IT Footprinting—Groundwork for Future Smart Cities

Sumi Helal, *University of Florida*

The goals for developing smart cities are clear and convincing, and the technology is promising and exciting, but achieving these goals requires a massive IT footprinting process.

Recent advances in pervasive and ubiquitous computing provide a glimpse into the future of our planet and reveal exciting visions of smart cities, homes, workplaces, hotels, schools, and much more.

Driven by a technological evolution offering "low-power many things and wireless almost everything"—for example, IEEE 802.15.4 radio, wireless sensor networks, and sensor platforms—we could, in only a decade, envision and prototype impressive smart-space systems that improve quality of life, enhance awareness of resources and the environment, and enrich user experiences.

For most of these systems, the goals are clear and convincing. But prototyping is one thing—commercial proliferation and creating a new industry are another.

THE PATH TO SMART CITIES

In particular, many governments around the world are pursuing the development of smart cities. Driven by increasing urbanization and serious economic and environmental challenges, smart cities are emerging as a way to offer technology solutions to bridge the widening gap between supply and demand while reducing urbanization's impact on the environment. This effort also offers an opportunity to recover from the effects of the global recession by creating new green industries and businesses.

Yoshiaki Kushiki, corporate advisor to Panasonic Corporation, points to an important requirement for such new industries to succeed: consumers must also change by choosing "spiritual richness" over "material affluence." This is a valid observation because most of the products and services in smart cities will offer intangible benefits such as energy savings, sustainability, and reduced CO2 emissions in contrast to a "materials only" approach—for example, acquiring the newest and fanciest iPhone on the market.

In principle, the path to smart cities is obvious—embed sensors, actuators, or computers into objects and spaces that make up the smart city's important elements. This "smartening" approach is not new, having driven the embedded systems industry for more than two decades. What's new here are the massive scale and the new ecology that the smartening process requires.

MASSIVE SCALE

Smartening an entire city is a massive IT footprinting process. To appreciate the scale, think about these questions. How many people live in a large city? How many homes, apartment buildings, and office buildings are there? How many electricity meters? How many wall power plugs? How many cars and parking spots? This is a sample set, but the list could grow very large, and the total number of objects and spaces that will have to be smartened could easily number in the hundreds of millions.

The smart grid alone—an essential part of most envisioned smart cities—will require installing a smart meter in every structure drawing electric power, thereby injecting tens of millions of sensing devices into the cyber-physical infrastructure. The smart grid will also require other controllers that integrate the electrical grid with the IT infrastructure, starting from the supply side, passing through the distribution networks, and ending at the demand side.

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Developing smart cities may start with the smart grid, but it doesn't end there. CO2 zero-emission homes and net-zero-energy buildings may necessitate additional IT footprints. Plug-in hybrid and electric vehicles will also require IT footprinting in the form of in-dash PCs. In addition to energy, other concerns such as healthcare, elder care, education, security, public safety, smart transportation, entertainment, and emergency response will require massive IT footprinting.

NEW ECOLOGY

But do we have all the ingredient technologies for such massive IT footprinting? Unfortunately, the answer is no. Achieving this objective requires rethinking embedded computing's role and goals. Existing embedded operating systems (OSs), for example, will need to change. They're currently focused only on smartening an object or a device—they're smart but introverted. They don't know about the cloud or the edge devices in between.

To put it another way, current embedded OSs are for smart cities what DOS was for the PC in the early 1980s. We need a new breed of embedded OSs capable of natively and autonomically integrating, connecting, and programming enormous numbers of sensors to the cloud. Without this fundamental change, the IT footprint will simply look like a massive array of stovepipes that needs an army of engineers to integrate it, no matter how smart each individual pipe is.

Advances in hardware are also required. Common components and subsystems will need to enter the marketplace at a faster pace. Memory cards are an example of an industry that has successfully followed this model. Developers will need to tightly integrate more "brain" and communication elements into common modular components in useful packages and form factors. Perhaps what's needed is an ecosystem parallel to the auto parts industry, offering the same standardized functional part in various forms, sizes, and shapes.

Once IT footprinting is enabled, adding point-of-service delivery and interaction platforms such as set-top boxes, smartphones, and public displays will complete the necessary infrastructure for smart-city rollouts. Then, a new world of powerful and serious applications and services will be unleashed, making the app store as commonplace as the local grocery store or Facebook.

This special issue offers four articles on smart cities covering the IT perspective, applications and services, interaction and user experience enrichment, and a fast-progressing smart-city initiative in South Korea.

The topic will obviously be revisited in the future to assess progress and refine our understanding of the changing landscape of goals and requirements. We look forward to your active participation in this area and to receiving your future contributions on this topic.

Sumi Helal *is a professor in the Department of Computer and Information Science and Engineering at the University of Florida. His research interests include pervasive computing, mobile computing, and networking. Helal received a PhD in computer sciences from Purdue University. Contact him at sumi.helal@gmail.com.*