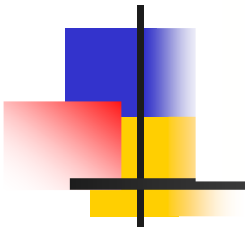
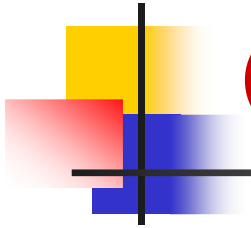


Power Consumption Issues for WLAN Systems

Tzu-Ming Lin
tmlin@itri.org.tw

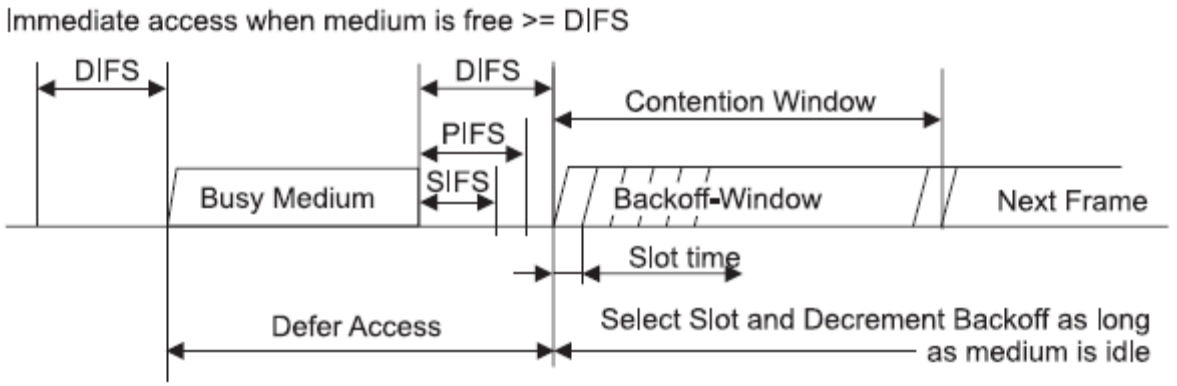


Outline

- WLAN Operations Overview
- Problem Description
- Power Consumption Analysis
- Summary

WLAN Operations Overview

- Active Mode



Ref. 802.11-1999

WLAN Operations Overview

- Power Saving Mode

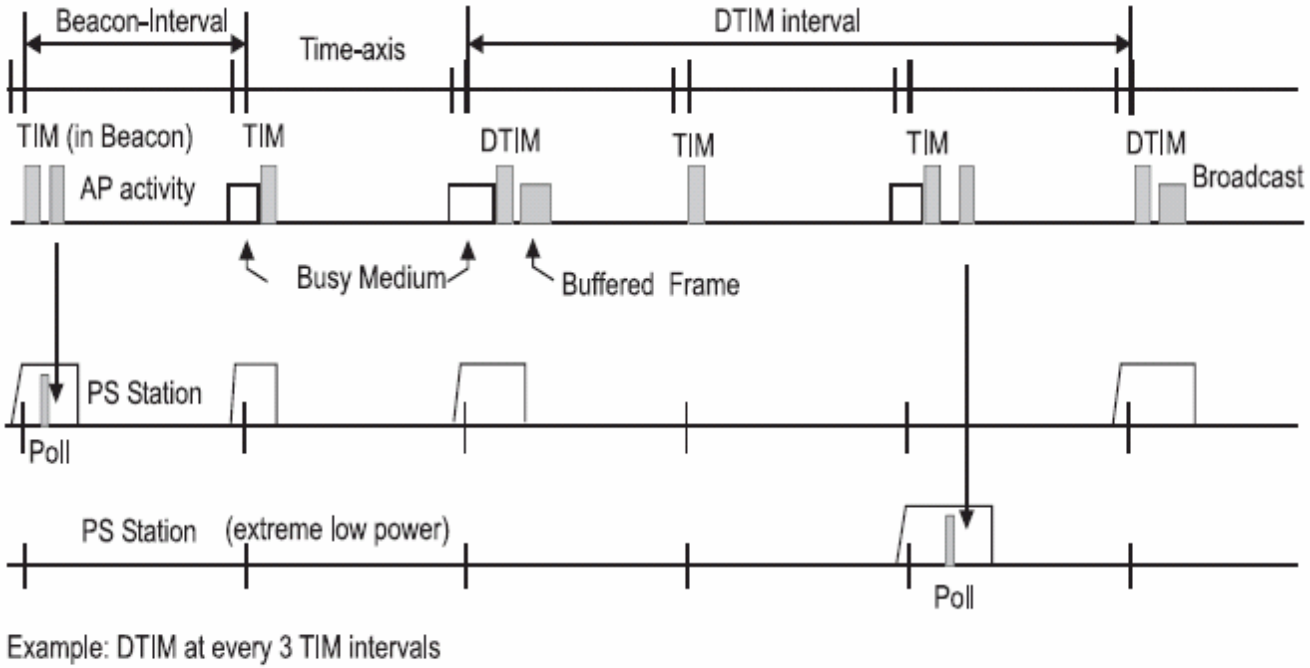


Figure 67—Infrastructure power management operation (no PCF operating)

TIM: Tafiic Indication Message
DTIM: Deliver Traffiic Indication Message

Ref. 802.11-1999

Problem Description

- WLAN power consumption
  - ~10mW at doze mode
  - <500mW at RX mode
  - <700mW at TX mode
- Wi-Fi phone example (1350mA)
  - Energy will be drained in 3 hours (active mode) and 24 hours (power saving mode)
- Power consumption of WLAN is a crucial issue

Problem Description

1~3% power consumed of the total system power in standby mode

Wi-Fi Chipset

Vender	standby	active
TI	2mW	
Broadcom	6mW	Tx: 1412 mW Rx: 951 mW
Philps	3mW	Tx: 760 mW Rx: 525 mW

Wi-Fi Device

Vender	Battery	Standby mode	Active mode	Bandwidth
HP WLAN600 (VoIP phone)	1350 mAH	21~23 hours (270 mW)	3.2 hours (1771 mW)	87Kbps (G.711-64Kbps) 32Kbps (G.729-8Kbps)
Cisco (VoIP phone)	1960 mAH	30 hours (274 mW)	4.25 hours (1936 mW)	
iPAQ+WLAN (PDA+WLAN)	1250mAH	18 hours (285mW)	2.6 hours (~2000mW)	4Mpbs (11b)

30~60% power consumed of the total system power in active mode

- **Different modes have different power consumption behavior**
- **Power consumption problem of active mode is more serious**

Problem Description

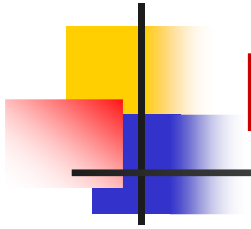
WLAN power consumption should be reduced in standby and active mode individually

Chip/Software/Hardware power consumption optimization

	standby	Active	Bandwidth	Note
GSM	10 ~ 50 mW (Handset) (smart phone)	1000 mW	9.6 kbps	Handset
Data on WLAN	~150 mW	Tx : 1400 mW Rx : 1000 mW	~4 Mbps	LAN card only
VoIP on WLAN	~150 mW	1100 mW	87Kbps (G.711-64Kbps) 32Kbps (G.729-8Kbps)	LAN card only

WLAN power consumption should be based on system throughput and applications/services

Application specific optimization & Cross layer power management !



Power Consumption Analysis

- PHY Issues
- MAC Issues
- Network Issues
- System Issues

Analysis - PHY

- More sensitivity carrier sense threshold causes more unnecessary processing
- Power level adjust method influences the power saving performance
- False packet detections of sampling waste power
- Symbol rate and throughput tradeoff
  - Symbol rate vs. bit per symbol ?
- Higher power radiation causes higher interference level
- How to measurement the distance and then adjust the transmission rate and power

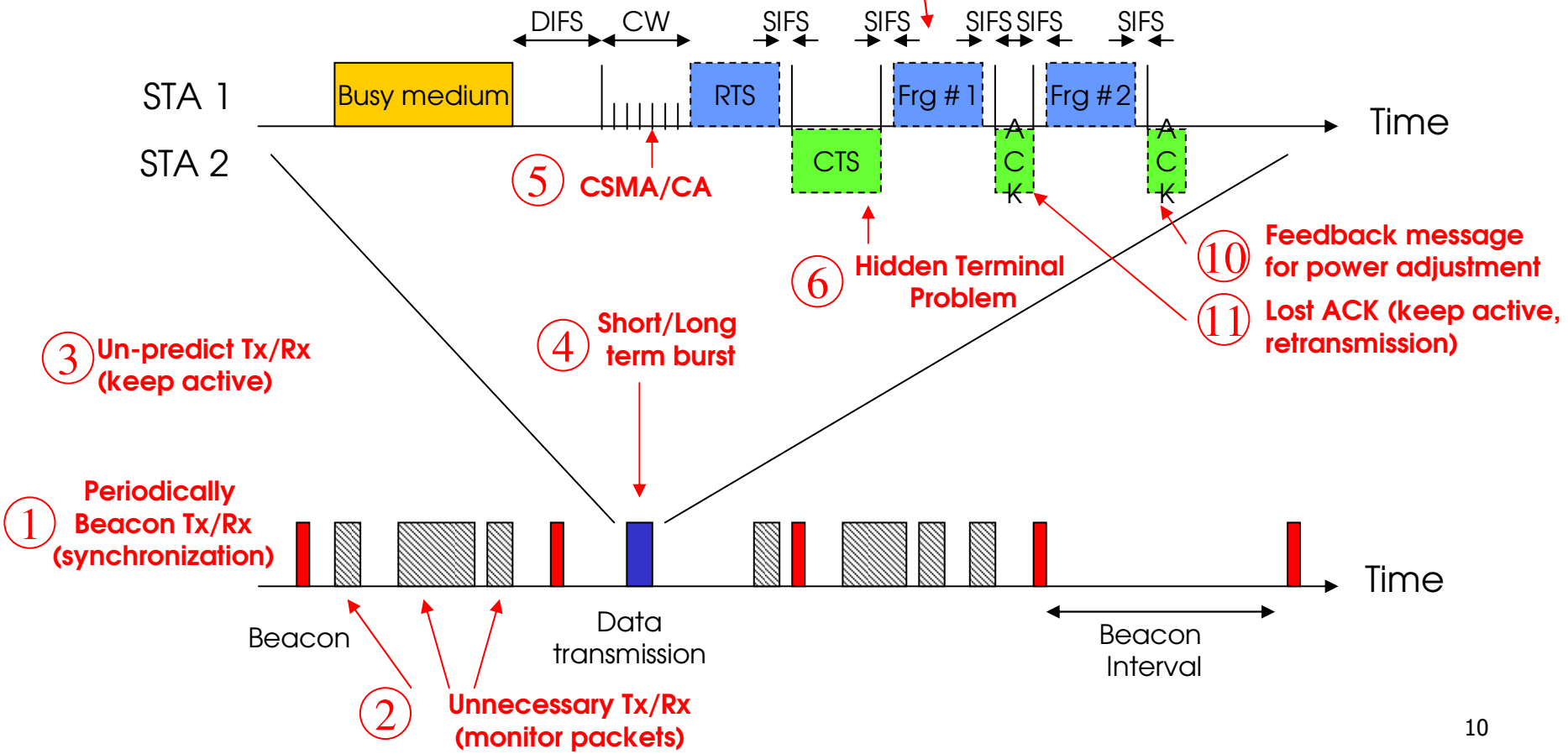
Analysis - MAC

- Measurement in sleep mode
- Full power to receive short control message
- Power saving impact QoS (delay)
- More control messages increase overhead

7 Short bursts impact the power adjustment

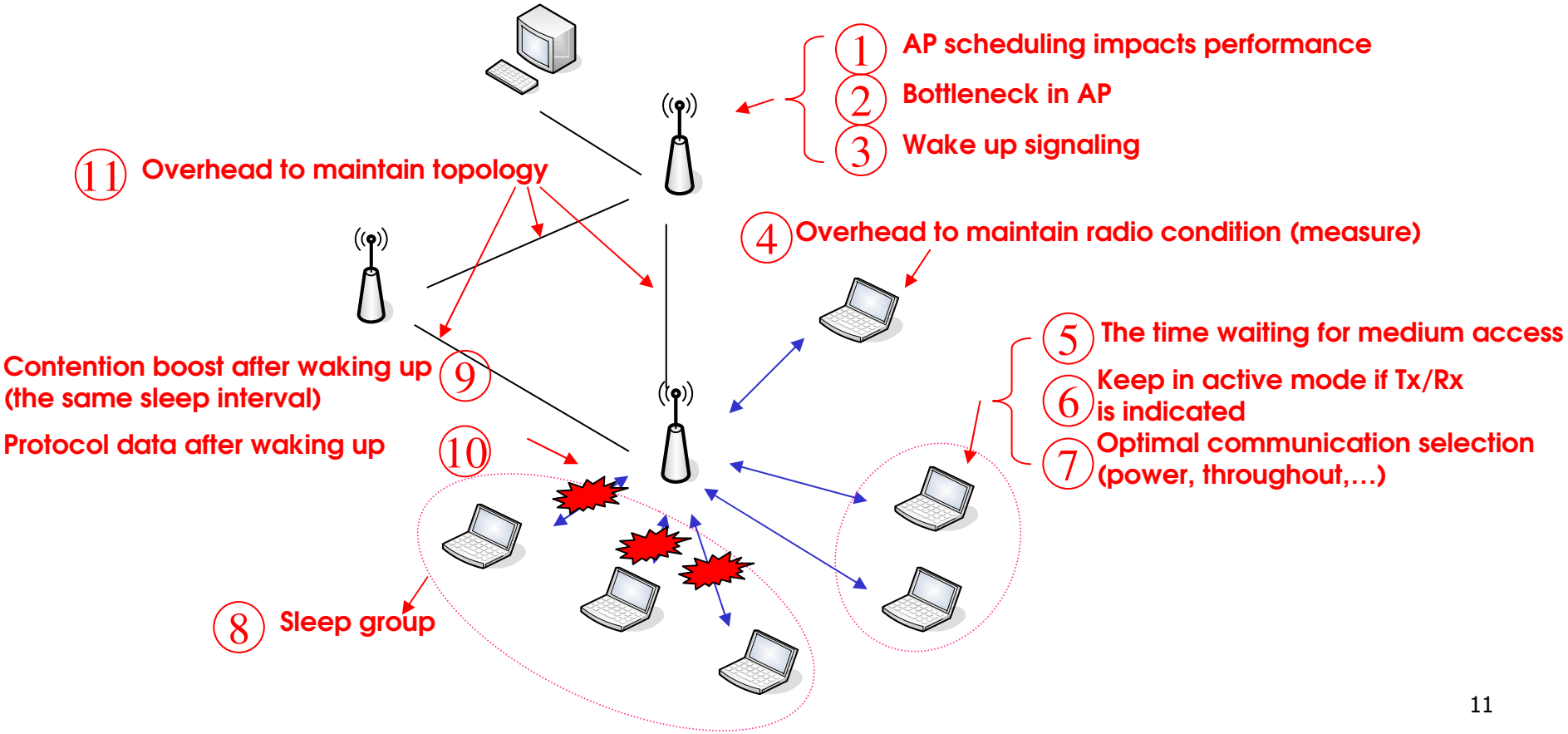
8 Short packet increase control overhead

9 Long packet increase retransmission



Network Issues

- Network stability influences synchronization (Ad Hoc)
- Overhead increases with decreasing group members
- Some mechanism needs compliance power saving state between MSs (Direct Mode)
- Broadcast of synchronization message is required even when there is no data for transfer

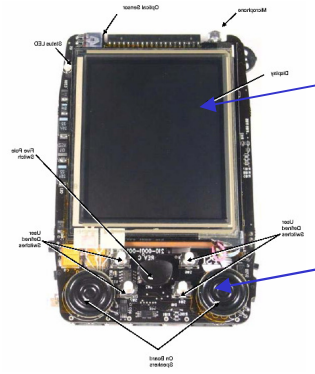


Analysis - System

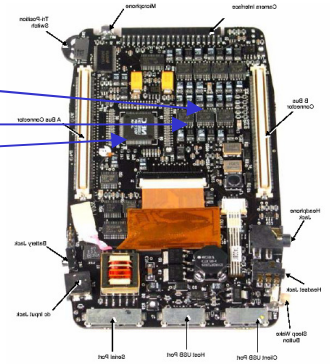
- Sleep and active mode switch timing
- Spare system resource also drains power
- System needs partial operations in sleep mode (synchronization)
- Too long or periodical wake time decrease performance
- Un-applicable wake/sleep time miss critical event (signaling message)
- Power up cycle time influence performance directly
- Non-compliance state between system, application, and network
- System cannot be put in deep sleep because of too short sleep time and long wake up time

Wi-Fi phone

① Full CPU operations waste power in sleep mode



- CPU
- LCD
- uController
- DSP/Codec
- Memory
- WLAN NIC
- Speaker/Mic
- Vibrator
- Battery
- …

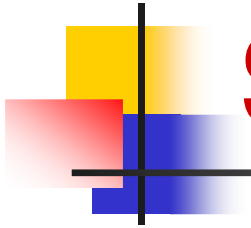


② Modules/circuits on/off in active/sleep mode

③ Modules/circuit power optimization (timing and sequence)

④ Long power up time influence power saving performance and throughput

⑤ Modules and circuits have various wake time



Summary

- Power consumption is a crucial problem in the WLAN systems
- Low Power issues can be divided into
  - Two mode
    - Power Saving /Active mode
  - Four types
    - PHY/MAC/Network/System
- To solve the power saving problem should also consider the application behavior