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Smart Cities

Big Data



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Our ever-accelerating pace of development

The digitisation of our lives is causing a paradigm shift to occur in our cities. This is being driven by the general advancement of computing that has brought us the Internet, the Social Web, smartphones and, more recently, the Internet of Things (IoT) ^[1]. Forces are culminating into what is being called a third industrial revolution ^[2], characterised by unprecedented access to information, new emerging technologies and the convergence of information, energy and transport networks. We exist in a networked world, and so do our cities.

Our relentless pursuit to master our environment through the application of knowledge has brought about this change. More than a survival strategy, it has improved our quality of life and longevity. The process continues into the 21st century and is accelerated by the sharing of information at unprecedented rates that is affecting the very basic levels of the way in which we live. Our world is becoming more intelligent.

At its core, this march has been underpinned by the concept of the scientific method – our feedback loop on nature. The process calls to observe what is real and makes either a deductive or an inductive assessment of the dynamics of a given situation. With this, an amazing ability emerges – an ability to describe, predict and prescribe, with the net effect of being able to better control our world. This approach has been developing since the age of Greek

philosophers such as Socrates, Plato and Aristotle, through the Renaissance and to modern-day academia, scientists and engineers. Through the open-access policies and open-source movement, the core body of our collective knowledge has never before been more accessible to citizens of the world.

While this has happened, we are now seeing an unrelenting movement of people towards the urban areas. We have passed the point where globally more people are living in cities than rural areas, attracted by the digital economies, opportunities for work, access to education and other amenities for an overall improved quality of life. This trend is set to continue especially in emerging economies where city populations are forecast to have their population grow from 2 billion to 4 billion between 2000 and 2030 [3]. To support this growth, innovative ways of managing resources are being sought out. This has culminated in the idea of a technologically interconnected city, which is aptly referred to as the “Smart City”. According to a recent study, the expected global market size for products and services for this market will be \$1.5 trillion by 2020 ^[4]. To support this movement, new modes of consumption have emerged and will emerge, critical resources will need to be monitored and optimised to reduce costs, and decisions will need to be made to accommodate city dwellers. All of this can be supported by the adoption and use of Big Data.



The effect Big Data has had on society

It has been said that we have entered the age of Big Data ^[5], which has opened a vast number of opportunities for new value creation, moving forward.

The phenomenon of Big Data has long been characterised by volume, velocity and variety in data types that have been created at ever-increasing rates ^[6]. It has been remarked that more than 80% of the world's data has only been created in recent years. For some, data has become a subtle force of its own and has affected their daily lives. For others, who perhaps work with it on a daily basis, an image of a tidal wave comes to mind.

Big Data gained centre stage with the advent of the social web and the emergence of interconnected devices that have almost overnight created a world where data of all types of information exists, particularly personal. Smartphones and connected computers and devices have allowed us to monitor and share everything – from the weather, our geographic location, health, fitness levels, finances to household energy consumption, to name but a few. These have also given us access to new modes of telecommunication in the form of VOIP, video conferencing, internet TV, streaming music, among others. Mobile apps, tailored to our every need, are the successors to “old” webpages.

Without knowing it, our daily activities are recorded and are used to support transactions we have with all types of organisations. This has raised privacy concerns centred on who has the right to own and use data about individuals, causing governments to instate regulations to protect its citizens. The concern is that information in the wrong hands could be used for identity theft, which could lead to fraud being committed. However, having access to the same data can vastly improve service delivery and efficiencies. To this end, governments and municipalities are looking to drive Open Data initiatives, where information locked in cities is made available to citizens, businesses and other agencies to share, re-use and

distribute around cultural, scientific, finance, statistics, environment and transport themes ^[7].

In the face of Moore's Law, a guideline that states that our ability to process information doubles every two years, the cost of copying and processing a single bit of information is limiting to zero. There is every indication that the impact of Big Data to our lives is set to continue. As citizens, we can look forward to more transparency and improved service levels from both private and public organisations that make use of their data assets to support and enable new forms of services that innovate on the past.



New ways of harnessing data

To meet the growth in data sizes, new technology solutions are appearing that are able to harness this new data source, such as back-end systems that use in-memory computing and massively parallel processing systems, a technique made popular by search engine companies such as Google and Yahoo. Techniques and methods of managing its integration have also appeared, such as data virtualisation, efficient processing of unstructured data and advanced machine learning that is able to identify patterns across large data sets.

The use of data has changed from tapping into stagnant pools to harnessing it as it is generated and as it flows. To handle volumes, cloud-based solutions are emerging in order to lower the cost of managing data and to provide for scalability leveraging economies of scale.



How Big Data is making cities “Smart”

A new scope opens up for what can be controlled in cities through Big Data. From the commercial world, it has been shown that organisations that effectively use the data to drive decisions in their organisations out-perform their competitors by a margin of 5% to 6% [9]. This approach equally applies to the city managers at the management of their operations.

In developing cities, the reality is that operations are uncoordinated and data capture is still a heavy manual process. Modern environments benefit from having consolidated services across areas such as asset, fleet and workforce management where pertinent information is available from these departments to facilitate shorter turnarounds in service delivery, overall customer satisfaction and the understanding of bottlenecks. This is enabled by the implementation of data warehouses and business intelligence – ICT assets that developing cities still lack.

The best practice for this is taking the form of establishing an operations centre. Here, city managers are able to access data in real-time streams and city operators are able to form dynamic communities of interest around incidents as they occur. Data is tapped into to provide collaboration, situational aware decision-

making (CSADM) capabilities to fulfil the objective of servicing the citizen. With the correct infrastructure, a city can more effectively close out on first-tier and second-tier service delivery issues.

A data fusion pattern, which underpins this type of environment, allows for a variety of data sources, such as video from CCTV cameras, voice, social media, streaming data, sensor logs, supervisory control systems and data acquisition (SCADA), traditional structured and unstructured data to be fused together to support the mission of the city. This is being supported by emerging industrial standards that range from alert signal protocols to industrialised wireless sensor networks for smart meter readings.

This has called for a unique blend of commercial off-the-shelf (COTS) technologies not seen in current enterprise data landscapes. This includes software that supports real-time key performance indicators, industrial supervisor control systems, dashboards, instant messaging for field operators, wikis, advanced analytics, geospatial mappings systems, proprietary systems, web service interfacing and financial systems integration, among others. Many forward-thinking companies are building their vision and strategies on this as the next competitive differentiator [10], [11] and [12].

The operations centre powered by Big Data crowns a city's tactical strategy. The value proposition for cities becoming “smarter” needs to also be seen in the strategic context. More broadly, the value proposition to the city pivots on:

- Cost savings through the consolidation, monitoring and optimisation of shared ICT assets and services
- Stimulating business by creating a city-wide digital strategy that fosters economic growth through access to broadband and Wi-Fi services
- The driving of efficient citizen relationships systems geared to resolving their requests and complaints on first call and benchmarked call closure times

- Lowering costs by providing for an analytics capability to monitor and optimise city processes and resources that can be benchmarked against international standards
- An ability to provide for enhanced second-tier, cross-department and agency support to the citizen and moving away from operations that work in silos

Caution, however, needs to be exercised in terms of the expectation of the capabilities of Big Data in the areas such as city planning. Due to the nature and complexity of cities, no matter how much data is available, the city managers and planners are confronted by a so-called wicked problem [8] where there are too many variables to be pulled that can affect a desired outcome or state. Here, heuristics and approaches based on the experience of city managers still need to be exercised.

Combining software and wetware (i.e. human mind) and by adopting strategies that are flexible and that require lowered adoption hurdles, cities can – through the weaving of a real-time nerve centre – place themselves at the forefront of service excellence. This infrastructure is often already in place and only needs a realignment with the developing technological trends to track along the path to becoming “smart”.



Conclusion

Big Data is an essential component that is driving the Smart Cities movement, along with more general advances in technology. This is informing new forms of consumption with citizens and the demand for services that are underpinned by smarter systems. The social contract for taking care of citizens remains for cities that prompt its managers to consider and invest in appropriate processes and systems to support this mandate. In this, certain best practices have emerged and others are indeed still to emerge, as this is a dynamic environment. Cities that make use of the current state-of-the-art approaches, which can be benchmarked against international standards, are positioned for future success and may have the opportunity for advancing society forward to a smarter future.



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