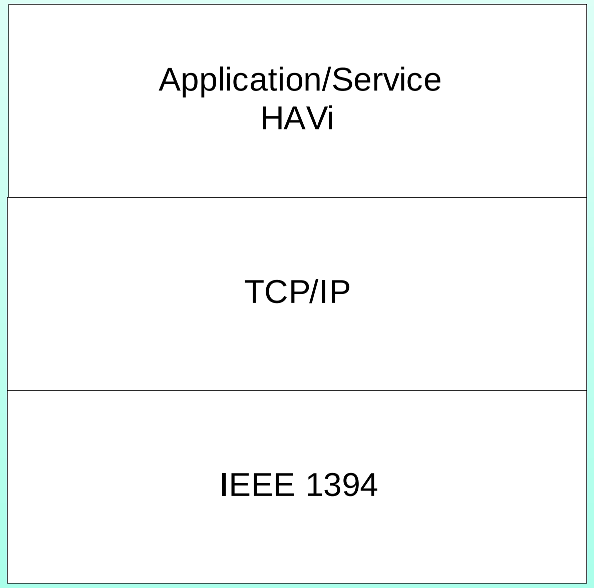
Networking Protocols

- Two Groups
  - Physical interconnects
    - X-10
    - CEBus (Consumer Electronics Bus)
    - IrDA (Infrared Data Association)
    - HomePlug
    - HomePNA
    - WiFi 802.11
    - Bluetooth
    - Ethernet
    - IEEE 1394
    - USB (Universal Serial Bus)
  - Service or application middleware
    - HAVi (Home Audio/Video interoperability)
    - UPnP (Universal Plug and Play)
    - Jini
    - OSGi (Open Services Gateway initiative)

Notes

Application Layer Protocols

HAVi Protocol Architecture



Application/Service
HAVi

TCP/IP

IEEE 1394

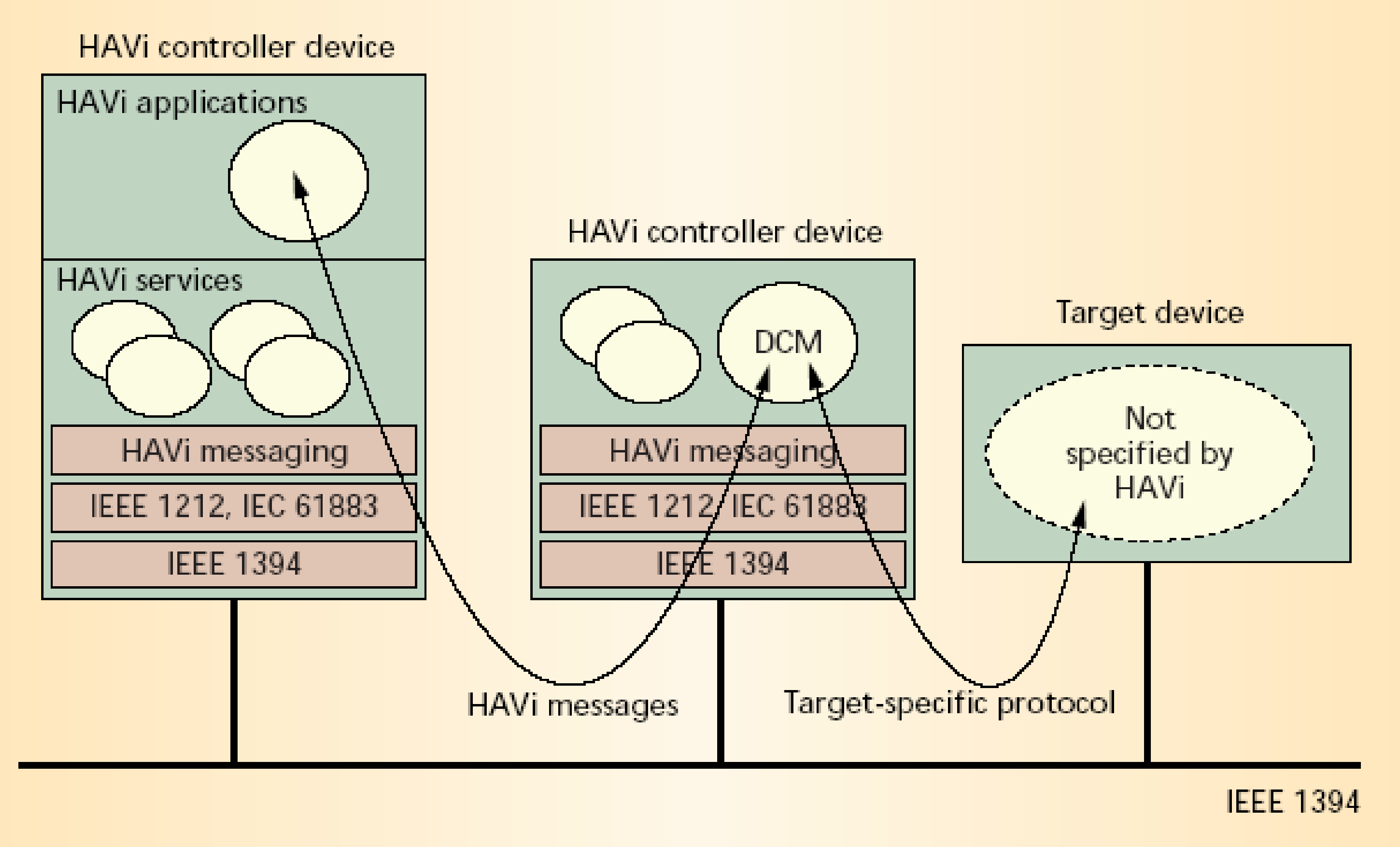
Home Audio Video interoperability (HAVi)

Notes

- **Application for home entertainment and AV devices**
- HAVi Components
  - Device
    - FAV (Full Audio Visual)
    - Intermediate AV
    - Base AV
    - Legacy AV
  - Device control module (DCM): Aggregate of FCMs
  - Functional control module (FCM): Controls application functions
- Peer-to-peer environment

The HAVi device supports several types AV inputs

HAVi Communication

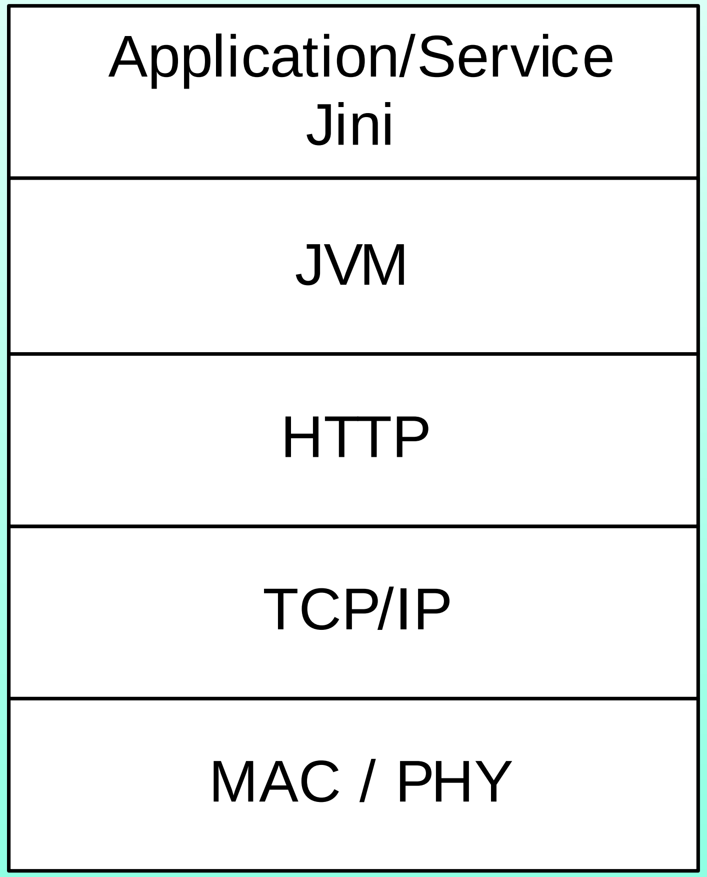


Notes

- Lower layer: IEEE 1394
  - Function control protocol: IEC 61883.1
  - Device control protocol: IEEE 1212
  - HAVi messages
- Services

• Discovery	Messaging
• Lookup	Events
• Configuration	Reservation
• Device control	User interaction

Jini Middleware



Application/Service
Jini

JVM

HTTP

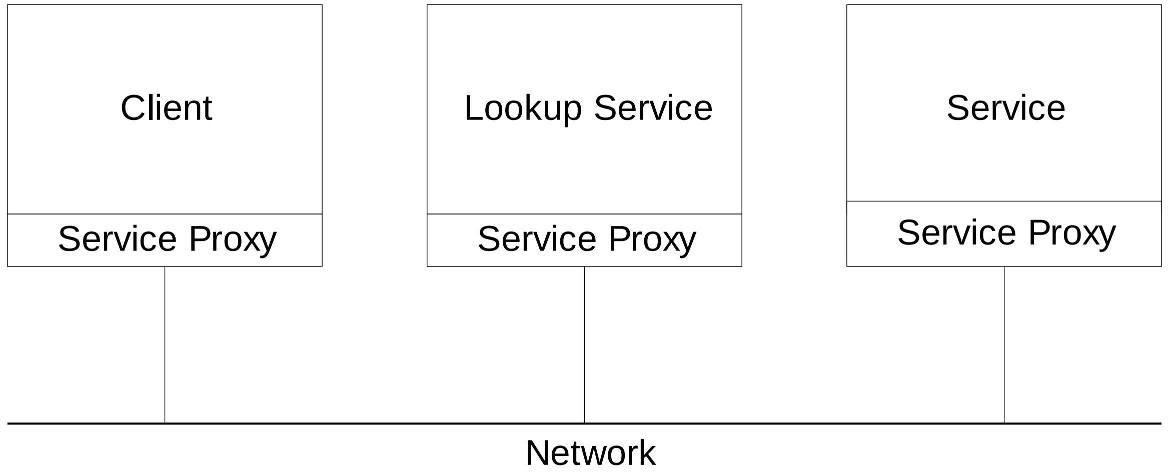
TCP/IP

MAC / PHY

- Components
  - Device – Java object / Client
  - Access: RMI (Remote Method Invocation)
  - Services
    - Lookup
    - Discovery
- Based on Java platform
- Distributed environment for devices to communicate; Not housed in a single computer
- Forms impromptu communities – Group of shared services
- Federation: Jini communities linked together
- Jini surrogate host to handle non-Jini host
- JiniME (Mobile Edition) for mobile devices

impromptu = done without being planned, organized, or rehearsed.
surrogate = a substitute بديل, especially a person deputizing for another in a specific role or office.

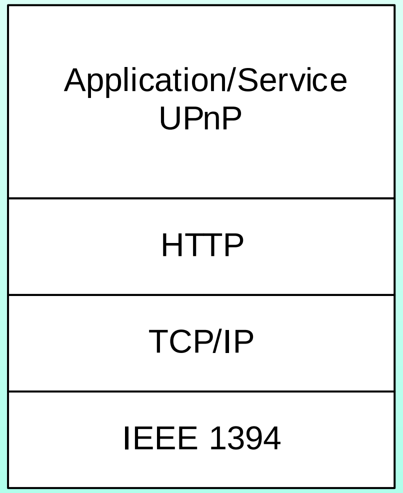
Jini Network: Service



Notes

- Lookup Service:
  - Client requests service (e.g., clock)
  - Lookup service: locator
  - Service provides the service (e.g., TV)
- Network: Any network supporting Jini service

UPnP Protocol Architecture



Application/Service
UPnP

HTTP

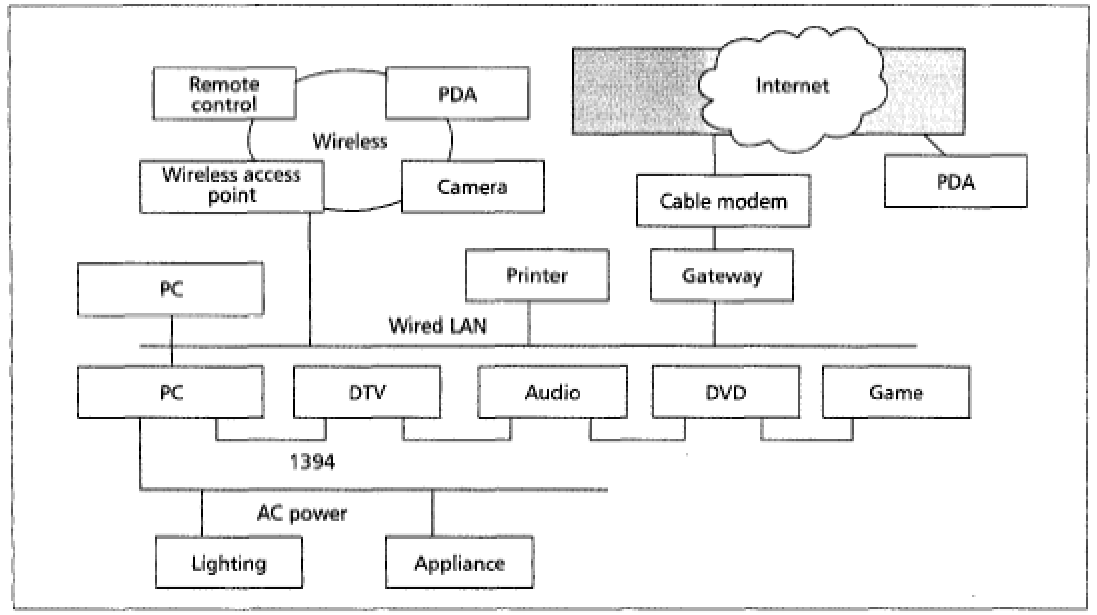
TCP/IP

IEEE 1394

Notes

- Universal plug and play
- Active addition and deletion of devices
- Components
    - Devices
    - Services
    - Control points
- Peer-to-peer network

UPnP Network

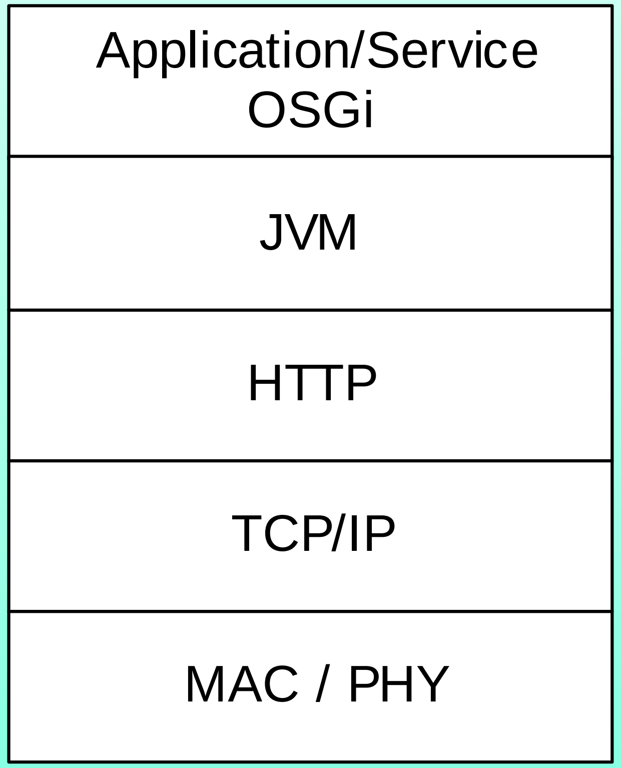


Notes

- Underlying networks with standard protocols:
  - HomePlug
  - IEEE 1394
  - LAN
  - WLAN
- Gateway and cable modem link to Internet
- Dynamic configuration of **devices** offering **services** requested by **control points**
- Needs zero-configuration
- Automatic discovery of devices

OSGi Gateway

Notes



Application/Service
OSGi

JVM

HTTP

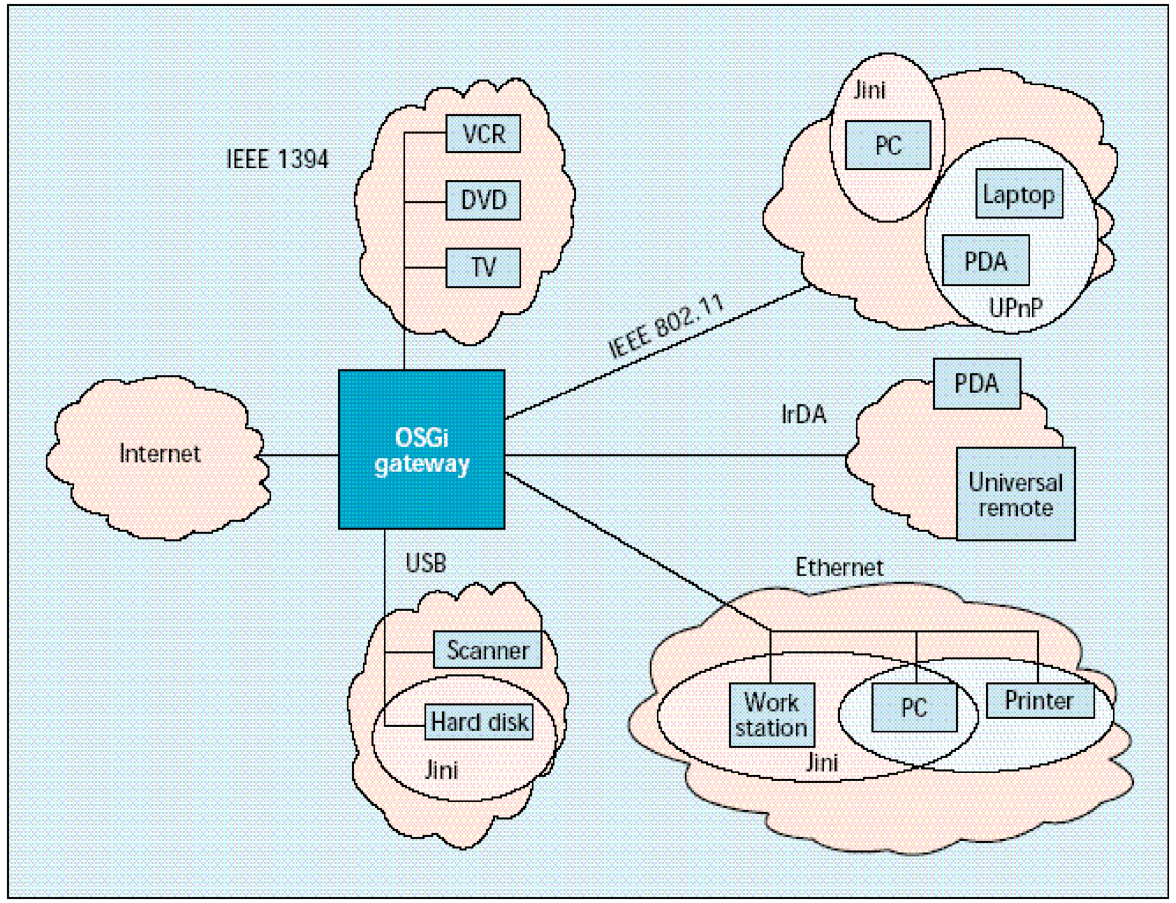
TCP/IP

MAC / PHY

- OSGi: Open Service Gateway initiative
- Platform for residential gateway
- Specifies API only, not underlying implementation; Platform and application independent
- Service and device discovery functions
- Imports multiple discovery protocols and registers them as OSGi services

a **residential gateway** allows the connection of a local area network (LAN) to a wide area network (WAN). The WAN can be a larger computer network (such as a municipal WAN that provides connectivity to the residences within the municipality), or the Internet.

OSGi Home Network Architecture



•Source: Dobrev, et.al., IEEE Communications Magazine, Aug. 2002

Notes

- Residential OSGi Gateway
- External link to Internet via embedded modem with interface to cable, DSL, or wireless access network
- Intra-home networks with multiple protocols integrated with OSGi
- Jini creates impromptu communities automatically
- IEEE 1394 network for AV devices
- IEEE 802.11 and Ethernet networks for mobile fixed data devices
- Imports discovery services from other protocol networks

Lower Layer Networking Protocols

Lower Layer Protocols for Networked Appliances

Category	Appliance	Protocol
Home Automation and Control	Lighting, Appliances, Climate Control	EIB, LonWorks, X10, CEBus
Entertainment	A/V Equipment, TV, PC	IEEE 1394
Communications	Telephone, Cell Phone, Intercom	IEEE 1394, HomePNA
Computers and Information	PC, Peripherals, PDA	Ethernet, WiFi

Notes

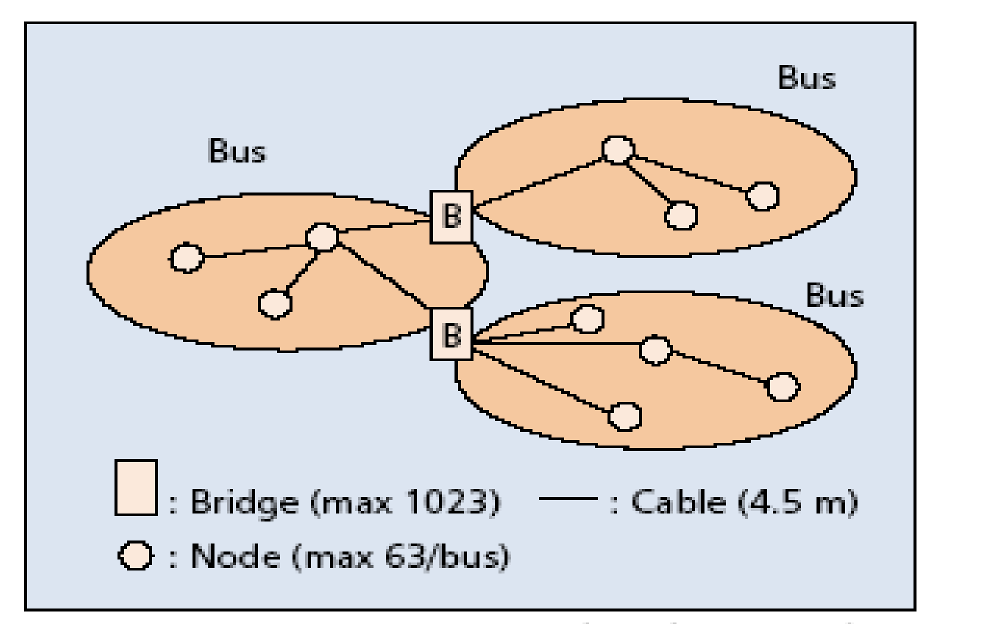
- Issues:
  - rt, near-rt, and non-rt, requirements
  - Multiplicity of component networks
  - Backbone QoS
  - Interoperability

REAL-TIME, near rt, NEAR REAL-TIME

An **intercom** (intercommunication device), **talkback** or **doorphone** is a stand-alone voice communications system for use within a building or small collection of buildings, functioning independently of the public telephone network

A backbone is the part of the computer network infrastructure that interconnects different networks and provides a path for exchange of data between these different networks. A backbone may interconnect different local area networks in offices, campuses or buildings. When several local area networks (LAN) are being interconnected over a considerable area, the result is a wide area network (WAN), or metropolitan area network (MAN) if it happens to serve the whole city.

IEEE 1394



•Source: Nakagawa, et. al.

Notes

- Wired IEEE 1394
  - Applicable to audio, video, and high-speed data
  - Transport speed 100, 200, and 400 Mbps
  - 1394b: 800 and 1600 Mbps
  - Extension to 3.2 Gbps in the future specifications
  - Supports asynchronous and isochronous
  - Flexible topology; supports daisy chaining and node branching
  - Active connect and disconnect
- Wireless /1394 bridge

USB

USB 1.0	1.5 Mbps	Low speed	Cable length = 3m
USB 1.1	12 Mbps	Full Speed	Cable length = 3m
USB 2.0	400 Mbps	High speed	Cable length = 5m

•Source: Nakagawa, et. al.

Notes

- Universal Serial Bus (USB)
    - Alternative to Ethernet as a computer peripheral interface
    - Data-centric, not multimedia-oriented

Residential Ethernet

- Medium
  - UTP-CAT5 (Unshielded twisted Pair Category 5); Maximum 100 meters
  - Optical Fiber in new homes
- Requirements different from enterprise Ethernet
  - Multiplicity of multimedia and networked appliances
  - Single physical port, multiple logical / channel interface handled by ifStackTable (RFC 2863)
  - ifOctets redefined to handle 10 Gbps
  - IP phones wired with powered Ethernet cable
  - New MIB for powered Ethernet

Notes

Power Ethernet MIB

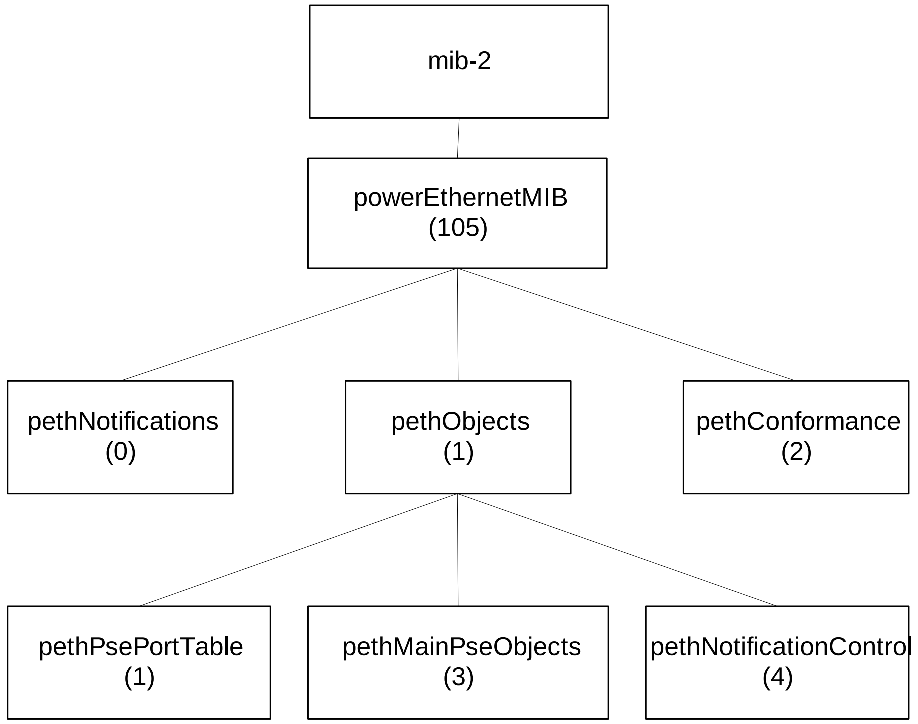


Figure 15.3 Power Ethernet MIB

Notes

- pse: Power sourcing equipment
- *pethObjects* has three groups:
  - *pethPsePortTable*: MOs for status of PSE device ports
  - *pethMainPseObjects:* MOs for PSE device
  - *pethNotificationControlTable*: Notifications

IEEE 802.11
Wireless LAN

802.11 PHY & MAC

- MAC Layer
  - CSMA/CA (CSMA/ Collision Avoidance) is used: (CSMA/CD in 802.3)
  - BSS Basic service set comprise AP (Access Point) and STAs (Stations);
  - Choice of coordination function by AP
    - DCF Distributed coordination function
      - Asynchronous
      - Contention-based
    - PCF Point coordination function (optional)
      - Synchronous
      - Contention-free
- PHY Layer
  - 802.11b @ 2.4 GHz & data rate 11 Mbps
  - 802.11a @ 5 GHz & data rate 54 Mbps
  - 802.11g extends 802.11b to 54 Mbps with OFDM

Notes

- IBSS: Independent BSS
  - Ad-hoc configuration of 802.11

•Distributed coordination function (DCF) is the fundamental MAC technique of the IEEE 802.11 based WLAN standard. DCF employs a CSMA/CA with binary exponential backoff algorithm.

•Point coordination function (PCF) is a Media Access Control (MAC) technique used in IEEE 802.11 based WLANs. It resides in a point coordinator also known as Access Point (AP), to coordinate the communication within the network.

In statistical time division multiplexing, **contention** is a media access method that is used to share a broadcast medium. In contention, any computer in the network can transmit data at any time (first come-first served).
This system breaks down when two computers attempt to transmit at the same time. This is a case of collision. To avoid collision, carrier sensing mechanism is used. Here each computer listens to the network before attempting to transmit. If the network is busy, it waits until network quiets down. In carrier detection, computers continue to listen to the network as they transmit. If computer detects another signal that interferes with the signal it is sending, it stops transmitting. Both computers then wait for random amount of time and attempt to transmit. Contention methods are most popular media access control method on LANs.[1]

802.11 Standards & Amendments

Notes

Table 15.1 IEEE 802.11 Standards and Amendments

802.11a	54 Mbps data rate 5.15 MHz to 5.35 and 5.4 MHz to 5.825 MHz
802.11b	11 Mbps data rate at 2.4 GHz
802.11e	Addresses QoS issues
802.11f	Addresses multivendor AP interoperability
802.11g	Higher data rate extension to 54 Mbps in the 2.4 GHz
802.11h	Dynamic frequency selection and transmit power control for operation of 5 GHz products
802.11i	Addresses enhanced security issues
802.11j	Addresses channelization in Japan's 4.9 GHz band
802.11k	Enables medium and network resources more efficiently
802.11v	Wireless network management (in preparation)

Residential WLAN

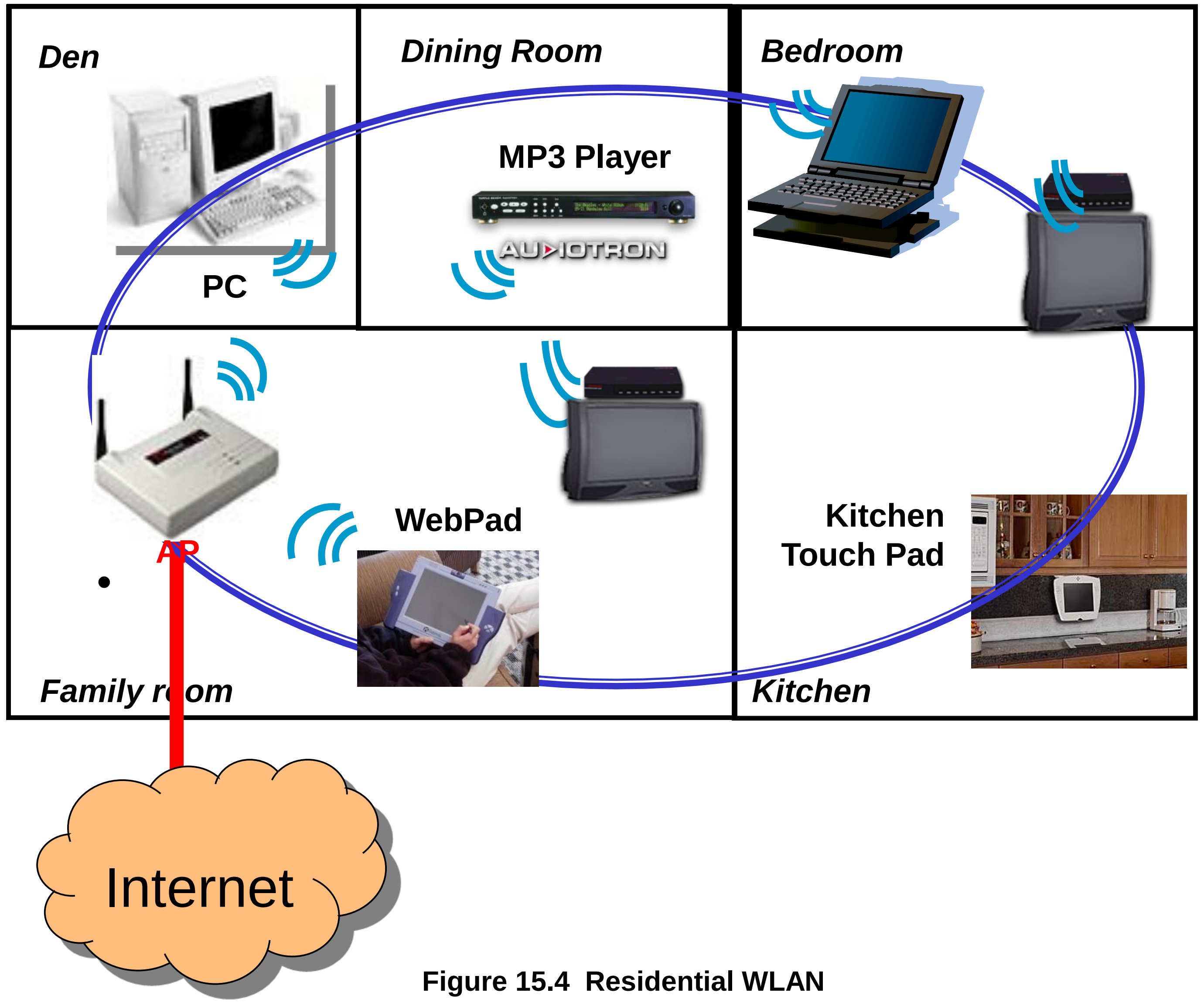


Figure 15.4 Residential WLAN

WiFI Network Infrastructure

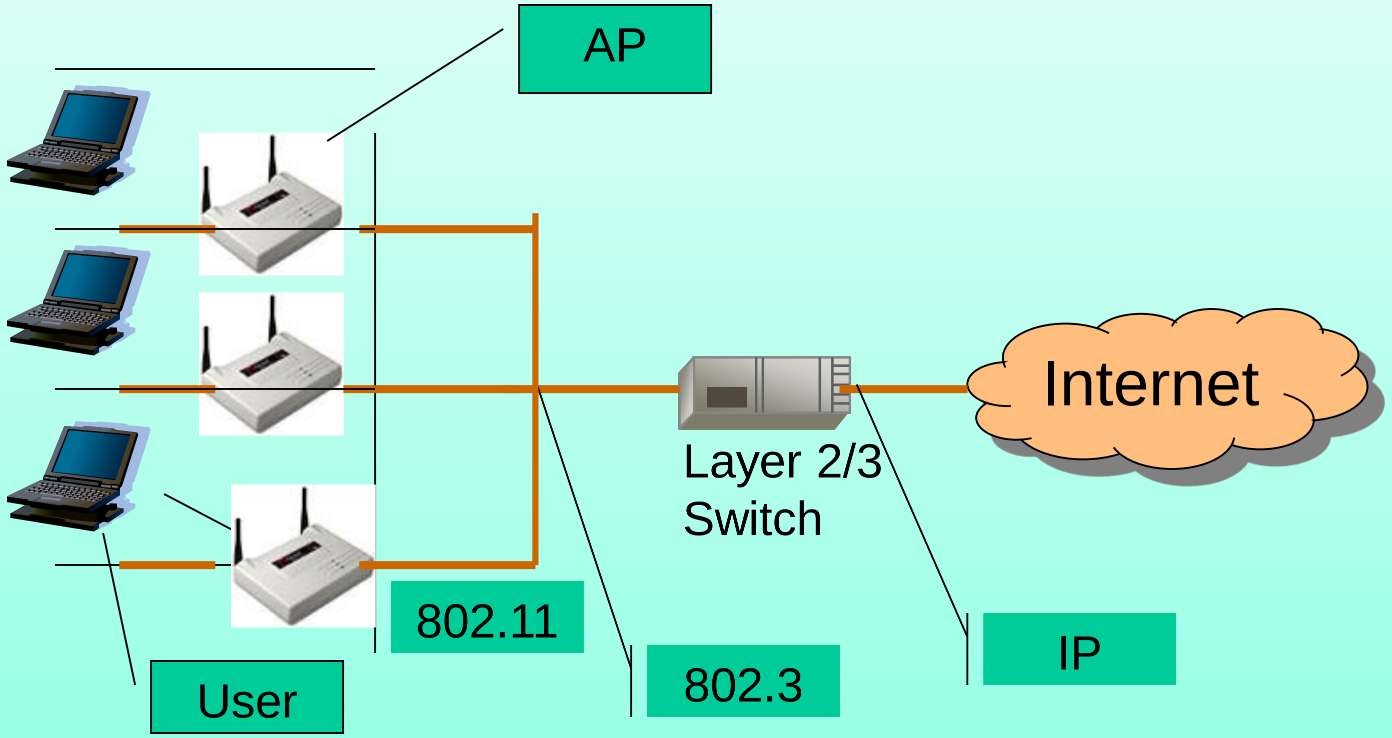


Figure 15.5 WiFI Network Infrastructure

- •802.3 is a standard specification for Ethernet, a method of physical communication in a local area network (LAN), which is maintained by the Institute of Electrical and Electronics Engineers (IEEE).
- •IEEE 802.11 is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands.

Notes

- Layer 2/3 bridge is traditional Ethernet hub
- AP performs security functions

Enterprise WLAN

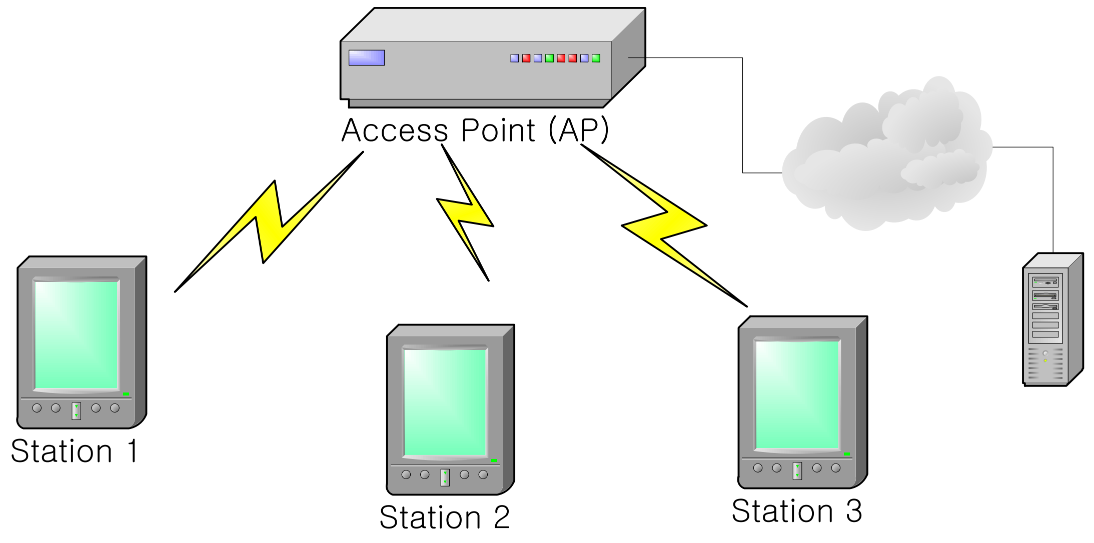
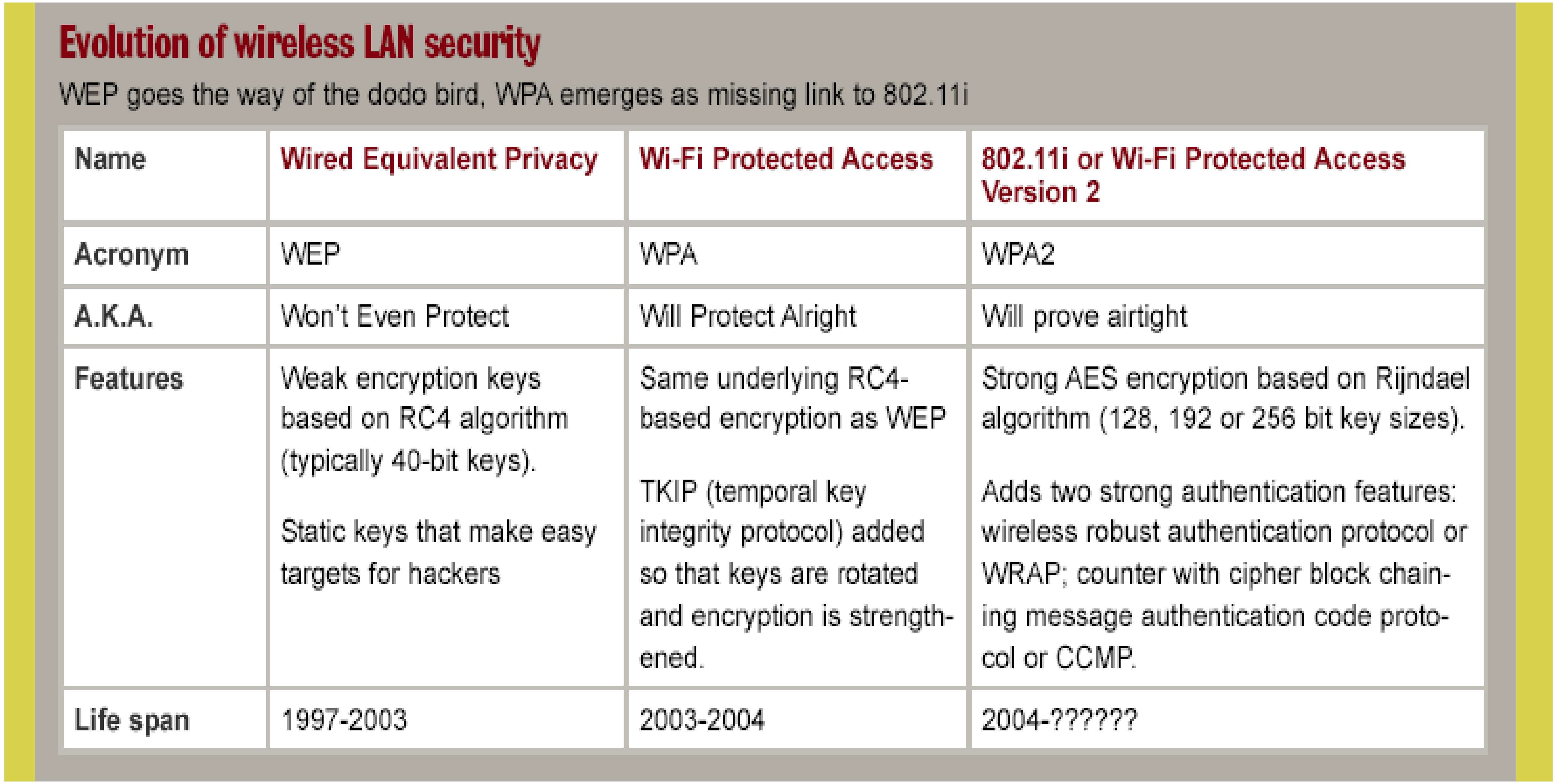


Figure 15.6 Enterprise WLAN

Notes

- An access point (AP) and multiple stations (STAs)
- AP works as a bridge
- Every transmission is between AP and STA(s)

Evolution of WLAN Security



Evolution of wireless LAN security

WEP goes the way of the dodo bird, WPA emerges as missing link to 802.11i

Name	Wired Equivalent Privacy	Wi-Fi Protected Access	802.11i or Wi-Fi Protected Access Version 2
Acronym	WEP	WPA	WPA2
A.K.A.	Won't Even Protect	Will Protect Alright	Will prove airtight
Features	Weak encryption keys based on RC4 algorithm (typically 40-bit keys). Static keys that make easy targets for hackers	Same underlying RC4-based encryption as WEP TKIP (temporal key integrity protocol) added so that keys are rotated and encryption is strengthened.	Strong AES encryption based on Rijndael algorithm (128, 192 or 256 bit key sizes). Adds two strong authentication features: wireless robust authentication protocol or WRAP; counter with cipher block chaining message authentication code protocol or CCMP.
Life span	1997-2003	2003-2004	2004-??????

WEP Wired Equivalent Privacy

WPA WiFi Protected Access – IEEE 802.11i based

WPA2 802.11i (?)

Source: Network World 2003

Security Management

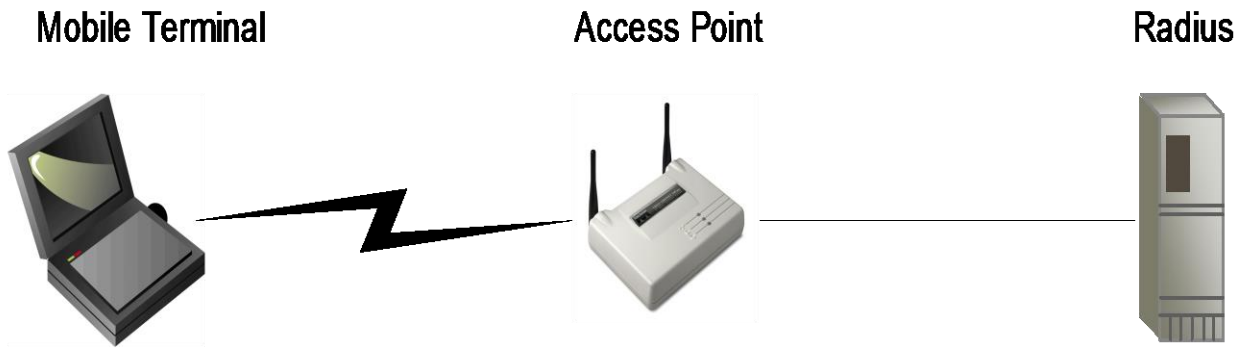


Figure 15.7 EAP over Wireless LAN

Notes

- Evolution:
- WAP (Wireless Application Protocol) Security
  - WAP Wireless transport layer security (WTLS)
    - Based on transport layer security (TLS) or secured sockets shell (SSL)

• WEP	Wired Equivalent Privacy
• WPA	WiFi Protected Access
• WPA2	WPA with IEEE 802.11i

- 3G network security
  - 3GPP (Third Generation Partnership Project) and 3GPP2 plan for IP to wireless device
  - Open standard SNMP-based

Security Management

Security for wireless LAN, WiFi , started with Wired Equivalent Privacy (WEP), which is a scheme trying to replicate the security in the wired network. Since it has a lot of holes, the WiFi consortium developed WiFi Protected Access (WPA) protocol. WPA was made more secure in WPA2, which used IETF 802.11i security. WEP used static weak encryption keys based on RC4 algorithm of typically 40-bit keys. WPA enhanced WEP by using the same RC4 encryption, but adding temporal key integrity protocol (TKIP). WPA2 uses strong AES encryption based on Rijndael algorithm with 128-, 192-, or 256-bit key sizes. Two strong authentication protocols, namely, wireless robust authentication protocol (WRAP) and counter with cipher block chaining message authentication code protocol (CCMP) are added in 802.11i.

802.11i data protocols provide confidentiality, data origin authenticity, and replay protection. These protocols require a fresh key on every session. Key management delivers keys used as authorization tokens after channel access is authorized. Key hierarchy comprises pairwise keys and group keys. These are supported by extensible authentication protocol (EAP) over WLAN, as presented in Figure 15.7.

Authentication can be approved by either an EMP authenticator or by an external authenticator such as

Remote Authentication Dial In User Service (RADIUS).

WLAN Broadband QoS Issues

- Broadband comprises:
  - Voice: Real-time data
  - Video: Streaming data with/without delay
  - Data: Non-real time data

•Distributed coordination function (DCF) is the fundamental MAC technique of the IEEE 802.11 based WLAN standard. DCF employs a CSMA/CA with binary exponential backoff algorithm.

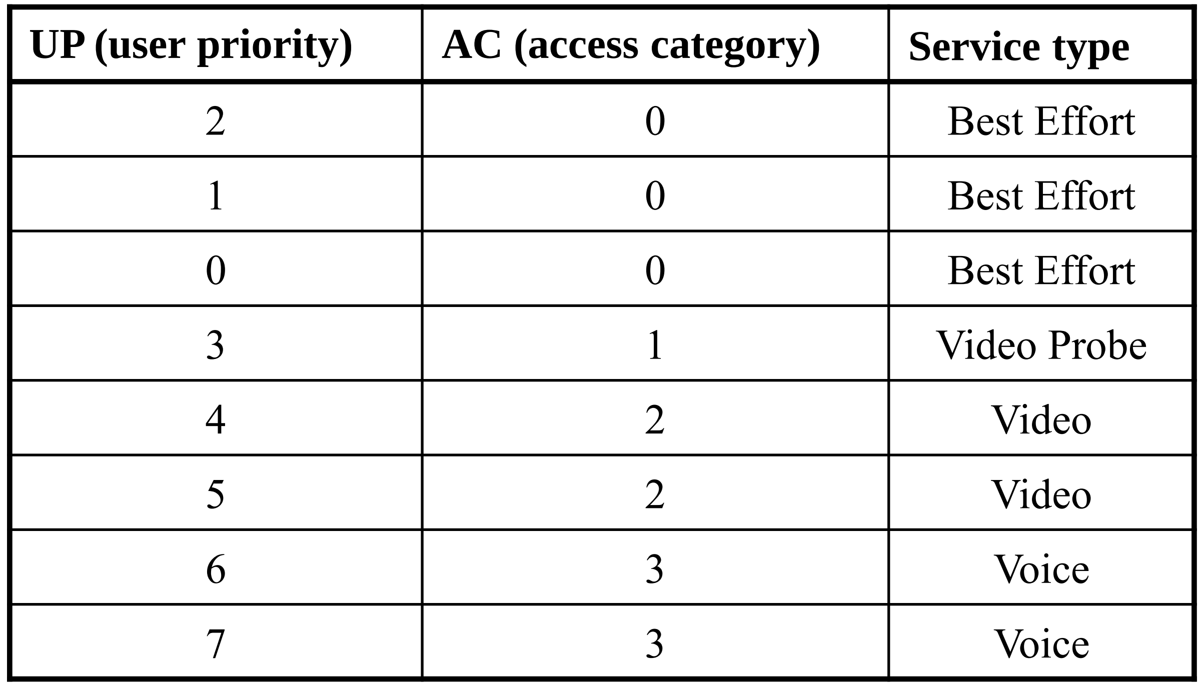
- Broadband QoS determined by MAC and PHY layers
- QoS Parameters:
  - Datarate
  - Delay bound
  - Jitter (slight irregular movement, variation, or unsteadiness, especially in an electrical signal or electronic device.)

- Two **sublayers** of media access (MAC)
  - DCF (Distributed Control Function): CSMA/CA
  - PCF (Point Control Function):
- Both DCF and PCF fail to satisfy broadband service
- Range dependencies
  - Power level
  - Antenna choice
    - Diversity antenna focuses beam
    - Diversity reception improves S/N ratio
    - MIMO (Multiple Input Multiple Output) technology enhances reception

•Point coordination function (PCF) is a Media Access Control (MAC) technique used in IEEE 802.11 based WLANs. It resides in a point coordinator also known as Access Point (AP), to coordinate the communication within the network.

IEEE 802.11e QoS Table

Table 15.2 IEEE 802.11e QoS Table



UP (user priority)	AC (access category)	Service type
2	0	Best Effort
1	0	Best Effort
0	0	Best Effort
3	1	Video Probe
4	2	Video
5	2	Video
6	3	Voice
7	3	Voice

Notes

802.11 MIB

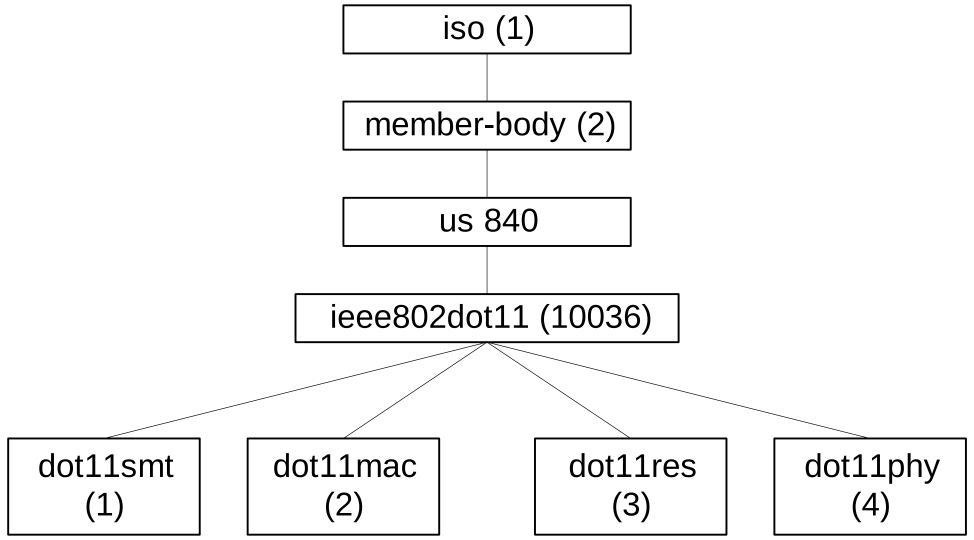


Figure 15.8 802.11 MIB

Notes

Entity	OID	Description
dot11smt	ieee802dot11 1	Station management attributes: WEP security, power, transmission
dot11mac	ieee802dot11 2	Mac attributes
dot11res	ieee802dot11 3	Resource type attributes
dot11phy	ieee802dot11 4	Physical attributes

Centralized Management of WLANs

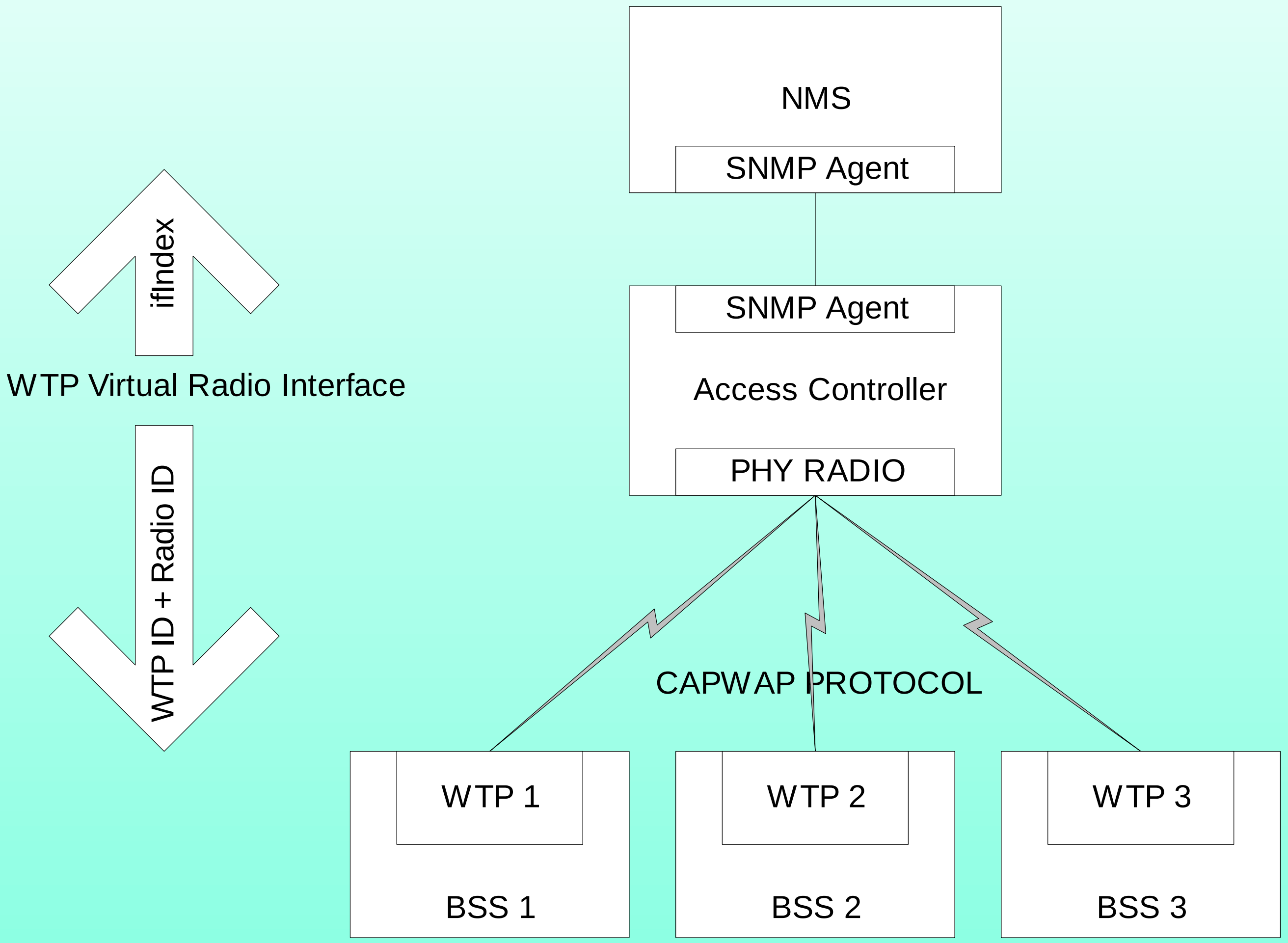


Figure 15.9 Centralized Management of WLANs

Notes

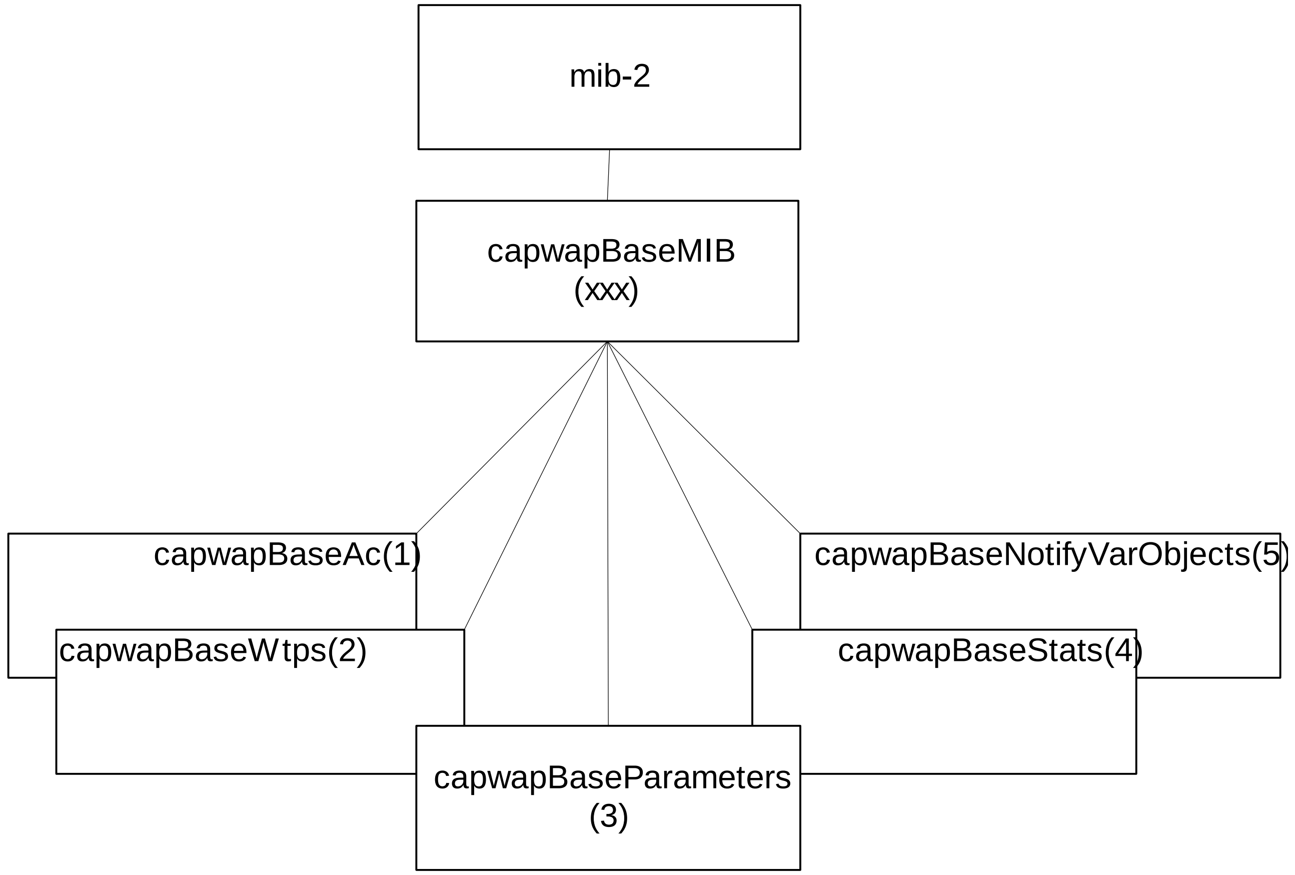
- CAPWAP interoperable protocol standard
- Centralized Access Controller manages multiple BSSs via Wireless Termination Points (WTPs)
- CAPWAP – IETF compatibility achieved by one-to-one relationship between *ifIndex* and WTP ID + Radio ID

•As a prelude to developing a MIB that makes all WLAN components, including APs, interoperable, the broad set of AP functions has been divided into two categories: 802.11 functions, which include those that are required by IEEE 802.11 standards, and Configuration and Provisioning of Wireless Access Point (CAPWAP) functions, which include those that are not required by IEEE 802.11, but are deemed essential for control, configuration, and management of 802.11 WLANs on a centrally managed basis. Another term that has caused considerable ambiguity is “access point,” which usually reflected a physical box that has antennas, but did not have a uniform set of externally consistent behavior across multiple vendors. To remove this ambiguity, AP has been redefined as the set of 802.11 and CAPWAP functions, while the physical box that terminates the 802.11 PHY is called the wireless termination point (WTP).

•CAPWAP Protocol defines a standard, interoperable protocol, which enables an access controller (AC) to manage a collection of WTPs, as shown in Figure 15.9. The network management system communicates with the AC using the SNMP. The AC communicates with WTP using the CAPWAP protocol. In Figure 15.9 each WTP coordinates the stations in its basic station set (BSS).

• The wireless interface is shown as PHY radio in Figure 15.9 and is assigned a unique ID by the combination of the serial number of WTP and a radio ID for the wireless service in BSS. The left side of the figure shows the one-to-one relationship between ifIndex and the virtual radio interface.

CAPWAP Base MIB



Figuire 15.10 CAPWAP Base MIB

Notes

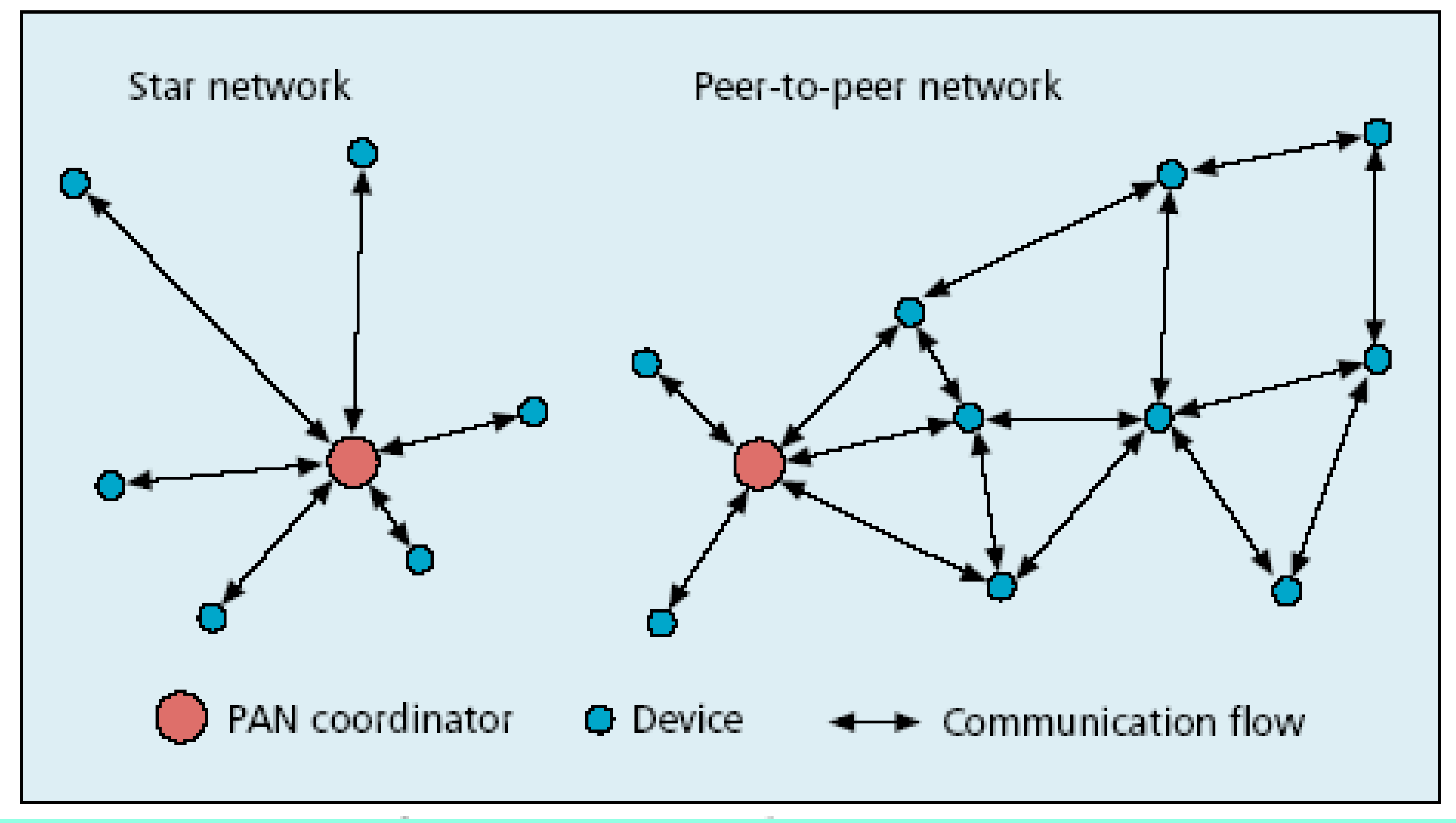
- CAPWAP MIB in proposal stage

CAPWAP Base MIB

•Entity	•OID	•Description
capwapBaseObjects	capwapBaseMIB 1	CAPWAP MIB objects
capwapBaseAc	capwapBaseObjects 1	Access Controller Objects group
capwapBaseAc NameListTable	capwapBaseAc 9	Objects that display AC name list
capwapBaseMac AclTable	capwapBaseAc 10	Set of objects that configure station ACL
capwapBaseWtps	capwapBaseObjects 2	Wireless Termination Point Objects group
capwapBaseWtp StateTable	capwapBaseWtps 1	Objects that display WTP CAPWAP FSM state
capwapBaseWtp Table	capwapBaseWtps 2	Objects that display and control WTPs in running state
capwapBaseRadio BindTable	capwapBaseWtps 3	Objects that display mapping relationship between specific interface of 'WTP Virtual Radio Interface' *ifType* and PHY radio
capwapBaseStation Table	capwapBaseWtps 4	Objects that display stations which are accessing the wireless service provided by the AC
capwapBaseWtpReboot StatsTable	capwapBaseWtps 5	Objects that display WTPs' reboot statistics
capwapBaseRadioStats Table	capwapBaseWtps 6	Objects that display statistics on radio’s behavior, and reasons why the WTP radio has been reset.
capwapBaseParameters	capwapBaseObjects 3	CAPWAP Base Parameters group
capwapBaseStats	capwapBaseObjects 4	CAPWAP Statistics group
capwapBaseNotifyVar Objects	capwapBaseObjects 5	Objects used only in notifications

IEEE 802.15
WPANs
(Wireless Personal Area Networks)

WPANs



•Source: Callaway, et. al., IEEE Communications Magazine, Aug. 2002

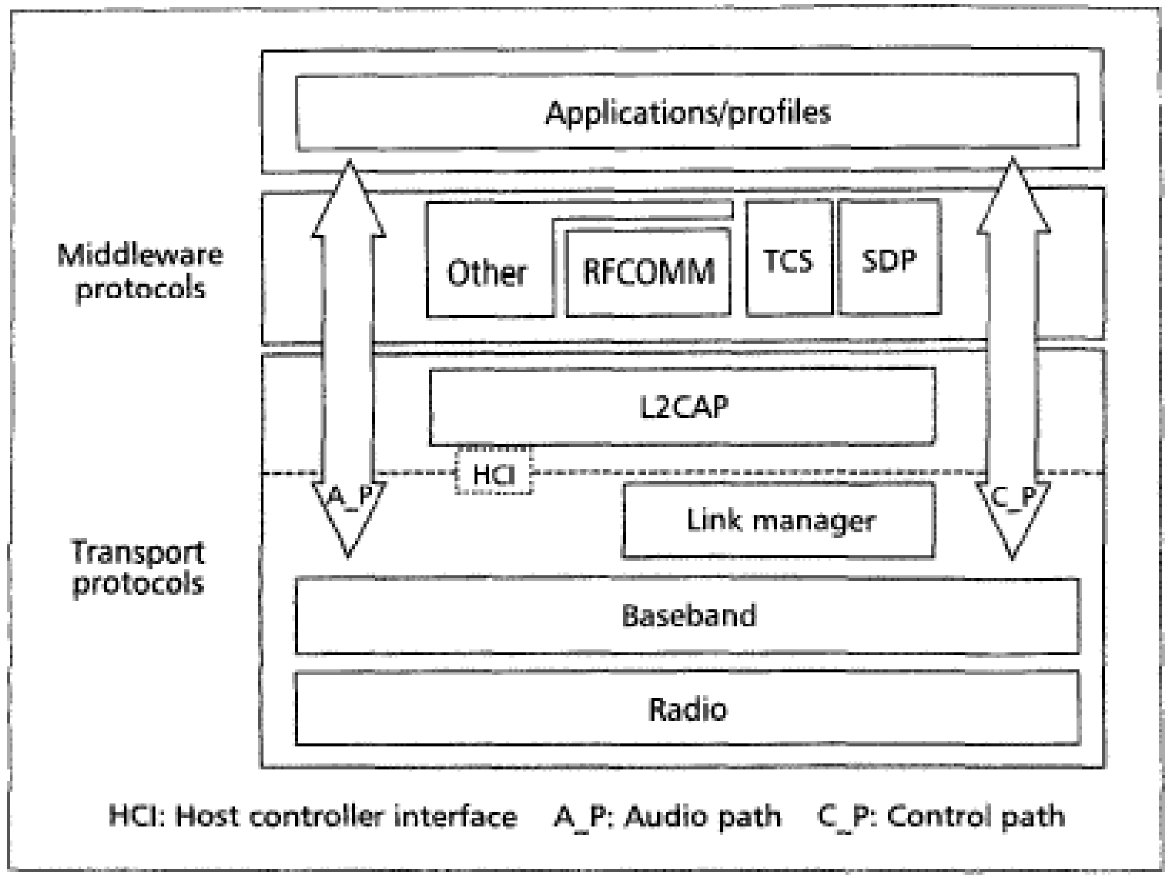
Notes

- 802.15.1 Bluetooth base line standard
- 802.15.2 Coexistence of 802 wireless technologies
- 802.15.3 High-rate radio (>20 Mbps)
- 802.15.4 Low-rate radio (<200 kbps)

A *wireless personal area network* (**WPAN** for short) is a low-range wireless network which covers an area of only a few dozen metres. This sort of network is generally used for linking peripheral devices (like printers, cellphones, and home appliances) or a personal assistant (PDA) to a computer, or just two nearby computers, without using a hard-wired connection. There are several kinds of technology used for WPANs:
The main *WPAN* technology is **Bluetooth**

http://ccm.net/contents/834-wpan-wireless-personal-area-network

Bluetooth Protocol Stack



•Source: Bisdikian, IEEE Communications Magazine, Dec. 2001

Notes

- Short range up to 10m
- 2.042 GHz to 2.483 GHz band
- 79 channels of 1 MHz width
- Data rate 1 Mbps
- Time division multiplexing
- Master-slave architecture
- Voice support synchronous connection-oriented link
- Data support using asynchronous connectionless link