Self-organizing transmission scheduling mechanisms for wireless sensor networks

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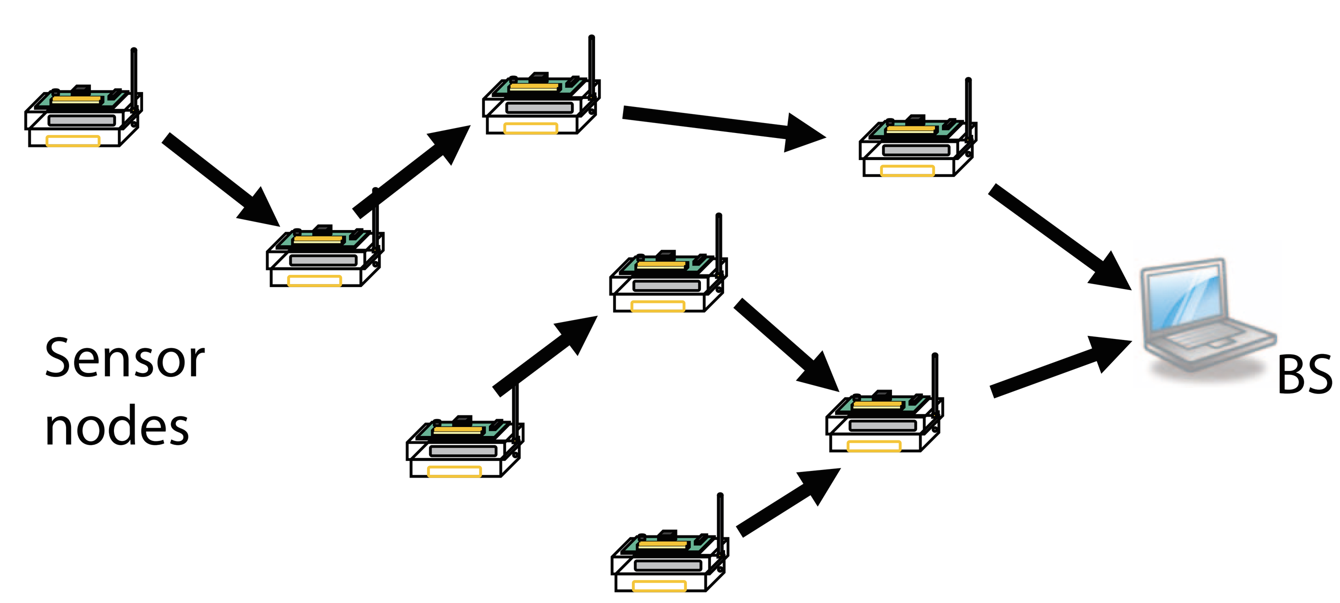
Wireless sensor networks

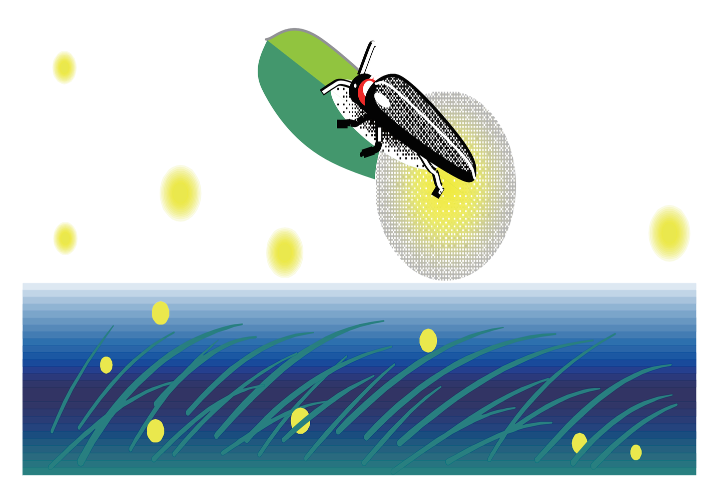
Wireless sensor networks (WSNs) have attracted attention from many researchers and developers, particularly for monitoring applications. In typical monitoring applications, the WSN consists of a base station (BS) and many battery-powered sensor nodes, each with a general-purpose processor with limited computational capability, a small amount of memory, and a wireless communication device. Sensor node data are gathered at the BS through wireless multi-hop networks at regular intervals. In WSNs:

- **Energy-efficient** control mechanisms are required to prolong the lifetime of battery-powered WSNs. Sleep **scheduling**, i.e. turning off the wireless communication device when the device is not used, is highly efficient to save energy consumption.
- **Self-organizing** control mechanisms are required because many sensor nodes are randomly deployed and the network topology dynamically changes due to environmental noise, sensor node failures, and so on.

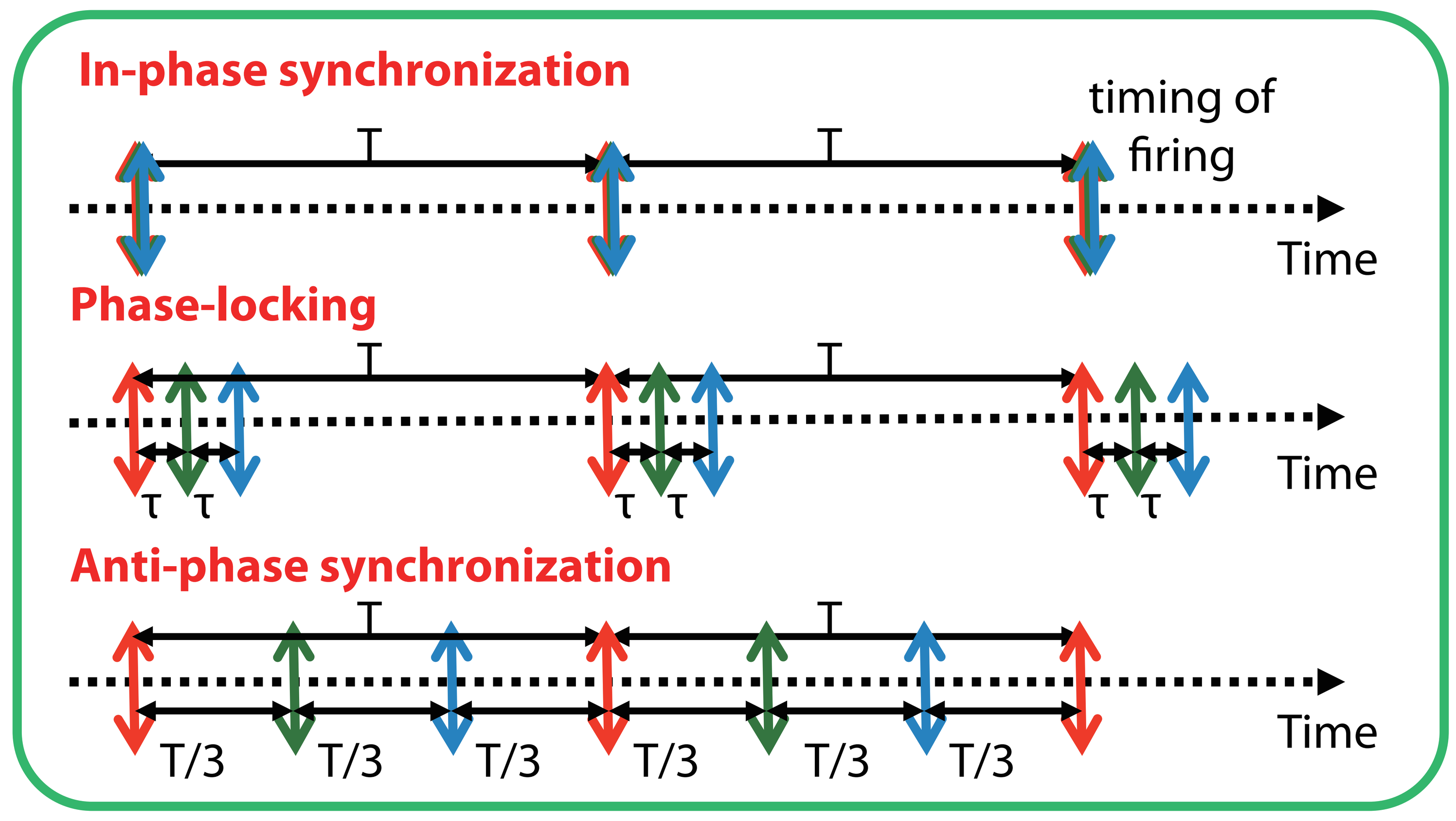


Wireless sensor networks

Pulse-coupled oscillator model



Pulse-coupled oscillator (PCO) models are models of biological **self-organizing** synchronization behavior such as observed in flashing fireflies. PCO models explain several kinds of synchronous behavior among oscillators, such as in-phase synchronization, where oscillators completely synchronize, phase-locking, where oscillators synchronize with a constant offset, and anti-phase synchronization, where oscillators synchronize with an equal interval.



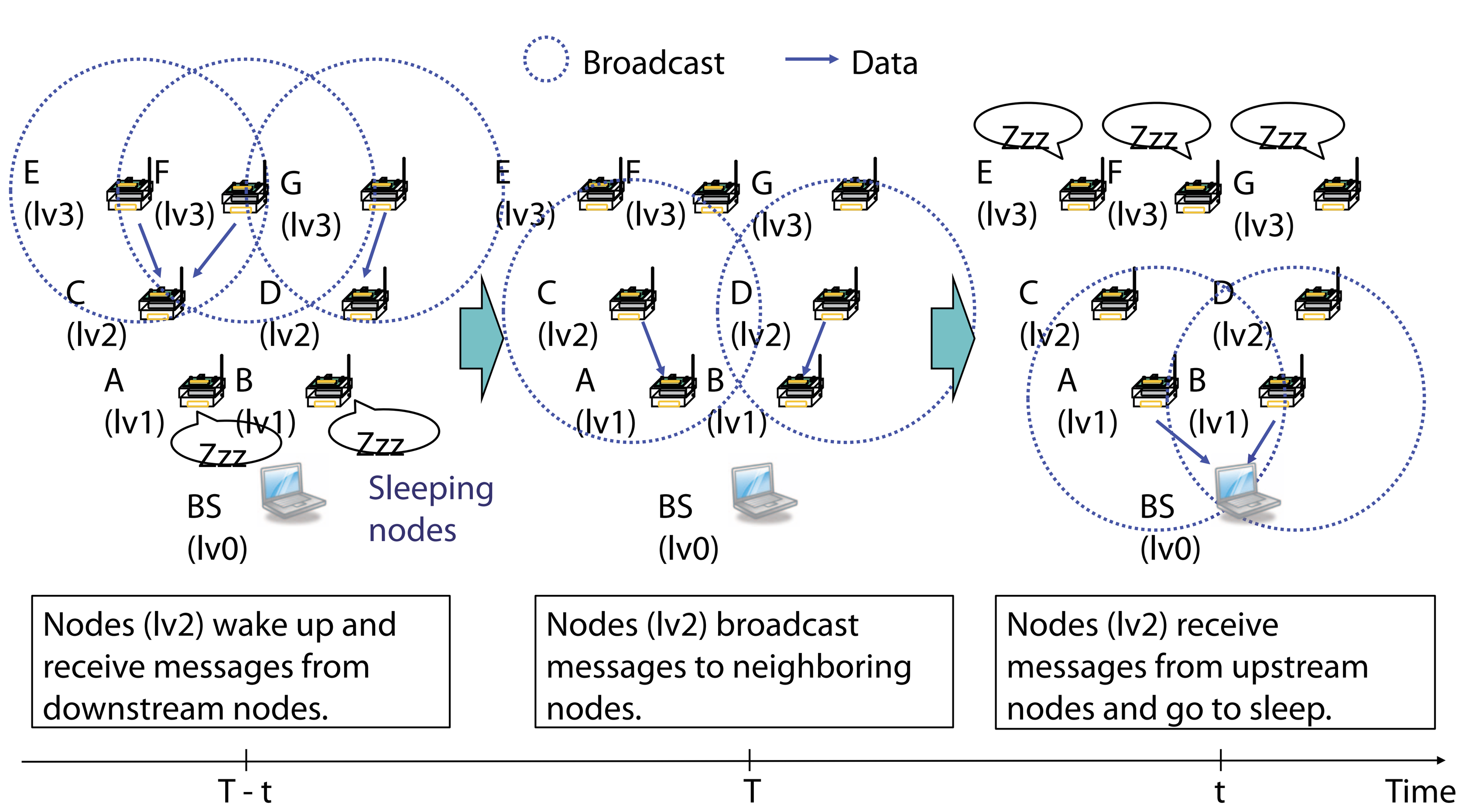
Three kinds of synchronization

Applying PCO models for WSN scheduling

Self-organizing communication mechanism using phase-locking (WAVE) [1]

We have proposed a self-organizing communication mechanism (WAVE) based on phase-locking that can organize two kinds of communication pattern in multi-hop WSNs, namely, diffusion and gathering. In WAVE, **a sensor node self-configures its message transmission and sleep timings.** For gathering, sensor nodes configure their transmission timing so that sensor nodes with the same hop count from the BS simultaneously wake up, receive messages from downstream sensor nodes, and forward the message to upstream sensor nodes. Sensor data from the edge of the WSN are therefore gathered at the BS.

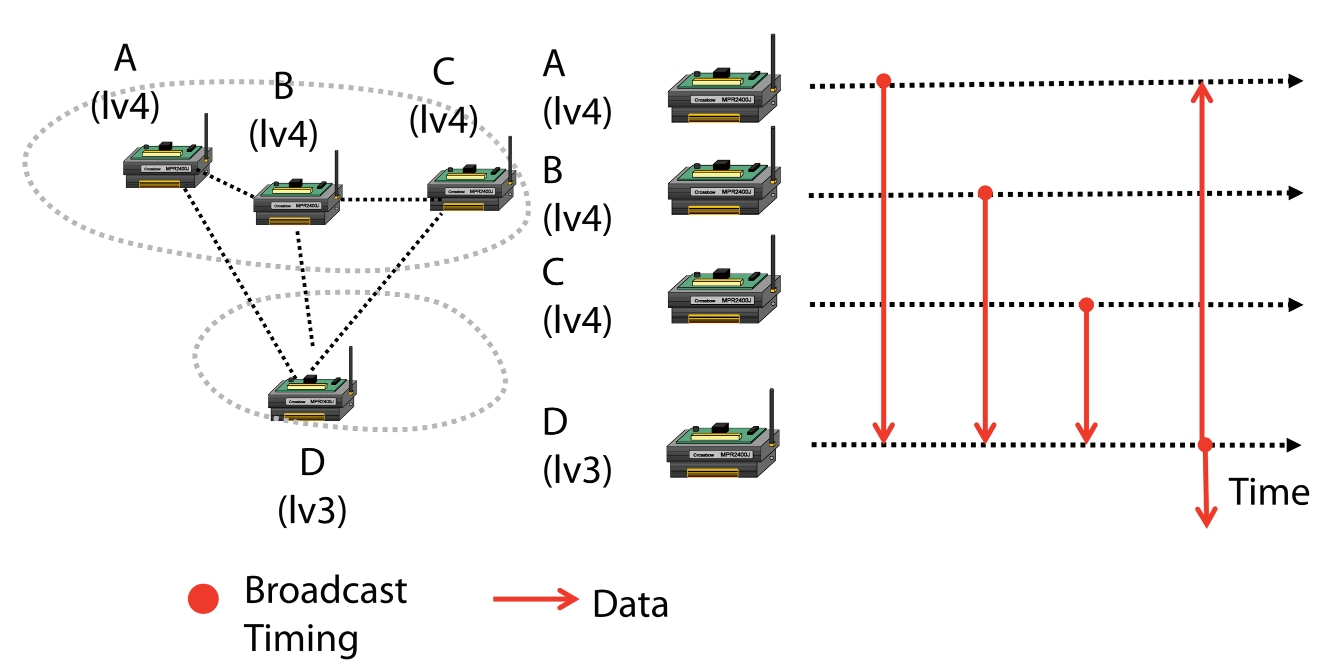
WAVE focuses on phase-locking applications to organize two kinds of WSN communication patterns, and detailed mechanisms for monitoring applications have not been well studied. For example, WAVE does not consider collisions due to simultaneous transmissions among sensor nodes with the same hop count, which lowers the data gathering ratio.



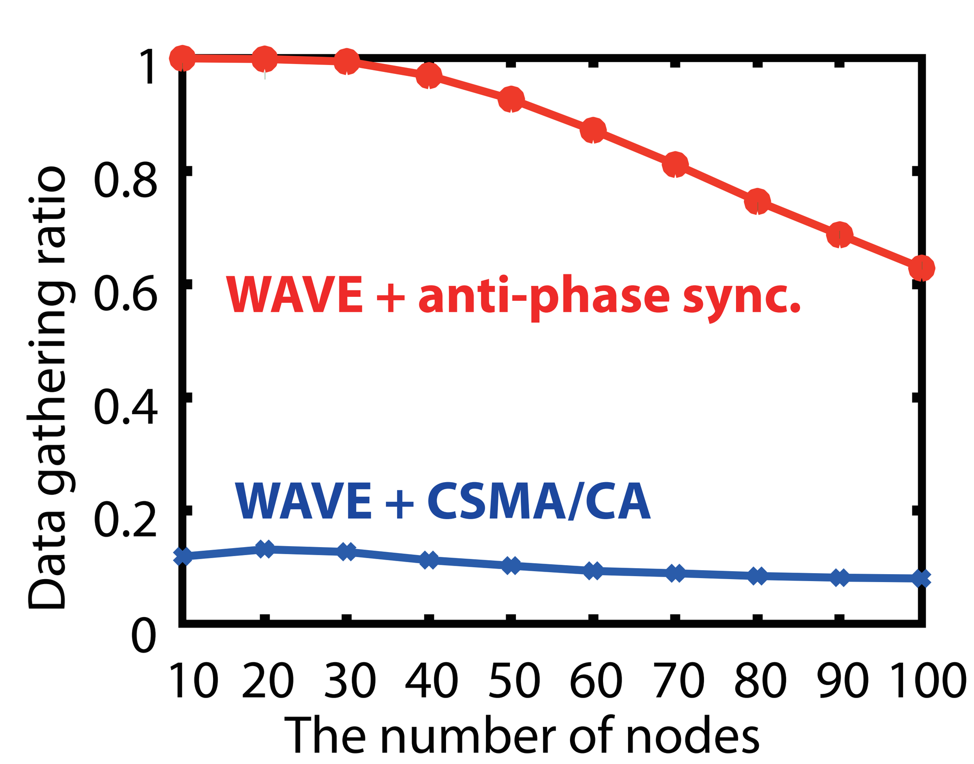
Basic behavior of WAVE in the case of gathering

Self-organizing data gathering mechanism using phase-locking and anti-phase synchronization [2]

To avoid collisions among sensor nodes with the same hop count in WAVE, we are now proposing a self-organizing data gathering mechanism by applying anti-phase synchronization in the PCO model to WAVE. Preliminary results show that the proposed mechanism significantly improves the data gathering ratio.



Example of message transmission timing



Data gathering ratio against the number of nodes

[1] Y. Taniguchi, et al., "A traveling wave based communication mechanism for wireless sensor networks," Journal of Networks, vol.2, no.5, pp.24-32, Sep. 2007.
[2] Y. Taniguchi, et al., "Self-organizing transmission scheduling mechanisms using a pulse-coupled oscillator model for wireless sensor networks," in Proceedings of ICDIPC 2012, pp.85-90, July 2012.

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