connected sustainable cities

William J. Mitchell & Federico Casalegno

Printed in the United States of America.
First printing 2008.

ISBN-13: 978-0-9821144-0-7
ISBN-10: 0-9821144-0-0

Library of Congress Cataloging-in-Publication Data

MIT Mobile Experience Lab Publishing

www.connectedurbandevelopment.org
www.mobile.mit.edu

Illustration Coordination, Daniel Cardoso
Book design by Pamela Botacchi, Pearl Graphics

six/conclusions

These scenarios have demonstrated some of the practical ways in which ubiquitous connectivity can help us to create and manage sustainable cities. From them, it is possible to draw some general conclusions.

Sensing and data mining

First, connected sustainable cities will depend upon continuous, fine-grained, electronic sensing of the human activities unfolding within them. Tiny, inexpensive sensors and tags of varied kinds are increasingly being mounted on buildings and infrastructure, carried in moving vehicles, integrated with wireless mobile devices such as telephones, and attached to products. These sensors are harvesting enormous streams of data that can be mined, by means of sophisticated software, to generate detailed, real-time pictures of evolving human activities, needs, and demands within the buildings and neighborhoods of cities. This provides the foundation for much more efficient response to mobility, space, environmental control, and other needs than has been possible in the past, and supports the optimal allocation of scarce resources – energy, water, materials, road space, and so on – to meet those needs.

Decentralized action

Ubiquitous networking allows the collection of this information everywhere and distribution of the information to wherever it may be needed – to the edges of networks as well as to central points. Further,

distributed memory and processing capabilities enable effective use of this information in local contexts. Thus buildings, vehicles, and mobile individuals can become intelligently aware of the broader contexts in which they operate, can effectively manage their own actions – taking account of sustainability as well as other goals, and can begin to function as actors in larger self-organizing systems that respond to these goals on larger scales.

Electronic actuation

The responsiveness of connected sustainable cities can be achieved through well-informed and coordinated human action, automated actuation of machines and systems, or some combination of the two. For example, the entry of sunlight into a building can be controlled by manual operation of blinds and shutters or by sensor-controlled and electrically actuated blinds and shutters that respond automatically to changing external conditions and interior needs. Similarly, you can switch lights on and off when you enter and exit a room, or you can leave it to sensor-controlled systems to do this automatically. In both the manual and automated cases, resources are conserved by controlling the relevant systems attentively and precisely.

Human attention and cognitive capacity, however, are scarce resources, and generally it isn't effective to burden people with having to think constantly about controlling the systems that surround them. Furthermore, with the ongoing development of actuator technologies, it is becoming increasingly feasible and cost effective, in many contexts, to provide automated actuation. Therefore, in the connected, sustainable buildings and cities of the near future, we can expect to see increasing use of automatically actuated mobility systems, climate control and lighting systems, water and sewer systems, industrial plants, product supply and waste removal systems, appliances, and other elements and surroundings. Buildings and cities will evolve towards the condition of rooted-in-place robots.

Control systems and software

Just as online environments, such as retail sites, are now managed by extremely sophisticated software, so too will be the physical systems of connected buildings and cities. The standalone software that controls individual machines and systems at present will increasingly be combined into larger-scale, more broadly integrated systems. Widely accepted standards will be required to make this possible – much as with the integration of many smaller networks into the Internet.

This integration will enable efficiently coordinated responses to needs across different systems – as, for example, when the linkage of a home thermostat system to the GPS navigation system of an automobile enables the heating system to be turned down automatically when the inhabitants are out and then gradually turned up as they begin to return home.

These integrated systems will enable real-time response to dynamically varying conditions such as traffic and weather. The accumulation of data from their operation will also enable identification of long-term trends and patterns in urban activities for use in planning and design.

Local versus extended loops

Today's cities have very complex supply chains for the water, food, energy, materials, and goods that they require. These supply chains not only extend into their hinterlands, but also globally. There are also complex removal chains for the processing and elimination of waste products. Recycling of resources takes place when supply chains, consumption points, and removal chains are connected to form closed loops. In connected sustainable cities, entire supply and removal loops will be managed efficiently through electronic tracking and control.

Furthermore, there will be opportunities to achieve efficiencies by shortening these loops. In pre-industrial cities, for example, buildings often collected rainwater from their roofs, consumed it on the premises, and then disposed of wastewater locally – a low-tech solution, but

one that entailed a very short supply and removal cycle. Similarly, food might be produced in a domestic garden, and then food waste mulched back into the garden. In the industrial era, though, growing cities sought economies of scale by vastly extending supply and removal chains. Thus, water might be transported from reservoirs hundreds of miles away, and then wastewater conveyed to regional-scale sewage treatment plants. Now, in connected sustainable cities, the combination of electronic monitoring, decentralized processing, and automated systems can enable efficient, high-tech versions of short supply and removal cycles – as, for example, in electronically managed, domestic-scale, rainwater collection, water recycling, and garden irrigation and management systems.

A particularly important instance of loop-shortening occurs when connected urban villages replace regional-scale workers. Here, the combination of connectivity with electronic devices and software tools allows the development of live-work dwellings organized into 24-hour neighborhoods. Rather than commuting to work at distant locations every morning and returning in the evening, inhabitants of these urban villages can travel much shorter daily distances – with resulting savings in energy use, carbon emissions, and traffic congestion.

Multitasking and spatial flexibility

In the pre-digital era, urban environments were largely subdivided into places for specialized uses. Homes were for living, offices were for working, cafés were for eating and drinking, and trains and buses were for traveling. When these spaces were not in use as intended, they mostly remained vacant. With the spread of wireless mobile and portable devices, though, the use of space began to become more flexible. Any place where you can sit down and get a wireless connection to your laptop now becomes a potential workplace, for instance.

In combination with architectural and vehicle design that responds appropriately to this new condition, this enables spaces to be more intensively and effectively used. In combination with scheduling and coordination software, it enables spaces to be allocated flexibly to meet needs as they arise. Further, from the perspective of mobile, connected inhabitants of a city, it means that "wasted" time – such as time spent

sitting idly on a bus or train – can now be used for working, shopping, socializing, or entertainment. All this adds up to more flexible, effective, and efficient use of the real estate and the hours in the day available to city dwellers.

Informed, responsible choices

In our digitally networked, information-saturated era, ignorance of the consequences can be no excuse for ill-considered actions. It is increasingly possible to keep close track of our energy, water, and carbon footprints so that we can evaluate the sustainability consequences of our daily choices and actions. We have, at our fingertips, the tools and computation power to enable participation in sophisticated new markets, such as personal carbon trading markets. Connected sustainable cities will encourage new forms of personal and group responsibility, and will establish powerful incentives to meet those responsibilities.

Like individuals, government institutions and businesses – be they small or medium enterprises, or large corporations – also have responsible choices to make. The success of a connected sustainable city depends on coordinated policy and action in the development and introduction of information and communication technologies.

Businesses must commit to changes in how they work and to adopting sustainable technologies to use for that work. This is not only about the large-scale, systematic use of, say, renewable energy, but also about daily operational choices, from using recycled paper to replacing vehicle fleets with hybrid cars. Businesses must also promote a culture change that encourages remote work and virtual office solutions, as well as social networking within offices, without any of the drawbacks or penalties that often exist today for employees who engage in these activities.

Governments at every level (federal, regional, municipal) need to adopt policies and regulations that promote such choices. Worldwide organizations also play a crucial role, but local authorities – because they are in direct contact with citizens in the local loop – are especially important in fostering the development of connected sustainable cities and social sustainability.

The next generation of ICT tools

New tools and applications are becoming available that make it less-expensive, easier, and more effective than ever to coordinate collective action among people that can promote sustainable development and behavior. Often referred to as Web 2.0, these technologies allow easier knowledge- and information-sharing, both crucial to the development of connected sustainable cities. On these emerging collaborative platforms, people can share and capitalize on lessons learned from best practices around the world. These types of tools can advance the rise of a new bottom-up culture of decisonmaking and promote civic engagement on topics of great importance, encouraging people to get involved and take action locally and on a global level.

Advances in how the global ICT network will work in the future will fuel the changes. One is Internet Protocol version 6 (IPv6), which provides much more space for Internet addresses than is currently available. This enables far more things to be connected to the Internet and allows tremendous traffic routing flexibility. Another is the "Internet of Things," a concept in which all of the 50 to 100 billion objects of daily life (from a can of soda in your refrigerator to a city bus on the other side of the world) would have radio-frequency identification tags that make it possible for them to be managed by computers.

Education and new culture

A new dynamic of participatory citizenship dynamics can be leveraged on the emerging technologies described above. But it will not happen simply by putting the technological tools in people's hands. We also need to raise the consciousness about the issues and about the role individuals and communities must play. This will require a new literacy about connected sustainable development, one that shows people worldwide that the complex challenges we face must be confronted by us both as individuals and collectively. Education will be crucial to creating a new culture of sustainability based on responsible choices.

Inventing sustainable urban futures

Connected sustainable cities will not emerge automatically. We will have to use our imaginations to invent them, and we will need to be determined and resourceful in pursuing implementation. This book, we hope, has provided some starting points for the necessary debates about goals and priorities, and for the formulation and evaluation of technology, policy, planning, and design options.

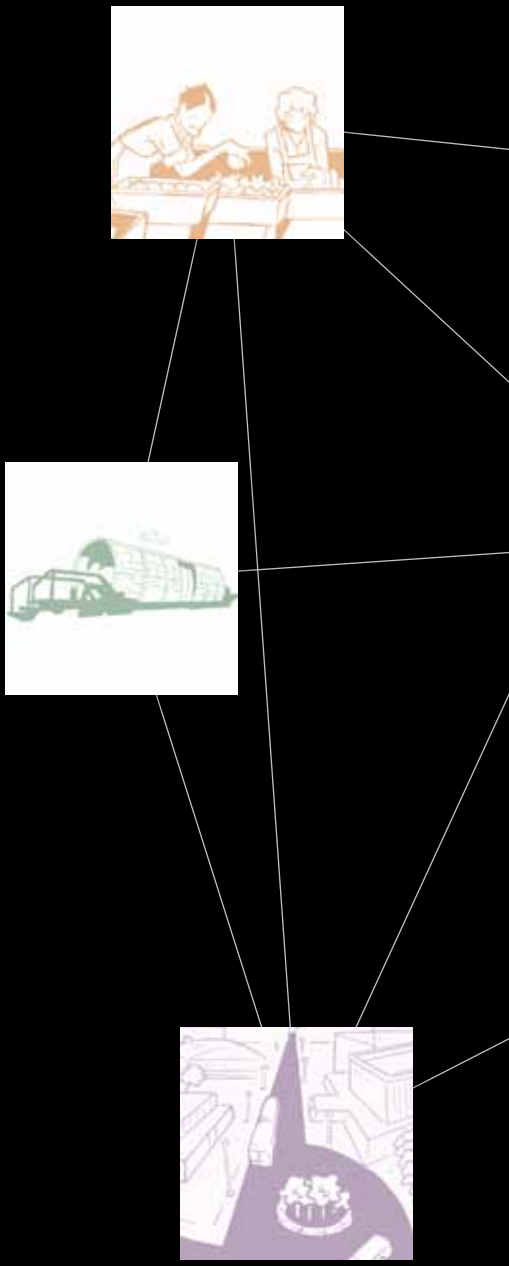
The development of connected sustainable cities will, of necessity, be a broadly based, multidisciplinary enterprise. It will require researchers and technology companies to create and make available the necessary devices, systems, and software. It will demand the rethinking, by architects and urban designers, of some fundamental assumptions about the organization and use of space. It will need the clever integration of information systems with urban infrastructures of all kinds – mobility systems, energy systems, water systems, and waste removal and recycling systems. And it will depend upon the development of appropriate policy frameworks and business models.

The challenges are great, but there is no realistic alternative to confronting them. Cities will continue to grow in the 21st century, and the aspirations of their inhabitants will continue to rise, but the resources available to sustain them will be limited. To keep supply and demand in appropriate balance while preserving the quality of urban life and social equity, we must harness information, intelligence, and connectivity to create systems and patterns of urban life that manage those resources in the most efficient and responsible ways.

Connected sustainable cities, which will evolve over the next decade, employ ubiquitous, networked intelligence to ensure the efficient and responsible use of the scarce resources – particularly energy and water – that are required for a city's operation, together with the effective management of waste products that a city produces, such as carbon emissions to the atmosphere.

Through a series of prospective scenarios, *Connected Sustainable Cities* illustrates some of the ways in which inhabitants may use and manage their living spaces, move around the city, work, shop, pursue their educational, cultural, and recreational interests, and make well informed, responsible personal choices. These scenarios are accompanied by brief sketches of the existing and emerging technologies, products, and systems that will support new, intelligently sustainable urban living patterns. In addition, there are short discussions of some of the theoretical, policy, and design issues that these scenarios raise.

Connected Sustainable Cities is a starting point for the investigations and debates that will be necessary as citizens, technologists, designers, policy experts, and political and business leaders begin to shape the new urban areas we urgently need to create in the near future.



FSC © Mixed Sources
Product group from well-managed forests, controlled sources and recycled wood or fiber
www.fsc.org Cert no. SW-COC-002514
© 1996 Forest Stewardship Council

Printed in the USA with soy based inks on FSC certified paper

ISBN-13: 978-0-9821144-0-7
ISBN-10: 0-9821144-0-0

MIT Mobile Experience Lab Publishing

CONNECTED URBANDEVELOPMENT