If You Have Time, Save Energy with Pull

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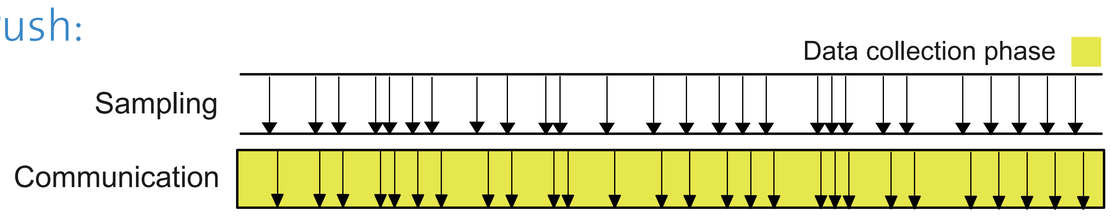
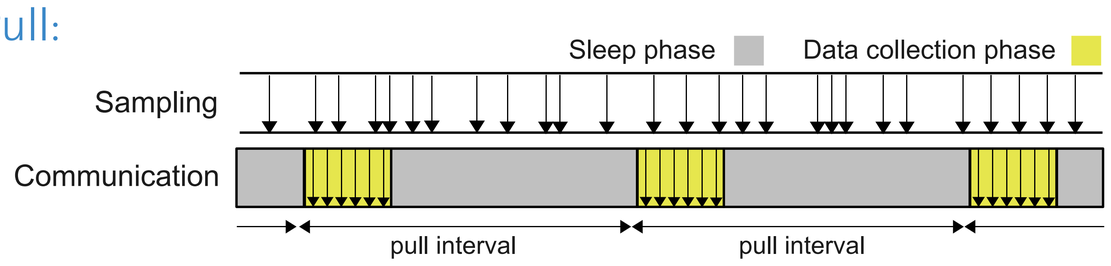
Data Collection: Push vs. Pull

Push:



Nodes transmit (push) data immediately to the sink.

Pull:



Nodes defer data transmission until requested (pulled) by the sink.

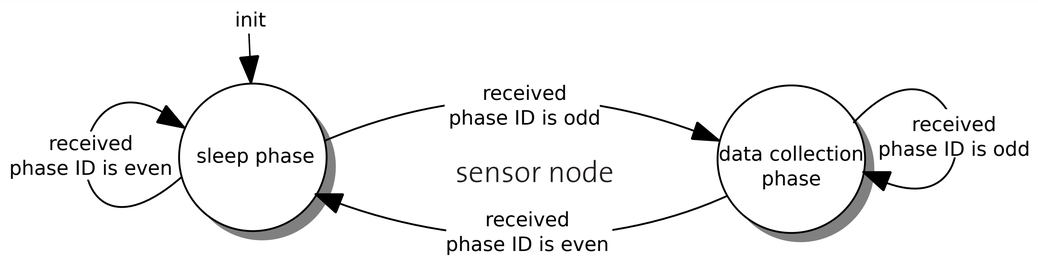
Qualitative Comparison:
- Push features low latency but requires to maintain up-to-date routing paths.
- Pull minimizes radio activity in the sleep phase but consumes additional energy for periodic route initializations.

Most data collection applications use push, even if latency requirements would allow for pull.

Fair Comparison

Transform push-based protocol into pull-based one:
- Split operation in sleep and data collection phases.
- Sink triggers phase changes by setting the phase ID in its beacons.

Buffer management and flow control maximize data yield.

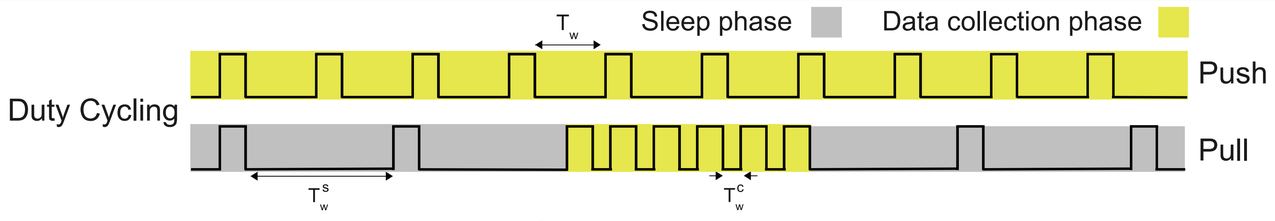


Sink triggers phase changes by incrementing the phase ID in its beacons.

Common MAC and network layers and data yield maximization provide a fair comparison.

Optimizing Pull

Use two MAC wake-up intervals for pull:
- Long T_w^s reduces idle listening in the sleep phase.
- Short T_w^c provides enough bandwidth in the collection phase.



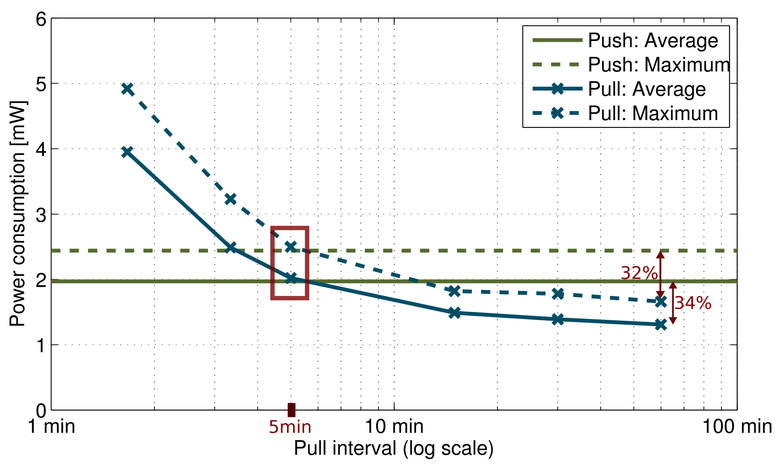
Possible to optimize T_w^s and T_w^c offline in contrast to T_w.

Pull-specific protocol optimizations due to decoupling data sampling from data transmission.

Experimental Comparison

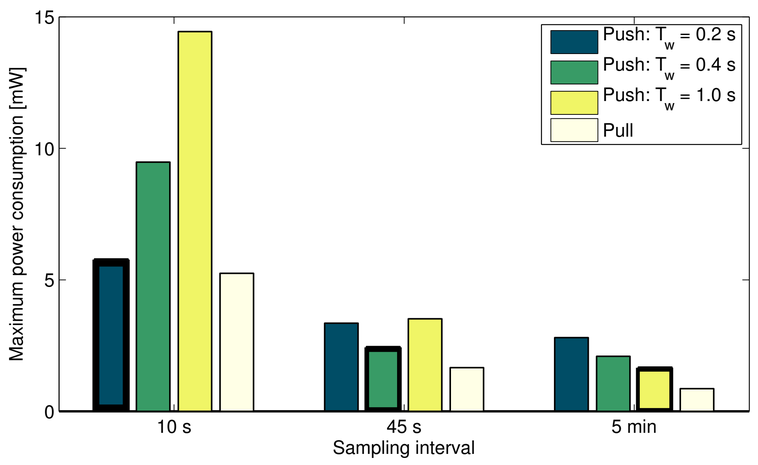
Feasibility demonstration with a basic implementation of the Collection Tree Protocol (CTP) [1] running on top of X-MAC [2]:
- 35-node sensor testbed equipped with Tmote Sky devices running the Contiki OS.
- Compare power consumptions of push and pull, due to reliability modifications 100% data yield achieved.

Impact of Pull Interval



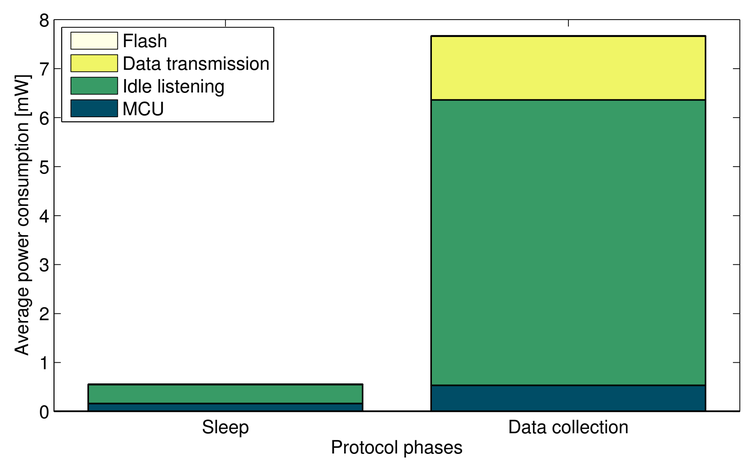
Pull uses less energy than push for pull intervals above 5 min.

Impact of Sampling Interval



Pull outperforms optimized push on all three sampling intervals.

Pull's Power Consumption



Pull consumes 90% less power in the sleep than in the data collection phase.

30% to 40% energy gain with pull, provided application has relaxed latency requirements.

[1] O. Gnawali, R. Fonseca, K. Jamieson, D. Moss, and P. Levis. Collection tree protocol. In Proceedings of SenSys'09.
[2] M. Buettner, G. V. Yee, E. Anderson, and R. Han. X-MAC: A short preamble MAC protocol for duty-cycled wireless sensor networks. In Proceedings of SenSys'06.

The work presented in this poster was supported by CTI grant number 8222.1 and the National Competence Center in Research on Mobile Information and Communication Systems (NCCR-MICS), a center supported by the Swiss National Science Foundation under grant number 5005-67322.