Building Agile Data Driven Smart Cities

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Situation Overview

The world is urbanizing at an astonishing rate. By 2050, as per the United Nations' (UN) forecast, nearly 70% of the world's population will be concentrated in urban centers, as compared with 54% in 2014 and 30% in 1950. And around 90% of this increase in the global urban population is expected to occur in Asia and Africa.

Such a rapid shift in the rural–urban population distribution, along with increasing utilization of information and communication technology (ICT) among individuals, businesses, and governments, is driving the social and economic transformation of cities around the world. As we steadily transition to the digital world, we will increasingly expect the same of our cities.

To continue to flourish, cities will need to address and manage not just population growth, but also challenges relating to safety, traffic, pollution, commerce, culture, and economic growth, among others. Adding to the challenge is the fact that, quite often, the bulk of municipal budgets are already committed to ongoing programs; city administrators thus have to balance these new requirements while trying to optimize budgets and resource allocation, and still meet citizen needs and requirements.

Cities will also have to manage the expectations of their occupants (i.e. citizens, residents, visitors and businesses), which are also changing. They expect to have more transparency and openness from governments, access to services, and more importantly, the ability to engage with government by providing feedback on services, decisions, and laws.

In a bid to ensure that they build sustainable, competitive, and innovative cities that are satisfactory for businesses and citizens alike, governments around the world have launched various initiatives to aid the transformation of their urban centers into Smart Cities.

What is a Smart City?

IDC defines a Smart City as being a "*finite entity (district, town, city, county, municipal, and/or metropolitan area) with its own governing authority that is more local than national. This entity is built on an ICT foundation layer that allows for efficient city management, economic development, sustainability, innovation, and citizen engagement*."

A Smart City can easily be termed as a long-term technology initiative. Despite being ubiquitous, technology is increasingly becoming an element that works in the shadows, aiming to deliver a high-quality sustainable environment for citizens.

Figure 1: Smart Cities Services

Source:IDC, 2015

The benefits of Smart Cities are that they:

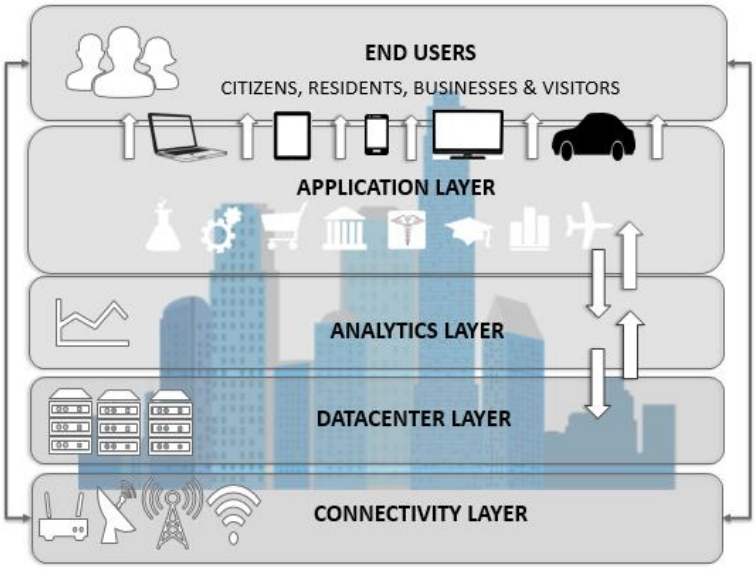
- Aid in building and implementing operational efficiencies around citizen and business services, such as ensuring efficient traffic management during peak traffic times or eservices for business permit approvals.
- Create an environment that is attractive to businesses and sustain economic growth — building an efficient urban environment and business processes will attract foreign direct investment (FDI) and promote innovation.
- Present a safe and energy-efficient environment for citizens through the implementation of solutions such as CCTV, smart meters, and intelligent building management and lighting systems to better monitor citizens and allow for efficient use of energy.
- Support growth and innovation with rapid technology adoption. Some cities can choose to deploy robots to provide surveillance services in some pre-defined areas or allow cities or companies to utilize citizen data to create new innovative services or applications.
- Ensure higher levels of citizen engagement and provide a higher quality of life, since smart cities will allow for citizens to provide feedback and engage city authorities in real time.

Smart Cities will consist of initiatives and programs such as online and mobile services, intelligent traffic management, smart lighting, smart healthcare, smart meters, smart grids, and physical security systems to create an ecosystem that ensures a robust sustainable environment for their citizens.

ICT Building Blocks of a Smart City

Data is one of the most critical elements that will underpin the success of a city's transformation into a Smart City. To be deemed successful, a city should be able to harness data from existing government systems, online and mobile applications, third-party applications, and, most importantly, from citizens — the ultimate beneficiaries of Smart Cities. The data that is gathered can be used to make informed, automated decisions that can improve the life of citizens.

Figure 2: Building Blocks of a Smart City



Source:IDC, 2015

Smart Cities are made of various layers where each aspect involves technologies that aid in generating and gathering data, aggregating and analyzing the data, and being able to execute an optimal response. A strong connectivity infrastructure layer or pervasive broadband platform underpins all of this.

The five core layers, or blocks, that are crucial to building out a Smart City are as follows:

- Connectivity Layer: This layer encompasses all the types of connectivity such as cellular (3G, 4G, 5G), WiFi, Bluetooth, sensors, collectors, and the *Internet of things (IoT)* in general. These can be owned by private or public operators, municipalities, or different government entities- local or federal ones. Strong connectivity infrastructure enables access to systems and allows cities to capture and respond to data effectively.
- Datacenter/Operations Layer: Given the amount of data that is being generated and gathered, the datacenter/operations layer ensures that the data is stored in a common repository and is easily accessed across various departments and applications.

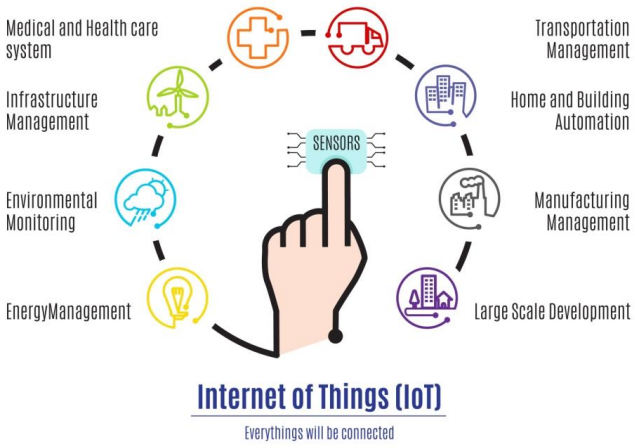
- **Analytics Layer:** At this layer, cities are able to take all the data that has been collected and turn it into valuable insights and actions. At this point, cities will be leveraging solutions that enable them to structure and analyze the data. Increasingly, cities are turning to Big Data analytics that enable them to analyze all types of data — structured, semi-structured, and unstructured — in near real time. Through the use of predictive analytics, smart cities can implement prescriptive actions for the optimal allocation of resources.
- **Applications Layer:** At this level, cities implement various industry-specific and horizontal applications that allow for data input, capture, and collection across various platforms such as online services, mobile devices (e.g., smartphones and tablets), sensors, and cars. This layer will also allow for users to have a seamless experience by implementing applications that will be able to integrate services from various entities, improving overall efficiency. Governments, for example, will be able to deploy a single application that will provide users access to functions from various departments, instead of having separate and disparate systems. These applications will also be able to provide "contextual" information (i.e., users will be able to gain insights on how they compare to other users within the city).
- **End-User Layer:** The final building block of a Smart City is that of the end user, which can range from an individual — be it a citizen, a resident, or a visitor — to public agencies, to private businesses. This is the level at which the data is captured, be it via online applications, smartphones, tablets, sensors , or GPS, and also the layer that eventually absorbs the outcome of the Smart City initiatives. The effectiveness of this layer is essential to being recognized as a truly Smart City.

To ensure effective use of these building blocks, cities will need to do their due diligence to ensure that the systems are properly integrated between various departments, systems, and applications.

INTERNET OF THINGS

IDC defines the "Internet of things" as "a network of networks of uniquely identifiable endpoints (or 'things') that communicate without human interaction using IP connectivity." Essentially, IoT takes into account sensors, smartphones, tablets, RFID, NFC, wearables, and GPS devices that can transmit information and execute actions based on analysis of the information; in short, all "smart devices" form the IoT ecosystem. The simplest example is that of intelligent lighting systems, whereby the system can regulate the lighting conditions of the building based on factors such as weather and occupancy. An effective IoT ecosystem — be it around smart utilities, traffic management, building management, or smart healthcare — will require a city or department within a city to consider standardization of the devices being deployed (or the use of open-source devices), improvements in connectivity levels, the type of data that is being accessed, the applications that will process the information, and the additional services that can be developed based on the information. Billions of things are now being deployed, transmitting vast amounts of data and being managed by intelligent systems. There are currently 13 billion connected things; IDC forecasts that by 2020 there will be 30 billion connected things generating a revenue of $1.7 trillion for the worldwide IoT ecosystem.

Use Cases of Internet of Things



Source:IDC, 2015

ICT Innovation in Smart City Development

Smart technologies can help cities in tackling their emerging challenges. Technology innovation is fueling a transformation of cities' management of their human capital, natural resources, infrastructure, and intellectual assets. A Smart City uses various ICT solutions to integrate information and operations within and between city systems and domains, and engage with citizens, businesses, and the broader community in new ways.

The Data-Driven City

Data generation continues to accelerate at an unprecedented rate, with the amount of data in the world expected to reach 44 zettabytes by 2020[1]. Cities realize that in order to transform they will increasingly need to leverage Big Data technologies across various data feeds to be able to extract quality, predictable and actionable insights, ensure strategic decision making, and deliver improved performance management. For example, effective and quality data feeds from building sensors and CCTV cameras can allow a city to make decisions on how to improve district-level security. In addition to being able to respond to information, data consolidation and protection are essential to becoming a data-driven city. Consolidating and protecting citizen data from various government departments will simplify the use of citizen services while also sustaining continuous access and ensuring effectiveness.

In order to truly transform, cities have to consider the following aspects relating to data:

- **Data Sources & Integration:** Cities will need to ensure data is being captured from various sources, including online services, mobile devices, commercial entities, and sensors or IoT. In addition to capturing the data, cities will need to define how they will classify and store the data and determine what levels of data access rights will be provided across various public and private entities. In the early stages, cities will need to manage issues around data interoperability, data quality, and data formats. In addition to

[1] http://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm

varying data formats, cities need to be mindful that not all Smart Cities are greenfield initiatives with cities capturing new data for the services they wish to provision. Many initiatives will involve the modernization of existing ecosystems that will already have data that cannot and should not be discarded. Cities will need to achieve synergies across the old and new ecosystems and the data that is being generated.

- Analytics and Big Data: By leveraging analytics and Big Data technologies, cities will be able to ensure they gain valuable insights, provide solutions to "citizen" problems, and measure performance. Cities will be able to leverage solutions that will be able to provide real time analysis from various data sources. In addition to understanding the data, by using predictive analytics solutions cities or governments will be able to forecast outcomes based of the analysis defined metrics. This can be taken a step further by utilizing prescriptive analytics, i.e. they will be gain insights on what actions they should take to achieve or improve on a particular outcome. Using these analytics solutions, cities will be able to provision users and businesses with targeted and personalized services. For example, a transportation company will be able to gain insights on what are the best possible routes to take if there is traffic congestion, or a user maybe directed to the best hospital that will be able to attend them immediately based on feedback from sensors and systems on hospital occupancy.
- Data Governance: Governments will need to address how all the data that is being captured will be governed and will need to find a balance between data security, accessibility, and privacy. If governments seek to implement open data governance, then they need to address data quality as well. It will be important for governments to ensure that citizen data is being managed properly and not being shared by third parties without due consent. Smart City data governance cannot be done in isolation of "cybercrime" laws, since these laws address both the Internet and the systems that are connected to it.

For example, a city will be able to improve its traffic management by analyzing data feeds from sensors or cameras at various traffic junctions, cars, social media feeds from commuters and pedestrians,

or even information from government or third-party mobile applications. The traffic department can use this information to manage traffic flow, ease congestion, and even redirect traffic in the case of an accident.

Cloud-Empowered City

Many Smart City projects are usually industry- or domain-specific; for example, healthcare, utilities, transportation, and border control. These industry-specific projects will have their own dedicated set of systems and applications. As cities expand, these projects must scale while sustaining their service levels. City-level projects such as energy management require interconnectivity between various departments and stakeholders — for example, utilities, municipalities, and building owners. Adding to the complexity is the increasing deployment of sensors and the data being captured by these sensors.

Cloud technologies can be leveraged by cities and industries, consolidating data from various applications and sensors while gaining access to improved and scalable compute and storage capabilities. As industry-level projects become part of citywide or national-level smart initiatives, cloud services become critical to establishing a common platform for communication, collaboration, information, and services.

To create cloud-enhanced cities, governments and organizations should enhance their existing datacenter investments or build out new and more powerful datacenters. Next-generation datacenters can be built using concepts and technologies such as modular datacenters, converged infrastructure, and software-defined technologies for improved agility, scalability, standardization, and efficiency.

In addition to infrastructure, Smart City clouds will need to address applications. Applications can be developed for industry-specific projects or citywide initiatives, though as IoT becomes more pervasive, a cloud-enhanced city may need to access data from third-party applications that are capturing the data from sensors. However, despite the value proposition of cloud around operational efficiencies, productivity, scalability, and costs, the challenges around data and sensor security and data portability remain a major concern, especially

when the data involves industry-level mission-critical information or citizen information. Furthermore, compliance with data sovereignty regulations limits public cloud adoption in sectors such as government, finance, and healthcare, leading to a preference for private or hybrid cloud deployments.

The Secure City

Smart Cities aim to build a sustainable environment that allows for economic enhancement and diversification. Any city wishing to ensure a quality and sustainable environment for its citizens, businesses, and investors will need to make investments to enhance both physical and digital security. City planners will need to engage with various stakeholders to deploy the right kind of solutions, establish proper guidelines, and facilitate effective remediation.

To secure a city, planners will need to seek a holistic approach to security by addressing aspects such as the physical, industrial, and digital levels of security.

For enhanced physical security, cities need to deploy video surveillance systems in public, residential, and commercial areas. In addition to surveillance, sensors should be deployed to improve the response of emergency services and law-enforcement agencies.

Improved Internet connectivity has left industrial control systems (SCADA) vulnerable to manipulation. Organizations in industries such as energy and utilities are deploying sensors for improved monitoring and real-time analysis. Companies need to address the security of these sensors and systems, since sectors such as utilities form a part of critical national infrastructure. Organizations in these sectors need to engage in security audits, vulnerability assessments, access management, and security monitoring.

Digital security for a city can range from securing industry or project-level networks to citywide or federal-level security strategies. Countries, not just cities, will need to ensure nationwide network integrity and availability. Cities will need to enforce and adhere to cybercrime laws. In addition to cybercrime laws, cities need to take

steps to ensure that all the citizen data that is being captured is secure. Any breach of citizen data can have severe repercussions for the government in question, since it will impact citizen trust. Smart Cities can deploy solutions such as data encryption and identity and access management, as well as security monitoring and analysis, to ensure the safety and integrity of city networks.

While cities and stakeholders can invest or deploy all these various solutions, they need to be cognizant of the fact that many ICT solutions are typically linked to proprietary hardware and software solutions. This can lead to solutions that lack interoperability or lock users (citizens or businesses) into a single ecosystem, and overcoming this challenge can be an excessive undertaking for cities, suppliers, and developers. Cities that leverage cloud computing to create a common platform will encounter issues if varying IoT sensor software solutions are used. As such, open-source solutions represent a very attractive value proposition for Smart Cities. With open-source solutions, cities can deploy sensors and infrastructure and develop applications that are interoperable and cost effective, and provide developers and users with greater levels of flexibility. Open-source solutions will have wider implications, especially around "open data," whereby cities need to ensure the availability, transparency, and quality of public data, that is freely accessible to the public. The data needs to be made available on open data platforms, enabling the development of applications and services that can be used seamlessly across the ecosystem.

ICT is a major enabler when it comes to Smart City transformation, but Smart Cities are driven by and for the citizens. The need to meet citizen expectations drives cities, businesses, and individuals to use technologies as a means to do things differently and, more importantly, to drive innovation.

Building a Smart City Partnership Framework

Building a Smart City goes beyond technology. Boosting and institutionalizing innovation in any large multi-stakeholder entity requires building relationships across groups that are able to contribute to improving the status quo. The goal of developing such a

partnership ecosystem around Smart Cities is to bring diverse stakeholders together to discuss goals, processes, policies, and financing mechanisms for new technology adoption that can ultimately benefit the whole city, as well as each individual participant. Simply put, an innovation ecosystem seeks to create "win-win" solutions that will provide an impetus for the launch of specific Smart City initiatives.

As is often repeated when talking about building Smart Cities, no one stakeholder group can do it alone. To build and execute a successful Smart Cities framework, a city should ensure that it has set up the necessary building blocks/foundations for the initiative. However, the success of a Smart City is heavily dependent on ensuring the involvement of key stakeholders.

The key stakeholders in Smart Cities are citizens, governments, ICT and infrastructure suppliers, planners and developers, private investors, and utilities.

Figure 3: Major Stakeholders Within a Smart City Framework

Source: IDC, 2015

» **Citizens:** The ultimate success of a city and its services is defined by its citizens. The citizen plays the most pivotal role in any prospective city, and the satisfaction level of the citizen becomes a major key performance indicator (KPI) for measuring the

effectiveness of the initiative. Citizens are not only the source for most of the data that is needed to drive Smart City services; they are also the main consumers of the "analyzed" response from the data. Smart cities are not just limited to citizens or nationals, but also encompass residents, visitors, and businesses that wish to engage with the city.

- Governments: Federal- or local-level governments drive Smart City agendas, stating the level of cost effectiveness, sustainability, and innovation, all of which leads to a better environment for citizens, residents, visitors, and businesses. Governments are major enablers within the Smart City ecosystem; any IT investments being made by the government around applications or infrastructure can be utilized across other departments such as utilities, transportation, and healthcare. While this might not be a direct indication of return on investment for the IT departments within the government, the city should measure the benefits gained in terms of improved traffic management, improved safety standards, reduced power consumption, and so forth.
- ICT and Infrastructure Suppliers: These suppliers are needed to ensure citizen safety and deliver a seamless experience for citizens while they interact with their solutions. This will include technology vendors and telecommunication firms as well as companies specializing in the deployment of roads, rails, bridges, and so on.
- Planners and Developers: This essentially refers to city planning departments and developers who will engage with the city to construct or modify the city. They need to keep the citizen in mind while creating practical, habitable, and sustainable living environments.
- Utilities: These refer to the providers of basic amenities such as water and electricity (renewable or non-renewable sources). These are critical members of the ecosystem, since they need to ensure continuous and cost-effective services.

Synergies need to exist between the various stakeholders. It is important to understand what each stakeholder wants, and they should be able to identify common goals. This will help ensure that the building blocks are being leveraged effectively and are ultimately addressing the end goals of the city.

Smart City Transformation in Gulf Cooperation Council (GCC) Countries

"Smart" is increasingly becoming synonymous with urban development and regeneration in the Gulf Cooperation Council (GCC), and various cities and countries are implementing state-of-the-art ICT solutions and services to enhance the experience of businesses and improve the quality of the life of citizens and visitors.

For example, the UAE, Saudi Arabia, and Qatar were recently ranked by the World Economic Forum among the top 10 countries when it came to the "Importance of ICT to Government Vision of the Future" in the organization's 2015 Global Information Technology Report. The GCC is also expected to have one of the highest urbanization rates by 2050, ranging from 90% to 100%.

Given these emerging trends, the GCC's leaders are well aware of the need to transform their respective cities. Smart Cities form a core part of various national strategies in the UAE, Saudi Arabia, and Qatar, and cities within each of these countries have launched Smart City initiatives. The success of these initiatives will enable those countries to realize their strategic visions.

In the UAE, Dubai is at the forefront of becoming a Smart City as mandated by His Highness Sheikh Mohammad Bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai. The underlying theme that forms the basis for smart initiatives and strategies is that of "happiness." The aim is to have a city that ensures the "happiness" of its citizens, and empowers them. Technology innovation is seen as the enabler that gives citizens access to various integrated services, allowing the city to make efficient use of its resources. Dubai is the top-ranked city in the Middle East and Africa as per Mercer's Quality of Living Survey, 2015, followed by Abu Dhabi.

Dubai's transition into a "Smart City" is an evolutionary process that is being driven by the successful deployment and implementation of eGovernment and mGovernment initiatives, with the aim of giving

businesses and citizens access to government services anywhere and on any mobile device. Mobile is a major technology enabler for Dubai becoming smart, and rightfully so given the emirate's high mobile penetration rate of 200%. Numerous mobile applications are continuously being developed, allowing citizens and businesses to access services across various government entities. The strategy for the Dubai Smart Government is based on six "pillars," or the transformation of six sectors, namely infrastructure, transportation, communications, financial services, urban planning, and electricity. In addition to 100 initiatives being launched across these sectors, nearly 1,000 services are mandated to go "smart" by 2017. The success of Dubai Smart Government has a lot to do with three key factors — connectivity, mobility, and data. With the first phase of the transformation set to be completed by 2017, the second phase — and a major driver for this transformation — will be evident in 2020, when Dubai hosts the World Expo.

EXPO 2020

In 2020, Dubai will become the first city in the Middle East to host the World Expo. The event is expected to attract as many as 25 million visitors. The 438-hectare site will be built around a sustainable ecosystem that will be powered by renewable energy sources. Running with the theme "Connecting Minds, Creating the Future," Expo 2020 is expected to showcase sustainable solutions to global problems, while subthemes such as opportunity, mobility, and sustainability will be explored as key drivers of progress. It is expected that over the next few years the Expo will create as many as 275,000 jobs, and have an estimated economic impact of $19.6 billion. – Source: Expo2020

In early 2015, Dubai's Roads and Transport Authority (RTA) declared that close to 100% of its services were now "smart," with the agency offering nearly 173 services across online and mobile platforms to road users, public transport users, and the business sector. The RTA stated that it has experienced nearly 260,000 transactions over the past year. In order to ensure service efficiencies and effectiveness, the RTA established a state-of-the-art datacenter, enabling it to integrate data from various services and create a much-needed integrated control center. This helped it to

create a robust infrastructure through which it can continue to streamline and deliver smart services.

IoT is also very much a reality in Dubai, with one the first initiatives being piloted by Dubai Electricity and Water Authority (DEWA), which is deploying 200,000 smart meters that will be operational by early 2016. The smart meters allow citizens to monitor and control their electricity and water consumption online or on their mobile devices, hopefully facilitating a reduction in wastage. The plan is to deploy more than a million such sensors by 2020. To further emphasize its commitment to improving sustainability, DEWA is also deploying a Smart Grid, harnessing solar energy and installing fuel-charging stations for hybrid vehicles.

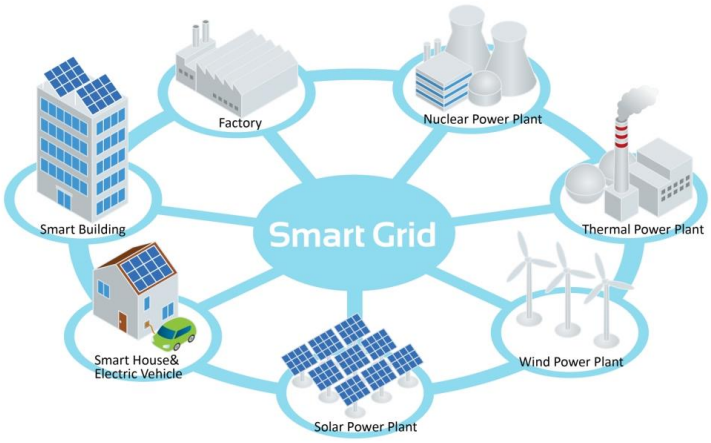
Security is another key component of Dubai's ambition to become the "smartest" city in the world. Dubai Police has introduced smart services that allow citizens to locate high-traffic locations, report accidents, and issue fine payments, among other things. More importantly, it has deployed around 650 external CCTV cameras to monitor commercial locations, as well as 550 mobile cameras on police cars to monitor traffic. The feeds from these cameras help to improve police efficiency and reduce the amount of time taken to resolve cases.

To further strengthen the emirate's commitment to becoming "smart", Dubai has established two major projects — Dubai Design District (D3) and Dubai Silicon Park. Both of these developments are greenfield initiatives where the communities leverage Smart City building blocks and solutions to provide an environment that is sustainable and interactive, and promotes innovation in both technology and design. Both projects will leverage solutions around mobility (WiFi accessibility), electric vehicle infrastructure, green buildings, and sensors to create a truly interactive and smart environment.

All the initiatives designed to make Dubai "smart" rely heavily on technology that the government aims to make omnipresent in its bid to provide citizens and businesses with a seamless experience. Data will be an integral part of this, with plans to set up a command center where the city can get a unified and integrated view of all Smart City operations. In addition to this, the emirate is also set to implement a new open data law in late 2015.

SMART GRIDS

Smart Grid Network



Source:IDC, 2015

Smart grids are grid systems that allow for the efficient and cost-effective management and distribution of electricity. These grids are able to monitor and control electricity utilization, taking in information from systems and digital smart meters. Smart grids enable optimal utilization of energy by distributing surplus energy generated from one grid to other grids that are not able to keep up with demand. Pooling grid contribution and redistribution will allow cities to build effective smart grids. Alternatively, cities can consider deploying "micro-grids" that are more localized than a centralized energy grid. "Micro-grids" enable cities to employ a phased approach to building a larger smart grid. This gives both the local area that is being served and the overall city greater flexibility and efficiency. Micro-grids utilize smart technologies to allow redistribution of surplus energy production (renewable or fossil fuel), and allow users to control their usage. They provide an alternative energy source when the greater grid needs to undergo maintenance or upgrades.

In Abu Dhabi, the "Smart City" plan is largely around economic diversification, moving the emirate away from its dependency on natural resources to become more focused on knowledge, innovation, and sustainability. Set up in 2006, Masdar City aims to set an example by which cities can effectively deal with rapid urbanization while providing inhabitants with a high-quality, ecofriendly environment. Masdar City uses harnessed solar energy, employs green building standards, utilizes electric cars and buses, and ensures energy is managed effectively across commercial and residential spaces.

In Saudi Arabia, the motivation for transformation is largely around economic diversification to establish the kingdom as a "knowledge" economy. This has driven the country to set up economic cities such as King Abdullah Economic City, Knowledge Economic City, Jazan Economic City, and Prince Abdulaziz Bin Mosaed Economic City with the aim of fueling diversification, innovation, and job creation. The Saudi Arabian General Investment Authority (SAGIA) estimates that economic cities will contribute $150 billion directly to the Saudi economy in 2020 and an additional $100 billion indirectly. As well as setting up economic cities, Saudi Arabia has been undertaking improvements in its transportation infrastructure, healthcare, and education, as well as expanding its government and telecommunications services to transform the country and meet the objectives of Vision 2024. Smart initiatives in the kingdom are largely being driven at the municipal level.

While the major municipalities are undertaking initiatives to become smart, the most prominent ones are the Holy City of Makkah, Medina, Riyadh, and Jeddah. The initiative within the Holy City of Makkah is modernization and expansion of existing infrastructure. The municipality is working with the Ministry of Hajj to improve the integration of services so that city residents and religious pilgrims can access electronic services (eServices) and mobile services (mServices). The municipality has been effectively leveraging information from Geographic Information Systems (GISs) to help track the movement of Hajj and provide information to ensure Hajj safety, reduce waste, and improve crowd management. The city is also introducing public transportation systems, with Makkah Mass Rail Transit comprising four lines that will further connect to a bus system. In addition to expanding public transportation services, the city is also implementing an intelligent traffic management system to monitor traffic,

prevent congestion, reduce accidents, and improve overall safety. Other major municipal "smart" initiatives in Jeddah, are using GIS to improve urban planning, setting up a smart grid, and deploying a traffic management system, as well as solutions for flood control and evacuation.

These efforts are not limited only to the large metropolitan areas of the Kingdom. For instance, Yanbu City, an urban settlement in the west of the country with a population of 300,000 residents, has been slated to transform itself from an industrial hub into the first Smart City in the country. Investments are being made to improve and expand the existing network infrastructure. The city will also house two data and control centers that will ensure it provides occupants with access to smart services, while also ensuring security and management. It is estimated this project will lead to the creation of as many as 80,000 new jobs in the city.

While the majority of the initiatives are driven at the municipal level, Saudi Arabia has also undertaken national-level initiatives, particularly around security and electricity. In terms of security, cities have been deploying CCTV cameras and sensors allowing the Ministry of Interior to improve citizen safety. For electricity, the kingdom is undertaking a project to deploy a smart grid and smart meters to improve energy provision and consumption.

In Qatar, while the government does not have an official mandate around Smart Cities, many of the ICT initiatives in the country are largely centered on the realization of "Vision 2030," as well as setting up the facilities and infrastructure required to ensure the successful execution of the FIFA World Cup in 2022. In line with Vision 2030, many smart initiatives have been launched within the country's telecommunications and transportation sectors, while numerous private real estate developers have also been establishing their own Smart Cities.

The most prominent projects in Qatar are those of Lusail City, Msheireb, Barwa City, Energy City Qatar, and Pearl Qatar. Lusail City is being developed by Qatari Diar Real Estate Investment. Lusail will extend across 38 square kilometers, forming a mixed-use residential and commercial development. It is estimated that the development will eventually cater to 450,000 people. To ensure it is able to deliver an efficient and sustainable experience for its occupants, Lusail will have integrated fiber-optic

network infrastructure connecting its command and control center with various smart services. The smart services will range from intelligent transport systems, smart grids, and video surveillance to building management systems and the deployment of WiFi in public and commercial spaces. All these services are to be monitored from a central command and control center that is supported by a datacenter to ensure business continuity.

The transportation sector in Qatar has made significant investments around smart initiatives, with Qatar Rail launching three main projects: the Doha Metro, the Qatar Long Distance Rail, and the Lusail Light Rail to service Lusail City. Qatar Rail recently entered into an agreement with the Qatar Mobility Innovations Center (QMIC) whereby it will utilize the QMIC "Marsarak" platform, essentially an open intelligent platform that provides an integrated suite of solutions around intelligent transport management, logistics management, road safety, and public services. The platform will take in feeds from different sources such as GPS, mobile devices, and WiFi and Bluetooth devices and analyze the feeds to provide outputs around traffic management. QMIC will set up a Logistics Transport Coordination Center (LTCC) for Qatar Rail with the aim of improving traffic monitoring to decrease congestion, ensuring efficient public transit, and providing viable alternative routes to Doha residents and visitors.

While Qatar has addressed elements such as open data, Vision 2030 will remain the underpinning factor for any future plans regarding its ambitions to become a "smart" country.

OPEN DATA

Open data governance essentially involves governments making data available to the public and allowing the data to be re-used. The aim of "open data" initiatives is to promote transparency, facilitate innovation, and improve public policy. However, it is not enough for a government to just make raw data available. A successful open data policy requires governments to provide users with access to meaningful and quality datasets. In the GCC, Dubai is enacting an Open Data Law that will provide citizens and private organizations with access to data that can be leveraged to develop innovative solutions. Qatar has already enacted an Open Data Policy that promotes transparency and efficiency, and encourages citizen participation.

Smart City initiatives in the region are largely focused on improving the quality of life of citizens while building cities that allow for economic improvements as well as diversification, and innovation around science, technology, and design. The ultimate aim of these initiatives is to fulfill the strategic plan or vision of the relevant nation over the next five to ten years.

The GCC has been able to pursue many greenfield initiatives such as the various economic cities in Saudi Arabia, Lusail in Qatar, and D3 in Dubai, UAE. However, not all Smart City projects necessarily have to be new "greenfield" engagements. Many projects in other parts of the world are "brownfield" projects, whereby existing cities are revamped to become smart. This is evident within the GCC as well, with cities such as Dubai, Riyadh, Jeddah, and Msheireb (Qatar).

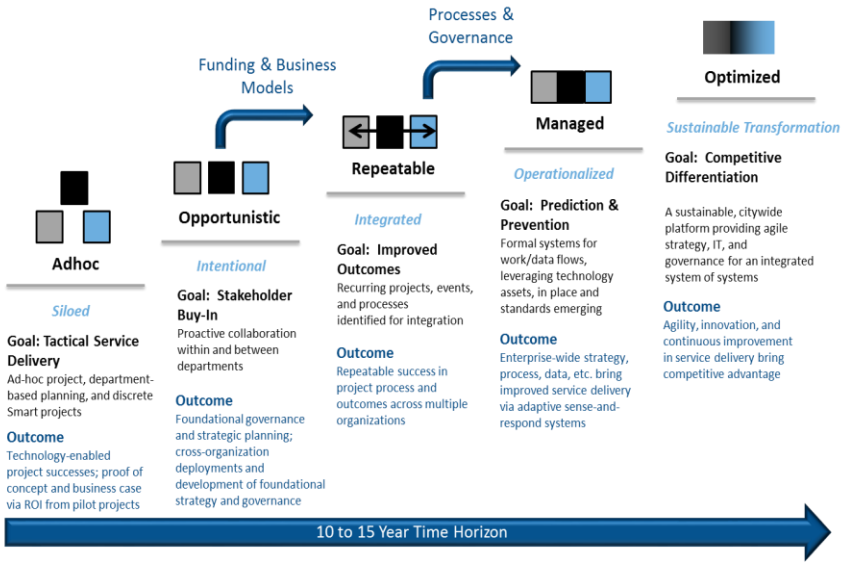
Future Outlook

IDC expects the number of Smart City initiatives within the GCC to grow exponentially over the next decade. The underpinning success of Smart Cities will be based on how these cities leverage the data that is being generated and gathered across these diverse initiatives. Cities will need to deploy the right set of solutions to ensure that the data, the response to the analysis of the data, and the execution is seamless, in order to provide the highest level of services to their citizens. There

should also be increased synergies between citizens, governments, and public and private entities to encourage the development of innovative solutions. Along with data, a holistic approach to security is an absolute necessity to ensure the safety and integrity of the city.

To help cities assess where they stand in terms of their ICT readiness, government processes, coordination, collaboration, and data governance, IDC has developed a Smart City maturity model. This model can be used to assess a single Smart City stakeholder or project or multiple stakeholders within the city ecosystem.

Figure 4: IDC Smart City Maturity Model



Source: IDC, 2015

There are five stages of maturity when it comes to developing Smart Cities. The aim of every Smart City is to reach the "Optimized" stage of maturity, whereby a properly defined strategy helps a city achieve its ultimate goals around sustainability, economic development, and, more importantly, the provision of higher quality of services for its citizens.

The five stages of the IDC Smart City maturity model are as follows:

» Stage 1: Ad Hoc – At this stage, Smart City projects are executed on an ad-hoc basis. These kinds of projects help to prove the value of initiating Smart City projects, and help stakeholders develop the

business case and ROI for the project. Technology is leveraged for the execution of a particular project, the data is gathered in a siloed manner, and the project at times will not be as well integrated with other parts of the Smart City ecosystem.

- Stage 2: Opportunistic – Cities at this point engage in proactive collaboration between various departments and stakeholders. Cities start to develop strategies, barriers are identified, and roadmaps are developed. Technology is seen as enabling the achievement of the strategy, and stakeholders begin to define the types of data and ICT systems that may be needed to achieve the end goal.
- Stage 3: Repeatable – At this point within the maturity scale, cities have formal committees in place, with proper documentation of strategies, processes, and ICT, as well as the buy-in of all key stakeholders. The city aims to improve service delivery, certain projects begin to be scaled, and the process of integration commences. Data is used extensively for improved outcomes. Cities also begin to address issues such as sustainable funding.
- Stage 4: Managed – As a "managed" city, proper systems are put in place and technology is leveraged extensively. Cities are able to respond to defined KPIs and, accordingly, shift budgets, IT investments, or the governance structure. Cities at this stage are able to predict the needs of their citizens and businesses and put into place preventive services before problems arise.
- Stage 5: Optimized – The city has an agile strategy in place, and systems are well integrated and compliant. The city is able to constantly improve its processes and deliver superior outcomes. The ultimate aim at this stage is for the city to be capable of achieving its vision for its occupants at large.

Cities within the GCC are largely in the "Opportunistic" stage as they seek to develop formal strategies, identify various stakeholders, and decide on the type of technologies that need to be leveraged. Many cities are still in the process of learning how technologies can be leveraged, deciding what kind of governance needs to be put in place, and evaluating their ability to ensure sustainable funding. This creates a slight delay in terms of building a business case for an integrated Smart City strategy.

EMC's Approach to Smart Cities

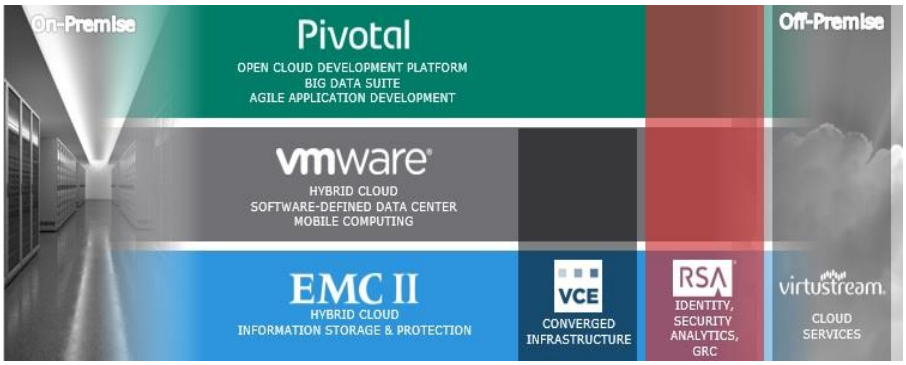
EMC aims to provide Smart City platforms that are open, agile, software-defined, and data analytics driven, while ensuring its security. The platform will be supported by the capabilities of EMC's federation of companies: EMC Information Infrastructure ([EMC II]), RSA, Virtualized Computing Environment (VCE), Pivotal, VMWare and Virtustream.

EMC's Smart City platform is based on three modular building blocks that are open and extensible, and aligns closely to the IDC framework described in "ICT Building Blocks of a Smart City" section of this document.

- Infrastructure Foundation Layer: this is a software-defined infrastructure layer that forms the basis of the Smart City Cloud. This layer enables the abstraction, aggregation, and pooling of the entire infrastructure resources such as storage, network and compute to be offered as a Service. This open "software-defined" solutions based hybrid cloud layer will enable cities to build out scalable, flexible and agile infrastructure that are cost effective and allow cities to optimally use resources to accelerate innovation and to provision additional citizen services on demand.
- Data Lake Layer: this forms the basis for aggregation and analysis of data, it provides an open architecture for the ingestion, protection, management, analysis, and collaboration of data. This layer will allow cities to leverage the exponential volumes of data that is being generated and use predictive analysis to seek actionable and predictive insights and be proactive to influence outcomes.
- Application Layer: this enables the consumption of all the information aggregated and analyzed in the Data Lake. It provides for visualization, monetization, collaboration and also a platform for testing, developing, deploying, operating, scaling, and managing applications in an agile manner. The Application Layer abstracts and automates all the binding between applications and the infrastructure where the application is deployed. It provides all the necessary mechanisms for the application to scale dynamically and on demand. This allows for cities to develop, extend, modify and

scale applications and services in a shorter period of time thus accelerating market innovation and growth.

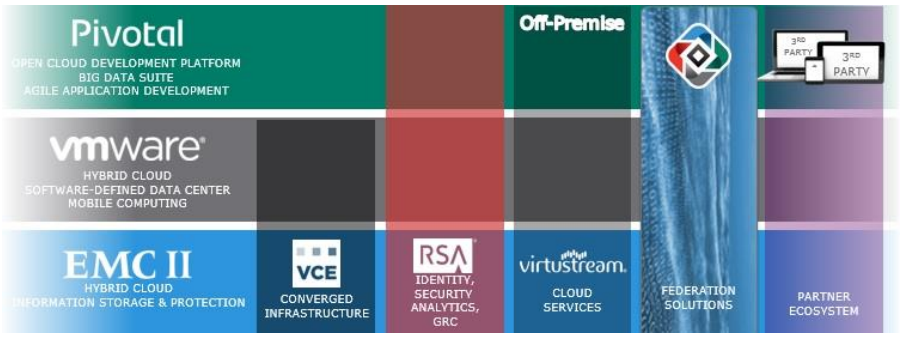
Figure 5: EMC Federation of Companies

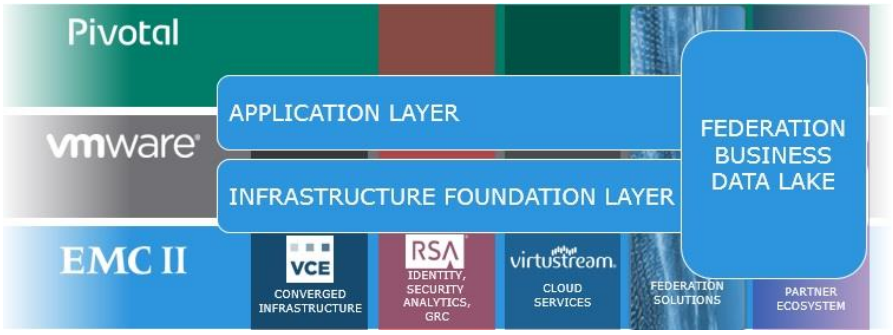


Source: EMC, 2015

The three critical layers which form the basis of a Smart City Platform providing for infrastructure, data and applications automation is supported by a strong security framework that spans end-to-end. The critical security framework provides for user authentication, comprehensive visibility (on users and networks), critical incident response, security operations control, advance persistent threat management and security analytics across the entire smart city platform on-premise and of-premise cloud environments. The framework is wrapped with a governance, risk and compliance layer allowing cities to manage their security risk posture and take remedial actions.

Figure 6: EMC Federation Smart City Platform





Source: EMC, 2015

The Smart City platform is delivered by the EMC Federation as a proven solution, it leverages the best of breed solutions of the companies that form the federation. The Infrastructure Foundation is based on Enterprise Hybrid Cloud solution developed with technologies from EMC II, VMware, and VCE. The Data Lake layer is based on EMC Federation Enterprise Data Lake Solution that leverages EMC Pivotal, EMC II and EMC's partner technologies. The Application Layer is powered by EMC Pivotal's open market leading Platform, Pivotal Cloud Foundry, and other partner technologies. The security framework that will secure these layers is provided by RSA.

EMC Federation consists of six brands organized into five federated, independently managed organizations.

EMC Information Infrastructure (EMC II) which is a union of EMC, RSA and VCE. EMC II as a whole helps organizations store, manage, protect, analyze, and secure ever-increasing quantities of information, while at the same time, improving business agility, lowering cost, and increasing competitive advantage.

Within EMC II each of the organizations also have their own core offerings:

- EMC provides companies with storage systems, data protection, content management, backup/ recovery, and other solutions allowing customers to transform their services and thrive in the digital business economy.
- RSA targets security concerns of mobile, on- and off-premise architectures by delivering technologies for identity management,

security analytics, and governance, risk and compliance concerns (GRC).

» VCE provides converged infrastructure systems. These systems allow for all-in-one storage, network, and compute platforms eliminating the complexities associated with maintaining multi-vendor components. VCE Vblock allows for fast, agile deployment of IT infrastructure. VSPEX Blue and VxRack deliver Hyper-Converged Infrastructure (HCI) experiences to customers looking to leverage commodity hardware and Software Defined data services.

VMware delivers technologies that deploy and manage entire software-defined datacenters. It has offerings around hybrid clouds, as well as technologies for delivering and managing end-user desktop computing solutions to server, storage and hybrid cloud. The virtualization layer allows customers to capture improved levels of efficiency, control, and agility.

Pivotal delivers an enterprise-ready version of the open source Cloud Foundry PaaS for the agile deployment of applications, a lab for training developers in agile and pair programming methodologies, and technologies for the development of Big Data solutions. Pivotal is a major contributor in the open source community, providing enterprise-ready versions of Hadoop and Cloud Foundry, among others.

Virtustream is a cloud software and managed services provider that helps businesses, service providers and government agencies migrate and run mission-critical applications in managed hybrid, private or public clouds. Virtustream completes the Federation Enterprise Hybrid Cloud on-premise solution with a managed off-premise option, which provides a seamless experience for all workloads.

Essential Guidance

This section provides guidance to stakeholders within Smart City ecosystems on the essentials they need to become an "optimized" city that is agile, well integrated, and capable of providing citizens with a superior experience.

- **Build a Data Strategy:** The ability to meet citizen requirements rests heavily on being able to provide meaningful responses or outcomes from the inputs provided by citizens. Define what data will need to be captured, analyzed, protected, and stored. Do not ignore data from older or existing initiatives, since it will help to provide context. Cities will need to work on ensuring data quality and transparency not just to their citizens, but also to those that wish to use the data to create new services.
- **Embrace Convergence:** Cities should consider avoiding creating disparate silos of technology, and lean toward converging both technology and data. By embracing convergence, cities can leverage a platform model providing access to both data and technology for various departments and entities.
- **View Governments as Innovation Enablers:** A successful Smart City provides an ecosystem that encourages innovation. Governments are not just owners in Smart Cities, they also play a critical role in enablement. To do so, governments need to build an "open" ecosystem by provisioning data and platforms on open-source platforms that are easy to use and encourage development.
- **Employ Agile and Holistic Strategies:** Cities need to develop a holistic strategy that involves all the stakeholders to create superior outcomes. Additionally, cities need to avoid building rigid strategies; they need strategies that are agile and enable the city to respond to changes effectively. The policies and frameworks that are developed need to encompass all stakeholders and departments.
- **Embrace Co-Innovation:** Cities need to form relationships with stakeholders to create innovative solutions together. Public-private partnerships will provide cities with added flexibility, improved strategies, and increased funding.