TinyOS 2.1: Adding Threads and Memory Protection to TinyOS

The TinyOS Alliance
(Including all members of the TinyOS 2.x Working Groups)
http://www.tinyos.net

TinyOS 2.1 is the next stage in the evolution of TinyOS. It takes a step towards easier and more robust application development. The most notable features include:

- **TOSThreads**: A fully preemptive application-level threads library that preserves the time-sensitive aspects of TinyOS.
- **Safe TinyOS**: A runtime memory protection service with memory safety checks.
- **Other additions**: 4-bit link estimator, FTSP, IRIS and SHIMMER support, DIP, and optional 802.15.4-compliant MAC layer.

## TOSThreads

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Given motes’ resource constraints, an event-based OS permits greater concurrency. However, preemptive threads offer an intuitive programming paradigm.

**Problem**

Leveraging the user/kernel boundary, the TinyLD component dynamically links applications in the MicroExe format to a static kernel.

**Solution: TOSThreads**

TOSThreads allows fully preemptive application calls to run concurrently, making blocking calls to a single higher priority TinyOS kernel thread. Message-passing threading model does not sacrifice the underlying TinyOS event-driven model.

**Evaluation**

Leveraging the user/kernel boundary, the TinyLD component dynamically links applications in the MicroExe format to a static kernel.

TOSThreads context switches and system calls introduce an overhead of less than 0.92%. TinyLD requires less than 90ms on a representative sensing application.

TOSThreads has been used in various projects:

1. **Latte**, Johns Hopkins University.
2. **Tenet**, University of Southern California.
3. **MAMMARK**, University of California, Santa Cruz.

## Safe TinyOS

John Regehr, Eric Eide, Nathan Cooprider, Will Archer, Yang Chen, David Gay

**Problem**

- nesC is not type or memory safe
- Motes lack hardware-based memory protection
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- Pointer and array errors lead to memory corruption
- Symptoms: Motes act flaky, drop out of the network, etc.

**Goals:**

- Trap all pointer and array errors
- Provide useful diagnostics
- Provide recovery strategies

**Solution: Safe TinyOS**

Exploit Deputy: Deputy is a source-to-source compiler for ensuring type and memory safety for C code. Code compiled by Deputy relies on a mix of compile- and run-time checks to ensure that these annotations are respected, and hence that type and memory safety are respected.

**Conclusion**

Our effort shows that Safe TinyOS is a practical system for the development of reliable sensor network software. Platforms currently supported: Mica2, Micaz and TelosB. Visit our webpage for more information:

http://www.cs.utah.edu/~coop/safetinyos

## Other Additions

- **Collection Tree Protocol (CTP)** with the new 4-Bit link estimator: Rodrigo Fonseca, Omprakash Gnawali, Kyle Jamieson and Philip Levis.
- **Flooding Time Synchronization Protocol (FTSP)**: Miklós Marót, Branislav Kusy, Gyula Simon and Ákos Lédeczi.
- Two new platforms: IRIS (Crossbow Inc.), and SHIMMER (Harvard University and Intel Corporation).
- **A dissemination protocol that scales to hundreds of values**, called DIP: Kaisen Lin and Philip Levis.
- **Optional 802.15.4-compliant MAC layer**: Gabriel Montenegro, Nandakishore Kushalnagar, Jonathan Hui and David Culler.

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