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# Smartening up the city

New technologies promise a breakthrough for efforts to improve urban living

By David Pringle

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As the world becomes more and more urban, mayors and municipalities are striving to make their cities smarter. In theory at least, information and communications technologies can keep traffic moving; detect and prevent crime; monitor the condition of roads, lighting, parks and other urban infrastructure; and efficiently allocate public resources.

In practice, making existing cities smart is proving difficult. Many different stakeholders need to be involved, while sensors, controls and connectivity can be difficult to install in dense urban environments. In response, some cities are now experimenting with low-cost, low-power “Internet of Things” technologies that could usher in a new wave of smart city applications. In the medium-term, “5G” technologies are also promising to give municipalities access to ultra-reliable, low-latency bandwidth. Is the smart city era finally upon us?

## THE RISE OF THE SMART CITY

### Strain in the city

The world is quickly urbanizing. Every week, more than 1 million people move into cities across the world. At the end of 2015, more than half (54%) of the world’s population lived in cities, according to the CIA Factbook, following a 2% increase in the urban population each year between 2010 and 2015.

In rich countries, urbanization is a two-way street, as economic and cultural factors prompt population shifts between cities. People are migrating to highly diversified cities, such as London and Houston, while abandoning conurbations, such as Leipzig and Detroit, which rely heavily on now declining industries.

Of course, both people and employers tend to gravitate towards cities perceived to offer a high quality of life. For example, Vienna, the historic and picturesque capital of Austria, claims to be welcoming five new inhabitants every hour.

Although urbanization can have a positive socio-economic impact, it can also happen too quickly. In much of the world, the strain on city administrations is all too apparent. Across Africa, developing Asia and Latin America, cities are increasingly densely populated, congested and polluted. In May 2016, the World Health Organization warned that more than 80% of people in urban areas around the world are exposed to dangerous

levels of air pollution: Ambient air pollution, made of high concentrations of small and fine particulate matter, causes 3 million people to die prematurely every year, according to the WHO. As more newcomers arrive, cities’ limited bus, rail, energy and water networks also come under massive pressure.

In China, where the number of people living in cities is rising 3% every year, air quality in Beijing and some other urban areas is often dangerous to health, while grid-locked road networks mean people spend hours sitting in traffic jams each day. When urbanization reaches 50% to 70%, social problems arising from overcrowding also tend to increase, notes Dr. Wan Biyu, chief

scientist of National Smart City Joint Labs in China.

In other words, city infrastructure around the world is under severe strain and local governments are grappling with pressing problems that need to be urgently addressed.

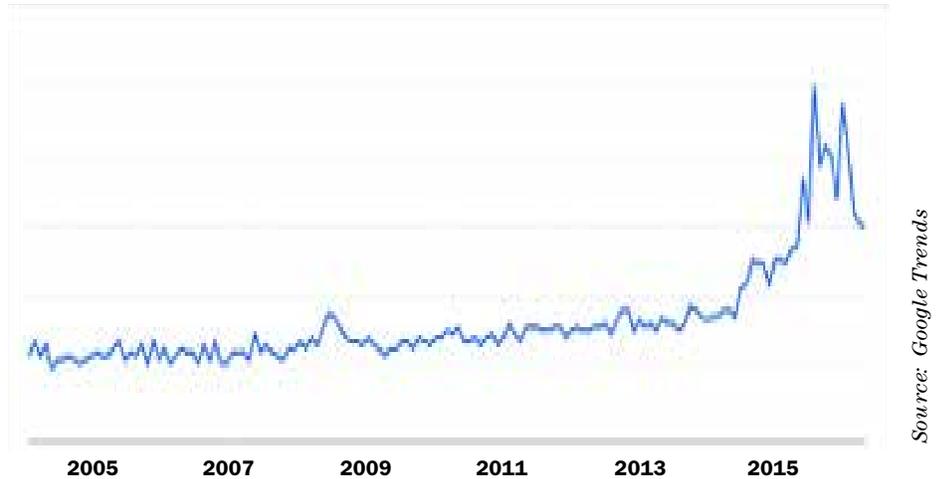
**Has the smart city come of age?**

ICT has long been regarded as key to addressing the growing challenges faced by crowded cities. In fact, the notion of using connected sensors and controls to create a so-called smart city has been around for decades. Few cities have managed to actually become smart - many solutions have been trialed and piloted, but few have been deployed on a large scale. The smart city has been a slow burn.

That may be about to change. In the past year or so, interest in smart city concepts has leapt (see Figure 1) as urban challenges intensify and technologies improve - the capabilities of connectivity and sensors (including digital cameras) are increasing even as the cost of this equipment falls.

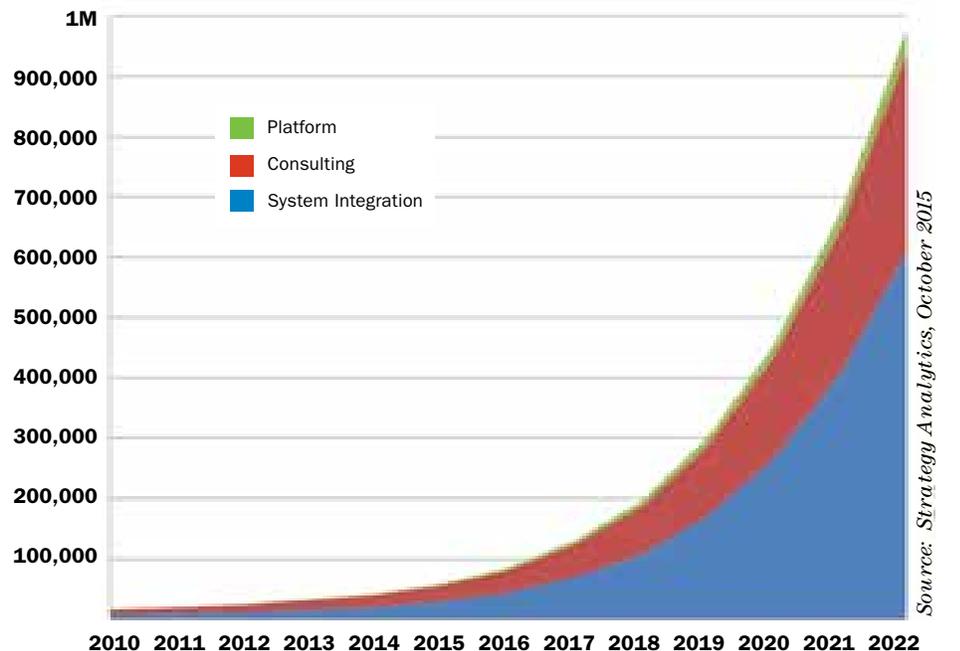
For the ICT industry, the smart city represents a major business opportunity. Strategy Analytics,

**FIG. 1: Google searches for smart city over time**



Source: Google Trends

**FIG. 2: Total Smart City ICT Revenue by Solution Area (US\$ Millions)**



Source: Strategy Analytics, October 2015



*Jeremy Green, Principal Analyst at Machina Research*

for example, has forecast “urban ICT revenues” will reach \$977 billion by 2022 (see Figure 2). The research firm believes smart health, smart infrastructure and smart government represent the largest ICT opportunities.

“It is definitely the case that the pace of the excitement and engagement in this topic is accelerating,” said Paul Wilson, managing director of Bristol Is Open, the smart city unit for Bristol, England. “It is a complete fast-paced ride right now. Ten years ago people were doing this work and it was slow and visionary. Today, it is extremely

fast. So, yes, there is something of a tipping point. But we still have another 10 or 20 years of work to do.”

However, some experts remain skeptical about how fast smart cities can develop, noting large-scale deployments are still relatively rare. “We have lots of really good pilots, and some of them have made it to production grade. But they are generally not in the operational guts of the cities,” said Jeremy Green, principal analyst at Machina Research. “I don’t think we are at tipping point, not yet.”

#### **Pilots and trials abound**

One of factors holding back the arrival of the smart city is politics. Many different stakeholders can be involved in the decision-making process, both inside and outside the city administration, leading to either gridlock or an uncoordinated, piecemeal approach.

“City administrations can amount to a ramshackle collection of separate organizations under loose political control with a lot of statutory obligations and nondiscretionary spending,” noted Green. “Cities typically don’t have a CIO, and if they do they are in charge of keeping the

lights on and keeping the desktops running. They are managing the current estate rather than thinking about the next five years.”

Recognizing this issue, some cities have set up dedicated smart city units. Atlanta, for example, created a centralized smart city team with a dedicated director who works on nothing else. “We have competing priorities and we are never going to move the needle unless we have a dedicated team working on it,” said Samir Saini, commissioner and CIO for Atlanta. “You need the buy-in from your department heads and



*Samir Saini, Commissioner and CIO for Atlanta*

your commissioners. All the data in the world won't solve anything unless your department heads use that data to make decisions."

National and international politics can also muddy the waters. Green notes European Union funding for smart city pilots is spread far and wide, rather than focused on the creation of a few centers of excellence. He says this approach tends to lead to duplication and can hold back the learning process about what works and what doesn't.

Elsewhere in the world, some countries are embracing the smart city concept at a national level, developing comprehensive strategies. China, for example, is employing a top-down approach in which the government is directing the use of ICT to improve urban living. Across the country, more than 300 metropolises are piloting smart city solutions, which use a combination of sensors, connectivity, data analytics and automation to make more efficient use of resources and provide innovative new services. These pilot smart cities are located in more than 30 provinces around China,

which differ greatly in many ways, said Dr. Biyu, who has visited more than 200 pilot cities and towns.

Some of the pilots are well advanced. Yinchuan, China, for example, started a smart city initiative in 2009. After striking a partnership with telecommunications equipment vendor ZTE in 2014, Yinchuan's initiative now spans 10 domains, including smart governance, smart transportation and smart climate. Some of the technologies being deployed appear futuristic: Bus passengers, for example, can now pay their fare via face recognition - they simply look at a camera as they board the bus, said Carl Piva, VP strategic programs at TM Forum,

who visited Yinchuan in 2015.

#### **Greenfield versus brownfield**

Of course, the most advanced smart cities tend to be those that have been built from scratch - so-called greenfield, as opposed to brownfield, cities. New urban developments typically embed ICT, including fiber broadband links, into the core infrastructure. In China, South Korea, Abu Dhabi, Brazil, Spain and Portugal, smart cities or smart districts are effectively being built from scratch: street lights, car parks, traffic controls, waste disposal facilities and other city infrastructure are all built with connected sensors installed.

Andrew Brown, executive director



The 22@Barcelona district.

for enterprise and IoT at Strategy Analytics, points to the 22@Barcelona project in Spain as a good example of what is possible when entire districts are being created or redeveloped. Funded by taxpayers, the 180 million euro (\$201 million) project involved changing 100 hectares of industrial land on Barcelona's seafront into a business district between 2000 and 2010. With the help of Cisco and other technology partners, the district employs temperature, humidity, dust, noise and gas sensors; a parking management system; connected waste containers; smart lighting, a connected watering system; and bus stops equipped with digital kiosks.

#### **SMART CITY TECHNOLOGY:**

##### **Lowering power requirements and costs**

Mobile operators have typically used their existing 2G and 3G cellular networks to support M2M connections. Designed primarily to connect mobile phones, these existing networks aren't well suited to serving the emerging IoT market, which increasingly requires dedicated networks specifically designed to meet the requirements of machines, vehicles and appliances.

In response, both startups and major equipment vendors are developing new LPWA technologies designed to make it increasingly viable to connect large numbers of devices, machines, vehicles and appliances. As the name suggests, these networks are frugal with power, enabling a connected device to have a battery life measured in years, rather than weeks, and dramatically reducing maintenance costs, making it more feasible to deploy connected sensors in inaccessible locations. Although some proponents of LPWA technologies forecast battery lives of 10 years, Green believes that may not be realistic in practice.

Still, LPWA networks are seen as low cost to deploy and run - connectivity costs could fall to a few dollars for each connection per year, rather than per month. These advances promise to make it easier, quicker and cheaper for cities to use wireless networks to monitor and control large numbers of connections in a small area. For example, it is becoming increasingly viable to connect every streetlight, every parking space or every waste bin.

The mobile industry is set to finalize the LPWA standards over

the next 12 months, before thrashing out the standards for the next generation of cellular technologies (5G), which is set to arrive towards the end of the decade.

##### **Step change in data processing**

Digital sensors are also improving fast. Green points to dramatic improvements in image processing capabilities, which can enable a video camera to analyze images and then transmit the salient information back to the city administration. "You can now increasingly do processing at the edge of the network," Green says. This technology could enable a city to deploy connected cameras to fulfill a number of roles, such as security, congestion monitoring and road charging.

The combination of these technology advances is seen as giving the smart city a new sense of momentum. "Why now? There is a perfect storm of technology evolution that has enabled these things to happen," said Brown of Strategy Analytics. "The platforms are there. We are seeing M2M morph into IoT with the involvement of the big data analytics players, such as IBM, Accenture, Cisco and Oracle. The



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communications part and the IT part are starting to operate together and there are signs that the market is moving from piecemeal pilots to a more systematic approach.”

Indeed, smart cities are rising up the agenda of the TM Forum, a trade body that looks to straddle IT and telecoms. In May 2016, TM Forum launched a smart city maturity and benchmarking model, which is designed to enable an aspiring smart city to assess its strengths and weaknesses in five key dimension areas and to set clear goals as



*Juanjo Hierro, CTO of Industrial IoT and Smart Cities Platform at Telefónica*

to how it will transform over the next two to five years. The Shanghai Academy plans to use the TM Forum model to support 200 smart city pilots in China.

#### **Harnessing data analytics**

There is also a sense the focus of smart city projects is moving from cost savings and greater efficiency towards innovative solutions designed to enhance the lives of inhabitants and increase economic activity.

“Traditionally the vision of a smart city has been focused on making the city more efficient for citizens,” said Juanjo Hierro, CTO of the industrial IoT and smart cities platform product unit at Telefónica. “But what is coming now, with the economy of data, are engines of growth. We are looking at how to transform the city and enable new services that are created around data. Data is the gold mine.”

Telefónica and rival operator Orange are advocating the widespread use of the open source framework FIWARE to enable data interoperability and portability. Telefónica says the Open and Agile Smart Cities initiative,

which is adopting FIWARE as a standard, is supported by 89 cities in 19 countries. Proponents see FIWARE as an international information hub, which will enable services to be connected across multiple territories.

Hierro envisions service providers will be able to mashup data from multiple sources, including both the city administration and third parties, to create new propositions and business models. “It is essential to have central application programming interfaces, a common infrastructure, and common data models and a common single market,” Hierro explained.

Others also see data analytics as the key to unlocking the potential of ICT to transform urban living. Jane Chen, chairperson of ZTESoft, the software arm of ZTE, says the “Smart City 3.0” (the next phase in the evolution of smart cities) will use software platforms to analyze data from multiple sources to enable the deployment of innovative new solutions.

#### **Setting data free**

Uber and its rivals have shown how real-time data can be used to



Millennium Square Bristol

Source: Advantage Engineers

allocate resources in real time to make the process of finding a ride faster and more efficient. Cities are increasingly experimenting with the idea of opening up their data and enabling private companies to come up with solutions designed to meet the needs of local consumers and businesses. Bristol, which is the third most congested city in the U.K., is giving developers access to near real-time data about the state of the transport network.

“The first API put out by the council is a transport API, which relates to all interactions of buses and off the traffic lights, so you can model

the traffic flow in the city in a five second delay environment,” said Wilson. “The second one was around air quality.”

Bristol is also looking to harness the creativity of its citizens and companies in other domains. The city is working with the local university on a project to improve the quality of life of elderly people occupying assisted living homes in the city. The project involves the development and deployment of a large number of low-power sensors throughout a pilot house: in the shower, the kitchen, the floor and many other places. These sensors are designed to detect a fall, an accident

or a change in behavior that might indicate the occupant has a problem, and enable care workers to prioritize which houses they visit. The next step is to put people in the pilot house to find out which sensors they consider the most intrusive, and which feel acceptable and ignorable. Once the pilot team have these insights, Bristol plans to scale up the solution to 50 houses, and then making a model that can be scaled up to thousands of houses.

#### The programmable city

The growing use of software within telecom networks could also give a smart city more control over the available connectivity and how it is deployed. In particular, the advent of software-defined networks and network functions virtualization are making it easier to adapt telecom networks to serve the needs of specific applications.

Bristol is working with the local university, NEC and InterDigital to deploy SDN across the city and enable NFV.

“We describe what we are doing in Bristol as a programmable city,” said Wilson. “The phrase smart city has so many meanings ... what we

are doing involves programmable networks, it involves software-defined networks. We are taking quite a technical approach to the whole thing.”

Bristol is seen as one Britain’s leading smart cities, according to new research commissioned by Huawei and conducted by Navigant Consulting. “I see London, Bristol, Birmingham, Manchester Milton Keynes, Leeds and Peterborough as cities that I count amongst European pathfinders,” said Eric Woods, research director at Navigant.

#### SMART CITY APPLICATIONS:

##### The low hanging fruit

Right now, the most widely deployed smart city solutions tend to be those for which there is a very straightforward business case. That business case is usually based on significant cost savings. Strategy Analytics says cities are embracing smart street lighting simply because the cost of the sensors required to check whether the lights actually need to be on is lower than the potential energy savings. If the sensors are connected, they can also flag when a particular streetlight is broken and needs replacing. Some

streetlight providers may even provide this technology for free, if they are allowed to harness the data to provide ongoing maintenance and other services, reckons Peter Sany, CEO of the TM Forum.

There is also a clear business case for connecting waste bins. Sensors can monitor when a bin is full, and then a wireless connection can relay that data back to the waste disposal team. They can then use the information to optimize the deployment of waste trucks and ensure bins don’t overflow. Chen of ZTEsoft says that in China the business case is even stronger. As some new buildings are full and others half empty, the speed at which garbage bins fill up can

vary dramatically.

“We collect all this information and build an API and give all this data to the garbage company, so they know how often to visit each building,” Chen says.

Smart parking is also gaining traction. In this case, a connected sensor can signal whether a space is empty or occupied, and that information can be aggregated and made available to drivers looking for a vacant lot. As a result, drivers spend less time seeking somewhere to park, congestion could drop, pollution can be reduced and the parking provider could potentially increase charges. In fact, connected parking sensors could be used to enable dynamic pricing



Singapore skyline

Source: I23RF

in which parking charges surge at times of high demand (Uber-style) and then fall when there are many spaces available.

Transport for London, for example, has introduced intelligent smart parking technology across its 61 car parks, which have approximately 10,000 spaces. The technology provides real-time information on space availability accessible through smartphones and navigation devices to help commuters plan their journeys..

#### Tackling transportation travails

In a similar vein, many cities believe ICT could help them optimize the use of precious road space and encourage greater usage of public transport. In February 2016, Singapore announced it has awarded a \$556 million tender to develop a next-generation electronic road pricing system to the consortium of NCS Pte and Mitsubishi Heavy Industries Engine System Asia.

Singapore's Land Transport Authority said the system could allow for more flexibility in managing traffic congestion through distance-based road pricing, where an on-board tracking unit enables mo-



North Avenue, Atlanta, Georgia

torists to be charged according to the distance they travel on congested roads and whether they travel during off-peak. It's set to be implemented progressively beginning in 2020.

For some cities, the focus is on getting people out of their cars entirely. Vienna has set some aggressive targets to reduce car usage, says Andreas Trisko, head of urban development department Vienna. The city administration wants to reduce the proportion of journeys by car from 27% today, to 15% by 2030. Vienna is using real-time data collected

by connectivity to encourage greater usage of public transport and bike-sharing schemes, as well as to inform people of the cost and carbon dioxide emissions of individual journeys using different forms of transport.

But, transport and related pollution can be a tough domain to address, primarily because of the number of different parties involved, notes Green. "There are many different elements, a complex set of systems and multiple players and it can be hard to align their interests," he explained.

### Neighborhood by neighborhood

Some cities are following a different model. Rather than trying to address a specific challenge, such as congestion or waste collection, they are taking a street-by-street approach. Atlanta has begun by focusing on North Avenue, a major artery that is home to Coca-Cola, Georgia Institute of Technology, theaters, parks and public transport stations. It is now using North Avenue as a testing ground for how ICT can help the city pursue all three of its primary goals - improving mobility, public safety and sustainability.

“We are in proof of concept mode,” Atlanta CIO Saini told delegates at the recent TM Forum Live! event. If the results on North Avenue are encouraging, the city plans to expand the pilot to another district.

Saini notes North Avenue, which suffers from crime, congestion and water leakage, is a microcosm of the challenges facing the rest of the city.

“None of the traffic signals on North Avenue have communications. When they go down, we have to wait for a phone call from a citizen,” Saini explained.

“We have got peak congestion at key intersections and we have excess capacity at others. We have a completely underutilized bus and rail system.”

The city has started by working with AT&T to install cellular-connected cameras at a single intersection to get traffic flow data in real time. “We will also do this on the other 18 signal intersections on North,” explained Saini. “We’ll have a complete picture of what is happening on North, counting bikes and people, as well as vehicles.”

Atlanta then plans to feed the data collected by the cameras into a traffic management system and start changing lights based on real-time traffic information. It is also planning to pilot a bike-share scheme, deploy a citizen information kiosk and set up a public Wi-Fi network across North Avenue.

Saini says the city also intends to install sensors into the water network to monitor flow, detect leaks and analyze the resulting data to see how the network can be improved. “We are going to implement a sensor array with Georgia Tech that will measure air quality, sound and vibration,” he Saini noted. “We

will attach that array to the 180 poles we have on North Avenue.”

### NEXT STEPS FOR SMART CITIES:

#### Fast fiber links required

A core foundation of a smart city is fast and responsive connectivity throughout the urban area. In practice, that typically means having an extensive fiber network in the ground that can be used to connect wireless hot spots and cellular base stations. Atlanta is using a \$250 million dollar infrastructure grant, which was approved in a special election in 2015, to lay strands of fiber in main corridors to connect traffic lights and embed sensors in the concrete.

“We are rolling out our own municipal fiber network, built by the city, run by the city, that will be the backbone of all the smart city devices we lay on top,” said Saini. “This is a major undertaking that will take us several years.” However, the city isn’t going it alone - it has partnerships with AT&T, Cisco and Google Fi to improve connectivity across Atlanta.

A citywide fiber network can be used to provide backhaul for the wireless connectivity used

to connect individual pieces of infrastructure. For example, in Bristol, a wireless mesh network supplied by SilverSpring Networks complements the city's fiber network.

**Settling on standards**

Bristol is also making use of Wi-Fi, 2G, 3G, LTE and even an experimental form of 5G to provide connectivity for its smart city solutions.

"Then you start plugging in all sorts of devices and deciding what these devices use to connect: then the nightmare begins," said Wilson. "Almost all industries are heavily pregnant with all of this. What's

holding everything up is a lack of standards and a lack of confidence. Standards give you economies of scale, confidence and interoperability. I do think it is a serious problem. ... 5G will be a big moment, but I am not sure it is a cure all."

Machina Research has warned using nonstandardized technology for IoT will increase the cost of deployment, hinder mass scale adoption and stifle technology innovation for smart city initiatives worldwide. City authorities and their technology partners could

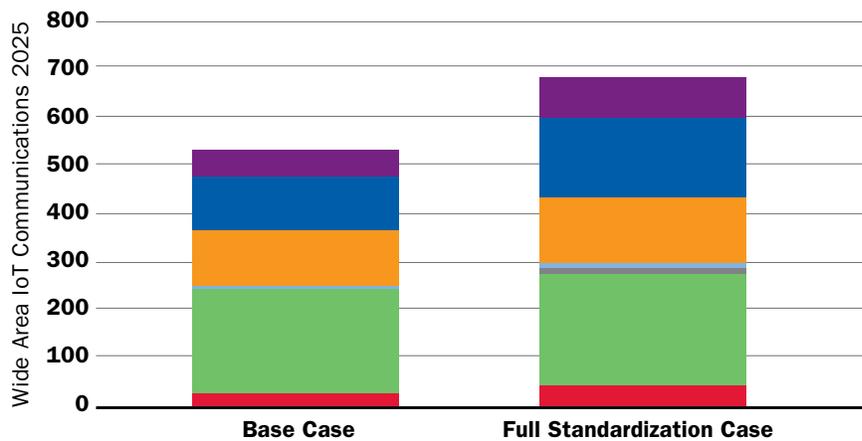
squander \$341 billion by 2025, if they adopt a fragmented, rather than a standardized approach to IoT solution deployment, Machina claims in a new white paper, commissioned by mobile technology and research company InterDigital. Machina believes standardization could stimulate deployments and wider usage of smart city solutions (see Figure 3).

"There is a lot of buzz about the different radios and networks, but for us, that is not the biggest problem," said Rafael Cepeda, smart



*Rafael Cepeda, Smart Cities Lead at InterDigital*

**FIG. 3: Machina Research's estimates of how standardization could increase smart city deployments**



Source: Machina Research.

- Alarms & Monitors
- CCTV
- Street Lighting
- Waste Management
- Public Transport
- Road Traffic Management
- Parking
- Other

cities lead at InterDigital. “The real problem is how you integrate all the data that the sensors will produce and how you make sense of it.”

Cepeda says the leading standards bodies need to address this issue. InterDigital is supporting the use of the open standard OneM2M, which covers requirements, architecture, API specifications and security solutions. InterDigital said it has developed an OneM2M-compatible platform, which it is deploying with cities in the U.K. to help integrate data that was previously isolated.

“We started this project two years ago as a feasibility study,” said Cepeda. “We are now in the pilot phase with four municipalities and we really see benefits in sharing knowledge with the local authorities.”

InterDigital envisions city administrations may be able to earn revenue by making data available in a standardized format to large enterprises and startups that become successful. Cepeda adds that the use of an open standard to manage and organize data will also help cities avoid being locked-in to a single vendor.

Bristol is alert to this issue. “We are not going to rely on a vendor to sort this out for us,” says Wilson. “If you outsource to a consultant, you can end up with lock-in. The local authority has been astute enough to hire people with quite sophisticated technology and procurement backgrounds to say: we are the city and we are the platform. We know our strategy and we will go to vendors to fulfill aspects of our strategy.”

Vendor lock-in isn’t the only potential pitfall. City administrations also need to consider how their solutions will fit into the broader ICT fabric of their region.

“Smart cities are not alone,” noted Cepeda. “As cities become successful, property prices rise and people travel longer distances. Cities need to start integrating what they are doing on a regional scale and ensure their solutions are interoperable with deployments in other cities. You shouldn’t have to download new apps to navigate in each city you visit.”

U.K. cities are working on common approaches through the British Standards Institute and the Future Cities Catapult initiative,

said Woods at Navigant. “But the nature of these innovation programs means that they are mostly being shaped by local needs, priorities and opportunities,” Woods adds. “There are opportunities for more sharing of successful ideas/projects and perhaps the chance to collaborate on deploying those solutions more widely or testing them in different environments without reinventing the wheel.”

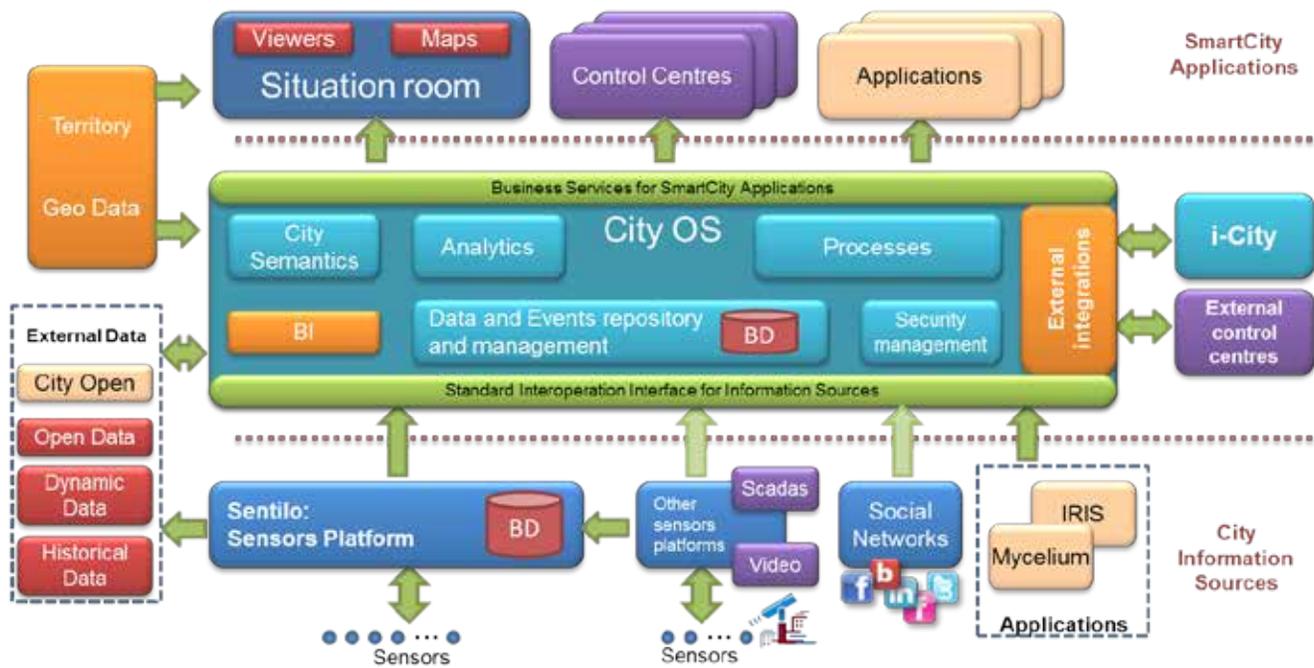
#### **The security challenge**

Beyond standardization, security is probably the other major hurdle the smart city sector will have to clear. If a city deploys connectivity and computing power in public spaces, there is a danger criminals or terrorists will try to hack into a smart city solution and cause damage.

“The risks are very big,” noted Green. “You could break quite a lot. This technology exposes some of the interfaces that wouldn’t have been exposed and the more you expose, the more scary it becomes.”

Green also flags that installing sensors and cameras across public spaces raises serious privacy concerns.

However, if cities follow best



Source: iBarcelona

CityOS Data Flow

practice in both security and privacy, Green believes these challenges can be overcome. The key in many cases will be balancing the commercial interests required to fund smart city deployments with the broader public interest in maintaining individual privacy and collective security.

“In 10 or 20 years, we will wake up and say who owns the data,” Wilson said. “Who owns the data is actually super important and if it just corporations that own the data, there will be a backlash.”

**All eyes on the economics**

Assuming standardization continues apace and the security and privacy challenges are contained, the speed at which smart city solutions are deployed is likely to boil down to hard economics. Brown at Strategy Analytics notes cash-strapped cities will judge each solution on the net overall benefit, compared with other infrastructure investments, as well as the likely sustainability of new solutions: will they stand the test of time?

Employing cloud-based “CityOS” solutions could help to keep costs down and maintain flexibility, Brown adds. But the major challenge will still lie in addressing and integrating legacy infrastructure systems.

“Cities need to make sure the path they go down is one that they can switch out,” Brown said. “They need to be careful not to be using obsolete technology. ... You can’t afford to rip and replace if someone turns the lights off.” (☹️)

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