HARDWARE PLATFORM

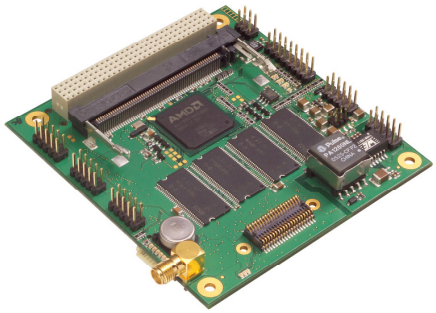
Reconfigurable Ubiquitous Networked Embedded Systems

Gateways and Robots

Since no single platform can achieve all the different goals in the embedded networking domain, RUNES technology is designed to be platform agnostic. In order to leverage more powerful networked embedded systems and validate the component-based middleware in end-to-end systems, two prototype platforms have been implemented: a gateway node and a sensor routing node. Prototype robots and new algorithms have also been developed in order to handle transient network disturbances such as load variations and topology changes. These underlying hardware platforms feedback information to the upper layers of the development, mainly the middleware, where the core of the reconfiguration and adaptation happens and from where it is driven.

cool MoteMaster

The *cool MoteMaster* is a gateway node for wireless sensor networks developed in the project. These networks are used in many applications where wireless connections are needed to allow flexible installations, or where wired networks are simply impractical. Both fixed and ad-hoc networks can be built using the cool MoteMaster. The board features an IEEE 802.15.4 transceiver and by using a ZigBee™ stack the board can communicate with motes supporting this emerging standard. The board also has connectors for Bluetooth and WLAN modules. The board can be controlled through a number of interfaces including standard PCI-104, miniPCI, Ethernet, USB and serial. The cool MoteMaster uses an AMD Alchemy Au1550 processor and runs the Linux operating system. Troubleshooting is made easy with supervision LEDs for power, watchdog, Ethernet and application-defined signaling. The PCI-104 bus allows system expansion with commercially available peripheral I/O boards. With a clock speed of 500MHz and 128MB of RAM and 256MB of Flash provided, cool MoteMaster is being used in several of the demonstrators and prototype systems developed in the RUNES project. Other application areas for the cool MoteMaster include home automation systems, medical applications and industrial control.



cool MoteMaster: a high-end gateway with 802.15.4 RF interface, extendable with Bluetooth and WLAN interfaces.

FP6 RUNES Integrated Project (IST 004536)

Overview
RUNES integrates and extends cross layered research ranging from hardware and network communication to application usability and middleware to advanced control theory and verification tools for validation of the methods and prototypes.

Objective
Provide an architecture, middleware and specialised simulation/verification tools that enables the creation of large-scale, widely-distributed, heterogeneous networked embedded systems that inter-operate and adapt to their environments.

Partners
connectBlue
CRC
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SICS
Università di Pisa
UCL
UC Berkeley
UC San Diego
University of Patras
University of Queensland
Victoria University

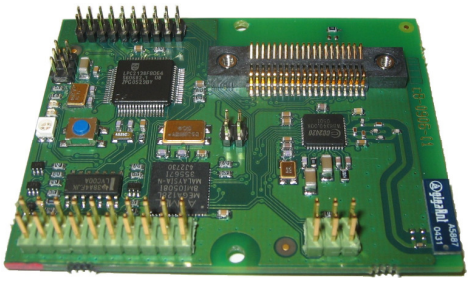
Countries involved
Australia
Canada
Germany
Greece
Italy
Hungary
Sweden
UK
USA

Start of the project
Sept 2004

End of the project
July 2007

Sensor Routing Node

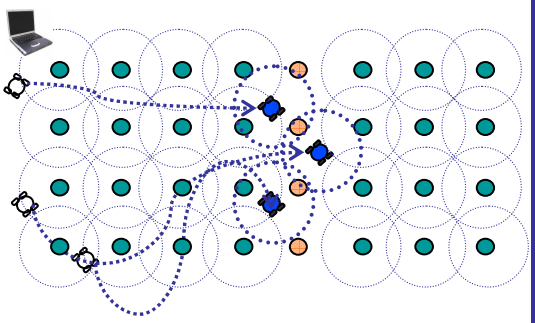
Also developed for the project, this sensor routing node platform supports the IEEE 802.15.4/ZigBee wireless standard using and integrated antenna. The communication capabilities can be extended by the optional Bluetooth or IEEE 802.11b WLAN modules. The platform is controlled by an ARM7 processor running at 59 MHz with 32 kB RAM and 512 kB Flash. The node is configurable by various I/O ports (digital, analog, serial) and can support a wide range of operating systems including FreeRTOS as currently being used in the RUNES demonstrators.



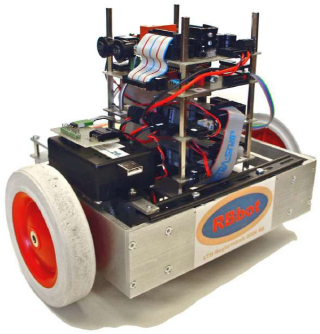
Sensor Routing Node a low-end gateway with two RF interfaces, one exchangable.

Advanced Control Methods for Network Connectivity

Advanced control components developed within RUNES are being demonstrated through a physical network reconfiguration scenario as part of the 'fire in a road tunnel' demonstrator. In this scenario, the tunnel network has been partitioned because of a malfunction of some of the nodes as a result of a fire. Autonomous mobile robots equipped with radio transceivers are sent into the tunnel to be positioned to bridge the gap between the network clusters. New software components in the RUNES platform are being developed to appropriately control the position of the robots and the transmission power.



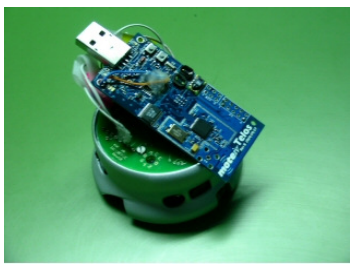
Robots carrying the sensor routing node re-establish wireless connectivity between parts of the network.



Mote-controlled robot.

The autonomous robot shown above was developed as part of RUNES and can be navigated via an ultrasound interface and data transmitted by stationary motes. The ultrasound receiver circuit is connected via a Tmote Sky A/D converter while the transmitter circuit is connected through a ATmega16 low-power consumption 8-bit microcontroller based on the AVR enhanced RISC architecture.

As part of the work undertaken in relation to the 'fire in a road tunnel' scenario, a source localisation robot in a hostile environment, has been developed. The operation of the system is as follows: luminance measurements are taken by robot sensors which are sent to a base station via motes. The base station sends directions to the robot and the robot converges on the source location. The current implementation is based on a Khepera II miniature robot and Telos motes. Khepera II are actuated by two DC-motors and are equipped with 8 light sensors. The communication is performed via a serial interface that is controlled by a Telos mote.



Source localisation robot.

Rationale

An embedded system is a special-purpose computer system contained within a device that is expected to function without human intervention. The wide range of devices containing embedded systems inevitably leads to significant complexity in appropriately interconnecting and dynamically reconfiguring their software. New approaches in software design are needed to address the power, computation and communication bandwidth limitations but also security. RUNES provides an adaptive middleware platform and application development tools that allow programmers the flexibility to interact with the environment where necessary, whilst affording a level of abstraction that facilitates ease of application construction and use. The results of the project should be of interest to technologists, product managers, manufacturing managers, strategic planners and consultants working particularly in the following sectors:

- Healthcare
- Transport
- Utilities
- Industrial processes
- Security
- Oil & gas
- Food and agriculture
- Environmental

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