Lec31

Thursday, April 2, 2020 5:19 PM

Wireless LAN - 5min

Thursday, January 17, 2008 5:17 PM

Wireless LAN starts as a way to provide high-speed data service for computers wirelessly and cost-effectively.

- use unlicensed spectrum
  - 2.4G band (2.4-2.4835 G)
  - 5G band (5.725-5.850G)
  - lower cost
  - flexible set up

- there are other systems that also operates on the same band
  - bluetooth
  - cordless phone.

- constraint on maximum power spectrum density that can be transmitted

- Use some form of spread-spectrum technique to tolerate other devices that use the same band

- Adaptive rates based on channel

condition & interference levels.

We will focus on 802.11 family of standards

802.11	1 - 2M bps	on 2.4G
802.11b	5.5 & 11M bps	on 2.4G
802.11g	up to 54M bps	on 2.4G
802.11a	up to 54Mbps	on 5G band
802.11n	up to 150M bps	

They are different physical layer technologies but identical medium access technologies.

Channels - 5min

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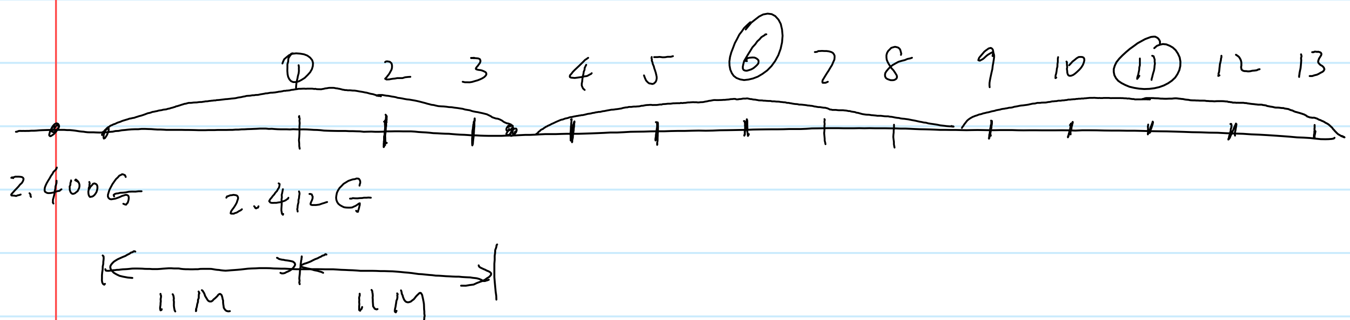
Channel Plan at 2.4G

The whole band is said to consist of 13 channels.

Channel 1 has a center freq of 2.412G, and bw of 22MHz

Channel 2 has a center freq of 2.412G + 5MHz, and bw of 22MHz and so on.



Channels can overlap. Overall, they cover the 2.4 ~ 2.483G band

In 802.11, a radio can only work on 1 channel at a time

- avoid interference from other devices (even other wireless LANs)

- maximum 3 non-overlaping channels can be used at the same time

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Physical layer - 10min

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802.11 (legacy)

- 1M, 2M bps
- Symbol rate 1M per second
- use either BPSK or QPSK depending on the interference level.
- use DSSS (Direct Sequence Spread Spectrum) in order to tolerate high level of interference from other devices.
- the spreading code is fixed

11-chip Barker code sequence
+1, -1, +1, +1, -1, +1, +1, +1, -1, -1, -1

Chip rate: 11M per second

DSSS is not used as a multiple-access mechanism among users
- used to combat interference from other devices using the unlicensed band

802.11 b.

- Add higher rates 5.5Mbps & 11Mbps

- Use complementary code keying (CCK). see p406 in Schwartz
  - different way of spreading
  - achieve higher data rate within the same 22MHz channel, when the channel condition is good.
  - robust to multipath fading (auto correlation is zero everywhere except at the zero shift.)

802.11g:

- add more rates, up to 54Mbps
- uses OFDM
  - 52 x 312.5 kHz subcarriers cover 16.6 MHz band
  - 48 subcarriers for data
  - 4 for pilot.
- adapt data rate by different coding & modulation scheme based on SINR.
  see p 410 Table 12.1 in Schwartz.

Table 1.Modulation Techniques

Data Rate (Mbps)	Modulation	Coding Rate	Coded bits per subcarrier	Coded bits per OFDM symbol	Data bits per OFDM symbol
6	BPSK	1/2	1	48	24
9	BPSK	3/4	1	48	36
12	QPSK	1/2	2	96	48
18	QPSK	3/4	2	96	72
24	16-QAM	1/2	4	192	96
36	16-QAM	3/4	4	192	144
48	16-QAM	2/3	6	288	192
54	64-QAM	3/4	6	288	216

802.11 physical layers have the typical features of a modern broadband wireless system.

- wide-band signal
- special considerations for multipath fading
- adaptive coding & modulations
- variable transmission power. (need to be careful of the consequence when we discuss the MAC layer).

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802.11 MAC - 20min

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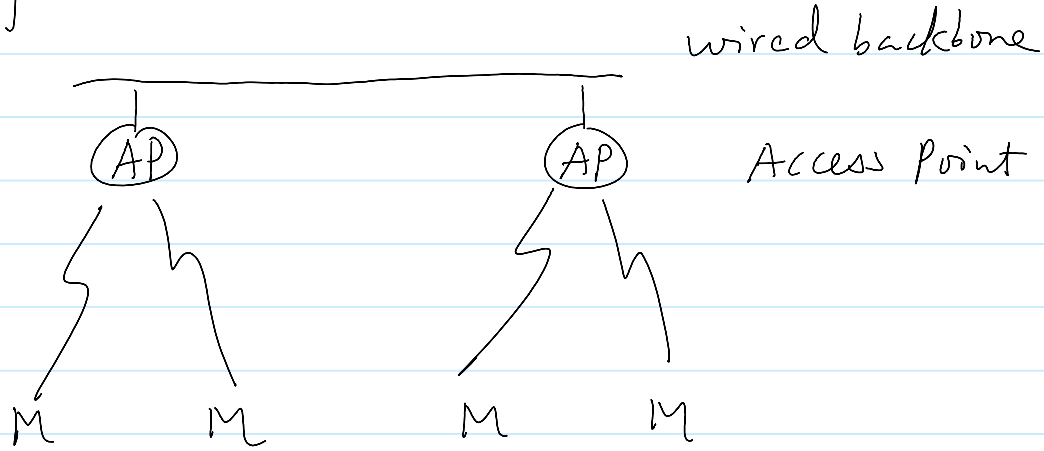
Two modes of operation

(1) Infrastructure mode



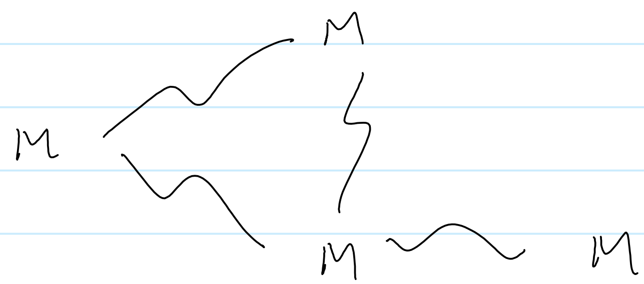
DS (distribution system): interconnection network to form one logical network (ESS: extended service set) based on several BSS.

BSS (basic service set): group of stations using the same radio frequency, or governed by the same AP.

AP (access point): station integrated into the wireless LAN and the distribution system.

Ad hoc mode

Ad hoc mode

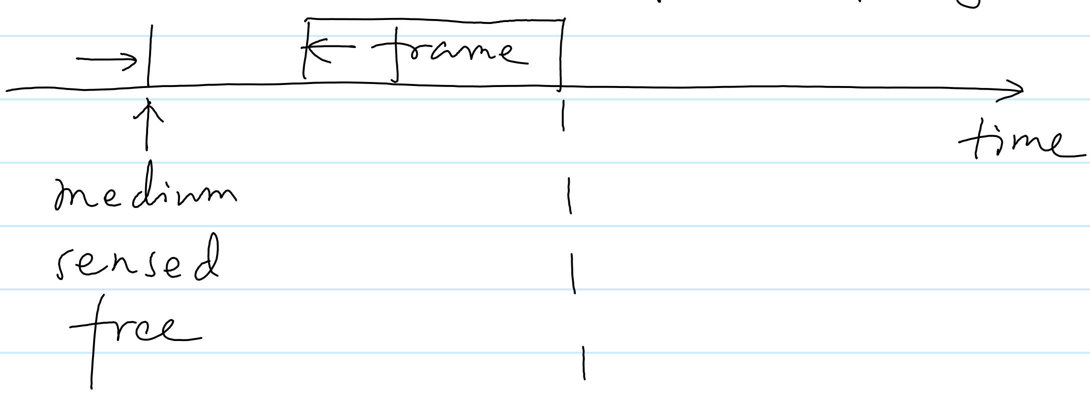


Basic MAC access mechanisms

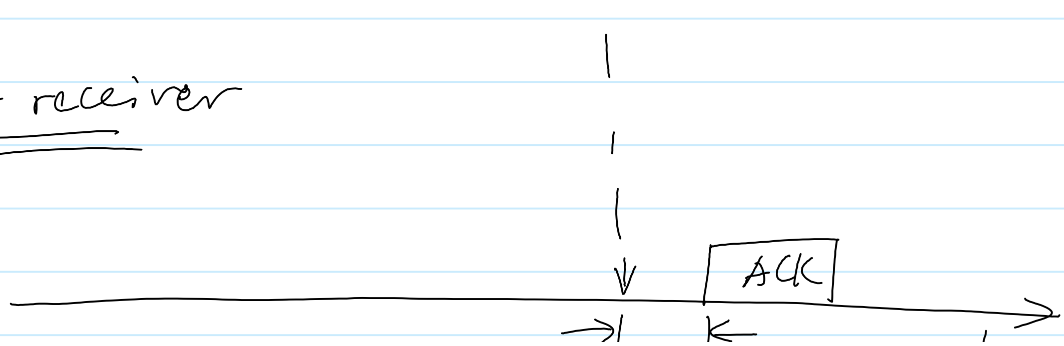
- Carrier Sensing Multiple Access
- A form of random access (in contrast to scheduled access)

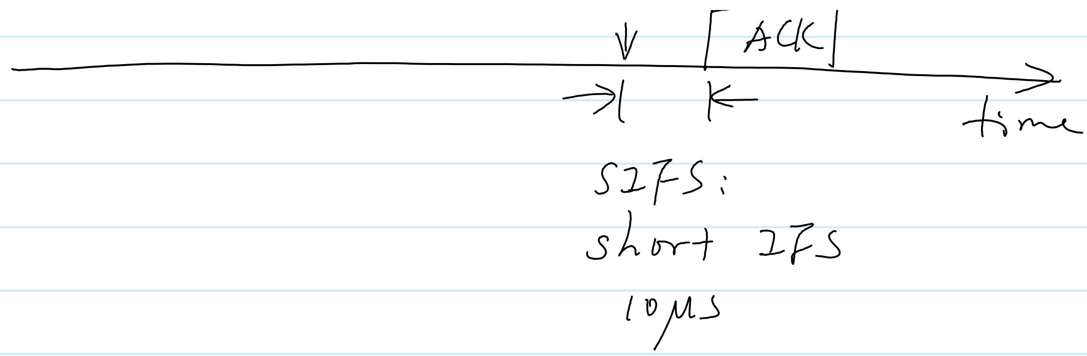
To transmit a packet/frame

DIFS: DCF Inter-frame Spacing

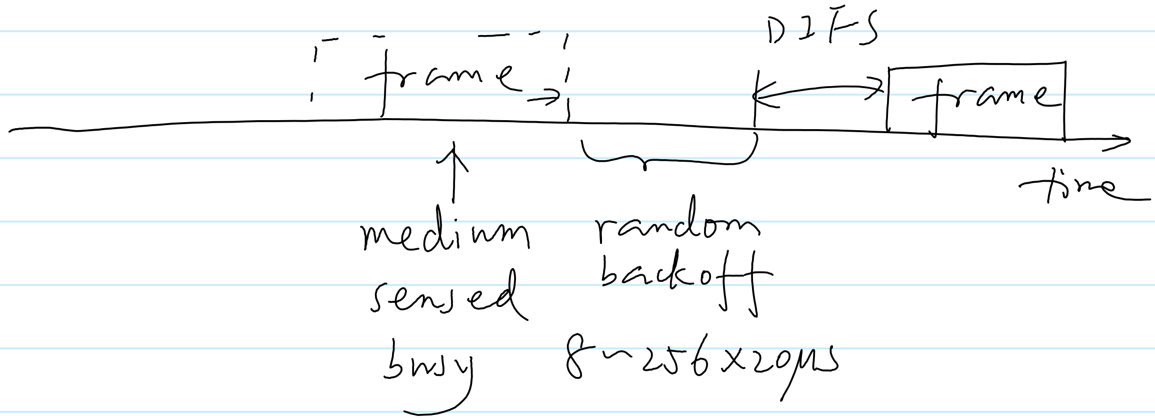


At receiver





Other transmitting node



Note: $DIFS = SIFS + 2 \times 20\mu s = 50\mu s$

$DIFS \geq SIFS + ACK$

$\Rightarrow$ give priority to ACK.

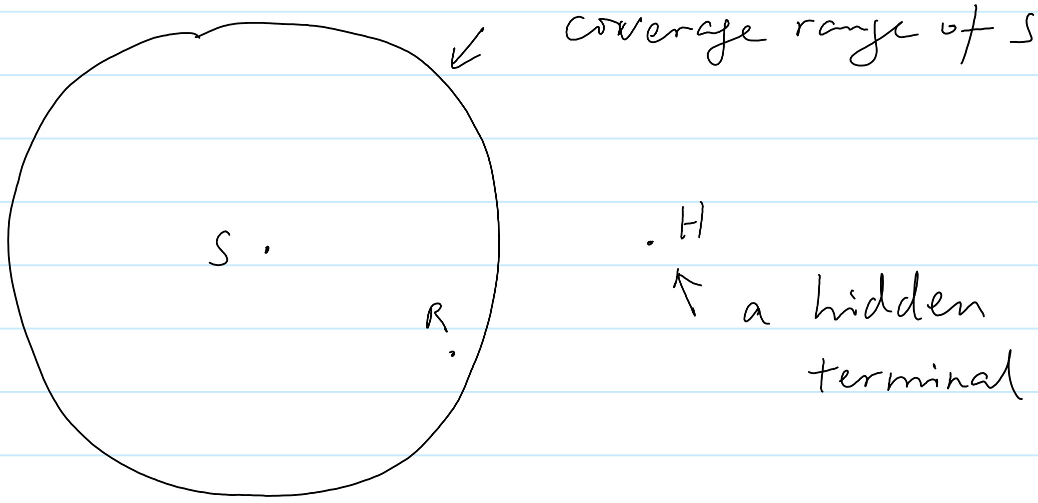
The above procedure is the same as Ethernet (a wireline random access protocol).

In ethernet, all stations can sense a busy channel.

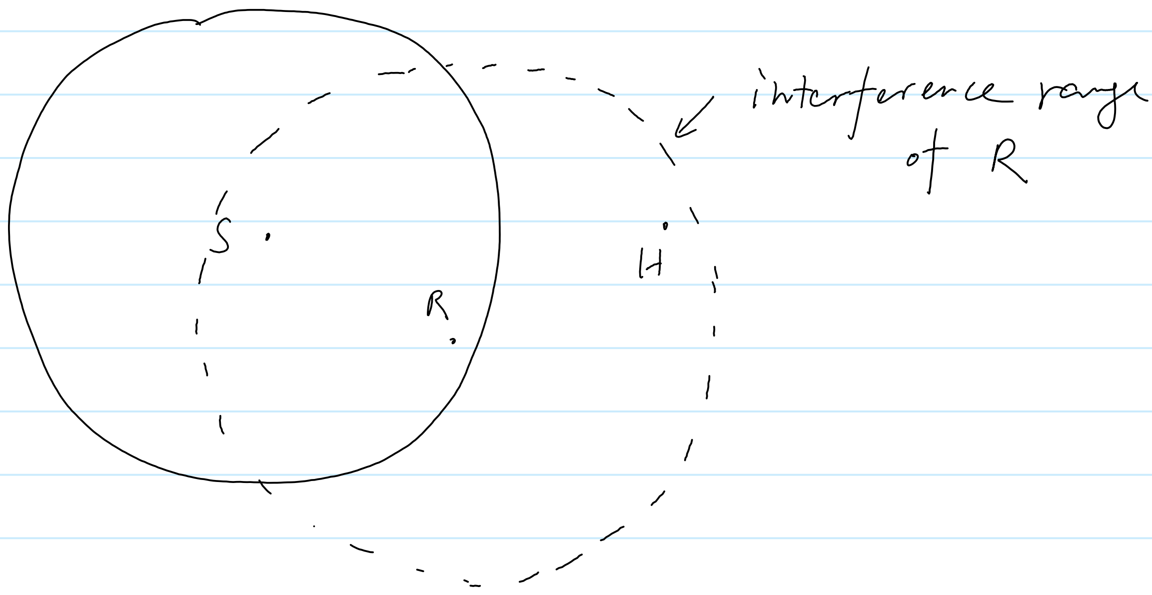
However, in WLAN, stations can only sense on-going transmission if they are close to the transmitter

⇒ hidden-terminal problem

The hidden-terminal problem



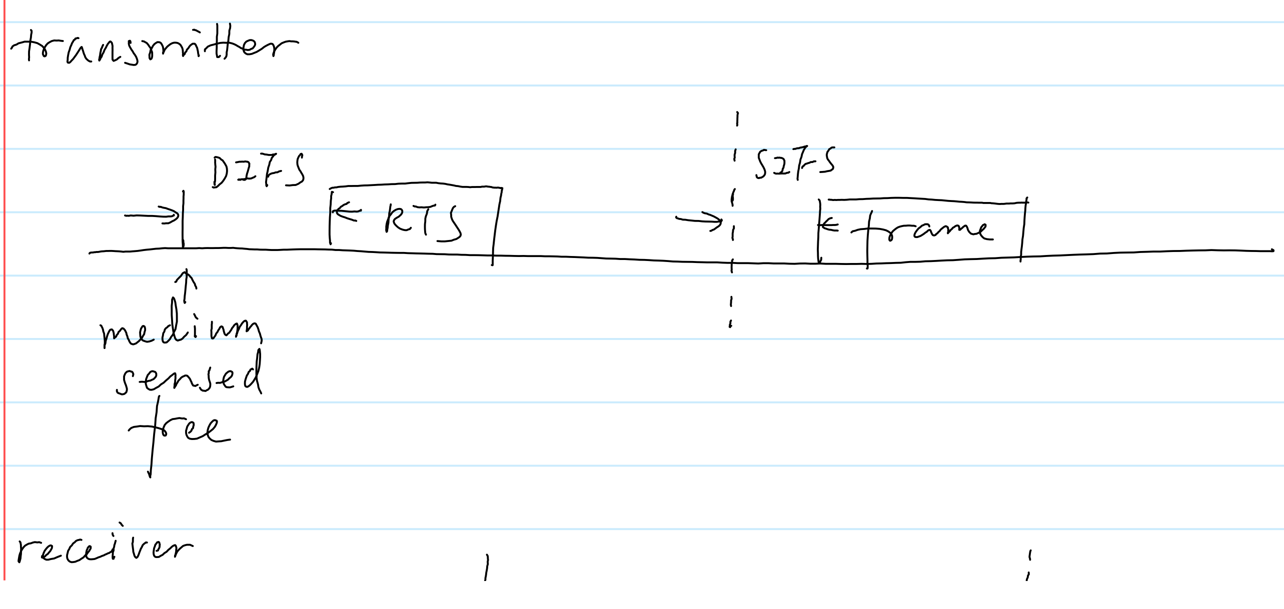
H may interfere with R but it didn't sense the transmission of S.



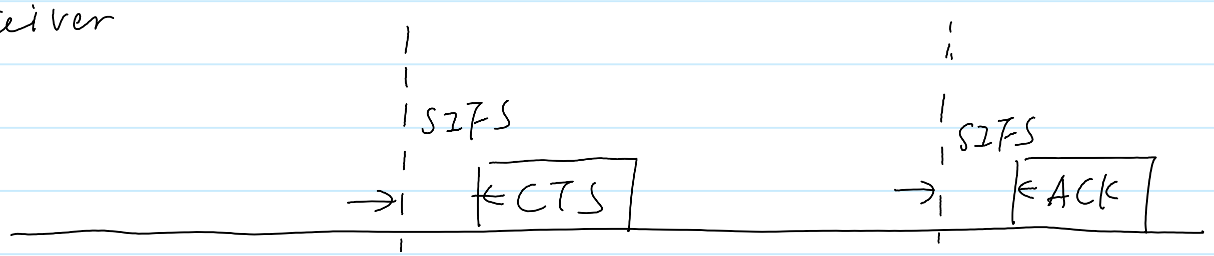
Both the transmitter & the receiver must acquire the stage.

802.11 DCF (Distributed Coordination Function)

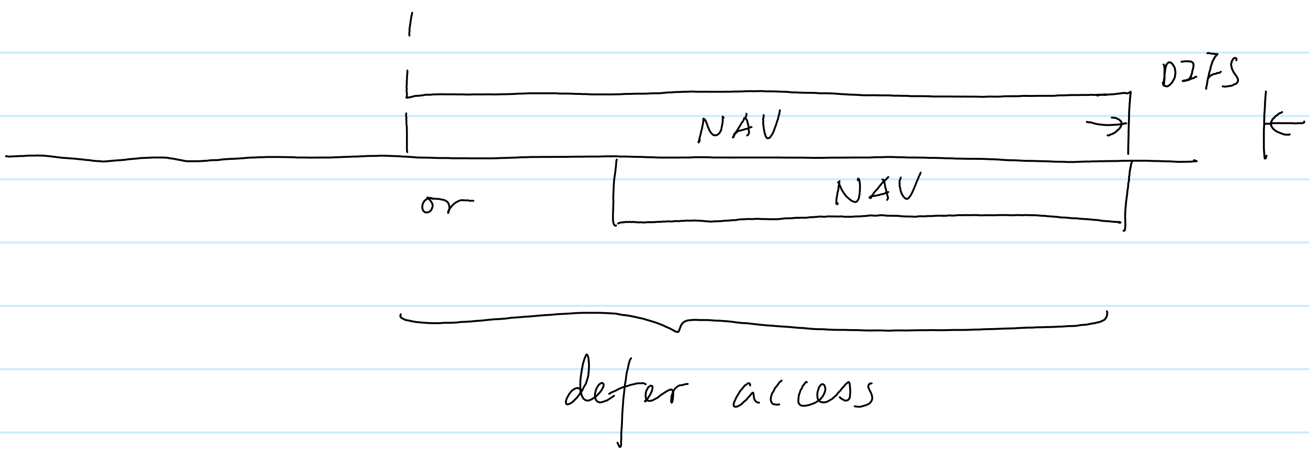
- uses CSMA/CA
  ((Carrier sense multiple access with collision avoidance)



receiver



other nodes



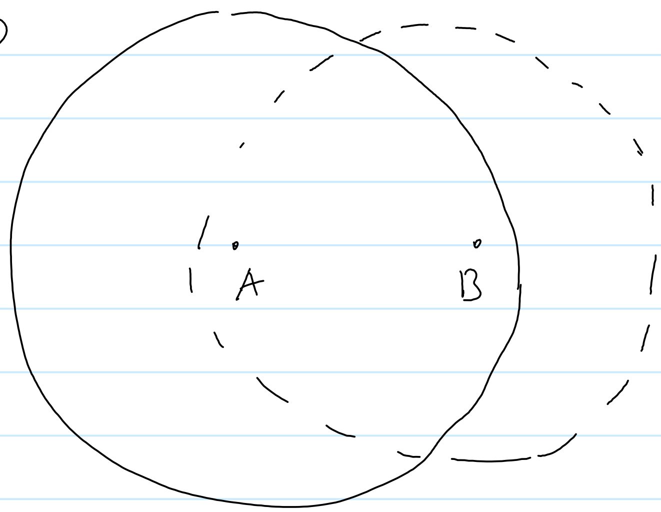
Both RTS (Request to send) & CTS (Clear to send) contains the duration (in μs) of the data transmission that follows. So other nodes can defer access up to NAV (Network allocation vector)

(Q) Is DCF always correct?

① . Collision of CTS may hinder the set up of NAV

② To ensure correct operation, the sensing relationship must be bi-directional

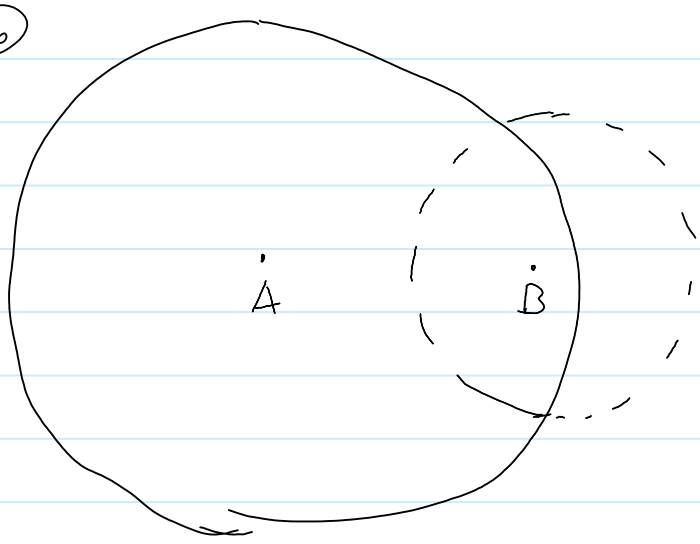
ⓐ



sensing relationship is bidirectional

If A can sense B's transmission, then B is also able to sense A's transmission

ⓑ



A may interfere with B, but cannot sense B's transmission

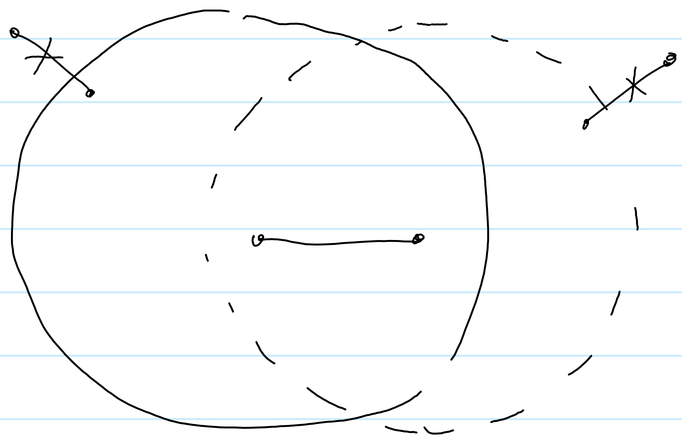
Hence, even though 802.11 allows transmitter to change power, it is required that RTS/CTS must be sent at maximum power.

Assuming that the channel gain is the same in both directions, sending RTS/CTS at constant power ensures that the interference relationship is bidirectional:

- If link AB interferes with link CD, then link CD also interferes with link AB.

Summary: The interference relationship in WLAN.

Each link interferes with links in a two-hop neighbourhood.



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Binary exp. Backoff -5min

Monday, January 21, 2008 3:07 PM

If no CTS or ACK is received at the sender, it is assumed that collision has occurred

The transmitter backs off a random time (uniformly between 0 to $W_0 - 1$) before it attempts again.

For every further collision, the range of backoff window is doubled until the maximum $2^m W_0$.

This procedure is called binary exponential backoff.

We will discuss in more detail later on.

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Frame format - 5min

Monday, January 21, 2008 3:00 PM

MAC Data

The following figure shows the general MAC Frame Format, part of the fields are only present on part of the frames as described later.

Octets:	2	2	6	6	6	2	6	0 - 2312	4
	Frame Control	Duration/ ID	Address 1	Address 2	Address 3	Sequence Control	Address 4	Frame Body	CRC

MAC Header (Frame Control through Address 4)

Frame Control Field

The Frame Control field contains the following information:

	B0–B1	B2–B3	B4–B7	B8	B9	B10	B11	B12	B13	B14	B15
	Protocol Version	Type	Subtype	To DS	From DS	More Frag	Retry	Pwr Mgt	More Data	WEP	Order
Bits:	2	2	4	1	1	1	1	1	1	1	1

P402 Fig 12.4

duration: used to set NAV

address 1: destination

address 2: source

address 3: id of the BSS (cell)

Frame control field

Type Subtype

00 management

00		management
10		data
01	1011	RTS
01	1100	CTS
01	1101	ACK

(RTS, CTS, ACK: control)

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WLAN versus cellular

Tuesday, January 22, 2008 4:30 PM

WLAN	Cellular data
- Interoperability among vendors/providers - economy of scale	- devices tied to provider
- unlicensed band	- licensed band
- low cost	- high cost
- small range / hot-spots 100 meter	- good coverage
- limited handoff/ mobility support	- good mobility support.