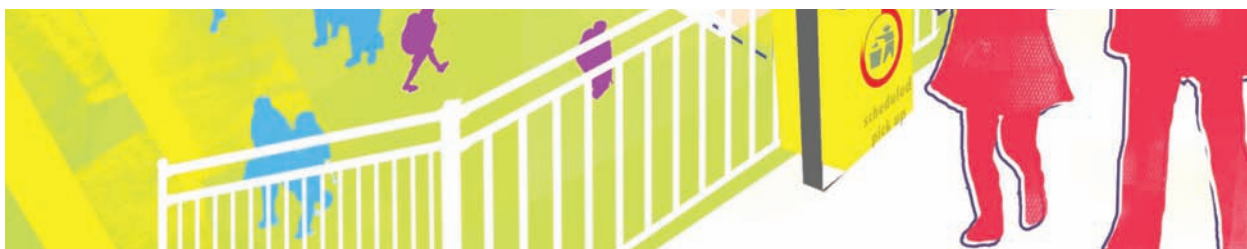


# Creating Smart Buildings and Cities



Central to the vision of smart cities is the concept that by fostering a better understanding of human-computer interaction, we can simplify data creation, consumption, and analysis to improve our quality of life. This concept harks back to Mark Weiser's vision of pervasive computing, which focused on the idea of the smart home.<sup>1</sup> Thirty years later, researchers and practitioners are still working to realize Weiser's vision, but we've also expanded it, building out from the smart home to the smart city. However, as this vision extends beyond the home, and as we continue to collect and analyze data at unprecedented scales, new research questions and challenges, as well as novel opportunities, emerge.

grow, users gain greater access to smarter and more appropriate services. In addition to traditional in-situ sensors, such as weather stations and air-pollution monitoring systems, city inhabitants are now carrying around new types of mobile sensors in smartphones, including GPS and Bluetooth sensors. The key to building smart environments is to fuse and seamlessly integrate multiple technologies, including these mobile sensors, along with the Internet of Things (IoT), communication networks, cloud computing, big data analytics, actuators, and various apps. Such technology integration is starting to provide near-real-time information about cities, complementing the more traditional, lower temporal resolution data often collected for cities.

We're in the middle of a data revolution that's providing new insights into cities, allowing us to better understand citizen expectations regarding "smart" buildings and cities. As we explore what infrastructure is necessary to support smart environments, we must determine the best ways for citizens to interact with such

Andrew Crooks  
*George Mason University*

Katja Schechtner  
*MIT Media Lab*

Anind K. Dey  
*Carnegie Mellon University*

Andrew Hudson-Smith  
*University College London*

## Building Smart Environments

As technology rapidly evolves, and as the number of sensing devices in our cities continues to

environments. We must also consider the return on investment for smart environments, and answer a myriad of other questions related to improving the quality of life in cities: How do people respond to traffic gridlock? Where do tourists go? How does energy consumption change from week-

Vladimir Zdraveski, Kostadin Mishev, Dimitar Trajanov, and Ljupco Kocarev demonstrate how to move beyond just displaying simple real-time information accessed via APIs. Instead, they propose aligning city dashboards with ISO 37120, a standard focused on the sustainable development of communi-

Oliver Bates and Adrian Friday discuss lessons learned from integrating data from existing energy and building management systems at Lancaster University in the UK. Their work aims to enable integrated analysis and optimization of energy use within the campus (so they can identify waste and set targets for energy savings), while simultaneously meeting the needs of the various stakeholders involved.

## If we can understand the multifaceted nature of a city... then we can define indicators to help us build better urban infrastructures.

days to the weekend? Where do people feel safe? Where are people most relaxed? How do we protect their privacy in an environment that is always sensing? If we can understand the multifaceted nature of a city, and how the different views contribute to creating a higher quality of urban life, then we can define indicators to help us build better urban infrastructures and services and provide an evidence base for quantifiable reporting on smart city investments.

This special issue presents a collection of articles and departments that shed light on some of these questions and showcase how technology can help monitor and analyze urban environments.

### In this Issue

In the first theme article, “Noninvasive Bluetooth Monitoring of Visitors’ Length of Stay at the Louvre,” Yuji Yoshimura, Anne Krebs, and Carlo Ratti use longitudinal data collected via Bluetooth sensors to examine the length of stay and routes of visitors in the Louvre Museum, Paris. Such analysis could lead to better management of visitor flow for tourist attractions and thus a more enjoyable experience for citizens and visitors alike.

In “ISO-Standardized Smart City Platform Architecture and Dashboard,”

ties—in particular, on indicators for city services and quality of life. The authors present an architecture that fuses diverse data sources and sensors (including Flickr and Foursquare) with government data, demonstrating their platform’s application in Skopje, Macedonia. The platform aims to complement slow-changing data (annual, quarterly, or monthly reports) with real-time data, potentially developing near real-time input for models that can then help infer or forecast future smart city indicators.

Our next theme article is “SenseCityVity: Mobile Crowdsourcing, Urban Awareness, and Collective Action in Mexico,” by Salvador Ruiz-Correa, Darshan Santani, Beatriz Ramírez-Salazar, Itzia Ruiz-Correa, Fátima Alba Rendón-Huerta, Carlo Olmos-Carrillo, Brisa Carmina Sandoval-Mexicano, Ángel Humberto Arcos-García, Rogelio Hasimoto-Beltrán, and Daniel Gatica-Perez. The article describes SenseCityVity, a project focused on engaging and supporting youth in Guanajuato, Mexico as they investigate, document, and reflect upon urban problems through mobile crowdsourcing. While Guanajuato was used as a test bed, such a platform could be used in other cities for promoting urban engagement among younger inhabitants.

In “Beyond Data in the Smart City: Repurposing Existing Campus IoT,”

Moving away from integrating existing sensor networks, there’s also the question of how to deploy new ones. It’s difficult and costly to deploy a sensor network, because you rarely know the detailed requirements and placements prior to collecting any data. Yasue Kishino, Yutaka Yanagisawa, Yoshinari Shirai, Shin Mizutani, Takayuki Suyama, and Futoshi Naya discuss how to overcome this issue in their article, “Agile Environmental Monitoring Exploits Rapid Prototyping and In Situ Adaptation.” The authors demonstrate how environmental monitoring systems can be rapidly constructed and deployed in the field and then adapted in-situ through trial-and-error testing. They present three case studies, which involve monitoring greenhouse growing conditions, fish habitats, and air pollution, exemplifying how the sensor design, hardware, and software can be customizable to reduce the risk of failure when deploying a sensor network.

Perhaps the greatest success of sensor networks in our daily lives is the role they play in providing us with current transportation-related information (such as when the next bus will arrive or what current traffic is like). While much of the focus until now has been on the hardware and software of such sensor networks, especially for optimizing public transportation, we’re now seeing the growth of smart mobility technologies. Such technologies provide a means for incorporating the wishes and preferences of individual travelers moving around the city. In the Spotlight department, “What Can

We Learn from Smart Urban Mobility Technologies?” Barbara Lenz and Dirk Heinrichs, from the DLR Institute of Transport Research in Berlin, discuss how smart mobility technologies have evolved. Specifically, they consider how such technology can help people access and exploit multimodal transportation options, and they present related challenges and research opportunities in relation to future transportation systems.

Finally, while many of the articles in this special issue take a technological or instrumental viewpoint, we also wanted to consider a more humanistic view of smart cities. For example, how might such technology be adopted by city administrators? To explore this question, Katja Schechtner interviewed Rob Kitchin, a professor at the National University of Ireland Maynooth. They discussed how there is a perceived gap between two groups involved with smart cities. On the one side, there are the electrical engineers and computer scientists, who focus on the instruments and infrastructure. On the other side, there are the urban planners and architects, whose role is to plan, create, build, and manage cities. Kitchen explains how this gap could be bridged through interdisciplinary work focused on communication and mutual learning between the two groups, which could result in the adoption of more inclusive smart city solutions.

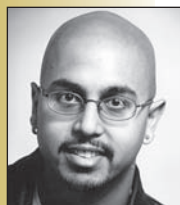
**T**his special issue demonstrates the state of the art of pervasive computing technologies that collect, monitor, and analyze various aspects of urban life. The articles and departments highlight the coming revolution in urban data via some of the different approaches researchers are taking to build tools and applications to better inform decision making (to reduce energy consumption or improve visitor flows, for example). Such research will be critical to setting goals for sustainable urban develop-



**Andrew Crooks** is an associate professor in the College of Science at George Mason University. His research interests include exploring and understanding the natural and socio-economic environments, specifically, urban areas by fusing together geographic information systems, social network analysis and agent-based modeling methodologies. Crooks received his PhD in geography from University College London. Contact him at [acrooks2@gmu.edu](mailto:acrooks2@gmu.edu).



**Katja Schechtner** is a visiting scholar at the MIT Media Lab and a visiting professor at the Vienna University of Technology. She is a senior advisor for urban technology investments for the Asian Development Bank, the Inter-American Development Bank, and European governments. Her research interests include finding ways to improve our understanding of the dynamic relationships between human behavior and the built, social, and technological environments. Schechtner received her MSc in architecture and urban planning from Vienna University of Technology. Contact her at [katjas@mit.edu](mailto:katjas@mit.edu).



**Anind K. Dey** is a professor and the Director of the Human-Computer Interaction Institute at Carnegie Mellon University. His research interests include ubiquitous computing, HCI, and machine learning in the areas of mobile computing, health, and sustainability. Dey received his PhD in computer science from Georgia Tech. Contact him at [anind@cs.cmu.edu](mailto:anind@cs.cmu.edu).



**Andrew Hudson-Smith** is the director of the Bartlett Centre for Advanced Spatial Analysis (CASA) at University College London. His research interests include real-time data, IoT, urban simulation, and human computer interaction. Hudson-Smith received his PhD in advanced spatial analysis from University College London. Contact him at [a.hudson-smith@ucl.ac.uk](mailto:a.hudson-smith@ucl.ac.uk).

ment within different global contexts. We need to better understand cities and their underlying systems if we want to improve the quality of urban life.

However, such reform is not without its challenges, and perhaps the largest challenge isn't in the technology itself but rather in the need to get buy-in from stakeholders—in particular, from citizens and mayors. The works presented here demonstrate that by relying on a multitude of sensors, we can collect rich datasets and develop new ways of integrating and analyzing information. Yet we must also understand the people within the city. This is specifically brought out in the article by Bates and Friday; to what extent should we change the norms of people, organizations, and governments within and across cities

to ensure more sustainable practices are adopted to improve our quality of life? If the vision of Weiser is paired with our new insights into citizens' lives and with a greater shared understanding between the engineers, urban planners, and civic society, then perhaps the answer to this question is just around the corner. ■

## REFERENCE

1. M. Weiser, "The Computer for the 21st Century," *Scientific American*, Sep. 1991, pp. 66–75.

**myCS** Read your subscriptions through the myCS publications portal at <http://mycs.computer.org>.