KARYON Kernel-Based ARchitecture for safetY-critical cONtrol

Distributed Diagnostics (WP 4.3)

LibReplay: Deterministic Replay for Bug Hunting in CPS

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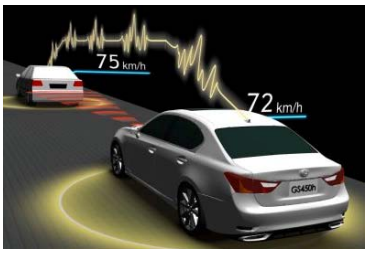
Motivation

Cyber Physical Systems (CPS):

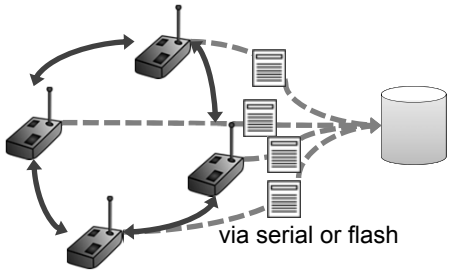
- Deeply embedded into the non-deterministic physical environment
- Wireless networking
- Complex applications: depending on interaction between nodes and environment



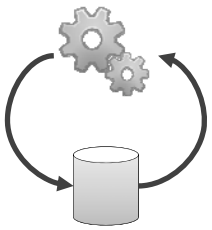
Challenges in Debugging CPS

- Distributed applications
  - Global state
- Non-determinism of
  - Physical environment
  - Wireless networks
- Bugs are often prompted by a particular, complex concatenation of events

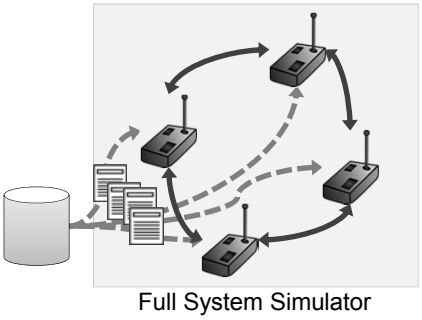
Concept



1. Log



2. Processing



3. Replay

Logging

- Distributed, lightweight logging
- Customizable to code regions
- 2-phase logging for side effect minimization

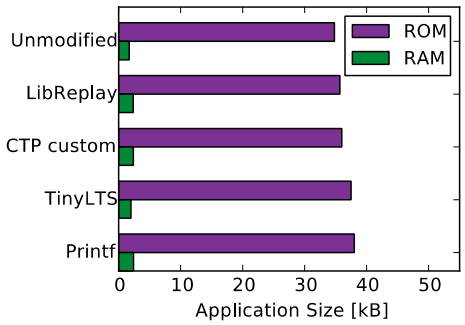
Processing

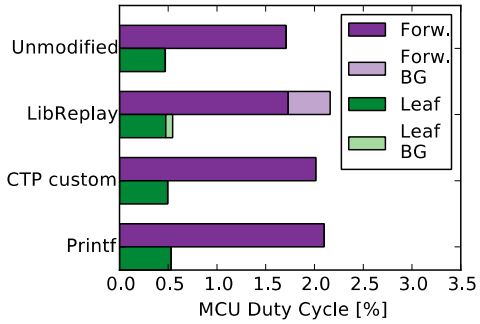
- Merge and sort event logs
- Logical times-stamps to construct a globally-ordered replay
  - Based on radio messages

Replay

- Replay logged input-events
- Full-system simulation
  - Deterministic, high fidelity replay.
- Breakpoints and watchpoints.

Results





Setting:

- TinyOS implementation
- Target system: Tmote Skyy
- CC2420 802.15.4 radio
- MSP430 MCU
- Cooja full system simulaor

Results

Memory (left) and run-time overhead (right):

- Similar to traditional logging systems
- Which to not enable replay

Publications

- "LibReplay: Deterministic Replay for Bug Hunting in Sensor Networks"; O. Landsiedel, E. M. Schiller, S. Tomaselli; in *EWSN: Proc. of the 12th European Conf. on Wireless Sensor Networks*; Feb. 2015 (accepted)
- "Towards Lightweight Logging and Replay of Embedded, Distributed Systems"; S. Tomaselli, O. Landsiedel; In *ASCoMS: Proc. of the Workshop on Architecting Safety in Collaborative Mobile Systems* held in conjunction with *SafeComp*; Sep. 2013; (Invited Paper)

This work was partially supported by the European Unions' Seventh Programme for research, technological development and demonstration, through project KARYON, under grant agreement No. 288195