Smart-Its: Computers for Artifacts in the Physical World

Tiny embedded devices attached to everyday objects can transform them with sensing, perception, computation, and communication abilities.

BY **Hans Gellersen**

SMART-ITS ARE SMALL DEVICES THAT integrate a microprocessing unit with sensors, actuators, and wireless communication. These devices are similar in composition to typical wireless sensor network nodes, but are conceived as add-on devices for artifacts in the physical world. As add-on devices, they are designed to operate in the background of physical artifacts. This gives primacy to artifacts and their familiar use in human activity while the technology is embedded invisibly to afford additional functionality. For example, personal artifacts may be augmented to support their tracking in case they get misplaced, and toxic artifacts can have technology added to alert inappropriate storage.

A platform for such augmentation must be highly configurable to support adaptation to a wide range of artifacts with different physical and digital attributes. This is reflected in both the hardware and the software design of Smart-Its.

The Smart-Its hardware is based on a modular device architecture and allows for a large degree of flexibility in terms of network support and type and number of sensors and actuators. Smart-Its can be as small as 10x10x10mm including a variety of sensors and battery (for information on Smart-Its particles, see particle.teco.edu/). Other Smart-Its modules are slightly larger, for example, to ease customization with a less compact board design [3], or to include Bluetooth connectivity and other interfaces [1]. A variety of device modules are available as part of a growing tool kit, and developers can build additional ones by adapting generic board designs. For further flexibility, device designs can be mapped to different physical layouts, allowing devices to be realized in customized form factors.

Smart-Its are programmed for single applications embedded in artifacts. They can be repurposed by replacing the executable code. Depending on the type of Smart-Its, this can be done wirelessly with an over-the-air programming tool. System functionality, such as managing subtasks for physical I/O and communication, is compiled into application code before deployment. C libraries provide programming abstractions at various levels, for example, shielding developers from hardware detail. At the application level, interfaces and code libraries are provided for the set of tasks typically performed by an embedded Smart-Its application. These include reading sensor data, processing sensor data to application-specific context, communicating context events over the network, processing received events, and the control of actuators.

The Smart-Its platform has been used to study a variety of applications deployed into physical artifacts. For example, in the Cooperative Artifacts project, we have used Smart-Its to build prototypes of augmented chemical containers that can detect and alert potentially hazardous situations. The embedded Smart-Its are configured with ranging sensors to measure the proximity of other containers, and they are programmed to share and evaluate context information across nearby containers, for instance, on type and mass of stored chemicals [5]. In a related application example, Smart-Its have been used to augment physical goods with an electronic seal that asserts their authenticity and physical integrity [2].

A particular strength of the platform in application research is its support for rapid prototyping of augmented artifacts. This was demonstrated at SIGGRAPH 2003, where an entire exhibition space was rapidly transformed into an interactive experience with a network of Smart-Its embedded in tables, chairs, and a range of smaller artifacts [4]. **C**

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