Enabling smart, safe and sustainable cities
Nokia’s vision for smart city success: the 6 s’s

We believe that cities looking to thrive must get smart, safe and sustainable by investing in shared, secure and scalable infrastructure, the 6 s’s strategy. This vision is achieved through a holistic and horizontally layered framework that utilizes advanced IP and optical transport, fixed and mobile broadband access, cloud technology, and the internet of things (IoT), enabling the human possibilities for present and future generations.
<table>
<thead>
<tr>
<th>Earth’s land taken up by cities</th>
<th>Global population living in cities</th>
<th>Global population living in cities by 2050</th>
<th>Mega-cities of at least 10 million inhabitants by 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>55%</td>
<td>70%</td>
<td>41</td>
</tr>
<tr>
<td>Global energy use and carbon emissions from cities</td>
<td>Estimated cost of air pollution in OECD countries due to road transport emissions</td>
<td>Average crime rate when population of a city doubles</td>
<td>Global GDP growth generated by 600 largest cities by 2025</td>
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<tr>
<td>76%</td>
<td>$1 trillion</td>
<td>+15%</td>
<td>65%</td>
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The challenges
Cities face increasing challenges:

• Urbanization: Urban areas of the world are expected to absorb all the population growth over the next four decades.

• Environmental impact: The world has realized the need for environmental protection. The recent COP21 agreement signed by over 190 countries introduces legal commitments.

• Economic pressure: Cities have to cope with financial crisis; doing more with less and increased competition. They must find sustainable financial models, optimize infrastructure and offer smarter services.

• Social responsibility: Authorities need to take care of citizens’ wealth, security, privacy, and well-being. Urban communities should be inclusive, participatory, and social.

The opportunities
Cities have many opportunities to address these challenges and become “smart, safe and sustainable” where everyone and everything becomes connected through data from billions of sensors and devices everywhere. This vision is being enabled by breakthroughs in technology and finance.

• Our world is entering a new, ultra-connected age:
  – Broadband speed has tripled since 2012.
  – 2.5 trillion bytes of data created every day
  – 9.7 billion connected things will be used by smart cities by 2020.

• New technology platforms, including platform as a service (PaaS), software as a service (SaaS), and open APIs, will further enhance smart city services, citizen convenience and cost efficiencies.

• New available tools for ingesting, managing, storing and analyzing data, including cloud and AI are offering tremendous potential and innovation.

• Creative financing models, including public-private partnerships (PPP) and vendor financing, enable all smart city stakeholders to invest today in the technologies they require to compete and thrive in a global economy.

The results
Smart, safe and sustainable cities provide dynamic urban environments that improve quality of life and bolster economic growth in an eco-friendly and responsible manner.
Smart Safe Sustainable

Enabling smart, safe and sustainable cities
The centrality of data is a common theme across smart cities, the essential ingredient of city’s services. Data comes from many sources: the city’s agencies and operations, its citizens, from automated apps, from the Internet of Things – those physical devices, systems, vehicles, buildings and other items embedded with electronics, software, sensors and network connectivity to enable them to gather and exchange information. Some cities collect and use their own data and build their own applications. Others take a “publishing” approach, making data available for service providers, or they “curate” data provided by others via open portals or marketplaces.

Data can be classified under three main application areas – smart, safe and sustainable – to translate that vision into reality:

1. **Smart**: Improves the quality of life for citizens, bolstering innovation, social and economic development. This makes cities more attractive places in which to live, visit and do business.

2. **Safe**: Prevents or minimizes the risks of adverse events, including crime, accidents, environmental pollution and natural disasters.

3. **Sustainable**: Minimizes the environmental impact of operations, businesses and citizens. Selecting the right business model to fund, invest and cost-efficiently manage innovations.

This requires a shared, secure and scalable infrastructure:

4. **Shared**: To maximize synergies and minimize costs, city administration services share applications and data over a single IP infrastructure. Application and service providers have access to this “horizontal” city platform with common set of capabilities, and residents have ubiquitous and real-time access to applications, anytime and everywhere.

5. **Secure**: In a world where cybersecurity and data privacy are high on the governments’ and citizens’ agenda, endpoint and data protection, device management, authentication and authorization, traffic profiling and encryption are key points to address and implement.

6. **Scalable**: Smart city initiatives will start small, but grow fast, and scale big. As such, the time is now to prepare for a massive increase of sensor devices and applications, along with equivalent growth in data and network traffic. This can only be achieved through a city ICT infrastructure that is scalable by design.
Enabling smart, safe and sustainable cities

**Smart**
- Smart public services
- Smart infrastructure & buildings
- Smart healthcare & education

**Safe**
- Smart surveillance
- Smart monitoring
- Smart emergency services

**Sustainable**
- Smart energy
- Smart mobility & transportation
- Business models

City applications

City IoT platform

City cloud

City shared network

City-wide access

Devices & sensors

Smart City Infrastructure

**Shared**

**Secure**

**Scalable**
Municipal services are often silo-based. This architecture is costly, time-consuming and often neglects interoperability, security, availability, scalability and interdependence. To get the most from your smart city components, you will require a holistic, horizontally layered architecture including the technological “building blocks,” which enable you to rapidly create, deploy, integrate and manage your smart, city applications. This framework is based on leading Nokia products, services and solutions from a large smart city ecosystem, allowing shared, secure and scalable operations support. It encompasses:

- City-wide connectivity to provide both fixed and mobile access to connect all people, devices, machines and sensors
- A city-wide network, a single converged IP-based network for operational efficiency and lower costs
- A city cloud with a virtualized software-defined network to flexibly connect sites, people and applications quickly and securely

- A city IoT platform to manage sensors and devices and collect, analyze and expose data to third-party applications
- City applications developed within an innovation ecosystem of trusted partners
Implementation strategy: three routes to the smart city

Because each city is unique, implementations never look the same. Machina Research, which developed the Nokia-sponsored report, The Smart City Playbook, found that cities typically take one of the following routes to becoming smart, safe and sustainable:

• **Anchor:** Deploy one or more standalone applications based on current needs, resources and priorities, and then consider how to expand further into the smart domain. This offers a shorter path to deployment and clear ROI but can make it hard to integrate applications in future.

• **Platform:** Focus on building the network platform before adopting any specific applications or services. This allows for synergies between applications and provides flexibility for future deployments, but can lead to the risk of vendor lock-in and significant upfront investment.

• **Beta:** Experiment with multiple applications without a finalized plan for operational deployment. This approach can enable easier access to funding for trials and research, and facilitate greater involvement from start-ups and small, innovative companies.
Customer testimonials

“The development of this high-speed communications infrastructure will further reduce the cost of broadband services through enabling open access to the City’s broadband infrastructure for commercial service providers.”

Leon Van Wyk, Telecoms Manager, City of Cape Town

“There was an opportunity to define the vision and architecture that we believed was needed for the City, that will allow us to evolve over the next decade, [...] The beauty of this design, as we move into the future, is that it’s going to be a single architecture that we can leverage and manage together, [...] The collective knowledge and support within the Nokia organization was quite significant.”

Doug Hodgson, CIO City of Calgary

“You don’t see many mid-sized cities that have the kind of activity that we have right now in Chattanooga. What the Gig did was change the idea of what our city could be. Mid-sized southern cities are not generally seen as being ahead of the technological curve, the Gig changed that. We now have people coming in looking to us as a leader.”

Andy Berke, Mayor of Chattanooga

“Dubai has historically pioneered in providing exceptional quality of life, and an unparalleled business and technology innovation environment, inspired by His Highness Sheikh Mohammed bin Rashid Al Maktoum’s vision to make Dubai the happiest city on earth. [...] Nokia’s eagerness to adapt to our new, stringent security requirements gives us the confidence to make our city the safest and smartest in the world.”

Yousif Al Ali, CTO of Nedaa (Dubai Government security networks provider)
Smart city use cases

- Smart administrations
- Smart buildings and assets
- Smart public spaces
- Smart lighting
- Connected bus shelter
- Smart parking management
- Smart fleet management
- Connected cars
- Unmanned aerial vehicle (UAV) traffic management
- Real-time traffic/crowd monitoring and analytics
- People/child tracking
- Smart healthcare
- Smart metering
- Smart waste management
- Water leakage detection and prevention
- Environmental monitoring
- Smart tourism
Sample use cases

Smart lighting

Smart lighting can save over 60 percent on energy costs in some cities. Smart light poles are a platform for local connectivity services, innovative use cases and new business models that can save costs and drive revenue.

Application opportunities and challenges
- Adjust street lighting for improving security and saving energy.
- Monitor energy, maintain dynamic control based on need; receive automatic flagging of malfunctions.
- Co-locate small cells/MEC equipment for other use cases on light poles, e.g. providing local communication, information and content services.
- Deploy visual light communication (VLC) for multiple uses.

Solution highlights
- Nokia’s solution is based upon wireless connectivity, the IMPACT IoT platform, complemented by partner components, such as poles and lights, sensors and local connectivity options.

Real-time traffic/crowd monitoring and analytics

Street cameras and CCTV systems are continuously capturing video streams. Much of this is not yet analyzed or archived, but that can change to provide valuable data.

Application opportunities and challenges
- Receive video-based monitoring and analysis with automated alerts.
- Automatically detect unlicensed structures, obstructions, public activity, etc.
- Detect and direct vehicles, people, and situations.
- Monitor and measure crowd congregations at public places, detecting traffic accidents, demonstrations, flash mobs and other disruptive activities.

Solution highlights
- Nokia’s solution is based upon the IMPACT IoT platform, and video cameras with real-time video analytics at the edge.
Connected bus shelter

Cities are discovering ways to turn a bus/metro shelter from a capital cost to a revenue-generating asset by providing concessions to (media-) agencies operating the transit shelters and in turn these agencies are entitled to use some of the shelter surface for advertising, enhanced services to passengers and monetize the data collected while obeying privacy laws.

Application opportunities and challenges
• Equip shelters with small cells/MEC equipment to provide local broadband connectivity and services.
• Provide relevant and real-time information to transit users, including route arrival times and maps, weather information and more.
• Provide digital advertising, video monitoring for security, tourism information and sponsored content for increased revenue.
• Offer business opportunities for city governments, transportation companies, and application and content providers.

Solution highlights
• A connected bus shelter market trial has been carried out by Nokia and our IoT Community ecosystem partners in Auckland, NZ.
• Amsterdam and Paris already have bus shelters equipped with small cells.

Proposed business model: Lease or rent space in or on roof of shelter in order to gain ongoing revenue. Examples include lease of space for sensors, licensed antenna or small cell, WIFI access points.

Water leakage detection and prevention

An estimated 2.1 trillion gallons of clean, treated water are lost every year to leaks in water infrastructure across the US. Wireless sensor networks can monitor water flows and provide significant savings of water loss.

Application opportunities and challenges
• Detect and localize water leakage for immediate mitigation.
• Control pressure and optimize water pumping throughout the distribution system; predictive maintenance of pipes, pumps, etc.
• Monitor water quality to ensure safety.
• Enable smart water metering, by extending the scope of the wireless signal to locations where the water pipe enters in the basement of buildings.

Solution highlights
• Nokia showcased an EC-GSM based leakage detection scenario with chipset partners Intel and Mediatek at MWC 2016.
• Orange and Nokia ran a live EC-GSM-IoT pilot in 2016.
Smart parking

Conventional parking costs time, fuel and pollution due to drivers looking for inter-city parking spaces. Smart parking solutions can help to steer drivers to most convenient parking spaces, and enable one-click parking payment and demand-based pricing.

Application opportunities and challenges
• Deploy in conjunction with a broader smart city opportunity.
• Detect free parking spaces within selected target geography via sensors and cameras.
• Direct drivers to most convenient/selected parking spaces.
• Offer one-click payment and demand-based dynamic pricing.

Solution highlights
• Nokia’s solution is based upon wireless connectivity, the IMPACT IoT platform, complemented by partner components, such as sensors, cameras, end-user apps, toll systems, etc.

Smart public spaces

Communication networks, video services and IoT technologies can significantly improve the experience, safety, wellness and utility in public spaces, such as stadiums, event venues, malls, airports and universities.

Application opportunities and challenges
• Provide high-density network and in-building coverage, with high throughput and low latency.
• Enable new services for mass event participants, including people finder, heat maps, user navigation, sharing of real-time videos, etc.
• Enhance the capabilities of mass event organizers, incl. venue security, crowd management, object tracking, etc.
• Monetize crowd and public data and insights to third parties.

Solution highlights
• Nokia solutions based upon small cells with Wi-Fi, NIB, Mobile Edge computing, AirFrame Server, IMPACT IoT platform, services and partner components. Various customer references in sport stadiums, concert halls and other venues.
Nokia’s commitment to smart cities

High-value IoT and smart city projects are very complex, and require expertise in many different fields to succeed. They get to market faster when they are built through the joint efforts of global leaders and innovators in infrastructure, devices, applications and content. Working with an open ecosystem of trusted partners – including technology vendors, application developers, service providers, system integrators, utility companies, research institutions and others – Nokia continuously explores new smart solutions and services.

One example of this high-value collaboration is our partnership with Machina Research, through which we developed the *The Smart City Playbook* to provide strategic, real-world guidance for successful smart city development.

Another case in point is the ng Connect program, through which we have built an ecosystem that enables more than 300 member companies, including leading network, consumer electronics, applications, platforms and content providers. We work with these partners to develop standardization initiatives, solution concepts, end-to-end prototypes, business models and market trials that will unleash the full potential of the IoT and smart cities.

All of this means that Nokia is uniquely positioned to help governments, service providers and large enterprises deliver on the promise of smart cities. We provide secure connectivity, and deploy scalable IoT services—serving the needs of the CIO and the city agencies, while addressing the smart aspirations of the city council.

These essential elements, combined with business modeling expertise from Nokia Bell Labs, are the foundation of our commitment to enabling human possibilities through the six s’s: building shared, secure and scalable infrastructures that enable the human possibilities of smart, safe and sustainable cities.
Nokia is a global leader in the technologies that connect people and things. Powered by the innovation of Bell Labs and Nokia Technologies, we are at the forefront of creating and licensing the technologies that are increasingly at the heart of our connected lives.

With state-of-the-art software, hardware and services for any type of network, Nokia is uniquely positioned to help communication service providers, governments, and large enterprises deliver on the promise of 5G, the Cloud and the Internet of Things.

We’re financially strong, with the resources, capabilities, and ambition to lead our industry. Our 106,000 people serve the world’s most successful telecom operators, service providers, and enterprises, as well as governments and citizens around the globe.

With a yearly R&D spend of €4.5 billion in 2015, our more than 40,000 research scientists and engineers invent and deliver the technologies shaping the future of the connected world.

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