Power-Saving Protocols for IEEE 802.11-Based Ad Hoc Networks

Present by Lin Yu-Chen

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Outline

- Introduction
- Problem Definition and Motivation
- Global synchronization
- The asynchronous protocols
- Analysis of energy saving
- Conclusion
- Reference

Introduction

- MANET: Mobile Ad hoc Network
- Various aspects of solution for saving power
  - Transmission power control
  - Power aware routing
  - Low-power mode
- Power saving modes in IEEE 802.11
  - Active mode
  - Power saving mode (PS)

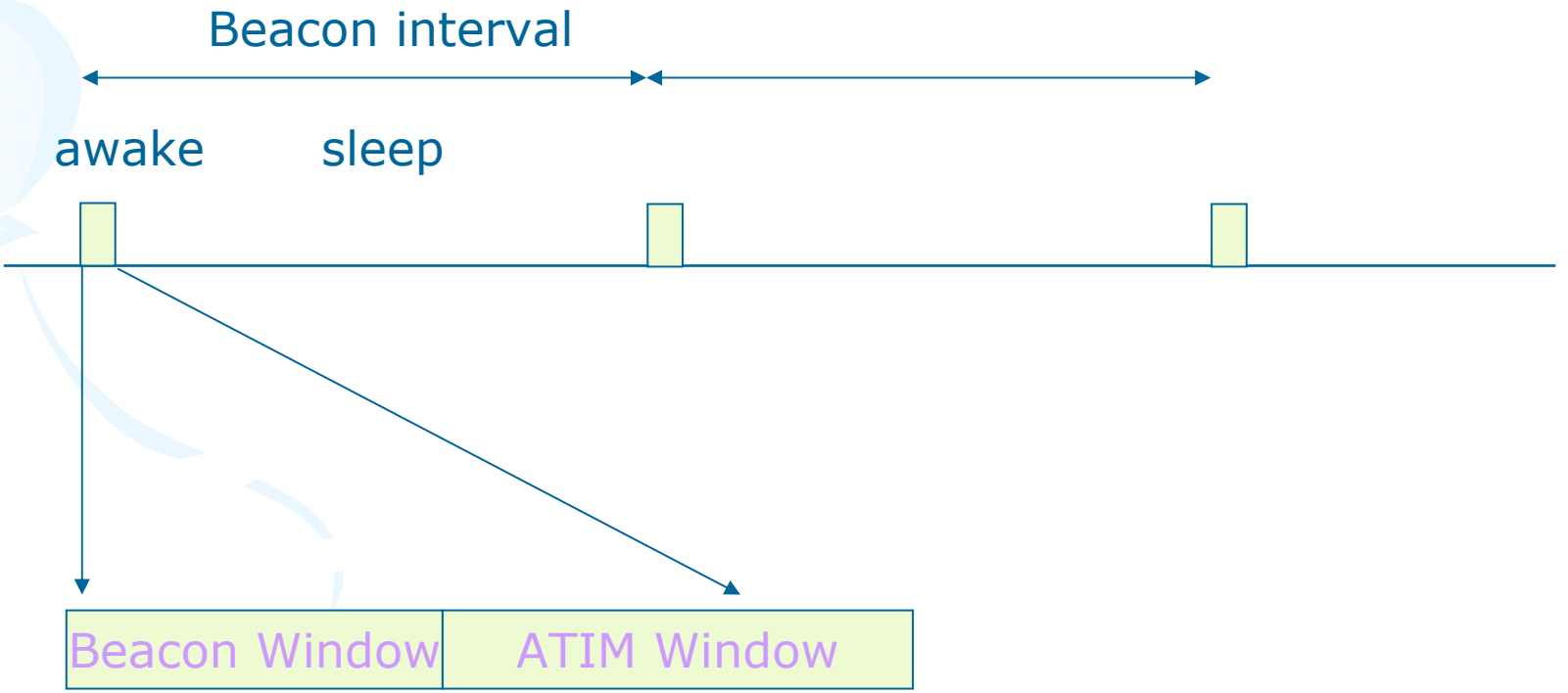
Introduction

- The node have to monitor the channel and consume power even through the packets are not directed to them , a large amount of energy is consumed unnecessarily
- Lucent IEEE 802.11 WaveLan pc card characteristics (2Mbps)

Modes	Energy Consumption
Sleep Mode	14 mA
Idle Mode	178 mA
Receive Mode	204 mA
Transmit Mode	280 mA

Introduction

- Power Saving at MAC Layer in IEEE 802.11(PS mode)



Problem Definition and Motivation

- MANETs have some characteristics
  - Multi-hop communication
  - Unpredictable mobility
  - No plug-in power
  - No clock synchronization mechanism

Problem Definition and Motivation

- The PS mode of IEEE 802.11 is designed for a single-hop (or fully connected) ad hoc network. When applied to a multi-hop ad hoc network, three problems may arise.
  - Clock Synchronization
  - Neighbor Discovery
  - Network Partitioning

Problem Definition and Motivation

- What if it is difficult or impossible to synchronize clocks? (Multi-hop)
- To sync or not to sync?
  - Yes ,(enhanced IEEE 802.11 power-saving algorithm[1])
  - No ,(Three different asynchronous power-saving protocols[2])

Global synchronization

- “A Power-saving Scheduling for IEEE 802.11 Mobile Ad Hoc Network”
- ICCNMC’03
- Ming Liu, Ming T. Liu
- The Ohio State University

The enhanced power-saving algorithm

- The ad hoc mode of 802.11 supports only single-hop ad hoc networks
- Use the overheard ATIMs to generate a contention-free schedule for data transmission
- Dynamic beacon interval

The enhanced power-saving algorithm

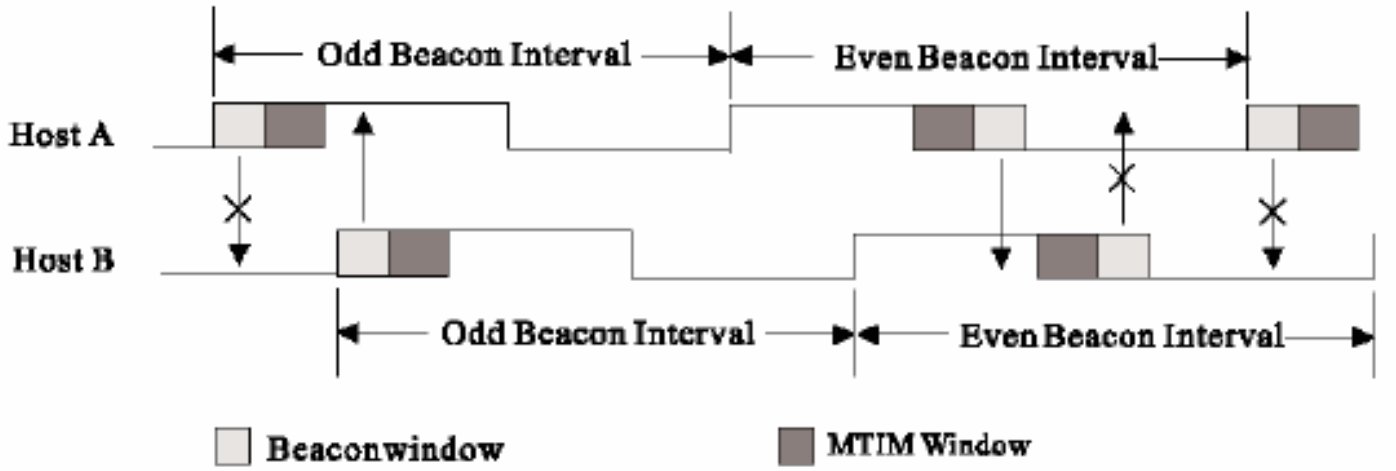
- Scheduling-based mechanism
- Benefit:
  - Improvement Network throughput
  - Decrease overhearing and idle listening
- Defect:
  - Complicated control
  - Can’t work well for burst traffic
  - Can’t work well if the topology is dynamic

The asynchronous protocols

- Design guidelines
  - More beacon
  - Overlapping Awake interval
  - Wake-up prediction
- In each beacon interval, there are three windows
  - Active window
  - Beacon window
  - MTIM window

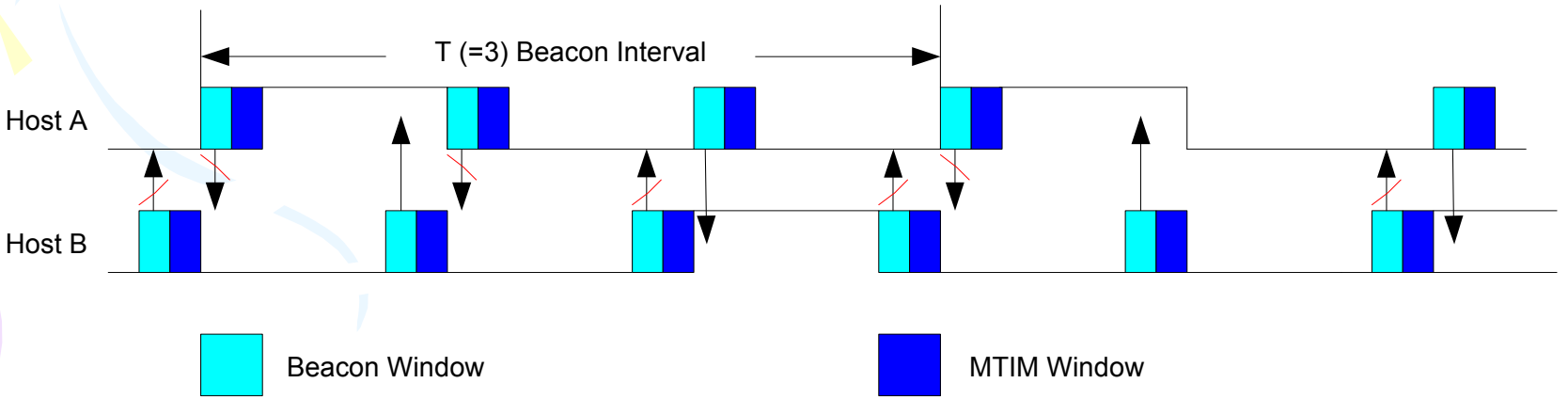
Dominating-awake-interval

- Awake > BI/2 + BW
- Alternatively labeled odd and even sequence of beacon intervals
- Suitable for highly mobile environments



Periodically–fully-awake-interval

- Two types of beacon interval
  - Low power intervals
  - Fully awake intervals
- Suitable for slowly mobile environments

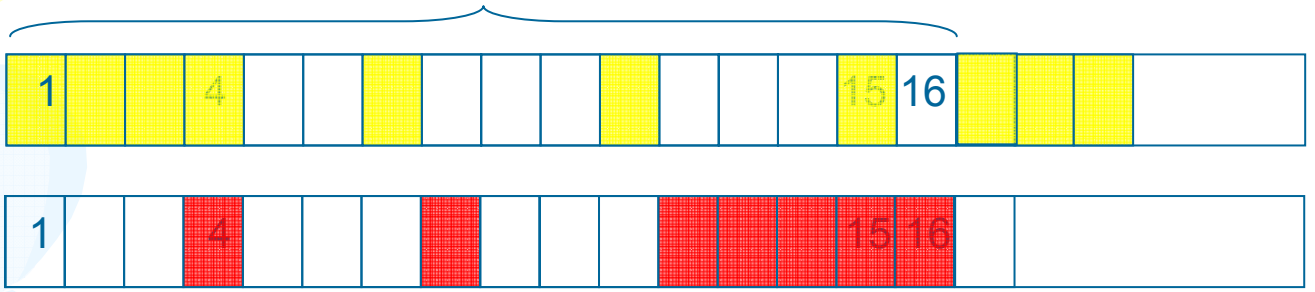


Quorum-based

- PS host only needs to send beacon O(1/n) of the all beacon intervals
- Quorum interval
  - Beacon + MTIM, AW = BI
- Non quorum intervals
  - Starts with an MTIM window, after that, host may go to sleep mode, AW=MW
- Suitable for expensive transmission cost

Quorum-based

- An Example



1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

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Summary

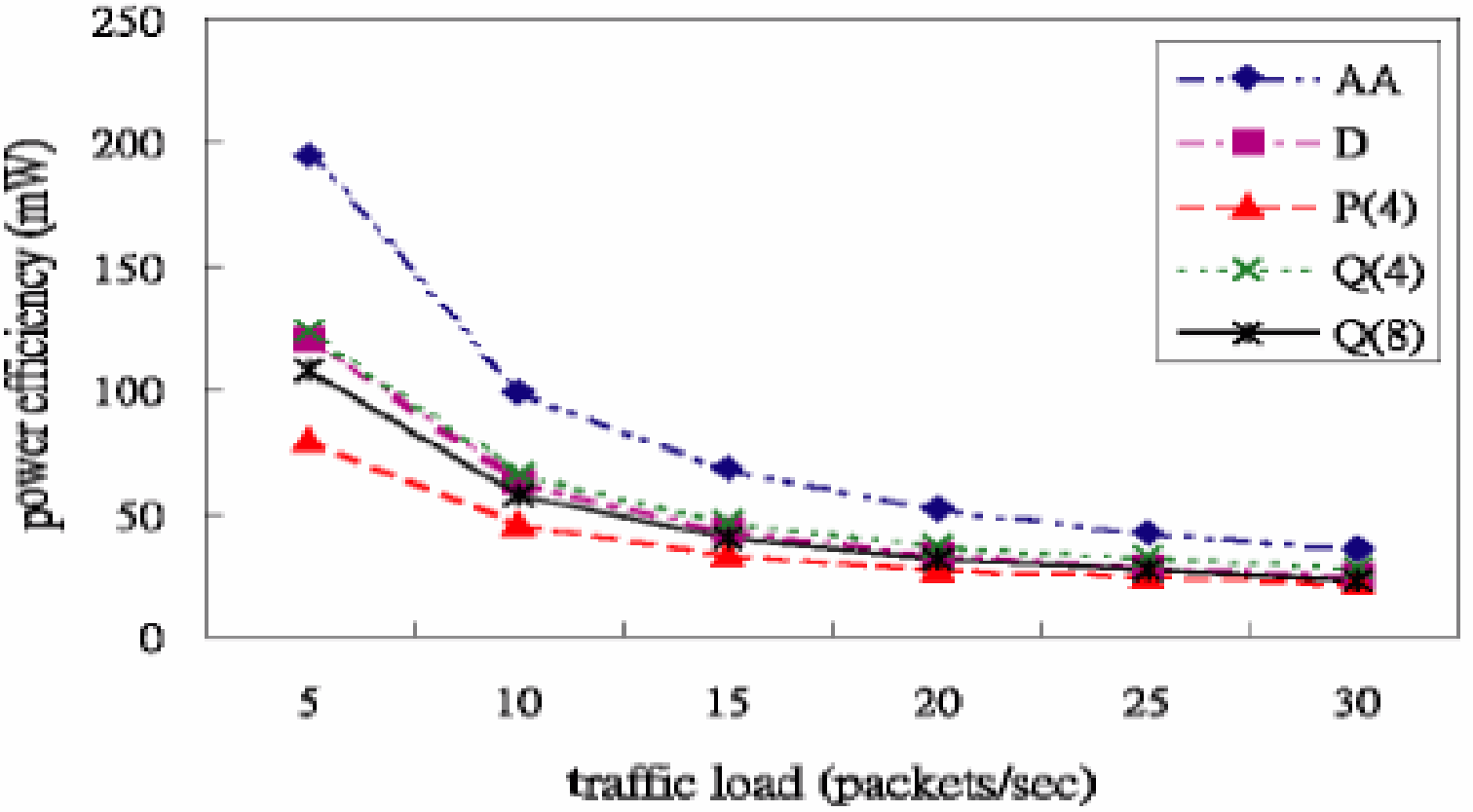
- Dominating awake interval
  - Most power consumption,
  - Lowest neighbor discovery time.
- Periodically-fully-awake interval
  - Balance both power consumption and neighbor discovery time.
- Quorum based
  - The most power saving
  - Longest neighbor discovery time

Analysis of energy saving

Parameter	Value
Beacon Interval length	100ms
Beacon window length	3ms
ATIM window length	7ms
PFAI T value	4
Quorum-based n value	6

Clock synchronization method		Awake time ratio
No Synchronization	DAI	53%
	PFAI	32.5%
	Quorum-based	35.4%
Global Synchronization		10%

Analysis of energy efficiency



Conclusion

- It can make trade-off between power saving and latency
- Global Synchronization has the best performance in energy saving ,but needs a good synchronization algorithm
- No Synchronization is simple and no need for clock sync ,but less efficient in power saving

Reference

- [1] Ming Liu; Liu, M.T. , A Power-saving Scheduling for IEEE 802.11 Mobile Ad Hoc Network, ICCNMC 2003. 2003 International Conference on , 20-23 Oct. 2003 Pages:238 - 245
- [2] Yu-Chee Tseng; Chih-Shun Hsu; Ten-Yueng Hsieh, Power-Saving Protocols for IEEE 802.11-Based Multi-Hop Ad Hoc Networks ,INFOCOM 2002.
- [3] Feeney, L.M.; Nilsson, M. , Investigating the Energy Consumption of a Wireless Network Interface in an Ad Hoc Networking Environment , INFOCOM 2001.
- [4] Wei Ye; Heidemann, J.; Estrin, D. , An energy-efficient MAC protocol for wireless sensor networks , INFOCOM 2002.
- [5] Takeuchi, S.; Yamazaki, K.; Sezaki, K.; Yasuda, Y. ,An improved power saving mechanism for MAC protocol in ad hoc networks , GLOBECOM '04. IEEE