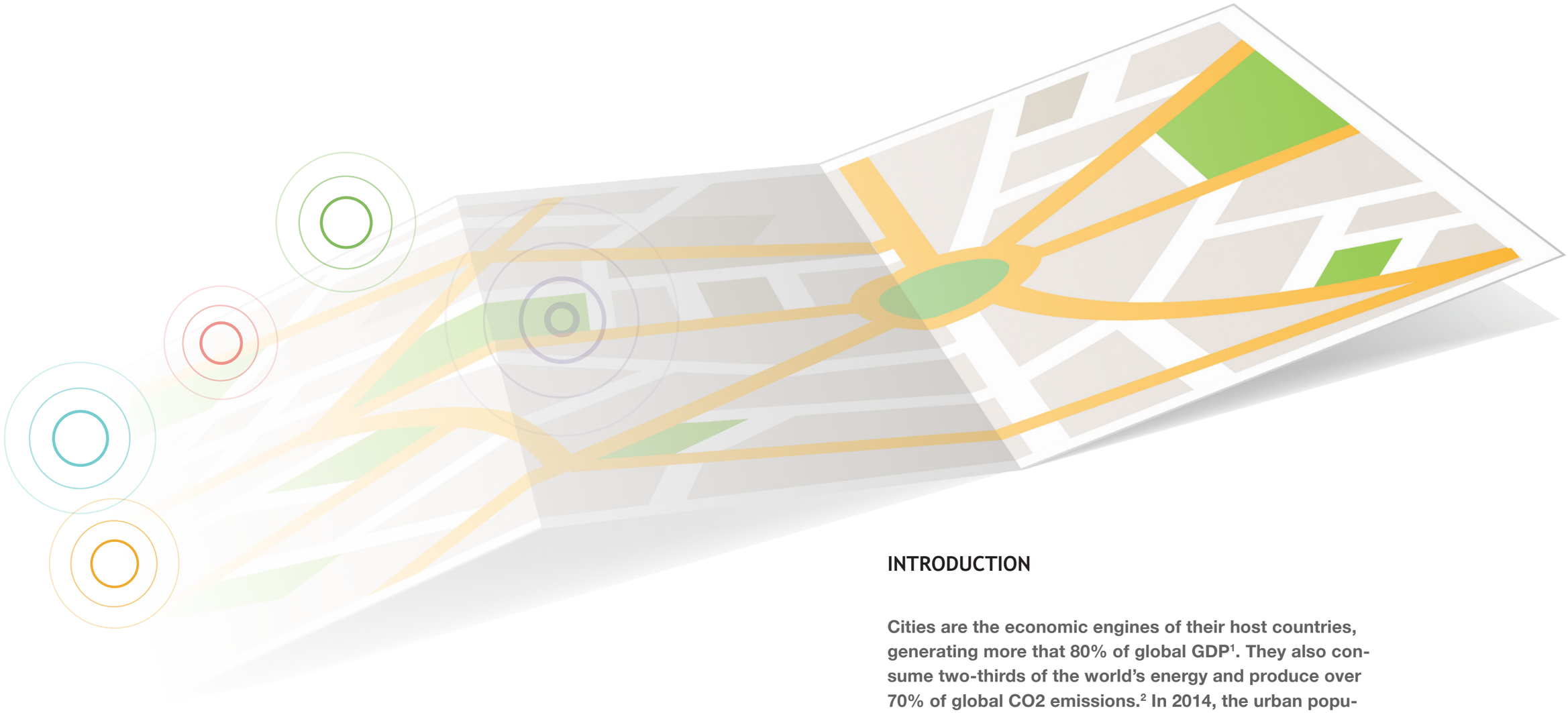
Building the Future:

New ICT Enables Smart City

IDC GOVERNMENT INSIGHTS WHITE PAPER



INTRODUCTION

Cities are the economic engines of their host countries, generating more that 80% of global GDP[1]. They also consume two-thirds of the world's energy and produce over 70% of global CO2 emissions.[2] In 2014, the urban population was 54% of the total population and this number will increase by an additional 2.5 billion people by 2050 with 66% of the global population living in urban environments.[3] This continued growth in concentrated urban populations will have significant ramifications for the future and will worsen current challenges such as traffic, access to clean water, crime rates, and the growth of slums or informal settlements.

1.http://www.worldbank.org/en/topic/urbandevelopment/overview
2 International Energy Agency, Cities, Towns and Renewable Energy: Yes In My Front Yard, http://www.iea.org/publications/freepublications/publication/cities2009.pdf (2009)
3 United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

Smart City technologies are differentiators for the cities that deploy them. IDC believes that Smart City technologies and initiatives will play a key role in helping municipalities tackle these growing challenges and compete more effectively in a global digital economy. Smart Cities harness the power of technology and drive local innovation to create jobs, provide a safe and high quality of life for residents, and attract talent, tourists, and visitors. In order to do this, however, city leaders need concrete strategic plans, investment strategies, and better information on the best practices of successful Smart City implementations to reduce risk and improve outcomes.

The potential impact of a Smart City transformations should not be understated. With current and projected urban populations, these solutions can touch the majority of people in the world making them safe and supporting most of the global economic growth. With quality of life improvements as a fundamental tenet of Smart Cities, it is up to cities to leverage data, technology, and people to affect change and design their cities.

The white paper will discuss current trends in smart cities and provide insight into Huawei's concrete abilities in Smart City development.

GLOBAL TRENDS: SMART CITIES ARE KEY FOR SOCIETAL DEVELOPMENT

The global interest in Smart Cities is at its highest level since the Smart City movement began, and cities are at a tipping point for investing in research and pilots as well as in large, scalable, and transformative deployments (much of the latter spurred by monies from national agencies). The growth in cities combined with recent technological advances have come together to shift attention to smart cities and Smart City-related technologies. This interest is driven by the opportunities that Smart City initiatives can provide as they use operational technologies, civic technologies, the Internet of Things (IoT), and the 3rd Platform (cloud, social, mobile, and big data/analytics) to understand the workings of a city at a level of unprecedented detail, provide new and innovative services to residents and local businesses, and change the collective behavior of government workers, local business, and residents to achieve broad social, environmental, and financial outcomes.

Smart Cities Are National Priorities

As part of its FutureScape process this past year, IDC forecasted that "by 2017, at least 20 of the world's largest countries would create national Smart City policies to prioritize funding and document technical and business guidelines."

The growing adoption and awareness of the Smart Cities as a catalyst for change has resulted in a more active role by national governments in developing Smart City strategies. And while the strength of national governments in relation to cities and other levels of government varies by country, IDC predicted that many more countries would set a national agenda for funding-specific Smart City initiatives. To date, countries with national Smart Cities plans ***include:***

Japan: Japan's Smart Japan ICT Strategy was devised to catalyze the nation into sustainable growth at a pivotal moment in its history. Its national strategy seeks to foster innovation by connecting all manner of things, systems and services through intelligent ICT. Its vision is to become a knowledge, information and data-driven nation by 2020, commensurate with hosting the 2020 Olympic and Paralympic Games in Tokyo. Japan's national smart cities plan is in fact also focused on creating international synergies. Focused keenly on its international economic competitiveness, Japan believes that by 2020 its national strategy will lead to annual overseas sales of 17.5 trillion yen, a five-fold increase over 2012.

China: Many of the foundational themes outlined in China's 13th five-year plan (2016-2020) pertain to cultivating Smart Cities. Accelerating new urbanization and consumption, smart manufacturing, smart buildings and smart grid initiatives all feature prominently in the plan. China has been committed to Smart Cities for a number of years now; as of 2014, China had 277 cities, including metropolises such as Beijing and county-level urban areas, piloting Smart City projects, with $13 billion invested in deployments.

The United States: In September 2015, the U.S. White House announced new Smart Cities investment of $160 million for federal research and grants to help cities tackle traffic congestion, crime, the changing climate, and the delivery of city services. On September 26, 2016, the White House committed an additional $80 million in new federal funds to the Smart Cities Initiative, which will also double the number communities participating to over 70.

United Kingdom: The United Kingdom has created a Ministerial Smart Cities Forum and the Future Cities Catapult. The Future Cities Catapult is one of seven Catapults under the United Kingdom's innovation agency, the Technology Strategy Board. The Future Cities Catapult, as its name implies, is focused on urban environments and the technologies that will help solve urban challenges.

Singapore: Singapore's Smart Nation strategy and ICT masterplans functionally animate the concerted desire for public sector transformation to meet the social, economic and political aspirations of citizens. In 2015, Singapore branded itself as the world's first Smart Nation, instilling an ambitious pan-national vision, precisely when many cities globally were experimenting and delivering 'Smart City' technologies to address isolated challenges such as street lighting, water and waste management, and traffic light management.

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Competing Pressures to Transform

Whereas government organizations used to speak about e-government, the conversation, function and theme of Smart Cities is more broadly stated in terms of digital transformation of citizen services and daily operations. Cities and local governments around the world are under pressure to improve their infrastructure, sustainability, and economic opportunities for citizens as well as transform the citizen experience. Following years of sustained underinvestment, the global annual infrastructure cost burden is estimated to be $3.3 trillion, simply to meet existing growth projections (http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/bridging-global-infrastructure-gaps). 3rd platform technologies combined with other technologies like cognitive computing, video analytics and IoT offer unparalleled opportunities to deliver new government capabilities to all aspects of the city while sustaining budget levels. For example, smart parking solutions that guide drivers to available spaces deliver multiple benefits to residents, decreasing congestion, pollution, and traffic while increasing consumers to business districts.

Technology as a Strategic Lever

At their core, Smart City leaders are embracing technology not as a cost center tied solely to operational efficiencies but as a strategic investment tied to programmatic outcomes, new services, and economic development. Smart City leaders understand that technology can impact both topline "revenues" in terms of the tax base and new services as well as ensuring budgets break even via operational efficiencies and cost savings. The city of Copenhagen, Denmark has recently created the Copenhagen Data Exchange, where it is creating new revenue streams by aggregating and monetizing the various streams of data coming from business, citizens, utilities, to create entirely new services.

Long-term Viability for Multiple Stakeholders. Smart City technology investment also directly impacts sustainability and resilience, and the livability of a region (i.e. in traffic and urban mobility, public safety and modern education).

Business and residents that operate in the global digital economy want to know what continued future investment cities will be making for progress in these areas while tourists look for a city that is safe and easy to navigate. These investments require a level of innovation to test emerging technologies, and the ability to work with new combinations of partners, from universities to operational and IT companies to real estate developers and urban planners, and to be transparent and open around the impacts of new technologies. New York City, for example, is working with local universities and the private sector to use technology to meet a variety of strategic goals outlined in its OneNYC vision. The city is using Open Data and City Neighborhood Labs to test technologies and bring more tech sector companies to the city as well as using smart kiosks to provide free, high speed WiFi to the public.

FIGURE 1 **Evolution of Global Smart City Trends**

Figure 1 outlines the evolution of Smart City trends over the past several years, summarizing the progression of thinking about Smart Cities, as discussed above.

source: IDC Government Insights, 2016

Smart City DEVELOPMENT

Smart cities have entered a new, more practical phase of development. Many cities are working on a smart vision, or have already articulated a smart vision, and leading cities have shown that investment can lead to success.

The Benefits of Smart Cities

The core goal of a Smart City is sustainable economic development and growth. Smart Cities use Smart City initiatives to attract more businesses, start-ups, tourists, visitors and residents.

More specifically, Smart Cities:

- **Optimize urban transportation** - Make it easier for commuters and residents to shop, attend events and go to work through intelligent transportation systems, smart parking and many transit options, from subways and buses to ride-hailing and car-sharing services.

- **Deliver public security** - Provide a safe city for people to live in and for tourists to visit, using sensors, video cameras, police body cameras to support community policing and intelligent (even mobile) command centers that discourage and prevent crime, and respond more quickly to emergencies.

- **Modernize education** - Offer modern educational opportunities for families with children and for college and university students by offering up-to-date technologies in classrooms, online learning and high speed connections, and partnering with universities to provide the city as a living lab for students.

- **Catalyze connected healthcare** - Enable the healthcare and social services support for all people, especially those that are vulnerable like the elderly, with home-based telehealth options and social programs that use analytics to identify causes of health issues like low birth weights, obesity or diabetes.

- **Deliver sustainability** - Ensure a clean environmental by using environmental and water sensors and applications to monitor the air and water quality and take steps to reduce air pollution as well as alerting people of dangerous conditions. Smart Cities also include utilities that develop smart grids that can monitor energy use in real time, smart lighting that uses programmable LEDs for streets and parks, and smart building technologies that reduce energy use.

- **Optimize city administration** - Provide more efficient city operations by using IoT technologies to track infrastructure and workers in real-time and adjust operations on demand. One example of this include changing trash collections to reduce air pollution and collecting trash as needed when bins are full.

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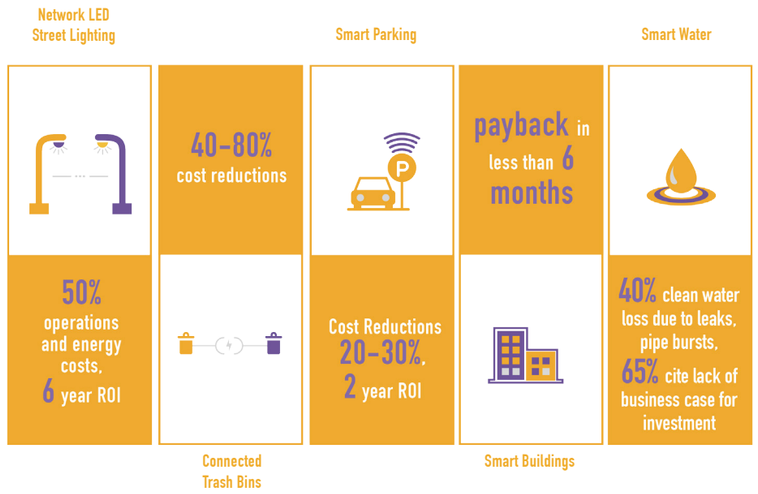
FIGURE 2 **Examples of Smart City Benefits**



source: IDC Government Insights, 2016

Ultimately, smart cities provide measurable outcomes over relatively short time periods. As shown in Figure 2, there are many examples of the benefits of smart deployments.

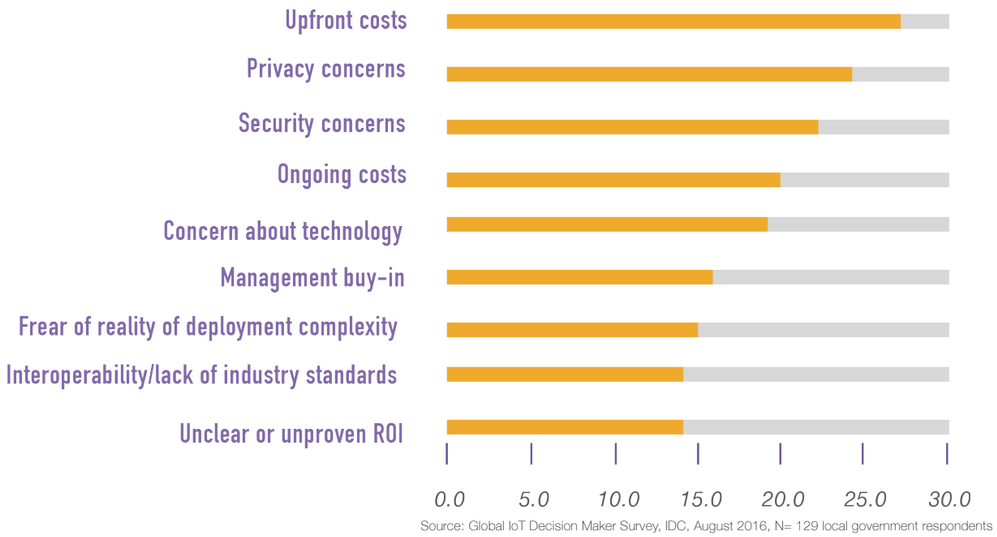
The Challenges in Smart City Development

Smart Cities, while they rely on ICT and data, require the development of non-ICT related areas, like governance, data management, and partnership models, for effective implementation. Smart Cities transform by integrating technologies and operational processes; cities must manage the complexity in new and legacy IT and operational systems, the connection between digital and physical environments, creating supporting regulation and policy, and effecting behavior change in government employees and city residents to meet desired goals. The resulting complexity and change management can be a daunting task for city leaders trying to manage their risk while testing new and innovative ideas. From sharing data to implementing new systems like video analytics or next-generation emergency services, Smart City solutions can be disruptive to the status quo.

Based on a global survey of business and government leaders, local government respondents indicated that the biggest challenges for Smart City IoT deployments are finding the budget for the initial costs of investments and managing the security and privacy concerns over data collections and transmission.

Secondary concerns including handling ongoing costs of initiatives, such as the cost of monthly connectivity charges or software license fees, and finding the right stable, technical capabilities in solution. These survey results are shown in Figure 3.

FIGURE 3 **Challenges to Smart City Deployments**

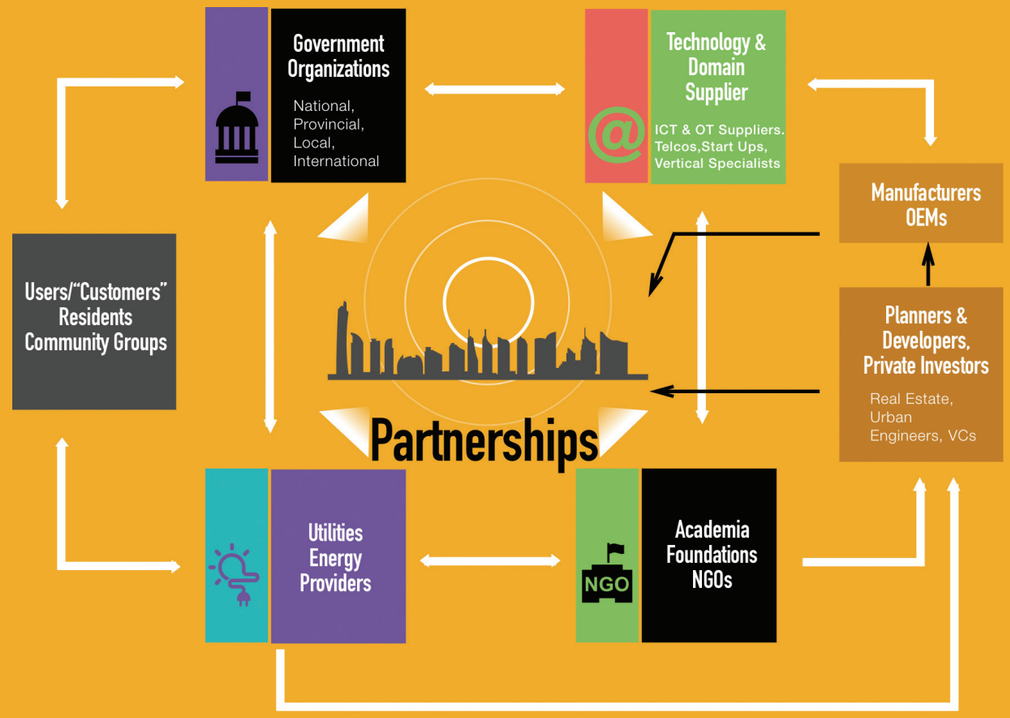


Source: Global IoT Decision Maker Survey, IDC, August 2016, N= 129 local government respondents

Smart City solutions also require working with multiple vendors for one solution; no one supplier can provide an entire Smart City solution. And often, within the city itself, there are multiple departments and quasi-public agencies that will be involved. Cities will also often leverage the skills from universities to supplement existing technical skills.

The Smart City ecosystem continues to grow with players from a multitude of sectors as shown in Figure 4.

FIGURE 4 **The Smart City Ecosystem**



source: IDC Government Insights, 2016

Smart City ARCHITECTURE

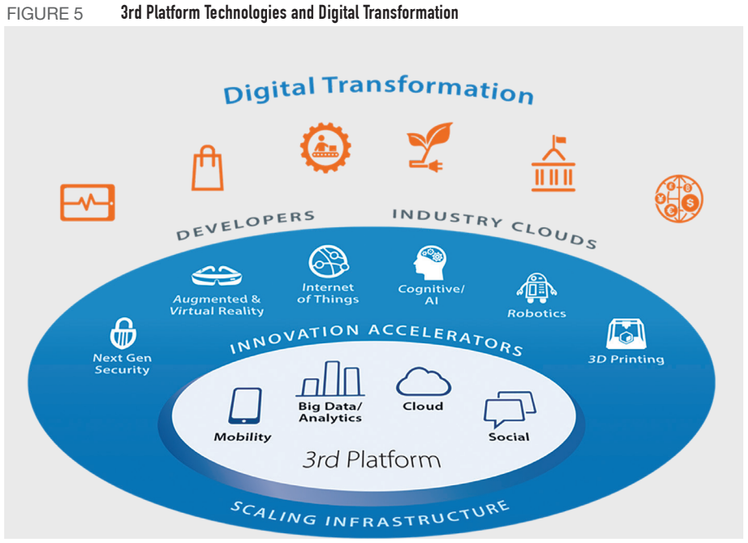
From a technology perspective, Smart Cities are made up of various layers — connectivity, datacenter, analytics, applications, and the end-user layer. Each one of these layers incorporates various types of technologies that allows for the creation and aggregation of data and provides the right level of response for end users in the city, be it a citizen, resident, tourist, or business. Furthermore, each technology layer evolves at varied paces which requires that each layer is decoupled so that products can be switched in and out as needed while continuing to interface with other layers to support the business.

In addition to the technology layers, a Smart City requires proper representation and integration of the city's various stakeholders (i.e. the public sector, planners and developers, utilities, ICT and infrastructure providers, private companies, and investors), with the most important stakeholder being the citizen/resident. As a result, Smart City deployment is a complex socio-technical endeavor that requires systematically incorporating organizational, financial, social, operational, technology, and psychological components in the context of the human, social, business, political and physical environments in which they will be used. In essence, achieving Smart City goals requires an architectural systematic approach, where each component can be replaced, while maintaining the ability to organically integrate with others to deliver the desired capabilities. City leaders that do not take this systematic approach will be stuck with obsolete systems, or, worse, will waste taxpayer money to buy expensive bleeding-edge technologies that are not aligned with business goals.

A multi-tier architecture implies a N-tiered architecture where the different layers – i.e. user/ presentation layer, application layer, data layer, infrastructure layer - are de-coupled from one another. IDC research shows how such an N-tiered model enables better scalability of capabilities, re-usability of data and applications and ability to choose different delivery models, from on premise to public cloud to leverage and agile hybrid environment. It also helps incrementally move away from legacy systems without carrying out costly and risky rip-and-replace projects. This will be the most appropriate high-level common reference architecture for use across multiple cities that want to be able to leverage 3rd platform technologies to digitally transform (See Figure 5 below)

The third platform is IDC's definition of the wave of computing platforms, driving by the inter-dependencies between mobile computing, social media, cloud computing, big data analytics, and innovation accelerators such as the Internet of Things.

FIGURE 5 **3rd Platform Technologies and Digital Transformation**



Source: IDC

source: IDC Government Insights, 2016

Through these 3rd platform technologies, ICT provides the capabilities required to build smart cities, laying the foundation for the following key platforms or solutions.

Connecting Service Platform

Broadly speaking, IDC defines the Internet of Things (IoT) as a network of networks of uniquely identifiable end points (or things) that communicate without human interaction using IP connectivity — be it locally or globally.

IoT solutions allow businesses and governments to improve processes and productivity, create new revenue streams and competitive advantage, enhance customer experience and improve citizen service delivery.

The rise of intelligent devices, or the IoT has been staggering. IDC estimates that the number of sensors in use is in the trillions. There were 13 billion connected intelligent systems in 2015, growing to 30 billion by 2020. This means that there are more than 5,000 connected endpoints being added every minute. Driven by ubiquitous broadband, commoditized sensor technologies, the increased widespread availability of analytical tools and cloud – based platforms, the IoT is a foundation to many Smart City initiatives. This makes IoT connectivity management is a critical component of connected service platforms as it provides for the easy integration of a wide variety of device types, data sources and applications platforms in a secure environment.

The Internet of Things is important in the Smart City context because it provides access to new and better information in real time. This rapid access to new and better information impacts the quality of government services, enabling them to be provided more quickly, more efficiently, and in a more predictive and less reactive manner. This ultimately impacts every single person — citizen, visitor, business owner.

To be more specific, the IoT offers:

- **Access to new information:** Devices, whether intelligent devices with embedded analytics or "dumb" IP-enabled devices that merely transmit information, can provide departments with new information. Some of this information will be new by virtue of the type of device. For example, strategically placed acoustic sensors that pick up gunshots have shown that previous assumptions on the level of gun activity in certain neighbourhoods in the U.S. were wrong. Police departments operated on the assumption that when shots were fired, 80% of the time someone called 911. In fact, this percentage could be as low as 20% of the time, a fact that was revealed when these sensors were able to pick up actual gunshots, providing new information and insight.

- **Rapid automation:** Some information may already be collected by people, but because of resource constraints, it cannot be collected as often or as detailed as needed. For example, inspectors collect data on the structural integrity of bridges and other infrastructure, but there are rarely enough inspectors to regularly and thoroughly inspect all the bridges that need it. Sensors on bridges can provide information on the structural integrity of the bridge at regular intervals, alerting inspectors when there are potential problems that need to be addressed.

- **Access to better, faster information:** Access to "better" information means access to more granular, automated information often provided in real time or near real time as opposed to waiting for an update manually. Parking sensors, for example, provide immediate information when a parking space is empty, instead of requiring people to drive around to find an empty spot. Public buses can alert a transportation management center of their location continuously, allowing managers to create improved routes and schedules, follow traffic patterns, and update digital signs or provide alerts via apps so citizens waiting for the buses know when they will arrive.

All IoT solutions require intelligent systems. Devices or things in the IoT are managed by these intelligent systems, defined as securely managed electronic systems that run a high-level operating system (HLOS) and autonomously connect to the Internet, execute native or cloud-based applications, and facilitate data analysis. Research indicates that traditional embedded systems are also being enhanced to function like intelligent systems in IoT solutions in some cases.

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IDC's current definition of the Internet of Things has evolved to underscore the requirement that the IoT system is defined precisely as an intelligent system or enhanced traditional embedded system that must have IP connectivity.

Often when buyers think of the IoT, they begin with the endpoints themselves — the vast types of sensors, wearable devices, and surveillance cameras. However, the IoT is a solution that covers the entire technology stack as well as the associated services to integrate, deploy, and support solutions and the security required at every level. Below, IDC has highlighted key platforms in the IoT architecture.

Connectivity

The connectivity layer includes the telecom network and Internet connectivity that enables to transmission of data from IoT modules, sensors and devices.

The connectivity segment of the Smart City market can involve any of the following connection types and can be provided by private operators, co-ops, or municipally owned networks:

Cellular	WIFI	Bluetooth	ZigBee	Wireline	MQTT	NB-IOT
Cellular leverages 2G (GSM, GPRS, EDGE, 1xRTT), 3G (HSPA, HSPA+, EV-DO, EV-DO Rev A), or 4G (LTE, WiMAX) wide area networks for connectivity.	WiFi leverages a wireless local area network using unlicensed spectrum on WiFi standards 802.11a/b/g/n bands.	Bluetooth utilizes open wireless technology standards for exchanging data over short distances.	ZigBee leverages low-power, low-cost connectivity that is primarily beneficial in short-range monitoring or controlling applications.	Wireline leverages existing wired infrastructure to monitor devices/ endpoints.	Message Queue Telemetry Transpoft(MQTT) leverages an extremely lightweight publish/subscribe messaging transport. It is useful in connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium.	NarrowBand IoT (NB-IOT)is a Low Power Wide Area Network (LPWAN) technology that enables a wide variety of things or devices to connect using cellular.

Long-Term Evolution-IoT (eLTE-IoT), of which Huawei offers its proprietary 'eLTE-IoT' line, enables high bandwidth, high availability and short latency connectivity for IoT devices.

Data Service Platform

Within the platform layer for Smart Cities, two types of platforms are included: **device enablement** and **application enablement.** Each type of platform offers functionality to support an endpoint; however, while they are not interchangeable, they are interdependent. Many platform providers deliver services across the layers offering comprehensive end-to-end solutions.

Device Enablement Platforms

Device enablement is a combination of services purchased from vendors and service providers for their municipal customers, such as device provisioning and enablement. At its most basic level, device enablement is about device management and providing software that ensures the flow of data to and from the end device. Key components *include:*

- Activation
- Certification
- Diagnostics
- Enablement
- Provisioning

Application Enablement

Application enablement focuses on the horizontal integration of enterprise applications and specific vertical applications to fit the use case for a connected endpoint. It also focuses on the burgeoning area of analytics and the capability to build analytical tools for businesses to make real-time decisions about collected data. Key components of this platform solution *include:*

- API support
- Vertically focused applications
- Analytics

Cities have many areas of potential use cases, like remote monitoring or surveillance in public safety, or in transportation, environmental monitoring, or energy monitoring. The challenge is less about the potential uses of applications but finding the business model that can pay back the initial investment as well as support the application system maintenance.

Another challenge is to build analytics into applications so that business processes can be improved. With devices able to capture critical operational information, it is paramount for analytics to become a standard feature in these applications.

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The data service platform takes the data from the communication hubs or controllers, sensors, RFID tags, or other such wired or wirelessly connected IoT devices and is capable of capturing massive amounts of multi-source data often in near or real-time. This near real-time processing requires highly efficient data processing, ***and includes:***

- **Analytics software**. This element uses the data collected by the connected endpoint to turn it into actionable insights that business decision makers can use to affect change in business processes.
- **Application software.** This element uses software that either extrapolates information produced by the analytics software or serves as an input mechanism and is designed to deliver a specific functionality, either horizontal or industry specific, within the IoT solution.
- **IoT purpose-built platform.** This element ensures the flow of data to/from the end device through the network, allowing the collection and analysis of connection-related information and the integration of enterprise applications and IoT-specific applications.
- **Security software.** This element is responsible for the security of the IoT solution and network. This can also be a preexisting security software solution.

Computing Service Platform

Three types of computing platforms are briefly highlighted below as emerging areas of IoT:

Cloud Computing

"Cloud is not only yet another delivery model supporting existing storage workloads — it is an essential enabler for development and proliferation of a broad range of next-generation applications and services."from http://www.idc.com/getdoc.jsp?containerId=US40702215&pageType=PRINTFRIENDLY

IDC defines cloud services more formally through a checklist of key attributes that an offering must manifest to end users of the service. To qualify as a "cloud service," as defined by IDC, an offering must support all of the following six ***attributes:***

- Shared, standard service: built for multitenancy, among or within enterprises
- Solution packaged: a "turnkey" offering, pre-integrates required resources
- Self-service: provisioning and management, typically via a web portal and APIs
- Elastic resource scaling: dynamic, rapid, and fine-grained
- Elastic, use-based pricing: supported by service metering
- Published service interface (API): web services, other common Internet APIs

These attributes apply to all cloud services — in all public and private cloud service deployment models — although the specifics of how each attribute applies may vary slightly among these deployment models. At the highest level, the two types of deployment models for cloud services are public and private.

- **Public cloud services** are shared among unrelated enterprises and/or consumers, open to a largely unrestricted universe of potential users, and designed for a market, not a single enterprise.
- **Private cloud services** are shared within a single enterprise or an extended enterprise, with restrictions on access and level of resource dedication, and defined/controlled by the enterprise, beyond the control available in public cloud offerings.

Edge Computing

Edge/fog computing is defined as computing performed near the edge of a WAN or near sensors, devices, or equipment (collectively referred to as "endpoint devices") at the edge (as opposed the center of a cloud). This form of computing allows organizations to satisfy response speed and low-cost requirements that were impossible through direct communication between endpoint devices and servers gathered in a central location.

Edge/fog computing is similar in concept to cloud computing, and is in fact a supplemented and expanded version of that technology. Although edge/fog computing itself is not a new concept, it is again gaining a great deal of attention in the context of IoT.

Edge/fog computing is crucial for using ICT to link people and things distributed widely throughout society, as endpoint devices that generate raw data and clouds are simply not enough to accomplish this. Edge/fog computing is capable of providing high value to the real world by analyzing data at a more granular level close to the source of the data and feeding the results back in real time.

In addition to improving real-time response close to IoT endpoint devices, edge/fog computing will also likely develop into wide area decentralized cooperative platforms for IoT and data distribution business platforms by connecting with endpoint devices.

High Performance Computing

Demand for high-performance computing (HPC), also called supercomputing, has skyrocketed in recent years, given that it boasts spectacular ROI. According to a recent IDC study for the U.S. Department of Energy, HPC delivers $356 in return for every $1 invested. The global market for HPC servers, software, storage, and services in fact grew from $2 billion in 1990 to $21.9 billion in 2012, and is forecasted by IDC to reach $30 billion by 2017. Once limited to government and university researchers, HPC today is used to help design products ranging from automobiles and aircraft to golf clubs, animated films, mutual funds, potato chips, and diapers — not to mention HPC's crucial role in finding oil deposits and forecasting the weather. IDC estimates that HPC has helped PayPal save more than $700 million by enabling real-time detection of credit card fraud, an HPC application that is finding its way into national government programs in the United States and elsewhere.
(http://www.idc.com/getdoc.jsp?containerId=244316&pageType=PRINTFRIENDLY)

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Together, the connecting, data service and compute platforms make it possible to deliver real benefits to residents, businesses and governments alike.

Common use cases for the IoT include:

- **Municipal administration:** Smart City administration aggregates and analyzes information within a Smart City ICT ecosystem and makes it accessible across all departments and agencies. This data serves as the foundation for new and improved internal business processes and decision making for a city's infrastructure (facilities, pipe lines, water, waste).
- **Smart lighting:** Connected LED lighting is IP- connected and provides remote monitoring, programmable, adaptable dimming and brightening, intelligent energy metering and billing and whose physical infrastructure is used for additional connected devices that are interoperable between devices and systems both to collect and transmit data to the community, utilities, the private sector, and multiple government departments. Connected LED generates hard benefits like energy and operational savings, and softer benefits like crime reduction due to greater visibility, and the reduction of light pollution. Additionally, the streetlight becomes a platform for additional Smart City services using the existing light pole infrastructure which is ideal for other sensors and devices given its ubiquity, elevation, and access to a power source; light post can function as a citizen services platform for things like directions, signage and alerts, charging, etc.
- **Smart grid:** The smart grid enables more efficient outage management and revenue-generating business processes while also allowing utilities to connect with end users and the premise-based assets that allow for improved management of electric usage, distributed generation, and customer experience. The smart grid consists of instrumented gas pipelines, electric transmission and distribution networks, smart metering and communications, and smart home energy management and demand response.
- **Smart transportation:** Intelligent transportation systems leverage IoT to monitor the movement of people and freight on transportation infrastructure such as surface roads, highways, intersections, public transportation (i.e., light-rail, subways, buses), bridges, and tunnels.
- **Smart education:** Smart education uses integrated hardware, software, services and sensors to improve all aspects of providing quality education — from managing facilities, student care, and safety to interactive classrooms and digital curricula.
- **Smart & Connected Healthcare:** The connected healthcare IT infrastructure is made possible because of intelligent devices (including smartphones and wireless medical devices) and pervasive broadband networks that provide always on connectivity, along with Big Data, analytics, and cloud computing.

Next generation ICT catalyzes the digital transformation of city administration, the daily lives of residence, the economic milieu, ultimately optimizing the efficiency and quality of government services. In the section which follows, we explore how some cities are leveraging the Intelligent Operating Center as a means to achieving these goals.

Intelligent Operation Center

IOCs are critical applications in day to day city operations. IOCs allow cities to integrate and coordinate disparate data sources in real-time or near real-time, giving cities a comprehensive, integrated, operational and actionable picture of the city's assets. Open data exchange, together with non-proprietary, standards-based IT creates a collaborative ecosystem where data is shared seamlessly and solutions are interoperable. Integrated near-real-time data visualization gives cities the understanding and insights necessary to manage operations optimally.

IOC solutions bring directional and actionable clarity to service delivery and operations. IOCs provide comprehensive, end-to-end support for Smart City businesses, acting as a central orchestrating element for numerous Smart City systems including: administrative systems (implementing business data exchange and coordination); industrial (integrating city needs with industrial planning), and; environmental (monitoring, forecasting and treatment of water, energy, air and soil). It bears noting that command and control centers are completely different entities than an IOC, with the latter functioning as data exchange layer for many different elements of a Smart City, including the safe city.

However, in times of crisis, IOCs are force multipliers for command and control situations – critical tools that allow public safety organizations to integrate a plethora of information sources, allowing tri-service organizations to leverage advanced analytics, GIS visualization software, sensor-driven data generated by the IoT and mobile-driven applications. GIS technologies should not be underemphasized in this regard; they pictorially make sense of the overwhelming flood of data with which organizations currently struggle.

In short, Smart Cities with strong safe city underpinnings are reliant on a suite of technology that includes video surveillance, emergent video communication, integrated incident command and control, big data, mobile, and secured public safety cloud.

The Safe City

The assurance of public safety is an historical founding driver of civil society, and, in the view of numerous notable political theorists, the essential reason individuals and societies agreed to create the institution of government. Safety is also arguably the primal

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or base motivation for humanity; psychologist Abraham Maslow calls out access to basic necessities like clean water, shelter, food, and safety as fundamental human needs which must be in place before individuals can pursue loftier goals like self-actualization. Today, moving beyond history and theory into very tangible practical realities, the Safe City is often an under-acknowledged prerequisite to realizing Smart Cities.

Safe Cities deliver both social value – in terms of better overall quality of life – and economic value – in terms of industrial development, improved employment rates and revenue generation from sources such as increased tourism. While we cannot directly correlate the two factors, cities with higher unemployment rates tend to have higher crime, and cities with lower crime rates have lower unemployment rates. According to a US study from 2015, the top 25 safest cities in the US have average unemployment rates of 5.2%, compared to a national average of 6.3%; in contrast, average unemployment in the US's top ten most dangerous cities is 28.5% (http://247wallst.com/special-report/2015/09/30/the-most-dangerous-cities-in-america-5/4/).

Similar correlations can be made between safety and the revenue generated by tourism. A 2004 study by Glensor and Peak stated, for example, that "the most important prerequisite for a successful tourism industry is a reputation for keeping crime under control and guaranteeing tourists' safety." (http://www.cops.usdoj.gov/mime/open.pdf?Item=1306) Indeed the stakes are high here as the global tourism industry generates $7.6 trillion dollars a year.

Safe Cities uses ICT to predict, prevent, and reduce crime; address new and emerging threats; improve emergency/disaster planning and response; reduce the cost of operations; and allocate resources more effectively. Safe Cities work to create safe and livable communities using a variety of tools such as advanced analytics, social media, collaboration and information sharing tools, and mobile technologies to support emergency response services (fire, police, paramedic, search and rescue, coast guard, etc.), local law enforcement and policing, and the justice and corrections system including local courts, locally operated jails and prisons, probation, community corrections, and parole

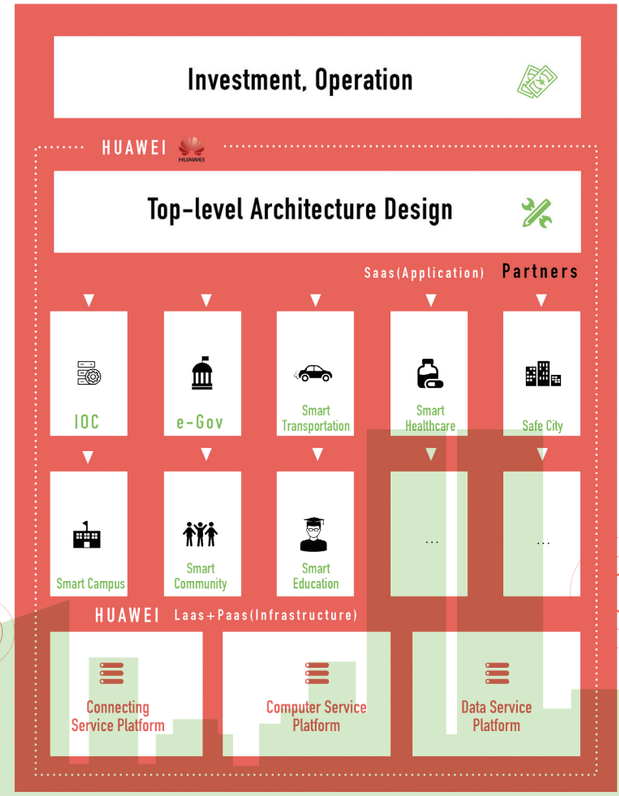
HUAWEI: NEXT GENERATION Smart City SOLUTIONS

Huawei's Smart City solutions have been deployed in more than 60 cities across 20 different countries, with 30 smart cities projects underway in China alone, where it is supporting the Chinese national government in its strategy to create a national standard for Smart Cities. Further to that, 100 Huawei's Safe City solutions span 30 countries and serve more than 400 million people. Huawei's Smart City solutions are founded on ubiquitous connectivity, information interoperability (both information sharing and integration), and inter-departmental collaboration.

Huawei has spent considerable time and effort building out specialized Smart City modules on a unified platform for multiple, integrated, interoperable uses that allow cities to address specific pain points related to a plethora of use cases such as traffic, energy, and public safety. Its Smart City enabling solutions are modular and focus on urban development, social development: and ICT Infrastructure.

As shown in Figure 6, the Huawei platform integrates the connection service platform, the computing service platform and the data service platform, leveraging the IoT, integrating innumerable information sources, in an intelligent, collaborative manner. Combined, the platform provides next-generation ICT through which it, in conjunction with its partners, can build Smart City applications.

FIGURE 6 **Huawei Smart City Architecture**



source: IDC Government Insights, 2016

Huawei's clients move through three waves of Smart City maturity. In the first, they concentrate on ICT infrastructure modernization. In the second, they focus on modernizing service delivery and service management; in the last they focus on internally and externally focused innovation.

Huawei new ICT integrates leading technologies, resources, and ecosystems to build a high-tech nervous system for city administration. IOC is the most important part of the Smart City. IOC serves as the brain for the digital world, while IoT connects the digital and physical worlds to bring the efficiency of city operation to a new level.

To realize the Smart City, three essential platforms need to be established:

- **Data Service Platform:** Acquire massive amounts of multi-source data, store the data, and process and analyze it for data sharing and improving operational efficiency
- **Connecting Service Platform:** Collect and consolidate information from every corner of the city, transmit them to the different functional platforms and applications of smart cities, and manage the overall transmission network. For instance, when a new city district starts construction, IoT networks connecting construction sites, street lamps, trash bins, parking systems, water meters, and environmental monitoring sensors can be integrated to achieve real-time monitoring, warning systems, and management.
- **Computing Service Platform:** Edge computing, Cloud storage, cloud computing, and high-performance computing

Huawei Smart City solution enables clients and partners to build leading win-win ecosystems, laying the foundation for sustained development of smart society. Huawei has focused on improving ICT infrastructure, delivering high-performance, agile, reliable, secure, and scalable infrastructure. At the same time, Huawei also works with partners to develop features and interfaces, collaborating with partners on various platforms to support customer business applications and rapidly respond to customer needs. One of the approaches to showcase Huawei's good partnerships in action is establishing the OpenLab.

Glocal Openlab

Part of Huawei's open innovation strategy, Glocal Open Labs cultivate open innovation by providing cutting-edge organizational and technical platforms that cater to local industry specialties. Stationed around the world adjacent to key industrial centers, Glocal Open Labs leverage an ecosystem of solutions, partner resources, subject matter and technical experts, and physical labs in which to explore and create solutions. The business innovation of Openlab drives innovation for client business, industry solutions, and ICT infrastructure. For example, the Singapore Open Lab is focused on Smart City, finance, and Internet of Things. It opened on August 17 2016 and serves Asia Pacific, including Australia, Singapore, New Zealand, and many other countries.

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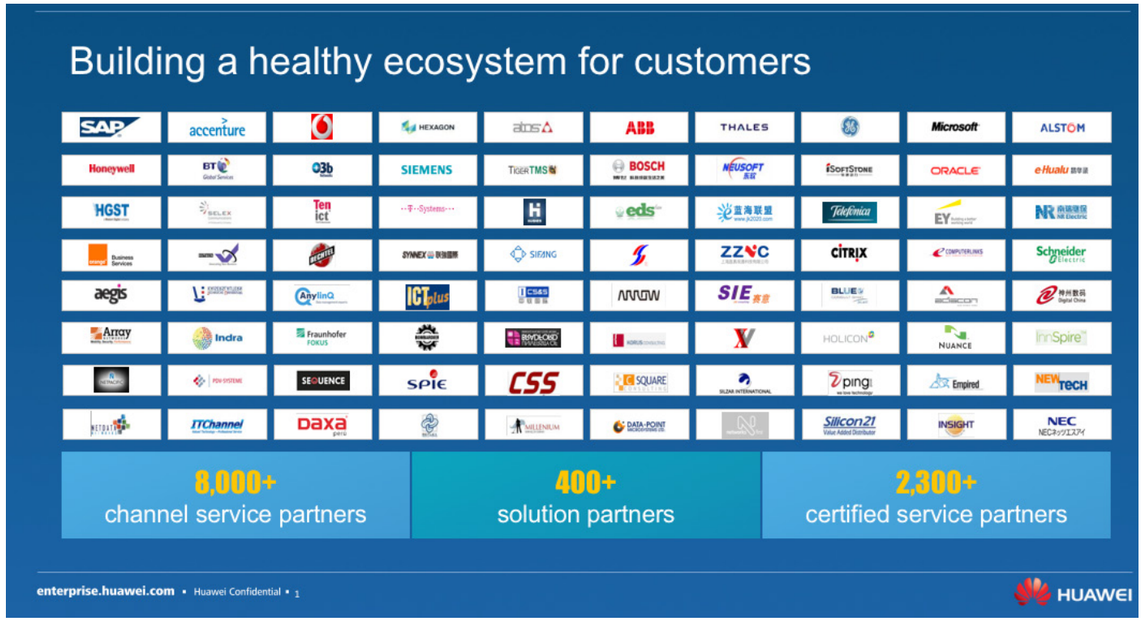
Huawei Smart City ecosystem

Huawei is laying a foundation for the future development of a smart society by building an ecosystem of partners and customers.

Huawei calls this a "win-win ecosystem" which involves a Smart City ecosystem for more than 5,000 partners. Huawei's Smart City channel strategy is built on both a broad and deep collaborative partner ecosystem. This maximizes value for Huawei, its clients, and its channel partners as it delivers core service strengths from all involved parties. Combined, Huawei's partner ecosystem includes more than 4,000 Tier 1 (Distributors and VARs), Tier 2 (Gold, Silver, Authorized) and Registered Partners who have accepted the Indirect Channel Partner Agreement and successfully registered as a Huawei partner. Partners benefit greatly from the arrangement as Huawei Enterprise Business Group (BG) offers its partners open API, access to global expertise and sand-box type lab resources.

Huawei offers IoT solutions in many of the industries and sub-verticals pivotal to Smart Cities, including smart metering, building energy-efficiency management, connected street lights, water heater monitoring, smart manufacturing and intelligent transportation solutions. Huawei's IoT solutions are delivered by partnering with local service providers in EMEA, ASIA, Latin America and, increasingly, in North America. Many of its partnerships are geared to pressing social issues specific to a given city or nation. In China for example, bolstering fitness was one of the stated objectives of China's 12th five-year plan. Huawei developed its IoT-powered Smart Gym solution to address China's comparatively low fitness participation levels; for example, less than 20% of Chinese citizens who reported exercising at all did so in a gym. Additionally, those who reported that they didn't exercise state that the lack of facilities was the main reason. Huawei's Smart Gym solution connects all equipment to the network so that accurate fitness data, trainers are patched in via the cloud to provide on-site training and guidance; the IoT solution comes with smart reservation, entrance control, goods storage, and environment adjustment. Lastly, operations and maintenance data are collected and managed preventatively.

FIGURE 7 **Huawei Partner Ecosystem**



HUAWEI'S Smart City SUCCESS STORIES

Kenya: Implementing the Safe City

Kenya is an excellent example of the types of smart and safe city solutions, leveraging both the commend center and the IOT, being implemented by Huawei. As part of its national strategy to protect its people, promote tourism and encourage foreign economic investment, Kenya recently implemented a next generation commend center aimed primarily at protecting its two largest cities – Nairobi and Mombasa. Kenya has been the target of a number of recent terrorist attacks including the Mandera quarry and school bus attacks (64 deaths), the Westgate mall shootings (67 deaths, 175 injuries), and the Garissa University shootings (148 deaths, 79 injuries). In addition, more than 30% of residents had suffered a robbery or carjacking, and the economy was suffering with a downturn in tourism and foreign investment. These events led the Kenyan president, Uhuru Kenyatta, to declare the implementation of the commend center as one of the country's highest priorities to improve public safety..

Huawei, in partnership with Safaricom (Kenya's largest mobile network operator) began working with the Kenyan government and police force to implement a next-generation commend center to manage this unrest. Huawei and Safaricom needed to surmount a number of challenges specific to Kenya: first, the Kenyan police had been historically under-provisioned in terms of ICT; second, the ratio of police officers to citizens was very low, 1,150:1 as compared to the American recommendation of 450:1; and third, there were considerable bandwidth issues to address across the country. The partnership with Safaricom sought to accelerate the implementation of a national mobile broadband network upon which the national safety network could be implemented. To date, the commend center consists of the following solutions:

The solution provides:

- **Panoramic surveillance:** Optical fiber transmission has been adopted for network access with different site models designed for different users to support national-level monitoring system.
- **Integrated direction:** Video surveillance, video conferencing, and eLTE solutions enable better monitoring and dispatch as well as more efficient administration.
- **Intelligent analytics:** a platform for video analytics for unified management of all video sources, allowing for on-site monitoring and mobile and digital evidence collection.

Measured success of the system has included:

- A **19-fold** increase in the number of effective **999** calls.
- A **decrease** in robbery and pilfering.
- The **proven ability** to handle emergencies and enact advanced contingency plans in the face of terrorist attacks.

While it is always difficult to measure incidents that were prevented or did not occur as a result of this' project, with Phase 1 of the commend center implementation complete, Kenya has tested the system during a number of prominent dignitary visits from the Pope and President Obama, during which there were no incidents. Kenya plan a future deployment of the commend center in 47 counties, touching18,000+ policemen, and 20,000+ auxiliary and special police. The country expects to see a decline in terrorist attacks, and an increase in public trust in its police and emergency systems as 999 calls are efficiently handled and police are better trained and monitored.

Smart Longgang Case Study

Longgang is an excellent example of a smart, safe city leveraging the IOC and IOT to deliver value to residents

A district of Shenzhen China, Longgang hosts a wide variety of high-tech, transportation and logistics, advanced manufacturing and financial firms. The city recently found itself struggling with triad of critical social and economic issues: digital transformation; social cohesion and governance, and economic development.

Seeking to build on its existing strengths, Longgang partnered with Huawei and its broad ecosystem of industry-leading solution providers to build an intelligent urban infrastructure, part of its Smart Longgang strategy.

For Longgang residents and municipal workers alike, the solution needed to be convenient, usable, and efficient in its delivery of next-generation public services. It also needed to provide city administration with smart, sophisticated tools that would help raise Longgang's livability as well as digitally enabling a number of its key existing industries.

Key challenges needed to be addressed by the solution:

- Solution platform must keep **citizens** at the center of city operations
- Urban safety must be enhanced through **next-generation technologies**

  Advanced analytical tools need to deliver **real social value** and increased livability
- Leverage the IoT, Big Data analytics, cloud computing, mobile, social and cognitive to **collectively catalyze existing industrial productivity**
- Take **key insights** from the Longgang pilot projects and iterate

Huawei and Partner Solutions

In conjunction with its partner ecosystem of leading vendors in the Smart Cities market, Huawei and the city of Longgang implemented a comprehensive, end-to-end platform solution leveraging cloud, virtualization, Big Data analytics, GIS and data visualization, and IoT.

Smart Longgang threads the device, to the network and its databases, leveraging visualization software, all deployed from a cloud delivery environment.

The Smart Longgang initiative centers on 11 pivotal projects all driving towards intelligent infrastructure, collaborative and efficient government service delivery, convenient resident utilization to create a more livable and productive urban environment for citizens and businesses alike.

The solution platform is premised on the following business needs:

- **Unified data exchange:** Smart Longgang integrates, or interoperates, a number of databases critical to information sharing. By eliminating the traditional siloes involved in municipal service delivery, Longgang is able to optimize utilization of its data sets. The solution integrates data from more than 50 departments across three jurisdictional levels in Longgang

- **Incident Management:** During an incident, the IOC provides first responders with collaborative, integrated communications channels, including integrated dispatch for public security / firefighting/ transportation/ medical treatment sectors and real-time voice and video information, so that tactics and instructions can be transmitted to the first line. First responders can also participate in real-time fusion consultations

- **Day-to-day data usability:** As important, the IOC is also the daily operations management system for the city. In Longgang, the IOC functions like connective tissue, seamlessly integrating a scalable multitude of information and data sources. A number of specific apps have been created to leverage the data, including planning tools for new building development and industrial development, and public safety monitoring. The IOC is a platform that is rendered live by data visualization tools that reach out to residents and businesses.

Hard and Soft Benefits

- **Unified data aggregation** and dissemination allows Longgang to engage in evidence-based service delivery

- Data visualization and spatial tools provide a **richer, more realistic, depiction of issues and solutions**

- Keeping citizens at the center, in the channel of their choosing, **has skyrocketed citizen satisfaction levels**

- Collaborative planning processes are **unified and efficient**

Collectively, the Smart Longgang platform delivers an intelligent ecosystem of city management tools that are providing a safe city environment while at the same time leveraging the intelligent operating center for city administration, and smart sub-vertical solutions such as smart transportation, smart healthcare and smart citizen services.

CONCLUSION: BEST PRACTICES MOVING FORWARD

Safe, smart cities that are interested in developing an IOC and move forward with Smart City maturity should consider the following best practices.

Create a city-wide inclusive Smart City strategy. Creating an inclusive city-wide strategy serves to gather stakeholder input to prioritize the goals the city has as a Smart City, to focus the discussion on specific challenges that real stakeholders face, align departments around a common vision with internal and external buy-in, and differentiate each city in its approach to becoming smarter. By including external stakeholder input early on, the strategy gains local buy-in and legitimacy, and increases the likelihood for support of the related initiatives.

Take a platform approach to technology and realize there is regional variation in IOC implementation. Many cities are adopting citywide open platforms which allow them to leverage cloud-based technologies across the entire enterprise but that often are implemented as a federal model. Western cities are less likely to have large, multi-department operating centers, preferring to work with physically separate locations but with a shared data layer provided via cloud solutions. Integrated data visualization at the enterprise level requires substantial buy-in from multiple stakeholders and departments. Once this is accomplished, however, the benefits of implementation will have far greater reach and impact for the city; risk will also be shared across departments.

Look for quick wins. The development of Smart Cities is a long-term, complex endeavor, but the implementation of discrete Smart City projects, which fit into the long-term vision, does not have to be. Develop your strategic vision and then identify small, measurable, and public projects that will demonstrate success for example in smaller video analytics or body-worn cameras deployments.

Governance. In IDC's case study research, many public safety organizations have stressed that organizations beginning on multiagency data sharing arrangements should pay special attention to governance. Comparatively, technology is the easy part.

Multiagency focus from the onset. Tied closely to the economic challenges currently facing law enforcement, we recommend that organizations fundamentally change the operational ecosystem so that various units within a given organization, and among multiple agencies, pool resources and create centralized cloud repositories.

Data quality. Data quality and validation is critical to leverage insights across multiple agencies, and organizations typically underestimate the amount of effort required to harmonize and integrate information from multiple systems and agencies. Information exchange models such as NIEM will become invaluable in ensuring that data sharing can occur as fluidly as possible.

Seeking out scalability and integration ease. Irrespective of the cloud deployment model being implemented, cities must build or purchase a scalable architecture that can accommodate and manage all digital assets.

Mobile. Mobile is the next frontier for effective police service delivery and mobile-enabling core business solutions is key as police officers need to be able to both enter and receive real-time data to enhance situational awareness.

Quantifying business outcomes. Oftentimes, municipal organizations do not make quantifying business outcomes a priority. However, IDC recommends that organizations define key KPIs prior to implementing an IOC to substantiate further business investments and to be able to effectively communicate success to citizens, tourists, and businesses.

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