Ferenc Pongrácz

Smarter Cities and Public Security

Ferenc Pongrácz, Business Development Executive of IBM South-Eastern Europe

Abstract

The world's population boom is concentrated in urban areas. The explosive development of information and communication technologies may enable cities to answer the challenges like the migration pressure in Europe or the environmental issues and the growing demand for energy due to the increasing global population and GDP growth. The concept of Smarter Cities is about using technology to ensure sustainable economic, social development.

The Smart City Assessment methodology of IBM analyzes the city in 3 levels: mission and Vision; subsystems supporting the Citizens and the Enterprises (Public Safety, Education, Healthcare, Public Administration); infrastructure (Telecommunication, Energy and Utilities, Transportation).

Of the above subsystems the paper focuses on Public Safety. After highlighting some of the social and economic aspects of the topic, the Smarter Public Safety model of IBM is introduced. The model is built on the following five key competencies: access to relevant data; coordinated and integrated trusted information systems; enhanced situational awareness; proactive planning and intelligence based decision making; unified threat assessment and response capability.

As a result of the rapid development of infocommunication technologies agencies need to apply Big Data technologies to analyse high volume, unstructured data of different formats and uncertain origin and content. Cognitive computing introduced by IBM could result in breakthrough in this area.

Keywords: smart city, public security, global challenges, IT, cybercrime, sustainable development, law of Moore, IBM, Big Data, cognitive computing

Introduction

Accelerated progress of infocommunication technologies, expected to continue in the next decades, opens up new perspectives for our cities. The "smart city" approach intends to explore and leverage these opportunities. In the first introductory part, this study introduces the smart city concept from the point of view of IBM. In the second, more targeted part described smart solutions employed in public security as part of the smart city concept, using examples and case studies, on the basis of international experience gained by IBM.

Challenges

In 2010, for the first time in history, more people lived in urban areas than in rural areas (UN, 2014). The pace of change is clearly indicated by the fact that the proportion of city dwellers was 30% in 1950 and forecasts predict that this figure will rise to 66% by 2050. One hundred years ago the number of cities with more than 1 million residents was less than 20. Today there are 450 cities on our planet in which the number of residents amounts to several millions (Dirks-Keeling, 2009). The extent of urbanization and its growth differ significantly from area to area. In 2014 in North-America, 82%, in Latin-America 80%, and in Europe 73% of the population lived in cities, while in Afrika and Asia the proportion of the urban population was 40% and 48% respectively, but that is where the rate of growth is the highest. By 2050, urban population is expected to rise to 56% and 64% respectively in these regions. The rural population of Earth is expected to shrink from 3.4 billion in 2014 to 3.2 billion and, as a result, the forecasted population growth of 2.5 billion will cause cities to grow even bigger, 90% of which will occur in Asia and Africa. Half of the urban population of Earth lives in settlements with less than 500 thousand residents, and every eighths city dweller lives in one of the megacities with more than 10 million residents (UN, 2014).

These demographic changes of unprecedented magnitude entail serious environmental, economic and social challenges (Pinter et al., 2013; Lados, 2015). For example, in China – based on a summary report published in *New York Times* in 2007 – only 1% of the country's urban population of 560 million people live in an environment where the quality of air is considered healthy according the standards of the European Union, and 500 million people do not have access to health and clean potable water (Kahn–Yardley, 2007). The energy industry giant BP forecasts that the global demand for power will rise further in the next 20 years owing to, in particular, the soaring demand in Asia. Despite the growing adoption of renewable energy, fossil energy carriers will account for 60% of the forecasted growth in energy consumption until 2035, and the proportion of their use will still be 80% (compared to 86% in 2004). Even though efficiency of energy use is improving and meaningful measures have been taken to reduce CO_2 emission, current trends indicate that between 2014 and 2035 emissions will further increase by 20%. This means that realizing the so-called IEA 450 scenario which defines a level of CO_2 emission that does not pose a risk of environmental disaster is seriously jeopardized today, and in order to adhere to it an unprecedented breakthrough would be needed in the area of energy efficiency and CO_2 emission reduction (BP Energy Outlook, 2016).

In Europe and Hungary, demographic trends show marked differences compared to the global ones, but at the same time we are not immune to the economic, social and environmental effects of changes, including security challenges, and we need to find ways to address them. Without going into detail, it is enough to refer to the pressure of migration on Europe (Borders 2020, 2012; Ryser, 2015), the political uncertainty in the immediate neighbourhood of the European Union, and the global environmental challenges (Pinter et al., 2013; Lados, 2015).

Smarter Planet and Smarter Cities initiatives by IBM

IBM's chairman, president and CEO, Samuel J. Palmisano, delivered a speech on 6th November 2008 at *The Council on Foreign Relations* in which he outlined a new initiative of the company called *Smarter Planet* (Palmisano, 2008) which aimed to leverage the most recent advances in information technology to address systemic social, environmental and economic issues, such as metropolitan traffic jams, responses to disaster situations, or the inefficient operation of the energy grid. Smarter Planet solutions can be described by their three characteristic features (marked by three "i"): *instrumented*, *interconnected*, and *intelligent*. IBM intends to respond to challenges related to social, environmental and economic sustainability with technical solutions that leverage the advances in technology to collect data captured by sensors, which are becoming cheaper and more ubiquitous (mobile phones, cameras, automated meteorological stations, instruments built into cars, etc.), using data transmission networks, which are becoming cheaper and more ubiquitous, to process them by using computing capacities and analysis methods, which are becoming cheaper and more ubiquitous, in order to resolve problems that could not have been resolved before (Horváthné Barsi – Lados, 2011; IBM Research Launches Project; Palmisano, 2008).

A high-profile element of the Smarter Planet framework program is *Smarter Cites*, which is specifically aimed at addressing urban challenges (Frost & Sullivan, 2014; Horváthné Barsi – Lados, 2011). In the past decade, IBM became a dominant global player in strategy making and business consultation as well as the development and implementation of relevant technologies, and, according to a number of leading analysts, IBM maintains its global leadership in these fields (Woods–Goldstein, 2014; Frost & Sullivan, 2014; Lados, 2015; Dirks–Keeling, 2009).

The Smart City model of IBM

IBM's Smart City model studies the operation of a city at three levels (Horváthné Barsi – Lados, 2011; Dirks et al., 2009):

- mission and vision of the city;
- services used by the residents of the city and the enterprises that operate there;
- infrastructure supporting the above levels.

City subsystems assigned to the individual levels, e.g. smart technologies available to the public safety subsystem, are not reviewed as standalone entities; rather, they are evaluated on the basis of whether or not they support achieving the strategic objectives of a city and how they serve the residents and local enterprises of the city.

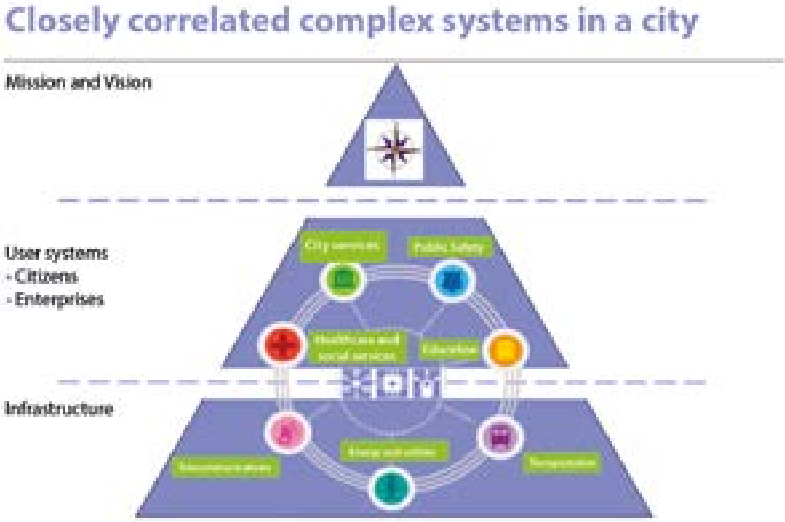

Figure 1
Smart City subsystems according to IBM's approach

Source: IBM Corporation

IBM's Smart City Assessment methodology can be used to create a survey of a city which evaluates the given settlement in terms of best practices and similar settlements. As a result of the survey, specific development and project proposals can be made. A simplified version of this methodology was used in a study of several Hungarian cities that was created in 2010 as a collaborative effort by IBM and the Hungarian Academy of Sciences (Horváthné Barsi – Lados, 2011). IBM can recommend complex solutions capable of supporting each of the subsystem of the above described city model, from strategic planning through technological implementation to operations support. The available extensive database of international comparative data allows for backtesting the results on an ongoing basis (Dirks et al., 2009). In the following chapter, we will examine public safety out of the several city subsystems.

Economic and social aspects of public security

The state of public security has a direct impact on the resident's well-being and quality of life, and on the decisions of businesses operating or planning to invest in the given area, and is closely related to economic performance. One of the most frequently used indicators to describe the state of public security is the number of detected crimes. Every act of crime has a social and economic cost that can also be expressed as an amount of money. In addition to direct material injury, this amount also includes e.g. lost revenues, damages to property as well as the costs of medical services provided to the victims, and the expenses incurred by the police, the judicial system and the penal institutions. A few examples:

- The amount incurred by each taxpayer in the form of crime related social costs was 3257 dollars on the average in the United States.
- The social cost of crime in the United Kingdom is 3000 pounds per household.
- In Brazil, damages directly attributable to crime are as high as 3–5% of the GDP, while in South-Africa this figure is 7.8%.

The real effects are probably much stronger as the measurements typically ignore costs that cannot be accounted for in an objective manner, and factors such as quality of life and psychological damages or pain, fear and sadness.

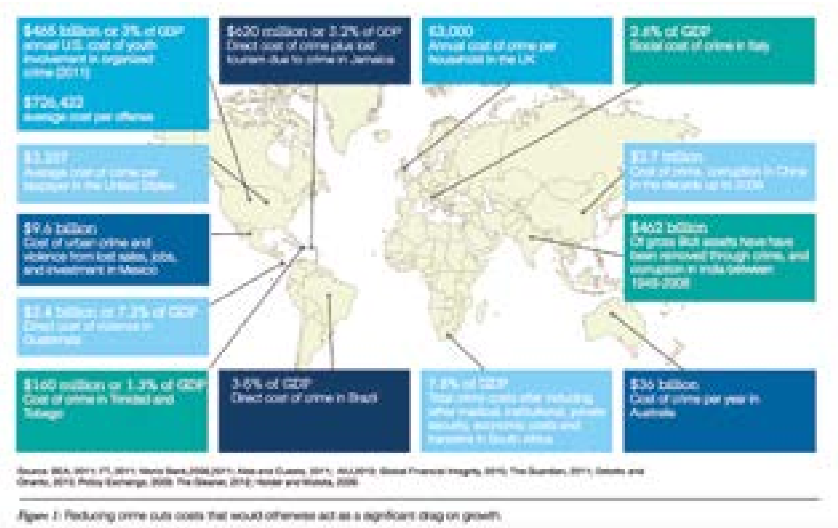

Figure 2

Social costs of crime in a few countries

Source: Keeling–Cleverley, 2012

Sense of safety is an important factor in almost all of the indicators that measure the quality of life. It is not surprising and it is easy to demonstrate that cities with a low crime rate are more attractive to people. In a knowledge-based society, the highly qualified and usually mobile tier of employees which actively seeks out cities offering high quality of life is of key importance for businesses.

Demographic changes that can be observed around the world, accelerating globalization, environmental challenges, and the accelerated development of infocommunication technologies entail a rise in crime and in the risk of attacks against the established social order. Organizations responsible for public security are facing new and complex challenges around the world. At the same time, popularity of infocommunication technologies may enable law enforcement bodies to upgrade their existing systems in order to identify patterns indicating crimes and forecast what crimes are likely to be committed and when, which, in turn, will allow them to implement appropriate preventive measures.

In regard to public security, IBM researchers identified the following five current trends:

1. Volume and significance of cross-border crime is increasing.
2. Risk of terror attacks and environmental disasters is rising.
3. The explosively increasing volumes of digital data must be tackled.
4. Cooperation between various national and international organizations is impeded by the lack of interconnectedness between applied information technology systems, and a lot of records are still unavailable in digital formats.
5. Prison populations are on the rise globally and the high rate of repeat offenders presents a serious challenge.
6. Law enforcement budgets typically either fail to rise in proportion to the increasing challenges or they are even cut back. However, to an increasing extent they are still expected to justify expenditures with measurable results. (Keeling–Cleverley, 2012).

Smarter public safety systems

A critical aspect of the application of information technology is the collection, processing and sharing of data generated at various organizational units and organizations. The volume and diversity of data produced is growing exponentially from year to year. The smaller part of the available data volume consists of so-called structured, comparable and verified data that can be arranged into standard tables and processed efficiently by conventional database management systems. The larger part of digitally available data is made up of so-called unstructured data (images, videos, e-mail, social media posts) which lack a standardized structure, and are much less interpretable for computers, not to mention that typically their authenticity is uncertain. Law enforcement agencies traditionally relied on structured databases in the first place, but the ability to process unstructured data that are produced at a frantic rate in ever greater volumes – the so-called *big data* analysis – has been given priority recently. As Dr. Richard Jankowski, a researcher at the University of Memphis has it: *"...We can't look at someone's head and their genes and say they're going to commit a crime. But can we forecast what's going to happen and where it's going to happen? Yes, we can."* There are a lot of different data based analysis methods, from charting the distribution of the individual crime categories in time and space and doing a statistical examination of influence factors to visualization of the studied persons' network of relationships. Obviously infocommunication technologies will continue to play a key role in areas of application that support administrative functions and are regarded by now as conventional, including crime record management supported by integrated document management systems or master data management solutions that can be used to integrate various isolated systems in order to extract information in a consistent and standardized format. Beyond the above mentioned examples, there are a number of other areas of applications. (Cotton, 2012).

Figure 1: Information Management and Analytic Applications in Law Enforcement

Management and Operational Functions		Information Management and Analytic Applications
Resource Planning and Optimization	Personnel Deployment	Understand crime patterns to optimize enforcement officer scheduling, ensuring an appropriate staffing level during peak, normal, and light demand period
	Risk-Based Deployment	Identify locations linked to specific types of crimes, and proactively deploy tactical resources to respond quickly or prevent crimes
Detecting, Solving and Predicting Crimes	Tactical Crime Analysis	Model a crime and series of crimes, build links to other cases, identify and apprehend suspects, prevent future crimes
	Behavioral Analysis of Violent Crime	Model behaviors and predictors of violent crime, identify at-risk individuals and current suspects; use the results in detecting, solving and preventing crimes, and in risk-based deployment
Enhancing Situational Awareness	Risk and Threat Assessment	Identify and characterize events and factors linked with increased levels of threat and risk; use as inputs for deployment, special operations, forecasting, and prediction
	Officer Safety	Understand the interaction of factors on creating unsafe environments for officers and better prepare the officers deployed
	Around-the-Clock Crime Analysis	Update crime monitoring and prediction models based on a regular flow of new data to improve command decision-making and response capabilities

Source: Frost & Sullivan Analysis

Figure 3

Categorization of information technology solutions supporting public security

Source: Keeling–Cleverley, 2012

IBM's Smarter Public Safety model (Cotton, 2012; Keeling–Cleverley, 2012)

1. Building on experience gained by cooperating with a lot of law enforcement agencies around the world, IBM created the *Smarter Public Safety* model. This model is built around five key elements:
2. Integrated, reliable and standardized operative information system.
3. Efficient and effective tactical response capability.
4. Pro-active planning and decision making.
5. Optimization of collaboration between various organizations, standardized interpretation of threats and uniform responses to them.

Secure access to a wide range of relevant data

Secure digital access to as wide a range of data as possible increases the effectiveness of law enforcement agencies. The first step is to provide electronic access to data that have not been stored digitally, such as written records made at the scene, investigation reports, arrest records, and fingerprints. Conventional databases can be created from sources such as voice and video recordings and other information stored on social media sites or available on the internet. It is important to monitor and improve the quality of data based on criteria such as consistency or the limitations of the storage format (e.g. resolution of images and videos). Other elements of the model are built on securely accessible core systems that retrieve data from a wide range of regularly maintained, standardized and reliable data sources (Keeling-Cleverley, 2012).

Case study: Ministry of Justice of the United Kingdom

One of the key objectives of the Ministry of Justice of the United Kingdom is to forecast criminal behaviour. High volumes of data must be quickly, accurately and efficiently processed to ensure that crimes can be prevented with a high probability. The ministry came to the conclusion that analyzing data about perpetrators that used to be stored in isolated databases in a standardized system is indispensable for having a more comprehensive view of them. As part of this program 4 million records related to incarcerated persons have been processed, including information such as the emotional profile and alcohol and drug consumption habits of these individuals. A standardized system was used to analyze the data and to create forecasts as to what risks of future problems could be detected using statistical methods applied to the individual convicts. The results were used to introduce more efficient crime prevention programs in prisons. As a result of the program, the accuracy of forecasts related to repeat offences improved by close to 10% in the case of violent crimes, while predictions related to other crimes improved by 4%. Based on the processed data it was possible to have a better understanding of what kind of treatment in prison has the greatest chance to reduce the risk of repeat offences.

"With almost 4 million records on file, it simply wouldn't be feasible to trawl through this manually... technology gives us valuable insight into offender data, helping us predict who may reoffend and enabling us to advise on preventive measures." said the spokesperson of the Ministry of Justice of the United Kingdom (Keeling–Cleverley, 2012).

Integrated, reliable and standardized operative information system

The second element of the model focuses on accessing information sources available within a given organization through a standardized system. Typically, organizations use multiple information silos that are implemented independently of each other. Data items are recorded in several system, which inevitably leads to inconsistencies that should be eliminated. In addition to consistency, another important aspect is that these data should be presented to the user in the most useful and comprehensible format so they may support decision making as directly as possible. Proper visualization helps greatly the practical use of information in all areas of police operations, from detectives through crime analysts to police leaders. Integration of former insular systems even allows for setting up a network of collaborating experts to support the work of emergency response teams in real time by processing information from multiple sources according to various criteria in order to provide assistance with rapid on-site responses and prompt decision making (Keeling–Cleverley, 2012).

Case study: Madrid

Looking to improve emergency response capabilities and to better protect its residents, the city set up an advanced emergency control centre *(Centro Integrado de Seguridad y Emergencias de Madrid, CISEM)* in the aftermath of the bomb attacks against trains in 2004. CISEM collects and processes data from the widest possible variety of data sources. This includes, among other things, conventional police databases, reports from citizens, data from video surveillance systems and traffic control, and many other data sources. Various organizations use the system to share their devices with each other and they use standard protocols in order to improve collaboration and to respond more quickly and successfully to emergencies. Using standardized and holistic real-time information about incidents, commanders have a better insight into how complex emergency situation affect the city as a whole. In this way they can evaluate the situation at hand more quickly and accurately, and are able to provide better responses. It also gave a boost to the review of requirements, the prioritization of measures that are to be taken, and the coordination of interventions. The time it takes to respond to emergencies was reduced by 25% thanks to the implementation of this system.

"The most innovative aspect of the center is its scope – the integration of all the people involved and the systems they use.", said Fernando Garcia Ruiz, Head of Innovation and Development, Department of Security, City of Madrid (Keeling–Cleverley, 2012).

Efficient and effective tactical response capability

The basic idea behind the third element of the model is to provide response teams in situations requiring police, firefighter, disaster management or medical intervention access to the widest possible range of information that help them complete the given task in the field. This means centralized, highly automated mission management systems that assist the response personnel by providing them with situation-dependent information, track the parameters of the crew and the mission environment, and send situation-dependent alerts about changes through mobile devices. Collaboration between various organization is of utmost important in this field too (Keeling–Cleverley, 2012).

Case study: Madison County, State of Mississippi, United States of America

Rapid growth of the county prompted the sheriff's department to implement a centralized and automated system that, in addition to monitoring police activities all the time, speeds up the sharing of data and sends out warnings if necessary. Once the new system is deployed, policemen will use laptops to connected to each other and to the central database of the police station that will also provide pro-active functionality. Thanks to these development efforts, policemen will have real-time access to critical information and documents such as alerts related to accidents and incidents as well as subpoenas and court orders. As the system is accessible from everywhere, policemen will be able to perform assignments such as identification of victims and suspects and apprehension of suspects much faster. The system monitors the policemen's location all the time, which makes it easier to provide assistance to them if necessary. Policemen can record reports and notices in the field, which allows them to spend more time on the streets, improving the community's sense of security and deterring criminals.

"Real-time data.....makes critical decision making easier for all officers — immediately. That's a law enforcement tool we've never had before."— Mary Rooney-Lucas, President, DCS, Inc.

Pro-active planning and decision making

The work of detectives and crime analysts essentially involves combing through huge volumes of seemingly unrelated data to find clues that may lead to the solution of the give case. Advanced data analysis tools may help them recognize hidden correlations. This is especially useful, for example, in the investigation of international cybercrimes. In addition to using analytical tools to identify perpetrators, they can also be used for risk assessments so that crime may be prevented in time. In addition to preventing crime, risk assessment may also help prevent various emergency situations. These tools can be used to speed up the sending of alerts, reduce response times, improve the efficiency of assigning response teams to various tasks, and provide them with information to support decision making (Keeling–Cleverley, 2012).

Case study: Addison Lee

Addison Lee operates the largest minicab fleet in Europe, processing more than 25 thousand bookings a day. In cases where the fair is paid with a stolen credit card, the company may face losses up to one and the half times the value of the ride. The company is forced to refund the sum debited from the stolen card to the bank while it is also obliged to pay the driver's commission. In order to combat such abuses of the service, the company created a database of fraud cases, and used advanced analysis tools to identify high-risk passengers. They developed a system that they were able to use to catch fraudsters as soon as they booked a cab, based on automated warnings. As a result of this project, abuse of the service was reduced from 5 to 10% to less than 1% of the bookings, whereas the monthly amount refunded to banks was reduced by more than 95%.

"...gave us real-time protection against fraud, as we were able to run incoming requests against our own intelligence in our existing fraud database and receive automatic alerts on any matches.", said Mark Willson, Fraud Control Manager for Addison Lee, summing up the key achievement of the project. Optimization of collaboration between various organizations, standardized interpretation of threats, and uniform responses (Keeling–Cleverley, 2012)

The fifth and final element of the model is the coordinated, combined use or integration of the other four elements/four competences. Efficiency and effectiveness of the work carried out by various law enforcement agencies and the related public, private and civil organizations can be improved significantly through uniform coordination and information sharing measures. This is especially applicable to the assessment of risks posed by various disasters and emergencies and to the forecasting of incidents. An integrated and intelligent control centre can provide a uniform and real-time view of all known aspects of a given emergency, and enables a coordinated approach to managing the work of the deployed response forces, for example, firefighters, disaster management teams, police, ambulance, and local governments.

Case study: Smart control centre in Rio de Janeiro

The Olympic Games and the FIFA World Cup were hosted by Rio de Janeiro in 2016 and 2014 respectively, while the metropolis which is home to 6.5 million residents and is surrounded by a suburb with 12 million people faced several emergencies in the not so distant past. The Rio Control Centre was commissioned at the end of 2010 in the city – its mission is to coordinate the work of all involved organizations, collect data from various sources (e.g. meteorological, traffic, healthcare, crime, city infrastructure related sources, etc.) and track and visualize the current public safety situation. The control centre processes information from 30 different organizations. The result is a comprehensive view of the actual state of the city, which supports prompt coordinated interventions, analysis of trends, creation of forecasts and implementation of preventive measures in Rio in areas of city operations such as traffic management and prevention of traffic jams, crime investigation and prevention, or the ensuring of the uninterrupted operation of critical infrastructure elements, for example, the electric grid and the water supply. The centre is also tasked with managing the organization of major events such as the above mentioned World Cup or the Olympic Games. Based on constantly collected information, the centre keeps improving its prediction models and emergency response capabilities. The system can use various mobile communication channels to keep the emergency response units as well as the involved citizens updated, depending on the location and the situation. In the city, it is particularly important to prevent emergency situations and damages caused by flood and landslides in the aftermath of heavy rainfalls. In case of emergency, the system can send early bulk alerts to e.g. mobile phones. The centre also streamlines and accelerates information exchange between various organizations, and reduces the time needed to get a grasp on the essential circumstances of the emergency and take response measures as necessary from days to hours.

"In Rio de Janeiro, we are applying technology to benefit the population...so as to empower them with initiatives that can contribute to an improved flow of city operations.", said Eduardo Paes, Mayor of Rio de Janeiro.

Interdependent elements of IBM's Smarter Public Safety model

Certain elements and competences in IBM's *Smarter Public Safety* model form an interdependent, hierarchical system (COTTON, 2012).

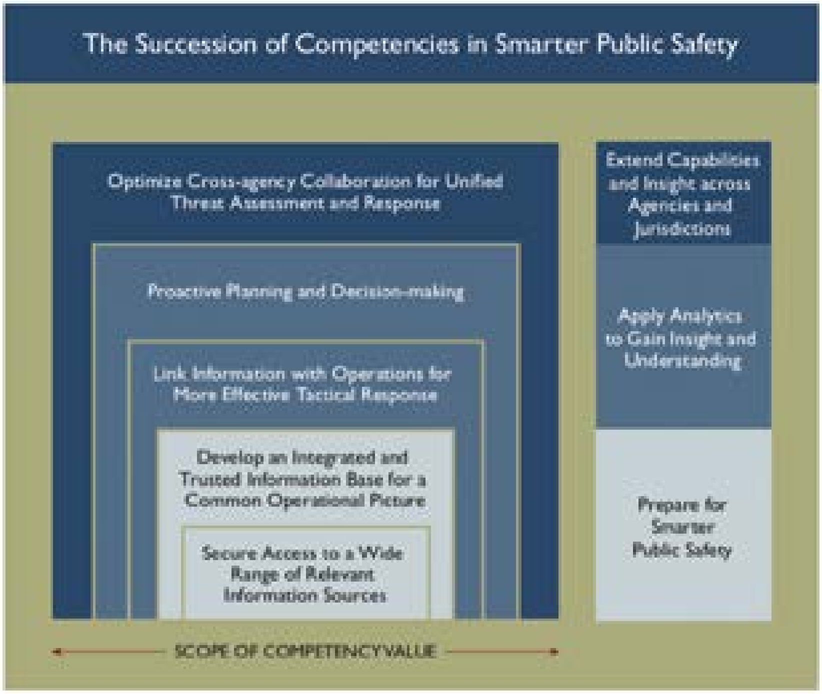

Figure 4

Interdependent elements of IBM's Smarter Public Safety model

Source: IBM, Frost & Sullivan analysys

Foundations – Prepare for Smarter Public Safety

Collecting available structured and unstructured data and making them accessible in digital format constitute the foundations of the system. These functions allow for answering questions like "who", "what", "when", and "where" in relation to crimes. Data should be retrieved from the widest possible range of sources, including data sources outside the organization, which means cooperating peer organizations or social media sites and the internet in general. The next step is to use these various data sources to create a central information system with standardized, reliable and suitable access control solutions and defences, which will serve as the basis of uniform operative management and analysis processes.

Apply Analytics to Gain Insight and Understanding

When uniform, reliable and secure data sources based on an extensive pool of information are available, the use of the statistical analysis tools that constitute the core of the *Smarter Public Safety* model may commence. Correlations revealed by these analytical tools make it easier to answer the questions of "how" and "why" in regard to crime. What is even more important is that by a statistical analysis of huge volumes of data not only analysis reports used for decision support can be created, but thanks to the prediction and risk assessment techniques crimes may even be prevented (*NYPD changes..., 2006; Putting a new byte..., 2006*).

Extend Capabilities and Insight across Agencies and Jurisdictions

The international character and complexity of threats against public security (international crime, terrorism, cybercrime, weather-related emergencies, natural disasters, etc.) makes cooperation between various organizations within and between countries essential. This has also to be supported by the implemented information systems. Sharing of information in a mutually comprehensible and quickly usable format, and coordination or even uniform management of resources and operative measures can also be of vital importance.

Public security reference model of IBM

Solutions developed by IBM form a modular system, the components of which can be used as standalone units or as part of a uniform integrated system, depending on user requirements and capabilities (Cotton, 2012).

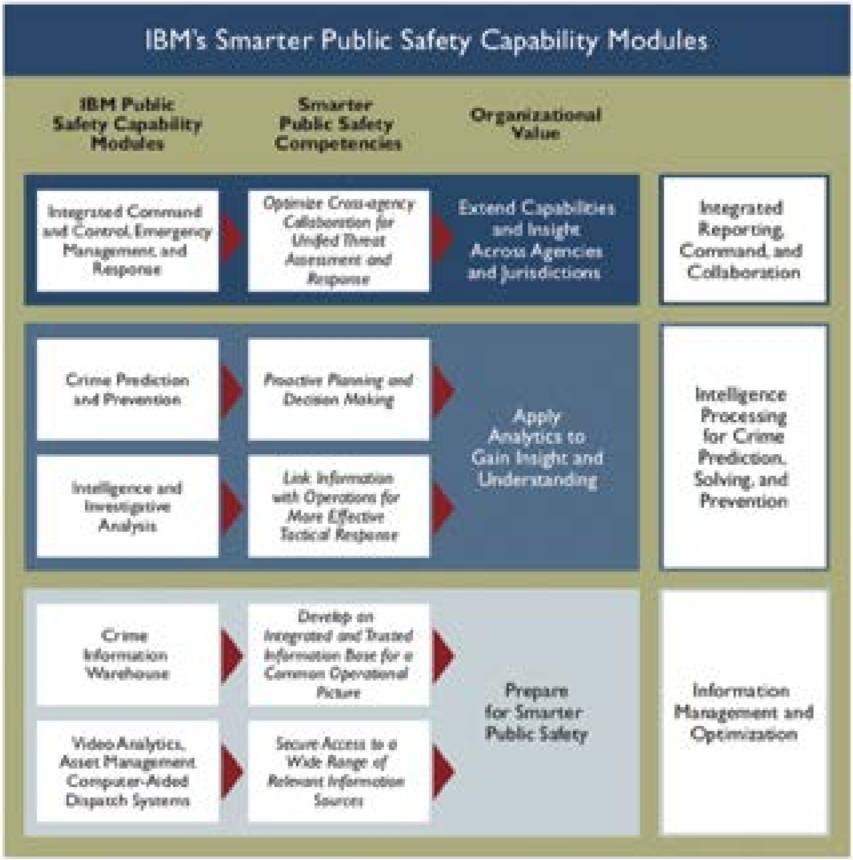

Figure 5

IBM's Smarter Public Safety Capability Modules

Source: IBM, Frost & Sullivan analysys

Big Data and cognitive computing

Data analysis solutions capable of processing huge volumes of unstructured data play a central role in the previously described model. IBM plays a leading role in resolving the so-called big data problems, and was the first to introduce the so-called cognitive computing (Kelly, 2015). In the following section, we will discuss a few important information technology trends that are relevant to our topic.

In 1965, a chemist, Gordon Moore, who was barely known at the time, published a study about relevant issues related to the electronics industry in the *American Journal of Electronics Magazine*. In the past 50 years, Moore's empirical law became a symbol of the explosive growth of infocommunication technology (Moore's law). As a result of this rapid growth, the speed and energy consumption of electronic processors, the capacity of memory circuits, and the area of image processing and data transmission often saw progress the rate of which was in the range of billions. One of the leading chip manufacturers, Intel, released a publication on the 50th anniversary of the publication of Moore's law, in which excellent examples are cited to demonstrate the incredible progress of information technology. One of those examples claimed that "if house prices fell at the same rate as transistors, a person could purchase a home for the price of a piece of candy". Another expressive example was that in 1969 the voyage to the moon took 3 days. If the speed of spaceships grew at the same rate as the speed of computers, that trip would now take one minute.

From the 1960s to the first years of the 1980s, users accessed large central computers using so-called *mainframe* terminals. This system was replaced by personal computers and the so-called client-server architecture, which was complemented by personal computers getting connected *en masse* to the Internet starting from the 1990s. By now personal computers have been dethroned as the dominant end-user platform by mobile devices such as smart phones and tablets. In the nearest future, machine-to-machine communication, the so-called *"Internet of Things"* (IoT) is expected to start its conquest in earnest (Komáromi, 2012). Soon the masses of people will start using wearable Internet-enabled devices, and the popularity of virtual and extended reality is also expected to go through the roof soon. With the spreading of mobile devices, infocommunication technology affects the lifestyle of billions of people. According to the *GSMA Global Mobile Economy Report*, by the end of 2014 the number of mobile subscribers reached 3.6 billion on Earth. This means that while 10 years ago the fifth of Earth's population had a mobile subscription, today this figure is 50%, and 1 billion more subscribers are expected before 2020, raising the global mobile penetration to 60%. The number of data connections entered the range of billions in 2014 and the number of so-called *machine to machine* connections exceeded 240 million.

Before IBM's personal computer made its debut in 1981, a couple of million users used a couple of thousands of software applications. The age of PC made tens of thousands of applications available to a few tens of millions of people. This mobile age represents another leap in magnitude: billions of users have access to millions of applications (Dirks et al., 2009).

The increasing popularity of mobile devices was mirrored by the spreading of a technological and business model called *cloud computing*, which reduced per-user IT costs to a fraction of what they were before, and as a result, software solutions that used to belong to the exclusive domain of large corporations and governments became available practically to everybody in the developed country, to many even in the developing regions.

Thanks to cloud-based computing and the evolving software development technologies – including, for example, the use of so-called APIs *(Application Programming Interfaces)* – that enabled developers to build software applications quickly from reusable and shareable building blocks, the cost and time spent on developing new applications and placing them on the global market were reduced by orders of magnitude. An important consequence of the spreading of mobile and cloud-based technologies was the popularity of social media that gave the world new ways to acquire and share information.

Due to the outlined changes, an unprecedented volume of digital data is produced every day, more than 80% of which is so-called unstructured data (Unstructured Data…, 2008), i.e. sound, image or e-mail. The steadily evolving big data analysis addresses the processing of unstructured data generated in huge volumes that the conventional database are incapable of handling. Compared to data analysis tasks that can be completed using conventional tools, problems posed by Big Data have usually 4 distinct characteristics *(The four V's of Big Data...)*:

1. *Volume:* Compared to what was considered mainstream a few years ago, the amount of data available today is greater by orders of magnitude. It is quite enough to recall the images, messages and social media posts produced by billions of smartphones. The growing data volume allows for building more accurate statistical models.
2. *Variety:* Tables and structured databases processed in a standard format that were used in the past now represent only a fraction of the available data. Most of the digital data sources are so-called unstructured data that are difficult to interpret using conventional tools: e-mail, text messages, images, videos, sound recordings, blog and other social media posts. IBM is a leader in the development of solutions that are capable of processing unstructured data. In addition to the popular SPSS data analysis tools, these include IBM's so-called cognitive Watson solutions which are capable of interpreting text written or read in a natural human language and processing images.
3. *Velocity:* Often there is very little time to collect, process, and interpret data, and to provide the correct response if the goal is to take immediate action rather than perform a follow-up analysis. For example, a traffic situation, a cyberattack or some other emergency may require an automated response, sometimes within a fraction of a second.
4. *Veracity:* Often the massive amounts of available digital data can be traced back to an unverified source of uncertain origin. Finding out how reliable the information obtained from these sources is could be the greatest challenge ever. The cognitive systems that we will describe in a bit more detail later can handle the uncertainty associated with data sources and even indicate the probability of accuracy of conclusions drawn by using advanced statistical methods.

IBM believes that in our days we reached another milestone in the development of computing, and we are on the threshold of the so-called cognitive era (Kelly, 2015). The paradigm shift is a result of the change in the way the data is processed. The first electronic computers were able to perform basic mathematical operations at high speeds. The next level, the era of programmable computers that we are still living in, is when computers run clearly defined programs and execute predefined instructions if certain pre-programmed conditions are met. In contrast, cognitive systems can also learn (machine learning) and modify their behaviour according to their "experiences". Cognitive computing system can also understand natural human speech and they also address the problems arising from the veracity or inadequacy of the available information. The first cognitive computing systems in the world were built by IBM, and named Watson after the founder of the company. The system made its debut in a quiz show called "Jeopardy!", which is popular in the United States, and won against two of the most successful previous winners of the show. During the show, Watson was not connected to the Internet, rather it stored in its memory 200 million pages of structured and unstructured data, including the entire Wikipedia.

By now IBM set up a dedicated business division to find business cases for cognitive computing, and repositioned its strategy around the new era of computing. The first large-scale commercial application was an oncology diagnostics systems, *IBM Watson for*

Oncology, that was developed in collaboration with researchers from renowned clinics and is capable of processing hundreds of thousands of medical articles, and it can deliver a highly accurate diagnosis based on the available clinical findings and other information and recommend therapies in cancer cases. Creating a global innovation ecosystem, IBM made its cognitive computing systems available to third-party developers.

Organizations responsible for public security should also adapt to the changes in the technological environment. The emergence of new technologies, tools, and information sources creates an opportunity for law enforcement to operate in a better organized and more efficient way, but it also carries risks as these technologies and tools and, in part, the information sources themselves are becoming more accessible to criminals from day to day.

References

Borders 2020. An IBM perspective on "Halt! Who goes there?" border controls. (2012) IBM Corporation, Somers. Source: www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&htmlfid=GOW03015USEN&attachment=GOW03015USEN.PDF (2016. 07. 19.)

BP Energy Outlook 2016 edition. (2016) Source: www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2016/bp-*en*ergy-outlook-2016.pdf (2016. 07. 19.)

City Region of Eindhoven. A regional government in the Netherlands pilots a traffic-management solution that collects and analyzes data from car and road sensors in near-real time, providing authorities with critical information they need to quickly resolve traffic issues. (2013) IBM Corporation, Somers. Source: https://casesimportal.newark.rutgers.edu/sites/default/files/files/City%20Region%20of%20Eindhoven%20uses%20existing%20data%20from%20road%20and%20car%20sensors%20to%20keep%20traffic%20moving.pdf (2016. 07. 19.)

Cotton, Brian (2012): *Smarter Public Safety: Enabling And Enhancing Crime Fighting Capabilities.* Frost & Sullivan, Mountain View. Source: www-01.ibm.com/common/ssi/cgi-bin/ssialias?infotype=SA&subtype=WH&htmlfid=GVW03037USEN (2016. 07. 19.)

Dirks, Susanne – Keeling, Mary (2009): *A vision of smarter cities. How cities can lead the way into a prosperous and sustainable future.* IBM Corporation, Somers. www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf (2016. 07. 19.)

Dirks, Susanne – Keeling, Mary – Dencik, Jacob (2009): *How Smart is your city? Helping cities measure progress.* IBM Corporation, Somers. Source: www.ibm.com/smarterplanet/global/files/uk__en_uk__cities__ibm_sp_pov_smartcity.pdf (2016. 07. 19.)

Frost & Sullivan 2014 Global Best-in-Class Smart City Integrator Visionary Innovation Leadership Award. (2014) Source: www.ibm.com/smarterplanet/global/files/us__en_us__cities__*FS*_IBM_Award_Report.pdf (2016. 07. 19.)

Horváthné Barsi Boglárka – Lados Mihály (2011): *„Smart cities" tanulmány.* MTA Regionális Kutatások Központja Nyugat-magyarországi Tudományos Intézet, Győr. Source: www-05.ibm.com/hu/download/IBM_SmarterCity_20110721.pdf (2016. 07. 19.)

IBM Intelligent Operations Center for Smarter Cities. (2012) IBM Corporation, Somers. Source: www-935.ibm.com/services/multimedia/Operation_Center_for_Smarter_cities.pdf (2016. 07. 19.)

IBM Research Launches Project "Green Horizon" to Help China Deliver on Ambitious Energy and Environmental Goals. (2014) Source: www-03.ibm.com/press/us/en/pressrelease/44202.wss (2016. 07. 19.)

Kahn, Joseph – Yardley, Jim (2007): *As China Roars, Pollution Reaches Deadly Extremes.* The New York Times. Source: www.nytimes.com/2007/08/26/world/asia/26china.html?pagewanted=all&_r=0 (2016. 07. 19.)

Keeling, Mary – Cleverley, Mark (2012): *Accelerating economic growth and vitality through smarter public safety management.* IBM Corporation, Somers. www.eu-ems.com/event_images/Downloads/IBM%20-%20Accelerating%20Economic%20Growth%20through%20Smart%20Public%20Safety.pdf (2016. 07. 19.)

Kelly, John E. III (2015): *Computing, cognition and the future of knowing. How humans and machines are forging a new age of understanding.* IBM Corporation, Somers. Source: www.research.ibm.com/software/IBMResearch/multimedia/Computing_Cognition_WhitePaper.pdf (2016. 07. 19.)

Komáromi Zoltán (2012): *Merjünk belevágni? Kockázatkerülés vagy innováció. IDC Hungary. S*ource: www-05.ibm.com/hu/events/valtsunkstrategiat/PDF/P_Merjunk_belevagni_IDC_KomaromiZoltan.pdf (2016. 07. 19.)

Lados Mihály (2015): *Introducing Smart Cities as Sustainable and Effective Responses to Challenges such as Climate Change, Rapid Population Growth and Economic Instability.* Source: www.polisnetwork.eu/uploads/Modules/PublicDocuments/lm-present_eu-china-smart-cities-panel_20112015-brussels.pdf (2016. 07. 19.)

Nestler, Gary – Jackman, Andrea (2014): *21st century emergency management.* IBM Corporation, Somers. Source: www.eu-ems.com/event_images/Downloads/IBM%20-%20Accelerating%20Economic%20Growth%20through%20Smart%20Public%20Safety.pdf (2016. 07. 19.)

NYPD changes the crime control equation by transforming the way it uses information. (2006) IBM Corporation, Armonk. Source: ftp://ftp.software.ibm.com/software/solutions/pdfs/ODB-0144-01F.pdf (2016. 07. 19.)

Palmisano, Samuel J. (2008): *A Smarter Planet: the next Leadership Agenda.* Source: www.cfr.org/world/smarter-planet/p34480 (2016. 07. 19.)

Pintér László – Almássy Dóra – Antonio, Ella – Niestroy, Ingeborg – Olsen, Simon – Pulawska, Grazyna (2013): *Sustainable Development Goals and Indicators for a Small Planet — Interim Report.* ASEF, Singapore.

Putting a new byte on crime in New York City. (2006) Source: http://unpan1.un.org/intradoc/groups/public/documents/other/unpan022488.pdf (2016. 07. 19.)

Ryser, Judith (2015): *Changing Cities – Changing Minds.* Proceedings REAL CORP 2015 Tagungsband, Ghent. Source: http://conference.corp.at/archive/CORP2015_132.pdf (2016. 07. 19.)

The four V's of Big Data. (é. n.) IBM Infographic. Source: www.ibmbigdatahub.com/infographic/four-vs-big-data (2016. 07. 19.)

UN (2014): *World Urbanization Prospects.* Source: https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf (2016. 07. 19.)

Unstructured Data and the 80 Percent Rule. (2008) Source: https://breakthroughanalysis.com/2008/08/01/unstructured-data-and-the-80-percent-rule/ (2016. 07. 19.)

Woods, Eric – Goldstein, Noah (2014): *Navigant Research Leaderboard Report: Smart City Suppliers. Assessment of Strategy and Execution for 16 Smart City Suppliers.* Navigant Consulting, Inc., Boulder. Source: www-01.ibm.com/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&appname=SNDE_LB_VL_USEN&htmlfid=LBL12348USEN&attachment=LBL12348USEN.PDF (2016. 07. 19.)