Chapter 2:
Power Saving in IEEE802.11

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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.

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TIM (<u>T</u>raffic <u>I</u>ndication <u>M</u>ap)

- 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
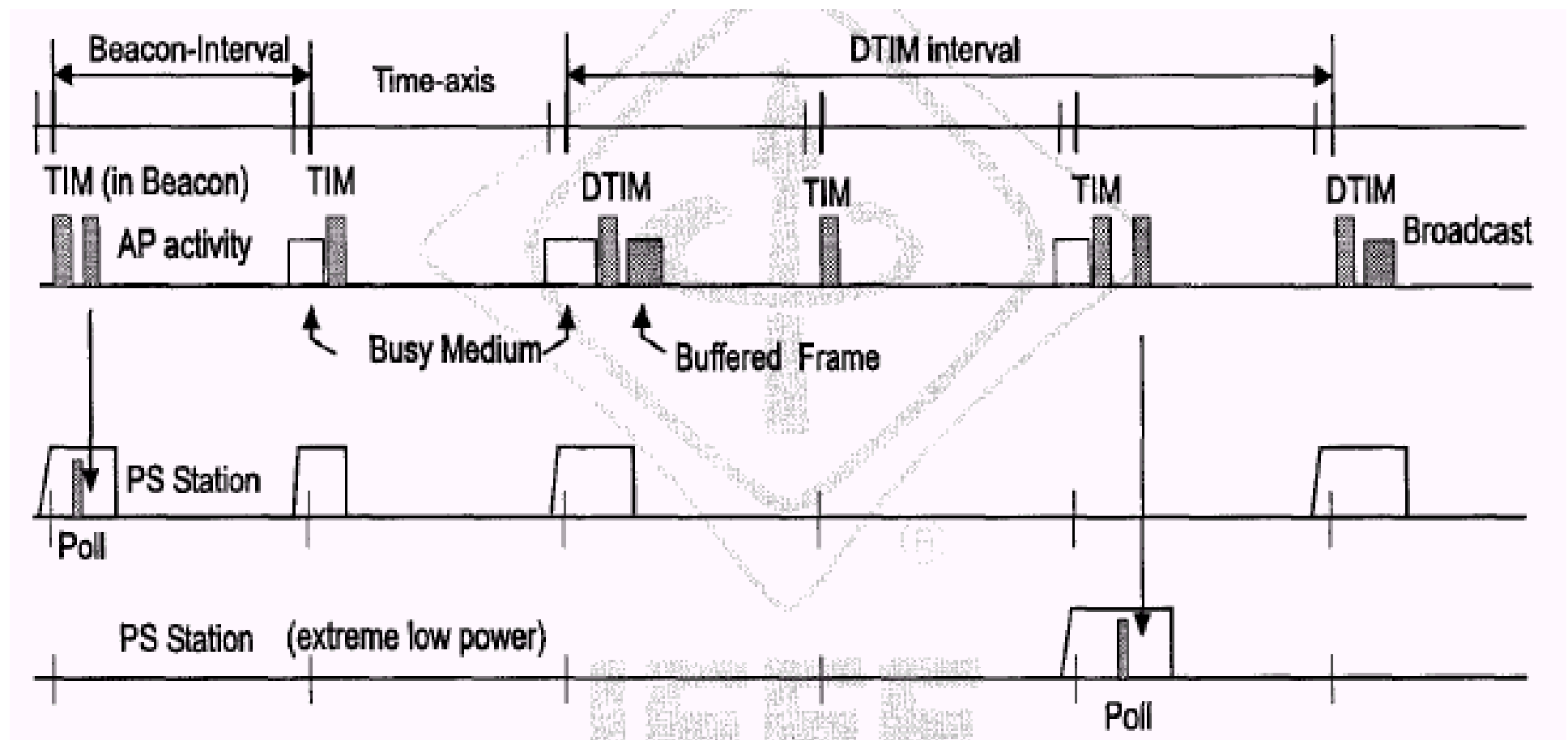- 工作站取得 TIM 後可自行研判其是否友訊框儲存在協調者中

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

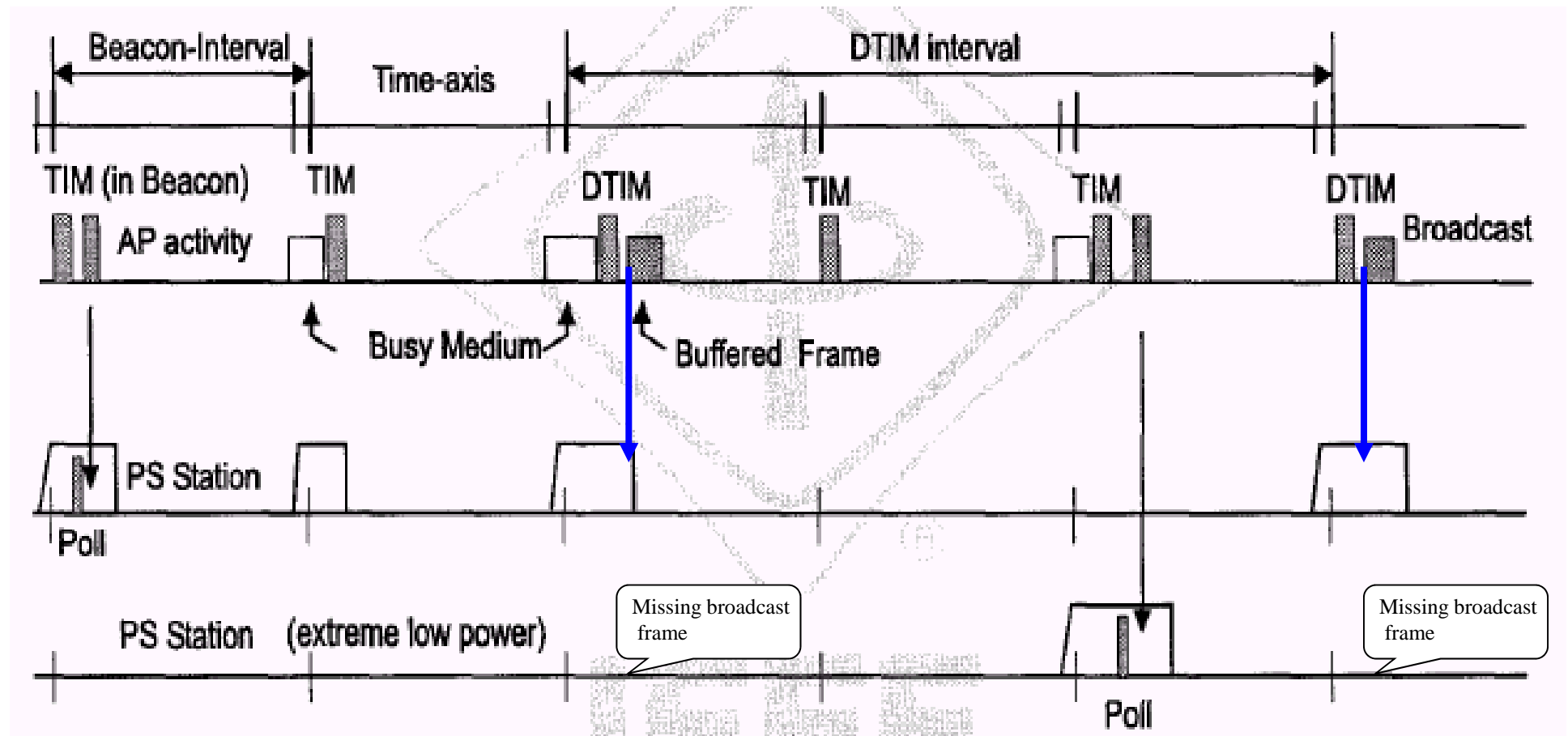 - RTS, CTS, ACK, PS-Poll are used to overcome the hidden-terminal problem

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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/mutlicast 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.**
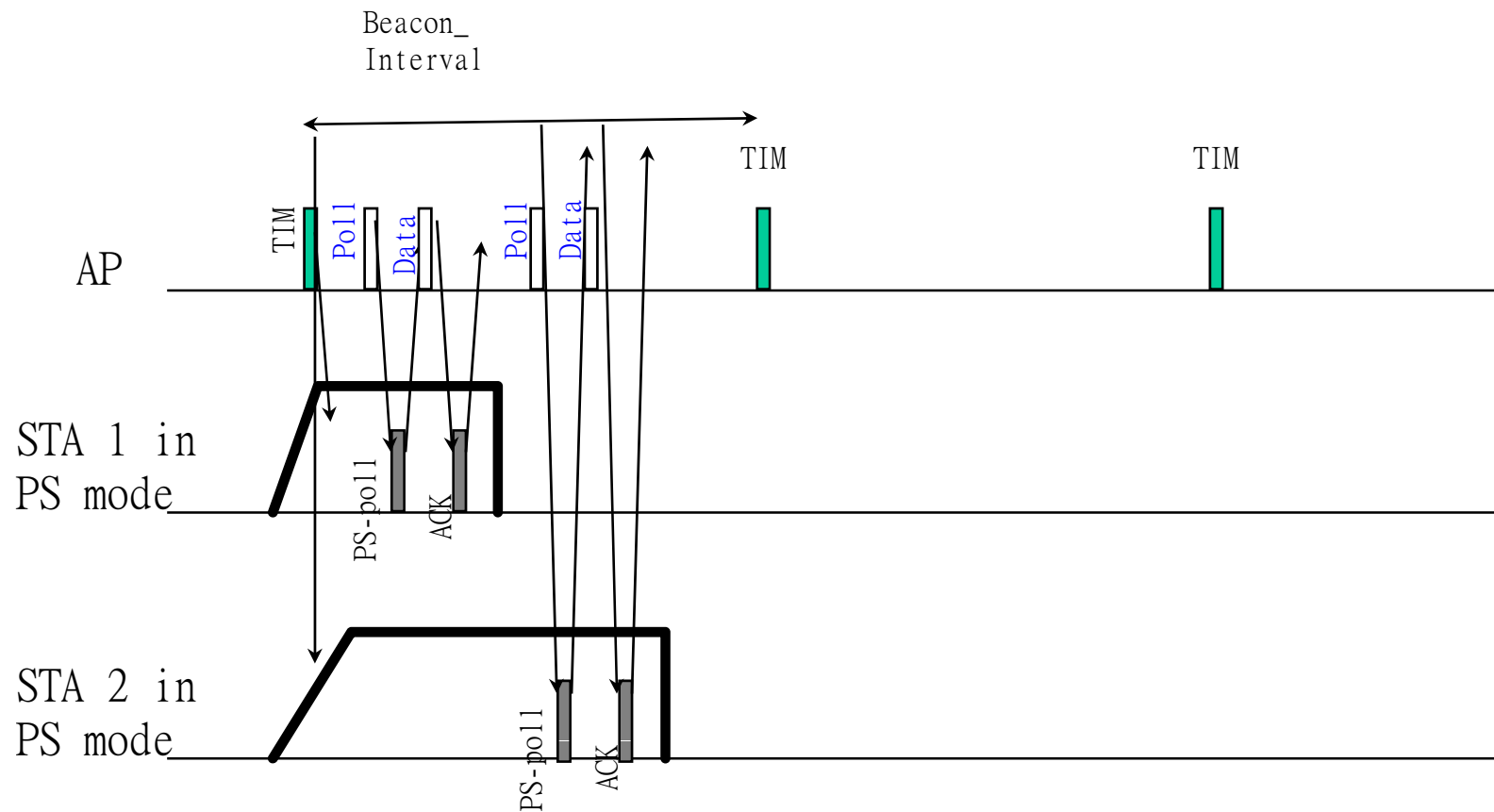
Under PCF (Infrastructure Mode)

■ 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.)
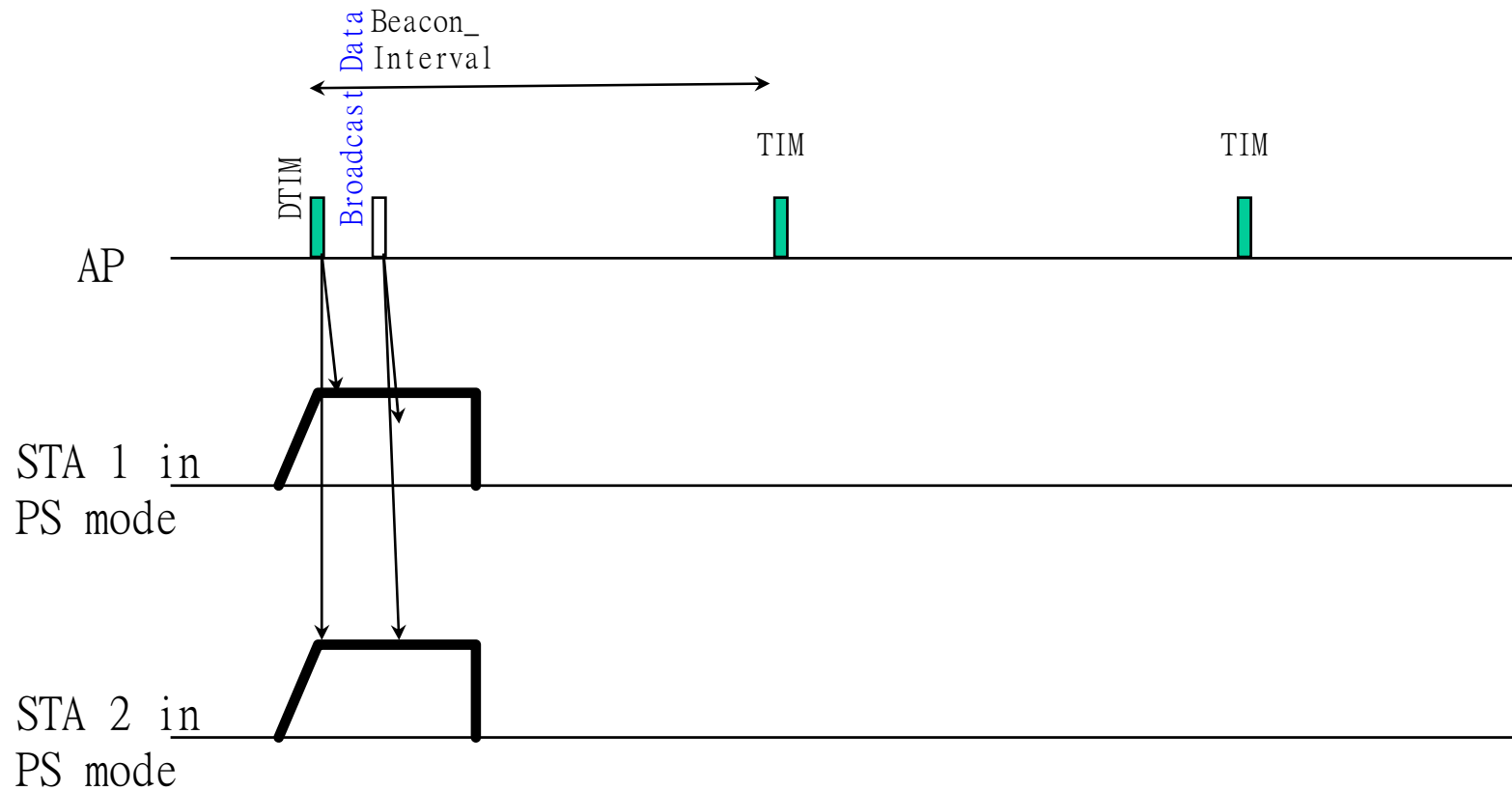- **AP must poll stations in PS mode first.**
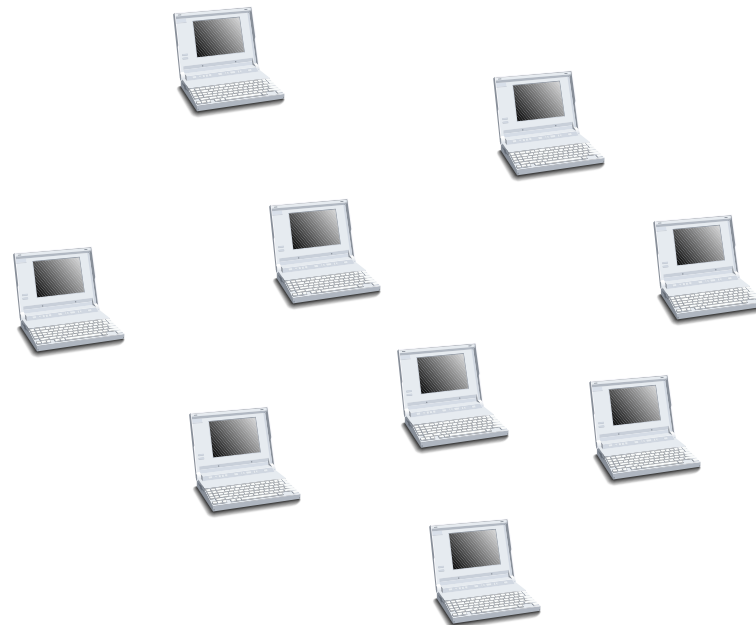
Example

Operations of DTIM (PCF)

- All CF-pollable stations need be in Active Mode when AP broadcasts DTIM.

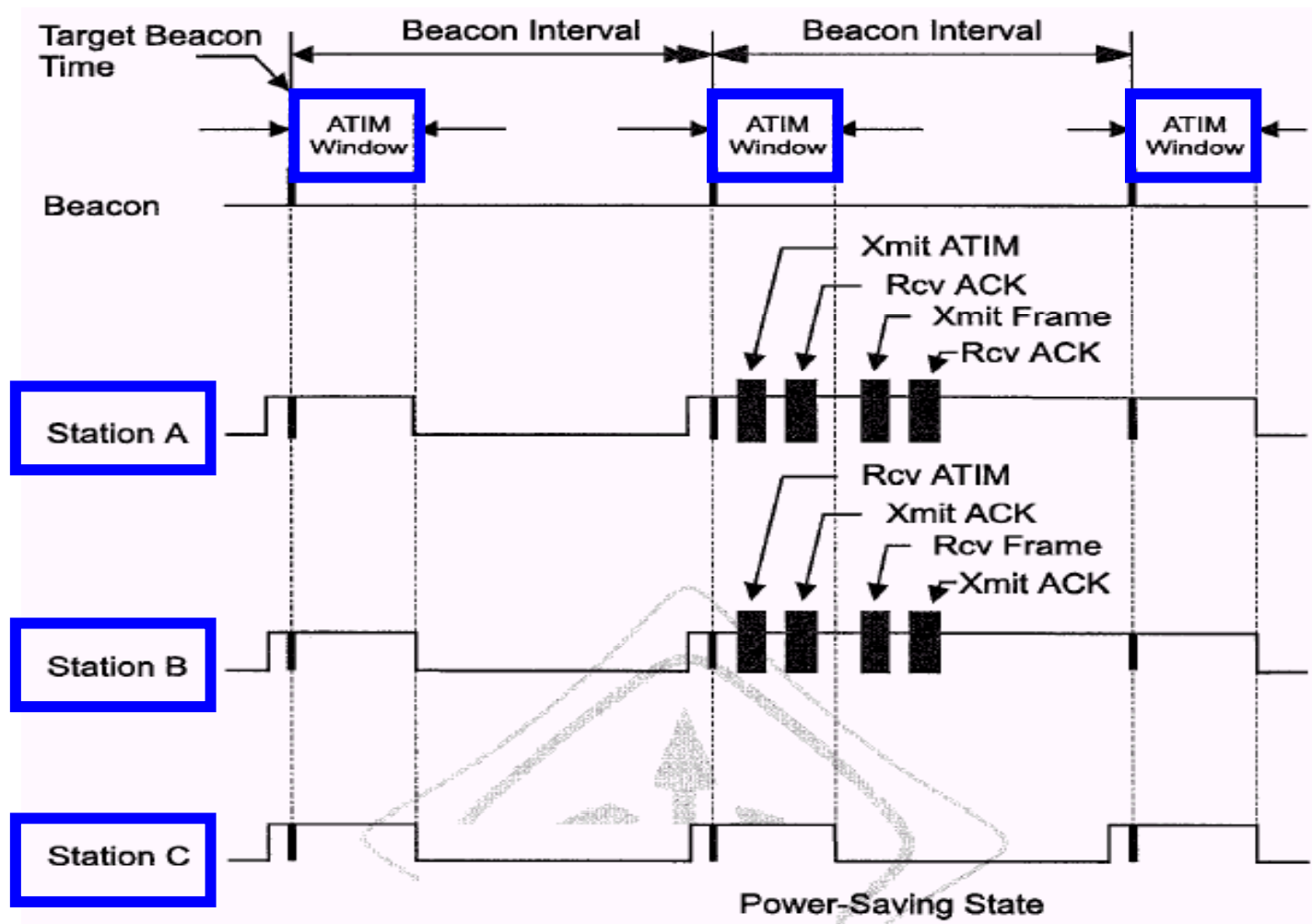- Immediately after DTIM, AP sends out the buffered broadcast/multicast packets.

Example

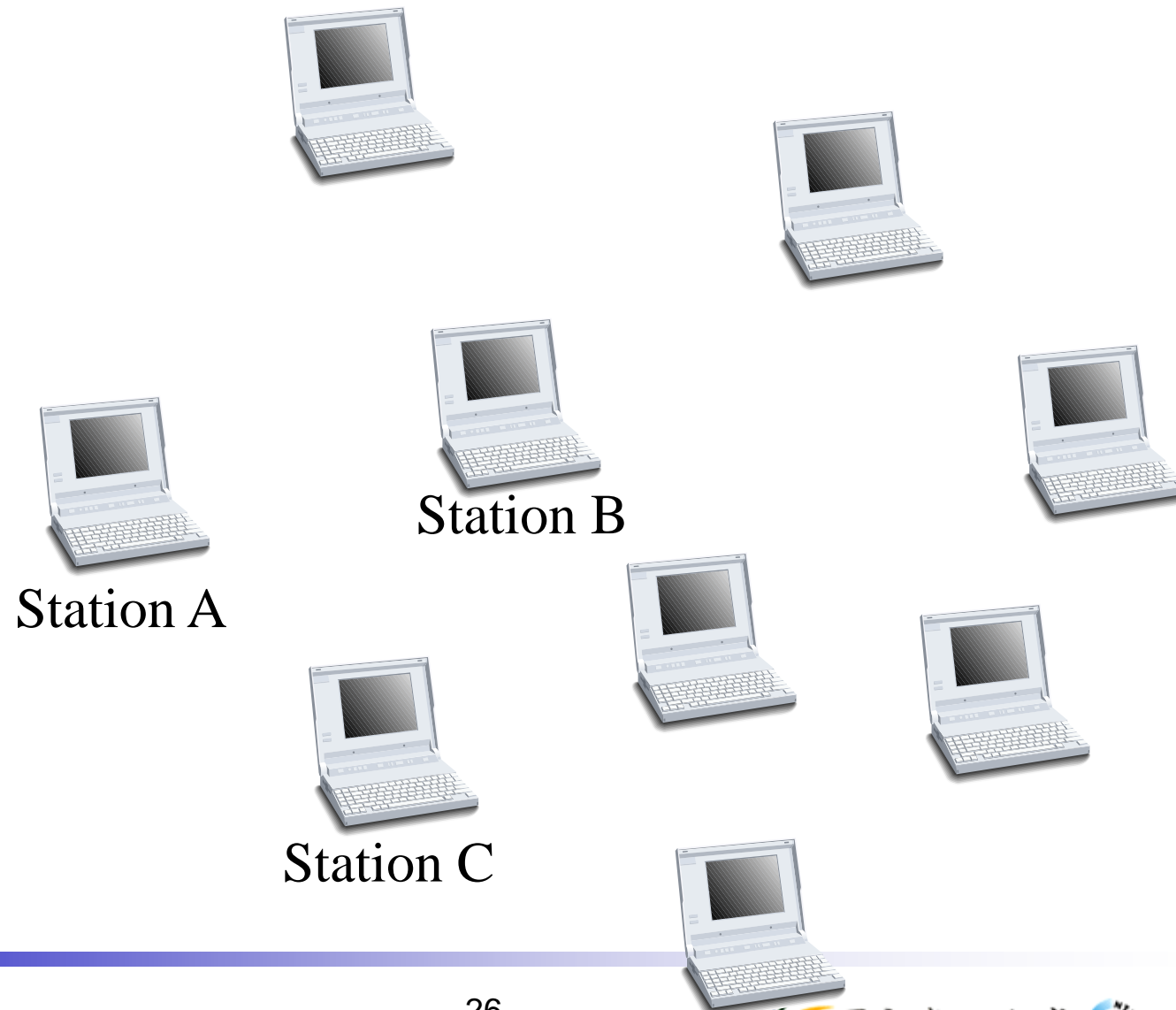# PS in Ad Hoc Mode
(without base station)

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

Station B

Station A

Station C

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.
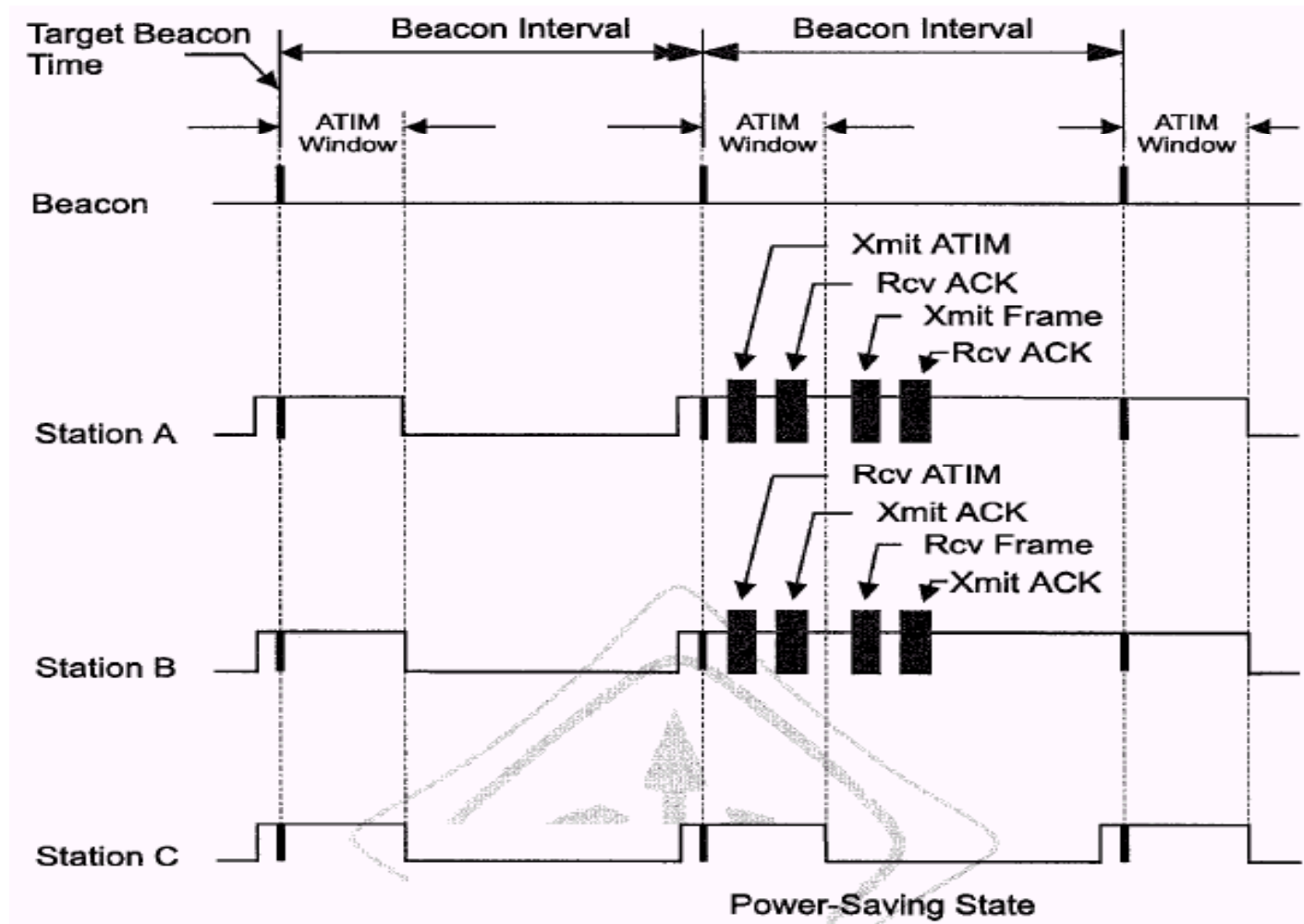 - ❏ Once a beacon is heard, the rest beacons are inhibited.

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.

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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 perform the PS in DCF ?
- How to perform the PS in PCF ?
- How to perform the PS in ad hoc mode ?