Poster Abstract: TOSPIE2:
Tiny Operating System Plug-In for Energy Estimation

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ABSTRACT
TinyOS2 (TOS2) is the state of the art operating system for wireless sensor network (WSN) programming. There are a number of testbeds and simulation tools for checking functional correctness and a few integrated development environments (IDEs) that support graphical user interface (GUI) and power profiling of WSN simulation as well. All these systems and environments are tailored towards design optimization of WSNs subject to functional correctness and energy conservation. Unfortunately, all these approaches lack self-contained support for energy harvesting systems (EHSs) which is the state of the art technique for tackling the energy conservation problem. Here, we present the design and implementation of a self-contained X-in-the-loop approach. TOSPIE2 is an Eclipse plug-in that integrates TOS2 installation and compilation support, power profiles and EHS efficiency in simulation and measurement.

Categories and Subject Descriptors
C.2.4 [Computer-Communication Networks]: Network Operations

General Terms
Algorithms, Design, Experimentation, Measurement

Keywords

1. ISSUES TACKLED BY TOSPIE2
Wireless Sensor Networks (WSNs) are applicable to a wide range of applications [13]. Though, they suffer dependability issues in that it is an error prone task to implement functional correctness and power aware behavior at the same time. While there is some support available for power profiling of WSNs there is no approach taken yet for integrating energy harvesting system (EHS) and device (EHD) simulation or even emulation. We provide a fully self-contained development environment with profiling capabilities in simulation and through measurements in hardware. The integration using an Eclipse plug-in allows using an X-in-the-loop approach for WSNs which is tested exhaustively with different types of hardware and software that is subject to power-optimization at different levels of abstraction. TOSPIE2 is an Eclipse plug-in and provides the following contribution to the field of WSNs. As a novel type of integrated development environment, it supports different versions of TinyOS2 (TOS2). Integrating state-of-the-art simulators and an accurate measurement setup allows for power aware WSN design and X-in-the-loop design: power state models (PSMs) and EHS efficiency models (EEMs) can be traced, tested and varied using a PSM/EEM database, EHS and mote hardware can be traced and partly be reconfigured on the fly and EHDs can be traced. Furthermore, we support automatic network scaling and reconfiguration in simulation and in hardware implicitly including effects like realistic packet loss in hardware. We improve over existing solutions in that we integrate all these capabilities into one single plug-in which can even be virtualized due to its remote interface. This allows a team of developers for independent testing using one single setup.

2. RELATED WORK AND COARSE GRAIN CONCEPT
For giving a coarse grain overview of related work we consider hardware and software case studies as well as tools for development, simulation and profiling and also measurement and emulation setups including software, hardware and systems in the loop design. We use Mica2 motes [4], and motes similar to the TelosB architecture [9] and two EHS [3] approaches for evaluation. First evaluation runs have been finished for low power listening (LPL) optimization and PSM and EEM measurements. Different simulation environments for power aware design have been proposed and designed. We set up an environment similar to the one in [1] but including energy harvesting and many opportunities for measurements of hardware testbeds. Furthermore, we interface with the state of the art TOS simulator [7] and Avrora [10]. While [10] improves over [7] with [6] with cycle accurate simulation and power profiling, we improve over that with adding another simulation environment including EHS simulation and trade it for a higher level of abstraction. Similar to other IDEs for TOS we provide a user interface for using the TOS tool-chain. Furthermore, we add a database for capturing PSM and EEM characteristics. Simulations can automatically be scaled in size in the simulation environments and on hardware with adjacency matrices automatically hardcoded to nesC using Matlab. One of the common pitfalls when designing power
aware WSNs is that of inaccurate measurements and power profiling in simulation. Especially the radio component is difficult to model with its different configurations and possible interference. Therefore, we integrate an accurate and high speed measurement setup [2] for FSM and EEM measurements. Updating the database with these values and configuring and even validating power dissipation profiles from simulation gives us the chance for system in the loop (SIL) methods. The SIL concept is similar to the approach taken in [12] and uses a similar hardware setup as well. It allows testing and configuring simulation environments, mote applications and EHS protocols. Different operating points for the EHS can be tested through EHS and mote configuration. Multiple EHDs of different types can be used with the setup where a lot of traces exist. These and EHD modeling in previous work [11] are being used for work in progress that deals with construction of a configurable EHD emulation. It is being implemented on the same measurement setup again using LabVIEW [5] as the setup for configuring FSM and EEM. It follows an approach similar to the one by [8], but it uses the irradiation modeling from [11]. Implementing EHD emulation is given priority over battery emulation due to the high impact of correctly operating an EHS [2].

3. RESULTS AND CONCLUSION

TOSPIE\(^2\) is an Eclipse plug-in for developing power aware WSNs. TOS2, Avrora and TOSSIM Support and front-ends are integrated as well as a novel simulation environment for EHS enhanced WSNs and a FSM and EEM database and measurement setup. Motes and EHSs can be measured very accurately where the EHS itself can be used for profiling EHDs in the field. Using these profiles and concept from previous work builds a basis for EHD emulation. The simulation and measurement setup allows to automatically scale for differently sized networks where the tested size is only limited by the number of available hardware entities. The measurement setup has a worst case error of 2.1% using measurement cards with 10\(^5\) and 10\(^6\) samples per second respectively. Different levels of abstraction in simulation face different sampling rates from traces of fine grained LPL measurements (Figure 1) to coarse grained EHS efficiency (Figure 2). The main result from using the approach and setup is that TOSPIE\(^2\) automation can greatly reduce development time and allows for a novel approach in testing of EHS networking policies in simulation and measurement to evaluate dependability and energy conservation at once.

4. REFERENCES


