WIRELESS COMMUNICATION SYSTEM
AN INTRODUCTION

FIRST EDITION 2021

ASLINDA   CT SALWANIEE   FAZIDA

WIRELESS COMMUNICATION SYSTEM AN INTRODUCTION

1st EDITION

ASLINDA ZAMAH SHARI
CT SALWANIEE BAHAYAHKHI
FAZIDA ADLAN

POLYTECHNIC SERIES

WIRELESS COMMUNICATION SYSTEM
AN INTRODUCTION

Special project by :
Aslinda Zamah Shari
Ct SalwanieeBahayahkhi
Fazida Adlan

PREFACE

The success and final outcome of this book required a lot of guidance and assistance from many people and we are extremely fortunate to have got this all along with the completion of our book.

There are no words that can be expressed for such generous support and guidance that utmostly has made this ebook become a reality in such a time and effort.

To all the individuals that have contributed, we would like to express our gratitude for being an inspiration and supporter through all the way of ups and downs including our families, peers and institution.

Without the experiences and assistance from all peers and teams, this book would have not existed.

Tremendously thanks to all of you .

AUTHORS' BIOGRAPHY

ASLINDA BINTI ZAMAH SHARI
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH
MASTER OF SCIENCE IN TELECOMMUNICATION AND
INFORMATION ENGINEERING

CT SALWANIEE BINTI BAHAYAHKHI
POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN
IJAZAH SARJANA MUDA KEJURUTERAAN (ELEKTRIK)
SARJANA PENDIDIKAN TEKNIK DAN VOKASIONAL

FAZIDA BINTI ADLAN
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH
MASTER OF SCIENCE IN TELECOMMUNICATION
AND INFORMATION ENGINEERING

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Writer
Aslinda Zamah Shari
CT Salwaniee Bahayahkhi
Fazida Adlan

Editor
Fazida Adlan
CT Salwaniee Bahayahkhi
Aslinda Zamah Shari

Designer
CT Salwaniee Bahayahkhi
Fazida Adlan
Aslinda Zamah Shari

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INTRODUCTION

Wireless communications is a large and evolving field that has sparked a lot of interest and technological advancements in recent decades.

The purpose of this book is to provide readers a thorough understanding of the fundamental principles of wireless communications. The features and performance constraints of wireless systems, insights and trade-offs and mathematical tools required to study them, are all covered by these concepts.

These fundamental ideas are motivated and exemplified using current and future wireless technologies. This book can be used as a student's textbook and as a reference for those working in the wireless field.

TABLE OF CONTENTS

Wireless Communication Systems: An Introduction

Fixed & Mobile Wireless Communication

FIXED WIRELESS COMMUNICATION

Operation of wireless devices or system in fixed location. Fixed wireless devices usually get their electrical power from the utility mains

Technology involves connecting existing fiber, cable, or DSL internet between two fixed locations through radio and a receiver

The technology has the ability to deliver faster internet speeds than 4G with lower latency

MOBILE WIRELESS COMMUNICATION

User connect a mobile device such as smartphone or tablet to a broadband internet connection wirelessly through a mobile phone network

Mobile broadband depends on cell towers to transfer data to mobile phone, maintaining the internet portable for millions of users

Networks used for high volume demanding fairly low bandwidth, focus on activities like streaming the internet or transferring voice data

DIFFERENCE BETWEEN FIXED AND MOBILE NETWORKS

Fixed	Wireless
Physical configuration required	No physical configuration required
Low data rate loss	High data rate loss
High data transmission, high speed, less delay	Low data transmission, less speed, more delay
Highly secure	Less secure
Fixed	Portable
Electrical power from main utility	Built in battery

"Success is like WiFi. Found Everywhere, to connect must have password called hard work."

WHAT IS WIRELESS COMMUNICATION?

Wireless communication is the transfer of information between two or more points that is performed and delivered using electromagnetic wave in open space (wirelessly).

The information from sender to receiver is carried defined as **channel**.

Each channel has a fixed frequency bandwidth & capacity (bit rate).

Different channels can be used to transmit information in parallel and independently.

CLICK

click here to watch video of what is Wireless Communication

Characteristics of wireless communication
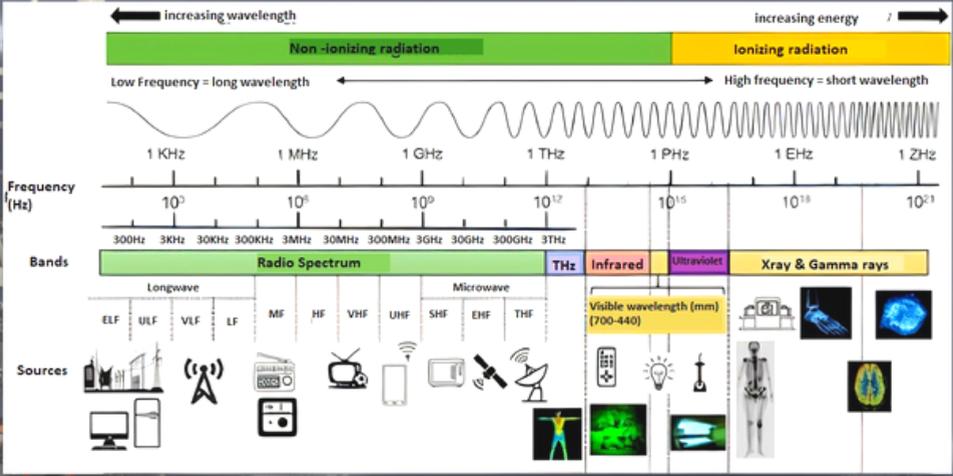
Electromagnetic spectrum frequency band

Wireless communication is form of communication that use unguided media to transport electromagnetic wave without using a physical conductor. The transmission medium are:

⫸ Radio wave
⫸ Microwave
⫸ Infrared

USING WAVE TO COMMUNICATE..

Electromagnetic spectrum for wireless communication
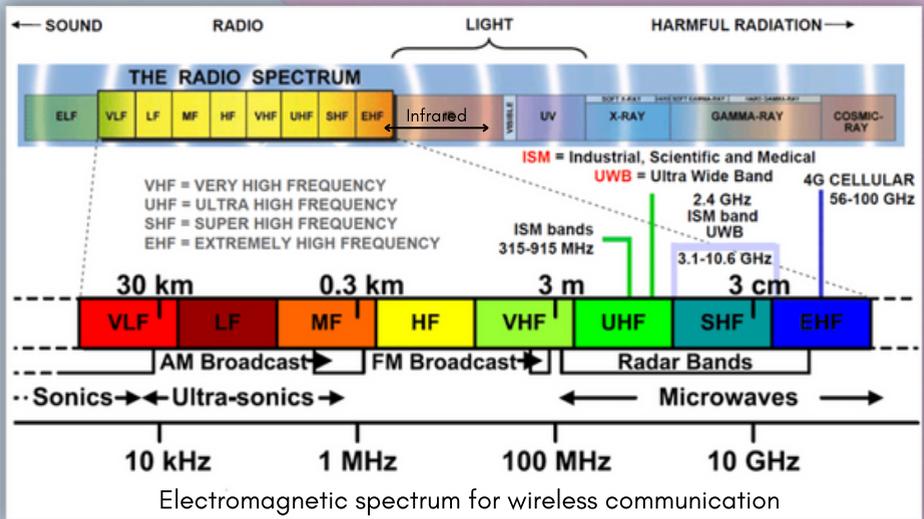
Radio wave
- Also called radiofrequencies.
- Spectrum ranging from 10KHz to 300GHZ
- Used for multicast communications, such as radio, television, paging system
- The wave can penetrate through wall

Microwave
- Sub-class of radio wave
- Used for unicast communication such as cellular telephones, satellite networks and wireless LAN
- Higher frequency range cannot penetrate wall

Infrared
- Used for short range communication in closed area
- line of sight communication
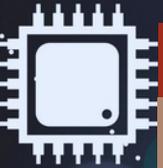
Advantage	Disadvantage
FLEXIBILITY & MOBILITY Freedom to move without being tethered by wires	**RADIO SIGNAL INTERFERENCE** Potential to interference between two different signal
INCREASED RELIABILITY Easy to maintain the system from failure network	**SECURITY** Possible for intruder to hack the networks
EASIER INSTALLATION Easy to install for any any device to be modified and stay connected	**HEALTH RISKS** Radiation from wireless devices can affect human health
LESS EXPENSIVE INSTALLATION No network cabling, reduce cost of installation task	**HIGHER STARTING COST** New technology equipment have high starting cost
DISASTER RECOVERY Robust – the system still exist and easy to relocate	**LOWER BANDWITDH SPEED** Low transmission rates for higher numbers of user
CAPABILTY Give worker ability to access the network resources for mobile workforce industries	**LIMITED SPECTRUM** Limited frequency allocation for new technology commuication

ADVANTAGES AND DISADVANTAGES OF WIRELESS COMMUNICATION

Wireless Communication Categories

WPAN
<10m
~ 1Mbit/s
IEEE802.15

WLAN
<100m
~ 11–54Mbit/s
IEEE802.11

WMAN
<5km
~ 70Mbit/s
IEEE802.16

WWAN
>15km
IEEE802.20

GSM,GPRS
,UMTS,LTE

UWB

Wi Fi™

wimax
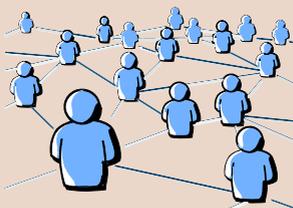
Wireless Personal Area Network (WPAN)

WPAN is short range area network can be defined as the network that coverage in small area place and connect two or more device that can share data and information

IEEE 802.15 refer as a standard for Wireless PAN.

Example for WPAN is Infrared, wireless RF, RFID, Bluetooth, ZigBee, NFC and etc
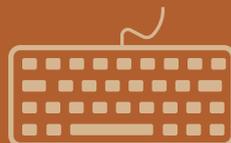
WPAN IEEE	Technology	Data rate	Range	Application
802.15.1	Bluetooth Bluetooth 2.0	1Mbps 2Mbps	Class 1 – 100m Class 2 – 10m Class 3 – 1m	Wireless speaker, microphone, hand free set Smart phone – synchronization
802.15.3	High rate WPAN (UWB)	22, 33, 44,55 Mbps	30-50m	Digital image/video download/ exchange
802.15.4	Low rate WPAN (Zigbee)	250kbps	100m	Sensor, meter reading, smart tag, home automation
802.15.4f	Low rate WPAN (RFID)		0.305m	Warehouse, retail, asset record, manufacturing

Types of Wireless Personal Area Network

“ When wireless is fully applied the earth will be converted into a huge brain, capable of response in every one of its parts. – Nikola Tesla ”

1. What is the data rate for Bluetooth 2.0 according to IEEE specifications?

2. What is the IEEE standard for RFID?

3. What is the standard that suitable for digital image transfer?

4. Range for Class 2 Bluetooth is : _____

5. Low rate sensor at 250 kbps is using standard 802.15.1, true or false?

Wireless Local Area Network (WLAN)

WLAN is a network that allows devices to connect & communicate wirelessly via Access Point (AP) within a limited area such as a home, school, computer laboratory, or office building, thus minimizing the need for wired connections. Normally known as Wi-Fi

WLAN operational frequency are the 2.4 GHz and 5 GHz radio bands with approximately 100 m range.

A WLAN is usually password protected, but may be open, which allows any device within its range to access the resources of the WLAN network.

Variation of IEEE802.11

802.11				
a	**b**	**g**	**n**	**ac**
Released				
1999	1999	2003	2009	2014
Frequency				
5GHz	2.4 GHZ	2.4 GHZ	2.4 & 5GHZ	2.4 & 5GHZ
Maximum Data Rate				
54 Mbps	11 Mbps	54 Mbps	600 Mbps	1.3 Gbps
Outdoor/ Indoor				
20 / 100m	35 / 120m	20 / 100m	38 / 140m	70 / 250m

Fun Fact !!

Wi-Fi is registered trademark for non-profit Wi-Fi Alliance which is consisted of more than 800 companies around the world
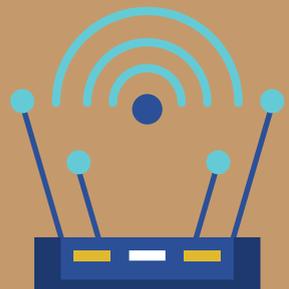
Worldwide Interoperability for Microwave Access (WiMAX) as Wireless Metropolitan Area Network (WMAN)

WiMAX is Wireless MAN is long range area network that providing a much larger coverage in wide area place such as city or metropolitan area based on IEEE 802.16 standard.

WiMAX is the first carrier system to offer a 4G cellular broadband network for wireless internet access, providing faster data downloads up to 100 Mbps (WiMAX 2.0)

- 802.16d – 2004, referred to as fixed WiMAX, has no support for mobility.

- 802.16e – 2005, introduced support for mobility and referred as Mobile WiMAX.

Wireless Metropolitan Area Network (WMAN)
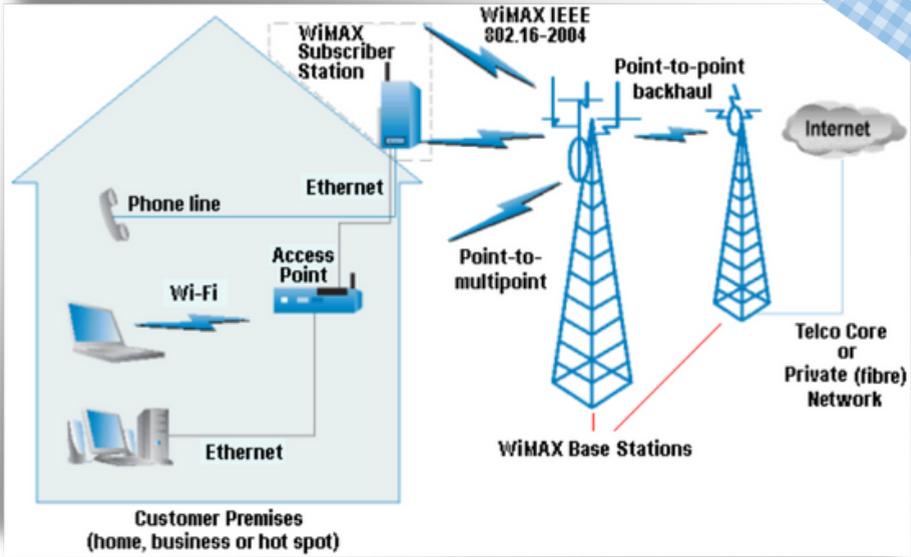
Wimax Backhaul

> " Wireless is freedom. It's about being unleashed
> from the telephone cord and having the ability
> to be virtually anywhere when you want to be.
> – Martin Cooper "

1). Radio signal is free space travel at _____
a. The speed of sound
b. Twice the speed of sound
c. Half the speed of light
d. The speed of light

2). How is a wireless network different from a wired
a. Ranks top among all security network
b. Not interrupted by physical obstructions
c. Easy to add new devices to the network
d. Conventional office setups

3). The frequency range of WI-FI is around _____
a. 2.4 GHz and 5GHz
b. 2.9 GHz and 5GHz
c. 3.4 GHz and 5GHz
d. 4.4 GHz and 5GHz

4). The throughput of the IEEE standard 802.11a is _____
a. $\leqslant$54Mbps
b. $\leqslant$64Mbps
c. $\leqslant$74Mbps
d. None of the above

5.) WiMAX is mostly used for _____
a. local area network
b. metropolitan area network
c. personal area network
d. none of the mentioned

QUIZ

CLICK

click here to answer Review Question 1

BLUETOOTH

✓ Bluetooth is WPAN standard that operates in the 2.42.485 GHz (ISM band) at data rate 1 Mbps.

✓ Bluetooth wireless technology is an open specification for a low-cost, low-power, short-range radio technology for ad-hoc wireless communication.

✓ Bluetooth employs Frequency Hopping Spread Spectrum (FHSS) modulation technique.
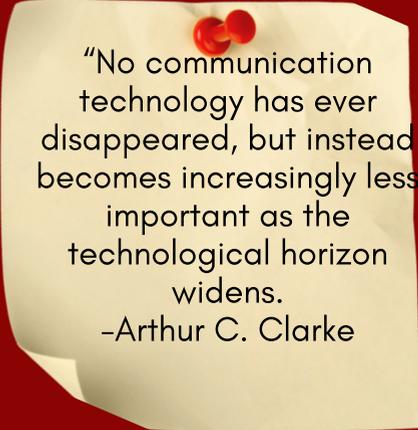
"No communication technology has ever disappeared, but instead becomes increasingly less important as the technological horizon widens.
–Arthur C. Clarke
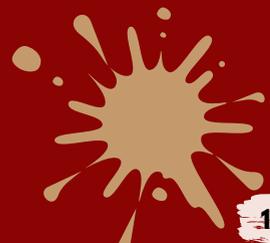
Bluetooth General Application

Data & voice access Point: Facilitates real time voice and data transmission by providing effortless wireless connection of portable & stationary communication devices
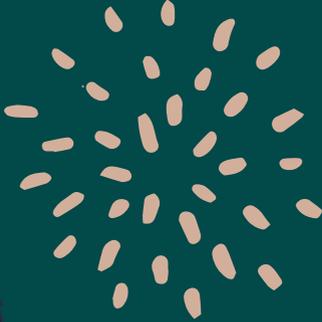
Ad hoc networking: device equipped with a Bluetooth radio can be establish instant connection to another Bluetooth radio as soon as it comes into range

Cable Replacement: Eliminate the need for numerous cable attachment for connection such as telephone, computer, camera and printer when they are short distance.

CLICK

click here to watch video of application of Bluetooth

Class of Bluetooth System

Class	SPECIFICATION			
	Frequency Band	Radio Transmit Power	Distance Range	Speed Data Rate
Class 1	ISM band 2.42 – 2.485 GHz	20dBm	up to 100m	1 Mbps
Class 2		4dBm	10m	1 Mbps
Class 3		0 dBm	1m	24 Mbps
Class 4		-3 dBm	0.5 m	24 Mbps

Fun Fact !!
Named after 10th Scandinavian king. Harold Bluetooth who peacefully united Norway & Denmark

H (ᚼ) + B (ᛒ) = ✴
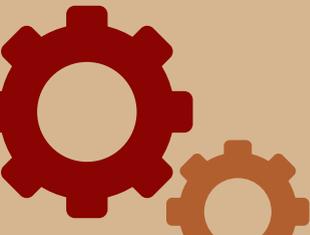
APPLICATION OF BLEUTOOTH

Bluetooth

Beacon
- Shopping
- Trade show
- Monitoring

Healthcare/ medical/sport
- Wristband
- Health check
- Racket

Car electronics
- Hands free
- Key fog
- Abnormality detection

Home Security
- Security sensor
- Baby care
- Security camera

Home automation
- Air conditioner
- Computer peripheral
- Lighting device
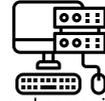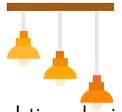
Entertainment
- camera
- Remote control
- Toys

Wearable devices
- Watches
- Accessory
- Shirts

Industrial devices
- Handy terminal
- Drying machine
- Work efficiency management
- Open/close control

1. The higher the class of Bluetooth, the lower the radio transmission power, true or false?

2. Higher speed rates need less power, true or false?

3. The band of Bluetooth system in ISM Band are:_____.

4. High distance of Bluetooth can provide only a low-speed rate?

5. Which class can provide the highest data rates?

Two types of Bluetooth network
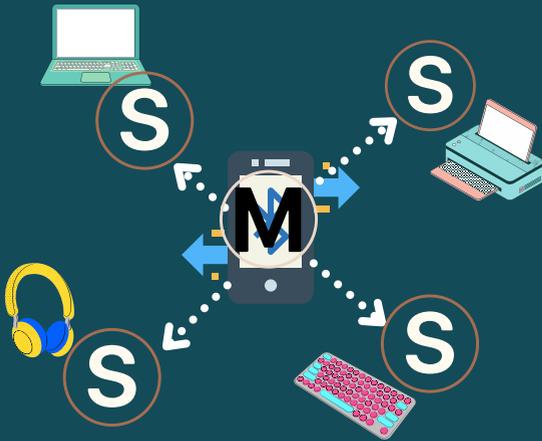
Piconet

- Small net
- Can have until 8 station (1 Master, 7 Slaves)
- All slaves synchronize their clock and hopping sequence with the master
- Communication between master and slave can be as one to one or one to many
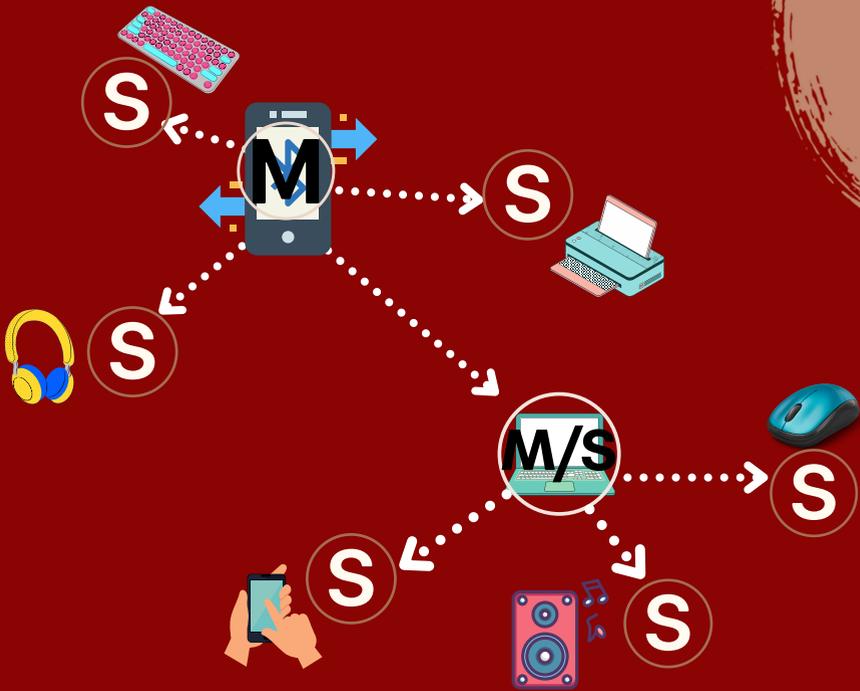
Scatternet

- Piconet are combined to form a Scatternet
- A device can be slave in Piconet and master for another layer of Piconet (M/S)
- M/S can receive messages from the master in the first piconet, thus can act as a slave and act as master in second Piconet by transmitting message to slave

ADVANTAGES AND DISADVANTAGES OF BLUETOOTH

Advantages

- It avoids interference from other wireless devices.
- It has lower power consumption.
- It has a range better than Infrared communication.
- The technology is adopted in many products such as headsets, in-car systems, printers, webcams, GPS systems, keyboards and mice.
- No line of sight hence can connect through any obstacles.

Disadvantages

- It can lose connection in certain conditions.
- It has low bandwidth as compared to Wi-Fi.
- It allows only short-range communication between devices.
- Security is a very key aspect as it can be hacked.

The wireless telegraph is not difficult to understand. The ordinary telegraph is like a very long cat. You pull the tail in New York, and it meows in Los Angeles. The wireless is the same, only without the cat. - Albert Einstein

1). The frequency band of Bluetooth radio is around _____
a.2.1 GHz
b.2.3 GHz
c. 2.4 GHz
d. None of the above

2). What was the range of Bluetooth?
a.Only 10m
b.More than 10m
c.Less than 10m
d.None of the above

3). The single piconet formed by _____
a.One slave and one master
b.One slave and multiple masters
c.Multiple slaves and one master
d.Multiple slaves and multiple masters

4). The scatternet is a combination of _____
a.Single piconet
b.Double piconet
c.Multiple piconet
d.None of the above

5). In which node the data is being received?
a.Master node
b.Slave node
c.Master and slave node
d.None of the above

6). How many nodes do piconet consists of?
a.Two nodes
b.Three nodes
c.Four nodes
d.Eight nodes

QUIZ

CLICK

click here to answer Review Question 2

RFID

- RFID is the use of a wireless system that uses radio frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking.

- It is also gaining increasing use in industry as an alternative to the barcode.

- RFID system contains several components including an RFID tag (transponder), antenna, RFID reader (transceiver) and Computer (Host)

- Can operate in Passive or Active Modes
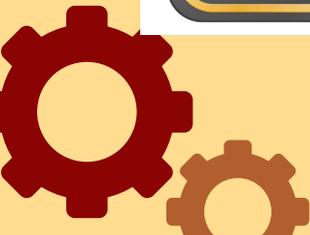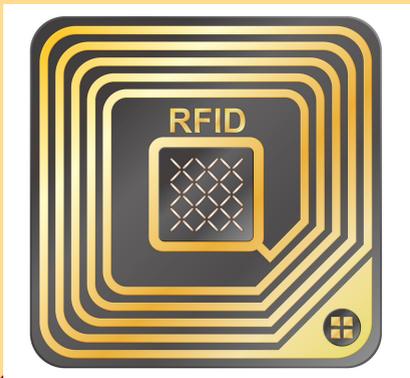
Application of RFID

Radio Frequency IDentification
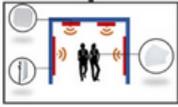
Personnel tracking | Access Control | Supply chain management | Books tracking in libraries | Toll Gate Systems

Electronic Passport

Automatic Vehicle Location

Smart Car Key
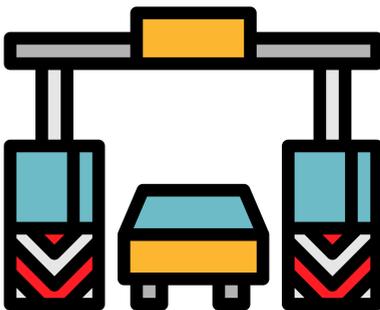
Toll Collection

Facility Access
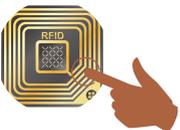
click here to watch video of application of RFID

1

RFID Tag
Device to transmit information
Contactless
3 types – Passive, Active & Semi-passive

2

Antenna
Attached to the reader to communicate with interrogator
Received store data from the tag and transmit its to reader

3

RFID Reader
Also known as interrogator
Receive data from RFID tag
Can be handheld or stationary

4

Computer Database
Data storage for evaluation

RFID CATEGORIES

Active Tag

- TAG with built in battery to communicate with reader
- Battery use to run microchip inside the tag
- Able to track real time location

Advantages

✓ Long reading distance, up to tens of meters, or even hundreds of meters.

Disadvantages

✗ Large volume, high cost, the service time is limited by battery life

Application

⬇ Industry, Logistics, Real-time traffic management, Vehicle access control
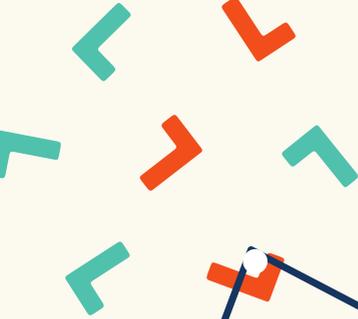
Passive Tag

- TAG that no energy source inside
- Provide energy source from reader.
- Reader send radio signal to the antenna

Advantages

Small size, lightweight, low cost, long life up to more than 10 years, and maintenance free,

Disadvantages

The reading distance is limited. Generally, RFID readers with large power are required.

Application

Security traceability, asset management, book management, and logistics management, etc.
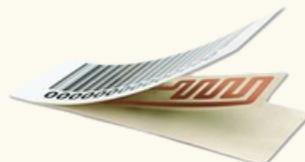
Semi Active

- TAG that have internal battery just to power the circuit
- Reading operation performed through EM field emit from reader like passive tag

Advantages

✓ Compared with passive tags, this tags have faster response speed . Compared with active tags, semi-active tags consume less power.

Disadvantages

✗ Large size and high cost

Application

⬇ Access control management, object positioning and parking management, etc.
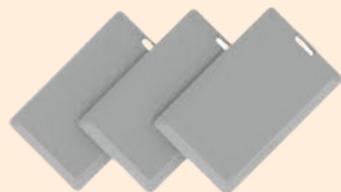
Passive and active RFID system

Attribute	Passive tag	Active tag	Semi passive/ active tag
Internal power source	No	Yes	Yes
Response distance	Short	Very long	Long
Weight	Light	Less light	Less light
Life cycle	Long	Short	Long
Cost	Cheap	Expensive	Less expensive

BASIC OPERATION FOR RFID

Computer Database 6

Data is transmitted into RFID database where it can be stored and evaluated

RFID Reader

Reader broadcast signal through antenna 1

RFID Tag

Transponder receives signal 3

Transponder is charged with enough energy to send back & identifying response like data 4

Reader send data to computer for processing 5

Antenna

Broadcast signal, receive data from tag and transmit to reader 2

Fun Fact !!
The smallest RFID tag is manufactured by Hitachi. It is .01 inches square attached to a bee. Helps scientist learn more about animal habits & environments
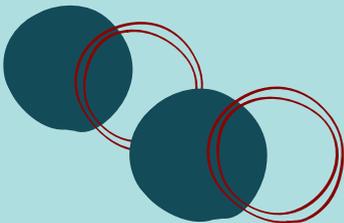
RFID WORKING FREQUENCY

Frequency Range	LF 125KHz	HF 13.56 MHz	UHF 868–916 MHz	Microwave 2.45&5.8 GHz
Typical Max Range	Shortest 1 – 12"	Short 2-24"	Medium 12-120"	Longest 12-180"
Tag Power Source	Passive tag, inductive coupling	Passive tag, inductive & capacitive coupling	Active tag integral battery @ passive tag capacitive storage, E-field coupling	Active tag integral battery @ passive tag capacitive storage, E-field coupling
Data Rate	Slower	Moderate	Fast	Faster
Application	Security, access control Identifying	Library books, access control Identifying	Supply chain, tracking, toll tag	Toll tag, asset tracking

Low Frequency (LF):
100-500 KHz

High Frequency (HF):
10-15 MHz and
850-950 MHz

Ultra High Frequency (UHF):
2,4-5,8 GHz

Range:
Up to 10 cm

Range:
Up to 30 cm
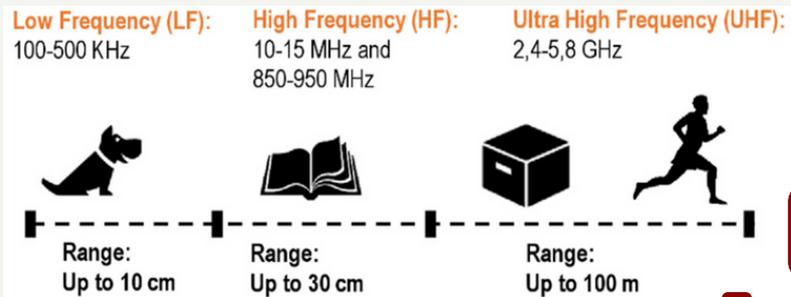
Range:
Up to 100 m

1. Which frequency is suitable for asset tracking?

2. Short-range transmission needs low or high frequency?

3. What kind of tag power source used by HF RFID?

4. The fastest data rate required the lowest frequency, true or false?

5. Which frequency range RFID can use both active and passive tag?

READ ONLY & READ/WRITE FOR RFID

Read Only

- Tag's information or ID is stored on them during the manufacturing process.
- The information on such chips can never be changed.
- No additional data can be assigned to the tag.

Read/Write

- Additional information can be added or change to the tag when the tag is within range of a reader.
- Read-write tags usually have a serial number that can't be written over. (part of data block is locked to prevent over writing)
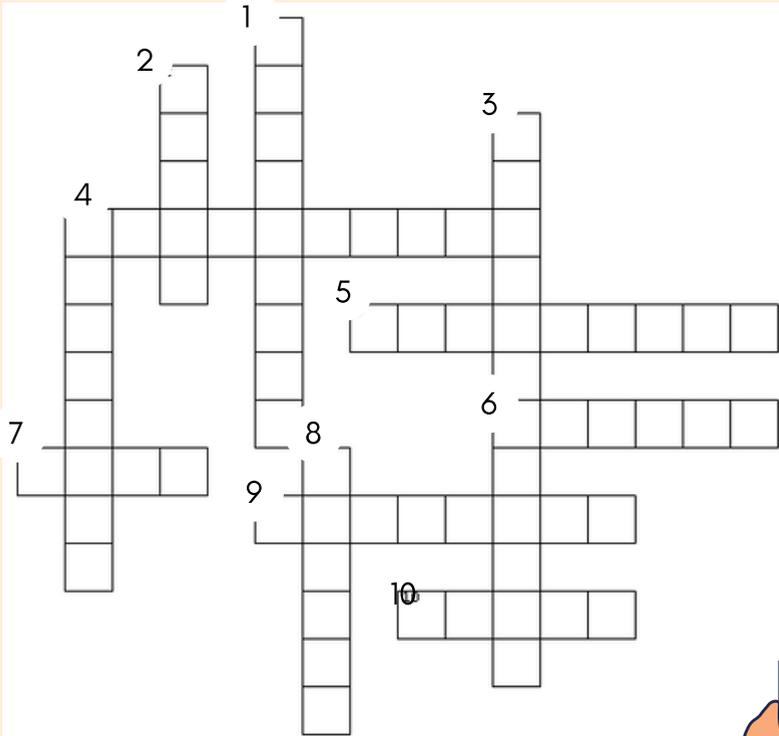
ACROSS
4. Combination of 2 or more piconets
5. One of wireless transmission medium
6. RFID system with built in battery
7. Network type, peer to peer communication
9. High frequency RFID data rate
10. Range of Bluetooth connection

DOWN
1. Example of Wireless Personal area network
2. Combination of wireless internet and broadband network
3. .... also known as reader in RFID
4. Disadvantages of wireless communication
8. Wireless types that depends on cell tower to transfer data

Answer

REVIEW QUESTION 1

1.D
2.C
3.A
4.A
5.B

REVIEW QUESTION 2

1.C 2.B 3.A 4.C 5.B 6.D

REVIEW QUESTION 3
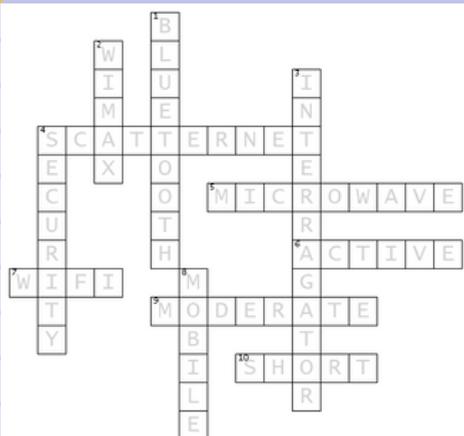
ANSWER

POP QUIZ 1

1. 2 Mbps
2. 802.15.4f
3. 802.15.3
4. 10m
5. False

POP QUIZ 2

1. True
2. True
3. 2.42 – 2.485 GHz
4. True
5. Class 3 and class 4

POP QUIZ 3

1. 2.45 & 5.8 GHz
2. Low
3. Passive Tag
4. false
5. UHF 868–916 MHz
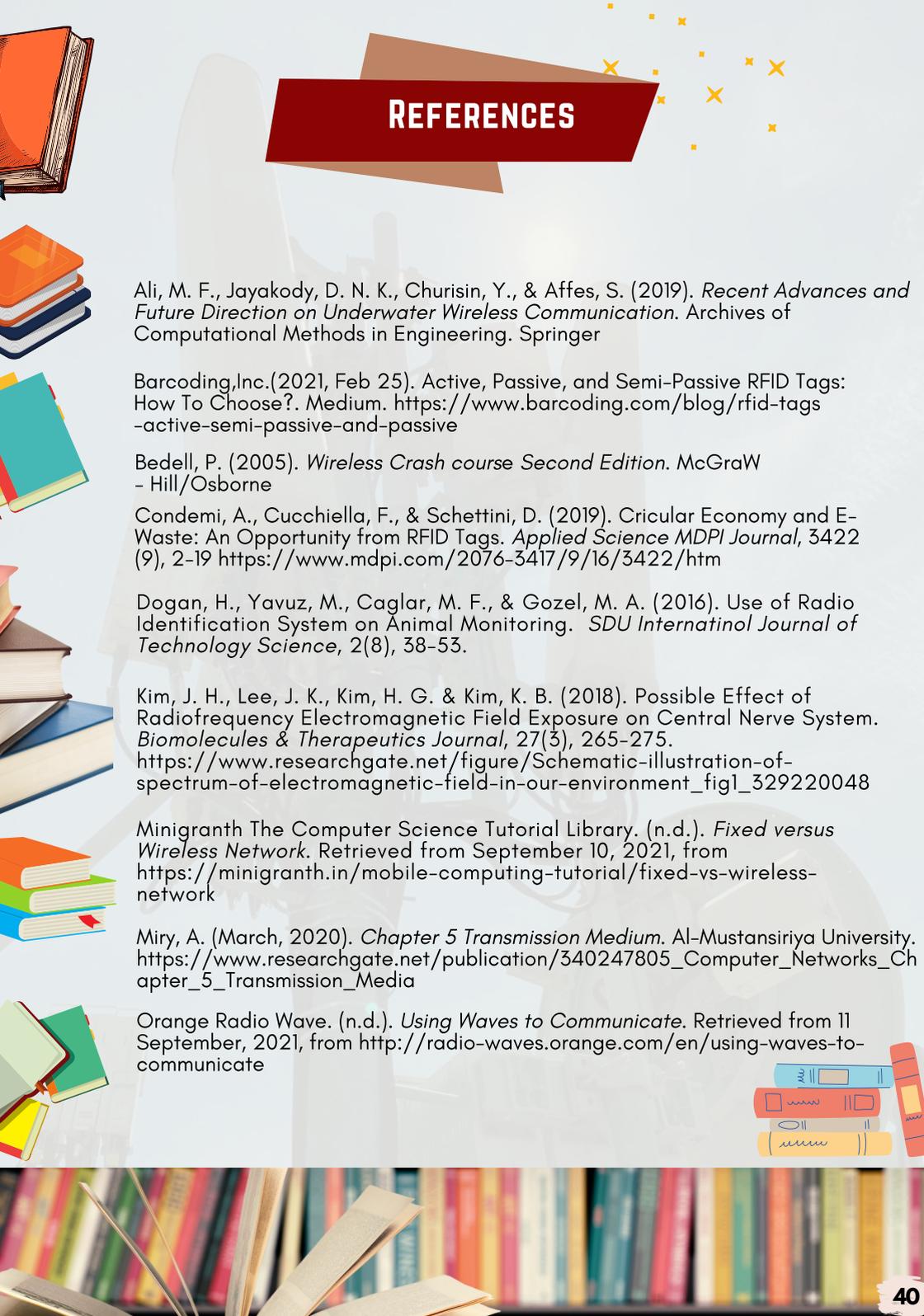
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POLITEKNIK
MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

POLITEKNIK SULTAN SALAHUDDIN
ABDUL AZIZ SHAH,
Persiaran Usahawan, Sec U1,
40150 Shah Alam Selangor.

Tel: 03-5163 4000 Fax 03-55691903
Web site : www.psa.edu.my