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An Oracle White Paper
November 2013

Oracle's Smart City Platform - Creating a Citywide Nervous System

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Executive Overview

Urbanization brings large scale challenges to both city governments and citizens. Cities are increasingly held accountable for the wellbeing of their residents while at the same time risk losing control because of the sheer size of the ecosystem that comprises a city. Citizens, enabled with modern technology, are in the position to take on more responsibility for the quality of life in their communities.

Matching the city's accountability with citizens' responsibilities requires the city and its residents to work together in a more intelligent way.

Information technology is becoming a strong enabler for cities to turn into intelligent cities, cities of the 21st century that appreciate the power of the communities while also respecting their legal and political responsibilities. Cities that understand this potential will create a *Citywide Nervous System* that establishes the foundation for intense collaboration between all constituents in a city.

Oracle's Smart City Platform addresses the requirements of cities that want to establish this *Sentient City Network*: listening to what is happening in a city, intelligently defining the response to citizen and environmental feedback and controlling the actions that are needed to improve the quality of life of citizens.

Introduction

Urban environments are by now the dominant residence for the majority of the people living on our planet. Cities are clear convergence points, absorbing and hosting important qualities that human beings bring to the community. Cities offer the fertile ground for people's creativity, increase the world's production capacity, are the home of education and research institutes, and are the basis for new forms of communities. But cities also bear the burden of being the largest consumers of energy, the cause of higher levels of pollution, the ideal hiding place for criminals, the place where people can live anonymously and potentially are left behind.

This stark contrast puts city governments in the challenging position to both cherish the collective power of citizens and businesses and at the same time to control all the negative side effects that large city communities can cause.

Disconnected Citizens

In an earlier era, smaller cities and villages meant that citizens were the city and cities were the citizens. Citizens were in control of most aspects of their daily lives and the community they were living in. Communities were self supporting and strong social control within communities was the basis of a stable, safe and livable environment.

The global urbanization of the last century however has led to a large disconnect between the city government, policy makers, administrative officers and the inhabitants of a city. Citizens have turned into consumers of city services instead of being part of the process; self sufficiency of citizens was traded in for full dependency on city facilities. Rather than trusting their own capabilities citizens often blame cities for lack of support. Likewise the evolution of public policy and city politics has turned most cities into bureaucracies, taking control of the day to day activities of their citizens, offering the reliability that citizens and businesses demanded, formalizing what was before controlled by the strength of the community itself.

Urbanization has rapidly become synonymous with a shift in responsibilities: control and power came into the hands of city officials; and citizens have been reduced to consumers. Needless to say this unbalance is not sustainable in the long run; and indeed – almost naturally – the trend is towards a turnaround of this disconnect into a more collaborative city-to-citizen relationship. Cities are requesting citizens to take more responsibility, citizens no longer accept being in the hands of anonymous officials but want to be made the center of attention, and businesses are most productive when they are treated as entrepreneurs contributing to the success of a city.

Citizens Take Ownership

Technology that supports the deep specialization of city operations is now also at the core of the swing back towards balanced sharing of responsibilities. Changes are seen both internally in cities and in the broader domain of the communities. Already many cities are optimizing their operations to become more citizen centric, processes are simplified and shortened using advanced technology, facilities are shared to reduce costs. Citizens exploit the improved access to technology to create new solutions addressing their needs immediately without the intervention of city services. Experiments and pilots initiated by citizens collaborating in communities are paving the way. Innovative technology is – again – the enabler for a major change. Citizens and cities are provided with the instruments that allow them to regain capacity to take responsibility, creating a livable city from both ends of the equation.

The Sentient City

This whitepaper outlines the information technology architecture of a city infrastructure that puts the control back into the hands of the citizens, while also appreciating the responsibilities that are allocated to city politicians and operators. Connectivity is the key to this city infrastructure, enabling the collection and sharing of feedback from all possible sources, allowing a city to measure and sense the quality of life in a city.
The following chapters describe how a citywide network of sensors – both human and technical – form a nervous system, with which the disconnected city of the past turns into a city that is sentient to its inhabitants' quality of life: a Sentient City based on the power of Oracle's offering and experience in dealing with the most challenging information management requirements.

City and Citizens in Balance

Both city governments and citizens are increasingly aware of their responsibilities towards solving the challenges that dominate the agenda of the growing world population. The quality of life on our planet is mainly determined by the quality of life in cities. Global concerns are without exception connected to the way cities operate and citizens behave. Responsible cities and citizens take the opportunity offered through innovative technology to bring back the balance – in city life, in ownership, in sharing responsibilities, in controlling the city.

Global Concerns Drive City Agenda

Operating a city has never been as complex as it is nowadays. Simple city services quickly develop into multi-disciplinary implementations addressing multi faceted concerns. Everything a city does needs to be assessed in the light of themes like the increase of carbon emissions, the difficulties of providing access to water, lowering the energy consumption, providing sufficient housing, etc. At the same time cities are challenged to meet their obligations with reduced budgets and in some cases even with loss of control or authority to collect taxes and fees.

City Sense & Control

Only an integrated, holistic approach that addresses the requirements of these diverse aspects will offer an effective solution to today's city requirements. Collaboration between the varieties of disciplines in a city cannot be accomplished without a solid basis for information exchange and process integration.

- Keeping control of carbon emissions requires a thorough administration of emissions across all departments of a city, a network of sensors that collect emission data, the intelligence to filter and analyze the relevance of the data, integration with the financial systems, etc.
- Provisioning and guaranteeing access to high quality water for consumption demands strong control and maintenance of the water grid, regular inspections of the quality of water providers, monitoring of water quality, immediate action on incidents, etc.
- Offering maximum mobility to inhabitants while keeping control of congestion mean the public transportation system, the network of roads, the parking facilities etc need to be of high enough quality to strike the balance between citizens' demands, energy consumption and air quality.

"We've changed people's lives. 311 is not just a citizen service hotline; it's the most powerful management tool ever developed for New York City's government. I can't imagine running a city without it!"

Michael Bloomberg, Mayor, City of New York

These are just a few examples where every single discipline impacts another. This assumes cities have the ability to share information between departments, a way to implement end to end processes and means to reach out for feedback. Feedback that could come from citizens and sensors alike – demanding multiple channels through which the city 'senses' what influences the quality of city life.

But sensing without responding is meaningless. When feedback is collected (through whatever means or channel) it should be used to take control of irregularities. Two-way interaction between the city and its sensors is needed to close the loop of the feedback systems.

City Budget

Offering higher value city services to satisfy the increasing demand from citizens and businesses is causing a financial challenge where austerity measures cut budgets. Similarly, innovations are very unlikely to be implemented where the return on the investment is unclear. The challenge is to achieve fast enough return to show improvements within the current budget period.

Moving responsibilities from the city (back) to the citizens is one common way to address the discrepancy between available budget and (tax) income of a city. Reducing the size of city operations and bureaucracy often is a way chosen by city governments.

Whatever measure is taken, making more effective use of information technology is a path that more often than not is supporting change. All scenarios that are implemented to more effectively use public taxes have at least three aspects in common:

- Collaboration – Moving or sharing responsibilities between departments or between a city and its residents always require a stronger infrastructure to support the expected interaction. Connectivity and accessibility facilitated by open networks are the keywords to enable interaction.
- Harmonization – Enabling end-to-end integrated and shared process support at lower costs requires a reduction of the number of (legacy) systems. Reducing the complexity of the IT landscape is a condition to cost effectively offer city services to internal and external users. Keywords in this context are shared service centers, hosted services and application stores.
- Modernization – In order to support adequate sharing of city officers' knowledge, citizen data, process content, etc. data should be made accessible, managed securely and modeled in a standardized way. Legacy modernization, detaching logic from data, virtualization at server level, tiered storage are means to this end.

These aspects can be summarized in one phrase: <u>cost cutting leads to consolidation</u>. Consolidation enables streamlined interaction and common ways to integrate and exchange information.

Citizens Inclusiveness

While the trend is that cities are growing like never before, citizens tend to look for more traditional, small scale communities to deal with. The role of people in the immediate vicinity is becoming more important than any institutionalized form of service. Large scale anonymous organizations are losing their direct impact on the lives of the average citizen. Citizens are willing to put in the extra effort to achieve results that come closer to their requirements.
Neighborhoods are taking more responsibility for their own public safety, healthcare is offered through personal networks, financial support is arranged via Non-Governmental Organizations (NGO's) and religious communities, and education is organized by and for segments of the population.

Inclusiveness starts with the network

Without the need to explicitly engage city services citizens are finding new ways to organize this traditional community collaboration. But rather than creating communities with people right next door, the Internet and related innovations allow for networks that span larger geographies. Access to functionally rich networks is the key to inclusion. Citizens are organizing this inclusiveness themselves, with or without the support of cities.

- Social Networks – Knowledge and experience are exchanged in social networks, where lively discussion forums provide immediate feedback and solutions. Despite the still existing 'digital divide', more and more people are connected and take active part in these networked communities. The

Ruter# Ruter coordinates the public transport (Metro, tram, boat and the main bus services) in the Oslo region in Norway. Their goal is to make your journey as comfortable as possible. Ruter uses Oracle's Siebel and Twitter to provide better service to its customers.

need to turn to cities as a source of answers is quickly diminishing; the shared 'knowledge of the crowd' is becoming the norm.
- Application Stores – The abundant availability of all sorts of relevant, handy and easy to use applications supports the self sufficiency of residents. Created by 'the crowd' and often replacing services that are (still) traditionally mastered by government

institutions – whether these are weather reports, public transport information, geographical information, reports on quality of education, etc.

- Sensors – Sensing and measuring what happens in a city has become easier than before. Traditional reporting, whether based on a census gathering a multitude of details directly from the population or based on professional monitoring systems, fall short on actuality, timeliness, detail and relevance. Direct feedback from social networks, real-time response from intelligent sensor devices, immediate analysis through analytical solutions are dominating decision processes of cities and their residents.

Cities that take their residents seriously will provide them with a citywide infrastructure that facilitates the further development of self-sufficient communities. These networks will be the source of relevant, real-time and detailed feedback to cities. Similarly these networks should be the source of public information and data: Open Data that stimulates further self-sufficiency and control by citizens. Engaged and stimulating cities will enable themselves and their residents to actively act upon this wealth of wisdom and creativity coming from their inhabitants.

City Balance Reestablished

Numerous experiments and pilots are raising the bar for cities that want to reconnect with their citizens. The balance between the agreed formal and legal responsibilities of city governments and the self sufficiency and self control of citizens is being reestablished as a result of many innovative projects. More and more cities are spending budgets to align their operations with the citizens demand to be serviced more adequately.

The Internet of Things is converging with the Internet of People, an inevitable trend that, despite the criticism that technology is taking over mankind, brings back the balance between the strengths of formalized city services and the dynamics of vivid citizens' communities.

Around the world we see positive examples of cities and citizens joining forces: bicycle sharing based on real-time demand, monitoring of available parking spaces to reduce traffic congestions, behavior based waste management fees, city councils actively using community forums as part of decision making, citizens building apps to simplify access to city service hotlines, small particle sensors owned by residents to influence programs to improve air quality and so forth.

Now let's address the requirements of communities to get connected again: the capabilities required to establish a Smart City Platform.

Oracle's Smart City Platform

Oracle's Smart City Platform is a comprehensive range of solutions addressing the ever increasing need to provide businesses and citizens with transparent, efficient and intelligent engagement with their local authority/administration - through any channel - for any purpose, from information requests and government programs enrollment, to incident reporting or scheduling inspections, to complete online start-up of a local business. Development, implementation and refinement of such a multi-channel, single point-of-contact platform to all government organizations lays the foundation for a range of additional capabilities from business recruitment and retention to self-selecting, interest- and knowledge-based communities amongst citizens to improved management of civil contingencies and emergency disaster planning.

Oracle's Smart City Platform allows cities to establish a *City Wide Nervous System*, enabling the citizens and the city to share responsibilities while offering maximum control at all levels in the community. This platform then will provide the framework for a *Sentient City Infrastructure* through intelligent controls that sense and action on the big data offered through connected citizens and sensors. Maximizing the reuse of existing infrastructure in combination with Oracle's Smart City Platform capabilities, allows for future sources to be added and will offer full independency towards additional solutions, disciplines and appliances.

City officials will use Oracle's Smart City Platform to establish a unified view of all aspects of the city operation, the quality of life in their city, the impact of initiatives taken, and the feedback from their residents. The City Platform brings together data from multiple sources for analysis by a cross-discipline business intelligence layer. Operating a city on the basis of shared services and processes drive down costs while opening opportunities for businesses and citizens to connect and action themselves. Processes spanning multiple actors within and outside the city are integrated once deployed on this open nervous system. The expected stellar growth in data production and sharing is supported by the elasticity of Oracle's Smart City Platform innovations in database, servers and storage facilities.
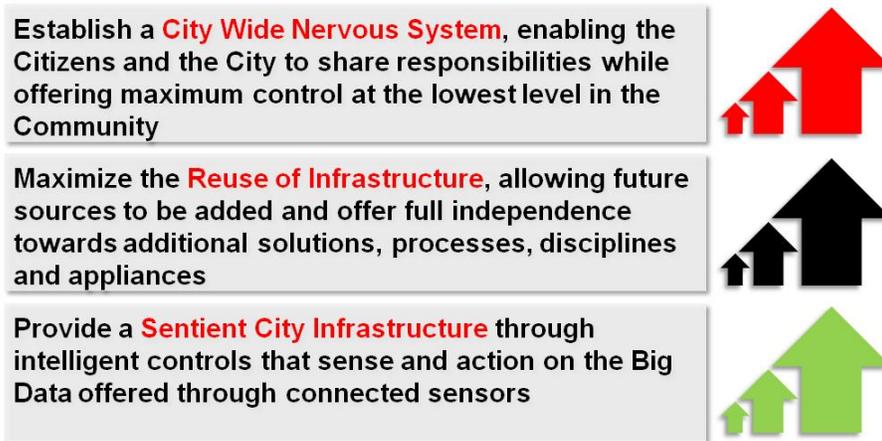
Establish a City Wide Nervous System, enabling the Citizens and the City to share responsibilities while offering maximum control at the lowest level in the Community

Maximize the Reuse of Infrastructure, allowing future sources to be added and offer full independence towards additional solutions, processes, disciplines and appliances

Provide a Sentient City Infrastructure through intelligent controls that sense and action on the Big Data offered through connected sensors

Figure 1 - Citywide Nervous System

Citywide Nervous System

Controlling a city, covering all aspects and dimensions that make up the quality of life for its inhabitants can be compared with the complexity of a human nervous system. Ranging from the strategic politics to the fine granular day by day operational aspects a city does require a well balanced closed loop interconnected system in order to live up to citizens' expectations.
Specialized departments, often working in silos, coordinate specific tasks within a city and without exception use their own network to communicate, have their own routes to facilitate feedback, to stay connected with public workers and citizens. The public works department differs in this respect from the public transport providers, the social welfare facilities are addressing residents' needs differently than the education system of a city. Although those specific services have in common that they represent 'the city' in dealing with the 'citizens' and 'businesses', the comparison often ends at this level.
The quality of city life will be greatly enhanced when different areas start to collaborate. Collaboration on the basis of sharing their respective networks and facilities is an important step, uncovering potential for cross-fertilization between services.

Just like in the human body, a Citywide Nervous System would consist of a strong and universal backbone, the central pathway that links up all the individual specialized networks – the network of networks. When networks of different kinds are equipped to work together, synergies can be expected. In cities this is clear in many ways already: what would the public transport network be without a decent road infrastructure, how would

business networks develop without the availability of power networks, how would the sewage operate without a working water provisioning system?

Oracle's Smart City Platform is the core backbone for those cities that are building on these existing networks; utilizing the vast amount of capabilities – whether in data, processes or services – that takes the quality of services to the next level.

Sentient City Infrastructure

Nervous systems without sensory divisions would be as dysfunctional as a city that doesn't listen to its citizens and what they require in their daily life. Also, just interpreting single dimension feedback from distinctive departments would be like having dinner with closed eyes or like cycling hands-free – it is possible and sometimes joyful, but not realizing its full potential.
Politicians and city governments tend to already look at matters with a holistic view: public transport is developed not only to transport people but also to improve the cities' traffic flow and to reduce air pollution; the education system is improved for obvious educational purposes but also to reduce criminality in neighborhoods and to increase the productivity of the workforce; surveys are held to gather direct feedback but also increases citizens' satisfaction and do bridge the gap between communities and politicians. The next step is to utilize today's technology to implement this in the city networks.

A Sentient City Infrastructure provides cities with the technical capabilities to really implement these crossovers in holistic thinking in the Citywide Nervous System. Sensing what is happening in the city has become a matter of creatively combining feedback from human and technical sensors alike; analyzing the incoming data in real-time to allow for direct real-time decision taking.
Cities and citizens are enabled to collaboratively exploit and improve the Citywide Nervous System – by providing feedback in social networks or directly to city service centers, by connecting sensors to private or public sensor networks, by publishing data and findings to the citizen community. Ideally the nervous system is used to connect both (city) internal sources/sensors and community networks. Only then is a true Sentient City Infrastructure established.

Pervasive Sensors

Looking at what makes up a Sentient City Infrastructure, we come across a wide range of different types of devices that provide the 'sensing' capabilities. Whether the input is

SFpark is expanding its parking sensor program this summer, adding 1,200 spaces to the 7,000 spaces that currently have sensors. These wireless sensors provide the real-time parking availability information on this [web] site, the SFpark iPhone app and soon an Android app, as well as the open data feed for other organizations and app developers. New technologies and approaches make parking easier and faster. This means less circling and double-parking, leading to cleaner air, safer streets and a clearer path for Muni vehicles.

SFpark website, posted July 26th, 2011

provided by machines or citizens, we see content being fed back like audio and video streams, geographically tagged data, feeds from news portals and social networks but certainly also from technical devices. Sensor technologies are available to track assets and automatically detect changes in temperature, motion, location and conditions.

Without noticing them, pervasive as they are, sensors are around everywhere already – in climate control of buildings, access control systems, in medical devices, security camera's, measuring water levels, meteorological equipment, GPS enabled PDA's, light sensors, radar or speeding camera's – we just need to tap into their potential.

Sensor devices are becoming more functional and intelligent – leading to a wealth of application areas in which sensors can play a role. Also the cost of sensor devices are quickly decreasing, opening even more opportunities to contribute to a Sentient City Infrastructure.

Applicability of Sensors in Cities

Around the world we are seeing promising, innovative and already affordable examples of the discovery of the potential of the city networks across multiple application domains – all exploiting underlying individual strengths to reach a higher level holistic cause that would not be achieved with disconnected networks.

Pervasive technology found its way into a wide range of different areas.

Traffic and Mobility

- **Traffic Management** – Measuring the actual flow of traffic and using the data to actively guide traffic through a city or to dynamically change the price of tolling and parking; often used in an attempt to reduce air pollution and to reduce traffic congestions.
- **Parking Management** – Sensors in parking places measure the actual use of the parking spot, feeding into intelligent systems that publish the availability of free parking spaces, potentially picked up by car navigating systems and dynamic parking (meter) pricing solutions.
- **Public Transport** – Following the location of public transport to inform citizens on expected arrivals and to monitor compliance with scheduled as well as driving behavior of drivers.

- **Mobility** – Sharing bikes, cars or other means of transport, as an alternative to self ownership, is supported by GPS enabled vehicles, connected payment machines, locking equipment, etc.

Environmental Controls

- **Environmental Control** – Both in the hands of citizens and city officials are sensors to measure the quality of the environment; whether this is about the amount of small particles in the air, radiation from the industry or the level of sound nuisance;
- **Street Lighting** – More and more cities around the world implement a dynamic lighting system, where the intensity of artificial light is determined by real-time measurement of light, either to increase public safety or to reduce energy consumption and hence lower energy budgets.
- **Smart Metering** – Energy providers are optimizing energy consumption of businesses and households by providing intelligent devices that not only measure the use of energy but also offer real-time advice on alternative usage schemes or energy sources and in addition provide automated control of appliances.

Quality of Life

- **Home Automation** - This may include centralized control of lighting, heating, air conditioning and appliances to provide improved convenience for the disabled, comfort for elderly citizens, energy efficiency for families and security to neighborhoods.
- **Public Safety** – Law enforcement agencies are analyzing behavior patterns of potential criminals, based on a variety of sources – ranging from closed circuit television (CCTV) to automatic number plate recognition (ANPR) – to proactively predict where criminality is likely to happen.
- **Location based services** – Using geographical information, often available from GPS equipped devices, services are targeted at specific locations or areas in the city. Vehicles can be sent to available parking space or routed to circumvent traffic congestion; citizens may receive location relevant guidance to use city services nearby.

Oracle has been engaged for many years in the above examples. They represent just the beginning of an era where cities and citizens are really uncovering the potential of being connected and sharing sources of knowledge, facts and best practices. Oracle's Smart City Platform is supporting cities to release this untapped potential and to shape the foundation for further innovation.

Architecting the Connected City

Oracle's Smart City Platform is the foundation for a citywide information technology (IT) infrastructure that turns cities into sentient cities. The platform is facilitating city operations as well as the cities' residents, capturing citizen feedback and messages from technical devices, mastering multimedia data and securing content.
It is meant to support participation by all functional areas and departments in a city, internally and externally, ranging from utilities like water provisioning and electric grid providers, from citizens to service providers, from social services to law enforcement. Different information streams are captured into a systematic view of the city and all its constituents.
Only an information technology architecture that enables a city to establish a holistic solution offering an aggregated analysis of different streams of data to control its quality of life deserves the label of the City Platform.

Citywide Architecture Prerequisites

An optimal citywide IT architecture would be more than the sum of its individual parts that it is consisting of. It would be the platform that
- Allows cities to **interact** with citizens through a multitude of channels;
- Bridges internal processes with external process participants by a strong **integration** capability;
- Forms the hub to **exchange** data between all the city and community stakeholders.

Multi Channel Interaction between Citizen and City Immediate & High Quality Resolution of Requests Providing means for Citizen Self Control	City to Citizen
Smooth, Harmonized Back Office Processes Towards higher Productivity of City Constituents Intelligence led Planning, Budgeting & Procurement	City to Business
Reliable Infrastructure to operate the City Network of Networks Real-time Closed-Loop Control	City to Network

Figure 2 - Connectivity at all city levels

As each city needs to be prepared for change, so should its IT architecture – the dynamics of any city's ecosystem requires an infrastructure that is **architected for change**:

- **Open Framework** – City operations will continuously ask for changes in processes and the supporting business applications. These solutions with their own life cycle need regular replacement or modification – requiring a solid and open framework in which multiple types and versions of solutions can reside.
- **Standardization** – In the public space there is an ongoing evolution of appliances, devices, networks, equipment that cities need to maintain, connect with or control. Standardization of connectivity provides the longer term stability.
- **Ready for growth** – Growing acceptance of technology in the interaction between cities and residents also requires the platform to sustain growth. In addition, the growing expectations of citizens and city officials raise the bar for non functional requirements like the stability of the operation, the performance of the facilities, the protection of the information, the scalability of the platform.
- **Generic** – Continuous shifting of responsibilities amongst all stakeholders in the city requires that the supporting city platform capabilities are defined independent from operational disciplines, functional areas, 3rd party processes, city policies etc. The platform should offer generic functional building blocks.

Really connected cities are those cities that understand what to do with the feedback provided by citizens, business and sensors. Only the information that really can be turned into actionable tasks will provide the necessary ingredients to make a city sentient and in the position to take control or allow the citizens to take more responsibility. Augmenting the value of individual bits of data is a key characteristic of the platform.

- **Ingestion** – Data arrives through a variety of channels, interactions, integrated systems and connected sources. Being able to connect to multiple sources and to capture and aggregate the data independent from their format are key requirements.
- **Evaluation** – Recognizing what data is taken in, being able to interpret the context of feedback, resolving the format in which the data is organized are qualities that make up an open information exchange platform.
- **Analysis** – Being able to analyze the information and to take informed decisions is a core quality of any city platform. Applying business intelligence instruments, visualization tools, statistical reporting and predictive algorithms is essential.

- **Communication** – Feeding conclusions and commands back into the network of city stakeholders is closing the loop. Being able to communicate in multiple ways in order to disseminate relevant information to the right audience, to control processes and to influence the city residents creates the foundation for a responsive city.

This context aware computing centers on the concept of using information about an end user or objects, environment, activities connections and preferences to improve the quality of interaction with that end user. The end user may be a citizen, business, or employee.

The above characteristics create a city that not only enforces, measures and listens, but also is capable of responding to what is needed to really improve the quality of life.

Liberating Budgets

Becoming a connected, sentient city is not only a matter of a technical architecture or maximizing the use of information technology. Traditional investment models no longer satisfy the dynamics that are linked to a truly connected city. Establishing a Citywide Nervous System does require a redesign of the way investments and revenue streams are constantly being matched. Inevitably it comes with a rearrangement of investments, financial budgets, taxation and revenue streams and expenditure patterns.

Another view on business models is needed in order to create a clear connection between the city investments and its constituents' experience in enjoying the city's services and innovations.

Austerity Measures

Around the world city operations are challenged by austerity measures. It is no longer accepted that city budgets can grow forever to accommodate constituents' demands. A turnaround is needed in the way city expenditures are matched with available budgets. Technology can be the enabler to support this financial and fiscal transformation. Lacking the support for investments on top of budgets that are already under pressure, the funding for changes can be found by unleashing budgets from existing operations. The exercise to find means to liberate budgets is a key element to catalyzing changes in a city. Cities do have untapped potential to save on budgets while keeping up the service levels, but do need to recognize and exploit this. . Innovation in technology and processes are the underlying means.

Budgets Follow Responsibility

The alignment of budgets with constituents' demands is an everlasting exercise. Although maybe regarded as the reason to change the business model of a city, the implementation of a Citywide Nervous System can in fact use existing funding principles. Publicly funded budgets basically need to follow the responsibilities given to each actor in the public domain. When cities are tasked with responsibilities, they deserve the budgets to implement these. Likewise, and this is the change we are now experiencing, when citizens are taking on more responsibilities, the budget needs to be realigned to facilitate that change. Establishing a Sentient City Infrastructure requires that budgets need to move from the traditionally internal focused operations to the model of interaction, integration and exchange.

Agile Funding

Innovative ways of funding are needed to expedite transformations. A clear connection between the intended change and the actual benefits is required, certainly also from a financial perspective. A few examples of the potential of immediate cost savings while investing in innovation will make this clear.

- **Dynamic lighting**. The infrastructural changes to become a green city can be paid for by the immediate energy cost savings of applying advanced sensor technology to dynamically control public lighting. Moving from a fixed energy bill to one that represents the actual need for lighting.
- **Dynamic parking fees**. Innovation in the city's transport and mobility facilities can be funded by the introduction of dynamic fees for parking. Citizens' behavior is financially incented through a direct relationship with the impact of the behavior. Changing from a fixed transport budget to a model where mobility drives the expenditures.
- **Self service interaction**. Establishing a multi channel interaction policy, enforcing citizens to use the most cost effective interaction channel, funds the required infrastructure to enable citizens to be more self sufficient and in control. Channel costs will then be directly related to the importance of the interaction.
- **Home care automation**. Offering a home automation infrastructure to allow those citizens that need healthcare or social care to help themselves will immediately have an impact on the costs of home care service delivery.
- **Managing waste**. Introducing dynamic pricing on waste processing creates a linear relationship between the production of waste and the costs of its processing.

Essex County Council adopts cloud computing for payroll to save millions and offer shared services. "With Oracle On Demand, we now have a secure, reliable, and flexible system that has enabled us to significantly reduce costs while improving service to our staff. In addition, we can provide state-of-the art shared services to enable others to take advantage of our excellent systems."

Mark Hobson, Head of Essex Shared Services, Essex County Council

- **Targeted inspections**. Using direct feedback from citizens and sensors to steer the activities of inspectors will directly reduce the amount of time spent on unnecessary inspections.

Sharing And Virtualization

Establishing a citywide infrastructure also represents a huge opportunity to control costs of information technology. Maybe seen as a paradox, but investments in creating a shared infrastructure to innovate city-to-constituent interactions, also have the potential to free up budgets for the innovation itself.

Harmonizing processes is enabled by standard business applications that in their turn can be offered as shared services – leading to lower ownership costs. Consolidating the application landscape of a city is possible through the deployment of generic functional capabilities and the use of standard components – leading to a reduction of maintenance costs. Virtualization of computer processing power across desktop computers, servers and storage immediately lowers costs of energy, maintenance and IT services.

Oracle's Smart City Platform, especially the City Operation and City Infrastructure elements, is enabling this in many ways, like described in the following chapters.

Oracle's Smart City Platform functional areas

Oracle's Smart City Platform covers the requirements of a broad range of disciplines and tasks of a city – the platform is designed to match the way cities organize their operation.
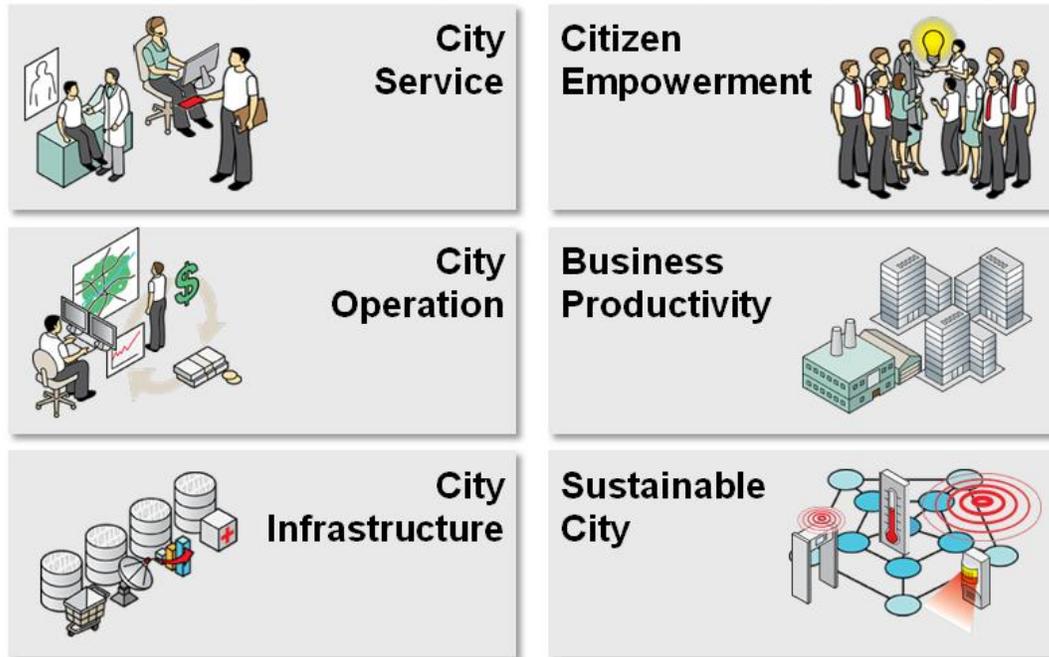

Figure 3 - Oracle's Smart City Platform addressing city requirements

City Service

Providing clear responses to citizens' requests is the core task of any City Service center. No matter what way of interaction is chosen by citizens or city officers, the quality of the response should be the same, the rules that are applied should be consistent, and knowledge should be shared to support the best possible outcome of the interaction. Ensuring management accountability while also enforcing resource distribution properly for non emergency procedures helps reduce costs to policing. Parking violations, public drinking, excessive noise, vandalism, and other quality life issues are where Oracle's Smart City Platform has had great impact.

Oracle's Smart City Platform offers a variety of functional capabilities supporting this high quality multi-channel interaction in the front office. Frontline, consistent first line service can be provided across multiple channels – telephone, web, chat, social networks, face to face – based on strong multi channel contact center functionality. Both urgent and non-urgent requests are handled, allowing emergency centers to be connected to processes in the regular service centers. Deeper case management capabilities allow for second line support and targeted, specialized service delivery by case workers. This is all underpinned by generic capabilities managing the business rules that are used in the citizen interaction and providing access to relevant and context specific knowledge to knowledge workers.

Combined with the right business intelligence instruments, cities influence how to best use the available channels, optimizing the cost of interaction. Likewise, using the professional marketing and campaign instruments, cities can reach out to citizens proactively – reducing the cost of communication and interaction.

Citizen Empowerment

Depending on the ambitions of a city, empowering citizen communities may vary from providing ready to use communication infrastructures to full reliance on citizens' initiative. Cities may provide all tools and instruments that citizens can exploit for interaction amongst them or with the city. Perhaps it is enough for the city to just create the circumstances for citizens to develop their own means of communication. Given the current increase in use of social networks, cities are likely to also use this channel to strengthen the interaction with the city residents.

Cities that want to stimulate citizens to take responsibility also take these 'human sensors' serious. Using citizen feedback in the City Operation center allows for a more focused, targeted and hence more affordable streamlined service on all city levels. In appreciating citizens, their communities and their (social) networks, cities do themselves a favor as this will increase the overall quality of city life.

Oracle's Smart City Platform components allow for two-way interaction, the basis for closed loop feedback interaction between the city and the residents. Connecting City Service centers with social networks creates a structure that allows a city to listen, interpret

CITY OF BOSTON

"With current resource constraints, we aren't in a position to have people running around gathering data. Now, we have a core system that will let workers gather data as it appears and will then populate the Hyperion system without any human intervention. From an integrity and consistency-of-data perspective, it takes us light-years ahead in terms of transparency of the data"

Bill Oates, Chief Information Officer, City of Boston

and respond actively. In a more traditional way cities can use Oracle's web platform to provide self service functionality to self supporting citizens. Business rules based interactive forms guide citizens through what before required complex paperwork.

City Operation

Cities would have two distinct types of back office operational processes: those meant to directly support services towards city constituents like citizens and businesses and those processes that take care of the generic business processes in for example HR, procurement, finance departments. The latter will be implemented and supported by standard business applications, whereas the former will cater for more city specific requirements. Managing a city is like a balancing act. The City Operation center provides the means to strike the balance between revenue and expenses, between control and quality of life, between consistency and personalized support, between bureaucracy and smooth processes.

Consolidation and Sharing

Oracle's Smart City Platform offers standard business applications for generic operational business processes. In their effort to cut budgets, cities are harmonizing their back office processes so they can use standard business applications without too much modification. Application landscapes are also consolidated into standard applications in order to cut administration and maintenance costs; this modernization of legacy systems is gaining ground rapidly. Shared Service centers are established to offer centralized, generic back office services to multiple departments within a city or to cooperating cities. By sharing services, cities are saving on their operational budget.

Fiscal & Revenue Management

Controlling the financial balance of a city is a subject that dominates many of the political and day to day discussions in a city. Taxes, fees and levies are needed to fund the city's operation whereas citizens and businesses regard them as an unnecessary burden. The consistency, transparency and relevancy of taxation are key qualifiers influencing the willingness of constituents to pay what is needed to run a city. Tax compliancy is strongly influenced by ensuring the right level of city tax is applied and when it is clear why fees are due for any given city service.

Creating this balance is supported by Oracle's Smart City Platform. It provides analytical insight in the fiscal streams and the impact of taxation on the constituents' experience. In addition it offers the instruments to implement taxation and to influence compliancy levels based on clear facts measured across the cities departments.

Licensing and Permits

Managing the quality of life of a city is a clear responsibility of any city. Licenses, permits and inspections are the controls that a city can use to manage the way businesses and citizens operate. The bottom line impact of these controls is determined by the quality of the information that is available on the behavior of those businesses and citizens that are licensed. Being in the center of all information streams the City Operation center is ideally positioned to make intelligent, informative decisions on who to inspect, which permit or license to endorse or what practice to stop.
Oracle's Smart City Platform offers the instruments to support this intelligence-led targeted inspections and information controlled permitting and licensing.

Closing The Loop

Oracle's Smart City Platform is at the core of a city's operating center, the city 'command and control' center from which both internal and outbound activities are evaluated and, where necessary, coordinated. Business applications support the standard operational tasks to maintain the city infrastructure, ranging from routine asset maintenance scheduling to targeted, intelligence-led inspections; from structured revenue and tax management to the collection of parking fees; from planning urban development to budgeting departmental projects.
The City Operation center is also the hub where the connection between the city and its constituents is maintained – in terms of business to business process support, in terms of controlling the networks of the city, in terms of managing and acting on the feedback coming from both citizens and devices in the network.
Business process management instruments tie individual processes together, controlled by business rules engines and workflow tools.

Sistema de Aguas de la Ciudad de México provides drinking water, drainage, sewer services, and wastewater treatment and reuse. They use Oracle's Siebel CRM to efficiently manage payment and collection information from 2 million customers and provide comprehensive monitoring of users' accounts. SACM projected water consumption with Oracle Business Intelligence to improve water supply management and respond to each area's needs. They developed marketing and awareness strategies for water management with graphical tools from Oracle Business Intelligence to simplify decisions regarding water rates, which vary by region. "Oracle delivers many advantages, such as experts who can help us develop applications, a highly competitive cost structure, and tools with the ability to handle our high volume of transactions. These are things no other brand or application can provide."

Francisco Núñez, Executive Director, Customer Services, Sistema de Aguas de la Ciudad de México.

Operational Insight

As a collective place where data comes together, Oracle's Smart City Platform enables the city to get a deeper understanding of the internal and external processes. Harmonizing the information coming from multiple city sources will shed light on the effectiveness of a city operation and cross-departmental analysis of facts will provide insight in the quality of life in the city. Business intelligence solutions that analyze the streams of information coming from city sources are recognizing patterns, predicting and analyzing circumstances and providing alerts on signals coming from within the city.

Business Productivity

City Productivity is a performance indicator for the wellbeing of a city. Cities offering a welcome climate for companies and organizations to establish a business within its limits are inducing wealth through the creation of jobs and tax income. Hence, offering favorite conditions to businesses to settle in a city is a key political and business practice for most cities. Collaboration between organizations and a city needs to be as smooth as possible, leaving out unnecessary steps in processes, reducing paperwork, allowing companies to become productive as soon as circumstances allow. Increasingly cities are moving responsibilities to comply with city regulations to third parties or the business communities – the trend of self regulation.

Additionally, the 'educational climate' of a city pretty much determines whether a city is productive: only an educated workforce is the basis of a sound labor market.
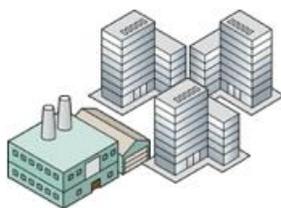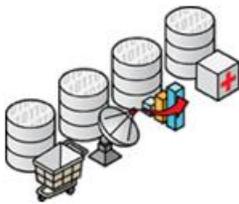
Oracle's Smart City Platform allows cities to be 'open for business', offering an open infrastructure for automated integration between processes of cities and businesses. Business-to-business collaboration is expedited using the integration capabilities of the platform, the city acting as the business-hub. Self service portals invite businesses to skip the paperwork when applying for licenses and permits and electronic data exchange speeds up information processing. Self regulation of business practices is facilitated by business intelligence

instruments that allow cities to streamline targeted inspections and enforcement. Cities procuring from businesses will use electronic procurement applications to get the best contractors while reducing formalities.

Plugging in standard applications, also those developed in the public domain, is possible on the standards based open Oracle City Platform – which would act as an Apps Store, servicing and consuming services from within and outside the city organization.
City officials responsible to interact with businesses are scheduled and dispatched from the City Operation center and increase their productivity – and the business productivity alike – using mobile devices, again reducing the amount of paperwork while being responsive at the same time.

City Infrastructure

Invisible to the regular citizens, yet undisputable key to the operation of a city is the City Infrastructure. Information technology is at the heart of the operations all city departments and stretches out to the city's community in many ways. With more processes, constituents, applications, devices depending on it, the City Infrastructure needs to be reliable, scalable, performant, secure and highly available. This is true for all elements of the infrastructure: the data stores, the network, the servers, the storage and its applications.

Within Oracle's Smart City Platform the City Infrastructure is a platform on itself. It is the foundation for all other elements of the City Platform, providing the multi-media information management capabilities, the internal and external connectivity between processes and people, the security of data and applications and the means to search, match, access and analyze information.

Big Data

Oracle's Smart City Platform is the host for Big Data: managing large sets of structured data; processing and dealing with multi-media content like images, video and audio; streaming traffic from social networks; supporting geographical and spatial data tagging; mastering data amongst multiple data providers and consumers; providing sophisticated searching and matching functionality. Cities following an Open Data policy, allowing multiple applications and processes to use public data, will find these Big Data qualities of

RheinlandPfalz
LANDESAMT FÜR UMWELT,
WASSERWIRTSCHAFT UND
GEWERBEAUFSICHT

Information and maintenance system that supports more than 30,000 geographical measurement points to use geodata for environmental management of the region's water system.
"Our new measuring-point solution based on Oracle Application Express and Oracle MAPS (part of OracleFusion Middleware MapViewer) is much easier to administer, saves time through automation, and improves data quality."
Salvador Gámez, Head of Division for Specialist Data Processing, Water Management,
Rhineland-Palatinate State Office for the Environment, Water Management, and Business

Oracle relevant. Oracle's Big Data capabilities allow this huge volume of data to be turned into nuggets of useful information for city administrators and citizens to consume.

Cost Control

Austerity measures are forcing cities to reduce the total cost of ownership of their information technology infrastructure. Sharing infrastructures for multiple purposes, for example by virtualization of hardware, helps to reduce the TCO, just like optimizing the use of infrastructure by implementing standard software solutions.
Oracle's Smart City Platform is deployed on pre-configured, engineered-to-work-together equipment, dramatically reducing administrative and maintenance costs.

Event Processing

Managing the interaction between processes, networks, devices and applications requires an event driven architecture and event driven process management. Real-time interpretation of events and data streams, immediate analysis and decision taking on incoming alerts is essential for a networked city. Oracle's Smart City Platform offers the middleware to implement business processes to become the core carrier for messages, feedback, commands etc.

Sustainable City

Maybe the ultimate goal of any city is to ensure residents regard their city being livable according to their own standards. Standards are defined in dimensions like the access to fundamental facilities like water and energy, the quality of housing, the choices in mobility, the availability of city services, the city climate, the available jobs and businesses. To any citizen, quality of life is the sum of one or more of these indicators and determining, influencing every step a citizen makes in a city, day by day.
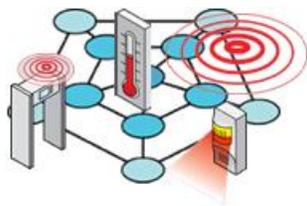
The arrival of affordable technology – be it the communications infrastructure, the access to internet, the availability of mobile smart devices – is causing a shift from a centrally controlled city to a more decentralized or even deregulated city. Or, vice versa, the same technology is helping cities to take on more responsibilities in those areas where

citizens were left behind. Around the world we see the contrast between these two trends diminishing as cities and citizens are recognizing their joint responsibilities and become partners in improving the quality of life of citizens.

Oracle's Smart City Platform provides the means to create a *Sentient City Infrastructure* capturing the feedback from city networks and controlling the services provided to citizens. The quality of city life shows in many forms. Some dimensions can be measured, like the quality of water, the strength of the power grid, the pollution of air, the flow of traffic. Some qualities are harder to sense, it requires more intelligence to draw conclusions on the feelings of citizens about the city climate, citizens' interpretation of public safety, the need to improve city parks or the success of urban planning and design.

Dongcheng District, Beijing, China
Migrates to an electronic city management platform
The Beijing Dongcheng District Government, together with Oracle, built a City Grid Management System that featured a wireless information Service, a geographical code enquiry system, data management, and safety management capabilities.
The system uses wireless functions to transmit data – with no reliance on extensive cabling. Accurate city planning is supported by a high-end geographic information system with Oracle Spatial.

Analyzing Signals

Oracle's Smart City Platform offers the means to gather all types of feedback from citizens, business and measuring devices alike. Data, measurements, messages and events are captured from high tech networks of devices, retrieved from smart grids, taken in by both traditional instruments and innovative sensors. The platform can intelligently combine these hard facts with softer information retrieved from social networks. Real-time interpretation of these flows of data and transactions allows cities to immediate take control of what influences the sustainability of a city. Community complaints on the low quality of the electric grid can be checked real-time by measuring the facts streaming in from the sensors in the same grid, allowing to precisely point causes of failure and potentially even solving the problems remotely.
Filtering of the large stream of data and further real-time analysis of patterns enable cities to respond intelligently: prioritized, targeted, using the facts 'with sense' and reducing unnecessary costs responding to less relevant signals.

Open Data

The collective set of information available to a city government and its residents, whether gathered through internal city processes or by collating external feedback and measurements, represents a huge potential for cities and citizens to improve the quality of life of citizens. When applied in the right way, information can be used in more ways than

illuminetsys, a specialist in lighting control systems, demonstrated that automatic light control based on traffic participant recognition and classification reduced electricity consumption by 85%, while the quality of lighting (intensity and homogeneity) improved.

initially defined. Opening data sources to a wider audience – within a city's organization and to the community - will release the creativity that allows people and organizations to find new solutions to challenges that were not solved before. The 'wisdom of the crowd', where citizen are provided access to the right information sources, can take a Sustainable City to a higher level. Oracle's Smart City Platform forms the open standards based basis for this Open Data infrastructure – providing the means to give access to a selection of the city's information sources, protecting what is necessary and releasing what support the public cause. Open to a new era of applications and solutions developed in open communities.

Internet of Things

The abundance of devices connected to the internet represents a formidable source of feedback to a city and its residents – that is, when cities are connected to these sources in an adequate way. Oracle's Smart City Platform provides the connectivity to this, even unpredictable range of, Internet of Things. The integration technology provided with the platform will connect the variety of city networks into a network of networks. Wireless internet networks, hardwired communication networks, water networks, electric grids – all are examples of already available networks that, when combined, represent a unprecedented source of information. Real-time filtering, interception, interpretation and routing of signals coming from these sources are required to make 'sense' out of this. Oracle's Smart City Platform provides the intelligent means to streamline this.

Sensor Intelligence

Oracle's Smart City Platform stretches out to the fine granular devices in the city network. Embedded technology in sensors and intelligent devices, applications and application servers in measuring equipment, often based on open Java standards, using RFID or other mechanisms to sense, are available.
Distributed data management and servers, as well as applications allow for load balanced processing of signals across the grid of networks, increasing the availability of the *Citywide Nervous System*. In-memory processing, filtering and dissemination of data from within the network guarantee the fastest route to intelligent use of device feedback.

Conclusion

The global urbanization of the last century led to a large disconnect between the city government, policy makers, administrative officers and the inhabitants of a city. The trend however is towards a turnaround of this disconnect into a more collaborative city-to-citizen relationship. Cities are asking citizens to take more responsibility, citizens are no longer prepared to be in the hands of anonymous officials but want to be the center of attention, and businesses are most productive when they are treated as entrepreneurs contributing to the success of a city.
Technology that supports the deep specialization of city operations is now at the heart of the swing back towards balanced sharing of responsibilities. Many cities are optimizing their operations to become more citizen oriented, processes are simplified and shortened using advanced technology, facilities are shared to reduce costs. Citizens exploit the improved access to technology to create new solutions addressing their needs immediately without intervention of city services.
Connectivity is the key to a *Citywide Nervous System* infrastructure, collecting and sharing feedback from all possible sources the basis, measuring and sensing the actual quality of life in a city the key driver for actual change.

Oracle's Smart City Platform provides all ingredients to establish a *Sentient City Network,* allowing cities to become livable to its residents. Starting with traditional City Service and City Operations, the Citizen Empowerment and Sustainable City capabilities of the platform are at the basis of further innovation and ignite the collaborative creativity of both cities and residents. The City Platform supports the joint responsibility held by citizens and governments to shape the city of the future today.

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Oracle's Smart City Platform –
Creating a Citywide Nervous System, v2.0
November 5, 2013
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