

Chapter 2: Power Saving in IEEE 802.11

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Motivation

- Since mobile hosts are supported by battery power, saving battery as much as possible is very important.
- Power management in 802.11
 - in infrastructure network vs. ad hoc network
 - PCF vs. DCF



Introduction

- Power management modes
 - Active mode (AM)
 - Power Save mode (PS)

- Power consumption of ORiNOCO WLAN Card

Transmit mode	Receive mode	Doze mode
1400mW	900mW	50mW



Basic Idea

- AP or source hosts buffer packets for hosts in PS mode.
 - AP or sources send TIM periodically.
 - TIM = traffic indication map (a partial virtual bitmap associated with station id)
 - TIM is associated with beacon.
- Hosts in PS mode only turn on antenna when necessary.
 - Hosts in PS mode only “wake up” to monitor TIM.

TIM (Traffic Indication Map)

- 協調者有訊框要送給省電模式工作站時，不可以隨時傳送，必須先將這些訊框儲存起來而自特定的時間傳送
- 有那些工作站有訊框儲存在協調者中待送，則是紀錄在 TIM 中
- 協調者每次傳送 beacon 訊框時會將此對照表放入其中



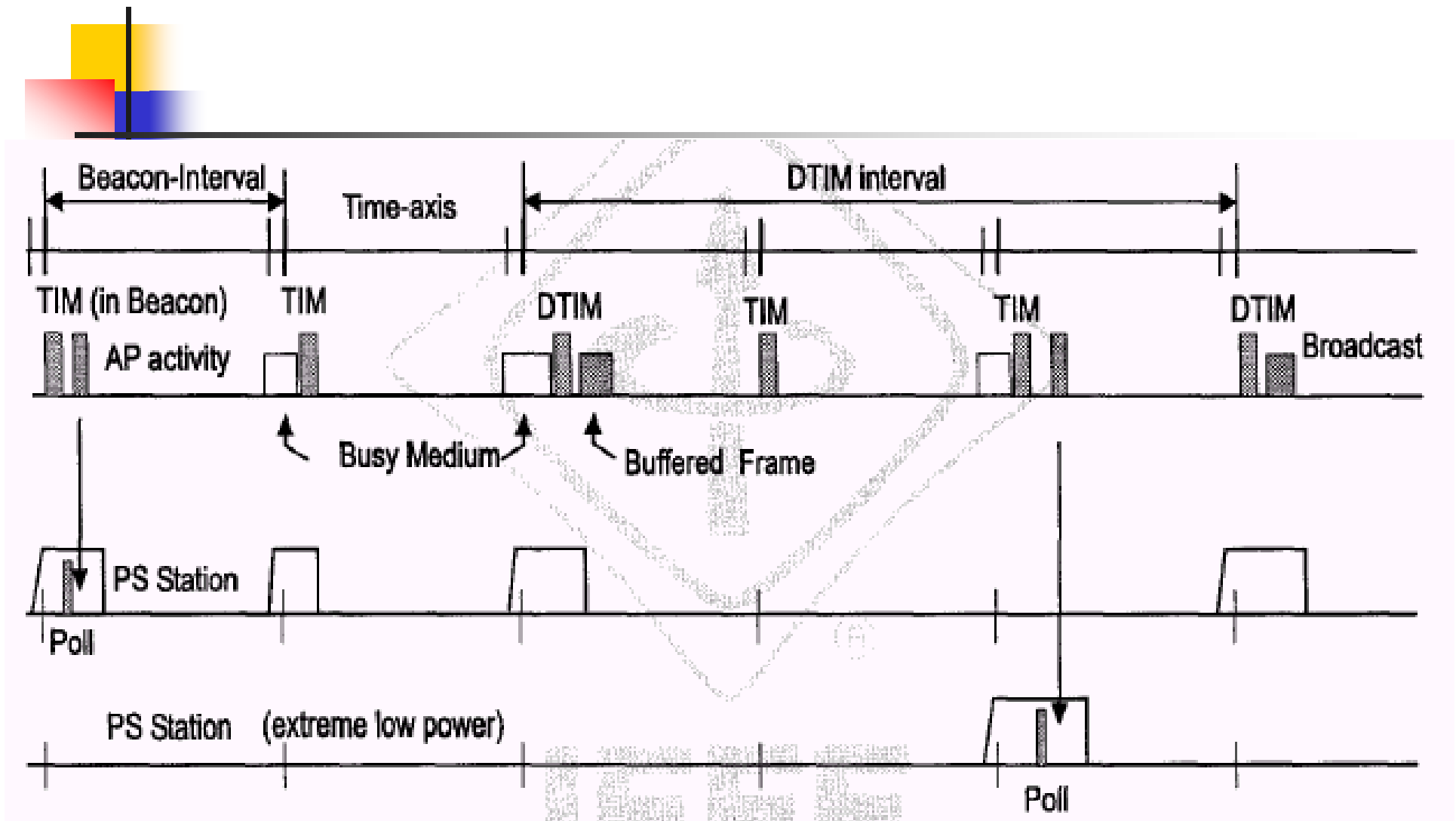
Power-saving operation

- 處於省電模式的工作站應定時的起來 (wake up) 接收 beacon 訊框
 - Time interval 是由工作站內部的 aListenInterval 參數定義
- 工作站取得 TIM 後可自行研判其是否友訊框儲存在協調者中



TIM Types

- TIM :
 - transmitted with every beacon (for Unicast)
- Delivery TIM (DTIM):
 - transmitted less frequently (every DTIM_interval)
 - for sending buffered broadcast packets
- Ad hoc TIM (ATIM):
 - transmitted in ATIM-Window by stations who want to send buffered packets
 - structured the same as TIM





PS in Infrastructure Network



PS in Infrastructure Network

- Assumptions:
 - TIM interval (beacon interval) and DTIM interval are known by all hosts
 - requires time synchronization
 - Stations in PS mode are known or can be predicted.
- Two Operational Models:
 - under DCF (contention-based)
 - under PCF (contention-free)

Synchronized in 802.11

- 讓每一個工作站都配置一個 (Timing Synchronization Function Timer, TSF Timer)
 - 希望每部工作站內的 TSF Timer 值都能相同
 - 由於 BSSs 所涵蓋的範圍可以部分或全部重疊，因此各個 BSS 的 AP (Access Point) 彼此之間應該不要同步
 - 以免所管轄的 host 在接收 beacon 訊框 發生 conflict



Under DCF (Infrastructure Mode)

- Basic assumption:
 - use CSMA/CA to access the channel
 - RTS, CTS, ACK, PS-Poll are used to overcome the hidden-terminal problem

Operations of TIM (in DCF)

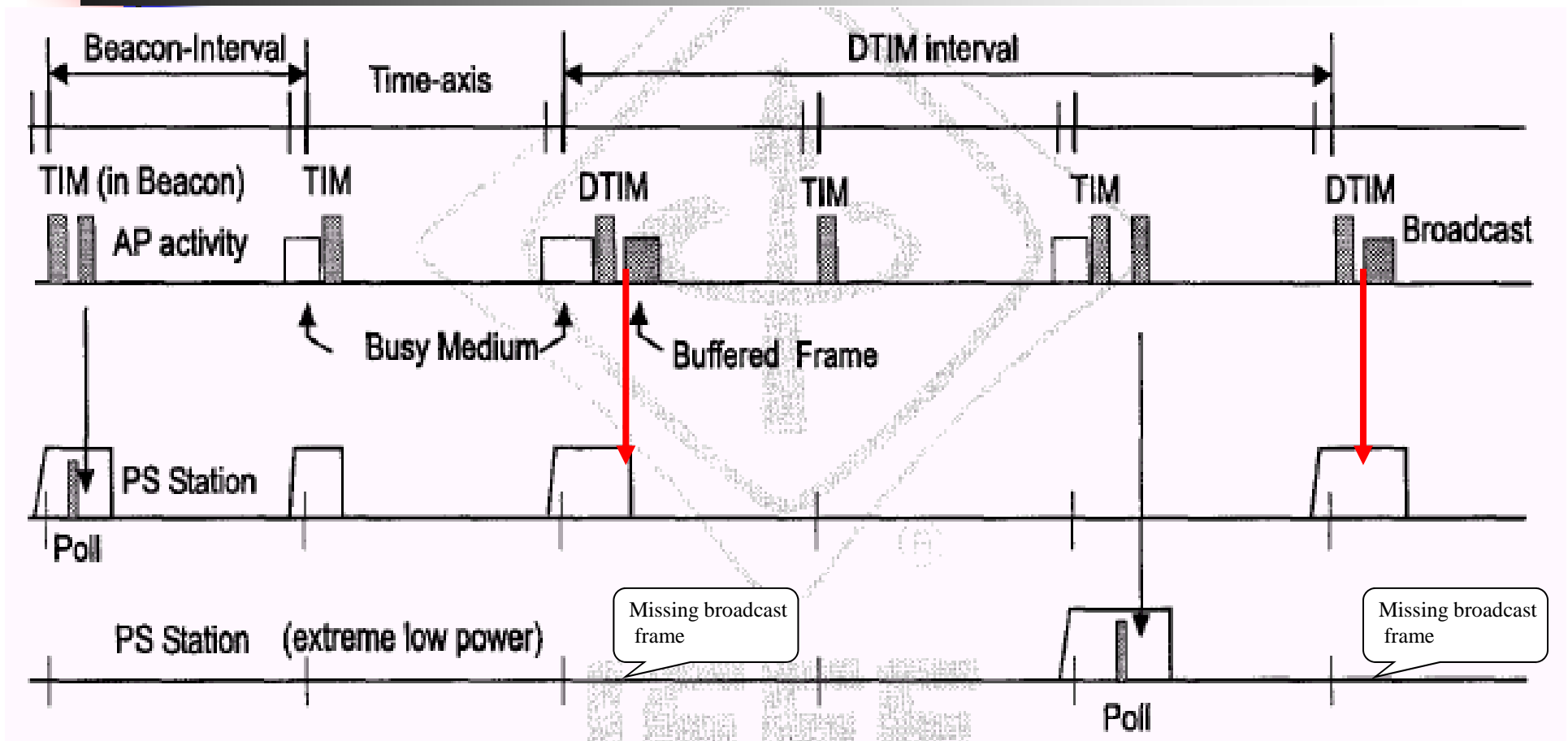
- AP periodically broadcasts beacon with TIM.
- Hosts in PS must wake up to check TIM.
 - Check for their IDs.
 - 每一個與協調者建立連結關係的host, 都會分配一個 station ID, SID
 - If found having packets buffered in AP, send **PS-Poll** to AP (by contention?).
 - 一個 PS-Poll 針對一筆訊框
 - Host 如果在 TIM 中發現還有其他工作站的訊框也同時儲存在協調者處, 則不能立刻傳送 PS-Poll 訊框, 否則其他工作站也會做相同動作, 而造成 PS-Poll 衝撞
 - 延遲一段時間再傳送 PS-Poll
 - Else, go back to PS mode.



Cont.

- AP replies PS-poll with ACK.
 - The receiver must remain in active mode until it receives the packet.
- AP uses CSMA/CA to transmit to stations.

An Illustration Example



When to wake up ?

- 處於省電的工作站要不要醒來, 或在何時醒來接收 TIM (DTIM) 是其本身的問題
- If each time to wake up, host can receive all frames (including broadcast and multicast frame), but it is not very power-saving.
- Otherwise, if it waits for a longer time to wake up, it is very power-saving but possibly misses broadcast/multicast frames.



Operations of DTIM (DCF)

- All stations need be in active mode when AP broadcasts DTIM.
- Immediately after DTIM, AP sends out the broadcast/multicast packets to all hosts.
 - Broadcast/multicast packets will not be ACKed by the receivers.
- In DTIM, the broadcast packets are unreliable.



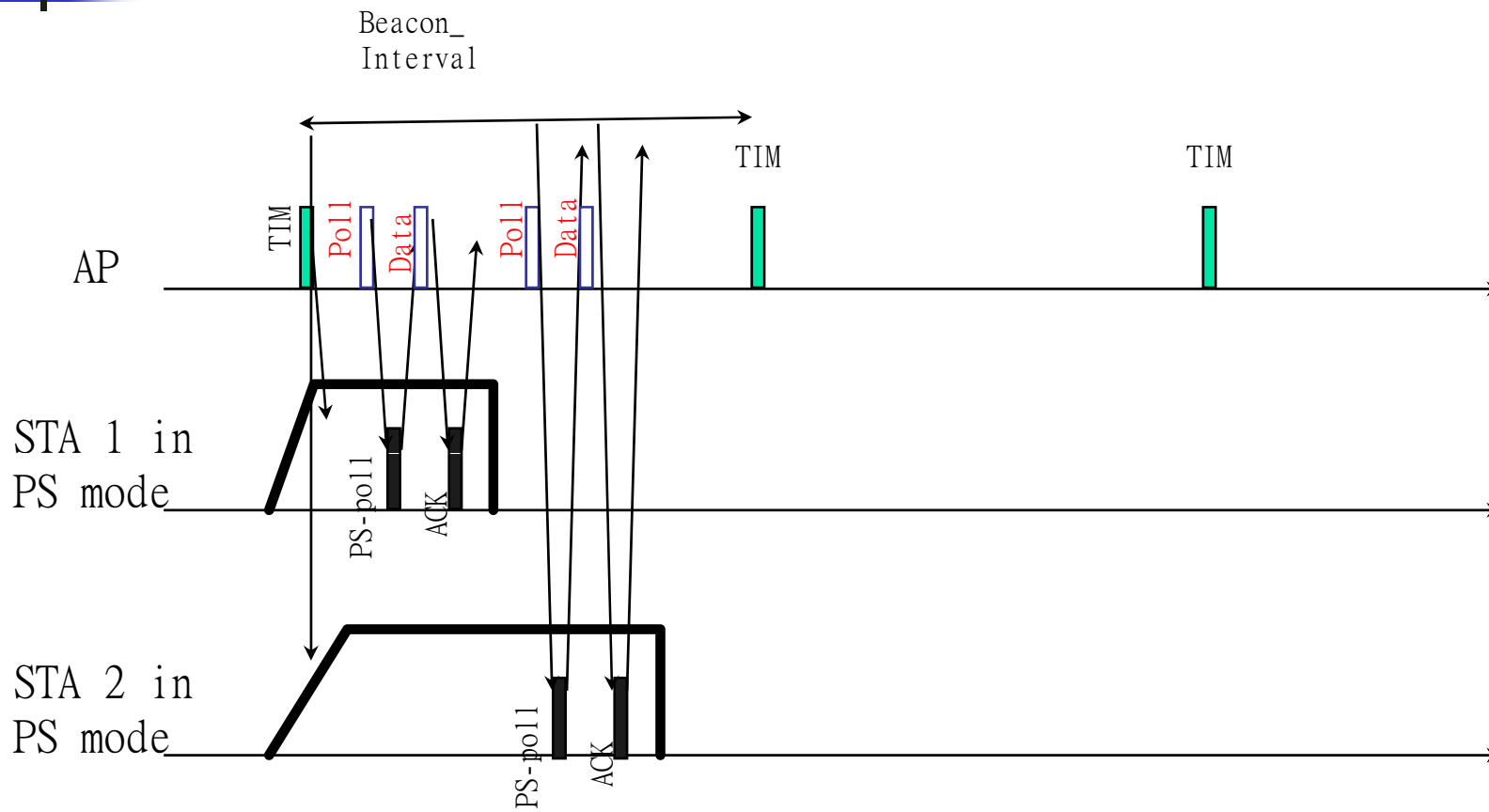
Under PCF (Infrastructure Mode)

- Basic Assumption:
 - Point coordinator uses CF-Polling to access the channel.
 - AP only maintains the CF-Pollable stations.

Operations of TIM (PCF)

- AP broadcasts beacon with TIM.
- Hosts in PS mode checks TIM for their IDs.
 - If there are buffered packets in AP, the host **must remain in Active Mode until being polled**.
 - O/w, the station goes back to PS mode.
- Then AP polls those PS stations.
- When being polled, the station (in PS mode) sends PS-Poll to AP.
 - Then AP sends buffered packets to the station.
 - (See next page.)
- **AP must poll stations in PS mode first.**

Example

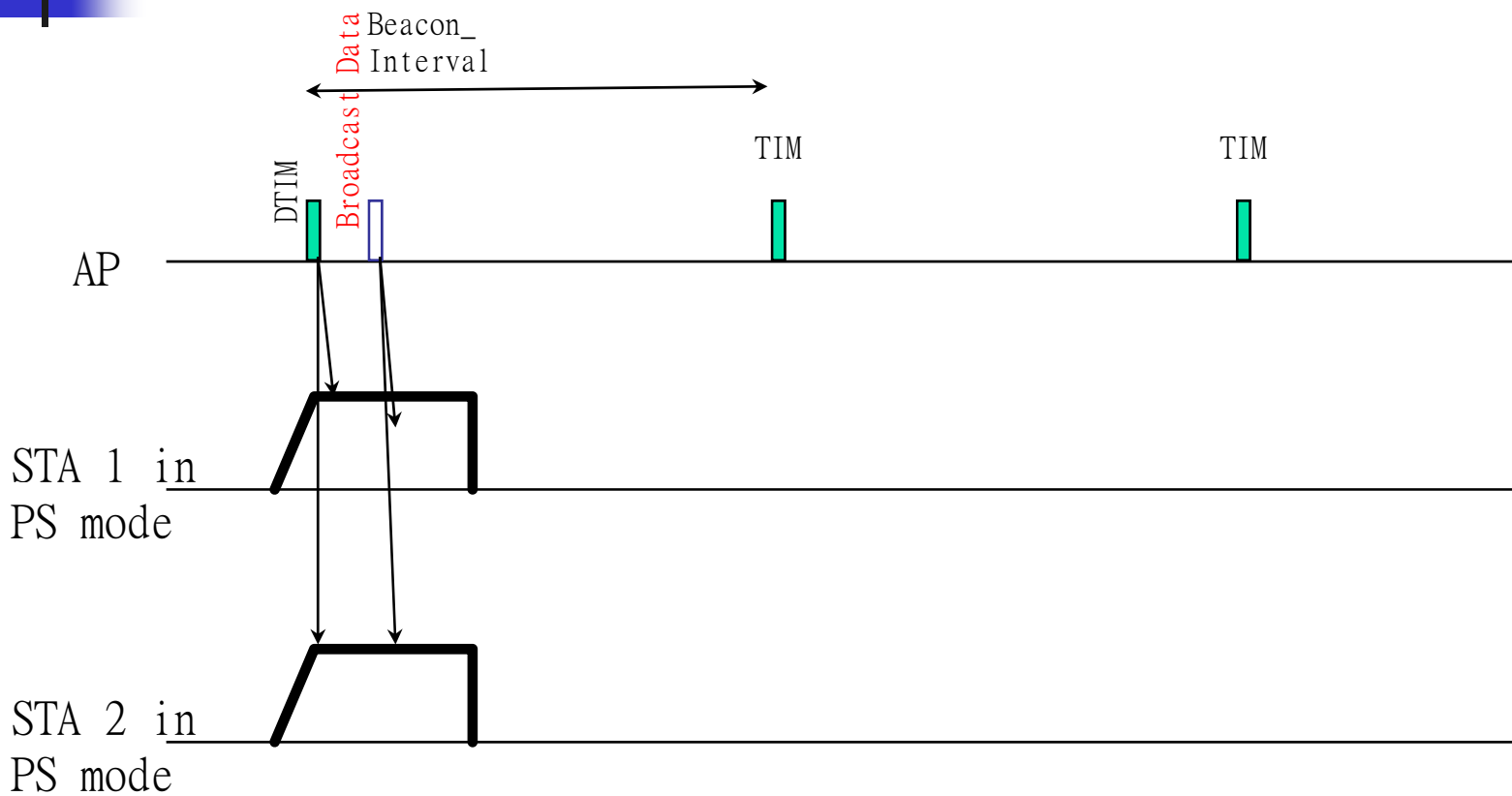




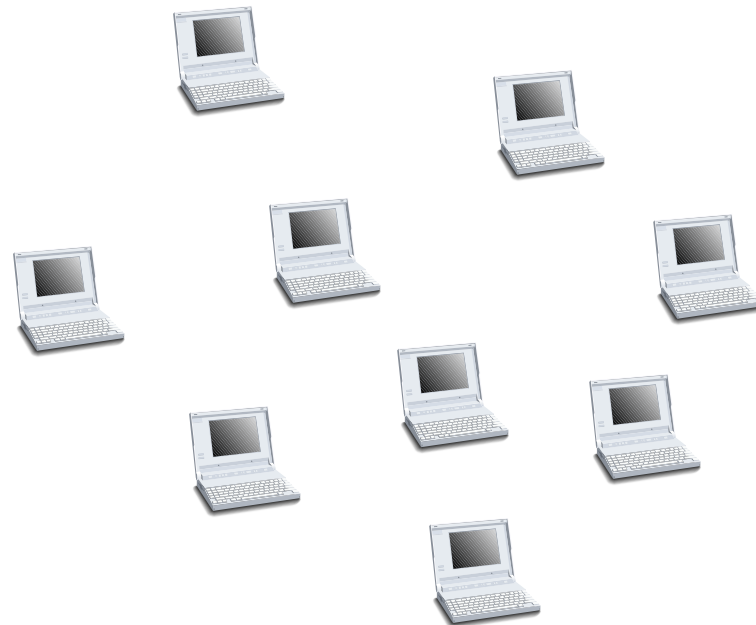
Operations of DTIM (PCF)

- All CF-pollable stations need be in Active Mode when AP broadcasts DTIM.
- Immediately after DTIM, AP sends out the buffered broadcast/multicast packets.

Example



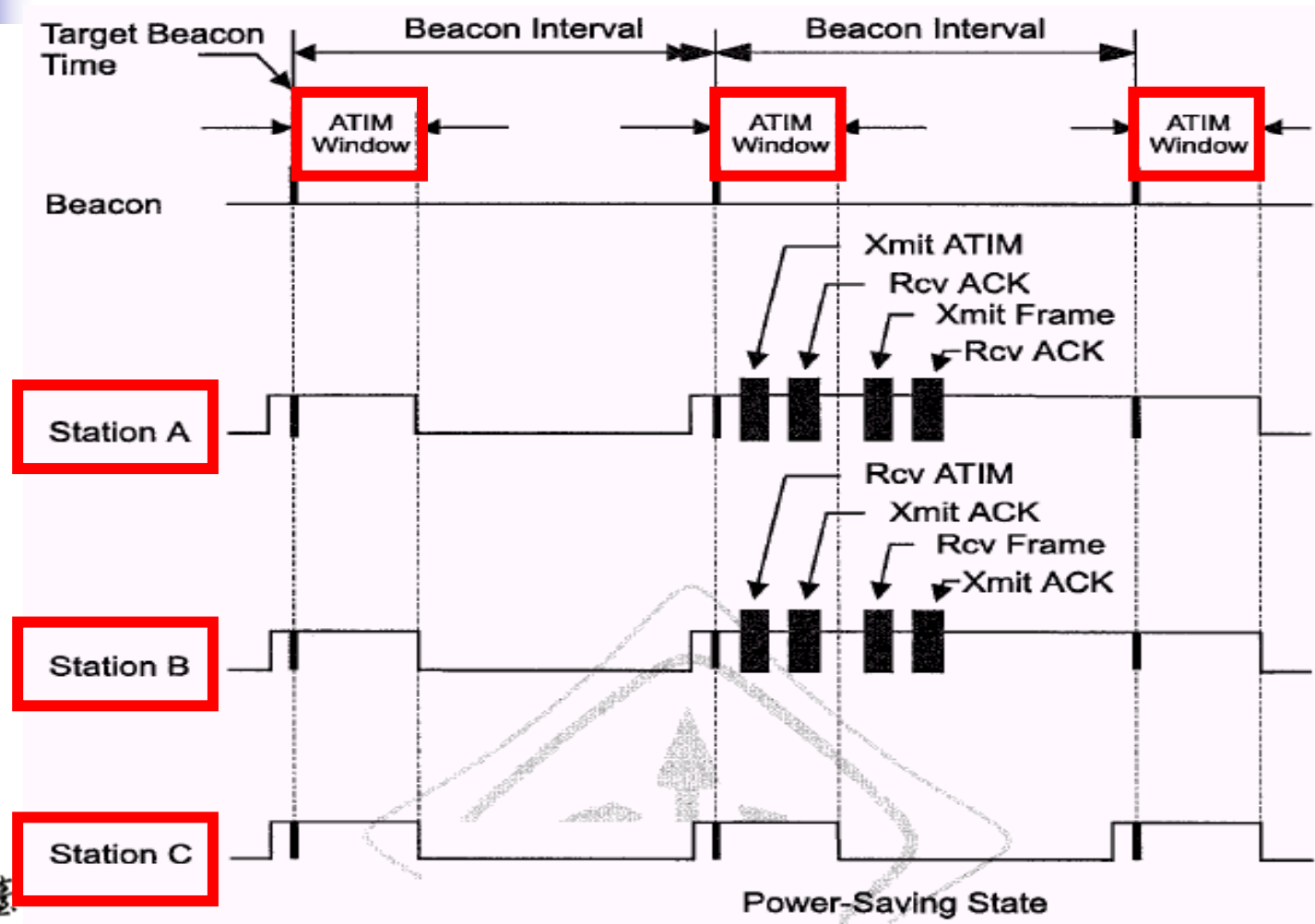
PS in Ad Hoc Mode (without base station)

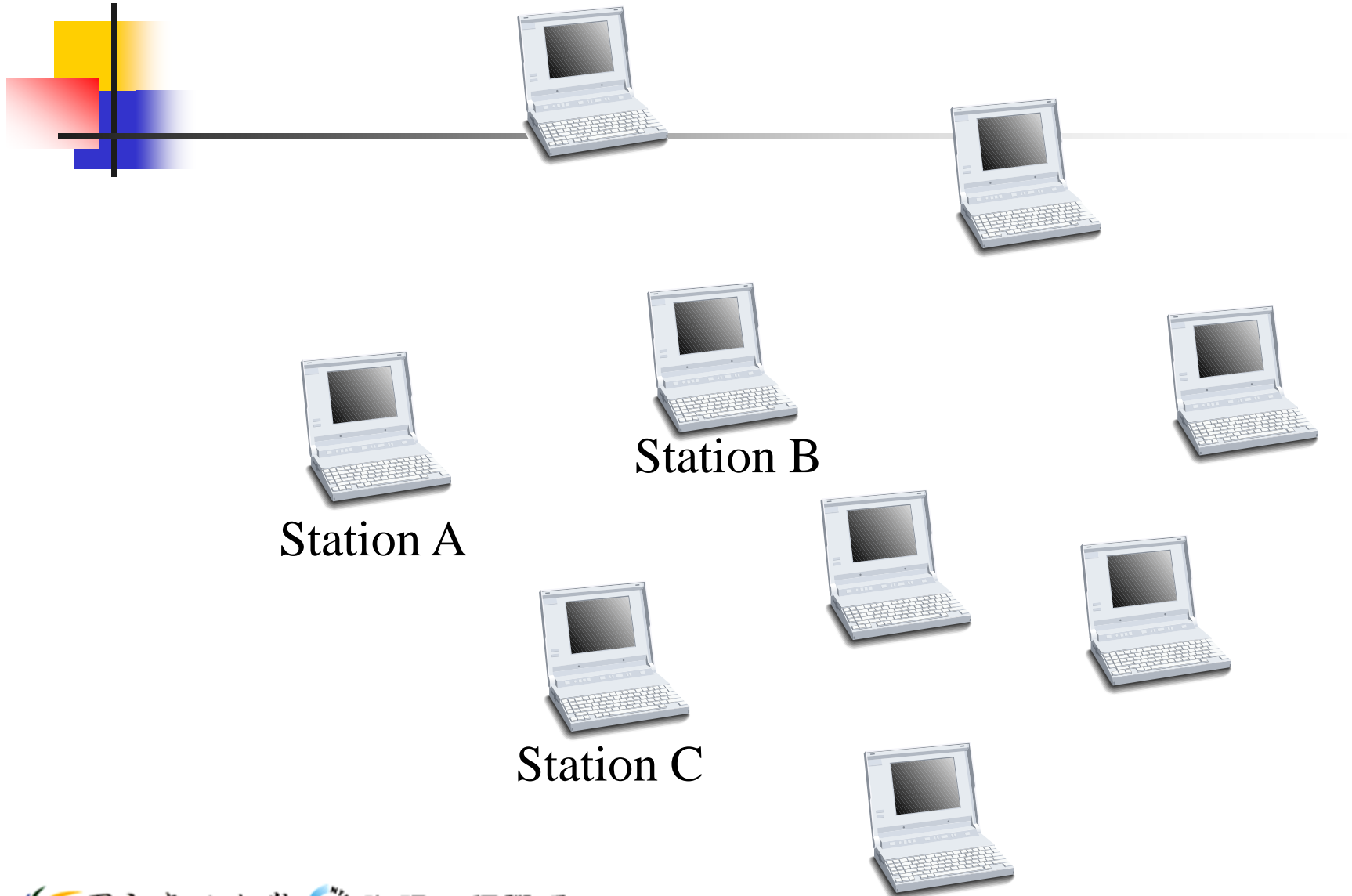


PS in Ad Hoc Mode

- Ad hoc TIM (ATIM):
 - transmitted in ATIM-Window by stations who want to send buffered packets
 - structured the same as TIM
- Assumptions:
 - ATIM interval (beacon interval) & ATIM window are known by all hosts
 - Each station **predicts** which stations are in PS mode.
 - The network is fully connected, (single-hop network ?)
- Basic Method:
 - CSMA/CA is used to access the channel.
 - RTS, CTS, ACK, PS-Poll are used to overcome hidden terminal.

Example







Operations of ATIM

- All stations should be in active mode during ATIM window.
- The station which completes its backoff procedure **broadcasts a beacon**.
 - Sending beacon is based on contention.
 - **Any beacon starts the ATIM window.**
 - Once a beacon is heard, the rest beacons are inhibited.



Cont.

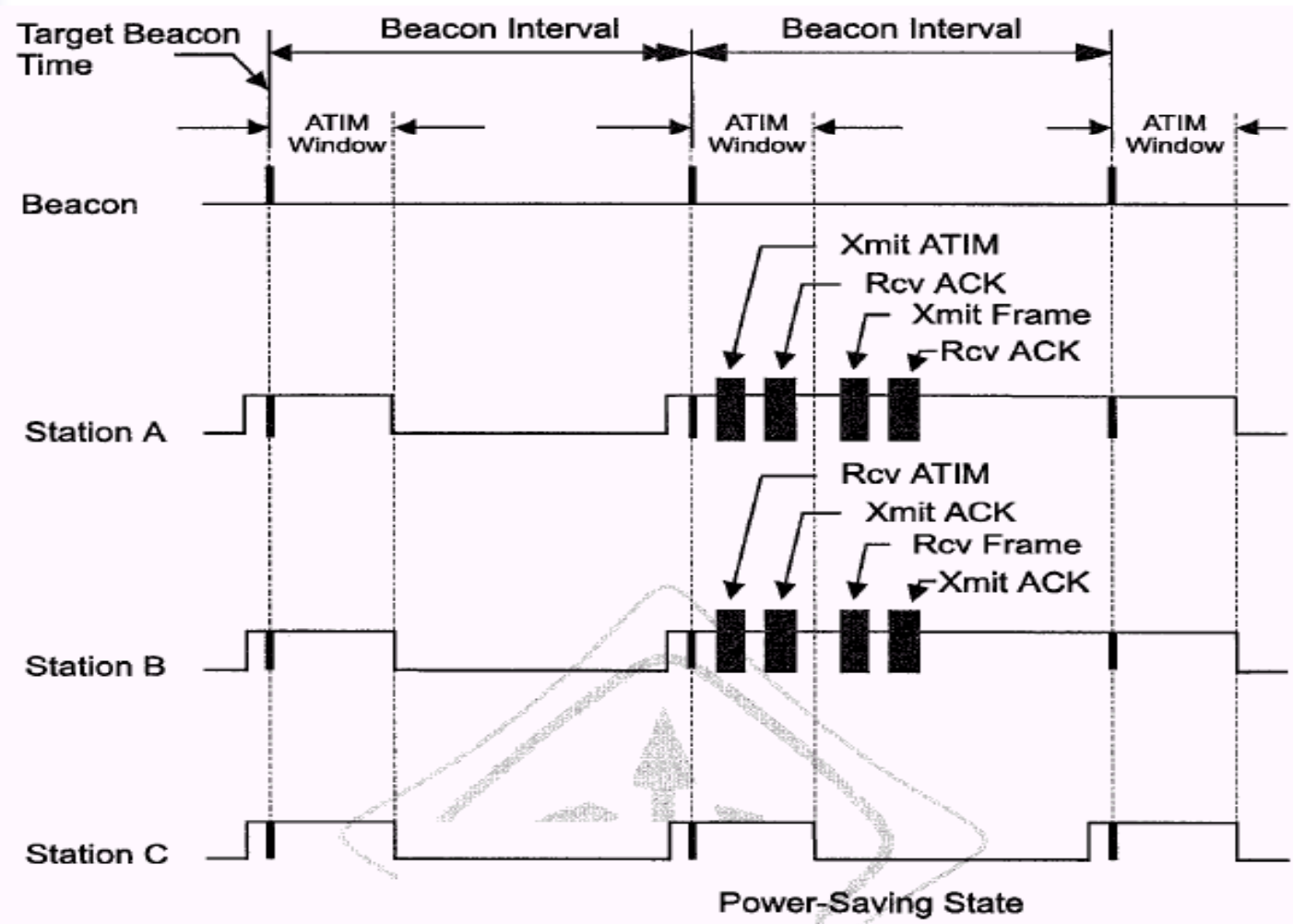
- In ATIM window, each source station having buffered packets to be sent contends to send out its ATIM.
 - If a host finds it is in the ATIM name list,
 - send an ACK to the sender.
 - remain in the ACTIVE mode throughout the beacon interval.
 - If the host is not in the name list,
 - it can go back to the PS mode.



Cont.

- After ATIM window,
 - all stations use CSMA/CA to send the buffered packets
 - note: data packet >> ATIM control frames
 - So the control frames go first, followed by data frames.
 - only those hosts who have ACKed the ATIM have such opportunity.

ATIM Example





PS Summary

- PS status:
 - In infrastructure network, stations must inform the AP on entering PS mode.
 - In ad hoc network, stations tell which stations are in PS mode by **guessing**.
 - power management field, history, etc.
- In DTIM, the broadcast packets are unreliable.
- For stations in ad hoc network, beacon is broadcast with CSMA/CA.
 - During ATIM_window, ATIM and ACK should be given higher priority.



Homework #2:

- How to consider the power management problem for multi-hop MANETs (does not fully connected) ?
 - "Power-Saving Protocols for IEEE 802.11-Based Multi-Hop Ad Hoc Networks," **IEEE INFOCOM 2002.**