Smarter Cities of the Future
White Paper: ICT Innovation and Adaptation

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Introduction

Advances in Information Communication Technology (ICT) have altered all aspects of life. **Research indicates that there are more than two billion people using the Internet, over five billion mobile subscribers, one billion transistors per human and a further 30 billion Radio Frequency Identification (RFID) tags embedded around the world.** The enormity of this merging of networks and connections in an endeavour to develop smaller and faster approaches that control systems and empower people, has also been the cornerstone upon which smart cities of the future are being built.

The concept of the 'smart city' has emerged as a term to describe a city that uses the Internet of Things (IoT) and the resultant data to improve infrastructure, public utilities, service delivery and more. Yet building a smart city is about more than just utilising technology; it is about ICT innovation, collaboration and transformation that improves the quality of life of citizens and generations to come.

Significant stress is being placed on cities and their infrastructure as urban growth and migration increase. According to the World's Cities in 2016 by the United Nations Department of Economic and Social Affairs, over 54.5 per cent of the world's population live in urban settlements. It is estimated that by 2030, urban areas will house 60 per cent of people globally and one in every three people will live in cities with at least half a million inhabitants. This number is projected to increase to 66 per cent by 2050, adding a further 2.5 billion people to our cities.

The potential of cities is incredible, but so are the challenges of managing their political, economic and social complexities as well as delivering public services. To reduce costs, improve efficiencies, and deliver the quality of life citizens expect - whilst still balancing budgets - cities are increasingly looking to ICT and new working practices.

Smart cities are measured on their ability to join the dots between ICT, basic services and the ability to harness the innovative and collaborative nature of the public, private and social sectors to put plans into action. Whilst people are inherently at the heart of a smart and successful city, delivery on the ideals that embody the city, requires all parties to be involved. Furthermore, building smart cities requires a holistic view that involves the management of expectations, changing cultures and behaviours and adopting new technologies along the way.

It is difficult to specify an extensive list of necessary qualities that make up a smart city. The very concept of a smart city is one that is constantly evolving in terms of technology, resources and mind-sets. Collaboration, automation, IoT and virtualization form part of this continuous evolution. Arguably only a limited number of cities have harnessed the full potential that ICT offers in terms of smart city development.

Many of the smart cities we look to for inspiration have been built upon existing systems and behaviours. If smart cities (and their leaders) of the future wish to become multidimensional in terms of sustainability, economic inclusion and adaptive leadership, then they will need to rethink their existing structures and embrace the potential that ICT provides.

The following white paper explores the challenges surrounding ICT in developing smart cities. It also highlights the practices which cities and their leaders will need to adopt to move beyond their current situation and enter a brave and exciting new world.

Context and Background

In 2001, governments from across the globe agreed on a defined set of Millennium Development Goals (MDGs) which they hoped to achieve by 2015. These goals anticipated the provision of a focal point and framework for governments to develop policies and programmes that would assist in the eradication of poverty and improve the livelihoods of all members of society. Upon reflection, the MDGs were too narrow and thus gave rise to a new set of refined goals, targets and indicators that all UN states will be able to use when framing their specific policies and political frameworks over the next 15 years. The Sustainable Development Goals (SDG), of which there are 17, are a series of goals developed in 2015 by the United Nations aimed at focusing on key areas of sustainable growth and development with particular reference to minority groups and developing economies.

In contrast to the MDGs, which made little mention of tackling global human rights and economic development, the SDGs attempt to delve into the root cause of poverty and inequality. The SDGs provide over 160 targets for all nations (not just developing economies), to aim for.

The SDGs are holistic in nature, ranging from "Ending poverty in all its forms everywhere" to "Promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable and inclusive institutions at all levels."

Of particular interest, specifically in light of the current white paper on Information Communication Technology (ICT) are Goals 9 and 11. Goal 9 states - **"Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation"** and Goal 11 - **"Make cities and human settlements inclusive, safe, resilient and sustainable."**

In order to develop knowledgeable societies where individuals have equal opportunity to learn, grow, build and engage with each other, access to ICTs and leveraging off IoT is imperative. Smart cities have always existed in some shape or form long before the term 'smart city' was even coined. Today, however, the term is used in parallel with technology, Big Data and IoT, as well as fundamental smart policies, smart governance and smart citizenship. In order to develop and manage smart cities and connected citizens, a holistic approach towards ICT needs to be adopted.

The economic and political importance of smart cities cannot be ignored, specifically with regards to solving major social, economic and environmental challenges. **Globally the correlation between ICT maturity and Triple Bottom Line (TBL) indicates that a city's ICT maturity is mirrored by their position on the development ladder – a high level of sustainable urban growth and development is concurrent with high ICT maturity.** Affluent cities, which are typical of developed economies, are able to invest more in ICT and are more adept at utilising their ICT investments than less affluent cities in developing economies. As these affluent cities shift towards more 'networked societies', an increased number of people are using ICT and improving the way ICT is used. This in turn allows new patterns of relationships to emerge, specifically regarding collaboration, working life and the manner in which businesses and governments interact to deliver services to customers and citizens. Europe, in particular, has devoted significant efforts towards addressing urban growth in a 'smart' way through as series of strategic imperatives, municipal toolkits and measurable frameworks.

Historically, smart cities have been viewed as a developed-world concept with the European and North American cities dominating the landscape and accounting for 43 of the top 50 global smart cities. This is partly due to well – established existing infrastructure. Although developing economies tend to start at a lower ICT and infrastructure level than their developed counterparts, **research indicates that cities with low ICT maturity tend to mature at a faster rate than cities with higher ICT maturity.** This signifies a catch-up effect that can be understood as evidence of how new ICTs provide solutions to many of the challenges and problems that limit development in what are often highly exacting environments. However, the potential for technology to boost economic development is vast.

In cities that experience low ICT maturity and social, economic and environmental challenges, such as Lagos, Karachi, Delhi, Jakarta and Manila, it is worthwhile to note that there are still several examples of where social enterprises have been built even on the most basic of ICT foundations. South Africa in particular is on a quest to utilise ICT to reshape societies and develop smart, innovative cities. Whilst cities in the developing economies are all striving for economic growth and improved living conditions, their ability to achieve this varies wildly.

The notion of a 'Fourth Industrial Revolution' is on the rise globally and is typified by a fusion of technologies that go beyond linear structures associated with the physical, digital and biological into a connected system of complex and evolving interactions.

The focus for this push towards a 'fourth industrial revolution' goes past the broad-spectrum benefits of living in a smart city such as efficiently managed service delivery; **it presents opportunities in the form of entrepreneurial development and improved quality of life for all.**

However, there are a series of challenges that need to be addressed prior to reaping the benefits of a connected and smart society. Foremost is the sheer volume of elements that form part of the framework for developing innovative ICTs and thus establishing smart cities.

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Challenges

The dual trends of rapid urbanisation and the development of sophisticated technologies have given rise to smart cities around the globe. Coupled with the emergence of these smart cities - or the desire to develop smart cities - are various challenges. These challenges range from providing good quality of life for citizens to ensuring appropriate socio-economic development year-on-year. The concept of developing 'smart' cities has grown out of the need to meet challenges such as these and to identify opportunities through integrated ICTs. Whilst ICT is certainly not a new concept, it is a concept that is evolving exponentially.

Rapid urbanisation over the past two decades has led to the global mushrooming of megacities (over 10 million in population). The sheer size and scale of these cities have placed overwhelming pressure on infrastructure development, environmental sustainability and public service amenities which cannot be solved by any solution used in isolation, least of all ICT.

The growth and expansion of developing economies is largely dependent on the availability of sustainable, quality infrastructure. **This is especially pertinent in South Africa where government's National Development Plan calls for it to spend 10% of the country's gross domestic product (GDP) on infrastructure projects. Unfortunately, as a country, South Africa is nowhere near that percentage yet (the majority of the nation's budget is allocated to roads, transport, electricity, water and sanitation).** Whilst these areas are of great importance to the maintenance of a country, the field of ICT and ICT infrastructures has the ability to drive economic growth exponentially and yet it is an area in which South Africa still under-spending.

Whilst mobile technology penetration is high in South Africa and the African continent, the cost of mobile communication and data remains exclusionary. In 2016, internet penetration in Africa sat at 28.7%; far behind the world average of 49.5%. The cost of broadband data is also particularly high in many African countries, South Africa included.

The emerging state of ICT adoption and digitalization in developing economies comes with significant challenges but equal opportunities. The 2016 African Economic Outlook cited that within the next four years, economies on the African continent were expected to strengthen their business environments, expand regional markets and benefit from increased use of integrated ICT. However, a large part of this is dependent on developing and implementing the right polices and legislation and on institutions taking advantage of this potential. Research indicates that there are generally misconceptions within developing economies specifically within the African continent, around digitalization and the benefits it can bring to business.

Achieving inclusive use is a further core challenge for developing economies since most smart initiatives tend to be rolled out in more affluent areas and at very sporadic rates. This is compounded further by the fact that most smart initiatives require stable and existing infrastructures to operate and in some parts of developing economies these are not only lacking but non-existent. Identifying a city's weak areas and prioritising them in order of need can be an equally challenging task; this is especially true for cities that require the integration and retrofitting of formerly isolated municipal legacy systems in order to achieve citywide efficiencies.

Internet Penetration
WORLD vs AFRICA

49.5% .... WWW **28.7%**

The processing and sharing of data is also crucial to the smart city project. However, cities rarely manage to create inclusive dynamics that involve residents, public and private actors in a shared ecosystem of innovation.

In both developed and developing economies there is a belief that promoting ICT as an isolated enabler for growth is essential. This is a fallacy. **Whilst ICT is certainly essential to the formula that leads to economic and social development, it is useless without sound frameworks and polices. Furthermore, as smart cities start to evolve, so do the layers upon which ICT systems and their respective networks are established.** With each new layer there sits the potential for everyday glitches and accidents to become compounded. In cities within Europe, the software to run trains has often crashed and has resulted in trains not being operational. Likewise, the seemingly mundane act of grocery shopping has had to stop due to automated check-out tills crashing, leaving the shop inoperable and effectively just a warehouse.

When combined with technology, critical infrastructure systems, such as those used in emergency situations, can benefit a city and its inhabitants in abundance. Unfortunately, when these systems are not protected properly or fall into the wrong hands, the effects can be devastating. In smart cities, where everything, from municipal services to financial services and transport systems, is connected, the threat of attack increases tenfold. Officials in major cities have acknowledged the very real threat to their municipal services through cyber attacks, citing over 6000 attempted hacks every second in some instances.

Advanced Persistent Threats (APS) are a major security threat to smart cities and are often targeted attacks executed by a hacker or group of hackers, motivated not by financial gain, but instead by political gain or "hacktivism."

A further concern and challenge is that of the rising levels of surveillance in cities as a result of directed, automated and networked technologies. From surveillance cameras on every street corner to biometric access control, the increase in monitoring a society's actions has been largely driven by a culture of control that necessitates security and risk management. Big data and data control centres have started to integrate previously independent data streams and combine them into a single vantage point that brings about daunting images of a society controlled and captured by Big Brother. **In an attempt to create systems that promote growth, effective modes of governance and connected communities, there is a very real threat in potentially stifling people's freedom of expression, privacy and confidentiality.**

A further challenge identified within the ICT arena is that of governments and municipal structures applying a 'one size fits all' approach when developing smart cities. The notion of being 'locked-in' to a specific technology and infrastructure is concerning, especially if little thought has gone into the rapid progress associated with technology and attempting to couple that with the slower pace that is required to effectively alter the fabric of a society and its urban spaces. **There is a very real need for partnerships to be developed between the public and private sectors, as well as between the ICT and energy industries within cities, in order to stave off the fear that when developing these smart spaces, proprietary systems simply won't interoperate with one another.**

The rapid acceleration of urbanization in developed and developed economies, is placing a severe strain on public services and natural resources and without correct planning, will have dire consequences. Building truly smart cities will require a holistic view that involves not only the adoption of ICT but of cultures and behaviours too.

Municipal officials in major cities have cited over 6000 attempted hacks every second.

Solutions

As they are envisioned currently, smart cities have immense promise, but to realize their potential, governmental frameworks and economic models first have to be developed. Developing a focused, strategically aligned and economically viable vision that targets long-term development and inclusivity, is the first step in developing a smart city. Leveraging off ICT to achieve these objectives is the second step. **By creating and utilizing smart, innovative technological solutions, cities will begin to make progress in terms of political, economic and social necessities that benefit all citizens.**

Invest and Develop

A key differentiator between cities that are 'smart' and those that are not will be their ability to leverage off technology in bringing about innovative, sustainable and inclusive solutions for all. **As the price of technology reduces and the depth and richness of data analytics increases, more cities are starting to turn towards the use of real-time analytics.** From managing how a city functions and is regulated, to developing improved infrastructure and communication methods, cities will need to invest in appropriate infrastructure systems that are measurable and sustainable.

Research indicates that due to increased urban migration, many major cities are struggling with the challenges of traffic and congestion, and the symptomatic consequences of pollution and environmental damage. Consumer/citizen behaviour and policy regulation need to be adjusted to address these challenges. Examples of where state directives have improved on the lives of those wishing to be part of a smart city, are in areas where pay-as-you go schemes are used for motorists who wish to use key roads at peak times as well as with rebates on the purchase of low-emission vehicles.

An area of opportunity also lies in the development of integrated and smart transportation networks. These rely on data from a network of city-wide cameras and transponders that is fed back to a central hub where the flow of traffic, traffic light sequences and speed limits can be monitored and adjusted accordingly and traffic penalties administered automatically. A similar network can be utilised to measure and respond to specific environmental concerns in a city such as air pollution, water levels and in some cases, seismic activities. Waste management is a key area of concern for many cities; the process is not only costly but also complex and, in many cities, fails to follow a process that is measurable and efficient. One way to address this challenge is by implementing smart trash bins. The process allows for waste bins to be equipped with sensors that alert the waste collection vehicles when the bins are full. As the trucks lift the waste, the system which has been installed in the vehicle, sends real-time data (bin capacity, location etc) to the cloud or a portable device and provides recommendations for future optimization as well as alerts for unusual events. Waste collection vehicles are then able to optimise their collection routes based on the data collected, reduce the number of trucks on the road and minimize the overall cost of waste collection for the city.

Intelligent street lighting using LED lights and sensors is becoming more popular in smart cities using sensors to dim, brighten or switch off depending on environmental conditions and motion detection. Research indicates that these interventions can assist cities in energy savings of no less than 30 per cent. Aside from the safety aspect, the sensors in the street lights also collect environmental data.

Further developments in ICT, focused on water usage, have resulted in smart cities turning their focus to centralised databases and innovative municipal park management. Sensors have been deployed onto parks in various global cities that provide live data on humidity, wind velocity, temperature, sunlight and atmospheric pressure. Municipal workers are thus able to decide what the plants need based on the relevant data and can adapt their schedule accordingly to avoid over watering.

Smart cities are also safe cities. This is important since the UN and the World Bank both ranked crime as one of the key obstacles to a country's development. Increasingly smart cities have recognised the need to invest in systems that integrate disparate data sources and streamline service delivery by using IP video surveillance, automated security alerts and public announcements to coordinate emergency response systems (police, fire and ambulance). Using a series of interconnected and automated alerts from advanced video and social media analytics, law enforcement agencies are increasingly able to achieve faster response times and understand and address citizen sentiments to a greater degree.

Participation and Collaboration

What will increasingly differentiate cities is not how 'smart' they are in terms of technology penetration, but the extent to which they leverage technology to bring about innovation, sustainability and inclusiveness.

Technology is a key enabler in this regard, and cities the world over are leveraging mobile connectivity to keep in touch with citizens and responsible public authorities. **A key opportunity in leveraging the possibilities that ICT presents is the creation and promotion of an administration that is open to citizen participation and ownership.** Crowdsourcing mobile apps have empowered citizens in certain cities to report immediately on local concerns from flooding to waste collection and road conditions; these crowd-sourced reports are then reported directly to the local municipal authority that is then able to act and respond appropriately, directly to the community. Not only do citizens feel part of the solution, but also the process acts as a mechanism for building trust between the public, private and social sector. **The volume of data collected via theses apps and process also allows for cities to start developing rich databases, working out patterns and prioritising and developing solutions for the most common complaints and notifications.** Using larger sample sets and linking wide-ranging forms of data, will allow cities to increasingly be able to develop and operate on a basis which is steeped in rational evidence as opposed to selective and political ideologies.

The sharing economy, also known as the collaboration economy, is taking off in various sectors across numerous cities. The driving force behind this trend is data and the way in which businesses develop solutions for consumers based on the data at hand. Citizens have entered an era where living with less and focusing on minimalism is not only acceptable but also promoted, and the advent of the digital and sharing economies has made this process much easier.

Platforms which promote and facilitate safe and reliable ridesharing, apartment/home lending, peer-to-peer lending, reselling and co-working spaces, have become indicative of smart cities and smart citizens. And, as technology continues to fuel the hurried explosion of collaborative industries, it would appear that everyone is a consumer, producer, or frequently both.

A recent study indicates that the sharing economy will see substantial growth in the next five years in terms of platform provider revenues. Due in part to their first mover advantage, the space and transport sectors are set to dominate the sharing industry with opportunities residing in corporate space sharing and, although to a lesser degree, the services sharing sector.

There are also many cases of private companies working in conjunction with city governments to solve chronic issues. **Collaborative efforts have resulted in parking problems becoming an issue of the past with the installation of wireless sensors that detect the availability of parking spots.** The information is made available through a mobile app that drivers can download to find the nearest available parking spot.

Growth and Management

The suggested universal hope of smart cities is to transform the way they are governed so that sophisticated, wide-scale and real-time understanding and control of their urban environments becomes the norm. The way to achieve this is through big data.

Whilst every city is involved in generating huge amounts of data in some shape or form, the problem lies in that too often that information is lost. Gathering information and knowing how best to use it is indicative of a smart city. **Whilst it is true that smart cities cannot operate without gathering information about their citizens in the form of meta-data (used to track public utilities, traffic, road conditions), it is equally important to point out that the data collected is largely innocuous, with the benefits of convenience and security outweighing the unease of sharing personal data.** That being said, as technologies improve and expand, cities will need to invest in better ways of regulating how data is used.

Data capture and analysis are becoming the evidence-based foundations upon which informed policies are developed and implemented. **The data that has been used to develop these policies is measurable, objective and free of political ideology.** Furthermore, it has given rise to citizens who not only feel empowered but also are more economically empowered too.

Future and Beyond

The difference between a thriving, surviving and developing city will be a city's ability to bridge the innovation gap and strategically use data that is no longer divided into silos but rather collaborative and united in nature. Sharing economy platforms, crowd funding and citizen–engagement tools will empower cities as they move from merely being 'smart' to becoming 'networked'.

Smart cities, by their very nature, should necessitate the sharing of resources, goods, services and experiences. Whilst the more traditional models of sharing have been diluted in modern cities due to increased commercialization and social fragmentation, cities of the future will focus on a shared and networked society that offers hope for all.

Smart cities of the future will largely be made possible due the IoT. However, in order to operate fully the IoT requires a secure, automated, transparent and reliable database – a blockchain. Blockchains are a unique way of keeping track of a normative set of information by making multiple copies of information and distributing them across a series of multiple nodes as opposed to the traditional methods that require data to be stored in a single central location. **Blockchains open up the possibilities of real-time marketing of peer-to-peer trade in which individuals retain control over their own data and thrive in a community that co-creates the market rules of how specific resources are managed and exchanged.**

Anything with an internet connection can link up to a blockchain resulting in anything with an internet connection having an accurate record of who owns it. Imagine using blockchain technology when renting out your home; from booking online, to opening the door, securing payment and locking the door once the guest has left; each step could be automated in one single secure loop via blockchain. This shift will move citizens from a previously passive reliance on technology to that of a more peer-to-peer focused and networked city. Not only will peer-to-peer platforms empower citizens to connect with one another but also they will help in re-generating city spaces. This will become especially true for traditional government imposed top-down approaches to city planning since cities of the future will be reimagined and built using the input of active citizenship.

The local economies that can grow from the sharing economy aren't just good business; they're good for the community at large, offering hope for the income equality that tech has long since promised but has yet to implement. By allowing the middleman economy to focus on being platform providers, rather than also vertically integrating product, profits increase and transactional costs drop in a way that allows local communities to afford entering the sharing economy.

Cities of the future will most certainly focus more on being low-carbon and highly connected using intelligent networks that respond to traffic jams, municipal services and long-term plans. Since physical space will become a severe constraint, cities will start to be built drawing inspiration from nature; from algae-powered bio-facades to anti-smog towers and vertically stacked farms in the middle of cities to communities that float on the waters surface during good weather and submerge beneath the waves when the weather is rough. **The key elements in making these a reality are technology and public-private partnerships.**

In order to track progress, make informed decisions and compare cities, it is imperative that cities measure whether they are in fact smart and the extent to which they are smart.

By developing city indicators that are both qualitative and quantitative in nature, cities will be able to accurately measure their performance and prioritise solutions. Whilst cities the world over publish city-specific indicators, these reports are more often than not long and difficult to understand. Cities of the future will start to re-imagine how this data can be collected and integrated in a collaborative manner with surrounding cities and how it can be presented depending on the audience. Using appropriate technology, smart cities will start developing and utilising dashboards that communicate information in an appropriate and easy-to-navigate manner.

Finally, as the service sector grows, there will be greater opportunities to telecommute. **Estimates indicate that as the sector grows and broadband Internet access increases, up to three times as many workers will telecommute. This will result in a greater circle of employment with less congestion and improved innovation.**

Conclusion

The notion of smart cities has gained much traction in recent years as a vision for stimulating and supporting innovation and economic growth. As highlighted in this white paper, an important aspect of the smart cities concept is the production of sophisticated data analytics for understanding, monitoring, regulating and developing smart cities.

With the onset of digital infrastructures, networks, sensors and devices becoming increasingly embedded within cities, the volume of data produced about them has grown exponentially. **This has resulted in the provision of rich streams of dynamic data that not only shed light on the needs of a city, but also those of its citizens.** This data has the potential to provide individuals with the necessary insight on how best to make decisions, improve everyday living and campaign for inclusivity within their own city limits. From a governmental perspective, the data presents an opportunity to efficiently and effectively manage and regulate services, interact with citizens and drive collaborative growth with the private sector.
The benefits presented by data to corporations, ie in its ability to drive long-term opportunities that are adaptable and measurable.

Although ICT and the resultant data offer a series of opportunities, they also raise a number of challenges and concerns with respect to the politics of such data, governance, system vulnerabilities and ethical issues with respect to surveillance and control. In light of these concerns it is imperative that the private, public and social sectors forgo working in isolated silos and learn to share processes and create interconnected systems that add value to all citizens. Given the role that ICT has to play in developing and creating cities of the future, it is imperative that the status quo begins to shift. City managers and administrators need to start looking towards coordinated and collaborative efforts that are supported across multiple functional areas. **The opportunity to transition cities into those that embrace the future resides in a collective effort that supports leadership, empowers citizens and leverages off smart, innovative technologies.**

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