Ubiquitous Networks

Wakeup Scheduling

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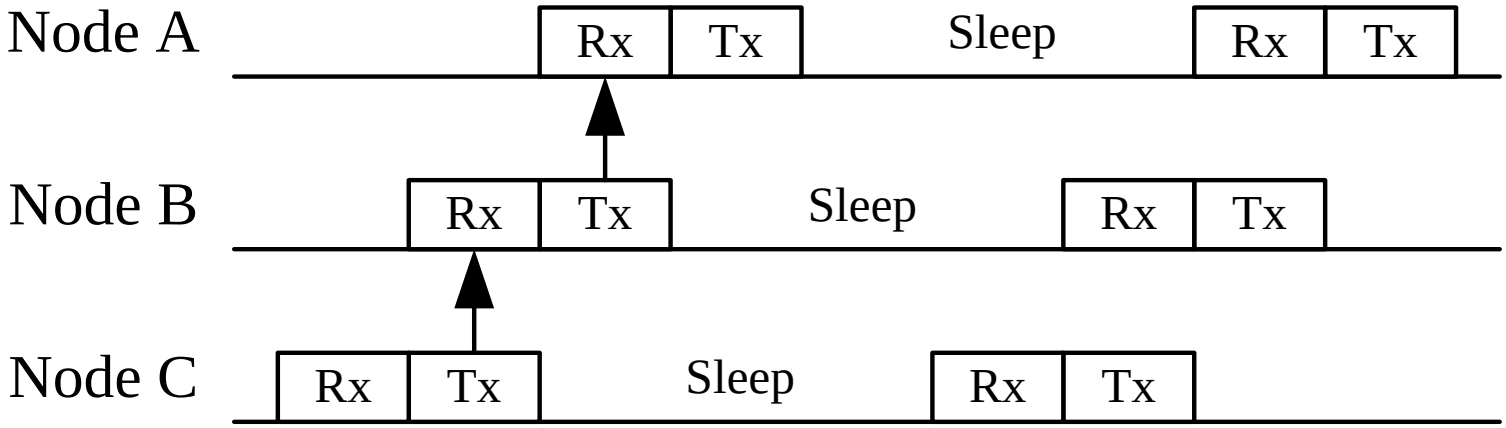
Motivation

- **Most of WSN applications have real-time constraints**
  - Sensors in battlefield to detect odorless biochemical weapons
  - Disaster monitoring applications
    - Forest fire alarm, volcano monitoring, seismometer
  - Real-time target tracking
  - Intrusion detection
  - Emergency health application
  - Traffic coordination

- **Existing MAC protocols focus on low energy consumption**
  - But, how about the communication latency required for real-time applications?
  - *Sleep delay*
    - A packet can traverse at most a single hop during each wakeup period

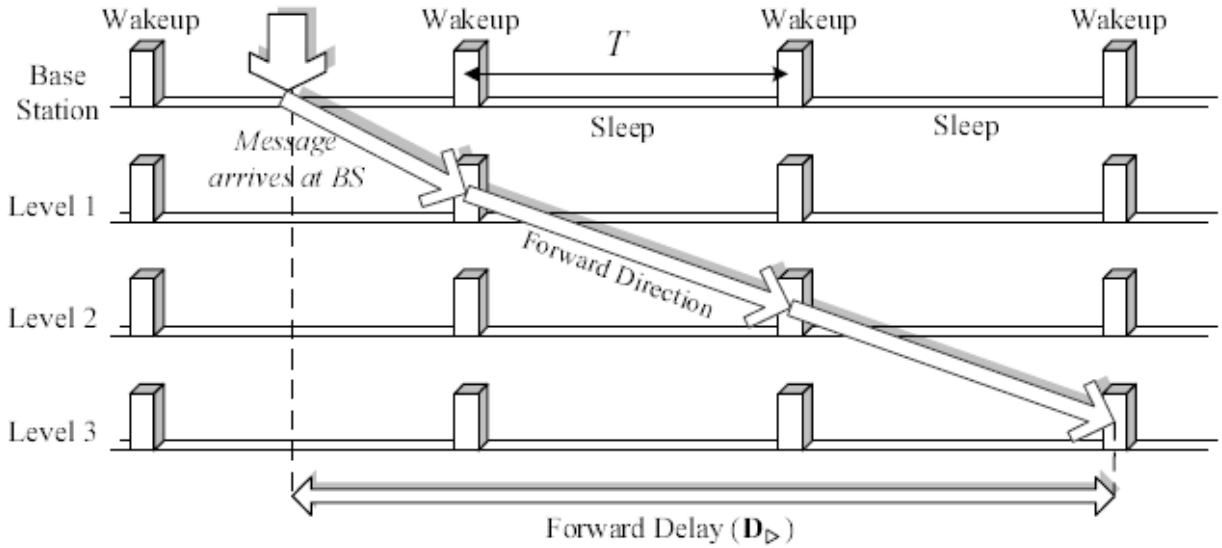
DMAC: Synchronous Skewed Wakeup

- ***"An Adaptive Energy-Efficient and Low-Latency MAC for Data Gathering in Wireless Sensor Networks"***
  - Krishnamachari and Raghavendra (at USC), IPDPS 2004.
- **DMAC calls this *staggered wakeup***
  - Skew the wakeup period of each node in the path from a source node to a sink node
  - Assume the tree topology starting from the sink as a root
  - The wakeup schedule of each node is determined by the level of the node in the tree



Wakeup Patterns

- ***"Wakeup Scheduling in Wireless Sensor Networks"***
  - Keshavarzian, Lee (at Stanford), Venkatraman, MobiHoc 2006.
- **Fully Synchronized Wakeup Pattern (SMAC)**

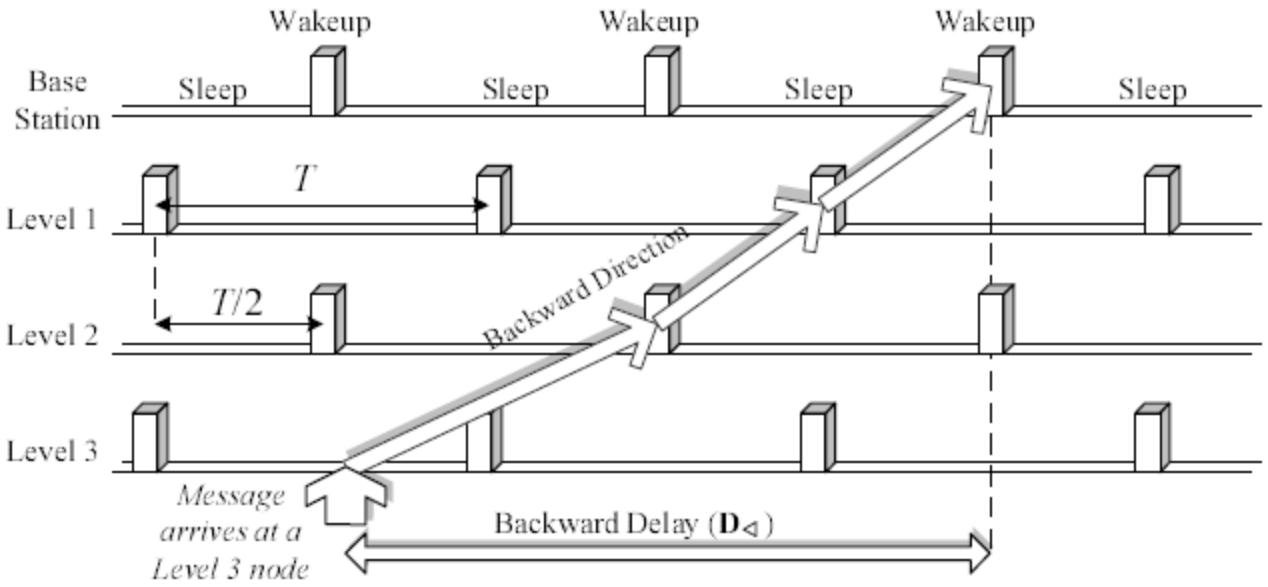


Source: ACM

- All the nodes wake up at the same time
- Delay = (#hops – 0.5) * T

Wakeup Patterns

Shifted Even and Odd Pattern

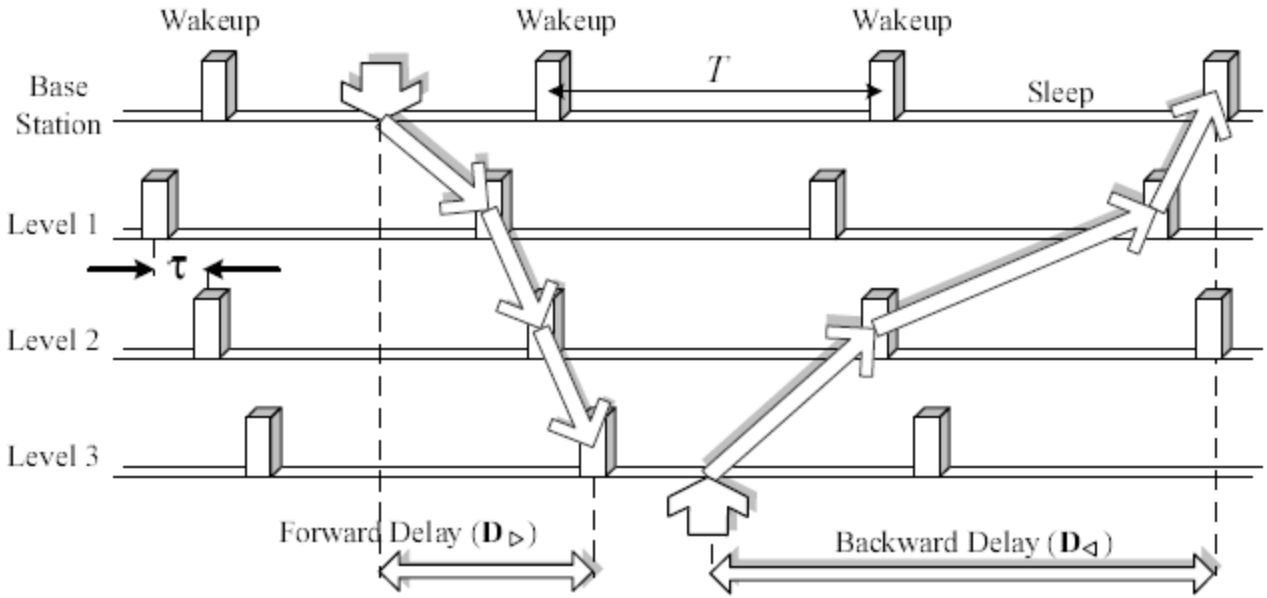


Source: ACM

- Shift the wakeup period of nodes in even levels by T/2
- Delay = 0.5 * (#hops) * T

Wakeup Patterns

Ladder Pattern (DMAC: staggered wakeup)

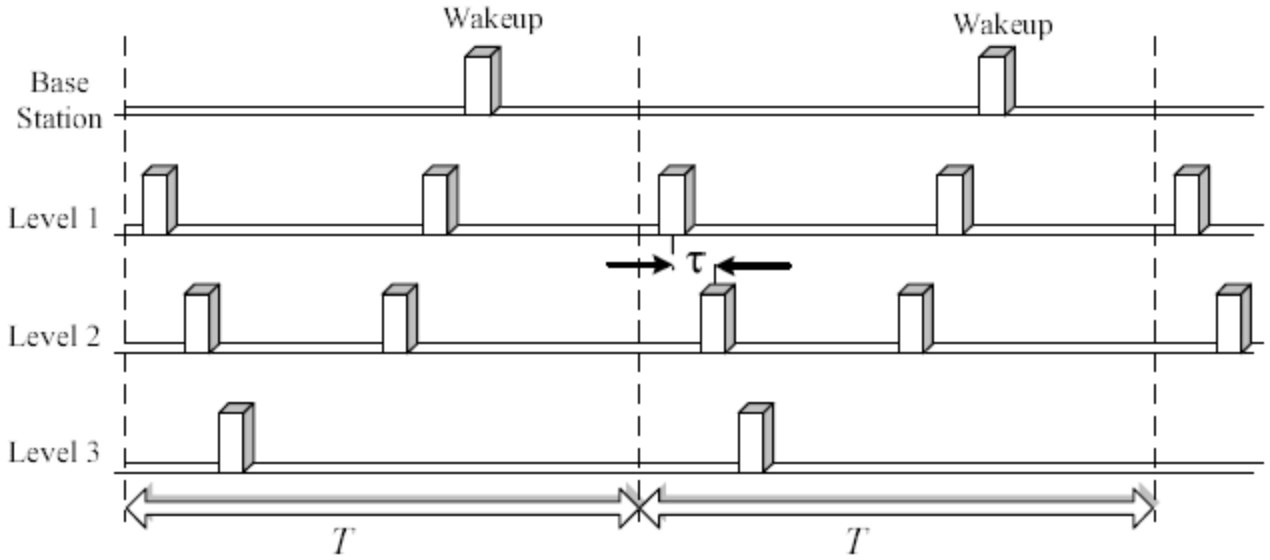


Source: ACM

- Skew the wakeup period of nodes in the communication path
- Forward and backward delays are asymmetric

Wakeup Patterns

Two-Ladders Pattern

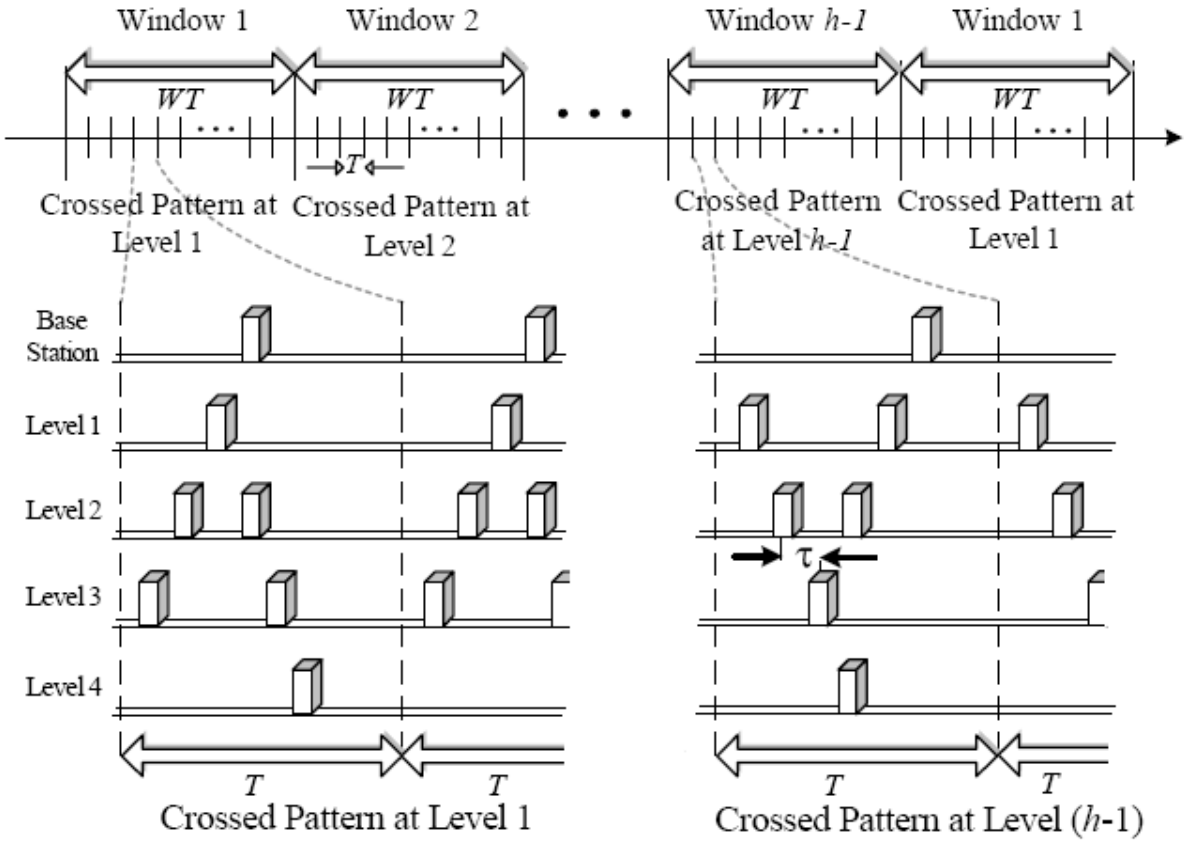


Source: ACM

- To improve the delay in both directions
- Combine the forward ladder with a backward ladder
  - Nodes in the middle levels wake up twice in every period T

Wakeup Patterns

Crossed-Ladders Pattern

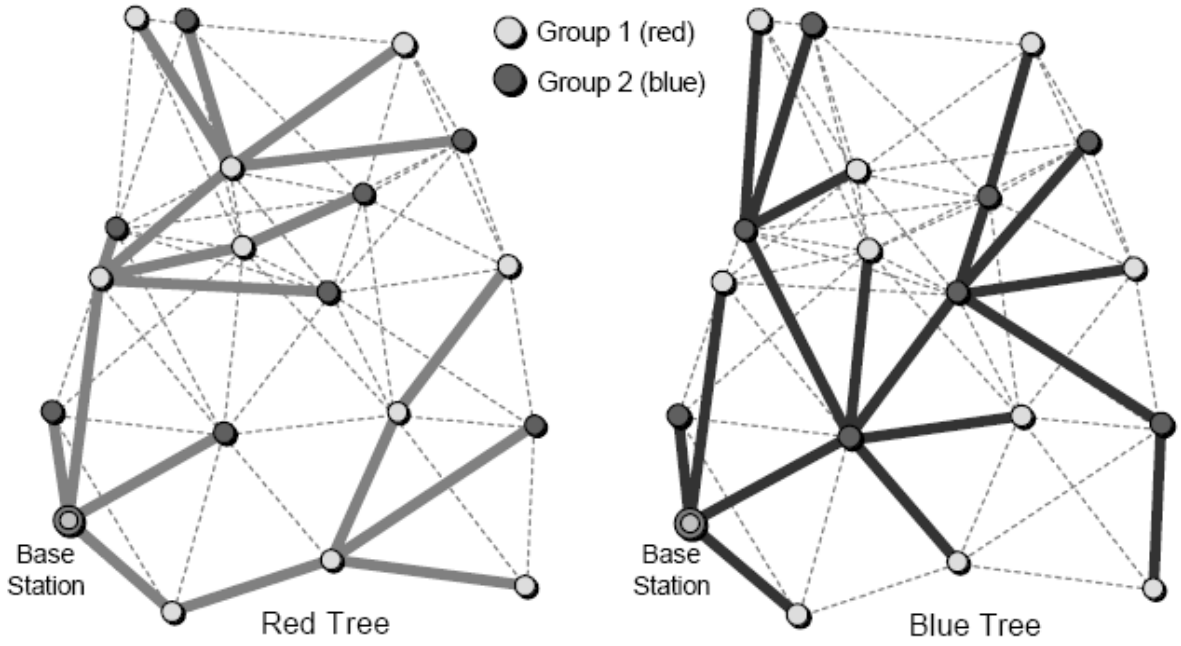


Source: ACM

- Cross the two ladders at one point so that the same wakeup can be used for both directions

Wakeup Patterns

Multi-Parent Method



Source: ACM

- Embed multiple trees in the network
  - Each node has multiple paths and multiple parents to the sink
  - Depending on the packet arrival time, a node can choose the fastest path to get to the destination