

Why is our WiFi so slow?

PROF. MICHAEL TSAI

2012/01/05

Outline

- **Spread Spectrum**
- **Principles of Infrastructure-based Networks**
- **Overview of 802.11 specifications**

Spread Spectrum

- **Increasing the bandwidth sometimes is good**
- **Why?**
 - Security: Make a signal difficult to detect
 - Robustness:
 - Inter-Symbol Interference Mitigation
 - Narrowband Interference Mitigation
 - Spectral efficiency: Sharing the same bandwidth
- **Invented for military use**
- **What is using it?**
 - 2G & 3G cellular network
 - 2G WLAN

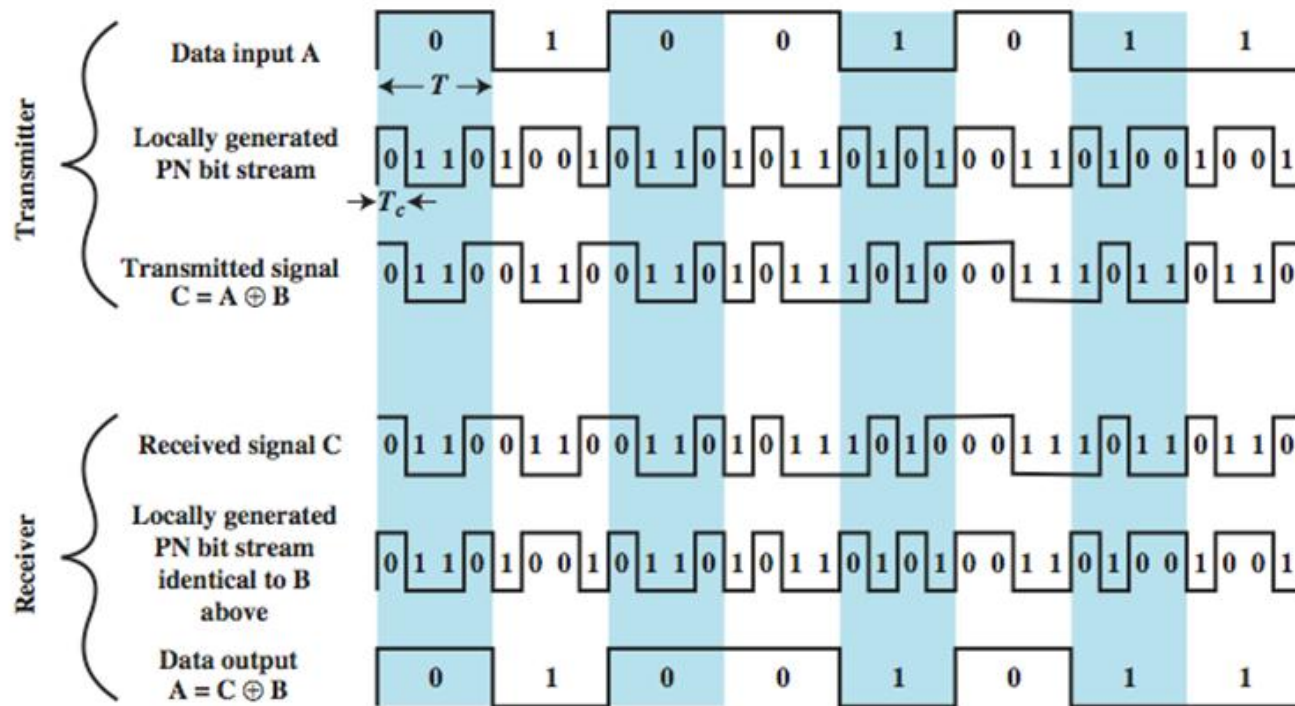
Properties

- The signal occupies a bandwidth much larger than needed for the information signal
- The spread-spectrum modulation is done using a spreading code
- De-spreading at the receiver is done by correlating (multiplying) the received signal with a synchronized copy of the spreading code

Spread spectrum

- 2 major spread spectrum techniques:
 1. Direct Sequence (DS)
 2. Frequency Hopping (FH)

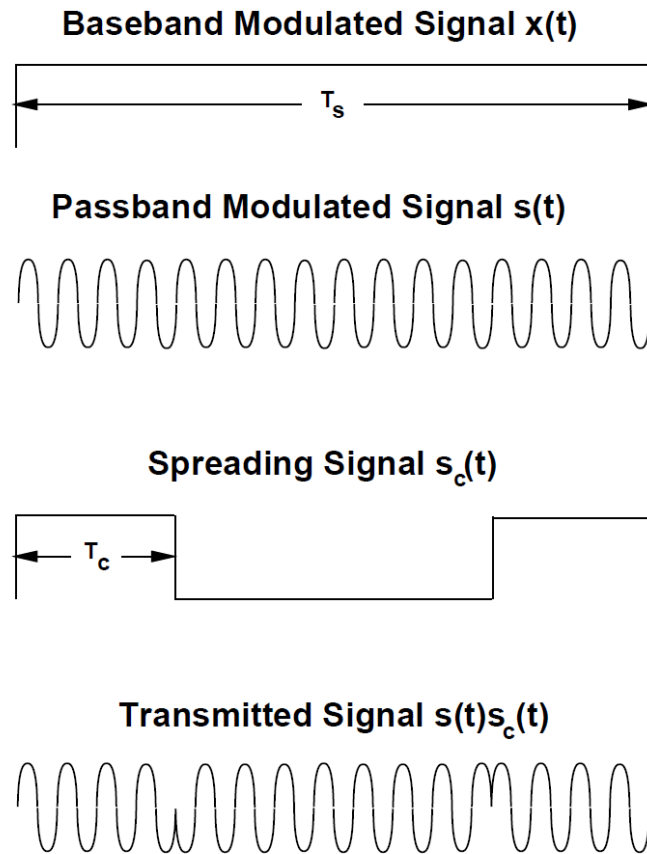
Direct Sequence Spread Spectrum (DSSS)



T_c : Chip period

T : Symbol period

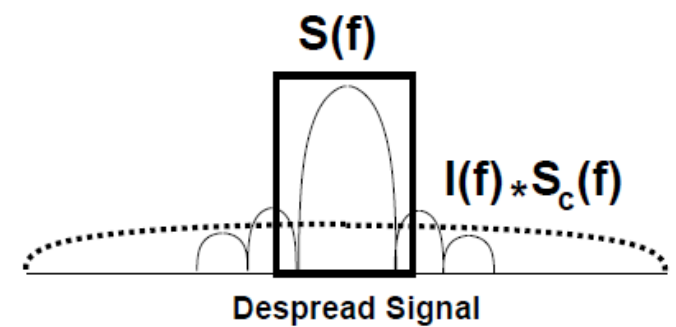
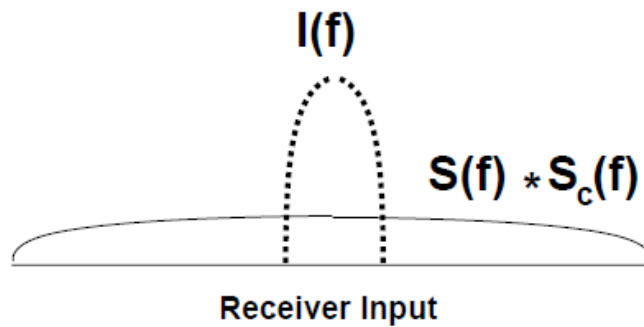
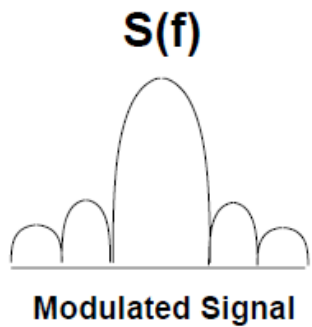
Direct Sequence Spread Spectrum (DSSS)



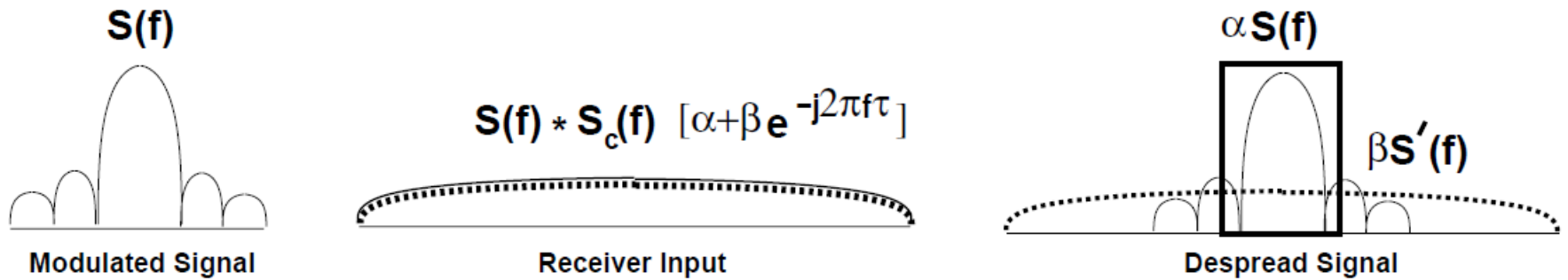
DSSS in Frequency Domain

DSSS in AWGN

DSSS: Narrowband Interference Rejection



DSSS: Inter-Symbol Interference Rejection

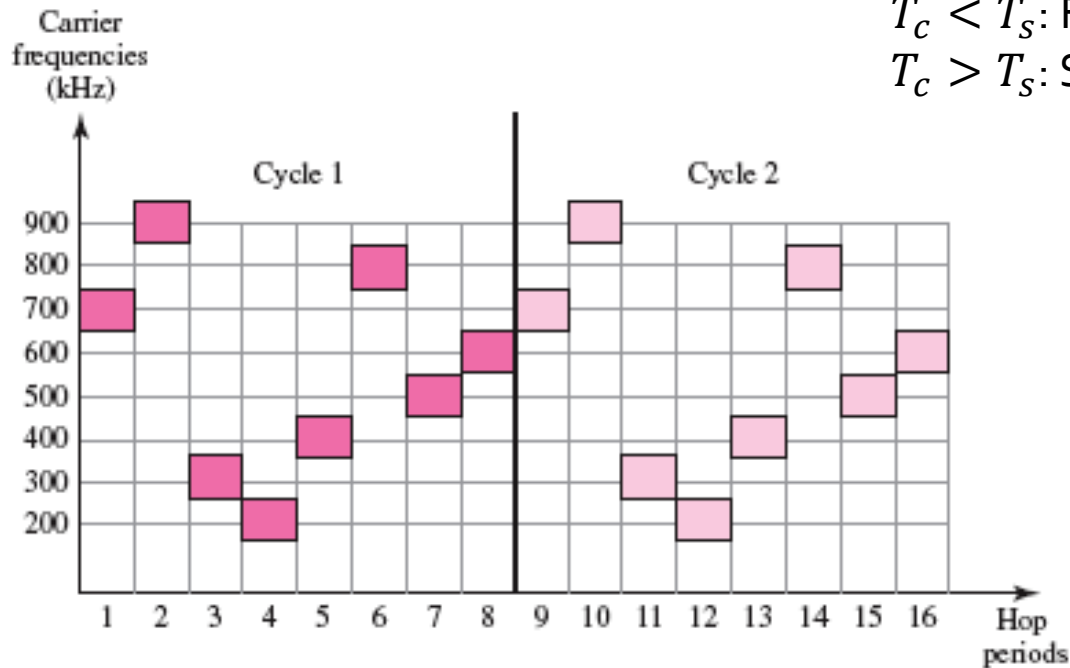


Frequency Hopping Spread Spectrum (FHSS)

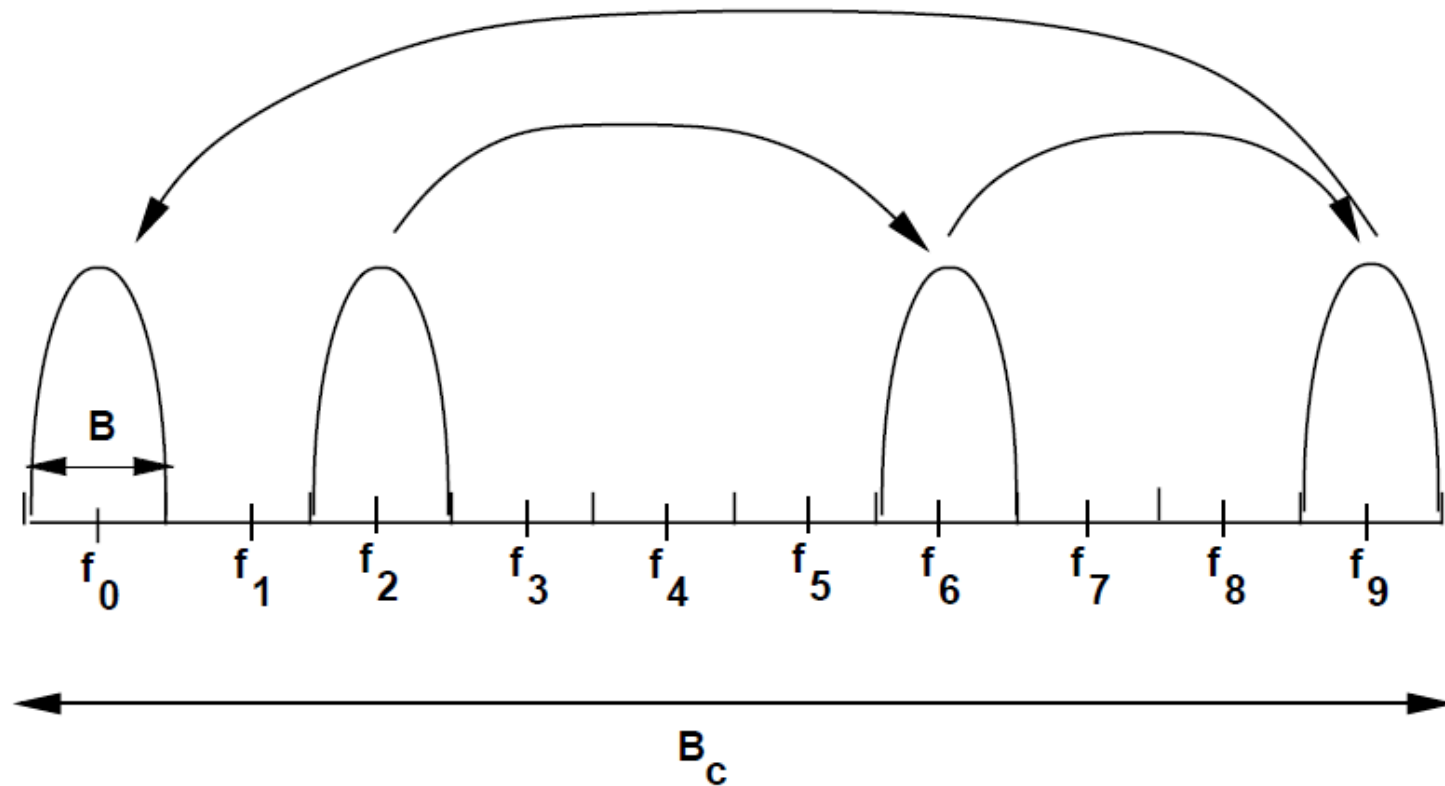
T_c : Chip duration – the time between hops

$T_c < T_s$: Fast Frequency Hopping (FFH)

$T_c > T_s$: Slow Frequency Hopping (SFH)



Frequency Hopping Spread Spectrum (FHSS)



FHSS:

Narrowband Interference Rejection

FHSS:

Inter-Symbol Interference Rejection

Multi-user:
sharing the same bandwidth

- **Orthogonal/non-orthogonal codes**
- **Synchronous/Asynchronous systems**

Infrastructure-based networks

- **The centralized “base station” or “access point” controls everything.**
- **BS can do**
 - Scheduling
 - Dynamic resource allocation
 - Power control
 - Hand-off
- **Why are infrastructure-based networks more widely used?**
 - Can allocate the network resources to meet the performance requirements
 - One hop to the BS (then one more hop to the other host) → better latency, loss rate, etc.
 - Good business model

Frequency/Channel Re-use

- Divide the area into non-overlapping cells
- Divide the channels into sets
- Each cell use a channel set
- A channel set is re-use in another cell sufficiently far away

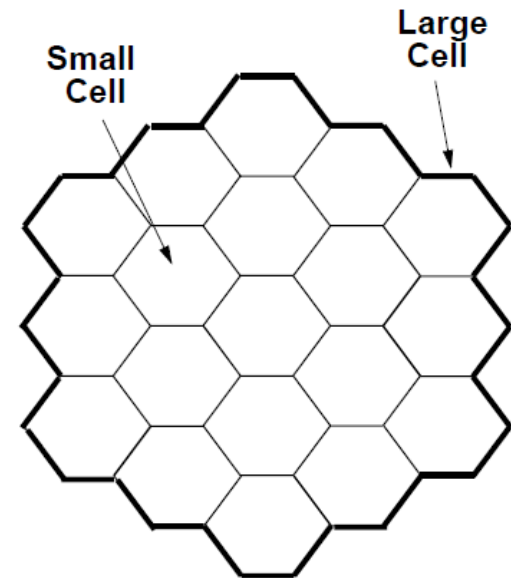
- **Parameters**
 - Distance between co-channel cells
 - Cell size

Dist. Between Co-channel Cells

- **Trade-off between**
 - Number of channels in a channel set
 - Distance between co-channel cells

Cell size

- Shrinking the cell size can increase the maximum number of total users which can be served by the system
- **Scale down everything**
 - TX power of the clients and the BS
- **What prevents us from doing so?**
 - Propagation characteristics change
 - Hand-off overhead
 - Other system overhead
 - Cost



Interference Reduction

- **Why?**
 - Because the system is interference-limited.
- **Two possible methods:**
 - Sectorization
 - FHSS

The overall system capacity limit

- If we can re-use and re-use, the maximum number of total users in the system is infinite?
- No.

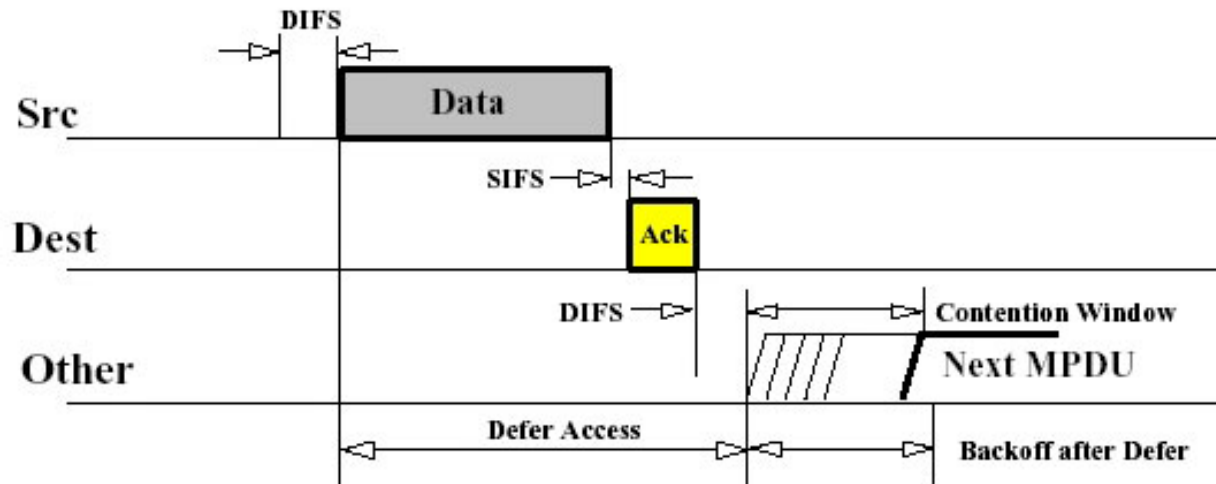
IEEE 802.11g/n

- **DSSS or OFDM is used**
 - Robustness to ISI and narrowband interference
 - Robustness to collision (if hidden-terminal applies)

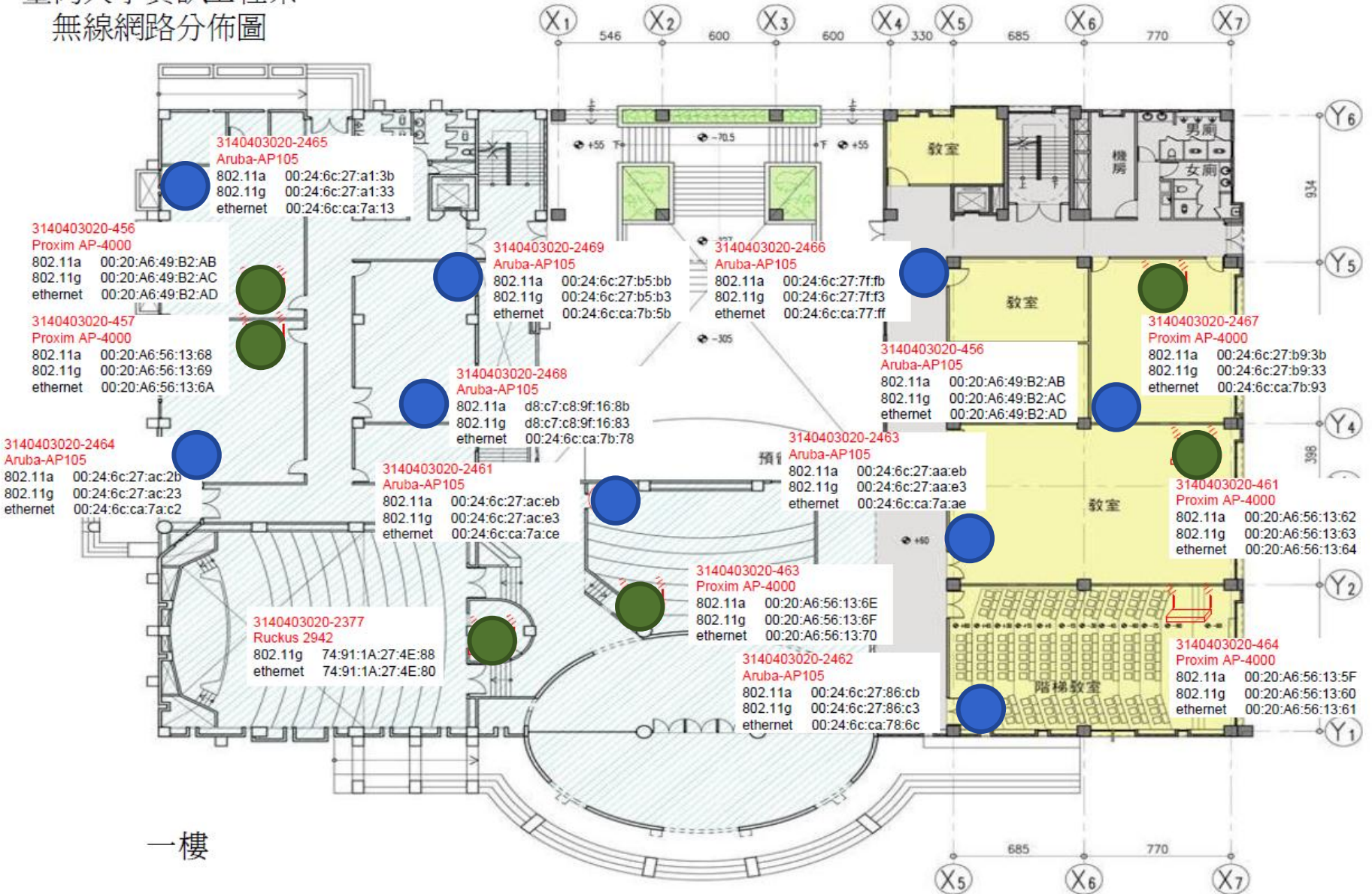
Data rate (Mbps)	Mandatory Modulation	Optional Modulation
1	DSSS	
2	DSSS	
5,5	CCK	PBCC
6	OFDM	DSSS- OFDM
9		OFDM, DSSS- OFDM
11	CCK	PBCC
12	OFDM	DSSS- OFDM
18		OFDM, DSSS- OFDM
22		PBCC
24	OFDM	DSSS- OFDM
33		PBCC
36		OFDM, DSSS- OFDM
48		OFDM, DSSS- OFDM
54		OFDM, DSSS- OFDM

DCF MAC

- **Distributed Coordination Function:**
 - Mandatory MAC in every 802.11 device
 - Contention-based MAC
-



臺灣大學資訊工程系 無線網路分佈圖



Adding more AP

- **Why?**
 - Increase the number of users we can serve
 - But TX power needs to be scale down!
- **Otherwise,**
 - Collisions
 - Back-off
 - Rate adaption algorithm chooses a lower rate

What we can do

- **Nothing we can do: only 3 channels (1, 6, 11)**
 - Co-channel interference everywhere
- **Sectorization: Ruckus AP already does that for us**
- **Make cells smaller: decrease the TX power**
 - (But only the BS's power can be configured by us)