Programming the World with Sun SPOTs

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Abstract

We describe the Sun\(^1\) Small Programmable Object Technology, or Sun SPOT. The Sun SPOT is a small wireless computing platform that runs Java\(^*\) directly, with no operating system. The system comes with an on-board set of sensors, and I/O pins for easy connection to external devices, and supporting software.

Categories and Subject Descriptors C.3 [Computer Systems Organization]: Special Purpose and Application-Based Systems – real-time and embedded systems.

General Terms Management, Languages,

Keywords Sensors Sensor Networks, Distributed Programming, Mesh networks, Network Management, Java.

1. Introduction

The Sun Small Programmable Object Technology, or Sun SPOT, is a battery-powered, wireless computing device for use in sensor and actuator networks that are embedded in the physical world (See Figure 1). The Sun SPOT is unusual for several reasons: it runs Java "on the bare metal" (there is no operating system). Furthermore the Java VM running on the Sun SPOT, called "Squawk," [1], can run many mutually isolated applications in a single VM. We are also experimenting with a capability that lets applications migrate as they run. With this capability, a user can move a running program over the radio, from one Sun SPOT to another, to achieve network load balancing, to facilitate in-the-field replacement, or any other of a number of novel applications.

The Sun\(^1\) SPOT is based on an ARM9 processor with an 802.15.4 radio chip. The Sun SPOT software comes with Java libraries that enable control over external devices such as speakers or servo motors. It also comes with several A/D lines, general I/O pins, 8 LEDs, and on-board sensors including an accelerometer, light detector, and 2 input switches. The system comes with software for writing, deploying, and debugging code. We are developing a system called SPOTWorld, a management tool that enables the user to inspect and manage the programs running on their Sun SPOTs.

2. Hardware

The Sun SPOT is based on a 32-bit 180 MHz ARM920T core, and has 512K of RAM and 4MB of flash memory. The Radio part is a CC2420 802.15.4 radio with an effective range of about 80 meters. The radio antenna is a trace on the processor board.

In normal operation the unit typically requires 25-90 mA of current depending on which sensor are enabled, and weather or not the radio is in use. The unit can automatically go into a "deep sleep" mode requiring 36 \(\mu\)A. A small auxiliary processor runs a real-time clock, which can be used to wake the unit from deep sleep.

The Sun SPOT also includes a “demo sensor board” with a collection of various sensors. It includes 8-tri-color LEDs, two push buttons, a 2G/6G 3-axis accelerometer, plus light and temperature sensors. There are also 6 analogue inputs, and 9 general purpose I/O pins, 4 of which support high current output.

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\(\text{ACM}~1-59593-491-X/06/0010\).
3. **Softwave**

“Squawk”[1] is a J2ME-level VM with added OS functionality. It is written largely in Java. On the Sun SPOT, the VM requires 80 KB of RAM, and can execute directly out of flash memory. The libraries and most of the Java components of the VM use 270K of the flash.

A Sun SPOT can be configured as a base station, and connected to a host computer by USB cable. The host can then communicate with Sun SPOTs, using the radio in the base station.

4. **SPOTWorld**

We are developing an integrated management, deployment, debugging, and programming tool called SPOTWorld (See Figure 3). SPOTWorld can be integrated with an IDE so that code can be written, compiled, and deployed to the Sun SPOTs.

In SPOTWorld the user sees each SPOT, and can query it for state including which applications can be launched, and which are currently running. The applications themselves can be accessed through pop-up menus on an icon representing the application. This enables the user to pause, resume, or exit the application. In an experimental feature, we can drag an application from one SPOT to the next, even as the application runs. We believe live application migration of this sort may have many novel applications.

5. **References**


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**Figure 1.** SPOTWorld can run as a panel inside the NetBeans IDE. Each of your Sun SPOTs is depicted on the screen. The triangles represent the applications running on each device. Pop-up context menus enable the user to start new applications, or to address individual applications—to pause, resume, or quit them. At the lower right are conventional networked hosts which are running the same version of Java, thereby enabling their applications to be managed as well.