Poster Abstract: BTnodes – A Distributed Platform for Sensor Nodes

Jan Beutel, Oliver Kasten, Matthias Ringwald *
Swiss Federal Institute of Technology (ETH) Zurich
8092 Zurich, Switzerland
beutel@tik.ee.ethz.ch

ABSTRACT

We motivate a prototyping platform for ad hoc networking research showing some requirements and constraints. The architecture of the BTnodes, each of which can store information, compute and communicate, is explained in conjunction with some demo applications that have been implemented. Important requirements and design trade-offs to be able to support multiple, compatible communication interfaces, to handle limited resources, for power-aware operation and for efficient testbed deployment are discussed.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design

General Terms

Management, Design, Experimentation, Standardization

1. INTRODUCTION

According to [4] and others, services in the network are the dominating factor for future growth. By using standardized communication interfaces, Wireless Sensor Network (WSN) nodes can interact with everyday appliances, peripheral devices, sensors and actors alike. Fostering this interaction are well established and acquainted user interfaces on already common devices such as PDAs and cellular phones that make it possible to reach out into the digital representation of smart everyday objects and interactions.

Typical applications in research are in fast prototyping of demo applications [2, 5, 7], interfacing to other devices (sensors, actors, multimedia and computing devices) [8] and the implementation of emerging networking concepts that have so far only been analysed in theory and simulation. Other applications such as the one shown in Fig. 1 want to interface networks of sensors to commercial devices such as cellular phones [8] and PDAs where compatibility and adaptability of the interfaces are most critical issues.

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Figure 1: Product monitoring using BTnodes as smart tags and SMS via mobile phones.

Bluetooth is a connection-oriented, wireless communication medium that assures interoperability between different devices. A standardized interface (HCI) hides most of the lower-layer abstraction from the system developer and releaves the host-system from digital signal processing and real-time system tasks. Networks of Bluetooth devices are organized in Piconets. These are Master-Slave star topologies that can be interconnected to form larger Scatternets. Compared to other media used in low-power wireless research [6, 3], Bluetooth offers considerably higher bandwidth, abstract and high-level link-layer functionality such as synchronous communication, multiplexing, integrated audio, different channel characteristics, link keys and encryption. The most apparent difference is that the developer is not dealing with a baseband and MAC interface but with dedicated communication channels.

Key requirements for a ubiquitous research platform are flexibility, power-aware operation, efficient deployment and the support of standardized interfaces. The target features that have been realized in the design of the BTnode are (1) in-circuit programmable Bluetooth platform, (2) remote update of system software, (3) low component count, (4) compact overall system size, (5) simple debugging capability, (6) sensor and user interface and (7) a single voltage design with power management.

2. BTNODE ARCHITECTURE

The BTnode is an autonomous wireless communication and computing platform based on a Bluetooth radio module and an Atmel ATmega128L microcontroller (see Fig. 2). Benefits of this platform are a small form factor of 6x4 cm and comfortable programmability while maintaining interoperability through its standardized wireless interface. Simple sensors and actors can be attached to generic interfaces.

The microcontroller features an 8-bit RISC core deliver-

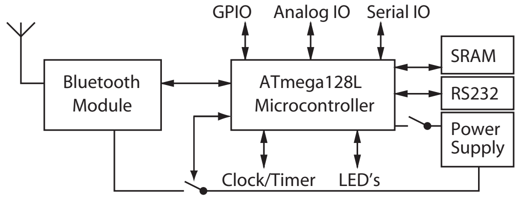

Figure 2: The BTnode system overview.

ing up to 8 MIPS at a maximum of 8 MHz. The on-chip memory consists of 128 kbytes of in-system programmable Flash memory, 4 kbytes of SRAM and 4 kbytes of EEPROM. There are numerous peripherals integrated as well as an external low-power SRAM that adds an additional 240 kbytes of data memory to the BTnode system.

An Ericsson Bluetooth module is connected to one of the serial ports of the microcontroller using a detachable module carrier and to an integrated planar inverted F antenna.

3. COMMUNICATION ORIENTED OS

The BTnode system software is a lightweight operating system made up of low-level drivers that are interrupt driven and a simple dispatcher for scheduling multiple threads. This OS is well-suited for the applications of such small-scale networking devices that will consist mostly of simple IO and monitoring tasks and communication.

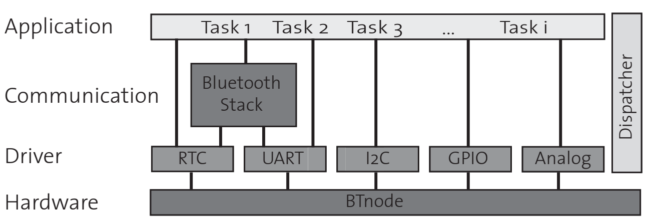

Figure 3: A lightweight communication oriented OS framework for WSN applications.

An event-driven programming model provides convenient functions for resource management. The dispatcher is used for the scheduling of tasks; it implements coarse-grained co-operative multithreading. A software component, such as a driver, can generate an event to notify other components of the occurrence of a change in state requiring further action.

4. POWER AWARE OPERATION

Different power-saving modes are available for both the microcontroller and the Bluetooth module. A real-time clock controlled by a separate driver is driven by a separate oscillator to allow to make use of the low-power modes of the BTnode over longer periods of time. Furthermore, the microcontroller can be operated at different software-controlled frequencies.

A simple qualitative sensor application example (see Table 1) with a 10 % duty cycle reveals a quite acceptable average power-consumption of 6.5 mW and a battery lifetime T on the order of weeks on a standard 840 mAh Li-ion battery. Newer Bluetooth hardware is much less power-hungry than our first generation developer hardware, reducing power-consumption in communication mode by a factor of 2-4.

Operation	t [sec]	P [mW]	T [h]
Sensing	4	12	252
Communication	2	160	19
Idle	54	0.5	6048
Total		**6.5**	**421**

Table 1: Power consumption example.

5. PLATFORM DEPLOYMENT AND TOOLS

Different tools are necessary in order to support fast prototyping and debugging. A software kit with documentation and demo examples, a mailing list and software repository are available to developers [1]. A separate build tree on Linux with the required interface and hardware emulation as well as the remote software updates that are performed by network flooding are other key items of a successful deployment.

The BTnodes have been developed and distributed in co-operation of the NCCR-MICS [4] and the Smart-Its Project, the latter being a part of the EU Disappearing Computer initiative. The low complexity and small bill of material of the BTnodes results in a unit cost of USD 110 for the initial deployment of currently 200 units that have been distributed among several research groups worldwide.

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