Smart Cities:
innovation, vitality, and scale

Are cities alive?

For the better part of twenty years, world-renowned theoretical physicist Geoffrey West worked on developing scientific models of both biological organisms and cities. West and his research team discovered that all living organisms scale according to a universal mathematical principle. To their surprise, they also discovered that the physical infrastructures of cities scale in a similar way.

When an organism doubles in size, West's research shows, the biological processes and the physical structures underlying them increase by only 75%. "This scaling law is truly remarkable," West says. "It goes from intracellular organisms up to ecosystems almost 30 orders of magnitude larger . . . It applies to me, all mammals, and the trees sitting out there, even though we're completely different designs."[1]

Cities follow a similar pattern. When a city doubles in size, **the elements of its infrastructure increase by only 85%.**

Every aspect of a city's resource network, from the total length of its roadways and electrical lines to the number of its ATMs and gas stations, scales this way. As with biological organisms, the scaling principle is universal. "It's the same scaling in Europe, the United States, Japan and so on," says West.[2]

The implications of this research can be surprising. Cities are often criticized for their apparent wastefulness, as demonstrated by the sheer volume of pollution and garbage they produce. The bigger the city, the conventional wisdom goes, the worse the problem. It turns out, however, that city infrastructures, like living organisms, benefit from economies of scale: that is, larger organisms make more efficient use of the body's resources than do smaller organisms. Similarly, larger cities make more efficient use of water, electricity, space, and every other conceivable resource than do smaller cities, or even rural areas, appearances notwithstanding.

Although exponentially increasing urbanization may be a major contributor to the world's most pressing environmental problems, the research suggests that urbanization may also be the source of sustainable solutions to those problems.

Open-ended innovation

Because it had been so successful describing and predicting the growth of urban infrastructures, West tried to use the scaling principle he discovered to describe the socioeconomic elements of citieshwealth creation, innovation, quality of life. It didn't apply, but he discovered that a different scaling principle did. Instead of demonstrating economies of scale, as resources and infrastructures do, those aspects of city life that have no biological analogues demonstrate increasing returns to scale.

Increasing returns to scale occur when the outputs or results of a process increase by more than the proportional change in inputs. In other words, when a city doubles in size, its socioeconomic output more than doubles. As West says,

"systematically, **the bigger the city, the more wages you can expect, the more educational institutions in principle, more cultural events, more patents are produced,** it's more innovative and so on."[3]

West's research shows that doubling the size of a city nets about a 115% increase in its socioeconomic richness. This scaling factor, it turns out, also seems to be a universal principle.

West's work puts some science behind the familiar feeling that cities are magnetic, exciting, innovative places. Cities are "the centers of wealth creation, creativity, innovation, and invention," says West.[4] According to his research, they are measurably so.

While economies of scale eventually encounter an inherent mathematical limit, increasing returns to scale do not: they are mathematically open-ended. This is good news for things like economies and creativity, which can theoretically grow without interruption. Of course, cities don't live forever. A municipality may face the threat of collapse for many reasons. It may run out of resources, for example, or the pace of life and growth may outstrip the ability of its citizens to adapt and adjust.

As West points out, continuous open-ended growth demands continuous innovation, but to be sustainable it has to be intelligent innovation, innovation that puts the capabilities, quality of life, and well-being of people front and center. Game-changing innovations can give cities renewed vitality, as many examples throughout history show.

"We discover iron, we discover coal, or we invent computers, or we invent IT," says West, "but it has to be something that really changes the cultural and economic paradigm."[5]

While the challenges and complexity of cities can seem daunting, the innovations exist today that can make substantive, transformative changes to the cultural and economic paradigms. These innovations include new thresholds in data communications and bandwidth, digital technologies such as LED lighting and controls, and smart devices of all kids distributed throughout the urban environment, including smartphones, smart sensors, smart energy meters, and more.

Smart devices all have in common the ability to gather, share, and respond to data. The networking and interaction of smart devices is what the so-called Internet of Things is all about. The Internet of Things, in turn, provides the foundation for the cluster of innovations and approaches known as the Smart City.

Connected public lighting: a powerful enabler for the Smart City

Increasingly efficient infrastructure, sustainable resource usage, innovations in digital technologies and smart devices, and a long-term vision with people's quality of life at the center: these are all key elements of Smart City thinking. While individual innovations can make significant differences by themselves, the

challenge and the opportunity of the Smart City is finding ways to integrate a wide range of innovations and deploy them intelligently.

Take LED street lighting as an example. Conventional street lighting can account for as much as 40% of a city's total energy budget. Switching to LED

street lights alone – available today from a wide range of manufacturers – can reduce the energy consumed by street lights by 30% or more. Combining LED street lighting with software-based monitoring and management can boost those savings to 70% or even higher.

Of the approximately **300 million street lights worldwide, less than 10% are LED today,** and fewer than 1% are intelligently monitored and managed.

The potential energy savings of converting all street lighting around the world to managed LED lighting runs to tens of millions of kWh per year. And these energy savings don't account for the additional massive savings in labor, infrastructure, and maintenance costs that cities would realize by combining LED street lighting with software-based lighting management and related data-rich applications.

Deploying the single innovation of LED street lighting intelligently and universally would by itself make a significant impact on the global economy. But the Smart City story isn't a street lighting story. It's a story about transforming urban infrastructures through intelligent innovations. Lighting may play a significant role in that transformation, but it's only a part of the whole.

To create the fully realized Smart City, city planners and managers need to stop thinking in silos, with each department or service running its own network, with its own data and processes, and no links between them. City resource networks need flexible interfaces to share data and achieve new levels of efficiency, both to

minimize consumption and maximize the effectiveness of the workforce.

If conceived of and deployed properly and intelligently, public lighting can play a unique role in making the Smart City a reality. Street lights, luminaires, light poles, and other lighting assets are everywhere. With LED and communications retrofits and new installations, a city's lighting infrastructure can take advantage of and even enhance the powerful communications networks available today – the mobile phone network, Wi-Fi, traditional wired IT networks, and so on. The light pole itself can become a point of intelligence and communications, offering a convenient integration point for wireless signal boosters, smart sensors of all kinds, and networking hubs.

Because the physical lighting infrastructure is ubiquitous – it's already installed wherever people live, work, play, and travel – it can serve as a backbone for many different applications. Open technologies and well-defined software interfaces allow city managers to link services together and manage them centrally and comprehensively. Well-defined interfaces also afford an opportunity to start small and implement new applications quickly, as technologies evolve and needs grow and change. Many new applications, unforeseeable today, will evolve, ensuring the vibrant city life that people expect well into the future.

Connected operations are also key. They ensure that access to

city service networks is available anytime, anywhere. Rather than supplanting existing processes, connectivity becomes part of how city departments get work done for their citizens. Better apps for technicians in the field streamline workflows. Centralized control of resource delivery optimizes scheduling. Over time, city managers can combine data and expert knowledge derived from city operations with other sources of information for new insight and informed decision-making. Here, too, lighting is leading the way, with sophisticated, extensible, cloud-based management platforms already available in many markets around the world.

In addition to all of this, it's important to remember that public lighting does something that no other city service can do: it illuminates city streets, parks, civic spaces, bridges, monuments, and buildings. Public lighting plays a special role in cities because it transforms the visual appearance of places, producing a particularly strong emotional impact. More than other public service, urban lighting is integral to a city's identity and character.

With connected operations powered by connected lighting technologies, the means for delivering the best light are quickly evolving. Connected technologies support lighting experiences informed by contemporary design practices and research findings, from ambient to dynamic, responsive to interactive. Smart, digital systems provide lighting when and where it matters for citizens, making cities safer, more inviting, and easier to navigate.

Smart citizens, **not just smart technology**

Innovations in technology are crucial, but it's important to remember that **social and economic considerations are equally crucial.**

A purely technical conception of a Smart City pays insufficient attention to the needs of its "end users" – the citizens who live there. People are drawn to cities for many reasons, including economic opportunities, social connections, and cultural diversity. A Smart City should reinforce the best of what a city can offer to the people who want to live there. That means, among other things, maintaining a high quality of life in

urban environments as they become ever denser and busier.

Urbanist and Smart City thinker Anthony Townsend has written about the importance of a two-fold emphasis: on realizing "the potential for efficiency and optimization" through technology and innovations on the one hand, and on enhancing "spontaneity, serendipity, and sociability" through people-centric applications and experiences on the other. Smart City planners will

most likely achieve success when they focus not only on infrastructure, operations, and energy savings, but also on livability, quality of life, and economic vibrancy. "The urgent challenge is weaving together solutions that integrate these aims and mitigate conflicts," Townsend writes.[6]

Municipalities around the world are putting Smart City theories into practice today, and in the process discovering which approaches work well and which approaches may not. As Townsend recommends, the most promising concepts combine top-down and bottom-up approaches to innovation. This means not only centralized planning and governance of resources and infrastructures, but also empowering citizens to use advances in communications, mobile computing, and data sharing to crowdsource meaningful solutions to problems and enhancements to urban living.

One interesting example of the bottom-up approach is the Citizens Connect mobile application, introduced in 2009. Cities such as Boston, Massachusetts, have integrated a Citizens Connect smartphone app into their work management systems, allowing city residents to report potholes, street light outages, and other issues. Such an approach

"empowers residents to be the city's eyes and ears, engaging them in the process of maintaining their own city neighborhoods," according to the website of New Urban Mechanics, a network of civic innovation offices that developed Citizens Connect. Citizen reports of issues on the city streets more than quadrupled in the first five years, improving work management processes in the city while engaging residents and giving them a more personal and informative view of how the city resolves problems, and the people who perform the work.[7]

The Rockefeller Foundation's Institute for the Future (IFTF) also points to the importance of integrating "smart city in a box" solutions from technology companies with grassroots, citizen-driven innovations that leverage "off-the-shelf components, open-source hardware and software, and cooperative strategies" to exploit urban data for the advantage of city residents. The many such innovations that the IFTF highlights include LIVE Singapore!, an open platform for sharing real-time urban data streams; SeeClickFix, a platform for citizen reporting and monitoring of issues and complaints about neighborhood conditions and city services; and the open-source Ushahidi platform,

originally intended to map reports of election-related violence in Kenya, but now used as a crowdsourcing tool for data collection, informed response, and event visualization.[8]

Only time will reveal the most effective combination of strategies and technologies to realize the substantive, transformative changes that Geoffrey West and other Smart City thinkers foresee. But whatever that combination is, it will almost certainly come out of urban experimentation and citizen activism, using an open and highly capable communications network and distributed points of intelligence.

"Cities and metropolitan areas are the engines of economic prosperity and social transformation in the United States," write Bruce Katz and Jennifer Bradley in The Metropolitan Revolution: How Cities and Metros Are Fixing Our Broken Politics and Fragile Economy, from the Brookings Institute. "Power is devolving to the places and people who are closest to the ground and oriented toward collaborative action."[9] A ubiquitous, rich network – one that incorporates broadband connectivity, smart devices, open data infrastructures, public interfaces, and cloud-based applications – is a crucial enabler of such action.

References

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