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.

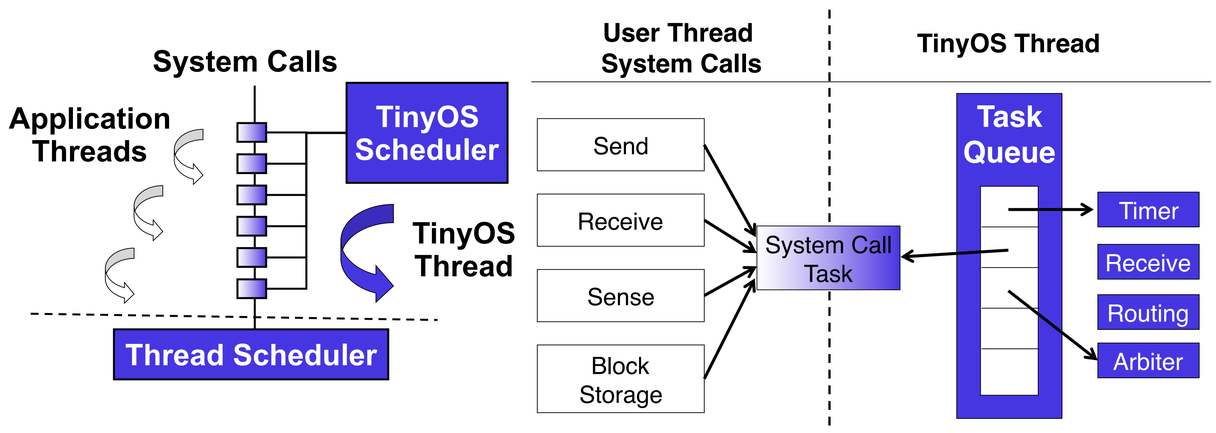
TOSThreads

Kevin Klues, Chieh-Jan Mike Liang, Jeongyeup Paek, Răzvan Musăloiu-E., Ramesh Govindan, Andreas Terzis, Philip Levis

Problem

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

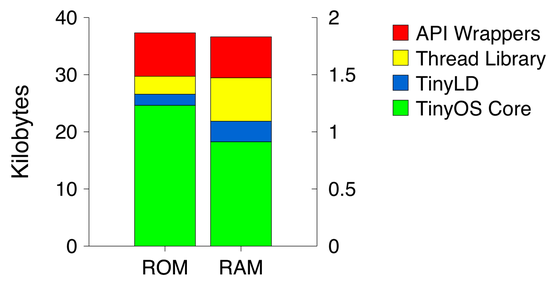
Solution: TOSThreads

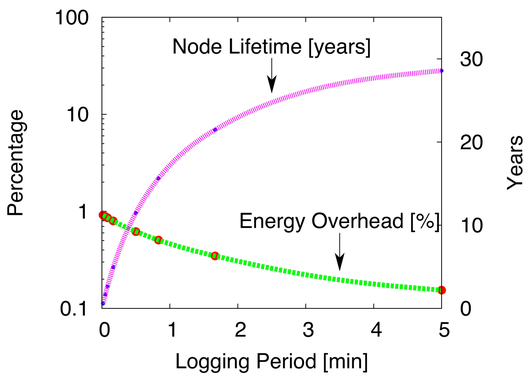


TOSThreads allows fully preemptive application threads to run concurrently, making blocking calls to a single higher priority TinyOS kernel thread. Message-passing threading model does not sacrifice the underlying TinyOS event-driven model.

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.
④ **SPINE**, Telecom Italia.

Safe TinyOS

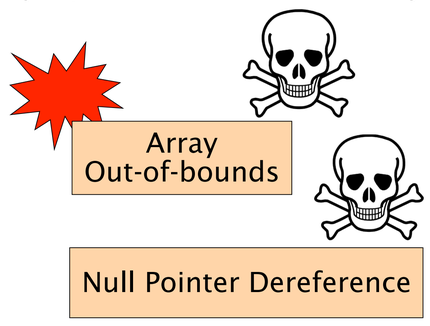
John Regehr, Eric Eide, Nathan Cooprider, Will Archer, Yang Chen, David Gay

Problem

- nesC is not type or memory safe
- Motes lack hardware-based memory protection

So…

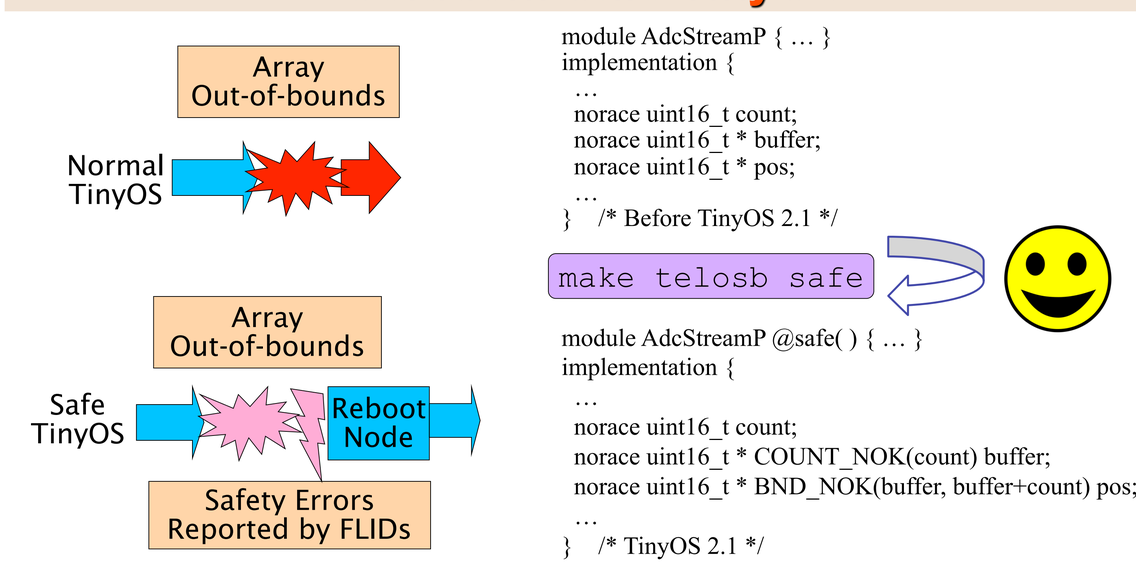
- Pointer and array errors lead to memory corruption
- Symptoms: Motes act flaky, drop out of the network, etc.



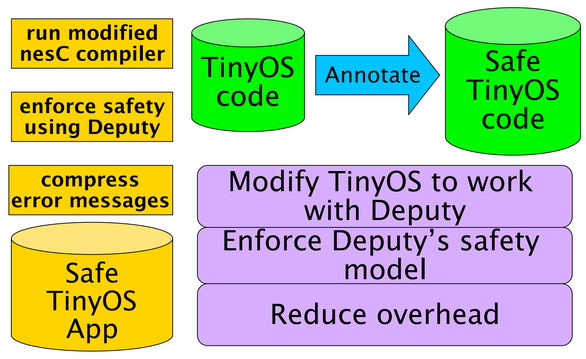
Goals:

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

Solution: Safe TinyOS



Implementation



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 Maróti*, *Branislav Kusy*, *Gyula Simon* and *Ákos Lédeczi*.
- Two new platforms: **IRIS** (*Crossbow Inc.*), and **SHIMMER** (*Harvard University* and *Intel Corporation*).
- A dissemination protocolthat 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*.

Acknowledgments

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We thank the greater TinyOS community for their valuable feedback.