Demonstration of WISDOM - a Wireless in Field Measurement and Debugging Platform for Wireless Sensor Networks and Devices

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***Abstract*—Energy consumption is one of the major concerns in battery powered wireless sensor networks (WSN) that should be considered not just at the end of the development process. It depends on several factors at different layers and accompanies nearly the entire product life cycle. Starting from the choice and layout of hardware, up to the decision of software, concepts such as an Operating System (OS) or driver libraries, the application itself, the overall system behaviour, ageing processes as well as environmental conditions. Therefore the power consumption of a single wireless node within the network and even the complete network should be carefully considered, calculated or estimated and simulated. Finally the overall consumption needs to be evaluated under real environmental conditions. The *Wireless in Field Measurement and Debugging Platform (WISDOM)*, presented in [1], has been created to support the developers during the overall development process and to support him at this type of questions. The demonstrator will give an overview of how to find potential power consumers and assess optimization potential even within complex systems.**

I. Introduction

Energy efficiency can not be implemented at the end of a development process. If it is part of the requirements, such as memory space, size or unit price, it accompanies the entire development process and should be taken into account. For that reason there is a strong demand for the evaluation of power consumption of nodes in a *Wireless Sensor Network (WSN)* during the entire development phase. This evaluation can be done in early design stages by using simulations and models, but there is also the need for an evaluation in a real setup. This demonstrator presents the WISDOM platform (revision 1.2), which is a sensor node by itself. WISDOM is equipped with a 24-bit *Delta Sigma Analogue to Digital Converter (ADC)*, that is used to measure power consumption of attached sensor nodes either locally during the development process on a given host (called *local operation mode*) or distributed within a WSN. Monitored measurements can be transmitted wireless in a low data rate to a sink or by USB in high speed mode in *local operation mode*. Thus a power consumption profile can be created for a large scale WSN under realistic load conditions. Also energy related optimization options can be investigated and fully used during the early development stage. The WISDOM platform as shown in figure 1 provides a dynamic range of 1 : 100000 for power metering, which is important for monitoring sensor nodes that operate in deep sleep modes as well as in high power transmission modes. It is based on a Texas Instruments MSP430F5 MCU and has an optional interface to communicate with an attached *Device Under Test (DUT)*. At local operation mode, current and voltage of a connected DUT will be measured at 7800 samples per second. Therefore the DUT power supply needs to be connected to the WISDOM device as shown in figure 4. This can be the DUT battery, a USB connector or another DC power supply.

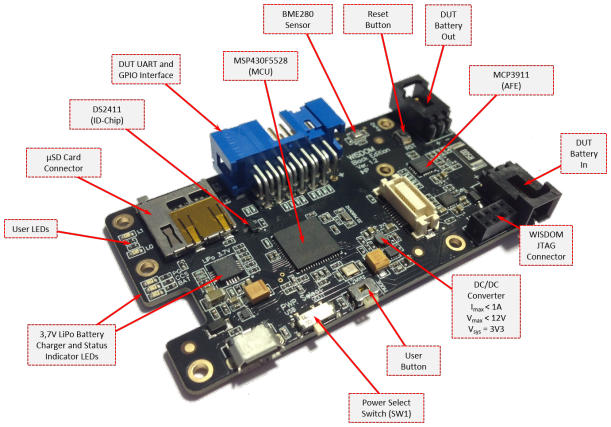

Fig. 1. WISDOM platform and its components.

II. Demonstrator

The demonstrator will show different ways and opportunities to help developers point out energetically expensive code or even concepts and increase energy efficiency based on WISDOM measurements. The demonstration will start with a simple tracking of power consumption, including the boot sequence up to the main loop as shown in figure 2. Even without a specific assignment of code and consumed power, the measurements will already give a rough impression about

what is going on within the embedded device or for example if basic sleep modes are working as expected.

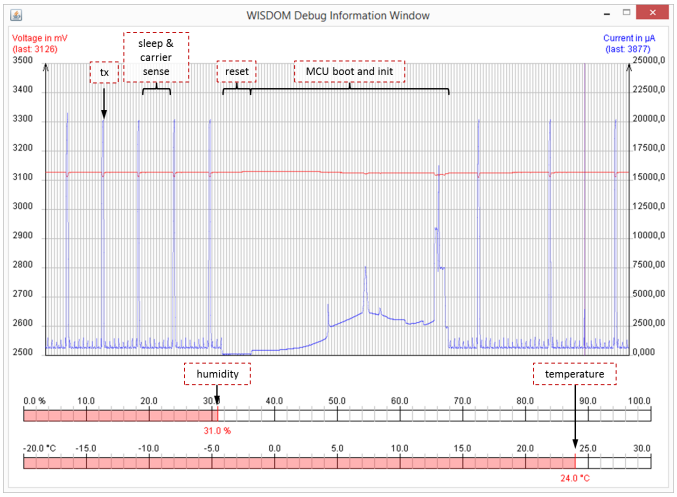

Fig. 2. Simplified view of WISDOM graphical user interface for local operation, DUT is a telosB node with 2 AA batteries, running a default Contiki beacon application.

Based on the same WISDOM device and within a second step, a more sophisticated view on the data will be presented as shown in figure 3. This tool for advanced developers will introduce and demonstrate the usage of states within the source code and their representation. Therefore the DUT will communicate in a lightweight way with the attached WISDOM device and decode its actual state by up to four *General Purpose I/O GPIO* pins. This states are used by the WISDOM device to assign power consumption to a previously defined and named state or sequence within the code. It links them with power measurements and the time that has been spend within that state. This will give developers an important indication about where to spend time and effort to optimize their code. Of course this platform and method has its limits, which will be demonstrated as well.

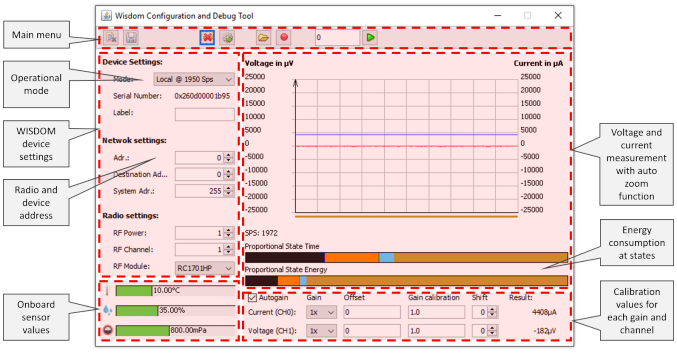

Fig. 3. More sophisticated representation including state based power consumption and basic configuration options.

The demonstrator shows the usage of WISDOM in a local operating mode. It is locally connected with a computer that will run its measurement software as shown in figure 3. The DUT is a battery supplied wireless sensor node as shown in figure 4, running a simple blink application. This application will be profiled by WISDOM at the beginning to get a rough outline about the actual status. It will then be modified step by step to optimize the power consumption and to show the benefits of using WISDOM already during the early development stage. Finally it will be demonstrated how to assess energy-related optimization options based on the states introduced above.

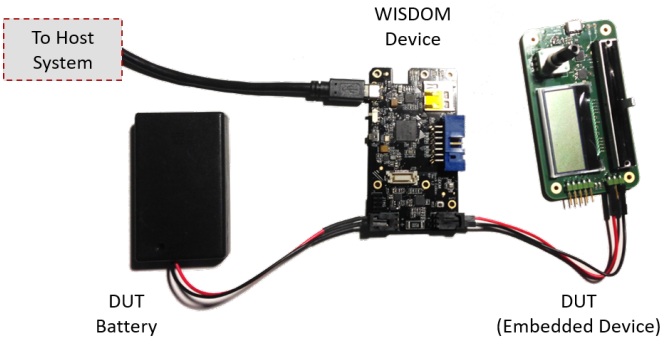

Fig. 4. Demonstrator equipment and composition showing an example of a embedded device connected to a battery such as in field operation.

WISDOM has been designed to operate in a field setup as well as in a local setup. However, the demonstration will only present a local operation due to export regulations, the release of frequency bands, transmission power and duty cycle in different countries and possible legal consequences.

III. Requirements for the Demonstration

The demonstration is mostly based on a software written in Java and operating on a standard notebook with Microsoft Windows operating system. The notebook as well as all cables are provided by the presenter. Only a 230 V 50 Hz power socket (EU socket type C or compatible), a 3-way distribution strip and a small desk or shared space on a desk of at least 60 by 60 cm is required.

Acknowledgment

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References

[1] M. Frohberg, E. Batlkhagva, and M. Schölzel, “Wisdom — a wireless debugging and power measurement system for field tests and device observation in wsn,” *2017 Signal Processing: Algorithms, Architectures, Arrangements, and Applications (SPA)*, pp. 319–324, 2017.