Energy saving survey

Outline

- The way of energy used
- Energy conserving aspects
- Three methods to save energy
  - Power management
  - Time Scheduling
  - Prediction
- Conclusion
- Reference

The way of energy used (at node level)

- Lower transmission distances (< 10m)
- Lower bit rates (typically < kbps)
- Limited battery capacity

Radio mode	Power consumption(mw)
Transmit	14.88
Receive	12.50
Idle	12.36
Sleep	0.016

The way of energy used (at network level)

- Collision
  – corrupted packets must be retransmitted and it increases energy consumption
- Overhearing
  – picking up packets that are destined to other nodes. Control packet overhead
- Idle listening
  – Listening to receive possible traffic that is not sent
  – This is the major source of energy inefficiency

Energy conserving aspects

- Energy efficient techniques
  - Transmission Power Control

    Reduce the transmission power and at the same time, to get a good topology (higher connectivity, lower end-to-end delay etc.).

  - Energy Efficient Routing

    Route the packets through the minimum-energy path, so that the overall energy consumption for delivering a packet from the source to the destination is minimized.

  - Energy efficient data-centric scheme

    using data gathering techniques to filter duplicate data for decreasing data transmission frequency
- Energy efficient MAC

Energy saving method(1)

- Power management

  Schedule nodes in *active-sleep* working cycles such that the radio unit of the node is powered off when not engaging in transmission or reception.

state	processing	memory	sensing	Radio
S0	Active	Active	On	Tx,Rx
S1	Idle	Sleep	On	Rx
S2	Sleep	Sleep	On	Rx
S3	Sleep	Sleep	On	Off
S4	sleep	sleep	Off	Off

Power management (cont)

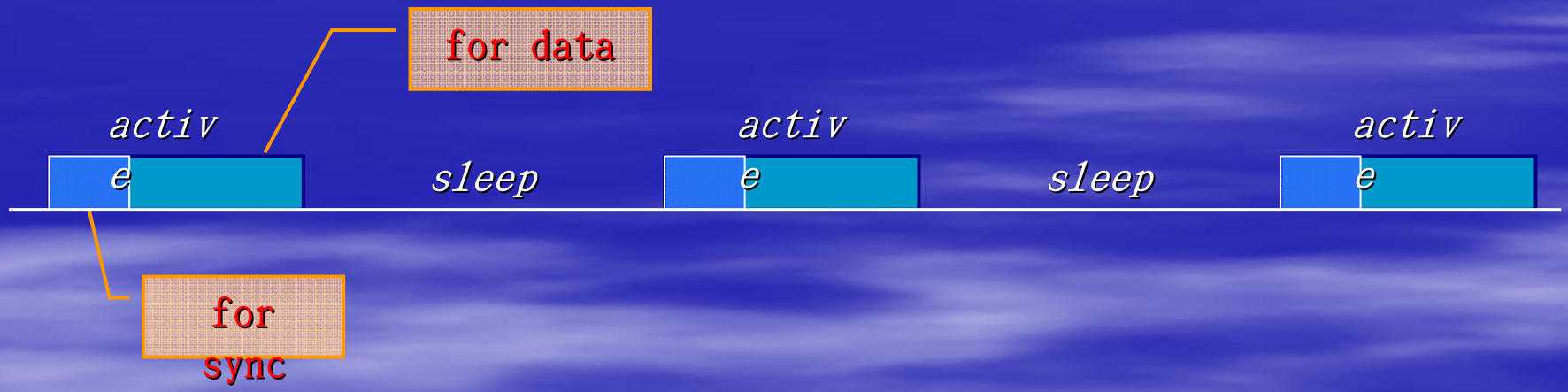
State	Power(mw)	Latency(ms)	Threshold
S0	1040		
S1	400	5	8
S2	270	15	20
S3	200	20	25
S4	10	50	50

- Goal:
  - “Go to Reduced Power Mode after the user has been idle for a few seconds/minutes,and restart on demand”
- Issues:
  - Cost of restarting:latency vs. power trade-off
    - Increase in latency(response time)
    - Increase in power consumption due to startup
  - When to change mode:
    - Optimal vs. Idle Time Threshold
  - When to wakeup:
    - Optimal vs. On-demand
  - Problems
    - How to make sure enough nodes wakeup
    - The ability to react to burst events is weak

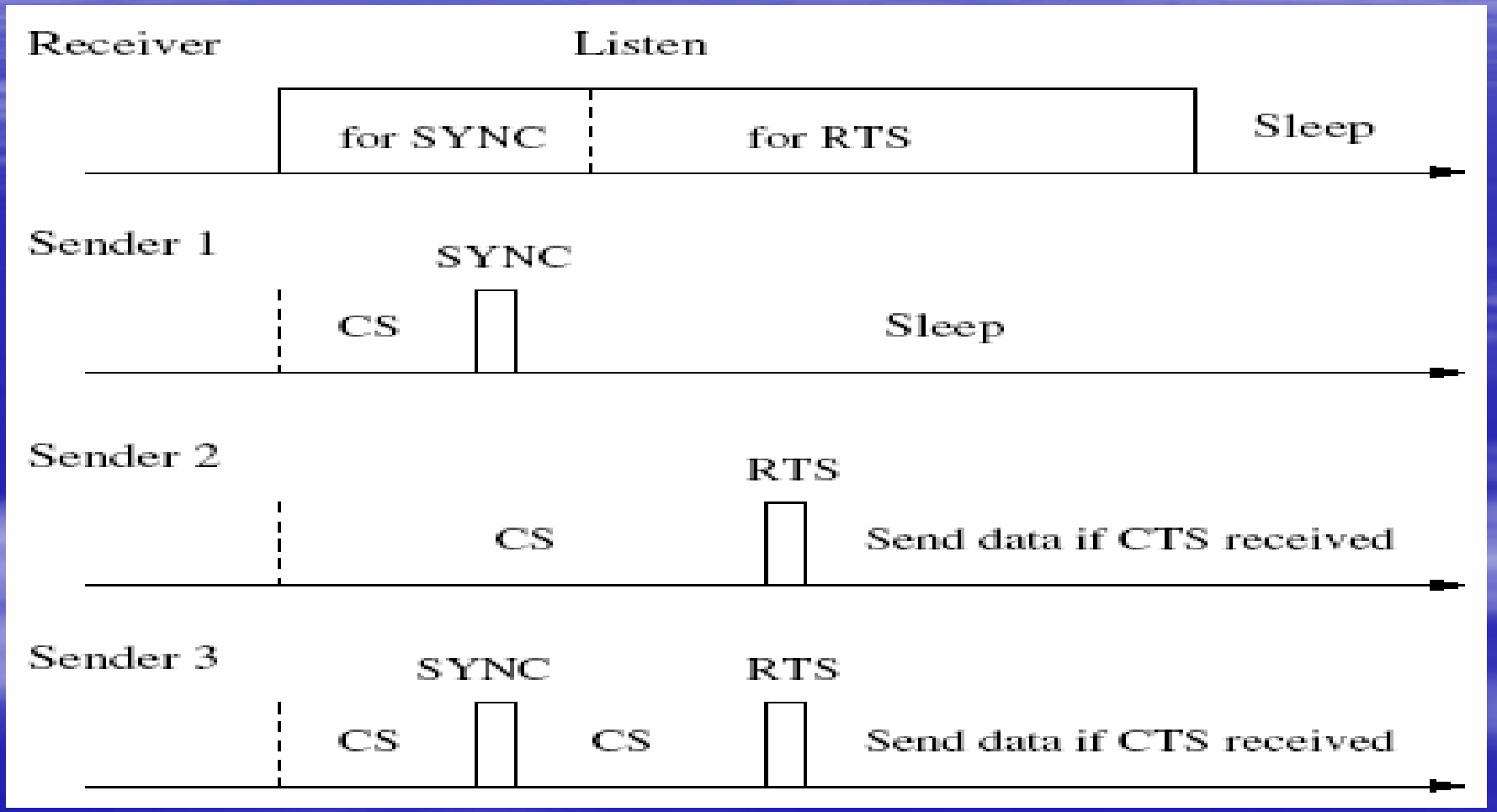
Power saving method(2)

- Time Scheduling

  --periodic listen and sleep
  - Fixed duty cycle – active period, sleep period
  - Synchronization is a major problem



S-MAC

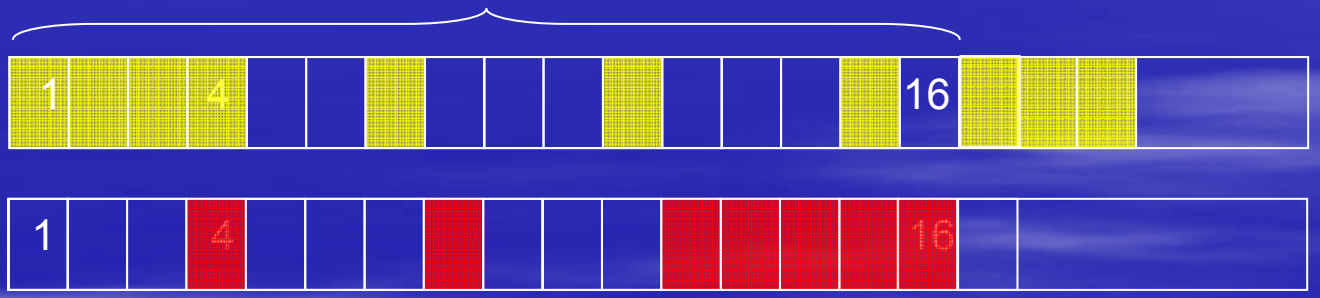

Receiver
Listen
for SYNC
for RTS
Sleep
Sender 1
SYNC
CS
Sleep
Sender 2
RTS
CS
Send data if CTS received
Sender 3
SYNC
RTS
CS
CS
Send data if CTS received

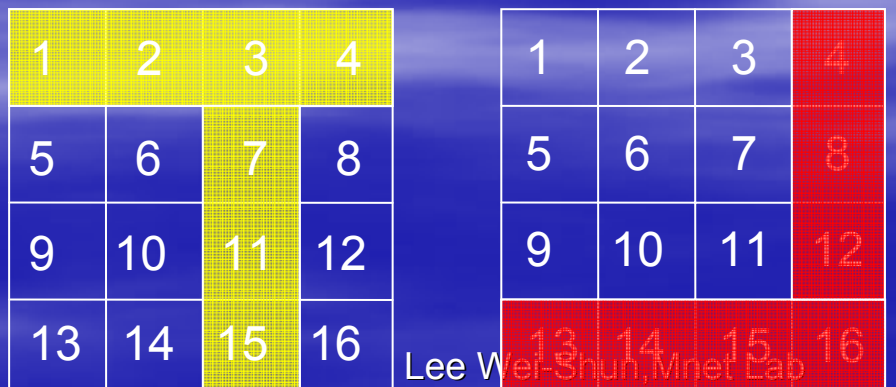
--Sync problem

- Global sync
- No sync
- Local sync

No sync

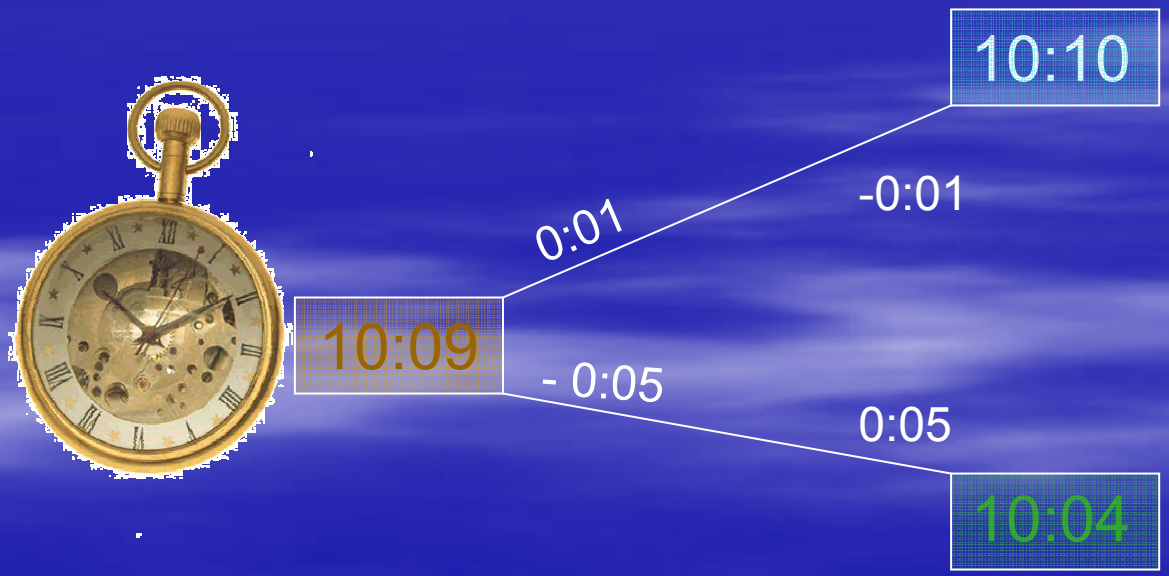
-- Quorum-based





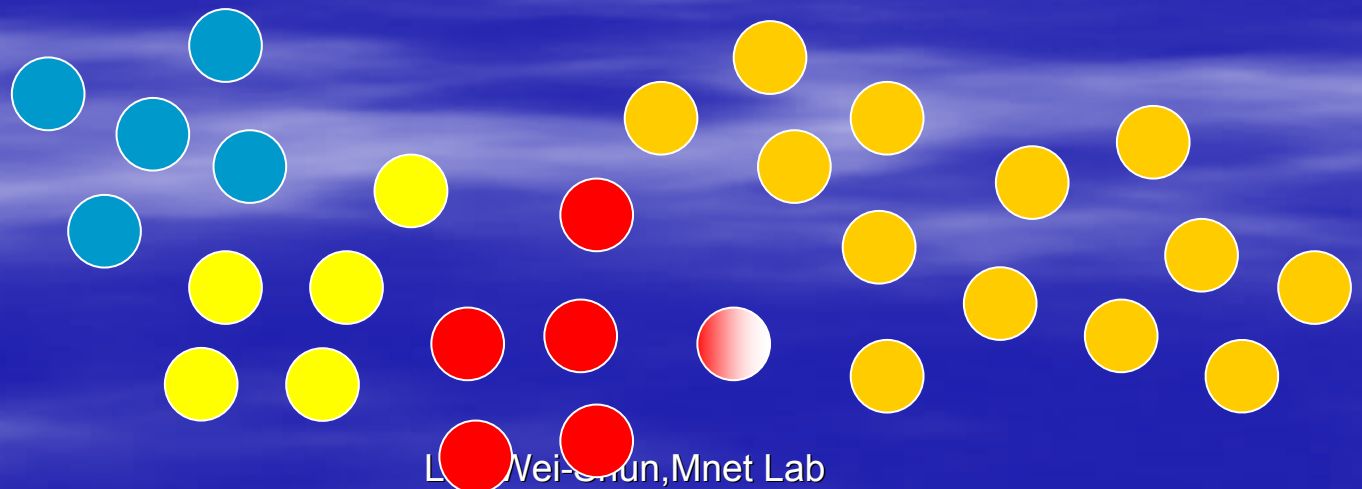
Local sync

- Offset



Local sync

- Nodes of same color -- synchronize with each other.
- Nodes of different colors – know each other's timing



Which one to choose

Clock synchronization method		Awake time ratio
No Synchronization	DAI	53%
	Quorum-based	35.4%
Global Synchronization		10%
Local Synchronization	2 schedules	19%
	3 schedules	28.4%
	4 schedules	37.87%

Pro and con

- Global sync
  - Best performance in energy saving
  - Needs a good synchronization algorithm
- No sync
  - simpler and more scalable
  - Simple = no need for clock sync??
  - Less efficient in power saving
  - Broadcast/multicast is inefficient

Pro and con (cont)

- Local sync
  - More scalable
  - Inefficient with multiple schedules
  - Protocols incomplete

Power saving method(3)

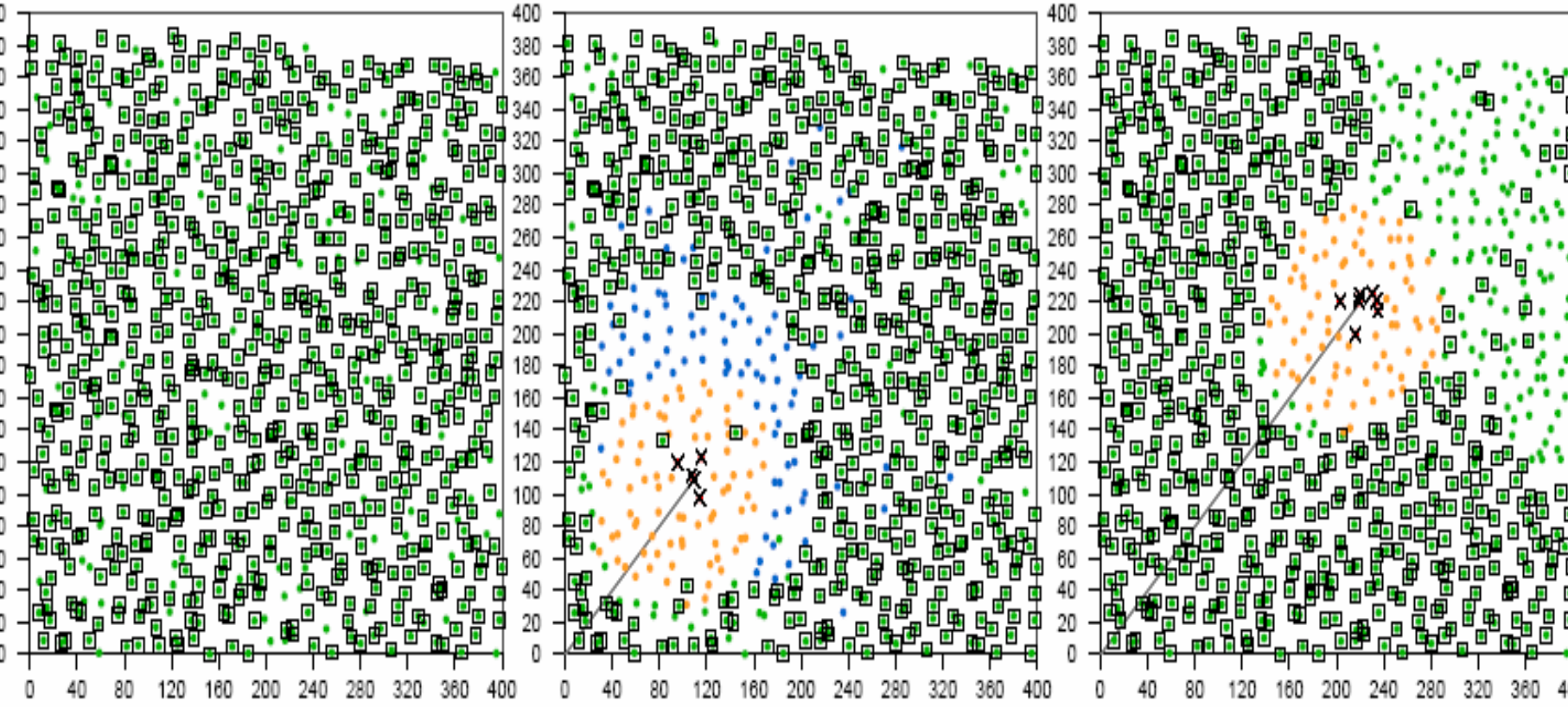
- Prediction method
  - Processing << transmission consumption
  - Use computation history to predict
    - Next position、direction of object
    - Next value collected
    - Next time may events occur
    - Next query result

  For the purpose of
  1.Reducing long distance transmission
  2.Duplicate data filtering
  3.Determining when can nodes sleep and wakeup

Prediction-based object tracking

- Dual prediction-based reporting
  - Both sensors and BS have the same prediction model and predict the future movement of mobile objects by historical information
  - Transmissions of sensor readings are avoided as long as the predictions are correct.
  - Prediction method
    - Instant
    - average
    - exponential

Selective activation based on prediction



(a) Timestamp=0.0 second (b) Timestamp=15.0 second (c) Timestamp=31.0 second

Conclusion

- saving most energy = Max network lifetime ??
- Can't not ignore coverage problem while using sleep mode for saving energy.
- Properly use of prediction methods can save much energy but recovery schemes are needed (like pre-wakeup scheme…etc).

Reference

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