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جامعة الإسكندرية
كلية الهندسة
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Lab3: Communication systems.

(Section-6)

WLAN module

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Problem 1: General report about WLAN Standard

1. Describe the history of the WLAN and how this standard started.

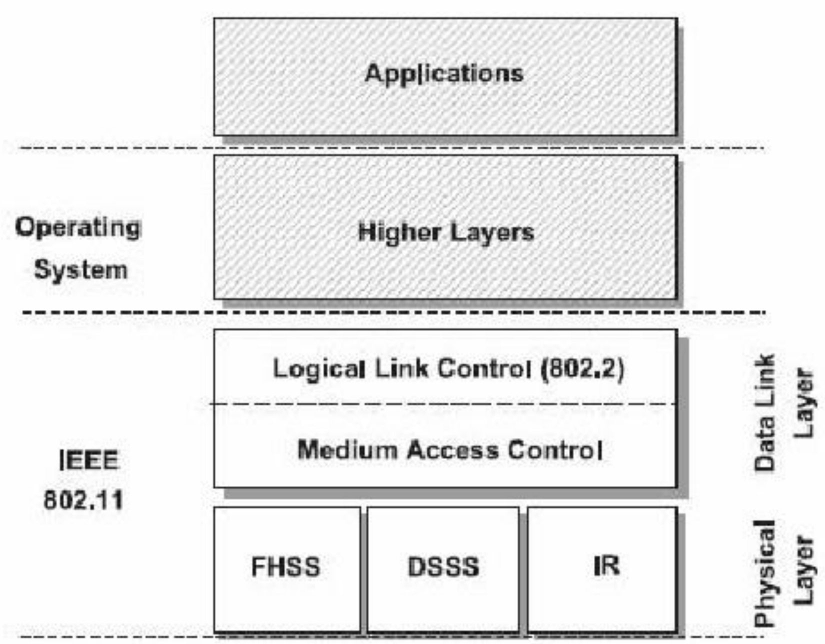
- WLAN: wireless local area network (802.11)
- First WLAN devices appeared on the market in mid 1990s and after 10 years LAN became the main technology for connection.
- Based on existing LAN standards created by IEEE (Ethernet 802.3)

2. Mention some of WLAN applications.

- LAN extinction saves installation of LAN cables
- Open hotspots

3. Describe the protocol stack of WLAN

The 802.11 standards focus on the MAC and PHY as a whole. WLAN Toolbox functionality focuses on the physical-medium-dependent (PMD) and physical layer convergence procedure (PLCP) sublayers of the PHY, the MAC sublayer, and their interfaces.



4. In details describe the WLAN system architecture (configurations), with the difference between the two modes.

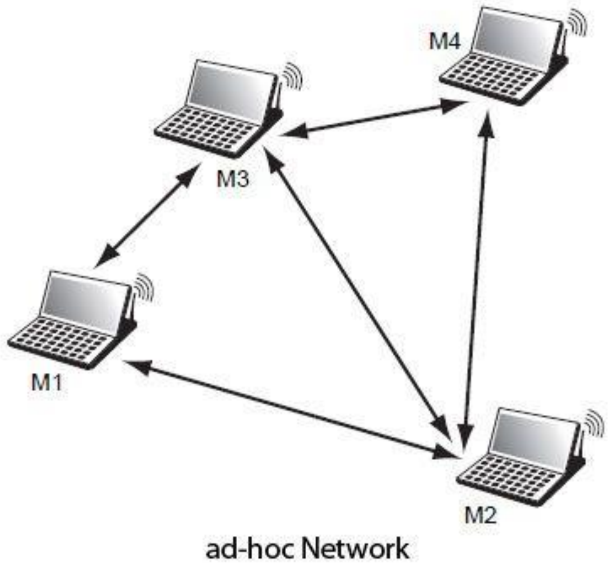
- An 802.11 LAN is based on a cellular architecture where the system is divided into cells called basic Service set (BSS) and each cell is controlled by a base station called Access point (AP). The WLAN can be formed by a single cell or several cells, where the access points.

Ad-Hoc Mode	Infrastructure Mode
• Two or more wireless devices communicate with each other • All devices are equal **Packets exchanged directly between two devices** • All devices share the same medium **The Packets received by all stations are ignored except for the intended recipient**	• Suitable to access local network and internet • Access points (APs) used as gateway between all wireless and wire line network for all devices of basic service set (BSS) • The data sent from one device to another device passes through AP first.

5. What are the advantages and disadvantages of Infrastructure mode?

Ad-Hoc Mode	Infrastructure Mode
• Two or more wireless devices communicate with each other over a larger distance with AP in middle	• Packets that is transmitted between two devices has to be transmitted twice over air

6. How to configure Ad-Hoc network?



- Network must have name (SSID Service Set identity)
- All users select the same frequency channel number
- All users use the same ciphering key
- Individual IP address has to be configured in every device

7. Show in detail how the WLAN standard changed through the versions 802.11b/g/a/n/ac/ad.

Version	Frequency band GHz	Theoretical max data rate	Changes
802.11b • **DBPSK** • **DQPSK**	2.4	1-11 Mbps	BW= 22 MHz No of channels= 11 in US / 13 in Euro Up to three Aps working on frequency channel numbers 1,6 and 11 Power up to 0.1 W **DSSS To limit interference effect from Bluetooth signals**

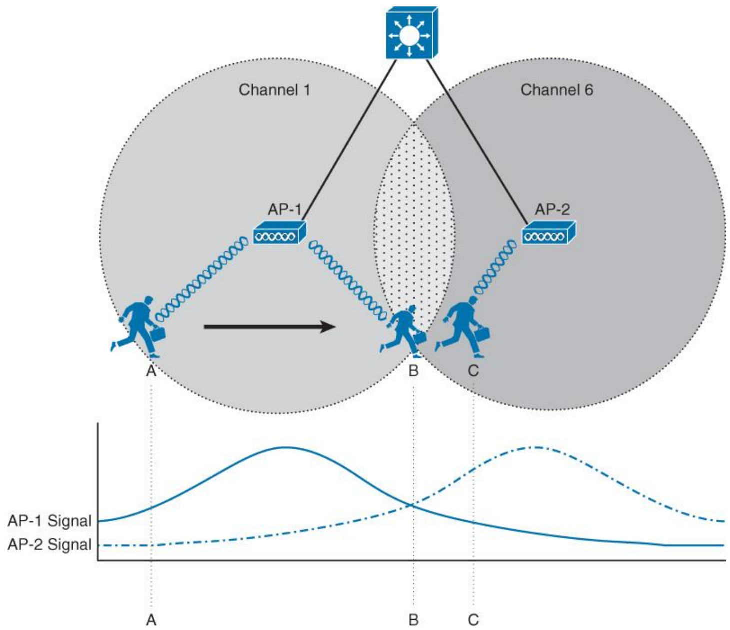
802.11g • **BPSK** • **QPSK** • **16QAM** • **64QAM**	2.4	6-54 Mbps	**Compatible with 802.11b** **OFDM to solve the multipath fading problem** **Same number of channels, BW and frequency band**
802.11a	5	6-54 Mbps	**Incompatible with 802.11b and 802.11g**
802.11n	2.4/5	6-600 Mbps	**Double BW** **Use MIMO**
802.11ac	5	Up to 6.93 Gbps	**BW 20/40/80/160**
802.11ad	60	Up to 6.76 Gbps	**BW 2,160**

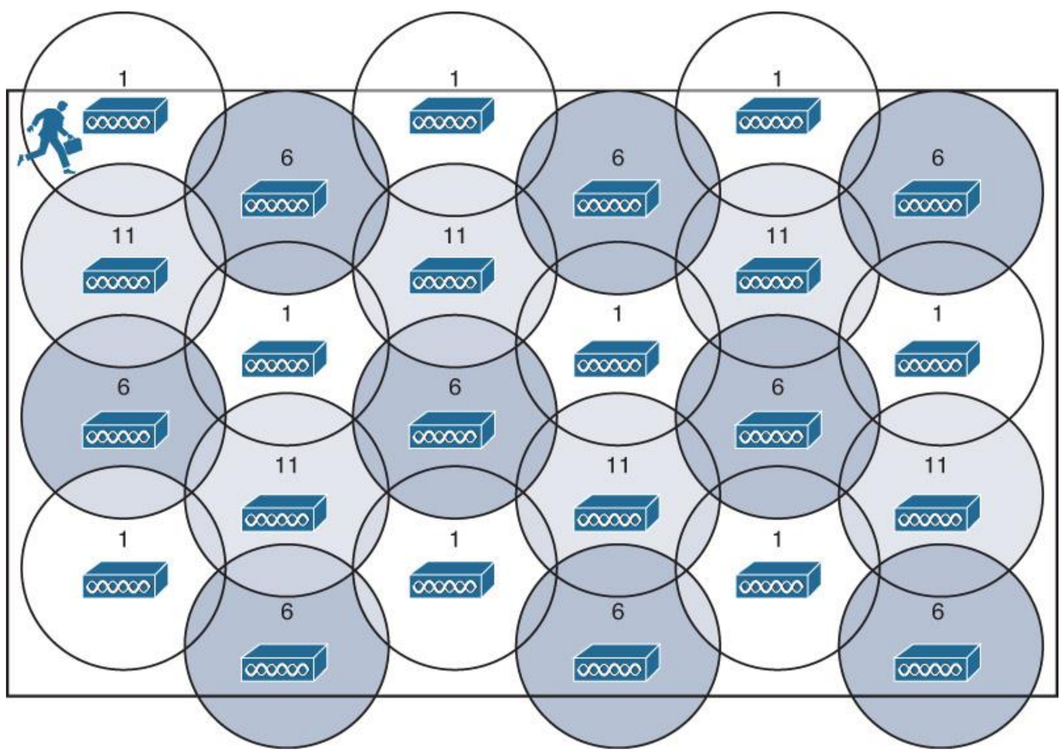
8. Discuss how the WLAN system improved through the versions 802.11e/f/h/i/w

802.11 standard	**Features**
802.11e	Adds QoS (Quality of service)
802.11f	Adds interoperability between APs
802.11i	Improves security of existing 802.11a/11b/11g based networks
802.11w	increases security of 802.11 management frames and protect broadcast as well as multicast robust management WLAN frames

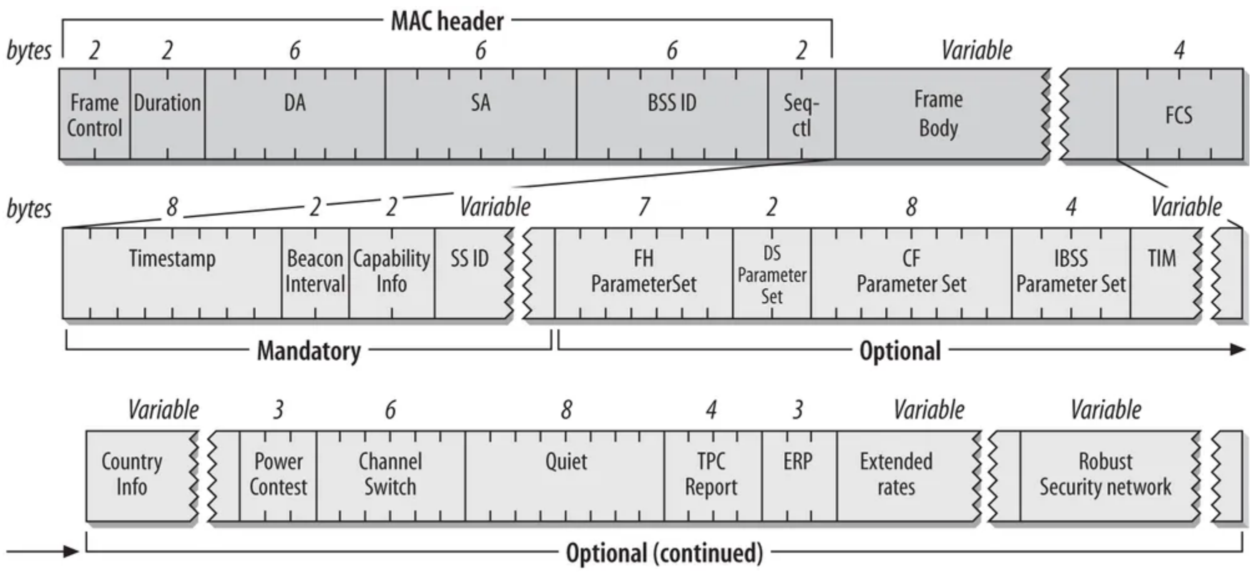
9. How to limit/decrease the interference between Access Points (AP) within the extended service set (ESS)

APs cells should be designed so that adjacent APs use different channels.





10. Discuss the MAC frame format for WLAN and mention the function of each group of bits in it.



12. Describe the ACK frame format and what is the functionality of the ACK frame?

Acknowledgment (ACK) frames is a control frame specifies which data frames have successfully arrived at the receiving end of the link.

13. Describe the CSMA/CA Protocol and RTS/CTS messages

- Carrier sense multiple access/collision avoidance (CSMA/CA) is a protocol for carrier transmission in 802.11 networks. It was developed to minimize the potential of a collision occurring when two or more stations send their signals over a data link layer.

    - Before node transmit data it checks the medium
        - Medium is free: node sends it’s signal
        - Medium is busy: wait for a random time then send again
- RTS/CTS is the optional mechanism used by the 802.11 wireless networking protocol to reduce frame collisions introduced by the hidden terminal problem.
    - If terminal sense idle medium, it sends RTS signal
    - If no other terminal is transmitting, AP sends CTS signal to terminal
    - If AP was busy, the terminal waits random time then send again

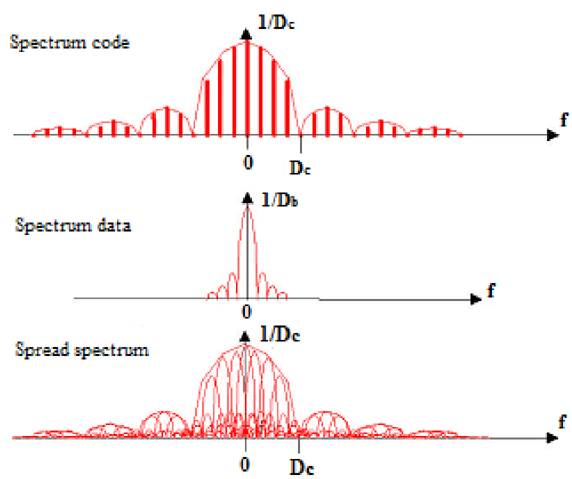
14. Describe both the RTS and CTS frame format.

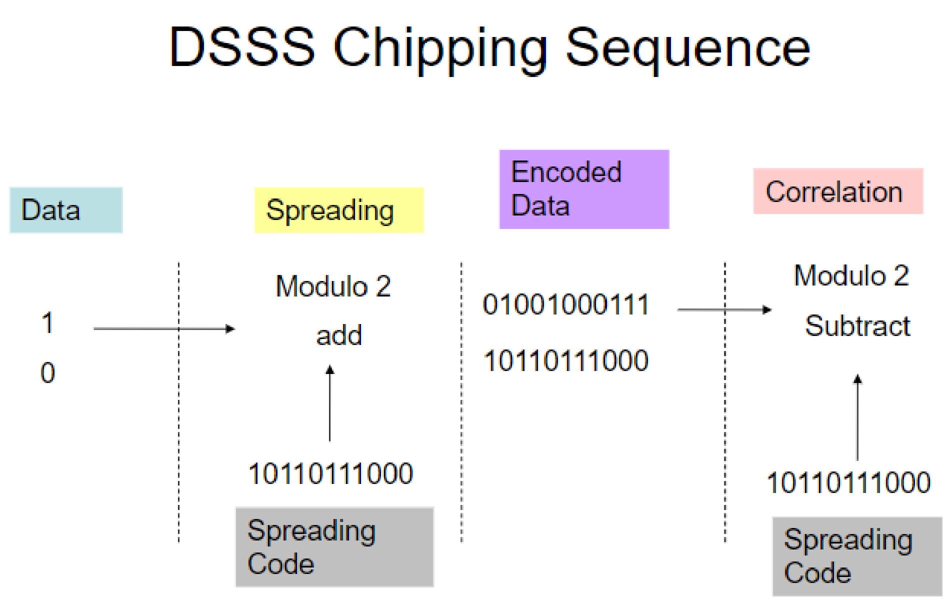
The RTS and CTS frame headers all contain a frame control field (two bytes of metadata flags), duration field, a field for the receiver MAC address, and a frame check sequence. Additionally, an RTS frame contains the transmitter's MAC address.

RTS	Frame Ctrl	Duration	DA	SA	FCS
CTS	Frame Ctrl	Duration	DA	FCS	

15. Discuss Direct sequence spread spectrum (DSSS) and how it is useful in WLAN.

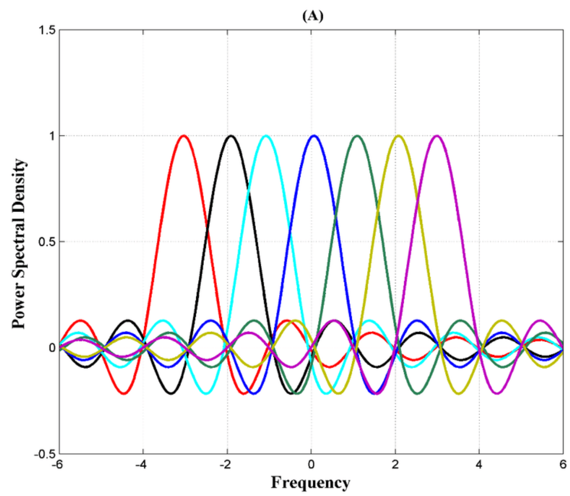
Direct-sequence spread spectrum is a spread-spectrum modulation technique primarily used to reduce overall signal interference. The direct-sequence modulation makes the transmitted signal wider in bandwidth than the information bandwidth.





17. Discuss orthogonal frequency division multiplexing (OFDM) and how it is useful in WLAN

OFDM is a specialized FDM having the constraint that the sub-streams in which the main signal is divided, are orthogonal to each other. Orthogonal signals are signals that are perpendicular to each other. A main property of orthogonal signals is that they do not interfere with each other.



It is used to solve problem of multipath fading

18. What is (MIMO) and how can we make use of it.

MIMO: multiple input multiple output, is the use of multiple antennas in both TX and RX

Spatial multiplexing	Diversity
Split data across two antennas	Send multiple copies of the same data
Increase data rate	Lower BER

Problem 2: Questions Related to the Experiment

1. For WLAN module in our experiment what is the type of antenna in it?

The MRF24WB0MA has an integrated PCB antenna.

2. How can we set the network name?

```
char strSSID[13] = "Ahmed50";
```

3. How can we change the channel number we use to transmit?

```
char channels[11]  = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11};
```

4. How can we change the mode of WLAN in our Experiment from Infrastructure to Ad-hoc?
   - Open CMD
   - Write this command: >> netsh wlan set profileparameter strSSID connectiontype=ibss

Code

```
clc; clear all; close all;
%% Initialization
Frames = 1000; %Number of Frames
fft_size = 128; %FFT Size (Number of subcarriers)
M = 16; K = log2(M); %16-QAM Modulation
delta = 312.5*10^(3); %Carrier Separation
delay_spread = 0.2*10^(-6); %Delay Spread
SNRdb = 0:3:30; %SNR Range in dB
delay_spread_max = delay_spread*fft_size*delta; %Number of paths
msg_size_bits = K*fft_size;
msg_size_symbols = msg_size_bits/K;
BER = zeros(length(SNRdb),Frames);
BER_avg = zeros(length(SNRdb),1);
%%
for i = 1:length(SNRdb)
for k = 1:Frames
%% Message Generation
msg_bits=randi([0,1],msg_size_symbols,K);
msg = bi2de(msg_bits,'left-msb')';
%% QAM Modulation
X = qammod(msg,M,'UnitAveragePower',true);
%% IFFT
x = sqrt(fft_size).*ifft(X);
%% ADD Cyclic Prefix
CP = x(128-31:128);
msg_CP = [CP x];
%% Channel (fading + noise)
[fadedSamples, gain] =ApplyFading(msg_CP,1,delay_spread_max);
msg_rx=awgn(fadedSamples,SNRdb(i),'measured');
%% Cyclic prefix removal
Y = msg_rx(33:160);
%% Freq domain equalization
Y_ = fft(Y)./sqrt(fft_size);
Z = Y_./fft(gain,128);
%% QAM Demodulation
msg_demod = qamdemod(Z,M,'UnitAveragePower',true);
msg_demod_bits  = de2bi(msg_demod,4,'left-msb');
%% BER calculation
[~,BER(i,k)] = biterr(msg_demod_bits,msg_bits);
BER_avg(i) = sum(BER(i,:))./Frames;
end
end
%% Plotting BER vs. SNR
figure
semilogy(SNRdb',BER_avg)
title('BER vs. SNR for 16-QAM with fading');
xlabel('SNR(dB)')
ylabel('BER')
```