3.10.3 Comparison between IEEE802.11 (WLAN/ Wi-Fi) standard and IEEE802.16 (WMAN/ WiMAX) standard

GQ. Compare Wi-Fi and Wi-max technology.

Table 3.10.1 : Comparison between IEEE802.11 and IEEE 802.16 standard

Sr. No.	Parameter	IEEE802.11	IEEE802.16
1.	Technology	WLAN	WiMAX
2.	Operating spectrum	2.4 GHz / 5.2GHz	2 - 11GHz / 11-60GHz
3.	Bandwidth	11 - 54Mbps	Upto 70Mbps
4.	Range (LOS)	100m	30 - 50 km
5.	Range (NLOS)	30m	2 - 5 km
6.	Mobility	Portable	Fixed
7.	Data rate	Upto 54Mbps	Upto 150Mbps
8.	Application	Indoor	Outdoor
9.	Protocols supported	802.11a/b/g/n/ac/ad etc.	802.16a/d/e/m etc.
10.	Modulation	OFDM,DSSS	QPSK

Table 1.4.6 : Comparison between all mobile radio standards

Sr. No.	Parameter	1G	2G	2.5G	3G	4G	5G
1.	Implementation year	1984	1991	1999	2002	2010	2015
2.	Standards	NMT, AMPS, NTT, ETACS	GSM, PDC, IS 136, IS 95	HSCSD, GPRS, EDGE	WCDMA, cdma2000, IMT2000, TD-SCDMA	Single unified standard	Single unified standard
3.	Technology	Analog cellular	Digital cellular	Digital cellular	Wideband CDMA, IP	LTE, Wimax	5G-LTE
4.	Multiple access technique used	FDMA	TDMA and CDMA	TDMA and CDMA	Wideband CDMA	CDMA	CDMA
5.	Data rates	2.4 kbps	14.4 kbps	171 kbps	3.1 Mbps	100 Mbps	Higher than 1Gbps
6.	Switching method used	circuit switching	circuit switching	circuit switching for voice and packet switching for data	packet switching	packet switching	packet switching
7.	Operating spectrum	800MHz	GSM:900MHz, 1800MHz, CDMA: 800 MHz	GSM : 900MHz, 1800MHz, CDMA : 800 MHz	2100 MHz	850 MHz, 1800 MHz	850 MHz, 1800 MHz
8.	Services	Voice	Voice and SMS	Voice and data	Integrated high quality of voice and data	Dynamic information access, wearable devices	Dynamic information access, wearable devices with AI (artificial intelligence) capabilities.
9.	Carrier frequency / Channel bandwidth	30kHz	200kHz	200kHz	5MHz	15MHz	28GHz
10	Whether analog or digital	Analog	Digital	Digital	Digital	Digital	Digital

*	FDMA	TDMA	CDMA	OFDMA
1) Method	Overall bandwidth is shared among many stations	Time sharing of satellite transponder takes place	sharing of bandwidth & time both takes place	It is possible to share both bandwidth & time
2) Synchronization	synchronization is necessary	synchronization is essential	synchronization is not necessary	synchronization is not necessary
3) codeword	codeword is not required	— — — not required	code words are required	codeword is not required
4) Data flow Rate	The rate of data is low	medium	high	high
5) flexibility	It is little flexible	moderate flexible	Highly Flexible	Highly flexible

1.19.2 Comparison between DSSS and FHSS

GQ. Compare DSSS and FHSS.

Table 1.19.1 : Comparison between DSSS and FHSS

Sr. No.	Parameter	DSSS	FHSS
1.	Abbreviation	Direct sequence spread spectrum.	Frequency hopping spread spectrum.
2.	Definition	Wideband PN sequence is directly multiplied with the narrowband data sequence and wideband spreading code is obtained.	Wideband PN code is used to generate hopping pattern. Data bits are transmitted by changing carrier according to hopping pattern.
3.	Chip rate	$R_c = 1/T_c$	$R_c = \max(R_h, R_s)$
4.	Modulation technique used	BPSK	MFSK
5.	Interference immunity	Low	High
6.	Receiver complexity	More complex	Less complex
7.	Application	CDMA	Bluetooth technology makes use of fast FHSS

2.36.4 Comparison between GSM and UMTS

Sr. No.	Parameter	GSM	UMTS
1.	Generation	2 G	3 G
2.	Data rate	14.4 kbps	2 Mbps
3.	Access technique used	TDMA	CDMA
4.	Switching methods used	Circuit switching	Packet switching
5.	Carrier bandwidth	200kHz	5 MHz
6.	Frame duration	4.615ms	10ms
7.	spectrum	800MHz, 1800 MHz	2100MHz
8.	Features	Voice calls, SMS	Video calls

3.9.1 Comparison of Different IEEE 802.11x Standards

GQ. Compare various IEEE 802.11x standards. (a/b/g/i/n etc.)

Table 3.9.2 : Comparison of different IEEE 802.11x standards

IEEE 802.x standard	Description	Frequency spectrum	Band width (MHz)	Data rate	Modulation used	Indoor range (m)	Outdoor range (m)	Year
IEEE 802.11	Standard for WLAN operation	2.4GHz ISM band	20	2Mbps	DSSS,FHSS	20	100	1997
IEEE802.11a	Standard for WLAN operation	5GHz unlicensed national infrastructure (UNI) band	20	Maximum 54 Mbps	OFDM	35	120	1999
IEEE802.11b	Standard for WLAN operation	2.4GHz ISM band	20	Max 11 Mbps	DSSS	38	140	1999
IEEE802.11g	High rate extension to 802.11	2.4GHz ISM band	20	Maximum 54 Mbps	DSSS, OFDM	38	140	2003
IEEE 802.11 n	Physical/MAC: enhancement to increase throughput	2.4 GHz, 5GHz	24,40	600 Mbps	OFDM	70	250	2009

Table 4.2.1 : ZigBee, Bluetooth, and WiFi Comparison

-	WiFi IEEE 802.11	Bluetooth IEEE 802.15.1	ZigBee IEEE 802.15.4
Application	Wireless LAN	Cable replacement	Control and monitor
Frequency bands	2.4GHz	2.4GHz	2.4GHz, 868MHz, 915MHz
Battery life (days)	0.1–5	1–7	100–7,000
Nodes per network	30	7	65,000
Bandwidth	2-100Mbps	1Mbps	20–250Kbps
Range (meters)	1–100	1–10	1–75 and more
Topology	Tree	Tree	Star, tree, cluster tree, and mesh
Standby current	20×10^{-3} amps	200×10^{-6} amps	3×10^{-6} amps
Memory	100KB	100KB	32–60KB

4.10.4 Comparison between MANET and VANET

Table 4.10.1 : Comparison between MANET and VANET

Sr. No.	Parameter	MANET	VANET
1.	Node density	Sparse	Dense and mostly variable
2.	Bandwidth	100kps	1000kps
3.	Communication range	Upto 100m	Upto 500m
4.	Change in network topology	Slow	Rapid
5.	Mobility of nodes	Low	High
6.	Node lifetime	Depends on power source used	Depends on vehicle lifetime
7.	Multi hop routing	Available	Weakly available
8.	Pattern in which node moves	Random	Regular
9.	Reliability	Medium	High
10.	Addressing scheme	Attribute based	Location based
11.	Overall cost	low	High
12.	Position acquisition	Using ultrasonic	Using GPS or RADAR

4.11 OVERVIEW OF ELECTRICAL VEHICULAR ADHOC (E-VANET)

- E-VANET is abbreviated for electric vehicular Ad hoc network. The basic architectural concept remains same only the difference lies in the type of vehicle. In this electric vehicle is addressed.
- The components of E-VANET connect with each other and the fixed nodes (RSUs and BSs) wirelessly using cellular networks (i.e. LTE, 3G, etc.) or Wi-Fi/Bluetooth connection approaches. E-VANET can be considered as a Green network version of VANET (G-VANET) and one of the intelligent transportation networks.
- The most important factor in this is energy consumption. This is because components in electric vehicle needs charging from time to time. This needs electric charging points or stations to be set up.
- It can help in applications like exchanging information about the accident, traffic, weather, etc
- E-VANET suffers from challenges like security, routing, connectivity, data forwarding etc.

4.11.1 E-VANET Applications

1. Safety applications

- It helps to reduce or prevent the accidents by forwarding message to vehicles. Safety application also include driver's assistance in finding alternative route in case of accidents time consumption etc.
- It also helps in preventing accidents by sending safety messages periodically to the drivers about the closest vehicles, speed average, traffic jam, air conditions, etc.

2. Environmental applications

It includes the applications like pollution control since it is associated with electric vehicles.

3. Convenience applications

- It includes applications like supplying the passengers and drivers with the necessary details about the estimated journey time, route navigation, road charging, parking place, tourist information restaurant location, suitable recharge stations and weather etc.
- This information is shared on demand basis to save energy.

4. Entertainment applications

- Even though they are treated as secondary applications but they are also important in some applications. They include file transfer, web browsing, music download, game, video chats and home control etc.
- These are also supported on demand basis since it consumes energy.

4.11.2 Comparison between VANET and E-VANET

Table 4.11.1 : Comparison between VANET and E-VANET

Parameter	Vanet	E-Vanet
Vehicles type	Diesel and gasoline	Electric
Vehicles speed	High	Low
The number of vehicles	High	Low
The number of charging station	High	Low
Standard	Yes	No
CO_2 generation	High	Low
Energy factor	Not important	Important
Cheaper ?	No	Yes
Green network ?	No	Yes
Cost saving	No	Yes
Supported	Yes	No
Environment-friendly ?	No	Yes

Differences

The major differences between piconet and scatternet are as follows –

Piconet	Scatternet
Piconet is the type of connection formed between 2 or more Bluetooth enabled devices.	between 2 or more Bluetooth enabled devices. It is a type of ad-hoc computer network consisting of 2 or more piconets.
It supports maximum 8 nodes i.e,1 master & 7 slaves	It supports more than 8 nodes.
It Allows less efficient use of Bluetooth channel bandwidth. It is usually applied to Bluetooth devices. It is a smaller coverage area	It Allows more efficient use of Bluetooth channel bandwidth. It is applied to Bluetooth devices too. It is a larger coverage area.

The figure given below depicts the piconet and scatternet together –

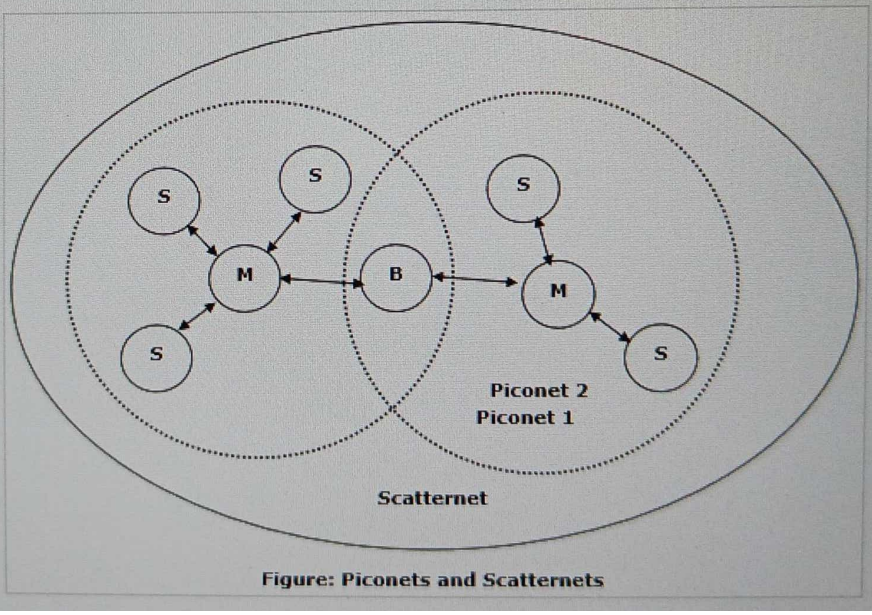

Figure: Piconets and Scatternets