Whitepaper

Smart Cities and Communities Infrastructure

This whitepaper is made from extensive research and collected knowledge from leading experts within the area of IoT and Smart City.

The whitepaper examine emerging and growing trends in smart cities, highlighting progress so far within smart cities and communities infrastructure and future potential, as well as spotlighting challenges, roles and key drivers within the field of more technology-driven, efficient and sustainable cities.

It is our expectation that we with this whitepaper can provide fundemental inspiration and insights to the Smart Cities and Communities Infrastructure.

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Table of Contents

Preface

Today, 55% of the world's population lives in urban areas. This number is estimated to increase to nearly 66% by 2050, according to the UN Department of Economics and Social Affairs. The global challenges of rapid urban population growth, climate change, and pressure on resources, infrastructure and the provision of services can all start to be addressed at the city scale.

Over the last two decades, the concept of Smart Cities and Communities has become a focus of public attention as an answer to emerging needs and challenges of urban areas. Fueled by the potential of ICT (information and communication technologies), cities around the world are adopting a variety of strategies to improve economic competitiveness, sustainability, social and capital attractiveness and most importantly the quality of life for everyone.

The 'Smart Cities and Communities' concept has emerged to represent technology-driven urban benefits and the products and services that deliver them. Smart cities are highly dependent on a well-functioning digital infrastructure. Smart cities key goals are to focus on people where environmental, social, and economic sustainability is a must to keep pace with this rapid expansion in our city's resources.

What does the digital infrastructure consist of and what are the challenges that the infrastructure suppliers and users are facing? With this project FORCE Technology and Smart Cities and Communities cluster will establish a national coordination group which will define what a Smart Cities and Communities infrastructure should consist of and map the possibilities and challenges for the adoption.

In Denmark, Smart Cities and Communities projects have been carried out in many towns and cities, usually by the municipal government in collaboration with business and academia. For governments, the Smart Cities and Communities is attractive because it represents an opportunity to improve its towns and cities and to access a large global market. Most of the governments are ramping up their efforts to remove barriers that are preventing regional and municipal governments from applying Smart Cities and Communities solutions and local businesses from developing and exporting related products and services. There is a recognition that government action is required to give the country a head-start in the race to attract international companies, talent and investment.

Smart Cities and Communities is focused primarily on issues of technology and its integration of networked devices into the built environment of the city. The use of big data and algorithms, and the construction of smart infrastructure are all centred in our conception of what it means for a city to be smart. Denmark is at the forefront of the accelerating global Smart City agenda, and to follow the acceleration, Denmark must keep investing in digitization, urban development, design and sustainability.

Denmark is really good when it comes to the development of the digital society. With several key initiatives, we have laid the foundations for a cohesive public sector. We already have the CPR number system which is linked to most of digital eco-system today, which can be further extended to future digital infrastructure. The digital opportunities and especially the opportunities and possibilities with the Internet of Things and sensor-based data have evolved in recent years. It opens up for even more ways to use real-time data and governance "in the present" for the support and development of society. But it also means we face new, fundamental challenges. Data is to a large extent a global development area where we as a nation - and as a small, open economy - cannot just build everything ourselves.

Danish companies and public service providers are increasingly using data and digital technology to deliver services and to respond to the Danish citizens' needs. Denmark offers a flexible environment for businesses with Smart Cities and Communities products and services to establish and grow with a sizeable market to tap into. The Smart Cities and Communities market has potential to grow across the following sectors: smart energy, smart transport, smart healthcare (including assisted living), smart infrastructure (combining waste and water sectors), smart governance, smart security, and smart buildings.

1. Introduction

1.1 Why do we need smart cities and is there a need for smarter cities?

First, a rapid urbanization process is taking place on a global scale. Some of the prominent researchers like Garner and UN Department of Economics and Social Affairs forecasted following:

- Every week, one million people move from rural areas into urban areas, and close to 4 billion of the world's current population of 7 billion now live in urban areas. This number is expected to increase to 6 billion people by 2050.
- Cities around the world have become hubs for the global economy. By 2025, the 600 biggest cities in the world are projected to account for 60% of global GDP.
- Growing economic activity has historically gone hand in hand with increased greenhouse gas emissions, cities have become major contributors to the climate problem which the world is currently facing.
- Around 70% of global CO2 emissions derive from cities, which are also facilitating unprecedented consumption levels among their inhabitants. This means that cities consume as much as 80% of total global energy production.

On the one hand, the world's growing cities can easily become chaotic and disordered places which contribute further to climate change and social inequality. However, to make the growing importance of the world's cities a positive force in the quest to develop a sustainable living, smart and innovative solutions for cities are needed. The concept of the 'Smart Cities and Communities' has been developed as a natural response to the process of urbanization, the economic importance of cities, and the increasing demand for sustainable living.

1.2 What are Smart Cities and Communities?

Smart Cities and Communities adopt innovative technologies capable of improving the lives of its citizens. It also means empowering citizens to improve their lives through better access to data and public services. This might include:

- Energy-efficient systems that reduce energy use.
- Intelligent transport systems that enable citizens to travel more efficiently; be that in private vehicles or using public transport, or new communication technologies that improve public safety and emergency response services.
- Connected applications put real-time, transparent information into the hands of users to help them make better choices.
- These tools can save lives, prevent crime, and reduce the disease burden. They can save time, reduce waste, and even help boost social connectedness. When cities function more efficiently, they also become more productive places to do business.

The possibilities are endless. The reality is that smart cities encompass all these things and more – broadly speaking, smart cities are those that:

- Adopt and promote innovative technology, processes and business models.
- Use data to be more efficient and transparent.
- Increase citizen engagement to improve the prosperity and sustainability of cities.

2. Smart Cities and Communities Infrastructure

2.1 Smart Cities and Communities Infrastructure Group

FORCE Technology and Smart City Cluster Denmark have created a discussion forum concerning the overall challenges for smart cities. The “Smart Cities and Communities infrastructure” group have identified key challenges and opportunities in each sector. The idea is to bring together different individuals to address how citizen-centric, business-centric applications can improve the lives of our citizens and businesses.

The group has also identified challenges to achieve overall objectives. These challenges appear to be both technical (security, interoperability, privacy) and non-technical (financial, governance, political). The main focus has been on the technical and organizational infrastructures with a primary focus on data collection, sharing and value creation for the Smart Cities and Communities. This includes but is not limited to:

- IoT platforms, communication networks and sensors.
- IT platforms for operations in the municipalities - excluding government technology systems.
- Open data/sharing and data exchange systems.
- Connectivity and Inter-operability of systems.
- Cybersecurity systems, processes and incidence response teams.
- Innovation, competence and funding infrastructure.
- Citizen engagement platforms.
- Physical infrastructures such as: Roads, public transportation, water supply, energy (gas, electricity, district heating) supply, lighting, waste and wastewater, buildings and city spaces, crime detection, Kiosk based information systems, Street lights.
- Space based infrastructure for navigation and earth observations.

FORCE Technology is also an active member of the Smart City Cluster Denmark which is identifying Smart City challenges and themes that go across the four national clusters within Building & Construction, Digital Technologies, Energy and Environmental Technology.

2.2 Who will lead Smart Cities Infrastructure?

The digital technologies deployed help to address environmental, economic and financial challenges. Businesses and entrepreneurs in the Smart Cities and Communities sector can play an important role in helping to achieve these priorities. They benefit from the Danish innovation ecosystem, which includes:

- Municipalities
- Government
- SMEs
- Top digital practitioners
- Visionary leadership
- Danish agencies
- Business support and investor networks
- World-class research and leaders in education

2.3 Key roles in the Smart Cities and Communities Infrastructure

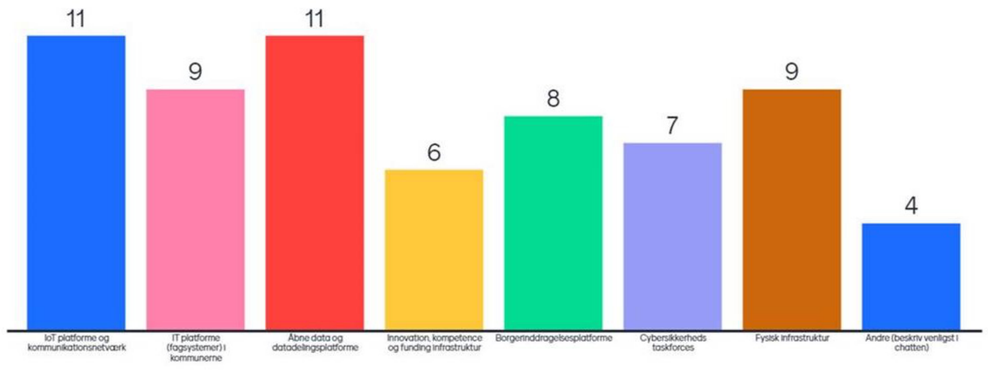
National Clusters
- Energy Cluster Denmark
- Inno-MT
- DigitalLead
- Bygge & Anlæg klyngen
- … and many more

Municipalities
- Copenhagen Municipality
- Odense Municipality
- Aarhus Municipality
- … and all the other 95 municipalities in Denmark

Knowledge Institutions
- Aalborg University
- Aarhus University
- DTU
- GTS Institutes
  - FORCE Technology
  - Alexandra Institute
  - Bioneer
  - DBI
  - DFM
  - DHI
  - DTI – Danish Technological Institute
- University of Copenhagen
- Nordic IoT Centre
- … and many more.

2.4 Smart Cities and Communities

Smart cities is defined by ITU-T as “Effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens”. Infrastructure is defined as a “society’s physical and organizational facilities for transport and communication, electricity and water supply grids and telephone connections, which are necessary for the societal operation”. However, in more modern understanding of infrastructure this also includes organizational infrastructure. Hence, when discussing smart city infrastructure it quickly evolves to all the facilities for supply, treatment, transport and organization of physical, digital and human systems. Therefore the challenge is to limit the scope of the current investigation, based on a poll to the participants in the discussion workshops facilitated in the project, the response was to focus on the less developed parts of the smart city infrastructure: The digital infrastructure, its relation to the organizations developing and using this infrastructure, and the coupling to the existing infrastructure. In addition to the items in the poll, the respondents also directed focus to space based infrastructure, cultural and political infrastructure, partnership creation infrastructure, and internal organization in the municipalities.



A Smart Cities and Communities infrastructure is predominantly composed of Information and Communication Technologies (ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges.

A big part of this ICT framework is essentially an intelligent network of connected objects and machines that transmit data using IoT and wireless technology. IoT applications receive, analyse, and manage data in real-time applications, e.g,:

- Connected traffic lights receive data from sensors and cars adjusting light cadence and timing to respond to real-time traffic, reducing road congestion.
- Connected cars can communicate with parking meters and electric vehicle (EV) charging docks and direct drivers to the nearest available spot.
- Smart garbage cans automatically send data to waste management companies and schedule pick-up as needed versus on a pre-planned schedule.
- Citizens’ smartphone becomes their mobile driver’s license and ID card with digital credentials, which speeds and simplifies access to the city and local government services.

FORCE Technology will together with different actors with the latest smart technologies help to optimize infrastructure, mobility, public services, and utilities and its benefits including the following:

- Help municipalities, enterprises, and citizens make better decisions that improve quality of life.
- Improve sustainability by pairing smart devices and data with a city’s physical infrastructure Reduce congestion and disruption of Denmark’s transport system.
- Improve urban air quality.
- Increase Danish wellbeing.
- Enable greater public participation in policy processes.
- Deliver economic benefits.
- Optimize public service delivery.

2.5 Smart Cities and Communities Applications

According to McKinsey Global institute, the following smart applications will be relevant for cities through 2025.

Security
• Predictive policing
• Real-time crime mapping
• Gunshot detection
• Smart surveillance
• Emergency response optimization
• Body-worn cameras
• Disaster early-warning systems
• Personal alert applications
• Home security systems
• Data-driven building inspections
• Crowd management
	Healthcare
	• Telemedicine
	• Remote patient monitoring
	• Lifestyle wearables
	• First aid alerts
	• Real-time air quality information
	• Infectious disease surveillance
	• Data-based public health interventions:
	  • Maternal and child health
	  • Sanitation and hygiene
	• Online care search and scheduling
	• Integrated patient flow management systems
		Mobility
		• Real-time public transit information
		• Digital public transit payment
		• Autonomous vehicles
		• Predictive maintenance of transportation infrastructure
		• Intelligent traffic signals
		• Congestion pricing
		• Demand-based micro-transit
		• Smart parking
		• E-hailing (private and pooled) Car sharing
		• Bike-sharing
		• Integrated multimodal information
		• Real-time road navigation
		• Parcel load pooling
		• Smart parcel lockers

Energy • Building automation systems • Home energy automation systems • Home energy consumption tracking • Smart streetlights • Dynamic electricity pricing • Distribution automation systems	**Water** • Water consumption tracking • Leakage detection and control • Smart irrigation • Water quality monitoring	**Waste** • Digital tracking and payment for waste disposal • Optimization of waste collection routes
Economic development and housing • Digital business licensing and permitting • Digital business tax filing • Online retraining programs • Personalized education • Local e-career centres • Digital land-use and building permitting • Open cadastral database • Peer-to-peer accommodation platforms	**Engagement and community** • Local civic engagement applications • Local connection platforms • Digital citizen services	

3. Key drivers for Smart Cities Infrastructure

At the core of Smart Cities is a strong infrastructure, seamlessly connected and coordinated. The key infrastructure pillars comprise of transportation, power, integrated utilities, urban development, resource management, and IT-based connectivity.

In Smart Cities and Communities, these basic infrastructure pillars form the foundation that supports building blocks like sustainability, inclusiveness and convergence. All aspects of daily life like education, health, connectivity, waste-management, basic utilities, upkeep and upgrade of civic services and functions are accessible through a single platform driven by IT.

Smart Cities integrate more efficiently the use of smart physical infrastructure, transport, energy, healthcare, information technology, environment, water, and waste management in a cohesive manner to underline progress, liveability, workability, and sustainability. It is driven by the major challenges of today, including climate change. Smart Cities also support a strong economic, social and cultural development by making efficient use of physical infrastructure.

As a very important, we have to consider the infrastructure in a “next practise” perspective rather than “best practise” perspective. The cities that we build now will be inhabited by children, that are not yet born. We therefore have to consider trends such as the sharing economy, personalized products, predictive public-private services and a Human centric approach to create livable cities.

3.1 Service Planning and Delivery Systems

Computer simulation, modelling and visualization tools will be central to interpret and understand the mass of data generated by the Smart Cities and Communities, allowing the relevant public authorities to coordinate their services and interact with its residents and businesses. In particular, smartphone applications are already central to the Smart Cities and Communities. Many cities are already using and testing applications to allow citizens to report littering, anti-social behaviour etc. via cameras on their phones, with the relevant city authority sending back a message when the problem is resolved.

3.2 Smart Infrastructure

Smart infrastructure provides the foundation for all key themes related to a smart city, including smart: people, mobility, economy, living, governance, and environment, etc. The core characteristic that underlies most of these components is the connection and data generation, which is used intelligently to ensure optimal use of resources and improve the quality of life for the citizens. Cities must create the conditions for continuous development:

- Digital technologies are becoming increasingly important, urban infrastructures and buildings must be planned more efficiently and sustainably.
- CO2 emissions should be kept as low as possible by for example investing in electric cars and self-propelled vehicles.
- Intelligent technologies can be used to achieve an energy-efficient and environmentally friendly infrastructure.
- Smart lighting only light up when someone walks past them by setting brightness levels and tracking daily use to reduce the need for electrical power.

3.3 Pilot Purgatory

The Pilot purgatory is the challenge of new innovative solutions being tested in smaller scale but not being implemented in full scale operation. It may seem contradictory that something negative is a driver, but in essence. The infrastructure makes it easier to transition from pilot projects to full scale operation, as the investments in the infrastructure enables:

- Faster and cheaper development time.
- Simpler solutions as less components needs to be developed.
- demonstrates commitment from the municipality and the society.
- More mature organizations with mature digital operational processes.
- Easier transferability from one municipality to the next.

This means that the adopters of smart city technology can focus on the stakeholder and organizational aspects of the smart city solutions, rather than the many small technical challenges.

3.4 Smart Transport and Mobility Systems

Smart mobility is best described as approaches that reduce congestion and foster faster, greener and cheaper transportation options. Most smart mobility systems use data collected from a variety of sources about mobility patterns to help holistically optimizing traffic conditions. Smart mobility systems include mass transit systems as well as individual mobility systems that feature bicycle sharing, ride-sharing (or carpooling), vehicle sharing and, more recently, on-demand transportation.

Smart Cities and Communities transport infrastructure aims to optimize those journeys that take place within a city and minimize their carbon impact. Real-time city transport planning and coordination of buses, trains and traffic lights, complemented by live travel information sent to people's smartphones, supports a seamless passenger experience and minimizes disruption.

- Pavement integrated sensors send real-time updates of the traffic flow to a central traffic management platform which analyses the data and automatically adjusts traffic lights to the traffic situation within seconds.
- It uses historical data to predict where traffic can go – everything without human involvement.

3.5 Smart Parking

- Intelligent parking solutions identify when a vehicle has left the parking area.
- The sensors in the ground report via smartphone the driver, where they can find a free parking space.
- Others use vehicle feedback to tell precisely where the openings are and nudge awaiting cars towards the path of least resistance.
- Smart Parking exists and does not require complicated infrastructure and high investment to make it ideal for mid-size Smart Cities and Communities.

3.6 Smart Energy Management

Smart energy management systems use sensors, advanced meters, renewable energy sources, digital controls and analytic tools to automate, monitor and optimize energy distribution and usage. This becomes increasingly important in light of the green transition and electrification of our energy sources. Where a more dynamic pattern of consumers and producers create new challenges for the balance in the electrical grid. Such systems optimize grid operation and usage by balancing the needs of the different stakeholders involved (consumers, producers and providers).

There are several innovations in smart energy infrastructure, such as distributed renewable generation, microgrids, smart grid technologies, energy storage, automated demand response, virtual power plants and demand-side innovations such as electric vehicles and smart appliances.

Key to creating a step-change in the sustainability of cities is smarter grids. One of the biggest challenges for cities is its energy infrastructure. In addition to needing to revolutionize the way we produce and distribute energy to meet climate change targets, the pressures of growing city populations increase energy demand and the need for greater resilience from national electricity grids.

- Smart grids to manage peak energy demand to reduce the need to build more capacity through new power stations.
- Smart grids also incorporate distributed and micro renewable energy (solar PV, combined heat and power, wind turbines etc.) thereby supporting the transition to a lower-carbon energy mix.
- Smart grids require communication between users and suppliers of electricity meaning that energy transmission infrastructure (substations, gas pipes etc.) need to be improved to allow data to be captured and transmitted.
- Smart grids also require smart appliances and smart citizens using those appliances to allow for automated systems to regulate energy demand.

3.7 Waste Reduction, Reuse, and Recycling

Smart waste management systems reduce waste and categorize waste types at the source and develop methods for proper handling of waste. Primary benefits are in improving the efficiency of waste collection, pick up, separation, reuse and recycling. A primary inefficiency of waste management is the inability to predict when waste is to be picked up; trucks are often sent to collect waste when bins are not full. This can be solved by sensors detecting when a certain threshold is reached. Optimizing the efficiency of waste collection reduce operational costs and fuel consumption of the trucks based on smarter route planning. Also, it helps to better address the environmental issues associated with inefficient waste collection. Sensors, connectivity and IoT offer ways to mitigate additional costs arising from such inefficiency. Smart waste management systems enable the movement of different kinds of waste to be monitored, and technology may be leveraged to better understand and manage the flow of waste from source to disposal.

Dealing with waste in Smart Cities and Communities will require, at a basic level, the facilities to collect, sort and recycle household and business waste. However, more innovative approaches include investing in a city-wide pipeline system for disposing of and sorting waste. An increasing number of 'up-cycling' projects that take waste streams and turn them into more valuable products (a good example is Freitag bags, made from truck tarps, used car safety belts and used inner tubing of bicycle tires). Businesses of this kind can be supported by the development of hub facilities where similar businesses can share costs and innovate together.

A particularly important aspect of this is the circular economy of the construction industry, where building materials can be reused in new buildings. This require digital models and traceability in our buildings such that we efficiently can reuse the materials that are used for our physical infrastructure

3.8 Smart buildings

Buildings provide essential shelter and structure while shaping the culture and physical character of the city. They are a crucial element of resilient infrastructures since they are the hubs that bring energy and water to consumers and provide destination points for most transportation systems.

Smart buildings use a complex combination of technologies and services that ensure energy efficiency, enhance security, and deliver better communal services. From wireless technologies to IoT devices, intelligent building systems help manage and control lighting, ventilation, heating, etc. the entire infrastructure of a modern building.Implementing smart building technologies results in improved security and health levels, as well as enhanced convenience of its residents.

3.9 Smarter City Planning

Collaborative data platforms can provide city planners and developers information on a wide range of city information to assist with smarter planning. Real-time information on traffic, land use, building typologies, demographic data, socioeconomic data, environmental data, infrastructure systems, and flood risk zones present new opportunities for much more intelligent spatial planning of city growth and infrastructure. Here, space based smart city infrastructure such as satellite positioning,and earth observations, is an integral part of modern city planning This is increasingly important in the context of sustainable urban development, which is increasingly resulting in mixed-use neighbourhoods. The process of making city planning "smarter" is an illustration of how technological advances can support and enhance existing management, policy and development processes.

When we plan a new city, we should not look 100 years back, but 100 years ahead and get an understanding of local context, e.g., culture, weather and mobility. Digital infrastructure helps to increase the understanding and the control of operations and optimize the use of limited resources in a city. One of the key value propositions of ICT in a smart city is the ability to capture and share information on time. If the information is provided in real-time and is accurate, cities can potentially take action before a problem begins to escalate.

Implementing smart city technologies often requires a robust, reliable and affordable broadband network, an efficient ecosystem for the Internet of Things and the capacity to make use of the big data generated.

4. What is the role of IoT in Smart Cities?

We are in the age of disruptive revolution, and IoT (Internet of Things) is one of the key technologies for a rapidly growing number of digital devices. IoT can facilitate connecting cities and managing infrastructure and public services. IoT infrastructure allows to capture meaningful data and further enable innovative business models with opportunities to monetize data by both municipal and private entities.

Connected technologies and IoT solutions for smart cities play important roles in transforming cities into smart cities. Implementing a smart city with IoT and connected technology helps to enhance the quality, performance, and interactivity of urban services, optimize resources, and reduce costs.

IoT offers new opportunities for smart cities challenges like using data to e.g., manage traffic, parking, water supplies, efficient lighting, waste garbage collection and disposal system, cut pollution, make better use of infrastructure, and keep citizens safe and clean.

4.1 What makes smart cities successful

In addition to people, dwellings, commerce, and traditional urban infrastructure, there are four essential elements necessary for thriving smart cities:

- Pervasive wireless connectivity
- Open data
- Trusted security
- Flexible monetization schemes

4.2 Wireless technology for smart cities

The first building block of any Smart Cities and Communities application is reliable, pervasive wireless connectivity.

While there is no one-size-fits-all, evolving Low Power Wide Area Network (LPWAN) technologies are well suited to most Smart Cities and Communities applications for their cost efficiency and ubiquity. These technologies include LTE Cat M, NB-IoT, LoRa, Bluetooth, and a few others that all contribute to the fabric of connected cities.

The advent of 5G technology is expected to be a watershed event that propels Smart Cities and Communities technology into the mainstream and accelerates new deployments.

4.3 Can smart cities be secured and trusted?

With the rise of digital solution using IoT, there is also increasing focus on the security, privacy and risks within smart cities, highlighting the threats relating to information security and challenges for smart city infrastructure in the management and processing of personal data. There are key questions which need to be considered when planning smart application:

- How to protect smart cities themselves from vulnerabilities?
- How can we defend against hacking, cyber-attacks, and data theft?
- How do we know the data they report is true and accurate?

4.4 Four core security objectives for Smart Cities and Communities solutions

All ecosystem partners - governments, enterprises, software providers, device manufacturers, energy providers, and network service providers - must do their part and integrate solutions that abide by four core security objectives:

- **Availability:** Without actionable, real-time, and reliable access to data, the Smart Cities and Communities can not thrive. How information is collected, distilled, and shared is critical, and security solutions must avoid adverse effects on availability.
- **Integrity:** Smart cities depend on reliable and accurate data. Measures must be taken to ensure that data is accurate and free from manipulation.

- **Confidentiality:** Some of the data collected, stored, and analysed will include sensitive details about consumers themselves. Steps must be taken to prevent unauthorized disclosure of sensitive information.
- **Accountability:** Users and developers of a system must be responsible for their actions. Their interactions with sensitive systems should be logged and associated with a specific user. These logs should be difficult to forge and have reliable integrity protection.

Using strong authentication and ID management, solutions we can integrate into the digital ecosystem in a way that will ensure that data is shared only with authorized parties to achieve above security core objectives.

4.5 Implementation challenges and obstacles

Actors and stakeholders in smart cities are facing the need to address a variety of challenges. This section provides a brief overview of these challenges identified in the scientific literature and communicated by stakeholders in cities around the globe.

Collaboration
- Weak collaborative engagement with external stakeholders.
- Weak collaborative engagement with internal stakeholders.
- The lack of an aligned vision of the city development with external and internal stakeholders.
- Issues concerning institutional resistance.

Financial
- Difficult to monetize on Smart Cities and Communities investments.
- Long term delay before reaching maturity/profitability.
- Lack of business model.

Governance
- Formulating the right governance structure given organizational barriers to supporting Smart Cities and Communities initiatives.
- Outdated rules and regulations hamper Smart Cities and Communities advancements.
- Legislation and policies.
- Trade-off between defining a holistic strategy and implementing small efficient solution.

Contextual
- Influence of geographical variables, the exportation of best practices may not occur easily as it requires focus on new stakeholder concerns.
- Difficult to extend local imitations to multi-city projects due to the localized character of initiatives.
- Lack of confidence or reluctance shown by citizens (lack of clarity around benefits).

Security
- Big Data in public clouds brings with its issues relating to security.
- Challenges of Smart Cities and Communities infrastructure integration.
- Outsourcing of power and control to private sector providers.

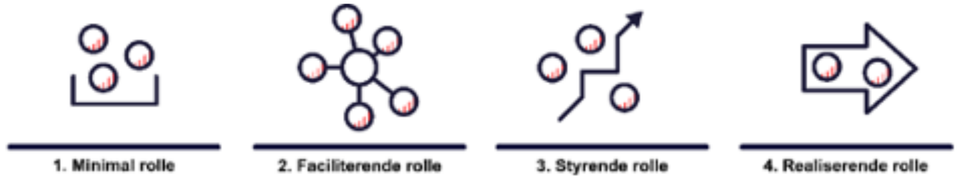
Interoperability
- Issues of service interoperability.
- Smart Cities and Communities infrastructure integration: system interoperability.
- Rapid developing technologies makes it difficult to plan, technology ages fast.

Privacy
- How to make sense and best use of such ‘big data’, while preserving citizens’ privacy and data security.
- Key issue relates to the privacy of the information monitored by sensors, and to the implications that the violation of this principle can have on citizens’ routines and habits in case of malicious or unintentional data exposure.
- Smart Cities and Communities technologies may encourage increased surveillance.

5. Collaboration and Business Models

5.1 Collaboration and Management Models

There are four typical collaboration and management models used by actors in Smart Cities and Communities infrastructure concerning the market.



Minimal role

The public sector takes a minimal role in relation to the definition of the project and actors. Here an advisor is used to provide support for the public actor when defining and framing the wanted smart city solution. This is used when a particularly complex solution needs to be developed or there are a lack of competencies within the application of the technology and an overview of potential suppliers.

Advantages: The public actor can focus on the value creation for citizens and society, and the process is run by experienced organizations within the field.
Disadvantages: It is essential to use the right advisor in relation to the process - at the same time this will naturally be a more expensive process during the development itself.

Facilitating role

The public sector takes a facilitating role in relation to the solution. Here the wanted solution is specifically defined, and the public sector must ensure that the market can partake and be a driving force in the development, including the identification of relevant actors and possible collaborations.

Advantages: Public actors has greater control over which solution is developed.
Disadvantages: A large network of the actor is required in relation to getting all potential actors interested in the project.

Governing role

At this 3rd step, the public sector is a proactive party that does not await the market, but both develop frameworks, initiates initiatives, and manages deliveries from the individual subcontractors in the market. The public sector plays a major role to play in ensuring concrete technical solutions that are also operationally stable in the longer term, of course in cooperation with the market.

Advantages: There is a relatively large control of the project, and it is possible to steer very concretely towards technical solutions. This also provides a lot of agility in changing the scope of the solution if needed.
Disadvantages: It becomes more difficult to keep value creation in mind as there are many decisions of a technical matter to be considered in this model

Realizing role

At this 4th step, the public sector is driving force in regard to platforms and components that they develop and drives themselves. The public sector has a realizing role in relation to the market, which, for example, is clear when developing and making a platform available to the market, but also by presenting defined and clear societal challenges that the market can then bid on.

Advantages: There is great control over the solution, also at the technical level, and as long as employees and knowledge also stay in the organization, there is control with the platform.
Disadvantages: Great technical skills are required from the public actor and it is very easy to be focused on the technologies rather than the value creation.

The roles are not static, and thus it is possible to change roles on an ongoing basis. Likewise, a public actor can apply elements from several different roles at the same time, thus helping to mitigate the challenges that might be in the individual roles. This can especially also be on several subject domains so that e.g. the minimal role is taken in relation to IoT sensors, but a controlling role is taken when creating a marketplace for data.

5.2 FORCE Technology's Role in Smart Cities

Due to the diversified background and expert knowledge, FORCE Technology is in the forefront of new technologies, and together with other key stakeholders in the Smart Cities and Communities Infrastructure, FORCE Technology has specialized in assisting municipalities and private organisations to choose the right collaboration model

FORCE Technology delivers services, research, innovation, knowledge and experts to help you take advantage of IoT – whether applied to customer-oriented business innovation, service innovation, product development, IoT troubleshooting or supply chain optimization.

FORCE Technology can guide you through all the steps in an IoT-based innovation process: From business modelling, product design and development to implementation, troubleshooting and technical analysis. In all parts of the process of exploiting IoT, FORCE Technology can partner up.

FORCE Technology help our customers transform their business, product or concept by enabling the full potential of IoT-driven solutions. At FORCE Technology's website, you can read about a wide range of customer challenges within IoT, data and digitalization, and how IoT-enabling and service-based innovation transformed the solutions. FORCE Technology also have experience in, and overview of standards that can be used to create and manage smart city developments.

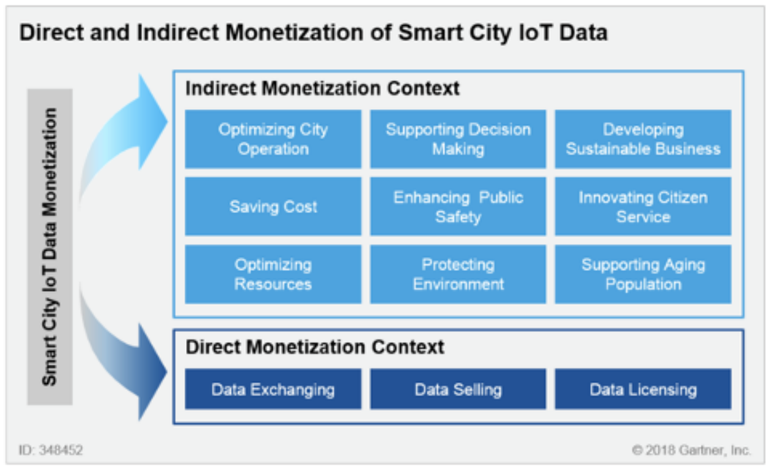
We do this in close collaboration with the IoT ecosystem, by facilitating collaboration through the nordic IoT centre.

For more information please visit:
https://forcetechnology.com/en/services/starting-with-iot
https://forcetechnology.com/en/iot-and-digital-technology
https://forcetechnology.com/en/cases/internet-of-things-iot-smart-city-planters
https://nordiciot.dk

5.3 Sustainable Business Models

Smart infrastructure projects require pooling public and private resources through creative financing and public-private partnership models. Policies, taxation and regulatory certainty also play an important role in this process. Governments need to address such issues to encourage the private sector to grow and innovate in new, thoughtful and increasingly strategic ways to invest in smart city projects. Strategically funding of smart city infrastructure and technology investments are critical to the realization of smarter cities. Smart city projects are often complex undertakings, involving long time horizons, multiple stakeholders and risks. In general, smart infrastructure is to benefits of people, and there are heavy investments which need to have a revenue model for business. So people must be made aware of the costs involved, the associated benefits and the prices they will be charged before the commencement of projects

There are numerous opportunities to extract value from IoT data ranging from operational efficiencies, revenue growth for local businesses (and thus increase of taxes collected), cost savings and expense avoidance. Direct monetization of data can be achieved via providing paid data access, exchanges and licensing. As per Gartner, we can have the following direct and indirect monetization using IOT.



Source: Gartner (March 2018)

5.4 Revenue Streams Model

Primary revenue streams for municipal governments are service fees, fines, taxes, and assets such as buildings and properties. Smart cities have attracted increasing international scientific and business attention and an enormous niche market is being evolved, which engages almost all business sectors. Being engaged in the smart city market is not free-of-charge and corresponding investments are extensive which in return creates value to its actors and new revenue streams model. Along with traditional business models, we can apply a new business model which focus on capturing and delivering value. In summary, smart cities with new digital technology have the following monetization opportunities and business models:

- Pay as you go: Application of different charge levels, according to content or service use.
- Product as a Service: Services that enable product payment per-use instead of ownership.
- Direct online marketing: Ad revenue sharing for contextual, personalized, connected smart ads across various exterior and interior screens.
- Asset Sharing Model: The cost of costly assets is shared across users.
- Use cases for pay-per-use revenue sharing: e.g., in-shuttle connectivity (Music / Jukebox, Skype Conferencing, Office, Xbox) while using public transport service.
- Paid mobility subscriptions for passengers
- Selling infotainment & passenger in-shuttle interactions data (personalized digital assistant usage, voice and gesture commands, gaming, UI interactions, purchases, browsing, productivity tools utilization) to advertising agencies or companies wanting to improve their service. E.g., Energy efficiency devices installed in buildings to monitor their energy consumption. The building manager benefits from this data but utilities or other aggregators can pay a hefty sum to receive aggregated data from thousands of buildings.

Conclusion

Smart technologies can provide solutions and applications for cities in many ways, e.g., by helping them save money, reduce carbon emissions and manage traffic flows. But the complexity of the agenda is hindering its progress. It involves a large number of stakeholders (local authorities, citizens, technology companies and academics) each having their own vision of what a Smart Cities and Communities should be; most of the debate gets bogged down on trying to understand what 'smart' means rather than focusing on how it can help cities meet their goals. Moreover, since the market for smart technologies is relatively new, it needs new business models and ways of working which are yet to be developed and implemented.

"SMART TECHNOLOGIES ARE ENABLERS - A truly SMART society is about people, vision and planning"

- Søren Hansen, Project Director Urban Development - Ramboll

Looking into the future, technology gives us many reasons to be optimistic about the improvements smart cities can make in citizens' lives. As we move towards an interconnected era that brings the cities and citizens closer together, cities across the world can also be more connected with each other, sharing best practices and key learnings. The inspiration and learnings smart cities provide can help us surpass the challenges presented by the increasing density in urban populations.

Investments in Smart Cities and Communities infrastructure will have big social and economic benefits, including:

- Enhanced urban mobility.
- Improved citizen and social care.
- Strengthened public safety by faster response times for ambulance, fire and police emergency services.
- Increased city and local business revenues.
- Cloud computing solution providers have developed technology frameworks to drive adoption by autonomous mobility providers and city infrastructure planners.
- 5G and new data streams from IoT infrastructure will enable innovative business models with opportunities to monetize data by both municipal and private entities.

Both large and small SMEs should:

- Work in partnership with cities on designing products and services that are financially viable and respond to local needs and challenges.
- Collaborate and work with relevant parties on identifying and building the business models needed to enable to take projects forward.

Key components of a Smart Cities and Communities:

- Inter-operability of systems.
- City wide connectivity.
- Security.

Recommendation

Smart cities and infrastructure designs need to be people centred. They should respond to the needs and challenges of specific urban systems and recognize the potential of technology as an enabler and at the same time understand its limitations.

- Focus on a future where technology delivers more than convenience. Use innovation to create emotional connections, strengthen relationships and expand social networks.
- Maximize data value — leaders must learn more than the basics of IoT and Cloud in order to build a better future, cities and happier citizens.
- Promoting collaborations in conducting pilot projects and benchmarking projects related to smart cities and infrastructure. Collaborations including municipalities, government departments, SMEs and Knowledge Institution.
- Some infrastructure data should be available to the private sector to maximize consumer value and drive commerce for local businesses.
- •Strike a balance between thoughtful utility and personalized targeting, to avoid uncomfortable feelings of privacy invasion.

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