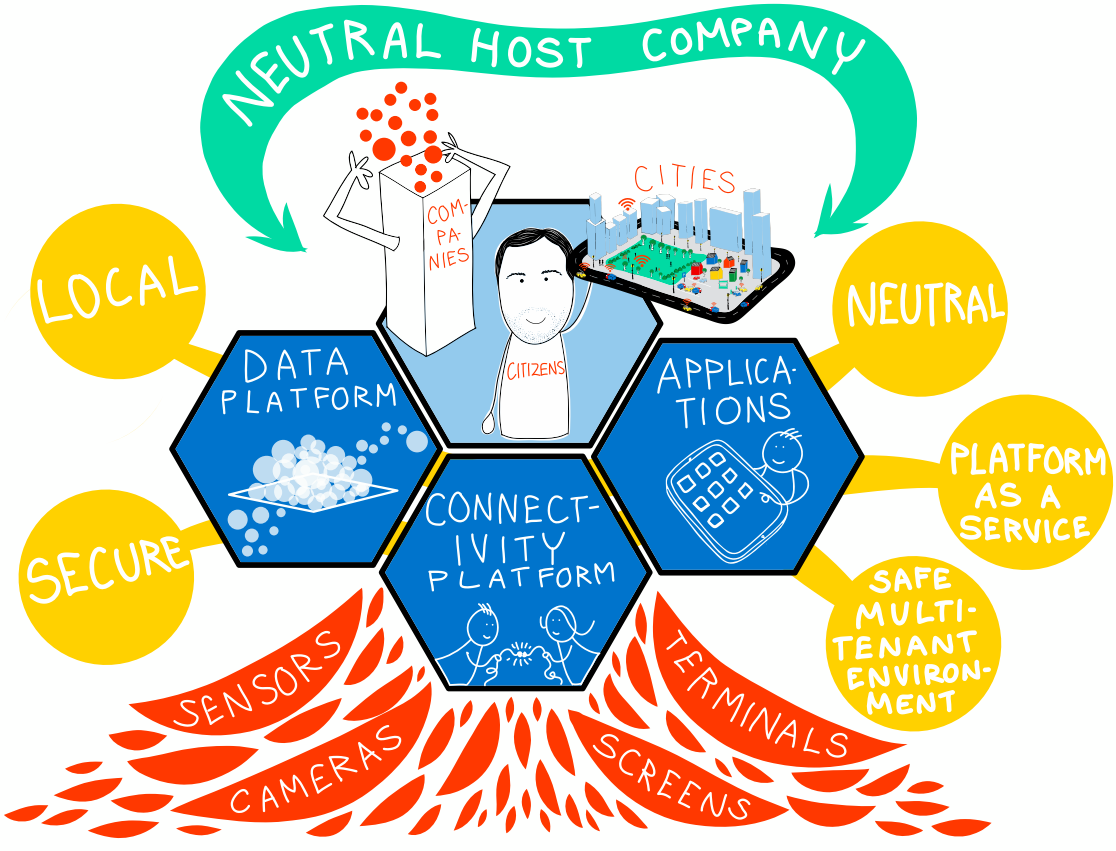
State-of-Art Understanding
Neutral Hosts in Smart Cities



Taina Tukiainen & Lauri Paavola (ed.)

Authors (in alphabetical order):
Anette Alén-Savikko [3]
Bu-Pasha Shakila [3]
Heinonen Petteri [1]
Himmanen Heidi [5]
Hämmäinen Heikki [1]
Karkkola Päivi [5]
Korpisaari Päivi [3]
Kotovirta Ville [2]
Lehtilä Sara [3]
Lähteenmäki Jarno [1]
Paavola Lauri [1]
Palviainen Marko [2]
Passi Sushant [1]
Rosales Ramírez Manuel [1]
Santos Figueiredo Sara [1]
Tukiainen Taina [1]
Vesala Juha [3]

Corresponding organisations:
[1] Aalto University
[2] VTT
[3] Helsinki University
[4] Nokia
[5] Traficom

This document has been created in the Neutral Host-project consortium, which consists of parties relating to a Business Finland-funded Joint Action. Parties are Aalto University, University of Helsinki, VTT, Nokia, Vaisala, Sitowise, Caruna, A-Insinöörit, LINK Design & Development, Vediafi, Agora Networks, Sensible 4, Traficom, City of Espoo and Spinverse.

Cover and Illustrations, Raquel Benmergui 2020

ISBN 978-952-64-9602-3 (PDF)

Unigrafia 2020

LuxTurrim5G ecosystem funded by the participating companies and Business Finland (Neutral Host grant number 1950/31/2019) (https://www.luxturrim5g.com/).

LuxTurrim 5G

TABLE OF CONTENTS

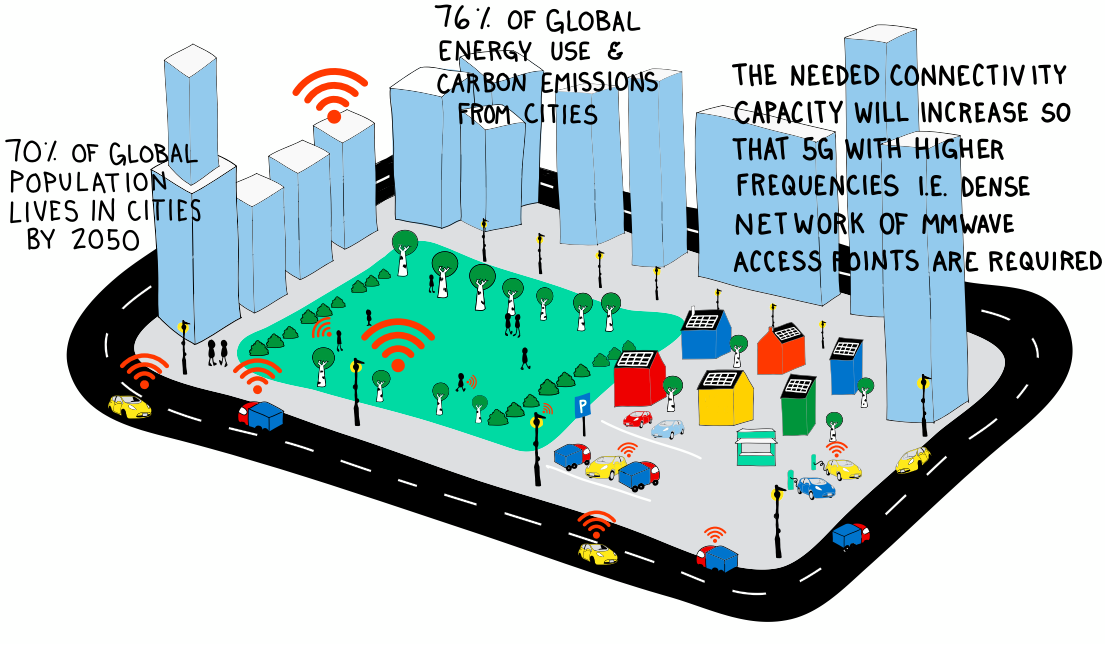
ABSTRACT

According to UN reports, 56% of the global population, and around 70 % of Europeans lives in urban areas. As the world population and urbanization rate rise at a tremendous rate, so rise the challenges on the quality of life of people. The way for cities to improve the quality of life is to discover and implement new technological innovations and solutions.

For this reason, cities are exploring Smart city and Neutral Host Network solutions as viable paths forward. In a nutshell, a Neutral Host Network, NHN, is a third-party cellular network in charge of providing localized mobile coverage solutions to a wide range of national mobile network operators, MNOs. The Neutral Host Network itself determines whether their commercial mobile network solutions are paid or free of charge or whether they belong to the mobile network operator's bands or a dedicated Neutral Host Network-owned spectrum.

In European regions, these technological solutions are expected to be first implemented within transportation, mobility and health sectors to increase functionality and citizen engagement. One outcome of such integration would be the reduction of the use of personal cars, as the cities are going to provide more reliable and pleasant modes of public transportation. With improvements to shared mobility, cities are expected to benefit in terms of environmental changes and higher satisfaction among the citizens. It is, however, important to note that neutral host technologies also play a significant role in various other industries, including media and entertainment, the automotive industry, logistics, safety, drone technology, healthcare industries, and energy, among others. Despite the technologies advancing all around the world, we still lack a clear picture of where the development is going at the moment.

In this report, we will provide a state-of-art understanding on the development on neutral host technologies within the EU, the state-of-art understanding on the relevant business models for the purposes of exploiting their future development and finally, the state-of-art understanding on the regulatory environment that sets the boundaries for the development.



1 INTRODUCTION

Our modern society and growing cities face great challenges nowadays, e.g. to improve safety, energy efficiency, air quality, effectivity of transportation, and general quality of living. Cities have started to see the value of data when seeking to provide this. Data is needed for new services to enable sustainable economic growth and development in the city area and to meet the UN SDG's (Sustainable Development Goals). Current operation models of mobile networks do not support the development of new data driven smart city services. There are no viable models for sharing data and creating the value from different data sources. This also sets new boundaries for the regulation of mobile networks.

Needed high capacity data traffic can be done with high frequency 5G small cells. Often small cells are integrated to city light poles where only one network is feasible. Without new solutions, cities will continue to implement vertical smart applications for single use or using more platform type approach but using still many different and often limited and not secured technologies.

This report seeks to provide a state-of-art picture on the understanding of how fast 5G-network-based neutral host infrastructure can be utilized and data platforms optimized for the local needs of smart cities. The report is written under the Neutral Host project that aims to demonstrate and utilize fast 5G-network-based connectivity and data platforms optimized especially for local needs of smart cities. 5G mobile networks are expected to change the current telecom operator business to become more local as the networks are based on small cells, i.e. high density of base stations. Under the Neutral Host project, a new operation model called Neutral Host Pilot will be designed especially for limited city areas which are usually highly populated and there is a need for high capacity mobile services as well as huge amount of IoT equipment. The research and piloting are planned to support the future development, where smart cities are expected to need digital service infrastructure to enable sustainable growth as well as to provide a better living environment for their citizens, which is a goal also set by the European Commission.

The Neutral Host Pilot project will be a highly multi-disciplinary joint R&D project developing new sharing business for digital smart city. The project will focus on the development of the data platform and operational model for the network, with the shared target to create an open ecosystem of citizens and companies to invent and create. The project will build upon the connectivity platform developed in the LuxTurrim5G consortium project supported by Business Finland.

LuxTurrim5G is a Nokia Bell Labs driven ecosystem project developing and demonstrating fast 5G network based on smart light poles with integrated antennas, base stations, sensors, screens and other devices. This active joint project has developed the concept and technological core for fast 5G networks based on smart 5G light poles, and created important understanding on the requirements of new digital services and business opportunities for a smart city (see: www.luxturrim5g.com)

Figure 1: LuxTurrim5G ecosystem partners

1.1 The future of cities[1]

As the focus of this is report is on smart city environments, we will now look into their futures. This chapter is based on report on Future of Cities[1], published by EU's Joint Research Centre (JRC), which is the European Commission's science and knowledge service.

Data from the UN shows that 56% of the world's population lives in urban areas. While other sources claim this percentage is higher than 70, the world's population is expected to grow in the upcoming decades. Some regions, such as Europe, are struggling with with declining population and lack of newborns. It is evident that cities are going to look in the direction of new technologies across different sectors to help improve quality of life and their environment.

The upcoming technology, which will stretch from transportation and mobility sectors to citizen engagement. One of the aspects that are expected to change in the future is the use of personal cars, as cities are planning to provide more efficient public transport and thus improve shared mobility. Simultaneuously, cities will have to focus on tackling is-sues such as the impact of climate change, energy poverty, and water scarcity.

The citizen engagement should grow in the upcoming years as new forms of urban governance take place. With that in mind, cities as a whole have the responsibility to ensure societal change, embrace innovative technologies, ideas, and resources and solve global challenges in the future.

After all, city networks play an important role in shaping the global picture. Each city is contributing in its own way to the global agenda of sustainable living. Through these activities, cities are expected to tackle common issues such as environmental pollution, long commuting times, poor transport structures, and congestion. The majority of these problems could be solved through a more efficient transportation system that would allow active and uninterrupted mobility and reduce the number of privately-owned vehicles.

However, governments and organizations will have to ensure that new modes of transport such as autonomous vehicles can co-exist rather than compete with public transport. The goal behind the idea of futuristic transportation improvements is to create reusable, efficient, and sustainable infrastructures that are personalized and data-driven at the same time. According to statistics, the life expectancy in the EU will rise to 88.2 years by 2070. This could bring new challenges to cities all over the world, especially those whose population is in decline.

The growing costs of health care and social benefits are challenges for cities with shrinking work forces. With that in mind, cities will have to adjust their health care, mobility systems, and housing to meet their citizens' needs. High population density has its pros and cons in any city. While it might bring forth the risk of spreading infectious diseases, as we have seen lately, high population density can ensure a better economy status. However, it is important to address that well-being can be improved through urban planning and new technologies. Cities must look into deprived neighborhoods and uncover the causes of the decline in population and quality of life. Based on the JRC report on Future of the Cities[1,2], the key issues are environmental footprint, climate action, tech and the city, cities as innovation hubs, the citizen's city, urban governance and resilient city.

- Environmental footprint – Supplying a city with water, food, and energy creates a lot of pressure on the environment. Due to the rapid growth of the human population in the last couple of decades, a large portion of planetary resources have already been used up. Cities will have to work toward achieving lifestyle changes to help reduce the environmental footprint. This could

1 This chapter is based on report on Future of Cities, published by EU's Joint Research Centre (JRC), which is the European Commission's science and knowledge service: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities

2 Future of Cities report: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities; page 7-9

be done through encouraging healthy diets, reducing waste, and reducing the number of privately-owned vehicles by replacing them with a sustainable public transportation system.

- Climate action – Every city, regardless of its structure, is exposed to the consequences of climate change. In the last couple of years, cities have started contributing to climate-change targets. However, they will need a lot more support from national and regional governments, including civil society and private organizations. It is interesting to mention that the greenness of European cities has increased by nearly 40% over the last 25 years. The public green spaces are contributing to the environment and the quality of life by improving the air and public health, as well as providing room for social integration.

- Tech and the city – As mentioned before, new and advanced technologies can be used to improve the quality of life and the overall structure of the environment. More specifically, new technologies can improve social interaction, advance public services, as well as address environmental issues and concerns. On the other side, new technology brings negative aspects into city development such as security risks, data privacy concerns, and data sharing standards.

- Cities as innovation hubs – Cities play an important role in innovation that enhances their cultural heritage and identity. It is evident that capital cities remain the most influential players when it comes to innovation. However, smaller cities are starting to catch up thanks to advanced technologies and their implementation.

- The citizen's city – A city would be nothing without the contributions of its citizens. In fact, citizens are an important factor of innovation and advancement in urban environments. They provide new ideas and solutions that can improve the quality of life and help understand standards and traditions that vary from one area to another.

- Urban governance – Urban governance is another important part of the equation, as more than half of urban agendas can be achieved locally in those urban areas. Therefore, no matter how small a community is, it can contribute to large scale changes with the right efforts and activities.

- The resilient city initiative assesses, plans and acts to prepare for and respond to both sudden and slow challenges.

Cities play a key role in solving grand societal challenges, which involve pressing real-life problems related to environment, health and quality of life. Due to the complexity, they require boundary spanning collaborations across different diciplines and multi-layered governance across sectors and cities. Based on EU's Future of Cities report[2].

- Cities are key sites where innovation and technological advancement happens. While this is a major opportunity for cities, both social and technological innovation should be further stimulated and progress should be made alongside new forms of social engagement, urban governance and cultural creativity.

- The appropriate management of new technologies and data is crucial. New tools and methods for better knowledge management are particularly important for enhancing the capacity to translate data into meaningful and relevant support to inform policy decisions. The use of real-time, consistent and reliable data (including big data and non-conventional sources) is essential and requires greater transparency towards citizens.

- Housing availability and affordability remains under threat due to changing acquisition and rental patterns, including new forms of financial investment that see strategic opportunities for the conversion of volatile assets into physical ones in cities. This challenges obsolete social housing measures which have to be re-thought to reduce social polarisation and conflicts.

2 Future of Cities report: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities; page 7-9

- Cities are essential hubs for both the implementation of global agendas and for citizens' engagement in policy decisions. While committed to providing a good life for their citizens, cities can push forwards behavioural and institutional changes that will benefit all, taking an active role in global governance. Several European cities are at the forefront of issues such as governance and citizen engagement, innovation and creativity.

- The fight for sustainability will be greatly influenced by what happens in cities. While cities usually place greater pressure on natural resources, they perform better in the use of resources and have a greater potential for energy efficiency. Actions on environmental sustainability, including climate change, are already being taken by many cities.

- Cities and city networks have a large collective power to act and to scale up solutions quickly and efficiently. Their influence can be significant, from supporting global commitments to providing efficient local solutions. The EU has successfully created an environment of sharing of good practices between cities, both within and outside Europe. In this sense, cities also have a certain responsibility to act towards societal change.

- There is a risk of polarisation both within and between cities. On the one hand, being unable to take stock of the issues highlighted will lead to even more inequalities within a city. On the other hand, a diverging path between cities falling behind and cities capitalising on emerging trends may cause additional social and economic imbalance between different urban areas.

- The close linkage between space/service/ people is at the core of cities' capacities to respond to people's needs and to manage new challenges in a wider context, beyond administrative boundaries and sectorial domains. A truly holistic approach is needed to optimise the provision of services and create an intelligent interaction between the city and its inhabitants while maintaining or enhancing quality of life[2].

The city communities play a substantial role in shaping their futures. Strengthening local administrations and empowering citizens will help build urban resilience to better re-spond to emerging challenges and to protect human, economic and natural assets in cities. Technologies such as neutral hosts are expected to play a role in this development.

2 Future of Cities report: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities; page 7-9

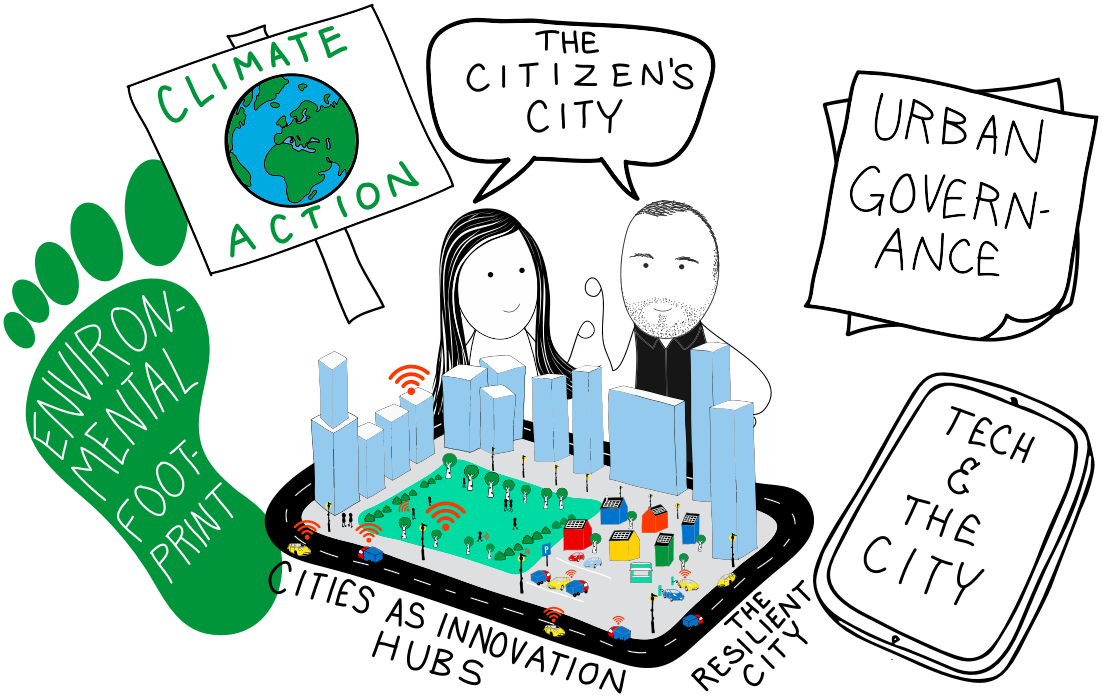


Figure 2: The future of Cities

1.2 What are neutral hosts?

In this report, we focus on neutral host technologies in changing the future of cities. The neutral host concept is a relatively new phenomenon in the area of data and communications. The concept emerged in the mid 2000s from passive infrastructure sharing operations, where distributed antenna systems (DAS) required an operator independent company to run the infrastructure (Muir et al., 2006). Later, the concept diffused to the business literature (e.g. Rayal, 2013) and furthermore to the science literature (e.g., Hadi, 2015). There have been several studies related to the concept recently, but it seems that the paradigm has not settled yet due to the fact that there are still several alternative definitions for the term neutral host (e.g., Paglierani, 2019 and Paolino, 2019). Most of the recent scientific papers use the term neutral host when they refer to a network operator which maintains a small cell based mobile network for sharing purposes.

This report takes a dense form of definition and defines a neutral host as a service provider that builds and operates an integrated technology platform that is solely for sharing purposes.

This definition contains the following characteristics:

1. The 'service provider' part proposes that a neutral host offers continuous services for its customers on the area of its operations.

2. The 'builds and operates' part defines neutral host value adding activities, implying that the service provider constructs required infrastructure together with its key partners and it maintains and develops the infrastructure to meet varying needs of customers.

3. The 'integrated technology platform' part scopes and constraints the area of operations. The scope defines that a neutral host strives to consolidate required technological components so that those can be delivered to customers as one uniform environment. It is good to notice that the definition does not limit which kind of technological components or applications are actually used but allows use of all data and communications related scenarios.

4. The 'sharing purposes' part steers the way how the built infrastructure is leveraged on the business-vice. The built infrastructure seeks opportunities to gather as many participants to the platform as possible so that opportunities of the environment are distributed as widely as possible. Although there might be cases where there are just one customer using some part of the platform, the strive to leverage economies of scale, innovation through collaboration and socially optimal markets pushes business decisions to seek maximize fair utilization and decreasing marginal costs.

1.3 What is the current state-of-art status?

Platform based approaches are expected to support cities in making the citizens life better, more efficient and safer and at the same time enable sustainable growth in city areas. Data will be usable mainly locally for citizens, companies and cities itself. Local data is easier to control and share openly based on the common needs and regulations. One shared connectivity and data-platform enables cost efficient smart light pole networks for cities.

Neutral hosted network helps mobile operators to enter to the hot spot areas. Operators don´t need to invest to own expensive 5G mmW network while they may rent a slice for those areas they like to enter.

In the future, the needed connectivity capacity will be so high that dense network of 5G mmW access points are needed. Also, the needed data collection, processing, storage, security and sharing is so massive that well defined structures and processes are needed. To build one system enables regulations, GDPR and MyData rules to be agreed only once to the whole city area. Creating of trust is a key element needed for data driven business. The ongoing Neutral Host project takes care of all this and builds a platform for active data-driven business and digital services meeting the needs in smart city. The project will develop and demonstrate not only the technical elements but also best practices for safe and ethical use of data and sustainable business meeting the sustainable development goals (SDG) by UN.

Currently there are no incentives for commercial mobile network operators (MNO) to build the needed platform infrastructure enabling digital ecosystems for smart cities. Regarding data, Apple and Google are offering Global ecosystems which limit the data sharing. There are also some individual small-scale data platforms available. Neutral Host data platform will however provide an accessible interface and link to those)

Many cities have understood the value of data. Hundreds of different “smart city” projects are ongoing. Step by step single vertical use case stories are starting to converge more horizontal platform direction. IoT solutions are available from many companies including big ones (IBM, Siemens, Huawei, even some CSPs etc.) But not yet really city digital ecosystem optimized neutral hosted. For example, Dublin will test neutral hosted 5G (so far 4G small cells using carrier’s carrier frequencies, Huawei, AirSpan, Indoor?)

There are some operational models for local operators to offer, for example, wireless internet access for public. Typically, these are used inside large venues or other busy locations. They are usually deployed, maintained and operated by a third-party provider and they are designed to support the full range of MNO technologies. However, these solutions are providing only connectivity, not the platform and support for application developers and solution providers. For smart cities, bringing applications, new services, and broader and better connectivity is vital.

As it seems that the journey of neutral host technologies is just about to begin, we are seeing varying developments taking place around the world. Whereas a wide spread consensus on the use and benefits of these technologies has not yet been formed, the entire concept has remained relatively opaque to many of us. The purpose of this report is to create a state-of-art understanding on where the development is heading, what is the current understaning of its benefits, what are business models and strategic decisions relevant for its exploitation, and what does the development mean from the perspective of our current legislation.

1.4 Structure and content of the report

The content of this report can be divided into three main sections: The state-of-art understaning on the development within EU; the state-of-art understaning on the relevant business models for the purposes of exploiting the future development; and finally, the state-of-art understanding on the regulatory environment that sets the boundaries for the development.

We will begin in Section I with Chapter 2 focusing on the relevant developments within EU as well as its implications for various industries. By first looking into the policy level objectives within EU, we create an understanding on the potential needs that changes in various industries can overcome. Futhermore, in Chapter 3, we narrow down the scope of the study and take the analysis to the level of different new services that these new technologies enable.

Next we move on to section II where we discuss the relevant business models for exploiting these possibilities. In Chapter 4 we introduce the business potential of emerging data business, present some key technologies that are being developed to facilitate data sharing and data business, give examples of state-of-the-art data market places and give examples of data business models in the smart city context. Whereas Chapter 4 takes a more focused look into the business models per se, Chapter 5 furthemore illustrates a more strategic view-points and analyses their use and implementation in varying real-life contexts.

Whereas new technologies change industries, enable the creation of new services, and make them expoitable through various business models, it is crucial to also understand regulatory environment that sets the boundaries for the development. In the final section (Section III) consisting of Chapter 6, we focus on current legal regulation and interpretations relating to processing of personal data, connectivity model, data platform, network regulation and competition law aspects concerning building and maintaining a smart city 5G network and data platform.

Finally, we finish of the report with Chapter 7 providing us with a brief summary and conclusions on the overall ensemble.

SECTION I:

STATE-OF-ART UNDERSTANDING OF NEUTRAL HOST APPLICATIONS IN INDUSTRIES AND SERVICES WITHIN EU

2 EU POLICIES AND IMPLICATIONS FOR INDUSTRIES [1]

The Smart cities actions aim to improve the liveability and sustainability of cities by reaching the 20/20/20 energy and climate goals. The transformations towards knowledge-intensive economies, cultural trends and growing shares of resource consumption and emissions, cities are a key driver of economic growth, social inclusion and environmental sustainability. Arriving at sustainability requires investments and efforts, even though many are already burdened with considerable debt. This section is based on Smart Cities, one of the EU's RIS3 thematic platform on Smart Cities[2].

The EU Commission highlighted Smart Cities and Communities already in 2012, which aims at collaboration in solving common challenges affecting cities like energy, transport, mobility and ICT.

On the market side the aim is to identify and validate new business models, new approaches to public procurement and converge on regulatory measures and standards. On the supply side the aim is to implement some large-scale projects affecting transport, energy and ICT in city contexts.

Smart city initiatives face the challenge of behavioural change at the citizen level. Governance must overcome administrative silos and adopt holistic policies. Citizens need incentives towards behavioural changes, not to mention the building of an adequate knowledge base. Technology vendors should join the movement and foster greater citizen engagement. Each city and country is unique and this means that a careful analysis of the specific institutional and regulatory framework must be carried out before any investments are made.

Based on EU's Factsheet on Smart Cities[3] the following issues needs to be covered when investing in smart cities:

- Analysis: Carefully analyse the institutional, regulatory and financial setting of the specific city/region. Spot the specific bottlenecks and barriers. Estimate the cost of investment to switch to smart cities solutions, investigate the potential sources of public and private financing and draw the new sustainable business models necessary to switch to smart cities. Determine the available skills and necessary resources.

- Governance/stakeholder involvement: Public regional and local authorities are the active and passive actors of the process. They are stakeholders and final users at the same time.

- Priority setting: Plan with operational targets and indicators, establish a specific roadmap to reach the defined goals, based on the analysis previously done.

- Policy mix: Smart cities will be implemented by all the actors concerned, at different levels and demand and supply side.

Through wider implementation, neutral host technologies are expected to play a role in the EU context, as an example of supporting the safe and ethical use of data and sustainable business meeting the sustainable development goals, SDGs, by UN. In this Chapter we will begin by looking into the policy level objectives within the EU and then see how neutral host technologies might impact various industries within the Smart city environment of the EU.

1 More information from author Taina Tukiainen

2 https://s3platform.jrc.ec.europa.eu/smart-cities

3 https://s3platform.jrc.ec.europa.eu/documents/ 20182/137912/Smart+cities2.pdf/880a4ec0-73d4-4d20-8171-71f062a6a5e9

2.1 EU policy objectives

Sustainable development has long been a key policy for the European Union. The first EU Sustainable Development Strategy, EU SDS, was adopted in the beginning of the 21st century. The EU SDS has since been revisited to meet the goal of a continuous improvement towards the quality of life of citizens while protecting the environment. In 2010 the European Council adopted the Europe 2020 strategy, which puts forward the three mutually reinforcing priorities of smart, sustainable and inclusive growth.

The EU has played an active role in shaping the UN 2030 Agenda. The EU proposed to integrate the SDGs into the European policy framework and priorities, and reflect on the further development of the EU vision after 2020. The SDG's have been monitored in the EU from 2017 onwards as a target towards evidence-based decision-making and has been active to put the SDG's on a global agenda, as a united global goal.

The 2030 Agenda, adopted unanimously by United Nations, UN, Member States in 2015, address some of the main challenges that affect both developing and developed countries. The Agenda contains the Sustainable Development Goals, SDGs and is based on the idea of economic prosperity, environmental protection and social well-being need to be addressed jointly.

The European Commission works towards "Next steps for a sustainable European future - European action for sustainability" (COM/2016/0739) and proposes implementation of the 17 SDGs and their 169 targets.

Eurostat monitors the implementation of the SDGs at the EU level and the reports of "Sustainable development in the European Union - 2017 monitoring report on progress towards the SDGs in an EU context[4]. In addition, the KnowSDGs platform, Knowledge base for the Sustainable Development Goals, supports the evidence-based implementation of the SDGs[5].

2.2 The European Green Deal

The global nature of the challenges, such as climate change, conflicts, migration and inequality, call for joint efforts. Economic growth, social inclusion and environmental protection are anchored in key EU Treaties. The EU is fully committed to implementing the SDG's together with its Member States. The European Commission by 'Next steps for a sustainable European future: European action for sustainability' provides a way forward in reaching the goals.

This work supplements EU reports on individual policy areas and builds on Eurostat's long experience in monitoring Sustainable Development in the European Union. It relies on a set of 100 relevant EU SDG indicators, selected in accordance with the quality criteria of the European Statistics Code of Practice. The EU SDG indicator set will be regularly reviewed in light of future policy developments.

This publication called 'Sustainable development in the European Union — monitoring report on progress towards the SDGs in an EU context 2017 edition' is the first document, which monitors the achievement of SDG's[4]. The main result of the first monitoring exercise shows that the EU made progress towards the achievement of all goals. The EU has made significant progress towards SDG 7, affordable and clean energy; SDG 12, responsible consumption and production; SDG 15, life on land; SDG 11, sustainable cities and

4 https://ec.europa.eu/eurostat/web/products-catalogues/-/KS-01-17-796

5 https://knowsdgs.jrc.ec.europa.eu

Figure 3: The European Green Deal

communities; and SDG 3, good health and well-being. Even though progress has been made, it doesn't mean that the current state is satisfactory, but will require continued effort to improve the achievement of also these goals.

Indicators related to SDG 11, sustainable cities and communities, mainly speak of progress, especially in the area of quality of life. Fewer Europeans live under poor housing conditions, suffer from noise or are victims of crime. In addition, the environmental impact of cities is positive with regard to municipal waste management and the urban population's exposure to air pollution. More work is needed especially in the area of sustainable transport.

The European Commission came out with the European Green Deal in the attempt to become the world's first climate-neutral continent by 2050[6]. The initiative contains a range of key policies from cutting emissions and to investing in cutting-edge research and innovation, to preserving the natural environment.

The European Green Deal has five policy areas: 1) Clean energy, 2) Sustainable industry, 3) Building and renovating, 4) Sustainable mobility and 4) Biodiversity.

In 2020 the European Commission has planned to put forward ambitious legislative initiatives. The aim is to proactively progress in forward-looking, strategic and thematic planning, through improved integration activities and a more results-oriented and longer-term focus on priority policy areas.

In the following, based on the report of Euractiv[7] by Frédéric Simon, the key content and objectives of the European Green deal[6] are:

6 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

7 https://www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/

- Climate neutral Europe by 2050 and to reach net-zero greenhouse gas emissions by 2050 is a goal, which will be shaped by a climate law in 2020. This means updating the EU's climate ambition for 2030, with a 50-55% cut in greenhouse gas emissions to replace the current 40% objective. The 55% figure will be subject to a cost-benefit analysis. More detailed climate objectives are:
  - strengthening green seal diplomacy in international climate and biodiversity negotiations,
  - European Climate Law the 2050 climate neutrality objective by March 2020,
  - launch of the European Climate Pact by Q3 2020,
  - new EU Strategy on adaptation to climate change by Q4 2020 and
  - focus on Covenant of Mayors.

The commission aim is to review every EU law and regulation in order to align them with the new climate goals. This will start with the Renewable Energy Directive and the Energy Efficiency Directive, but also the Emissions Trading Directive and the Effort Sharing Regulation, as well as the LULUCF directive dealing with land use change. Proposals there will be submitted as part of a package in March 2021.

A plan for smart sector integration, bringing together the electricity, gas and heating sectors closer together "in one system", will be presented in 2020. This will come with a new initiative to harness "the enormous potential" of offshore wind as an example.

- Circular economy. A new circular economy action plan was scheduled in March 2020, as part of a broader EU industrial strategy. It includes a sustainable product policy with prescriptions in order to use less materials, and ensure products can be reused and recycled.

- Carbon-intensive industries like steel, cement and textiles, will also focus the attention under the new circular economy plan. One objective is to prepare for "clean steelmaking" using hydrogen by 2030. New legislation will be presented in 2020 to make batteries reusable and recyclable.

- Building renovation. This is one of the flagship programmes of the Green Deal. The key objective is to "at least double or even triple" the renovation rate of buildings, which currently stands at around 1%. The detailed targets are: the future of national energy and climate plans, strategy for smart sector integration by Q2 2020 and "Renovation wave" initiative for the building sector by Q3 2020.

- Zero-pollution. The objective is to reach a pollution-free environment by 2050, whether it is water, air or soil. New initiatives there include a chemical strategy for a toxic-free environment. The detailed targets for revision of Trans-European Energy Networks, TEN-E and mobility TEN-T Trans-European Transport Networks.

- Ecosystems & biodiversity. A new biodiversity strategy was due March 2020, in the run-up to a UN biodiversity summit taking place in China in October 2019. "Europe wants to lead by example" with new measures to address the main drivers of biodiversity loss. That includes measures to tackle soil and water pollution as well as a new forest strategy. "We need more trees in Europe," both in cities and in the countryside. New labelling rules will be tabled to promote deforestation-free agricultural products. The detailed targets for environment are:
  - EU Biodiversity Strategy for 2030 preserving and protecting biodiversity due March 2020
  - New Circular Economy Action Plan, including a sustainable products initiative and particular focus on resource intense sectors such as textiles, construction, electronics and plastics due March 2020
  - Zero pollution action plan for water, air and soil 2021 as part of the zero-pollution ambition
  - 8th Environmental Action Programme by Q2 2020
  - Revision of the Batteries directive by October 2020
  - Chemicals strategy for sustainability by Q3 2020

- Farm to fork strategy. In Spring 2020, the new strategy will aim for a green and healthier agriculture system. This includes plans to significantly reduce the use of chemical pesticides, fertilisers and antibiotics. New national strategic plans due to be submitted next year by member states under the Common Agricultural Policy.

- Transport. One year after the EU agreed new CO2 emission standards for cars, the current objective is to reach 95gCO2/km by 2021. However, now, the target is towards zero by 2030. In electric vehicles will be further encouraged with an objective of deploying 1 million public charging points across Europe by 2025. The target by the commission is that every family in Europe needs to be able to drive their electric car without having to worry about the next charging station. Sustainable alternative fuels – biofuels and hydrogen – will be promoted in aviation, shipping and heavy duty road transport where electrification is currently not possible.

- Money. To leave no-one behind, the commission proposes a Just Transition Mechanism to help regions most heavily dependent on fossil fuels. "We have the ambition to mobilise €100 billion precisely targeted to the most vulnerable regions and sectors," said von der Leyen as she presented the Green Deal.

- A just transition fund that will mobilise resources from the EU's regional policy budget; the InvestEU programme, with money coming from the European Investment Bank and EIB funding coming from the EU bank's own capital. Every euro spent from the fund could be complemented by 2 or 3 euros coming from the region.

- R&D and innovation. With a proposed budget of €100bn over the next seven years from 2021 to 2027, the Horizon Europe research and innovation programme will also contribute to the Green Deal. 35% of the EU's research funding will be set aside for climate-friendly technologies under an agreement struck earlier this year. And a series of EU research "moonshots" will focus chiefly on environmental objectives.

- External relations. Finally, EU diplomacy to support the Green Deal. As Europe increases its climate ambitions, expect the rest of the world to play its role too. One proposal is to attract attention – and controversy – is a proposal for a carbon border tax.

To lead by example, the EU commission itself will aim for climate neutrality by 2030.

The previous paragraphs were based on the article of Euractiv[7] by Frédéric Simon on the key points of the European the Green deal[6].

6 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

7 https://www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/

2.3 Developing industries to support EU objectives

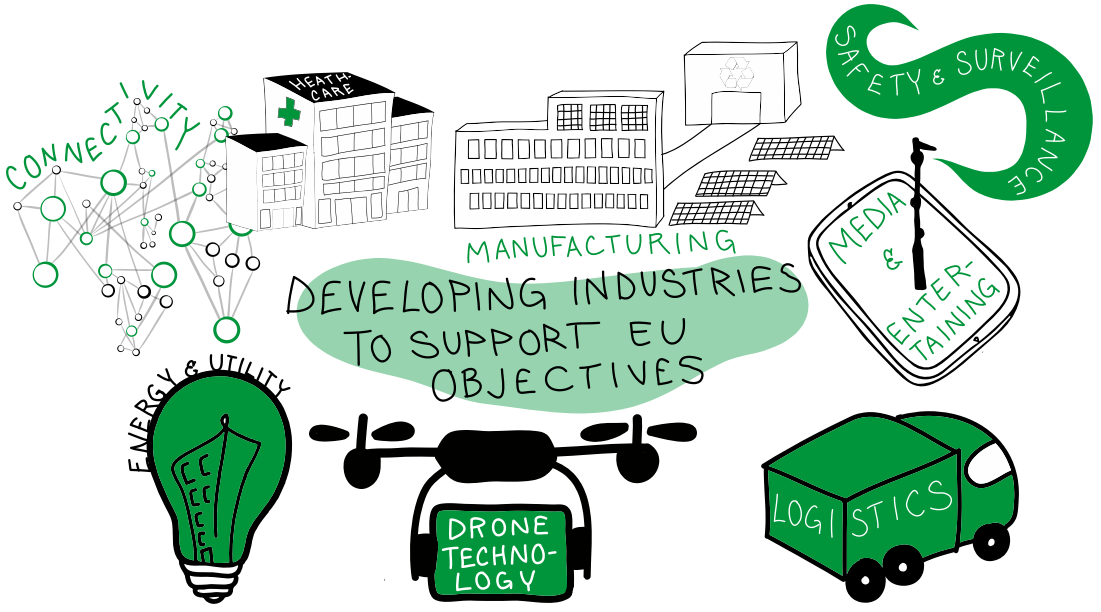


Figure 4: Developing industries to support EU objectives

Creating of trust is a key element needed for data driven business in order to support the EU goals. Next we focus on examples and analyses on the use of technologies in the context of neutral host and 5G solutions across various industries. The technologies related to 5G are considered to be an efficient contributor to new business opportunities as well as making the life in cities better. There already exist dozens of unique ideas for use case examples where 5G is integrated in specific niches and industries to add value and improve the quality of services. The small cell world report from 2019 states that the demand for connectivity solutions is growing rapidly in the transportation industry, including roads, railways, ports, and airports, as well as industrial and IoT niches. Any industry with mobility needs is expected to pick up on this technology to improve existing services. Below are several examples of specific industries in need of higher reliability network technologies. Whereas here focus on the possibilities that these technologies enable in different industries, the following Chapter (Chapter 3) we will take a closer look at the level of specific applications. This section is written largely based on insights gained from the Dot.Econ and Axon report on industry-level development (2018).

2.3.1 Automotive

Connectivity technologies play an important role in the automotive industry and the adoption of new automated vehicles. Report by Dot. Econ and Axon partners (2018) indicate that car manufacturers have shown tremendous interest in integrating connectivity features in new vehicles. The goal behind this trend is to improve the overall experience of the driver and passengers in the car. By manufacturing connectivity-ready cars, companies could improve traffic flow and road safety, which have been concerning topics for decades. Furthermore, connectivity technologies

could provide a better insight into the performance of each individual vehicle and thus assist the maintenance process.

Various 5G solutions have already been tested within the automotive industry. The same report mentioned earlier states that these technologies include trip advisory services, on-demand entertainment, traffic management, as well as weather services based on vehicle location. Other more complex technologies were tested to boost road-side assistance and GPS services. The report further explains the possibility that 5G services could be used to enable and enhance vehicle-to-vehicle communications (V2V), which would include providing mapping data, road routes, and information about the environment beyond the "line of sight."

On the other hand, these same features could possibly be achieved without integrating 5G solutions but rather through adjusting existing infrastructures. We can take predictive maintenance as an example where real-time exchange of data is not critical. Instead, the more critical feature is the intermittent uploading and sharing of information. Despite this range of possibilities with existing technologies that are already in-use, the automotive industry would significantly benefit from additional 5G solutions paired with neutral host infrastructures. These benefits include device density, mobility, and data transfer in times of need.

The general belief is that 5G is mandatory for achieving fully automated driving. However, it is important to clarify that some of the automation services don't require 5G solutions to operate. Instead, these services can be based on simple vehicle-to-vehicle communication without advanced wireless components or use of existing mobile broadband infrastructure (e.g. 4G). In addition, The Dot.Ecom and Axon partners report goes further to explain how dedicated Short-Range Communication and Intelligent Transport Systems (ITS) can be used for these purposes, assuming that the systems rely on IEEE 802.11 with a 5.9 GHz band. Furthermore, there are also LTE based options available for V2V communications.

The benefit behind these technologies is direct communication between two endpoints without requiring a cellular network to operate. Even though these technologies operate in a distributed manner, it is important to address that they only enable short-to-medium range vehicle-to-vehicle communications. With that in mind, there ought to be certain distance limitations when it comes to communication between vehicles or infrastructure on the road. The limitations could cause an inconsistency in the sharing of information related to road routes and objects on the path ahead.

Once we take this into consideration, it is evident that the automotive industry needs a better approach to enabling wider range communications. The said technologies are not nearly sufficient to ensure safe transportation if the communication needs go beyond simple vehicle-to-vehicle data sharing. For instance, if there is a need for communication between other factors such as present infrastructure on the road or nearby pedestrians (V2I and V2P communications), the mentioned short-range communication technology won't be of much use. The V2I and V2P communications are commonly referred to as vehicle-to-everything communications or V2X. The same report states that vehicles on the road will most likely require more advanced communication with infrastructure to provide information regarding road signs, traffic lights, or control centres, as well as other participants in traffic, including pedestrians and cyclists.

The situation gets a bit more complex once we consider that the same data must be exchanged with a backend server to enable processing and summarisation. As of today, the most relevant solution for vehicle-to-everything communications is Cellular-Vehicle-to Everything, also known as C-V2X. This system provides an efficient solution for integrated V2V, V2I, and V2P communications by using a cellular network infrastructure to allow two types of communications: a direct vehicle-to-vehicle communication and vehicle-to-network communication.

Speaking of cellular networks, the current global standard is LTE-4G. This cellular technology is merely a foundation for powering the C-V2X solution. There is no doubt that 5G would be a more fitting option for enabling complex C-V2X communication, as it provides a stronger and more

enhanced connection needed for autonomous driving. To quote the 5G Automobile Association (5GAA), it is important to indicate that "…to support the autonomous vehicles of tomorrow, the technology must evolve to meet more demanding safety requirements. 5G will facilitate this evolution. Its extreme throughput, low latency, and enhanced reliability will allow vehicles to share rich, real-time data, supporting fully autonomous driving experiences."

2.3.2 Media and entertaining

The internet has become the main source of entertainment of the 21st century. The growing consumption of online media and entertaining content has led to a growing demand for mobile networks and the expansion of their capabilities. The Dot.Econ and Axon report describes how the demand for high-resolution audio and visual services will continue growing at a rapid rate. Some of the most significant growing demands include higher downlink and uplink data rates for user generated content and live streaming on social media. A recent Ericsson mobility report states that "mobile video traffic is forecast to grow by around 50 percent annually through 2022 to account for nearly 3 quarters of all mobile data traffic. Social networking is expected to grow by 38 percent annually over the next 6 years."

With the media and entertainment industry growing consistently, we can expect the number of network requirements to increase, especially for mobile data usage. The main challenge is to find a sustainable solution to support this rapid growth yet still maintain the desirable level of quality when it comes to visual and audio content. These challenging technological solutions are especially needed for large public events and city centers where high-quality video and audio content is mandatory. As of right now, 5G seems to be the most logical and cost-effective solution for these requirements. The use of 5G won't only improve the quality of content while supporting rapid growth but it could also pave the way for new profitable services. For instance, technology could soon allow users to improve their experience at public events by using virtual reality headsets or replaying live video streams from different angles on their device.

What makes 5G such an attention-worthy solution is the fact that this technology is not limited to supporting the streaming of high-quality content at larger rates. In fact, 5G could provide significant contributions to media platforms by enhancing broadcasting and distribution. Consumer habits are already changing in regards to media and entertaining content. People are more frequently opting for TV content on a variety of different devices. This change has prompted broadcasters to look into new solutions for local caching and ways to distribute content at cost-efficient rates. The most common solution for this demand is the use of commercial content distribution networks.

Different network technologies will have to be fully integrated so that the users can move between them and jump from one content provider to the other without any lags or disruptions. As of today, distribution networks are quite independent from one another, which can create challenges for integration. 5G could play the key role in developing a single solution for different delivery modes, including unicast, multicast, local caching, and broadcast. There's no doubt that the future is still unclear when it comes to media production and broadcast. However, 5G will certainly bring forth the much-needed benefits to this sector. It could separate production from outside broadcast units and move it to a central location where content from multiple cameras will be connected. Furthermore, 5G will come in handy in situations where there is no adequate infrastructure or where there is a need for a more cost-effective wireless connectivity solution.

At this moment, 4G seems to be an efficient solution for demanding mobile data services for public events. It is certainly a far better option than its predecessor 3G. However, the growth of data requirements is soon going to overflow the current capabilities of 4G networks. New data hungry services are emerging at a rapid rate and introducing consumers with new technologies such as augmented reality, VR headsets, and 360 video streaming from all angles. All off this will require a stronger mobile network support where 4G is

inevitably going to fail and thus be replaced with 5G.

Another reason why 5G has become necessary is the broadcasters' hunger for new distribution and production methods. With broadcasters leveraging the transfer of information over IP, there is an unavoidable need for a better underlying infrastructure. While fixed Ethernet could be a reliable source of solutions for this issue, 5G will overpower it by allowing broadcasters to rely on wireless technologies for transferring content and media.

This is will be possible thanks to the enhancement of the main layers of the radio network, including the physical, transport, and application layer. In other words, 5G could open the door for broadcasters to deliver content over cellular networks at the radio level. The original issue with broadcasting modes for 4G is that this method is mixed with unicast traffic. 5G, on the other hand, could allow broadcast and unicast data to be transmitted at the same time to increase efficiency and lower costs. Even though this strategy works in theory, it is important to address that this research is still in its early stages and the possibility of this method is still not confirmed. Either way, broadcasters will continue to fight for network support to keep their content available to everyone. Even though 5G can solve the majority of broadcast challenges, this technology might not be available in all areas, which means other solutions must remain present as well.

2.3.3 Manufacturing

The European manufacturing sector is actively working toward digitalizing its processes and productions to increase efficiency and productivity. The majority of attempts to boost productivity in manufacturing have been tied to ICT enhancements. The concept of digitizing the manufacturing sector became known as the "fourth industrial revolution." Experts are looking at cyberphysical-systems (CPS) and the Internet of Things (IoT) as the two main drivers of the so-called fourth revolution whose goal is to pave the way for more efficient and internally connected factories.

Besides CPS and IoT, 5G could play a role in further shaping the manufacturing sector. The way 5G could impact this industry mainly revolves around enhancing wireless data rates and using mobile broadband networks to ensure connectivity among manufacturing sites and companies. With wireless technologies constantly evolving, there is no doubt that the manufacturing industry will be able to pick up on some of its advantages. For instance, better connection density and lower latency could enable machines and devices to communicate, thus creating more efficient and productive manufacturing environments. With that said, 5G could put an end to traditional manufacturing processes and open the door to more efficient and far more scalable methods.

As the significance of CPS production continues to grow, increased connectivity among multiple sets of devices is going to become mandatory. Besides exchanging information over a diversity of devices, the manufacturing sector will require faster response times and communication at a whole new scale. 5G could introduce the entire manufacturing sector to the concept of full connectivity where companies would be connected with products, value chains, and other participants in the industry. There are already plenty of use cases for 5G implementation in the industrial sector. 5G is found to be an efficient solution for enhancing the processes within a single factory, as well as integrating several different factories into one connected sphere. The industrial sector has already been introduced to a variety of IoT and M2M devices, which gave manufacturers a glimpse at the possibilities that further technological development could unravel.

While 5G could take the connectivity within the manufacturing sector to a whole new level, there is also room for RLAN solutions to answer to the growing connectivity demands. For instance, the challenge of wireless connectivity within a single factory can be overcome by integrating better Wi-Fi connectivity. With Wi-Fi continuing to evolve, we can expect more intelligent wireless networks that consist of combined 3G and 4G cellular concepts. Wi-Fi could also be integrated with 5G to allow better connectivity with lower latency. The Wi-Fi Alliance is working toward enabling power saving

features for Wi-Fi in order to make the use of battery-powered IoT devices possible. However, with the number of IoT devices growing rapidly within the manufacturing industry, this sector could face the same issues as the media and entertainment or the automotive industry. Namely, as the demands grow beyond the current network capabilities, the existing technologies such as Wi-Fi connectivity will most likely fail to withstand the pressure. This is where 5G could serve as a more powerful alternative because of its ability to provide better power saving methods.

Furthermore, 5G could ensure better flexibility and performance with higher reliability and much lower latency levels compared to Wi-Fi. The main benefit of 5G for manufacturers would be the ability to integrate different wireless technologies and allow multiple communication systems to operate together. Without 5G, manufacturers would either have to set up protocols for managing the interoperability of communication systems or they would have to use multiple frequency bands at the risk of high latency. 5G solutions, on the other hand, would allow them to set up a large number of devices and sensors to operate in close range without compromising any part of the infrastructure.

Even though machines can still interact through wired technologies, wireless solutions are far more attractive to manufacturers because of the ability to meet all connectivity requirements and thus adapt to the evolving technology. 5G could also boost management capabilities and allow for the management of security and data analytics.

2.3.4 Logistics

The main concern when it comes to Supply Chain Management (SCM) and the logistics industry in general is the journey of data and products through the distribution chain. The main concern lies in the flow of products from manufacturers to specific distribution centers and further to retailers and finally consumers. Tracking and reliability are two very important aspects of logistics that IoT could impact at a significant rate.

The logistics sector has already undergone significant changes thanks to evolving technologies. We must address that the current requirements of this sector can very well be met using existing connectivity technologies. Even the upcoming growth of the sector is not expected to overflow the current technological capabilities. However, that doesn't mean there is no room for 5G in this industry. In fact, the benefits of 5G could come in handy for boosting fleet management and introducing new delivery solutions. There is a growing demand for real time information and delivery predictions in the logistics industry. This opens up the need for automated systems that must be fast and extremely scalable.

Despite the existing technologies being able to provide the necessary solutions, 5G could help companies in the logistics industry stay above their competition by enhancing their services. One example where 5G could be extremely useful in this sector is the management of IoT applications in larger warehouses. Large warehouses commonly require a larger number of devices with lower power sensors, which is exactly where 5G could offer the advantage. The new connectivity solutions could also enhance the reliability of real-time data and enable automation of drone deliveries in the future.

2.3.5 Drone technology

Drone technology can be beneficial for many industries but its potential is hindered by a number of regulations that don't allow autonomous operation. Once the regulations and new technological advancements allow for autonomous operation beyond the line of sight, we will see a more implementation of drone technology across different industries.

One of the technological advancements needed for this scenario is a secure wide-area wireless network connectivity that would allow commercial use of drone technology. There is no doubt that the integration of drone technology in different fields is going to cause security risks. New regulations will have to be set in place to ensure safety both in the air and on the ground. The main safety concerns would be mid-air drone collisions and drones crashing down on the ground and potentially hurting people or damaging properties.

According to the current regulations, drones must not be operated autonomously. Instead, a human pilot must be in control the entire time. The flights are limited to low-altitude operations below 400ft or 120 meters. Regardless of strict and unfavorable regulations, businesses and corporations are still actively looking into autonomous drone operation. Such technology could be used for medical supply delivery, parcel delivery, and a variety of infrastructure monitoring operations. To make autonomous drones a possibility, companies will need mobile networks to support low latency and high bandwidth.

The development and integration of 5G networks will support many drone requirements and allow reliable communication. These conditions will make widespread use of autonomous drones not only possible but realistic. At the same time, companies will need licensed bands and encrypted communication to ensure full safety for autonomous drones. Mobile networks already provide the security requirements including encryption and more advanced security mechanism. The sidelink capability allows drone identification and reduces the risk of collision. The constant network connectivity enables drones to broadcast messages to nearby devices whereas the whole drone tracking mechanism can be integrated into traffic management systems. Forums such as GSMA and CTIA have already emphasized the potential that mobile networks provide for drones.

2.3.6 Safety and surveillance

Smart City environments have mandatory safety and surveillance requirements and needs that often can't be met with fibre optic cable and similar technologies. In scenarios where cable excavation is not possible, there must be some sort of wireless network set in place. The only problem is that the currently used wireless security networks are under too much burden, which makes them less reliable and less secure.

To make wireless surveillance a possibility, the network must have a high level of connectivity and speed. The already existing HD cameras and management systems are chocking the current network down by adding more traffic and causing speed reductions. However, the upcoming 5G networks will change this environment and open the door to new security opportunities. A 5G network will be faster and more reliable, thus allowing the connection of multiple autonomous devices and security systems.

Besides more room for connectivity, 5G will allow faster streaming and higher quality content in general. Smart cities are moving rapidly and most of them require multi-gigabit connectivity and more advanced cameras. Only a network such as 5G can support the vast variety of technological requirement. With 5G networks, it is now possible to provide uninterrupted bandwidth for a variety of wireless surveillance networks.

2.3.7 Energy and utility

The increased consumption of electricity, grid management, and uncontrollable output of renewable energy generators are only a few out of many challenges that the energy sector is dealing with. The largest challenges hide in areas where the demand for electricity is unpredictable. With various forms of transportation becoming electrified, the main question that arises is how to meet high demands for electricity at unpredictable locations and unknown times. Another challenge is to manage transmission networks more flexibly, especially with the growth of renewable energy generation technologies.

The sector is also dealing with the shortcomings of the current infrastructure, meaning there is a need for better and more efficient solutions. Aged infrastructure with outdated technologies can no longer respond to the growing demand for electricity and more flexible management. There is an evident need for better monitoring and control within electricity supply grids. EU Member States might soon be required to make urgent changes to their electricity management systems and introduce new transmission infrastructure for the sake of efficiency. The area where 5G could be useful is machine type communication or MTC. This type of communication could improve energy grid monitoring and control. Such integration of 5G would be necessary to support large MTC requirements for smart metering. The 5G-IA states

that: “the anticipated performance and flexibility of 5G will enable a communication infrastructure which is able to support the emerging energy use-cases…the ongoing evolution of the power grid into a grid supporting a much more distributed generation and storage of power as well as micro-grids would be a clear beneficiary of the high performance, but still very flexible communication architecture provided by 5G.”

The main focus of 5G use cases in the electricity sector is put on smart meters and smart grids. If integrated at the right level, smart metering could provide insight to consumers regarding their energy use in real time. This will encourage consumers to make more energy conscious decisions to lower their electricity bills and benefit the environment. Furthermore, smart metering could pave the way for more accurate bills as suppliers will get more precise information of consumers’ energy use. Manual meter readings will no longer be necessary and suppliers would thus be able to manage their activities more efficiently.

Smart grids, as the name suggests, would enable better connectivity of all grid components, thus making the grid more controllable. The idea of smart grids was proposed to increase energy grid control and beat the challenges of unpredictable energy generation. As the demand for electricity grows, both consumers and suppliers will benefit from smart grids that are connected and monitored on a higher level. However, to make smart grids possible, suppliers will need a far more secure and more reliable network for connecting power generation, transmission, and distribution systems, as well as managing each of them interchangeably. Even if fixed connectivity solutions already exist, there will be a need for a second backup solution to increase reliability in monitoring and control. This second solution refers to wireless technologies and 5G, more specifically.

It is important to clarify that smart metering services were already made available without any integration of 5G solutions. Since smart metering has very low data volumes and doesn’t require low latency, it is not considered a critical issue that 5G would eventually be needed for. The more relevant use case for 5G is the concept of smart grids. The currently existing connections within the energy grid rely on Ethernet infrastructure. While this solution has proved to be efficient at this moment, the grids are bound to become smarter over time. This will lead to an increased need for better and faster communication between control systems, sensors, and other energy management and generation assets. 5G could benefit the electricity sector by allowing more and more elements of the grid to be efficiently monitored and controlled. It is also important to address that the possibility of cyberattacks on power grids and other electrical infrastructure has become a concern in the industry. That is why the connections within energy grids and management systems must be secure and completely reliable.

According to the 5G-IA, 5G could be the most cost-efficient and reliable wireless solution that would bring numerous advantages compared to the fixed connections that are currently in place. Vodafone shares the same opinion as they say that: “5G networks can be used for monitoring and control of the grid in places where fibre networks have not been rolled out yet or where this would be too costly (e.g. rural areas). The resilience and reliability of 5G will give utility providers the confidence to push the technology deeper into the generation and distribution networks. It is also expected that the benefits of more control deeper down the network will trigger efficiency gains.”

2.3.8 Healthcare

Lastly, 5G could play a crucial role in improving the healthcare sector in various ways. A study by Ericsson has shown that the majority of surveyed healthcare executives are counting on 5G for the development of new services and the enhancement of the already existing ones. 5G is mainly expected to lead the healthcare sector toward efficient digitalization and virtualization of services, which would reduce costs and provide a better experience for both patients and the medical staff.

Besides automating simple tasks and digitalizing documentation, 5G could support some of the more complex endeavors such as enabling wireless solutions for robotic surgery. This technology could enable a significant breakthrough in tele-surgery and thus transform the entire healthcare

sector. However, such challenging goals would be followed by strict data speed, latency, and security requirements. In surgery cases like these, ultra-low latency will be extremely important, considering that even the slightest delay could have unprecedented consequences. It is likely that most remote surgery cases would rely on fixed networks. That means 5G would be left as the second option or an exception in very specific situations.

Another upcoming development within the healthcare sector are smart wearables. These wearables will include a variety of low power devices that will be compact to the point where they can be integrated into clothing. These devices will have to be waterproof to protect sensitive sensors that will collect data on environmental and health-related factors. The monitored data will include atmospheric pressure, blood pressure, temperature, and blood glucose among other metrics. Wide adoption of wearables would allow medical workers to collect data from different locations at a much larger rate. Instead of measuring the same metrics on each patient individually and in person, medical providers will receive the necessary data from multiple patients at the same time.

There are numerous ways that monitoring of biological data can be considered beneficial, from ensuring the patient sticks to their medical treatment to enabling faster reactions in case immediate medical care is necessary. Wearable healthcare devices will also encourage the population to lead a healthier lifestyle to prevent diseases and increase the overall quality of life. Back to the issue of remote surgery, the surgeons still have to rely on visual feedback through fixed network because these technologies still don't provide haptic feedback capabilities. 5G is evidently the only type of wireless technology that could provide the type of low latency and reliability needed for these applications. With proper integration of 5G solutions, wireless telesurgery can become possible by replacing the doctor's hands with robotic probes yet remaining the same haptic feeling.

To ensure telesurgery is safe for the patient, there must not be any discrepancy or delay between the visual feedback and the feedback provided by the sensory system. In situations where fixed connections are not possible, for instance in hazardous areas or small ambulances, 5G could serve as the only safe alternative. However, the most prominent 5G use case in healthcare is related to smart wearables and the capturing of big data. While it is true that fixed network monitoring devices already exist in hospitals, 5G could take big data capture to the next level by enabling patient monitoring outside of hospitals in cities. There is no doubt that the use of 5G for such monitoring would bring far more advantages over the existing technologies. For instance, 5G could support a large number of devices yet still maintain the needed security and reliability. Speaking of security, protecting consumer data is of utmost importance when it comes to enabling widespread patient monitoring through wearable devices. 5G could provide the security needed to protect patients' data and identity. However, despite all the potential benefits that 5G solutions would provide, there is still a need for an alternative solution to make the monitoring possible in areas that are not covered by 5G.

2.4 Concluding remarks

The EU Commission published a Communication on Smart Cities and Communities already in 2012, which aims collaboration in solving common challenges affecting cities like energy, transport, mobility and ICT. In 2019, The European Commission came out with the European Green Deal in the attempt to become the world's first climate-neutral continent by 2050. The initiative contains a range of key policies from cutting emissions and to investing in cutting-edge re- search and innovation, to preserving the natural environment.

The European Green Deal has five policy areas: 1) Clean energy, 2) Sustainable industry, 3) Building and renovating, 4) Sustainable mobility

and 4) Biodiversity. With a proposed budget of €100bn over the next seven years from 2021 to 2027, the Horizon Europe research and innovation programme will also contribute to the Green Deal and 35% of the EU's research funding will be set aside for climate-friendly technologies under an agreement struck earlier this year. And a series of EU research "moonshots" will focus chiefly on environmental objectives.

In this Chapter we have discussed these initiatives in detail as well as provided insights on the potential impacts they might have on various industries. According to the presented analysis, the neutral host technologies may play a major role e.g. in changing the automotive, media and entertaining, manufacturing, logistics, drone technology, safety, energy as well as heathcare industries.

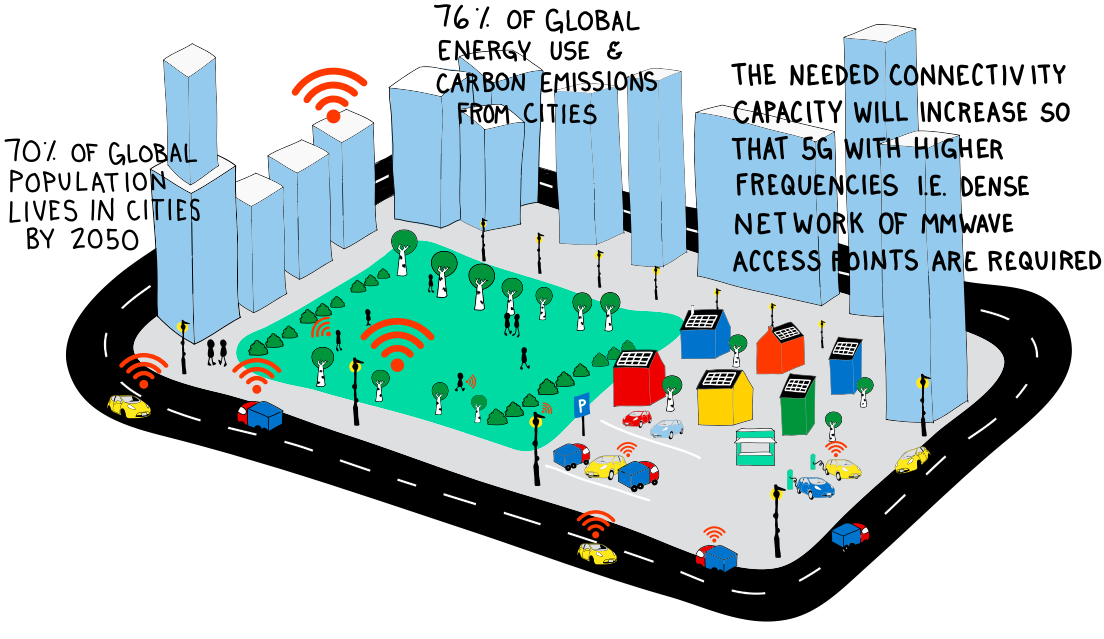


Figure 5: Importance of Smart Cities

3 SERVICES FOR SMART CITIES[1]

Services are crucial to providing wellbeing in cities around the world. With the megatrend of digitalisation, digital services became more valuable due to their impact on efficiency and reliability on daily life operations. Digitalising services implies that data is generated, analysed, and processed to manage all the resources that a service requires; thus, understanding which services a smart city will need and how they will operate, helps us to identify valuable data for the marketplace.

In this chapter we present a neutral host provided holistic approach about services in smart cities with a citizen-centric approach. The outcome is an infographic model analysis of the city in terms of areas and its layers; as well as service clusters that will be provided and their relation with the marketplace. The analysis is based on smart city services identified by Aalto Design Factory team for the LuxTurrim 5G+ project.

City services are crucial to maintaining the city's daily operations and functioning. The inclusion of 5G technology in the city will change the way some services operate. This technology enables the development of services for autonomous vehicles, drones and other IoT solutions; its value is that it enables real-time, consistent, and reliable data with near-zero latency for wireless devices. The transition towards a smart city, in terms of technology, implies first that the city's infrastructure and platforms must be upgraded to provide this network connectivity.

However, what makes a city smart is not the implementation of technology; smart cities are not technology-centric, on the contrary, they are citizen-centric. A smart city invests resources - human, social capital, transportation and communication - to fuel sustainable economic growth and citizens' well-being, with prudent management of natural resources, through participatory governance (Caragliu et al., 2011).

Under this citizen-centric approach, the value of services is focused on citizens as customers (represented by the city management) and end-users; the wellbeing will increase as both citizens and cities flourish. Technology is used to improve city management and operations, aiming to increase its efficiency with fewer resources, but the value capture resides within citizens. Thus, it is citizens who benefit from efficient, integrated and targeted place-based city services; co-creating value through social cohesion, engagement and participatory collaboration.

Citizens are the backbone in shaping the Smart City. They provide the real needs that the city must address; at the same time, the city must ensure that citizens participate meaningfully in the practice regarding the city's urban planning process, working alongside businesses and other stakeholders.

3.1 Services infrastructure, layers and composition

As part of their work, the Aalto Design Factory team working with the consortium conducted a holistic analysis of the planning of cities and the division of key functions therein. Since the final goal of said team is to design the next generation of physical infrastructure for the LuxTurrim 5G+ family, the initial goal of the analysis was to create a better understanding of the services that the LuxTurrim 5G+ ecosystem should provide in different parts of a city. This, in turn, would inform the team's work with the physical infrastructure of LuxTurrim 5G+, specifically pertaining to the features that would be incorporated into that infrastructure in different areas.

1 More information from authors Sara Santos Figueiredo and Manuel Rosales Ramírez

The outcome of this analysis was an infographic to help visualise the distribution and focus of the various services the LuxTurrim 5G+ ecosystem could support, as well as to serve as a platform for further ideation on those services. As its development was the primary focus of the analysis, considerations as to the LuxTurrim 5G+ infrastructure also influenced the segmentation of the infographic.

Since the planning and zoning of cities differ greatly both from city to city and internationally, it would be impossible to produce a detailed overview of how different functions correspond to different parts of a city. In reality, the areas of a city have considerable overlaps: for example, residential areas often have commercial functions embedded within in the form of ground-floor stores

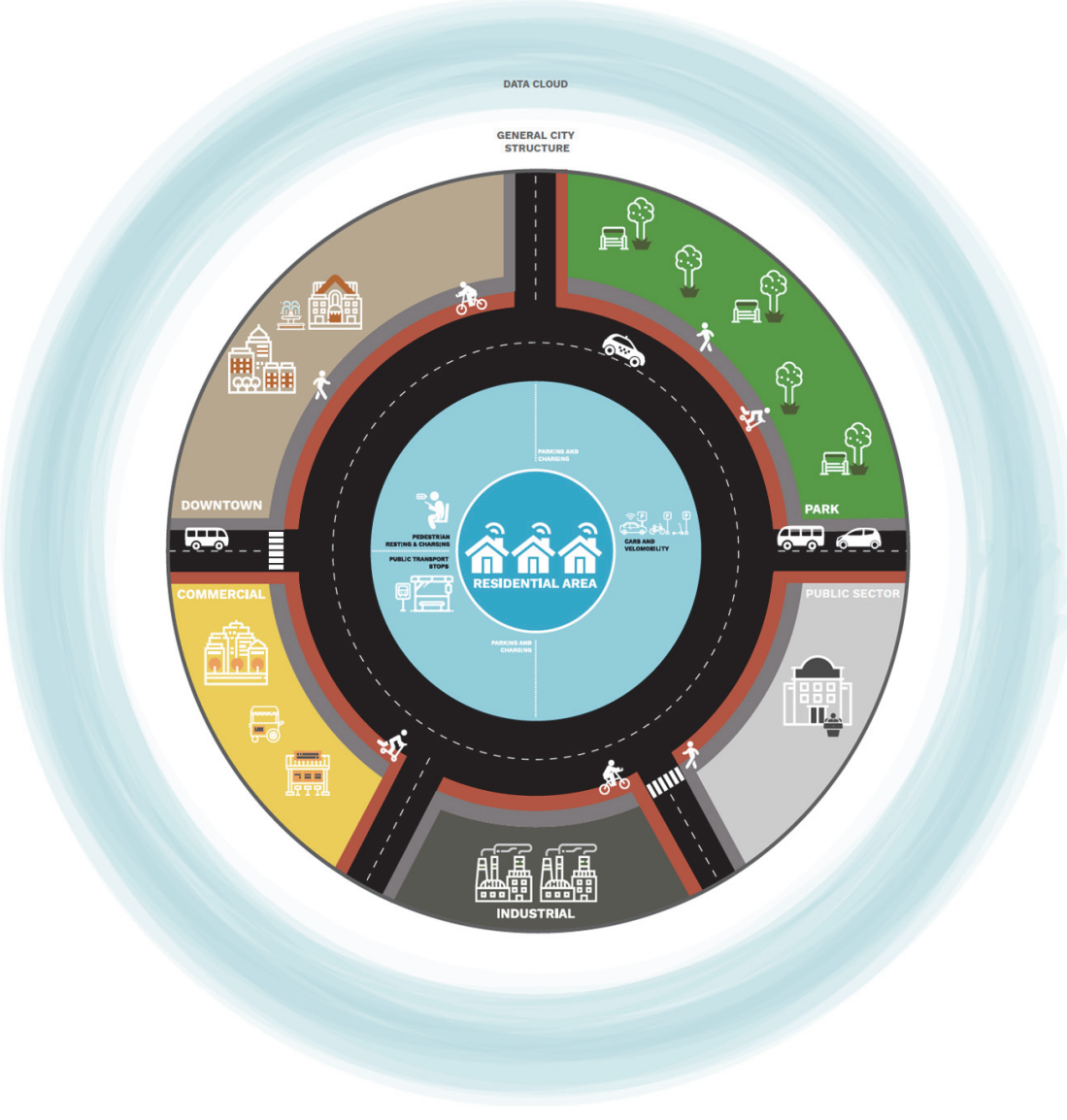


Figure 6: Infographic - City layers and compositions

and other services, especially in central areas. Furthermore, industrial areas are often interspersed with commercial parks, and green areas frequently exist in conjunction with residential or public-sector areas, such as campuses and governmental buildings.

The mixing of functions is also evident in rising trends in Finnish urban planning today: to optimise the use of space, many new or expanded shopping malls (such as Ainoa in Tapiola, Espoo or the Kamppi Centre in Helsinki) have apartment complexes built atop commercial spaces and other functions, namely public transport terminals. In the new plan for Espoo's Kera, which will act as a pilot program for a future smart city, services are deliberately mixed with residential blocks in order to bring the services to the residents and thereby avoid unnecessary commuting.

Thus, rather than attempting to provide an all-encompassing representation of a complex reality, the team instead set out to create an abstraction in which those functions would be represented by discrete zones, henceforth referred to as "layers", which stand in for areas and functions which may or may not overlap in reality. The locations of the layers in the chart are likewise abstract, and not indicative of those functions' physical locations within a city: the placement and segmentation of the layers was done largely for the purposes of visualising the information as understandably as possible.

The final infographic produced as a result of the urban area analysis takes the form of a series of concentric circles, some of which are further divided into various sectors. The innermost circle houses the residential areas; surrounding it is the parking and charging field, which is subdivided into fields for cars and velomobility, pedestrian resting and charging, and public transport stops. Around them are streets, which represent movement between the different areas. The next circle is segmented into parks, the public sector, industry, commercial areas, and downtown. Finally, around these sectors are two "meta-layers" that apply to all of the aforementioned areas: the general city structure and the data cloud. These layers are further described in the following.

Residential: Residential areas are placed in the centre of the chart. This layer represents any form of residence, from suburban detached houses to apartment blocks in city centers.

Parking and charging: The parking and charging layer represents the transition from one's residence to commuting to different parts of the city. Charging was given an emphasis in the chart as electric vehicles and personal smart devices are projected to become more common in the future, necessitating additional readily available charging points. Vehicle charging points have already been piloted in previous iterations of LuxTurrim 5G poles, as well as several other examples of smart poles worldwide.

The cars and velomobility field represent services meant for cars, bikes, scooters and other such vehicles; the latter examples being covered by the umbrella concept of "velomobility". Electric scooters and bikes, which are increasingly common, were a particular consideration as their users would benefit from charging services as well as potential IoT/smart vehicle locking and storage mechanisms.

The pedestrian resting and charging field represents services (or physical manifestations thereof) that the city can provide for pedestrians commuting or otherwise traveling within the city; the most obvious example being public benches. Charging in this case applies to smart devices, and would take the form of either USB sockets, or wireless charging surfaces, depending on when the technology is intended to be implemented.

The public transport stops field represents stops for buses, trams, and other modes of public transportation, and the activities and services that take place there. These sites have been recognised as one of the potential locations for smart city infrastructure. Within the consortium, the LuxTurrim5G+ project has already made a smart bus stop as one of their model examples. Said bus stop incorporates a concept by Teleste, branded as "Connected Zone", which uses the bus stop as a hub for a secure high-surveillance zone during an emergency.

Roads: Roads indicate travel between areas, whether it be through roads, streets, or other channels of transit.

Parks: Parks encompass all green areas that are part of cities, from thoroughly-maintained public parks within a city centre to forests.

Public sector: The public sector encompasses public facilities, such as governmental buildings, hospitals, schools, university campuses, etc.

Industrial: Areas covered by the industrial layer range from micro-industry to industrial parks, logistical centres, ports, and business campuses, but also pertain to industrial areas in the transition to other functions; one example of this being the new general plan for Espoo's Kera and the repurposing of its old logistics halls into spaces for sports, art, urban farming, and small-scale entrepreneurship.

Commercial: Commercial areas encompass any part of the city primarily dealing with private sector activity, such as stores, shopping malls, and megamarkets, as well as other miscellaneous privately-provided services such as hotels.

Downtown: The downtown, as defined in the layer structure, denotes the city's commercial, cultural and historical centre. Specific considerations as to the services in these areas include the high amount of traffic, the presence of tourists and non-permanent residents, as well as cultural landmarks.

General city structure: The general city structure is the first meta-layer, which surrounds the function-specific layers. It encompasses services that exist universally in all areas of a city.

Data cloud: The data cloud layer represents services that do not have a direct physical presence in any part of the city, but instead exist digitally within the Neutral Host ecosystem. While thus "invisible" to the regular citizen, this layer is a crucial consideration when planning the smart city services, as it forms the digital backbone of a smart city. It is here that the Neutral Host itself resides, processing and aggregating the vast amounts of data from across the city into a useful form, dispensing it to the proper parties, and, on the other hand, providing the means to manage the systems through which the data is gathered.

While dividing certain outward-facing services by area helps ideate and define those services, a meta-level view of the entire digital ecosystem is also necessary to understand how these services fit together, as well as how they are managed. Therefore, although the main focus of the Aalto Design Factory team's work remained on the physical infrastructure, the cloud layer was seen as an important factor in what form that infrastructure may eventually take. The data cloud also assumed further importance to the team's work through further sub-projects to better delineate and visualise the structure of the Neutral Host ecosystem.

3.2 An example of Service Clusters

The urban areas define specific services that citizens and the city need to operate. However, as urban areas share some spaces in the city, services within the city are shared too. To differentiate services by their purpose in the smart city, clustering them by their functions contribute to a better understanding of what needs they cover, independently of the urban areas they are present. The result of an extensive analysis cluster the services in six main categories: city monitoring services; transport and mobility services; cultural services; safety and emergency services; and public maintenance services.

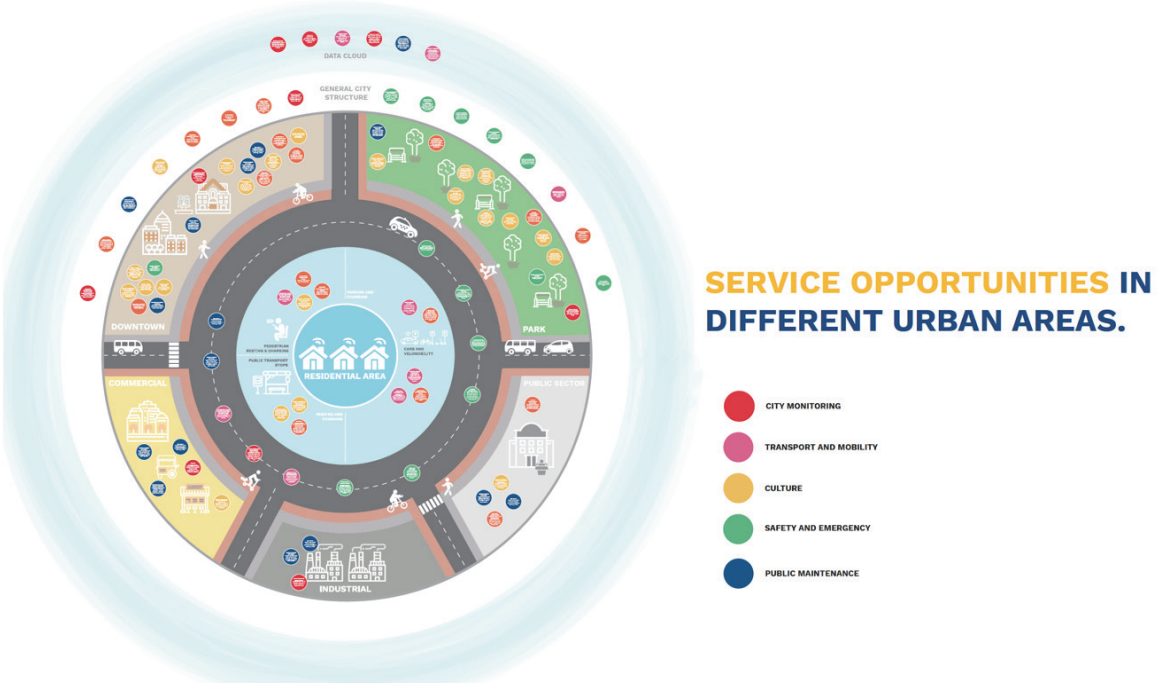


Figure 7: Infographic - Urban analysis of the service clusters

The city monitoring services cluster contains all the services related to surveillance, monitoring and awareness of the context in different layers in the city such as weather, people flow, emissions, roads' condition and others.

This cluster focuses on commuting needs and infrastructure that citizens require in different situations. The services contemplate different ways of commuting such as public transportation; e-bicycles and bicycles; e-scooters; private cars and pedestrian roads.

These services aim to enhance citizens' experiences in public spaces; they provide infrastructure that allows activities for engagement and participation of citizens; art installations and exhibitions; public events; learning; and historical context information.

Feeling secure and having a quick response during an emergency is crucial for citizens. These services focus on improving the operations for police, paramedics, healthcare and other situations that represent a threat to citizens' integrity and safety.

The city's infrastructure requires constant maintenance. This cluster contains solutions to improve urban spaces maintenance and operations.

Smart City services can be segmented into three main customers that capture most of the value of all services provided by the city. First, services that target the city management to improve their daily operations platforms; secondly, services for citizens to provide well-being; and thirdly, services for businesses and private services operators that add value to the ecosystem.

Figure 8: City Monitoring Services

Figure 9: Transport and Mobility Services

Figure 10: Cultural services

Figure 11: Safety and Emergency Services

Figure 12: Public Maintenance Services

3.3 Data marketplace and smart city services

A key part of the Design Factory team's work was also to create a proposal for the structure of the neutral host service platform in visual form. To accomplish this, the team conducted a brief benchmarking analysis, followed by an iterative process of mapping out the ecosystem on a digital whiteboard. Since the consortium does not yet have a clear model for the neutral host's structure, the Design Factory team was given considerable latitude to conceptualise the framework. As the details of the data marketplace have not been codified, many assumptions had to be made as to the relationships between the various parties involved with the platform.

The result of the analysis was a series of infographics visualising different aspects of the structure of the entire marketplace ecosystem. The infographics illustrate the relationships between the various public and private entities involved, payment models, the benefits for the different stakeholders, as well as the data sources and outputs in different parts of the process. The team went through three major stages of iteration to produce a singular model incorporating all aspects of the ecosystem. Due to its complexity, this all-encompassing model was then broken down into a collection of more specific infographics for better visual readability. These infographics, illustrated later in this chapter, include the following:

- Core analysis: summary covering key parties and relationships
- Stakeholders map: more detailed overview of stakeholders and instances
- Overview of value creation and capture: A chart detailing how value is generated within the different parts of the neutral host ecosystem
- Finally, more specific top-down analyses focusing on the following stakeholders were created: Data providers, Data buyers, Service consumers, and City department consumers.

The proposal is based around the data marketplace platform where data is monetised and exchanged. This data marketplace and its channels, illustrated in Figure 9, are owned by the city though the Neutral Host Pilot. The main stakeholders that interact with this data marketplace comprise of:

- The data providers that provide raw and processed data. Examples of these are the city's sensor network, corporations, individuals (citizens).
- The data buyers that tap into the data marketplace for this raw and processed data, which is aggregated, catalogued and anonymised.
- The city departments, such as the emergency and police departments, that receive confidential city data that is essential to their prime functionality
- The service consumers that use city services where city centric data provided by the data marketplace serves as the backbone to its functionality.

These main stakeholders are illustrated in and are further elaborated on later in this chapter.

The city and its various public departments are perhaps the most notable users of the data gathered by the various smart devices of the LuxTurrim 5G+ infrastructure, even confidential data that should be withheld from commercial actors for legal and ethical reasons. Therefore, we conceptualise the neutral host ecosystem as a so-called City Data Portal, which encompasses both the data marketplace and various channels through which the data is shared to different stakeholders.

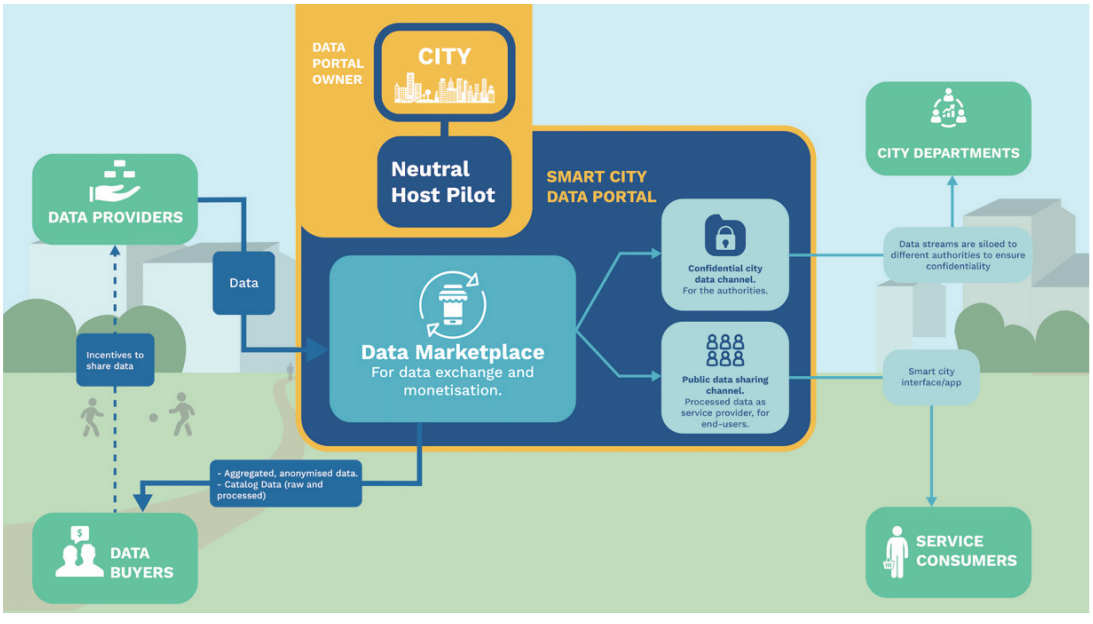


Figure 13: Infographic - Core analysis infographic

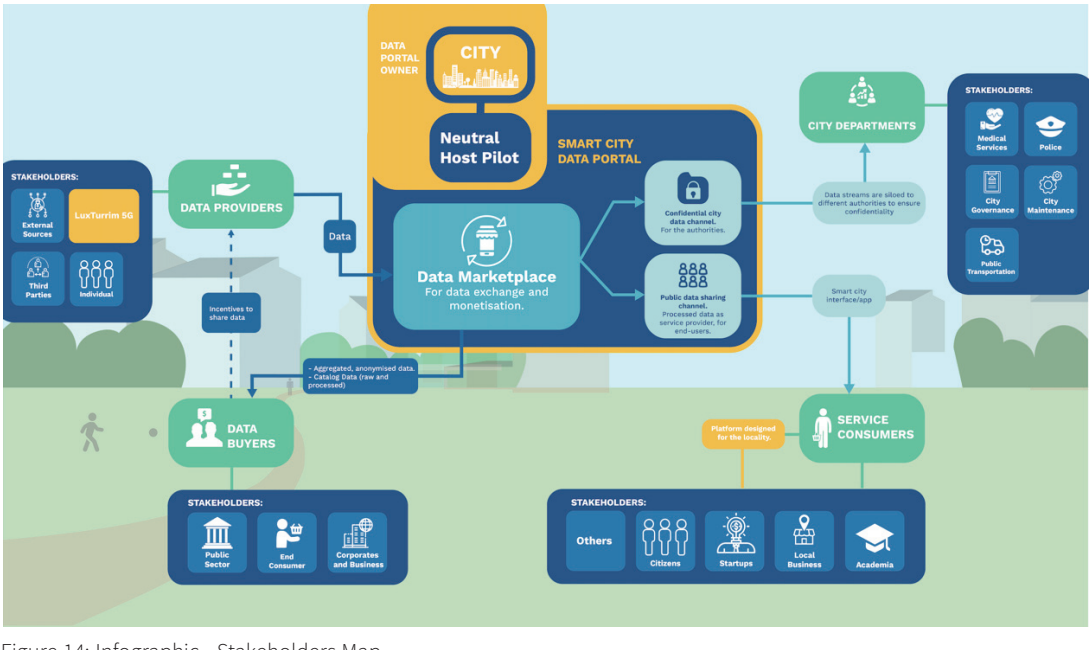


Figure 14: Infographic - Stakeholders Map

In our model, the City Data Portal is owned by the city through the neutral host wherein, one of its primary functions is to serve as an enabler for city services. In addition to the marketplace, which is available for commercial operators, there are two lanes for dealing with data targeted to the city authorities and citizens, respectively. The first is a confidential city data channel meant for the authorities. The second is a Public Data Sharing channel linked to a smart city interface or app for

sharing processed data, such as micro weather data, and providing access to a variety of city services for the benefit of the citizens.

To ensure security and to stay compliant to the GDPR laws, The Data Marketplace links the City Departments to the Data Providers through the Confidential City Data channel so that the city departments can receive sensitive data like citizen flow, facial recognition, cctv footage, hazard detection and audio streams, amongst others, essential to the functioning of a variety of public welfare and safety services. These data streams are siloed to the relevant authorities to ensure confidentiality.

The functioning of a variety of general city services rely on processed data coming from the data marketplace. These city services are made available to the Service Consumers via an integrated digital platform in the form of a smart city interface or app. This digital platform can be seen as a one stop shop for Service Consumers to access a variety of city services in the realms of Transport and Mobility, City Monitoring, Safety and Emergency, and Culture.

The Public Data Sharing Channel links this digital platform to the marketplace, providing the platform with data necessary to drive the city services.

In conclusion, the Neutral Host Pilot, its data marketplace, confidential city data channel and the public data sharing channel together make up what we have termed as the smart city data portal.

As mentioned earlier in this document, data marketplaces are platform ecosystems that collect data for exchange and monetisation. In those ecosystems, there are usually four main stakeholders surrounding the data marketplace that create and capture value from data that is located there as products; those stakeholders are the data provider, data buyer, data marketplace owner, and third-party service providers. When the data marketplace relates to smart cities, the city management departments and the citizens integrate into the stakeholder ecosystem.

In this section, the stakeholders for the neutral host data marketplace are described to understand who they are and their role in the ecosystem.

Ecosystem stakeholders:

- **Data provider:** The ones who generate and sell data for the marketplace are the data providers. The sources come from commercial and non-commercial stakeholders; moreover, the data they generate is classified into three types: archived data (historical), real-time operational data, and crowdsourced data. For instance, data providers (figure 11) are external data-based sources; third parties public or private organisations; individuals (citizens); and in this particular case for a smart city Lux Turrim 5G+.
- **Data buyer:** The ones who pay for data are the data buyers (Figure 12) they can buy data in different products categories such as raw data, derived (curated) data, algorithms, decision support data and automated decision-making data; however, data buyers can be data providers too if they sell their processed data to the marketplace. The main categories of buyers are public sector entities; private consumers; and corporates and businesses.
- **Data marketplace owner (Neutral Host):** The owner (Figure 9) is the one that hosts the data marketplace. It manages the data marketplace, its transactions and creates the data products for the other stakeholders.
- **City departments:** In smart cities, the city management departments (figure 13)—and the services they provide for citizens—require data products from the data marketplace to perform their daily operations. Even when they retrieve data from the marketplace, they generate data that is processed and collected. These stakeholders usually are police, public healthcare system, city maintenance, public transportation department, etc.
- **Service consumers:** These stakeholders are the end-users that benefit from the city services derived from the city departments and public open data (Figure14). These service consumers could use data from the city interface, either free or future marketplace business models that generates revenues for the city. The stakeholders could be for instance local businesses, start-ups, citizens, academia, citizens, etc.

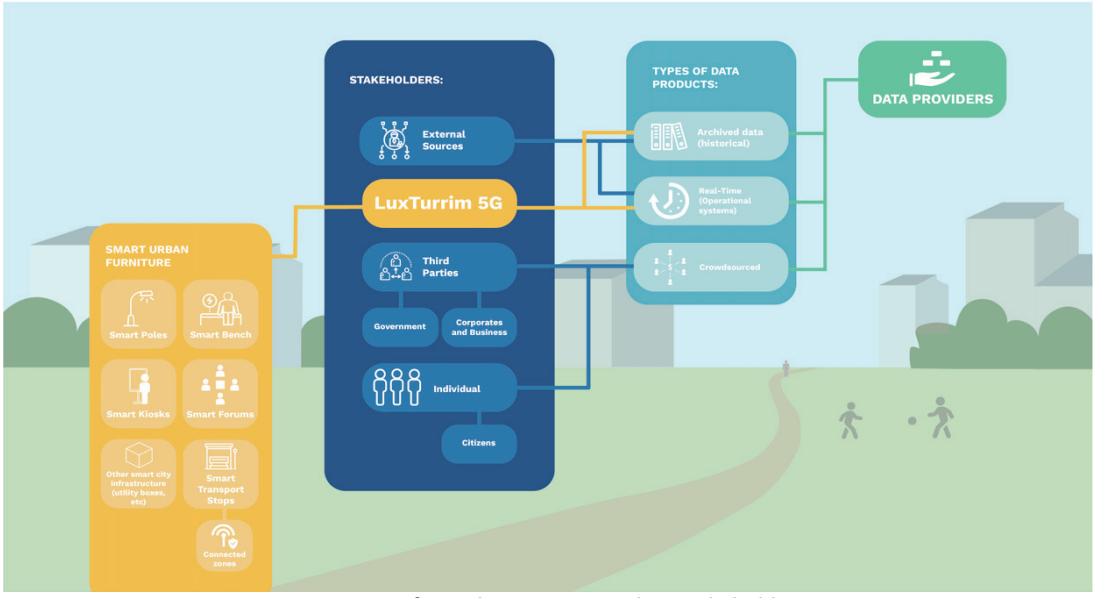


Figure 15: Infographic - Data providers stakeholders

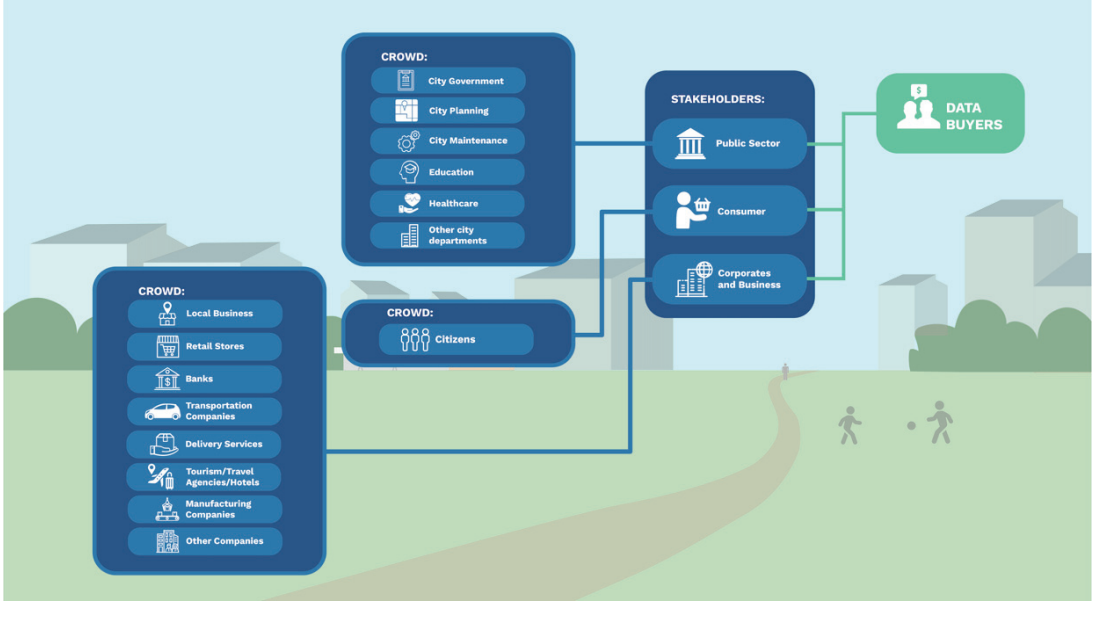


Figure 16: Infographic - Data buyer stakeholders

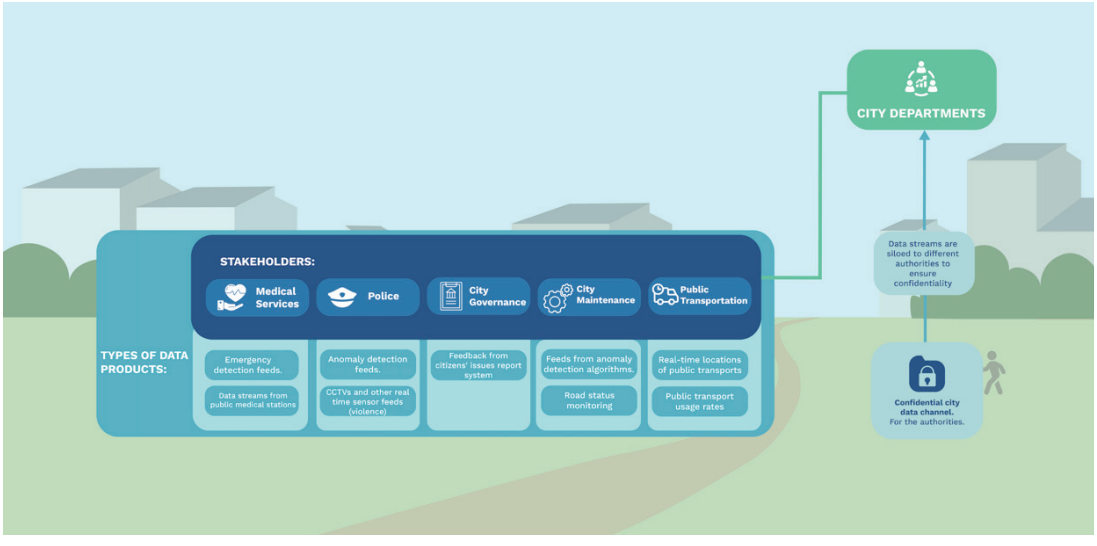


Figure 17: Infographic - City department stakeholders

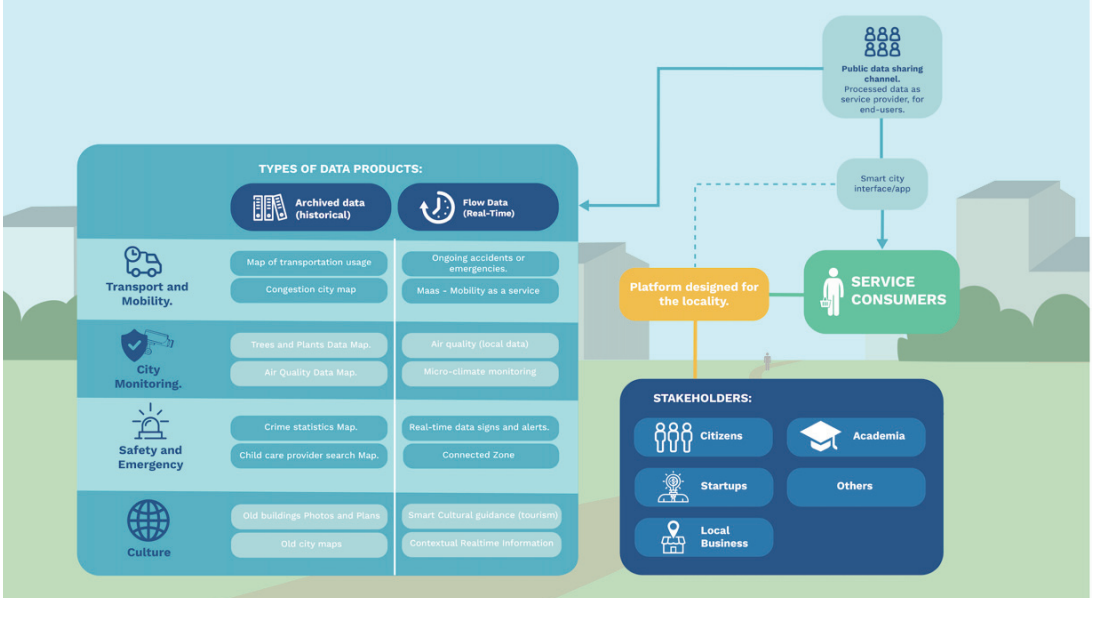


Figure 18: Infographic - Service consumer stakeholders

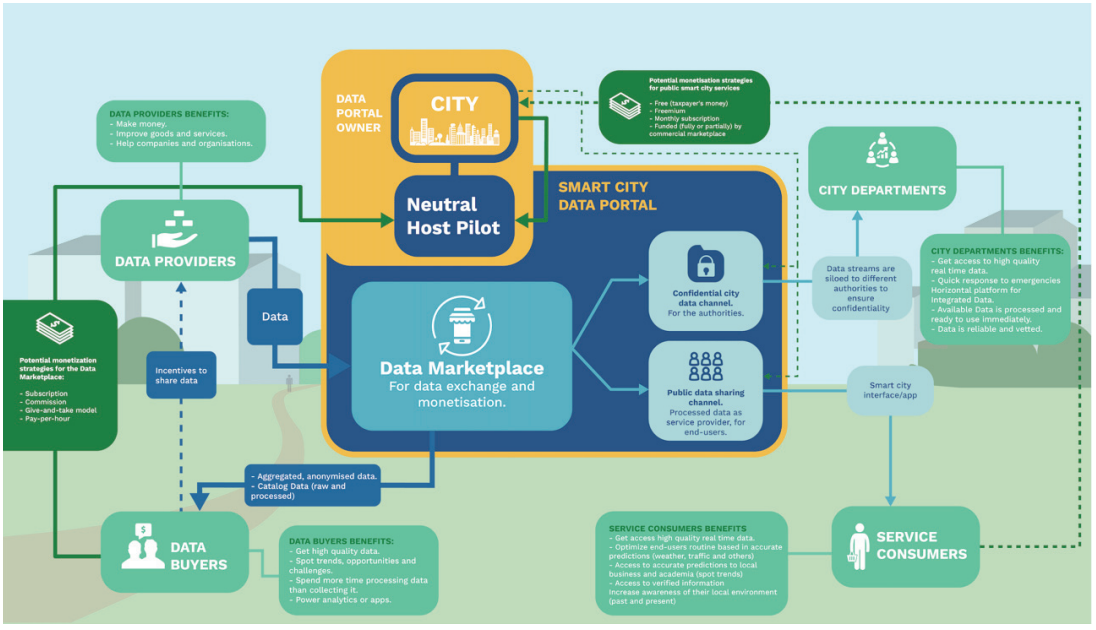


Figure 19: Infographic - Overview of value creation

Value is the worth of something in terms of the number of other things for which it can be exchanged; thus, data becomes valuable when providers exchange data or when it is sold as a data product among the stakeholders in the ecosystem. When suppliers exchange data, the value capture is shared equally by the stakeholders if it is the same type of data (e.g. raw data, derived data, etc.); on the other hand, when data is sold, the value capture reflects as a monetary transaction, in which the data provider set the product's price by the costs to generate it and its average value in the market.

From the city perspective, the value of data products is that digital services require them in their systems to operate; they use the data products to make their processes more efficient and reliable. As digital services retrieve data products from the data marketplace, simultaneously they create valuable data that is captured by the marketplace again to create other types of data products for data buyers. When it comes to citizens, the value captured by them resides in the public open data contained in the 'Smart City Interface' or the benefits that they receive using the city department services.

The discussion about the value of data products is related to how to identify which ones should be for open access (free) and which ones should be monetized. As the primary objective of smart cities is to fuel economic growth and citizens well-being; the data products related to that objective should be open to citizens and local businesses, the value capture should be aimed for them. However, to identify which data products can be monetized, further analysis should be done on which of the data products generated are not valuable for citizens that are valuable for private companies that are willing to buy them for their own purposes.

The outcome of the value capture by the stakeholders are the benefits that they get from the data products in the data marketplace.

Data buyer benefits:
- Get high quality data.
- Spot trends, opportunities and challenges.
- Spend more time processing data than collecting it.
- Power analytics or apps.

Data provider:
- Make money.
- Improve goods and services.
- Help companies and organisations.

Service consumer benefits:

- Get access to high-quality real-time data.
- Optimize their routine based in accurate predictions (weather, traffic and others)
- Access to accurate predictions to local business and academia (spot trends)
- Access to verified information
- Increase awareness of their local environment.
- Get access to a Horizontal platform for Integrated Data.

City department benefits:

- Get access to high-quality real-time data.
- Quick response to emergencies
- Horizontal platform for Integrated Data
- Available Data is processed and ready to use immediately.
- Data is reliable and vetted.

3.4 Concluding remarks

This chapter has provided us with an overview of the work and outcomes so far of the LuxTurrim 5G+ design research and development team at Aalto University Design Factory in the area of services within the LuxTurrim 5G+/Neutral Host Pilot ecosystem.

Firstly, we covered our human-centric approach to smart cities, which partly stems from our background as designers and in part from our research into smart city development worldwide. We then described our smart city infographic layer structure, created to ideate and map out smart services within a city. Third, we covered our model for categorising services in smart cities through a set of service clusters. Finally, we described our analysis and proposal for the structure of the neutral host data marketplace, its stakeholders, and the ways in which it could generate value.

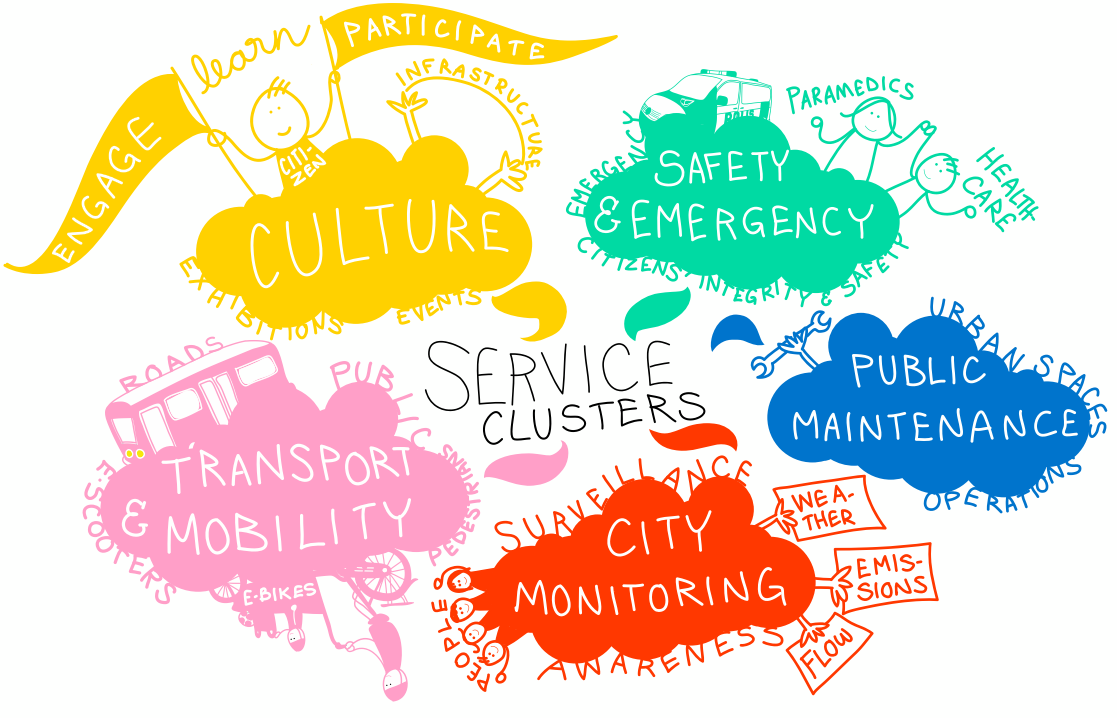


Figure 20: Example of service clusters

SECTION II:

STATE-OF-ART UNDERSTANDING OF NEUTRAL HOST BUSINESS MODELS IN SMART CITY ECONOMIES

4 ANALYSIS OF RELEVANT DATA BUSINESS MODELS[1]

Technological advancements in computer processing and storage capacities have enabled emergence of sophisticated software systems for data collection and processing in the city environment. However, fragmented product development projects have resulted in data silos that prevent third parties from exploiting data flows within the developed products and services. Collected archival data and near real-time data streams contain latent value that remains to be exploited.

Data business is emerging and new data business models are created to leverage private, public, open, and commercial data collected and processed. Data business models can be grouped into three categories (Schroeder, 2016): data users find new possibilities for utilizing data in developing their own business, data suppliers create, collect, mash-up and process data for various purposes, and data facilitators provide technologies and support for finding and exploiting new data.

In this section, we introduce the business potential of emerging data business, present some key technologies that are being developed to facilitate data sharing and data business, give examples of state-of-the-art data market places and give examples of data business models in the smart city context. As a conclusion, we consider what kind of activities and data business models there are and emerge as future smart city data economies are pursued.

4.1 Emerging data business and new business potential

The amount of data increases exponentially due to advancing technological development and global megatrends such big data, cloud computing, mobile technologies, social media, cognitive systems, robotics, 3D printing, IoT, blockchain, 5G infrastructures and privacy enhancing technologies (IDC, 2019). It is estimated that the global data sphere reaches 175 zettabytes by 2025 (Reinsel, Gantz and Rydning, 2017). However, a significant portion of the data is private and cannot be accessed by third parties. The data is stored beyond the reach of new applications and secured in proprietary databases or individual electronic devices. This hidden data contains hidden value that is not currently realized to address societal, environmental, healthcare, energy consumption and production, circular economy, sustainability and security challenges of smart cities. Data sharing is crucial for businesses and societies, and thus data business is emerging to give the needed motivation to open up currently inaccessible data streams and storages for new applications.

Data business enables sharing of data between different stakeholders in the markets, which provides benefits from different perspectives. Data users can access data more easily and cost-efficiently for the development of new data-driven products and services, and data suppliers are motivated to improve their data products and services to support the development of added value services by third parties. Furthermore, increased data sharing may lower the transaction costs of gathering data and allow data sources to combine their databases with minimal organizational changes (Pitkänen et al., 2019).

Motivation for data sharing comes from direct business benefits in business networks, and furthermore the data itself is the subject

1 More information from authors Marko Palviainen and Ville Kotovirta

of commercial activities in the emerging data markets. The number of companies sharing data within their business networks has been growing steadily alongside new technological innovations such as EDI, I-EDI and web service API's, being now 49% in Finland for example (Huttunen, H., Seppälä, T., Lähteenmäki, I., Mattila, 2019). As a result, data sharing creates a significant market in the Europe. According to IDC (2019), the value of data economy exceeded 300 Billion Euro in 2018 for EU28, and with annual growth of 12% the market will reach 680 billion Euro by 2025. EU has recognized the emerging data business and its importance is reflected by the EU strategies such as Digital Single Market, European Data Economy, Digitising European Industry, and the Internet of Things (IoT) (EC, 2017).

New cooperation has emerged in the European level to support the utilization of big data and promoting the development of data business. For example, Big Data Value Association (BDVA) is an industry-driven non-profit organization and the private counterpart to the EC to implement the Big Data Value PPP program. BDVA's mission is to enhance big data value creation and artificial intelligence in Europe, thinking data as a new currency underpinning a new data economy and catalysing the European economy to develop faster and more effectively (BDVA, 2019).

4.2 Rulebook for fair data economy

Data economy requires data networks that are fair, balanced and lawful in their processing of data (Pitkänen et al., 2019). These data networks must be just and impartial toward their members, ensure that the right of third parties are not infringed, and make sure that EU level and applicable national data protection regulations are followed in processing of personal data. The data network must identify and manage risks associated with the sharing and processing of data and ensure compliance with relevant competition legislation and that the data network will not have a negative impact on market competition and consumers (Pitkänen et al., 2019).

A workgroup in the International Humans Account Network (IHAN) programme of the Finnish Innovation Fund Sitra has published a Rulebook Template providing templates and a checklist to promote the fair data economy and creation of new data networks based on mutual trust that shares a common mission, vision and values (Pitkänen et al., 2019). As a result, it is easier for companies to define rulebooks for data networks, to assess requirements imposed by applicable legislation and contracts appropriately, and to adopt practices promoting the use of data and management of risks (Pitkänen et al., 2019).

For example, the provided templates assist companies to establish contractual frameworks for their data networks to define the legal relations within their data networks and to set out general terms and conditions for data sharing agreements. The checklist for key data related questions highlights the most important aspects to consider when building a data-driven collaboration and network. The checklist consists of:

1. Business questions - The key business questions related to data networks. This category includes questions considering value and utilization of data, data rights, and governance.
2. Legal questions - The key aspects to consider from the legal perspective. This category includes questions considering contractual principles, responsibilities, and content.
3. Technology questions - The key issues to be solved as part of the data network solution. This category includes questions considering infrastructure and common solutions, core functionality, and administration.
4. Data questions - The key questions related to data to be delivered in new data networks. This category includes questions considering governance and data structure.

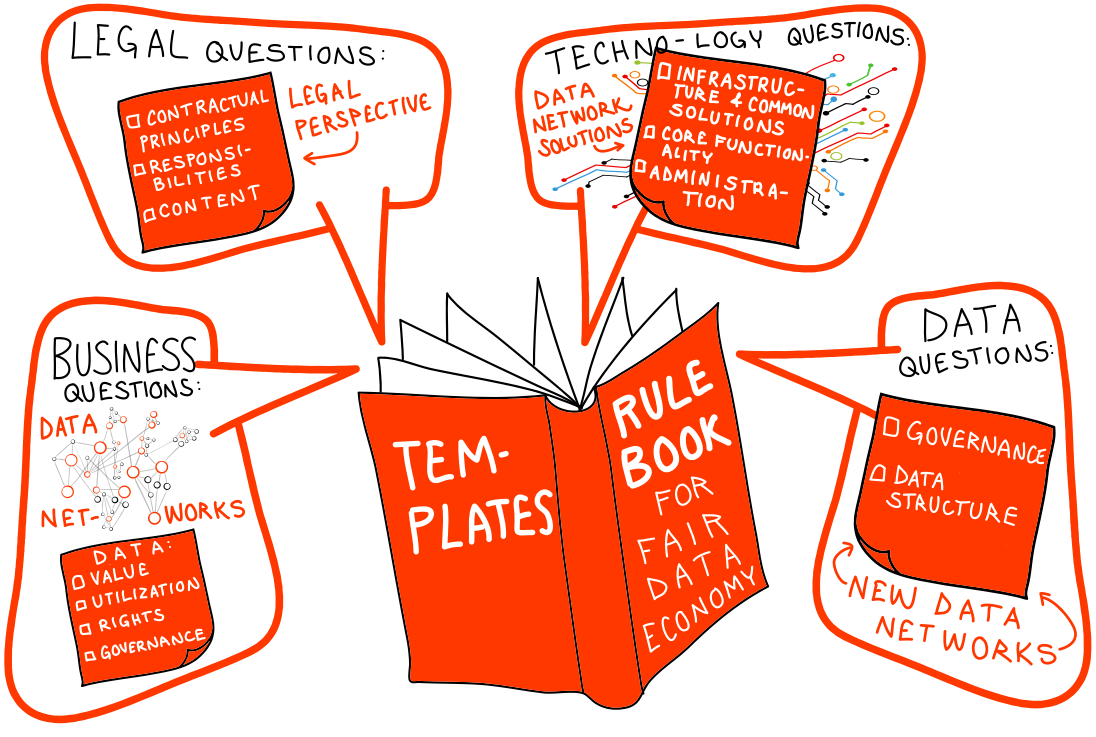


Figure 21 Rulebook for Fair data economy

4.3 Technologies for data sharing and data business

Technologies are being developed for data sharing that also include data market and data business perspectives. The reference architecture model for an International Data Spaces (IDS) promoted by International Data Spaces Association (IDSA), has its roots in the Industry 4.0 initiative, but since evolved towards broader business data transactions. It is increasingly recognized by key industry as the de facto standard for a trusted decentralised data space within which data can be securely shared while respecting sovereignty. A number of private reference implementations are in place. The IIC's Layered Databus is another emerging standard advocating the need for data-centric information-sharing technology to enable data market players to exchange data within a virtual and global data space. Since late 2018 the IIC joined forces with OpenFog, another relevant consortium that provided its own reference architecture. Fiware is an open source initiative defining standards for context data management for development of smart IoT solutions.

For personal data GDPR has come into effect to protect personal data collection and use. MyData Global was founded to promote the development of technologies managing and protecting personal data. IHAN (International Humans Account Network) is a project lead by the Finnish Innovation Fund Sitra, aiming at an international standard for personal and company data accounting. The Estonian company Cybernetica has developed UXP technology for trusted data sharing of personal and industrial data. The technology is used by Estonian X-road, and by Finnish Suomi.fi-Palveluväylä, service busses to exchange data securely between authorities and citizens.

Data exchange protocols for data business including smart contracting and micropayments are being developed. A revenue model based on usage rather than a flat subscription requires a backend that can deal with sales where individual data points may only be charged in fractions of a cent (Martin De Saulles, 2018). For example, Startup Streamr uses blockchain technology to issue its own virtual currency, the DATAcoin, that can be used on its data exchange. Datapace is adopting a similar strategy while Databroker DAO's DTX token can be divided down to 18 decimal points providing far greater flexibility for micropayments than traditional fiat currencies (Martin De Saulles, 2018). Ocean Protocol is a decentralized data exchange protocol that provides governance, incentives and value creation tools enabled by asset tokenization propelled by blockchain technologies. IOTA develops data sharing technology based on distributed ledger technology called "tangle" for data business. Their currency MIOTA is exchanged worth 10M$ per day.

4.4 Digital platforms as data marketplaces facilitating business

Digital platforms, which are often referred to as "electronic marketplaces" or "multilateral marketplaces", are businesses that enable and support interactions between distinct but interdependent groups of users (customers and suppliers) (Fruhwirth, Rachinger and Prlja, 2020). The platform acts as facilitator of exchanges of goods by using pricing strategies, and as participants co-create value between each other and create a "network effect" that means that a good or a service acquires more value to its user as more users adopt it. Network effects create self-reinforcing mechanisms that lead to market leadership, a large customer base economy of scale and the establishment of boundaries for other players (Fruhwirth, Rachinger and Prlja, 2020).

There is going a transition from the SaaS model to platform thinking and the Application Programming Interfaces (API) are a key enabler for digital platforms. For example, the online Web API registry, ProgrammableWeb (http://programmableWeb.com), has enjoyed a compounded annual growth rate of 100 percent (approximately) from 2005 to 2011, in terms of the total number of APIs registered (Tan et al., 2016) and now there are more than 22.000 registered APIs in the API directory of ProgrammableWeb. With the formation of this API ecosystem, an API economy is emerging (Tan et al., 2016). For example, 60 percent of Salesforce's transactions go through its APIs instead of the traditional Web GUI, contributing to its 1.3 billion daily transactions and more than $5 billion in annual revenue and 90 percent of Expedia, 60 percent of eBay, and 100 percent of Amazon Web Services (AWS) revenue are from APIs (Tan et al., 2016).

API ecosystems support data economy and can provide data for data users and processing services for data suppliers. Firstly, the Web APIs use typically REST as the communication protocol and JSON as the content format that together provide easy and more straightforward access to available data sources and data processing services (Tan et al., 2016). Secondly, in the API economy, a service usually represents a minimal reusable component that can be combined with many other services, forming value-added business processes, also known as composite services (Tan et al., 2016).

As the data business and data sharing technologies are emerging, data marketplaces are becoming increasingly popular in theory and practice. In general, the data market places offer a data exchange infrastructure by acting as intermediaries that create a link between data providers and data buyers (Spiekermann, 2019). Many market places have emerged, some of which have already been closed (e.g. Microft Azure data market place and InfoChimps), while many are running and growing (e.g. Dawex and IOTA). Spiekermann (2019) compares various data market places based on selected characteristics, e.g. whether they are transaction-centric or data-centric, cross-domain or domain-specific, or

whether their architecture is centralized or decentralized.

Data Market Austria is an Austrian lighthouse project developing the technical, legal, and business basis for a data market. The technical basis focuses on decentralised provision of both data and services through making standardized metadata visible to a search engine. The legal aspects have been analyzed from the Austrian perspective, but this could serve as a basis for similar analyses throughout Europe. The Finnish company Platform of Trust is developing a data market place for real-estate domain. Currently they are developing a data model and creating data connections between Finnish stakeholders. Their pricing model includes freemium, a transaction fee and two levels of monthly costs to get support for data publishing and monetization.

Caruso is developing a market place for mobility data and services. The aim is to market existing assets, compare data and services available, build new business cases and find new customers. Caruso is neither offering data nor services themselves, but brokering neutrally data and services in the ecosystem. The oneTransport data marketplace developed by Chordant Inc. focuses on traffic data. It began as two-year field trial in the UK with a set of private sector partners in city planning, transportation economics, sensor network management and advanced analytics. Currently it provides data storage and sharing services, and the pricing model includes a brokerage fee of 10% of data purchase fee. Dawex is developing a data marketplace that is currently being used by 7000 organizations from 20 sectors. Their pricing model includes a free access to find and monetise data as well as monthly subscriptions for businesses to get personalised advice and more advanced features. Dawex claims to be the largest cross-domain data market place, and with the yearly revenue of <10M€ (accurate figure was not available) they give a state-of-the-art example of a business volume possible to gain from data mediation.

Many market places are dedicated to static datasets, but some are considering also the use of real-time data sources and streams. BDEX Data Exchange Platform (DXP) is a dedicated market place for consumer data in order to enable focused marketing and selling. Finnish Streamr is creating a data stream economy for real-time data, where a device or person producing data can sell data and receive data coins in return and with the coins buy data from other sources. Streamr initiated their market place by releasing 1 billion data coin for 30 million Swiss francs, and currently, Streamr data coin is exchanged worth of 1M$ a day. It should be noted that the turnover of Streamr is less than the volume of daily data exchange. This example illustrates that a market place is a catalyst, and the value increase comes from utilisation of data by actors operating in the market place.

In addition to mediating data between vendors and buyers, there are digital platforms that create value-added data products from raw data. For example, Teralytics is monetizing mobility data by analyzing mobility patterns to improve targeted marketing, reach optimal audience segments, recognize new customers, measure ROI, improve public transport and analyze optimal locations for shops, outdoor media or ATM's. Their yearly turnover of 5M€ gives a state-of-the-art example of business volume gained from data monetisation and value-added data product creation. Turku City Data Oy is monetizing smart city data by creating value added data for new applications, e.g. an application for delivering food bags to people who stay home because of corona restrictions. The company is owned by the city of Turku, and operates currently mainly in Turku, but their vision is to serve other cities in Finland and elsewhere. Turku City Data Oy does not produce or own data, but processes and analyses data on behalf of their customers who develop services for end-users. The platform includes data quality control, event detection, data analytics, natural language processing and synthetic data generation for supporting privacy critical application development. Data models are reusable, which enables efficient creation of new use cases using similar data sources.

4.5 Data business models for smart city data economy

This section focuses on business models that are a fundamental part and enabler for a smart city data economy. The authors in (Osterwalder, Pigneur and Tucci, 2005) clarify the concept of business model, its usages, and its roles in the Information Systems domain and defines that:

> *"Business model is a blueprint that describes how a company does business"*

and:

> *"A business model is the translation of strategic issues, such as strategic positioning and strategic goals into a conceptual model that explicitly states how the business functions. The business model serves as a building plan that allows designing and realizing the business structure and systems that constitute the company's operational and physical form."*

Smart city data economy requires understanding how to provide commercial data and how to use commercial data to create value. This requires business models for data suppliers, data buyers, and data facilitators that enable selling and delivery of commercial data in smart cities. For example, Data-Driven Business Models (DDBMs) should (Kühne and Böhmann, 2018):

- Represent data types - As data is an essential key resource and the basis of DDBM and thus it should be represented in the business model. Business can be based on external or internal data that can have an influence on other parts of DDBM. As an example, external data from the customer cause the key activity data gathering because the data is not available within the organization but is stored on an external machine which is based at the customer's location.

- Represent quality, security, and availability requirements for data - The business model should cover confidentiality, integrity and availability issues. For example, inadequate quality of data will have a negative effect onto the data-driven value proposition. An example for this is predictive maintenance. If not all necessary data is provided, this can cause false maintenance intervals which have a negative effect on the customer's satisfaction. Thus, the data quality should be high and the aspects of security, confidentiality, integrity and availability should be covered within DDBM.

- Represent key activities related to data - The activities such as data visualization, data distribution, data generation, data acquisition, data analytics, and data management activities can process data and generate some new or changed data outcome. As these activities are the core of a data value chain, these activities should be represented in the business model and the connection to data should be clear.

- Represent data suppliers - Data can be obtained from the customers or partners of the company. This connection should be represented in DDBM to visualize and analyze effects of the key resources to the partner and customer perspective.

- Represent data-driven value proposition - The data-driven value proposition can be data, information/knowledge, or a non-data product or service. All in all, a DDBM causes a new or improved product or service that should be represented in the DDBM, too.

- Represent data revenue models - There are many possible revenue models in DDBM such as usage fee, subscription fee, licensing, lending, renting or leasing, asset sale, advertising, gain sharing, buy-and-sell- data and pay-with-data.

- Represent customer relationship patterns - If the business depends on data from the customer, the customer relationship is an important factor. For example, a company needs customer data about their consumption of products to build

endure-ads. Without this data, the business model cannot be successful because of the missing key resource data. Thus, the customer should trust the organization to give his private data to them. Such customer relationship patterns should be integrated into DDBM to help an organization analyzing and developing the customer relationship for their DDBM.

- Represent links to the foundational business models - If an established company develops a DDBM, a foundational business model of that organization already exists. For example, a car manufacturer can be a data supplier that sells data from wiper activity to support weather forecasting. The weather forecasting is a completely new business model for that organization but there are connections to the foundational business model. Without the car which is the value proposition of that foundational business model the data for the weather forecasting cannot be provided. Thus, there is a connection between these two business models which should be available in DDBM that helps the organization to trigger changes in DDBM if something changes in the foundational business model.

There exist data business models for open data and for big data that provide a starting point for smart city data economy. These business models are discussed in more detail in the following paragraphs.

The open data business models are developed for commercial use of open data that is typically government data published in an open format. The analysis of the use of open government data in companies provides empirical evidence regarding the potential of open data to generate innovation and competitive advantage and economic value (Magalhaes and Roseira, 2017). The commercial use of open data can be based on following five distinct, yet non-mutually exclusive, processes (Magalhaes and Roseira, 2017):

- Data to fact – individuals may seek out facts in an open dataset and by this way support their engagement in civic or bureaucratic processes, or in business planning.
- Data to data – sharing derived data. A whole derived dataset may be shared, an API onto a dataset created, or an interface that makes it easy to download subsets of a large dataset.
- Data to information – using one or more data sources for creating a static representation and interpretation of data. The produced information can be visualizations, blog posts, infographics and written reports. The data users can use AI or machine learning (ML) techniques for data analytics to extract higher-level information and knowledge from data. ML can be used in analysis tasks such as in structure discovery, finding unusual data points, predicting values, predicting categories, and feature extraction tasks (Saeid, Rezvan and Barekatain, 2018). For example, ML is used for analyzing the data collected from IoT-based systems that provides services and data for energy, mobility, and urban planning in smart cities (Saeid, Rezvan and Barekatain, 2018).
- Data to interface – creating a means to interactively access and explore one or more datasets. For example, creating a searchable mapping mash-up, or providing a tool to browse a large dataset and crowd source feedback or scrutiny.
- Data to service – where open government data plays a 'behind the scenes' role in making some online or offline service function. For example, the use of boundary data to route messages reporting potholes to the responsible authority.

Big data is more and more important element in a well-functioning economy. There will be more and more sensors, network capacity, and processing power and more advanced processing units for big data produced in a city environment.

The used business model depends on a company's role in data business. The companies can be grouped into following three categories in data business (Schroeder, 2016):

1. Data users - These are companies engaged in answering the question: how can data be used to create value within our business? Data users can use data either to inform business

decisions, or as an input into other products and services. For example, the IoT is based on the collection, manipulation and exchange of data. A key commercial driver for IoT investments is the value of this data in terms of how it can be deployed within business applications (Martin De Saulles, 2018). Like any emerging market, liquidity is required to make it worthwhile for data users and data suppliers to engage with each other and IoT data exchanges have a vital role to play in providing that liquidity (Martin De Saulles, 2018).

2. Data suppliers - These are companies that either generate data that is of intrinsic value and therefore marketable, or else serve a kind of brokerage role by providing access to an aggregation of data (Schroeder, 2016). These companies need not to specialise in the supply of data, but they can hold data that are of considerable value when some third party puts it to a use other than that for which is was originally collected. Since, like most information goods, the fixed data production costs are usually high relative to the variable costs of distribution, there are potentially large efficiency gains from this kind of data reuse (Schroeder, 2016). For example, a data supplier can follow the Data-as-a-Service (DaaS) strategy and expose its provided data through APIs on a cloud (Vu et al., 2012). As a benefit, the data users do not need to fetch and store giant data assets and search for the required information in the data asset but they simply find a suitable DaaS that provides the data asset having the desired information and call the corresponding APIs to retrieve the data (Vu et al., 2012).

3. Data facilitators - These companies focus on supporting third parties that are lacking in infrastructure or expertise and can perform a range of services including advice on how to capitalise on big data, the provision of physical infrastructure and the provision of outsourced analytics services (Schroeder, 2016). Data facilitators are in an especially important role as currently there are a large number of firms reorganising to make data more central to their business, but still lack the expertise or capacity to do so entirely internally (Schroeder, 2016).

Following subsections discusses data business models in more detail by providing business model canvases for five companies that act in a data user, data supplier, or data facilitator role in a smart city data economy for creating value from data. It is important to note that the companies will often act in several roles at the same time in data business. For example, a company can be a data supplier that provides processed data for its customers, but at the same time, be in a data user role as it buys data from other actors in the data market.

4.5.1 Business model example: a data user of location data

Data users can use data to inform strategic decisions and integrate data into their products. For example, Figure 16 depicts a business model canvas for a location technology company that creates value from maps, real-time traffic and travel information by improving driver navigation and by making autonomous driving a reality. The company is in a data user role as it uses smart city and location data to improve its products and services.

The company performs software engineering, service development and product development for providing products and services for different customer segments. The company gets revenue streams from licenses and from sale of services and goods. The costs consist of research and development costs, marketing expenses, and personnel expenses.

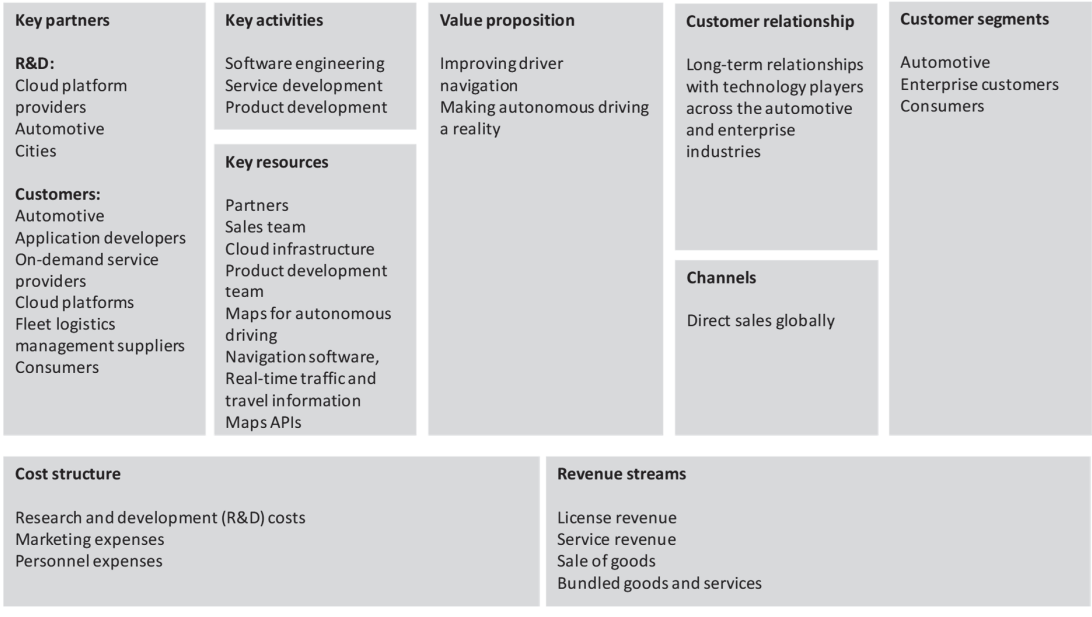


Figure 22: A business model canvas for a location technology business

4.5.2 Business model example: a data supplier of pedestrian and bicyclist information

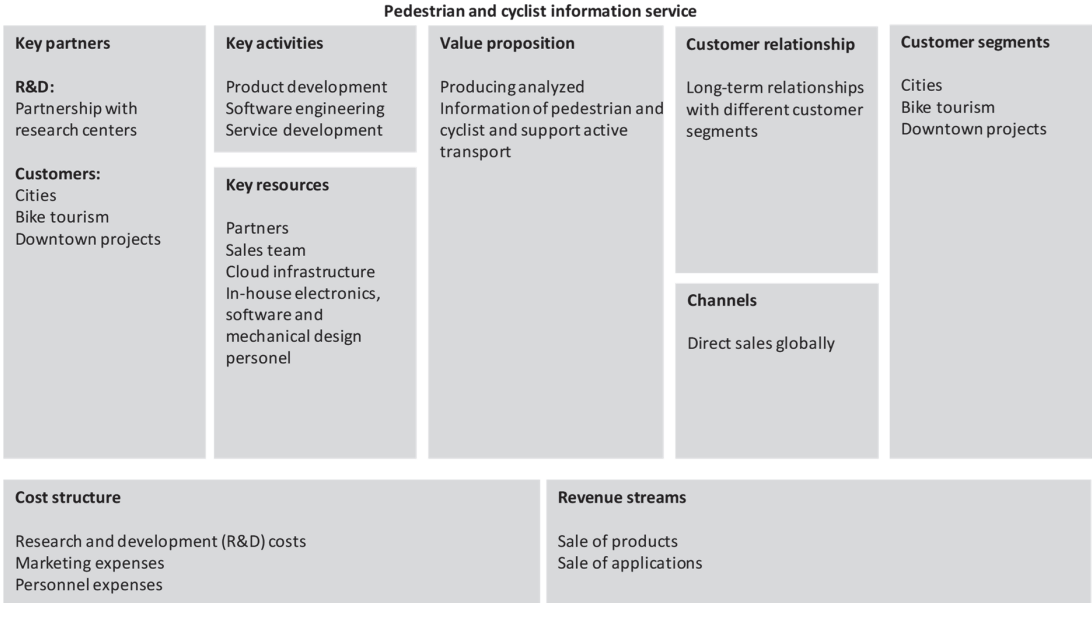


Figure 23: A business model canvas for a pedestrian and cyclist information service

A data supplier can generate data or aggregate and package data for sale. Figure 17 depicts a business model canvas for a company that focuses on producing analysed information of pedestrians and cyclists. The company is specialised in pedestrian, bicycle counting solutions, and offers a complete range of products from sensors to data analysis software to support active transport.

The company is in a data supplier role and follows the Data-as-a-Service (DaaS) strategy as it provides data about pedestrian and bicycle counting and APIs for pedestrian and bicyclist information sharing. The company performs software engineering, service development and product development for providing products and services for different customer segments. The company gets revenue streams from sale of applications and products. The costs consist of research and development costs and of marketing and personnel expenses.

4.5.3 Business model example: a data supplier of added value smart city data

A data supplier can collect data from open and proprietary sources, create additional value by processing and analytics, and provide added value data to end-user service developers. Figure 18 depicts a business model canvas for a company that focuses on monetising smart city data for various applications. The company has developed a data platform that enables data quality control, data processing, analytics, and simulated data generation. The customers include city departments and companies who develop new data-driven services for citizens, city personnel and other actors in the city domain. Different use cases are implemented in cooperation with partners such as city departments, universities and companies. First, the required data models and processing are developed, and then integrated into the platform to be operated and maintained as automatically as possible.The company is in a data supplier role as it provides API's for service developers to access the added value data. The company gets revenue streams from smart city data consultancy and subscription fees of using the data API's. The costs consist of research and development costs, server costs and marketing and personnel expenses.

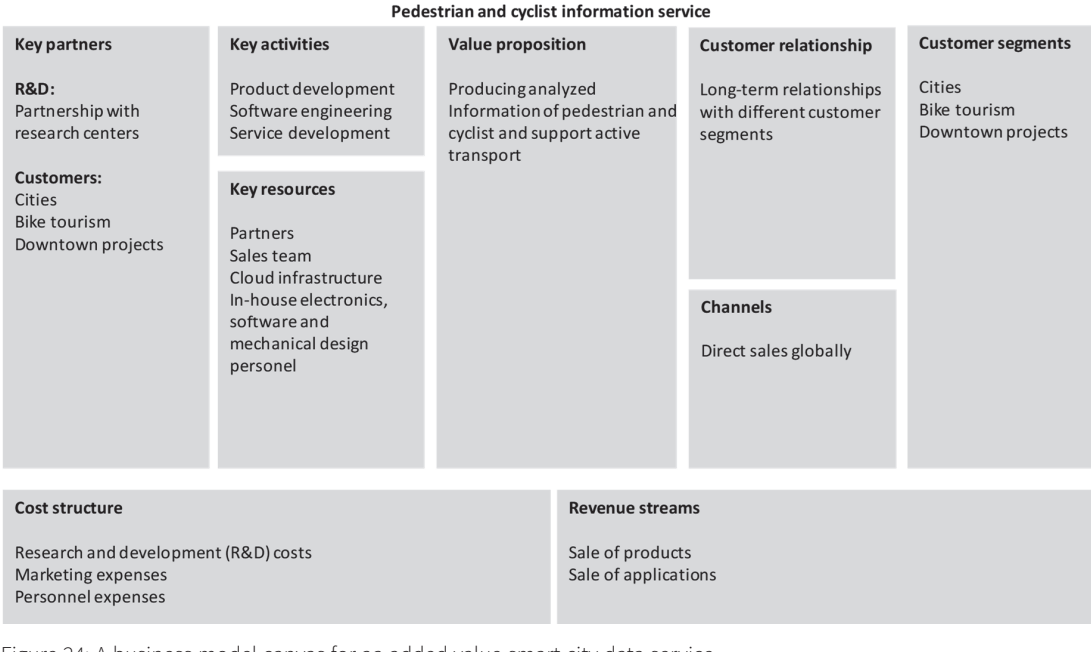


Figure 24: A business model canvas for aa added value smart city data service

4.5.4 Business model example: a data facilitator providing a harmonized data platform

Data facilitators are firms that support other organisations in creation of value from data. Figure 19 depicts a business model canvas for a company that is in a data facilitator role and provides a platform, APIs, and data models to support use of harmonized data in different kinds of business cases for real estate industry. The platform assists achieving more efficient service processes and better customer experience as it makes creation of data flows between the systems of different stakeholders more cost-efficient and faster. For example, the platform is harmonizing and transferring the real estate data coming from building automation systems and energy systems of different parties. The platform pairs the data with real-world objects, like apartments, rooms and devices so that they are readable and understandable for machines to read.

The company performs activities such as software engineering, platform development, and API and data model development and gets revenue streams from selling the platform as a service. The costs consist of research and development costs and of marketing and personnel expenses.

4.5.5 Business model example: a data facilitator providing data exchange technology

Figure 20 depicts a business model canvas for a company that is in a data facilitator role and provides a platform and data marketplace for data exchange in and between multiply domains. The company assists monetization of datasets and APIs, raw data, refined data and insights by providing a global marketplace for trading of customer and product-related data, financial data, and IoT data. The traded data can be licensed as one-off deals or by subscriptions. The company has partners such as data traders, consults, engineering service providers, and data platform publishers that provide support services for the data marketplace users.

The company performs software engineering, service development, and platform development activities and gets revenue streams from monthly fees and from data sale commissions. The costs consist of research and development costs and of marketing and personnel expenses.

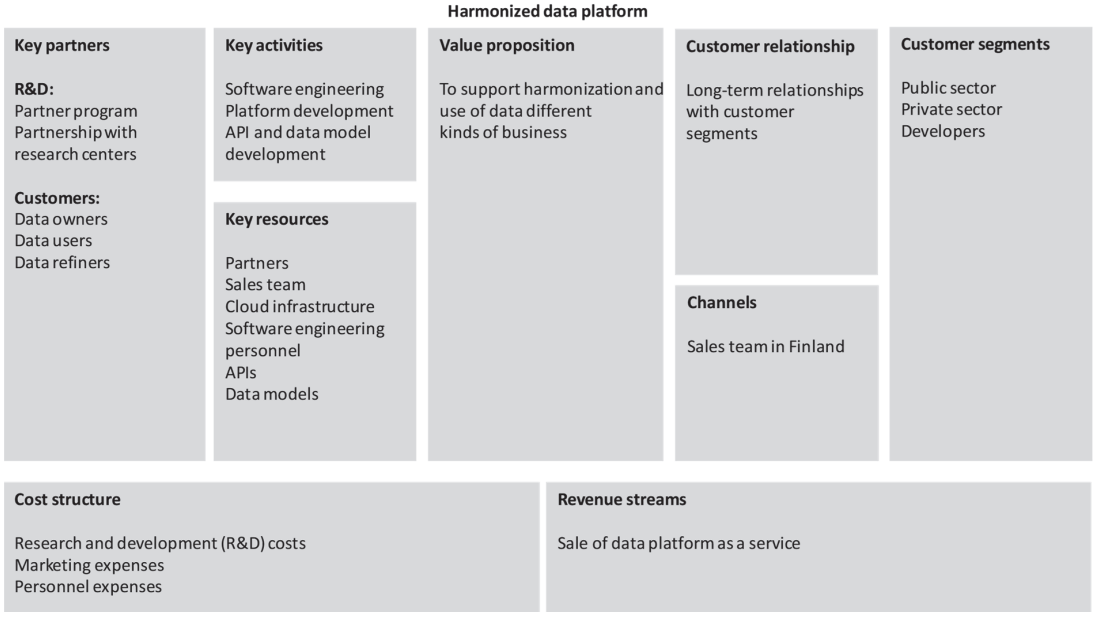


Figure 25: A business model canvas for a harmonized data platform

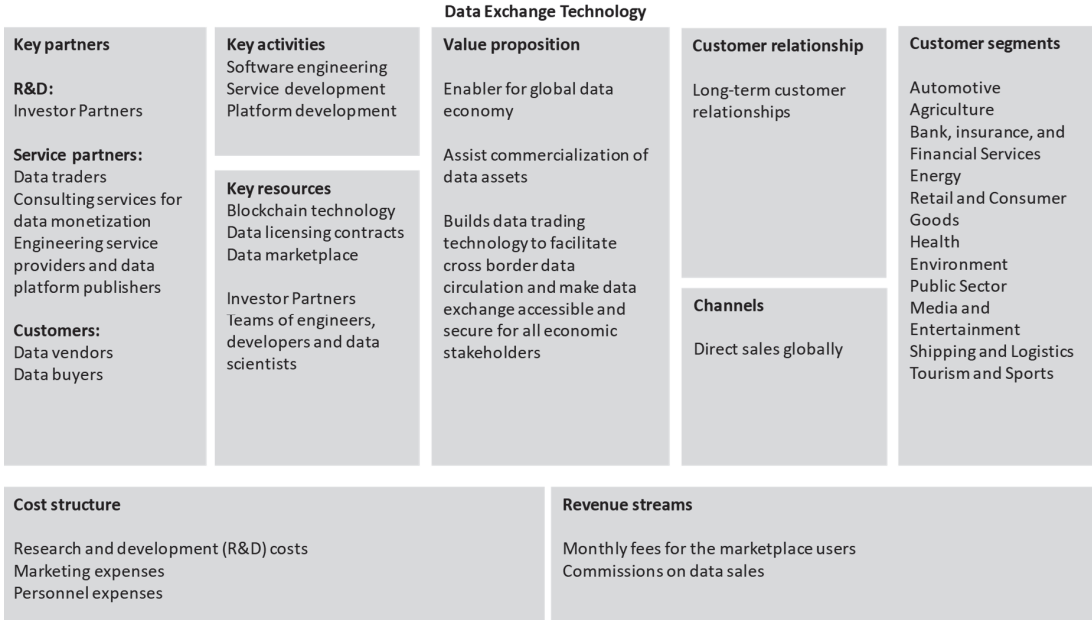


Figure 26: A business model canvas for a data exchange technology provider

4.5.6 Towards smart city data economy

The literature review shows that a smart city data economy requires actors such as data suppliers, data users, and data facilitators, business models for the actors in data business, and networks for data trading in cities. The actors can act in several roles in data economy. For example, a company A can provide analysis services for raw data and be a) a data user as it buys raw data from a data supplier and b) a data supplier as it processes raw data and sell the processed data for its customers. A company B can act as an owner of a data marketplace and be in three roles in data business: it is a data facilitator as it provides APIs, data models, and tools that assists its customer companies to create interoperable commercial data products of their data. Secondly, the company is a data user as it buys raw data and a data supplier as it processes the raw data and sells the processed data in the data marketplace.

The smart city data economy provides multiple identified data business possibilities for data suppliers, data users, and data facilitators and many more await to be discovered. The following lists examples of activities and potential data business models for the actors of smart city data economy:

1. Data users. Data users buy data products available in the markets and create new value for business, environment, health, etc.
   - Enrich products and services. Data users can purchase data to enrich their data-driven products and services to create additional value for their customers.
   - Analyse and predict. Big data analyses and data mining can be applied to understand activities within the organization or the business network and to make predictions to support decision making.
   - Apply machine learning. Machine learning could support analyses and predictions and be even used for automatic decision making in some parts of the processes. Machine learning can also be integrated as part of the products and service. Machine learning models require large amounts of good quality data for teaching the models and additional data could be purchased from partners in the value network.

2. Data suppliers - Data suppliers can offer selected parts of their data as commercial data products in a smart city and thus benefit from their own data by selling it to data users.
   - Original data production. Data suppliers operate sensor networks, data platforms or prediction models to generate new data for products and services in the smart city.
   - Utilizing side streams. The data generated by a company for some business specific purpose might provide data "side streams" that are useful for others and thus provide additional revenue streams for the company acting in a role of data supplier.
   - Data operator. Data suppliers can buy data and provide additional value by refining and selling the refined data. As many data users might have similar needs in accessing similar data sources, new type of data operator business models emerge which implement synergetic data needs in the data market.

3. Data facilitators - Data facilitators support creation of a smart city economy in various ways, and there is room for new business model innovations.
   - Creation of data product catalogues and data marketplaces. Buying and selling of commercial data products requires mediation between data sources and data needs in the markets and data product catalogues and data marketplaces are needed for domain specific and cross-domain uses.
   - Development of technical solutions for data delivery. Technical solutions such as connectivity, data delivery platforms, data sharing architectures and cryptographical techniques are needed to enable privacy-preserving secure delivery of data from data suppliers to data users.
   - Legal and ethical issues. Legal and ethical issues need to be solved regarding publishing and using private and confidential data.
   - Detection of potential for commercial data products - Identifying and preparing data sources that could become commercial data products but are not yet used.
   - Identification of potential demand for new commercial data products - Identifying the business potential of the unsatisfied data demand and needs in a smart city.
   - Creation of business models. The smart city data economy requires new business models that are adapted for the actors in the smart city data economy.
   - Funding of new business models. New business models require funding and various instruments could be considered such as grants (e.g. public funding), equity (e.g. capital in exchange for shares) or debt financing (e.g. loans). Selecting the most relevant instruments depends on several criteria, such as development stage of a product/company, need for partnering or need for additional support.

It is important to note that this subsection does not provide a comprehensive list of the activities of the core actors but provides some examples of the required business and technical activities in a smart city data economy.

4.6 Concluding remarks

The increasing processing, memory, and network capacity enable creation of more and more advanced systems for data processing and increases the volume of collected and produced data. In addition, the continuous development in big data, AI and machine learning techniques will provide new capabilities for data processing and utilisation to increase the commercial value of data. EU has recognized emerging data business as an important part of some of its key strategies, such as Digital Single Market and European Data Economy. In addition, API ecosystems will support data economy and can provide data for data users and processing services for data suppliers.

The data-driven value proposition can be data, information/knowledge, or a non-data product or service (Kühne and Böhmann, 2018). There exist data business models for data users, data suppliers, and data facilitators and emerging data sharing technologies such as data marketplaces and payment solutions for data-driven business. However, data is still fragmented in isolated systems and lot of potential value remains unrealized as all the data cannot be utilized to tackle various challenges of smart cities. Going beyond state-of-the-art requires new business models to develop smart city data economy that creates new value from data, boosts the use of private, public, open and commercial data, and opens up currently hidden data storages for new applications. Solutions and technologies for selling and buying of data products are needed as well as business expertise and funding to enable creation of new business models and new value from data in various business cases.

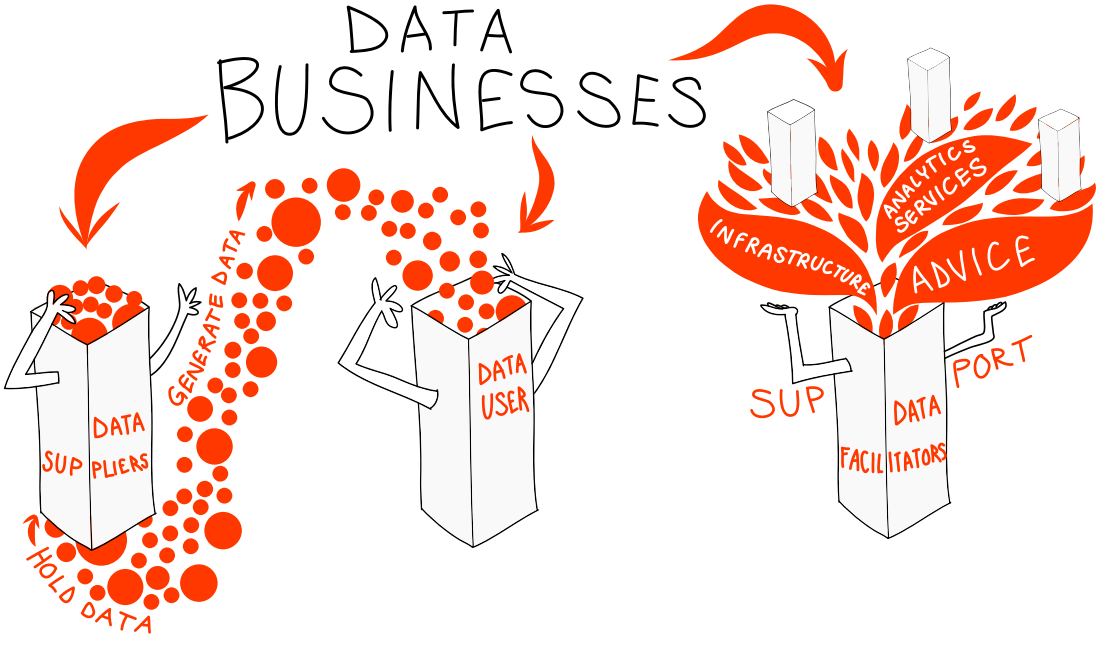


Figure 27: Data Businesses – Users, Suppliers and Facilitators

5 EMERGENCE OF NEUTRAL HOST BUSINESSES[1]

Several scholars have recently studied business models and strategy related issues in smart cities (e.g. Perätalo et al., 2018; Walravens et al. 2013). Previous studies define the smart City from the perspective of technological development by describing that the smart city uses Internet of Things (IoT) devices to collect data and that ubiquitous connectivity services are available (e.g. Strohbach et al 2015; Kibria et al. 2017). Furthermore, these studies envision that 5G-based small-cell networks will provide connectivity in cities such that neutral host companies operate the networks and these companies share the network infrastructure among all ecosystem stakeholders.

In this chapter, we use the term neutral host to refer an existing company on the market. The business scope of these existing companies may differ from the vision that the Neutral Host Pilot project has. We describe the typical traits of business models and enterprise-level strategies that current neutral host companies use in their data and connectivity businesses. We use public data related to existing neutral host companies for analysis. In addition, this chapter helps to understand neutral host companies as an actor in their ecosystems.

This chapter concludes that data and communications markets are significantly different and there are very few companies on the market that operates on both of these markets. Furthermore, it turns out that a neutral host company's original line of business and company ownership structure have impact on company level strategies.

5.1 Business models of data and communications

In this chapter we compare neutral host business models of data and communications. While each neutral host company makes its own business decisions, we find that some characteristics are common among the companies. We present these characteristics related to customers, offerings and finances; in addition, we interpret the realised business logic.

5.1.1 Customer needs and customers in Smart cities

Table 1 summarizes typical neutral host customer problems, and why customers use data and communications services. Data operators see directly the problems of end-customers and they focus more vertically. For example, cities are struggling with public safety and sustainability issues. To address these issues, data operators strive to extract data related to issues, process it and further provide the processed data. On the other hand, communications operators see their customers issues from a technological perspective. For example, customer organizations may lack a partner that can provide networking capacity and reduce investment needs. To address these issues, communications operators are working to build networks that can provide scalable transport-paths for data-flows with minimized costs.

1 More information from authors Jarno Lähteenmäki and Heikki Hämmäinen

Table 1: Data and communications related customer problems seem to be quite distant

Data services are used for solving	Communications services are used for solving
• Inefficient city infrastructure operations • Collected infrastructure data not utilized because it is not available • Safety issues in a city • Privacy issues • Inflexible public transportation in a city • Air quality problems • Sustainability problems	• Expanding capacity needs due to new applications • Redundant investments in several parallel networks • Lack of computing capacity proximity • Lack of places where to put sensors, cameras, etc.

Table 2: Customer segments of the data and communications areas are different

Customers of data companies	Customers of communications companies
• Data brokers • Municipalities (e.g. transportation, environment, healthcare units) • Commercial transportation companies • Private services companies • Data poolers	• Mobile network operators • Data and IoT operators • Infrastructure units of municipalities • Other infrastructure companies

Table 2 shows typical customer segments of the data and communications related offerings. Typical customer segments for data operators are other data operators and organizations that provide services on top of the data. Similarly, typical customer segments of communications companies are other mobile network operators and organizations that require infrastructure services in a specific area. These segments indicate that customers are not end-users for the actual service but are other service providers; however, the customer segments of these two areas are distinct.

Because customers and customer needs are different between these two areas, it can be interpreted that also value propositions are different. This also suggest that used resources, assets and processes to produce the service may differ. Thus, the outcome is two distinct business model categories. To gain a better understanding of the phenomenon, let's take a deeper look at the elements related to a customer front.

5.1.2 Neutral host operators' value propositions and offerings

Typical value propositions for neutral host communications offerings include the quality of service and cost-efficiency. The reason is mainly due to the fact that the communications market is commodity-product-based and the differentiation is realized through operational efficiency strategies. Communications-related offerings are typically categorized into three main groups: mobile network services; fixed network services; and, co-location or device placement services. Figure 21 illustrates traditional alternatives how modularity is implemented in the communications service product catalogue of a neutral host provider. These options apply also for 5G based offerings. Based on the sharing mechanism, the pricing scheme can also vary.

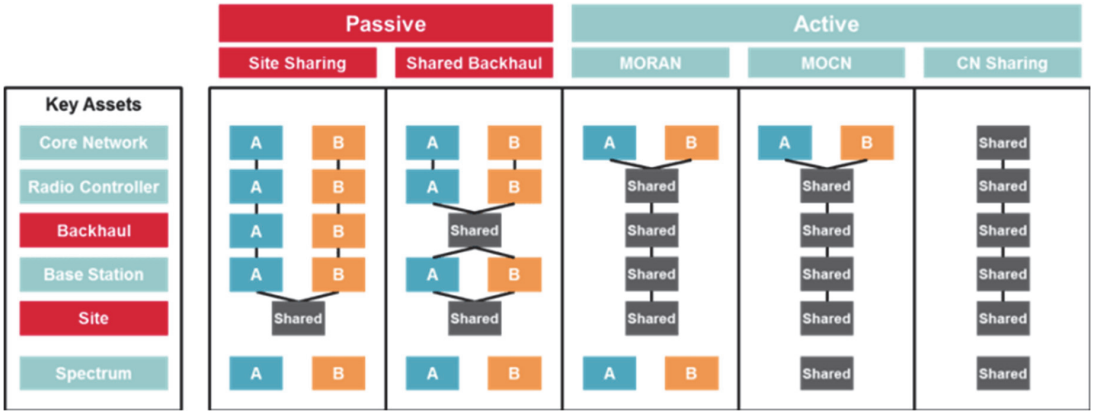


Figure 28: Infrastructure sharing can be practiced in several ways (Source: GSMA, 2019)

The provision of mobile network services is typically provided in a modular environment. This modularity means that the MNO as a customer can select those components from the neutral host offering that the MNO considers useful. A neutral host customer typically chooses between five classes. In the passive class, the lowest level is site sharing, where customers share physical equipment rooms and masts. This category is part of co-location services. In the passive shared-backhaul category, the customer of a neutral host also uses a passive fibre infrastructure to connect sites to the regional data centres. Active offerings contain three typical offering models. Customers can choose to leverage their own spectrum and core networks, and lease other components from the regional neutral host. In this case, radio controllers, backhaul network, base stations and site infrastructure are shared. However, this option is feasible only for incumbent MNO customers because others do not have their own spectrum. In another active option, if a neutral host has acquired a frequency for local use, the spectrum can be provided for the customers. This option allows non-MNO customers to be served. In the third option, the core network is shared. In this case, a neutral host operator can provide also end-customer services as a full-blown MNO. In this scenario the inter-connection to an MNO network can be implemented using a national roaming.

Recently, due to the emergence of 5G technologies, incumbent MNOs have started to adapt their offerings according to technological possibilities. These changes create demand for 5G related neutral host offerings. A number of new 5G related technological concepts are still waiting to gain momentum, such as (i) ultra-reliable-low-latency-communication (URLLC) based services for high-end critical applications; (ii) massive-machine-to-machine type communications (mMTC) based services for wide-scale IoT deployments; (iii) 5G new-radio-light applications for narrow-band-low-power-IoT applications; (iv) 5G network-slicing on general for quality-of-service over mobile-networks. At present, however, there are few implementations and deployments.

Communications related neutral hosts are typically positioned in the wholesale role in their ecosystem. However, it turns out that neutral hosts also offer complex products in addition to the typical simple and low-end products. This dualism shows that the market is in an era of fermentation, as neutral host operations continue to emerge and there is still room for new innovations.

The typical value proposition for data offerings of a neutral host is the creation of new valuable services through urban data ecosystems. The main reason is that the data itself is not seen to have value, but the information produced through different applications has value. Most data-oriented neutral host companies are part of the ecosystems that build those end-customer applications, while the neutral host company provides the data.

In some cases, the ecosystem may have a common value proposition that guides the supply. These common value propositions link the data to the real-world applications. These applications can also be seen in neutral hosts' data offerings as ready-to-use datasets for smart-cities. The constraining factor for service offerings is not technology but typically lack of feasible business opportunities which indicates a need for ecosystem level innovation processes. Let us now move on to financial aspects of business characteristics.

5.1.3 Revenue streams and cost structures of data and communications services

There are three typical charging models for neutral host communication services; usage-based pricing, revenue sharing, and flat rate. Billing models based on consumed capacity pose a risk to the neutral host operator in the form of non-consumption. This model is unlikely, especially in non-established markets. While it is possible to think of a model where charging is based on revenue sharing, there is no real company in this study that would use such a model. The most typical charging model for neutral host communications services is a flat-fee based on the allocated capacity. In the case of a neutral host business, the advantages of the flat-fee model are simplicity, predictability, and regulatory transparency. Disadvantages include a low revenue-costs correlation and a need for internal costing models to extract feasible price levels.

Communications-services related cost structures do not differ significantly between incumbent MNOs and neutral host operators. It could be said that communications business cost structure is similar to other platform business models. As the customer base of the service and the use of the platform grow, the marginal cost of a new customer is almost zero.

In the data markets, revenue models can be divided into single-sided and multi-sided models. In the single-sided models, a data provider sells access to the data to the customer so that the customer can use the data for their own benefit. The buyer pays a recurring or one-time fee. In multi-sided models, the data provider not only sells data to the customer, but also sells the transaction-related information to a third-party. The first customer is called the downstream-customer and the latter is the upstream-customer (Schüritz et al., 2017). The downstream-customer may be aware of the arrangement made or may not be aware of it. On the both sides, the revenue model can be subscription based, usage fee or gain sharing. On the downstream-customer side, a freemium model is also an option if the value of the information collected from the downstream-customer exceeds the potential price. Multi-sided models can be very dynamic and even complex, which limits how many different models one individual data company can leverage.

Data pooling and data brokering are other models used in the data markets. In data pooling models, the focal company and others in the alliance agree to aggregate some of their business-related information and share it among stakeholders. Pricing is based on the costs of aggregation activities. In data brokering models, a focal company purchases data from third parties, possibly combines the data with other data, and then sells the aggregated data. In addition, it is possible that some of this data is produced by the brokerage company itself. In data brokering, typical pricing models are subscription, auction and transaction-based. In both cases, pricing of the data may be a challenging task due to the intangible nature of data and platform-based cost structures.

Cost structures related to data offerings can be divided into two categories; data acquisition and data maintenance. Acquisition costs include both the collection of data from in-house sources, such as sensors; and purchasing data from external sources. These costs may be variable, such as transaction costs, but there are also fixed costs, such as the support for integration among ecosystem partners. Data maintenance costs are items that are related to; data transferring, storing and processing; maintenance personnel costs; and support costs of customers. Moving on now to consider the overall business logics.

5.1.4 Neutral host business logics

In the communications businesses, the main business logic is to build a regional small-cell based mobile network and supporting infrastructure for that. In this business, the infrastructure can be leased to MNOs and other regional stakeholders who require provided services. A neutral host network forms a platform with certain features and capacity. The features are mainly determined by standards (e.g. 3GPP, IETF, ISO) and the level of capacity offered is based on the customer demand. Pricing is determined using regulatory guidelines and cost-plus principles. This business per se cannot be described as complex or dynamic, but it is not simple either. However, the communications business is relatively stable and long-term due to customer's life expectancy and long technological cycles. Figure 22 shows typical business characteristics for the communications services of a neutral host provider.

Because most of the communications service operation costs are fixed, it is important that a neutral host company can engage more customers than the required threshold limit for profitability. Costs of operations cannot be automatically allocated to service prices because customer-pricing needs to be competitive and pricing should not be higher than any other competing options for the customers. That is why the communications operators typically choose cost-efficiency, economics-of-scale and service-quality-based strategies. Furthermore, products in the communications market are mainly commodity, and competition is mainly driven through the quality of service and pricing factors.

Typical data operators choose differentiation strategies due to the absence of a commodity market. Market competition is based on the distinctive factors such as, service features, how a new application can solve some problems more efficiently than others, and how agile the actual data implementation can be.

Table 3 summarizes the typical business strategies that neutral host companies choose for their businesses. Data businesses rely on

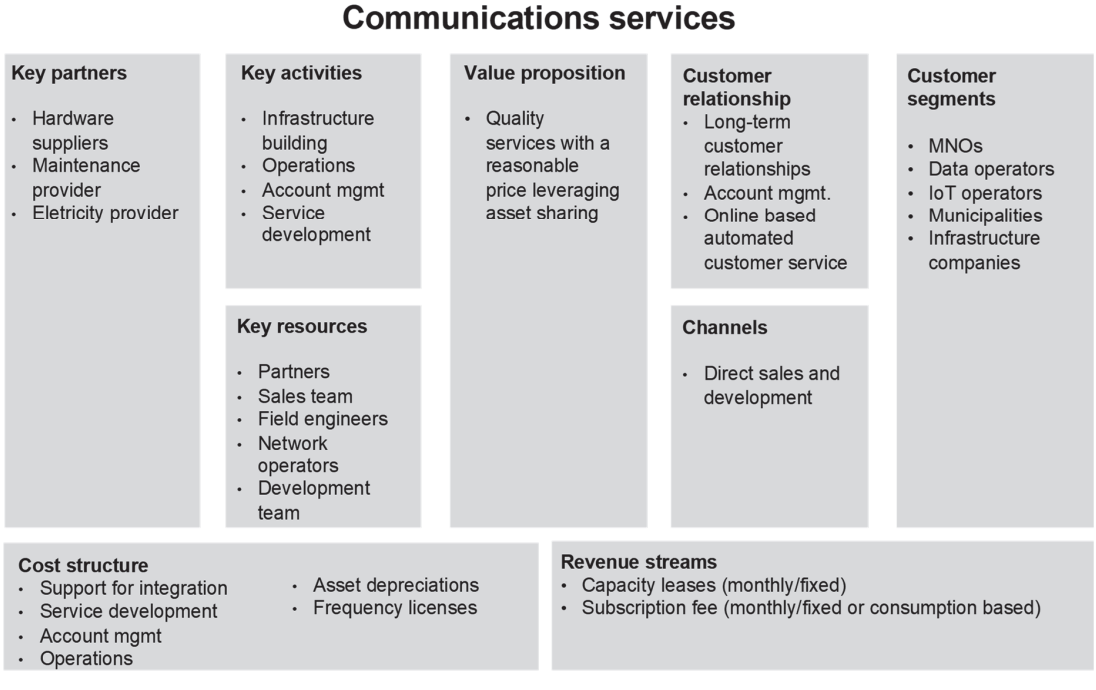


Figure 29: Business model canvas for typical neutral host communications services

differentiation, experimenting and continuous innovation strategies. On the other hand, communications businesses rely on economies-of-scale, cost-efficiency and service-reliability strategies. Furthermore, the business performance of these two business categories are measured by different metrics.

Both data and communications businesses typically have fairly strict customer relationship practices, which means that the customer and the neutral-host provider have appropriate account management practices. This eliminates the need for traditional sales channels. However, most neutral hosts need to market their presence to all relevant organizations at an early stage in order to attract the required customer-base for the platform.

Table 3: Data and infrastructure businesses rely on different strategies

	Data offerings	Communications offerings
Typical chosen business strategy	• Innovation and agility • Differentiation • Learning through experiments • Start-up co-operation • Security • Privacy	• Service stability and quality • Cost efficiency • Telco regulatory compliance • Tight MNO co-operation • Economics of scale • High degree of standardization • High degree of automation
Business metrics	• Created ecosystem value through the data • Number of successful and abandoned innovations • Customer satisfaction	• Service quality • Ability to provide a required capacity
Activities and processes	Sales • Entrepreneurial, opportunistic, integrative, solution-based, consultative • Packaged data mostly online based Customer service • Skilled data specialists • Application specific knowledge through partners Production • Data analysts and specialists that keep wheels spinning	Sales • Catalogue based • Standardized services Customer service • 24x7 automated incident management through customer portals • Automated service provisioning Production • Fixed network, radio network and infrastructure specialists • Automation application development
Core assets	Tangible • IoT sensors • Cameras • Power and lightning units Intangible • AI & ML algorithms • Application source code • Data sources • Knowledge network • Knowledge of data	Tangible • Poles and distribution • Mobile infra (active and passive) • Fibre and Datacentre infra Intangible • Radio frequencies • IP addresses • Service management applications • Automation systems • MNO customers

5.2 Background of neutral host business strategies

5.2.1 Historical market position

The results of the business structure analysis explain that the source from which the neutral host companies originated might affect the company's operations today. The assessed neutral host companies were divided into four separate categories. The grouping criterion was the original business area at the time of establishment. The emerged categories are; (i) leasing communications infrastructures, (ii) specialization to a certain domain, (iii) incumbent MNOs ally to share costs, (iv) and public stakeholder intervention. Now we discuss each of these categories and give some typical characteristics for a company in the group.

Leasing communications infrastructures

Leasing communications infrastructure is one of the ways neutral host companies have emerged. Part of the infrastructure leasing companies have emerged when mobile network operators (MNO) have corporatized their cell tower operations to separate units and divested the unit eventually to free the capital for other investments (Rasay and Shah 2019). Infrastructure funds have acquired and financed several such new ventures, (e.g. DIF 2020). Some independent infrastructure leasing companies have been founded by industry specialists together with infrastructure investment funds to challenge incumbents (e.g. WIG 2020). These cases represent a bottom-up approach, in which the starting point of a company's business is in the simple infrastructure elements and then the business has been expanded to other network elements.

Specialization to a certain domain

Some of the neutral host companies have faced challenges to scale their businesses due to a fragmented domain knowledge, but the situation has resulted in consolidation opportunities for investors. In their early days, some of those companies (e.g. BAI 2020) operated in the consultancy area by specializing into just one specific domain. These domains include railways, metro tunnels, airports, large sport venues, and exhibition centres. Over the years, the domain knowledge of these neutral host companies accumulated, and companies gradually transformed their businesses to the network operator area while still having their special domain knowledge. Through these explicit domain choices, companies were able to tighten customer relationships, use direct sales channels, and access strong customer references. Such choices provide an opportunity for companies to increase their business growth while introducing new lower-level value propositions. The total market size in the domain specialty area is not yet as large as in the infrastructure leasing area. The new domain choices allow pension funds, infrastructure investment funds and other investors to invest in domain speciality oriented neutral host companies, an opportunity which is likely to result in increased mergers and acquisitions.

Incumbent MNOs ally to share costs

The need to reduce network operations' costs and be compliant with strict spectrum license terms have caused challenger MNOs to seek strategic partners who they can ally with. For example, FSN was established in 2013 by DNA and Telia in Finland to build and operate rural mobile networks (FSN, 2020). And in the UK, MBNL was established in 2007 by EE and Three to ensure nationwide coverage of the services (MBNL, 2020). Furthermore, CTIL was established in 2012 by O2 and Vodafone to decrease operational costs of the urban network operations (CTIL, 2020). A strategic alliance seems to be a common way to improve operational efficiency by sharing the costs of network operations also amongst neutral host companies.

Public stakeholders intervene

Several cities around the globe have identified that there is a need for public authority driven network services in urban areas, thus many projects have been carried out to provide city-wide wireless services in a neutral way. Cities do not pursue their network services for profit, but to provide enablers

for the well-being of society, to provide business opportunities for companies and to enhance operational efficiency through new technologies. These objectives guide how the way projects are implemented.

Different cities use alternative MNO collaboration models to meet varying objectives. Some cities have used a horizontal collaboration model by setting up a separate city-owned network company to provide wireless services in a neutral way and to allow infrastructure to be shared with MNOs. At the same time, using a vertical collaboration model, some cities have outsourced network operations to allow the MNO to participate as a subcontractor. In addition, in some cases, the authority manages the entire network itself without MNO cooperation. For example, China's largest government-led network provided a public Wi-Fi network service to 50 major cities without MNO collaboration, but the introduction of MNO's 5G-based services has triggered a shift to both horizontal and vertical collaboration models. In short, collaboration models chosen by the urban network operators are highly dependent on regional ecosystem conditions.

In some cases, regulatory decisions have caused natural monopolies for certain services. For example, in 2006, Digita get an exclusive right to operate 450MHz spectrum for wireless broadband services in Finland. One of the decision criteria was that Digita clearly stated that it uses a neutral host type position in their ecosystem and provides wholesale services only. Regulatory authority saw that this kind of approach enhances ecosystem openness which has more advantages than the monopolistic situation has drawbacks.

These four different types of sources characterize certain aspects why a neutral host company acts how it acts. Next, let us discuss who the ownership structures are found to explain why a neutral-host company operates in the market in a certain way.

5.2.2 Ownership structures

Owners of neutral host companies have varying investment strategies, expected return-on-investment (ROI) targets and defined level of bearable risk-taking. It can be assumed that public stock listed companies have the most aggressive ROI expectations, while associations, foundations and community-based models have least aggressive ones. Table 4 lists seven categories of neutral host company owners, their characteristics and typical investment strategies. Also, some examples of real-world companies are given.

Table 4: Different owners have individual characteristics and investment strategies.

Company ownership structure	Owner characteristics	Typical investment strategy	Company examples	Implications to company strategies
Public	For-profit. Typically institutional investor. Medium to long term investment with relatively low-risk ROI.	Minor shareholder, Strategic investment. Annual dividend or bullet investment.	• Americal Tower • Crown Castle • SBA Communications	• Seek expansion through M&A • Tight financial discipline to meet market expectations
Private company – Joint venture	For-profit. Company extends its core assets to enable a wider offering or geographical operating area.	Joint venture. Strategic alliance. No dividend expected.	• Finnish Shared Network Ltd. (Telia-DNA) • CTIL (Vodafone-O2)	• Focus on quality and cost efficiency
Private company – start-ups	A few entrepreneurial individuals establish a new company to fulfil certain identified customer need.	Fast growth of the company. MBI or divestment of major shares.	• Ontix Ltd	• Fast growth through experimenting and entrepreneurial activities
Private company - Investment funds	For-profit. Funds seek diversified infrastructure investment targets which provide modest ROI with low risks.	Major shareholder. Long-term investment.	• BAI Communications (CPPIB Canada)	• Expansions through M&A activities where strategic fit is high
Municipality	For-profit. Local city ownership. Power to enforce	Major shareholder. Long-term investment to protect local infrastructures.	• NextLight (Longmont, CO, US)	• Prone to political disputes in competition situations
Community	Not-for-profit. Local.	Members invest to get access to community services.	• Verkko-osuuskunta Kuuskaista (owned by members)	• Need based development, low business aspirations
State	Not-for-profit. Nationwide.	Major shareholder. Long-term investment to protect national infra-structures.	• Critical Communications Finland (Erillisverkot)	• Tight control on who is the customers • Low cost sensitivity
Foundation	Not-for-profit. Local.	Long-term investments. Fill the gap that the market fails to fill.	• EstWin (Estonian Broadband Development Foundation)	• Purpose driven development, not business driven
Association	Not-for-profit. Global.	Minor or major-shareholder. Long term investment.	• EWIA (Investment fund)	• Low aspiration on expansions
Venue owner	For-profit. Local.	Major. Add value to venue.	• Tottenham Hotspur Stadium	• Asset ownership • Operations outsourced

5.2.3 Neutral host ecosystem-level aspects

Governmental actions have allowed new businesses to emerge, but also have forced some incumbents to react; let us take the United Kingdom as an example region. In the late 2010s, the UK government set ambitious targets. The aim is to provide fibre-access to all premises and ubiquitous access to 5G by 2035 (UK, 2018). Achieving this target using the traditional MNO model would increase investment needs to a high level due to multi-operator redundancies. This results in an opportunity for local neutral network operators who may share investment needs and share network assets in certain regions. For example, MBNL and CTIL are two of those neutral host operators in the UK which are going to leverage the opportunity. Both companies are joint ventures between incumbent MNOs, but these neutral hosts offer services for all MNOs.

By setting ambitious objectives, the government signals the market that there are new investment opportunities available, which results in new investment money and emergence of new players. For example, Wireless Infrastructure Group (WIG) (WIG 2020) was established in 2006 to operate on the cell-tower-leasing market and to introduce competition to the mobile-network-infrastructure market. WIG has changed their strategy to a more MNO co-operational way as WIG's customers are mainly large MNOs. The shift happened after the UK government decision to bet more on the ubiquitous 5G access. The company is privately owned but is nowadays backed by large global infrastructure investment funds (WIG-b 2020). WIG has expanded the service offering from cell-towers to cover all relevant mobile network infrastructure components. Furthermore, the company seeks new domains for a business. WIG is a major investor in an autonomous vehicle test-bed platform which is the UKs largest. Such a shift to higher tier applications may result in WIG being one of the earliest neutral host operators operating in both the communications and data markets.

Government-led 5G promotions have also taken place in other countries. The Danish Energy Agency has a nationwide plan to promote the use of modern communications technologies and to find ways to create smarter cities (DEA, 2019). Their 5G plan clearly states that the aim is the creation of new markets for independent small-cell operators. The plan contains several actions, such as site-rental, network-sharing, network-slicing and network-neutrality. Furthermore, the EU funded research project called 5G-CITY (2017) pilots the neutral host model in three different cities, Barcelona in Spain, Bristol in the UK and Lucca in Italy. Although the consortium of the pilot projects in Lucca and Bristol are entirely on public funding, Cellnex Telecom is participating as a private partner in the Barcelona project. The planned business model is largely based on infrastructure sharing, where street cabinets, lightning poles, passive and active components of the mobile network all are intended for rental purposes. Although these publicly funded projects aim to create feasible business opportunities, it is open if the projects actually produce them.

There are several initiatives that did not end so well. Some projects, especially in Western countries, faced disputes, MNO objections and even legal actions when an incumbent operator tried to prevent infrastructure owners and municipalities from becoming a network operator. For example, incumbent lobbying and public debate did prevent Philadelphia City in the US from improving its network operations (Abraham 2015). On the other hand, some cities previously had active network services for citizens, but have decided to shut down the network due to the emergence of 4G and 5G networks; for example, San Francisco, Dublin and Sydney.

To get access to a horizontal resource and knowledge sources, neutral hosts can seek partnering through joint-ventures. However, cities and neutral host companies can partner also vertically to get access to knowledge and resources. For instance, Barcelona agreed to collaborate with Huawei in late 2019 (Wray, 2019). The city is looking for a partner in the digital transformation industry that can help city businesses leverage 5G and build smart city applications. This collaboration can accelerate the adoption of smart city services in Barcelona.

Several municipality managed ecosystems have opted for the open ecosystem model and have also opted for free-pricing. For instance, Helsinki is classified as one of the most functional smart cities in Europe (Helsinki, 2018). The merit comes from the availability of open data sets. At the time of this study, more than 1000 open data sets are available (Forum Virium, 2019). Any company can continue to use them in their applications at no extra charge. Data is collected from applications related to urban use, such as tram location information. Using the data as a platform for new innovations, Helsinki aims to create new data-based markets. Typical goals for cities are to improve operational efficiency, improve the well-being of citizens, improve the visitors experience and enable business growth. The challenge for the data operator is to acquire relevant data and attract new ecosystem members to the platform.

5.3 Concluding remarks

Differences on customer-segments and value-propositions between data-business and communications-businesses indicate that these two business areas are fundamentally different. The implication is that if such a neutral-host was established which combines these offerings, the company is operating in two different markets. It may be hard to realize synergies between these two segments.

On the other hand, both data and communications businesses are platform based, which means that a certain number of customers are needed to cover all costs related to the operations. This indicates that the geographical operating area of a neutral host needs to be large enough to sustain the required customer base.

We presented categorization of the ownership structures in this chapter. In two extreme ends we have a neutral host that is; a public stock-listed company which is mainly a dividend machine for owners, and; in the other extreme, a non-profit foundation which strives to ensure that non-monetary objectives are met. Furthermore, there are several other categories between those. The company level strategies diverge between categories while strategies converge inside a category. These observations have a consequence that the ecosystem vary significantly if it run by different owner-base-neutral-hosts, and to have a real understanding of the market also the impact of ownership needs to be understood.

The second categorization presented in this chapter is the origin of a neutral host company. The interpretation is that companies within a particular category tend to choose similar strategies because of their historical background, and this behaviour partly determines how neutral hosts actually want to run a business. Understanding this dimension is important because not all neutral host companies are willing to expand their business in the same direction, but there are several paths to business growth.

This chapter described the typical traits of business models and enterprise-level strategies that current neutral host companies use in their data and connectivity businesses. Although the used public data can be considered as a representative, the qualitative and inductive nature of this study limit how the results generalise. However, this chapter sought to give a basic understanding of neutral host companies as actors in their ecosystems. Finally, we finished off with a state-of-the-art analysis and our interpretations of the content.

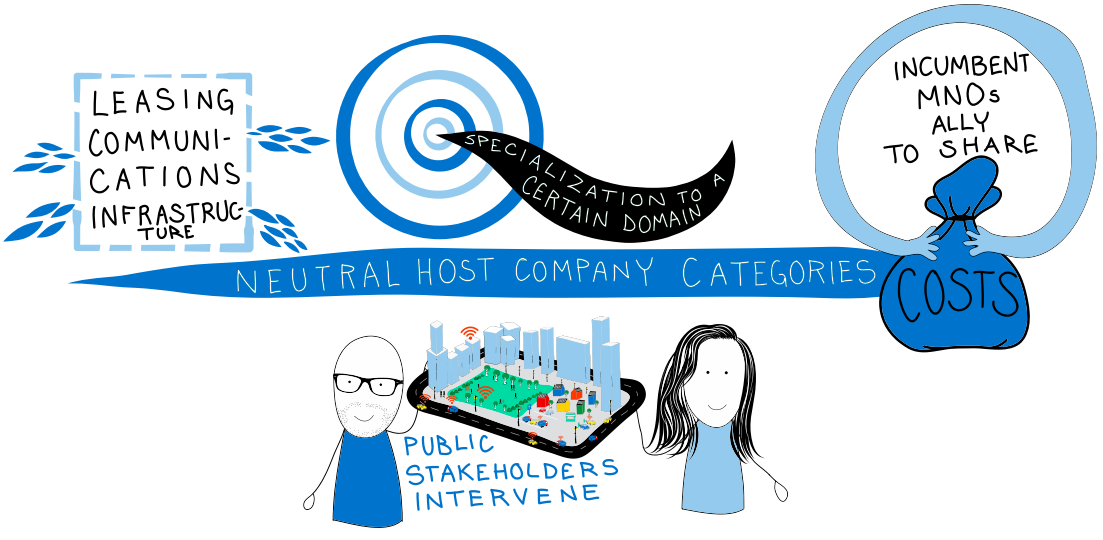
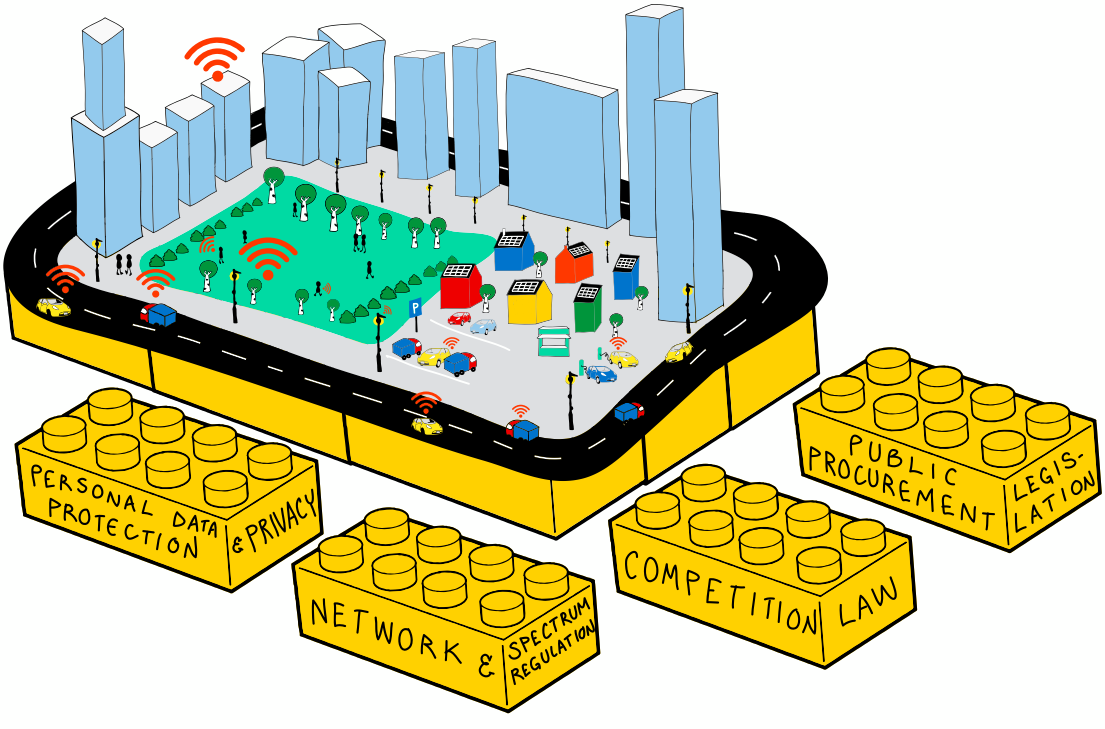


Figure 30: Neutral host company categories

SECTION III:

STATE-OF-ART UNDERSTANING OF REGULATORY ENVIRONMENT WITHIN EU



6 CURRENT LEGAL AND REGULATORY FRAMEWORK[1]

6.1 Introduction

This chapter considers the legal aspects to be taken into consideration when creating a smart city ecosystem. The focus of this state-of-the-art review is on current legal regulation and interpretation of personal data protection, regulation of frequencies, together with competition and procurement law in a smart city context. The current legal situation will be analyzed by benchmarking the smart city data platform regulatory environment and identifying the regulatory bottlenecks for the Neutral Host business model when creating data based services for people in a smart city.

There is no legal definition of the concept of 'smart city'. However, in practical terms a smart city is built on smart uses of information technology – for example, software systems, server infrastructure, network infrastructure, and client devices. A city that monitors and integrates the conditions of all of its critical infrastructures can help city residents and the city administration. Connected components might, for example, involve the city administration, education, healthcare, public safety, real estate, transportation, and utilities. (Washburn et al, 2010). A smart city can better optimize its resources, plan preventive maintenance, and monitor security aspects. It can also provide citizens with better services. (Hall, 2000).

The starting point in our project is that, in order to improve the quality of living this way, smart cities need a digital service infrastructure based on small cell 5G radio frequency technology and higher frequencies. This is because the capacity of mobile networks will be far too insufficient due to the increased number of users and new digital services. (LuxTurrim5G, 2017). As part of this project we also aim to create a platform that uses high-speed city networks, where a wide variety of data can be used in a reliable and secure way for development of digital services. This data platform is here termed Neutral Host. (LuxTurrim5G, 2019).

As using the Internet of Things (IoT) and 5G technology will be inseparable in a digital smart city ecosystem, it is apprehended that privacy and the protection of personal data will be at risk in 5G network-based platforms because of interconnected smart sensors and devices. Enhanced 5G services support network-based positioning capabilities in a more accurate way than before. Such a high resolution in locating the user and their personal data can trigger enormous benefits for network operators and their end users, but at the same time creating important privacy concerns from users' point of view. There is also a risk of hacker attacks against databases and malicious or erroneous data inputs. (Lohan et al, 2018, pp. 281–320). This explains why research is needed concerning threats to personal privacy and personal data protection in the context of the smart city.

In addition, network and radio spectrum regulation is explored because it is important to establish possible ways to use frequencies in the context of the smart city and Neutral Host platform. Attention has also been paid to competition law, because data sharing and platforms need to be designed in a way that does not include agreements restricting competition or, if Neutral Host were to become dominant in some markets

1 More information from authors Anette Alén-Savikko, Shakila Bu-Pasha, Heidi Himmanen, Päivi Korpisaari, Sara Lehtilä and Juha Vesala. The authors express their warm thanks to research assistants, law students Annika Antikainen and Oona Ojajärvi, and Päivi Karkkola, Annina Lehtonen and Henriikka Rosti, who are officials of Finnish Transport and Communications Agency (Traficom), for their help when writing the state-of-the-art review.

This chapter has been previously published in Päivi Korpisaari (ed.) Oikeuksia, vapauksia ja rajoituksia – Viestintäoikeuden vuosikirja 2019 (Rights, freedoms and restrictions – Communication Law Yearbook 2019), Helsinki 2020, pp. 159–195.

(for example, as data supplier in an area), does not lead to foreclosure of competitors or impose unjustified restraints on customers or suppliers. Moreover, certain aspects of procurement law are discussed here.

In this chapter we will focus on the following aspects that are relevant in the context of the digital smart city:

1. Personal data protection and privacy
2. Network and spectrum regulation
3. Competition law
4. Public procurement legislation.

6.2 Personal data protection and privacy

6.2.1 General remarks

Personal data protection and privacy are major concerns when planning and implementing smart city services. Personal privacy of individuals may be threatened and at risk in a variety of ways in a digital smart city platform. However, following legal mandates and properly fulfilling legal requirements can mitigate these concerns.

At present, the most important and comprehensive data protection law in the EU addressing protection of personal data is the General Data Protection Regulation (GDPR)[2] which deals with personal data protection concerns exposed via modern technological developments. The scope of material[3] and territorial[4] application is wide, as is also the concept of personal data.

To start with, it is important to discuss some terminology and provisions under the GDPR in the smart city context. For example, Article 4 (1) of the GDPR defines the concept of personal data:

> "'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person".

Recital 26 mentions that

> "[t]o determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used (...). To ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments."

2 Regulation (EU) 2016/679 of the European Parliament and of the Council on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC, OJ L119, 4 May 2016, pp. 1–88.

3 As a main rule, GDPR "applies to the processing of personal data wholly or partly by automated means and to the processing other than by automated means of personal data which form part of a filing system or are intended to form part of a filing system"; see more closely GRPR Art. 2.

4 See GDPR Art. 3:
"1. This Regulation applies to the processing of personal data in the context of the activities of an establishment of a controller or a processor in the Union, regardless of whether the processing takes place in the Union or not.
2. This Regulation applies to the processing of personal data of data subjects who are in the Union by a controller or processor not established in the Union, where the processing activities are related to:
(a) the offering of goods or services, irrespective of whether a payment of the data subject is required, to such data subjects in the Union; or
(b) the monitoring of their behaviour as far as their behaviour takes place within the Union.
3. This Regulation applies to the processing of personal data by a controller not established in the Union, but in a place where Member State law applies by virtue of public international law."

The CJEU has interpreted the concept of personal data widely. For example, in *Breyer*, the Court stated that a dynamic IP address can constitute personal data if the service provider has the legal means enabling it to identify the data subject with additional data which the internet service provider has about that person. (*Patrick Breyer v. Bundesrepublik Deutschland*, 2016). In *Breyer* the CJEU applied the Data Protection Directive (DPD),[5] but the line of interpretation regarding the concept of personal data is still valid. So, too, is the Court's practice relating to the concept of controller.

Article 9 (1) of the GDPR states,

> "Processing of personal data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation shall be prohibited."

Processing of such data requires special protection under the GDPR.

According to Article 4 (7),

> "'controller' means the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data; where the purposes and means of such processing are determined by Union or Member State law, the controller or the specific criteria for its nomination may be provided for by Union or Member State law".

The CJEU has also interpreted the concept of controller widely. For example in *Jehovan todistajat* the Court concluded that a religious community, such as the Jehovah's Witnesses, was a controller, jointly with its members who were engaged in preaching, for the processing of personal data carried out by the latter in the context of door-to-door preaching (*Tietosuojavaltuutettu v. Jehovan todistajat — uskonnollinen yhdyskunta*, 2018). In *Wirtschaftsakademie* the Court stated that the administrator of a fan page on Facebook was a joint controller jointly responsible with Facebook for processing the data of visitors to the page, when Facebook was – by means of cookies – collecting and then processing the personal data of visitors. (*Unabhängiges Landeszentrum für Datenschutz Schleswig-Holstein v. Wirtschaftsakademie Schleswig-Holstein GmbH*, 2018). As a result, processing of personal data carried out in the context of such activity had to respect the rules of EU law on protection of personal data.

Article 4 (8) in turn defines that the concept of 'processor' "means a natural or legal person, public authority, agency or other body which processes personal data on behalf of the controller".

EU Member States are under obligation to enact national data protection laws fulfilling the requirements of the GDPR in order to secure the rights of data subjects. Both the GDPR and national laws bind different entities which can collect and process individuals' personal data. To illustrate, technology companies or different digital service providers as data controllers have to comply with privacy laws at certain levels by ensuring certain proper features. They have to follow legal requirements in drafting their terms and conditions, privacy policies, and end-user license agreements in order to protect the data privacy of smart device users.

Legal issues that have to be resolved when developing the digital smart city include, for example, general principles of data processing, lawful grounds for processing, rights of data subjects, and obligations of data controllers and processors. Those who use smart city services enjoy some control over their personal data. For example, when processing is based on consent, service providers should avoid drafting long, one-sided policy statements and default settings in order to meet the requirements of EU

5 Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data, OJ L 281, 23 November 1995, pp. 31–50.

data protection law as well as to establish a fair, transparent and accountable data protection and data processing system. At the same time, companies and organizations can process personal data when operating a smart city platform if there is a legal basis for processing and if the requirements of the GDPR are fulfilled.

Articles 16–22 of the GDPR describe different rights of data subjects which need to be fulfilled. These rights include, for example, "the right to be forgotten" under Article 17 of the GDPR, which in the EU implies that a data subject has the right to require the controller to remove their personal data when such data "are no longer necessary in relation to the purposes for which they were collected or otherwise processed".

The integrity and confidentiality of personal data is mentioned in Article 5 (f) of the GDPR as one of the basic principles for processing personal data. Article 32 requires data controllers and processors to "implement appropriate technical and organisational measures to ensure a level of security appropriate to the risk". In the context of the smart city it is also important to explore the existence of such "high risk" to personal data that – according to Article 35 – requires a Data Protection Impact Assessment (DPIA), which can be called "a process for building and demonstrating compliance." (Article 29 Working Party, 2017). This is a new requirement that reflects the principle of privacy by design. Article 35 requires data controllers to carry out a DPIA if new technologies and data processing operations are "likely to result in a high risk to the rights and freedoms of natural persons". According to WP29, such a high risk is involved, for example, with "a systematic monitoring of a publicly accessible area on a large scale". (Article 29 Working Party, 2017, p. 8). Non-compliance with the GDPR can lead to fines imposed by the competent supervisory authority.

6.2.2 Identifiable information, anonymization and pseudonymization

Anonymization and pseudonymization can be applied to protect privacy and personal data. These two methods, though interconnected, are different and require different techniques in relation to protection of personal data. The relevance of identifiable information is evident in the definition of personal data in Article 4 (1) of the GDPR as already mentioned.

The name, address, phone number, personal picture, account information, social security number are amongst others considered as direct identifiers; on the other hand, information which can lead to reaching direct identifiers, for example, job designation, work location and salary, information on particular health syndromes and so on are indirect identifiers. According to the US National Institute of Standards and Technology, "De-identification is a tool that organizations can use to remove personal information from data that they collect, use, archive, and share with other organizations." (Garfinkel, 2015).

The main purpose of anonymization is to prevent irreversible identification. True and effective anonymization should ensure two criteria: it has to be irreversible and, after applying anonymization, it is not possible to identify an individual. In short, in anonymized data identifiable elements no longer exist and re-identification is not possible. After ensuring effective anonymization, data ceases to be personal data. (Bu-Pasha, 2018).

The GDPR does not define anonymization, although Recital 26 provides a conceptual definition:

> "… The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable. This Regulation does not therefore concern the processing of such anonymous information, including for statistical or research purposes."

Effective anonymization not only mitigates risks to personal data but also promotes opportunities to benefit from an open data platform. However, ensuring true anonymization is very difficult.

In pseudonymization, identifiable elements are replaced by pseudonyms or values in pseudonymized data with which data subjects

cannot be directly identified, but identifiable data are reversible. The GDPR introduces "pseudonymisation" with a legal basis, as Article 4 (5) states that

> "'pseudonymisation' means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organizational measures to ensure that the personal data are not attributed to an identified or identifiable natural person".

This means that, with the use of additional information, re-identification is possible in pseudonymized data. Article 25 (1) of the GDPR describes pseudonymization as an "appropriate technical and organisational measure" for implementing data protection principles.

According to Recital 26, pseudonymized personal data are considered identifiable information if they could be attributed to a specific natural person in association with some additional information. The controller should single out all the means which could reasonably be used to directly or indirectly identify a natural person. Objective factors – for example the required time and costs of identification, and the current available technology and technological developments – should be taken into account to determine the identifying means. Because the concept of personal data in the GDPR refers to an identified or identifiable person, pseudonymized data is personal data.

6.2.3 Consent and other legal grounds for processing

If processing of data is based on consent, the GDPR requires data controllers to obtain the data subject's explicit and freely given consent when processing their personal data. According to Article 6 (1) (a) of the GDPR, processing of personal data is lawful when "the data subject has given consent to the processing of his or her personal data for one or more specific purposes". Article 7 sets some conditions for consent: indeed, an important task for smart city initiators is to take those conditions into account when processing users' personal data.

When data processing is based on the data subject's consent, the controller has to be able to demonstrate consent [Article 7 (1)]. According to Article 7 (2), if consent relates to a written declaration, "the request for consent shall be presented in a manner which is clearly distinguishable from the other matters, in an intelligible and easily accessible form, using clear and plain language".

The data subject should be able to express their genuine or voluntary choice for freely consenting to processing of personal data (Recital 42). The text of Recital 32 can be a good guideline for obtaining data subjects' consent:

> "[c]onsent should be given by a clear affirmative act establishing a freely given, specific, informed and unambiguous indication of the data subject's agreement to the processing of personal data relating to him or her, such as by a written statement, including by electronic means, or an oral statement. This could include ticking a box when visiting an internet website, choosing technical settings for information society services or another statement or conduct which clearly indicates in this context the data subject's acceptance of the proposed processing of his or her personal data. Silence, pre-ticked boxes or inactivity should not therefore constitute consent…"

In a smart city context, consent can be a basis for processing – for example, when a data subject downloads an app, which collects and uses their personal data in order to provide smart city services. But it may not always be an appropriate basis when data are collected from bus terminals, streets, and other public places.

Other legal grounds for processing personal data include performance of a contract, compliance with legal obligations by the controller, protecting the data subject's or some other natural person's vital interests, for the purposes of the public interest or a controller's or a third party's legitimate interest.

In a smart city context, a legal obligation or public interest are common grounds for processing personal data by the city. Legitimate interest, in turn, is a common ground for processing for private purposes.

According to Article 6 (1) (e) of the GDPR, processing is lawful if it "is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller". Both public and private sectors can be entitled to rely on this ground in appropriate situations or in exercising public authority. The basis for processing must be laid down by European Union law or Member State law to which the controller is subject. The reason for regulation can relate for example to national security, crime prevention, safeguarding public health, social security, maintaining safety and quality of services and devices and so on.

According to Section 4 of the Finnish Personal Data Act (1050/2018, Tietosuojalaki) personal data may be processed in accordance with Article 6 (1) (e) if:

> "1) the data describe the position of a person, their duties or performance of those duties in a public sector entity, business and industry, activities of civil society organizations, or other corresponding activities, in so far as the objective of processing is of public interest and processing is proportionate to the legitimate aim pursued;
> 2) processing is proportionate and necessary for performance of a task carried out in the public interest by an authority;
> 3) processing is necessary for scientific or historical research or statistical purposes and is proportionate to the aim of public interest pursued; or
> 4) processing research material and cultural heritage material containing personal data and processing personal data included in their metadata for archiving purposes is necessary and proportionate to the aim of public interest pursued and to the rights of the data subject."[6]

The controller's or a third party's legitimate interest is another lawful ground for processing personal data unless overridden by other interests and the fundamental rights of data subjects [Article 6 (1) (f), Recital 47]. Many business entities being data controllers like to adopt the legitimate interest ground as a comparatively convenient option. According to Article 6 (1) subparagraph 2 it will not apply to processing carried out by public authorities in the performance of their tasks.

Recital 47 of the GDPR expresses direct marketing as a possible legitimate interest: "the processing of personal data for direct marketing purposes may be regarded as carried out for a legitimate interest." Debate surrounds the scope of several interpretations in defining legitimate interest. (Kamara and de Hert, 2018). It is also important to bear in mind the accountability principle in Articles 5 (2) and 24 (1) of the GDPR. According to this principle, the controller is responsible for demonstrating that processing is lawful – and must be able to do so.

6.2.4 Extra-territorial aspects

Worldwide, many companies, organizations and research institutions are experimenting on the smart city concept. In maintaining coordination with other smart cities as well as in running and spreading business platforms, data may be transferred from one region to another.

Moreover, we need to consider the possibility of processing data outside the EU. Article 3 (2) of the GDPR states:

> "This Regulation applies to the processing of personal data of data subjects who are in the Union by a controller or processor not established in the Union, where the processing activities are related to: (a) the offering of goods or services, irrespective of whether a payment of the data subject is required, to such data subjects in the Union; or (b) the monitoring of their behaviour as far as their behaviour takes place within the Union."

6 Unofficial translation by the Ministry of Justice.

This provision ensures protection of personal data with extra-territorial effect. On the other hand, business activities among different regions of the world can benefit from such simplified legal provision.

As for personal data transfers outside the EU, if the European Commission decides that, for example, a third country or an international organization, offers an adequate level of data protection, transfer of personal data can take place without the need to obtain specific authorization [Article 45 (1) (3), Recital 103 GDPR].

6.2.5 Principles relating to processing of personal data

Article 5 describes principles relating to processing of personal data which data controllers need to consider in implementing a smart city. These principles include lawfulness, fairness, and transparency in processing personal data [Article 5 (1) (a)]. According to the 'purpose limitation' principle, personal data can be "collected for specified, explicit and legitimate purposes": this prohibits further processing in a manner incompatible with the original purpose [Article 5 (1) (b)].

According to Article 6 (4), if processing is not based on consent or law,

> "the controller shall, in order to ascertain whether processing for another purpose is compatible with the purpose for which the personal data are initially collected, take into account, inter alia:
> (a) any link between the purposes for which the personal data have been collected and the purposes of the intended further processing;
> (b) the context in which the personal data have been collected, in particular regarding the relationship between data subjects and the controller;
> (c) the nature of the personal data, in particular whether special categories of personal data are processed, pursuant to Article 9, or whether personal data related to criminal convictions and offences are processed, pursuant to Article 10;
> (d) the possible consequences of the intended further processing for data subjects;
> (e) the existence of appropriate safeguards, which may include encryption or pseudonymisation."

The 'data minimization' principle requires that collected data shall be "adequate, relevant and limited" and necessary to achieve the original purpose [Article 5 (1) (c)]. Such data must no longer be stored after fulfilling the purpose [the 'storage limitation' principle, Article 5 (1) (e)].

In addition, the collected data must be accurate [the 'accuracy' principle, Article 5 (1) (d)], and the controller must maintain security and protection of personal data under the 'integrity and confidentiality' principle.

The 'accountability' principle requires that the controller be responsible for demonstrating compliance with the above principles.

6.2.6 The rights of data subjects under the GDPR

The GDPR promotes data subjects' control over their personal data and thereby confirms certain rights for them. In implementing a smart city ecosystem, companies and organizations as data controllers must consider those rights while processing personal data.

The European Data Strategy ensures individuals' right to their own data. This reflects the recent MyData concept by "giving users rights, tools and skills to stay in full control of their data". (European Commission, 2020). In the long run, this aspect is likely to be relevant in the smart city context as well. Accordingly, MyData models should be considered when thinking about the Neutral Host Pilot data platform as one possible business model. In short, the MyData model improves the right to self-determination by empowering individuals in terms of exercising control over their personal data.

According to the GDPR, data subjects have the right under Article 21 to object to the processing of their personal data in relation to their particular situations even if processing is conducted on the grounds of public interest [under Article 6 (1) (e)] or legitimate interest [under Article 6 (1) (f)]. They also

have the right to object to processing carried out for direct marketing purposes. They can object to processing of personal data for scientific, historical research or statistical purposes if that is not justified on the ground of public interest.

As per Article 15 of the GDPR and Article 8 (2) of the EU Charter of Fundamental Rights[7], a data subject has the right to access personal data on him or her in order to ascertain relevant information regarding the processing of their personal data. The GDPR confers on data subjects the right to immediate rectification of inaccurate and incomplete personal information (Article 16), prompt erasure of unnecessary information (Article 17) and restriction of invalid processing (Article 18). Even after giving consent, a data subject can withdraw it in a simple way at any time under Article 7 (3).

Controllers are required to inform data subjects about their identity and contact information, the purpose(s) of processing, how long the personal data would be stored, and other related information as per Articles 13 and 14. Informing data subjects about the location of data collection and the reason for it is important for maintaining transparency. In a smart city context, fulfilling these obligations is highly important in order to maintain citizens' trust in the system. Transparency must be assigned special importance when processing of personal data is not based on consent and the data subject may not even be able to prevent processing of their personal data. This is why special attention has to be paid to how and when citizens are informed of the processing of their data.

6.2.7 Controller, joint controller and processor

As mentioned in Article 4 (7) of the GDPR, controllers can process data alone or jointly. In relation to smart city platforms, controllers will jointly conduct data processing operations. Article 26 (1) states "Where two or more controllers jointly determine the purposes and means of processing, they shall be joint controllers. They shall in a transparent manner determine their respective responsibilities for compliance with the obligations under this Regulation".

As per the requirement of Article 35 (1) of the GDPR, smart city implementing authorities as data controllers have to carry out a data protection impact assessment if data processing operations – especially using new technologies – have a likelihood of resulting in high risk to the rights and freedoms of data subjects. It would be useful if the responsibilities of joint controllers were described in the DPIA. Controllers also need to implement proper technical and organizational measures for ensuring security of processing as prescribed in Article 32 (1).

In addition, there might be app developers and other entities that will process personal data on behalf of the data controller and act as data processors. Their duties should also be defined in running a smart city.

Without endangering personal data or by adopting adequate measures to protect personal data, the ecosystem can explore the opportunity to promote open data platforms by balancing with personal data protection and privacy. In doing so, data controllers need to be very careful and take into account the lawfulness of processing under Article 6 of the GDPR.

6.2.8 Summary

The use of modern technologies in developing smart city ecosystems involves issues related to privacy and personal data protection. In order to mitigate the risk to protection of personal and location data in a smart city platform, data controllers and processors need to follow the provisions of the GDPR. By following lawful procedures, maintaining principles of processing personal data and safeguarding data subjects' rights under the GDPR, organizations can conduct processing operations fairly in a smart city ecosystem. At the same time, data controllers must take into account the necessity of ensuring proper anonymization and pseudonymization of personal data in an efficient way.

7 Charter of Fundamental Rights of the European Union, OJ C 326, 26 October 2012, pp. 391–407.

6.3 Network and spectrum regulation

Exploring network and radio spectrum regulation in relation to running networks in a smart city ecosystem and recognizing the possible ways to use frequencies is important for the Neutral Host. The spectrum for electronic communication services is harmonized at a European level to enable common markets and use of the same user equipment within the EU. Indeed, global harmonization has been possible in some bands. The frequency bands identified for 5G in Europe are 700 MHz, 3,5 GHz and 26 GHz. The World Radio Conference in November 2019 further identified other high bands to be investigated for 5G in the future.

Finland has allocated more spectrum – relative to the population – to public mobile telecommunications networks than other European countries, in total about 1200 MHz. The following spectrum bands have been awarded to mobile operators in Finland: 450 MHz, 700 MHz, 800 MHz, 900 MHz, 1.8 GHz, 2.1 GHz, 2.6 GHz and 3.5 GHz. Three telecom operators have nationwide coverage. The bold spectrum policy together with functioning competition between operators is seen as one of the success factors for Finland, which is a top country in mobile broadband worldwide.

Applicable laws regarding the network and spectrum regulation are the national Act on Electronic Communication Services[8] (ECSA) and provisions of the European Electronic Communications Code.[9] The Decree of the Council of State on the use of radio frequencies and frequency plan[10] is also relevant in defining and deciding the factors relating to radio and public mobile (GSM, 5G etc.) network frequencies, spectrum band, licensing, and the like. It is still important to notice the ongoing reform of ECSA and the allocation of a new frequency band – 26 GHz – the impact of which on the Neutral Host will be crucial. The final implications of these amendments can only be seen later in 2020.

6.3.1 National network and radio spectrum regulation: Act on Electronic Communications Services

6.3.1.1 Application

The ECSA applies to many activities in the field of electronic communications. For their part, teleoperators (section 3, paragraph 27) are those engaged in *public telecommunications services*, in other words, companies that provide network or communication services to an unrestricted circle of users: "telecommunications operator means a network operator or a communications service operator offering services to a set of users that is not subject to any prior restriction, i.e. provides public telecommunications services".[11] If and when Neutral Host aims to operate locally, catering for an unlimited amount of people, it will be regarded as a teleoperator under the ECSA. Moreover, there are other relevant definitions in ECSA: "network service means a service which telecommunications operator (network operator) provides comprising a communications network in its ownership or for other reasons in its possession for the purposes of transmitting or distributing messages" (section 3, paragraph 34), while "communications service means a service consisting either completely or primarily of transmitting messages in a communications network, and of transfer and transmission service in a mass communications network" (section 3, paragraph 37).[12]

The relevant factors are thus whether the circle of users is unrestricted and in which phase(s)

8 Act on Electronic Communication Services (917/2014).

9 Directive (EU) 2018/1972 of the European Parliament and of the Council establishing the European Electronic Communications Code (Recast), OJ L 321, 17 December 2018, pp. 36–214.

10 Decree of the Council of State on the use of radio frequencies and frequency plan (1246/2014).

11 Unofficial translation of the Information Society Code (917/2014) translated by the Ministry of Transport and Communications.

12 Id.

the service provider is involved in transmitting messages. (See also Traficom, 2019).

6.3.1.2 Spectrum for mobile telecommunications and licensing procedure

Prior to operating in the field of telecommunications, the teleoperator is required to follow a specific procedure defined in the Act. The teleoperator must notify the Finnish Transport and Communications Agency (Traficom) (section 4). To operate in the public network, a license is needed "to provide a network service that uses radio frequencies in a digital terrestrial mass communications network or in a mobile network practising public telecommunications" (network license; section 6)[13].

The Government grants network licenses (section 8). At the national level, network licenses are granted either via a comparative procedure – the so-called 'beauty competition' (section 10) – or by auction (section 11). Since 2009, the auction process has been the main procedure in use for new mobile frequencies. Licenses are granted for a fixed term, with a possible covenant which includes, for example, the geographic area of function and an obligation to prevent interference on the frequency band (section 16). The given range for teleoperators on the market is normally nationwide. An operator which has been granted a network license at auction can lease the right to use its frequencies (section 20). Leasing out the right to use frequencies requires governmental approval.

Besides public networks, the Act also regulates private radio networks. Private networks are used in business and professional communications, for example, in industry, public utilities (energy and water supply), transport and traffic control, and by the authorities. A radio license "is required for the possession and use of radio transmitters" (section 39), and the licensing authority is Traficom (section 40). Radio licenses are granted to private radio networks on the basis of case-by-case frequency planning. The license and frequencies are granted for a specific geographical area, such as a harbor or factory, based on the customer's needs. On the other hand, private 4G networks have been built by telecom operators in ports and similar environments using the spectrum of commercial operators. The first dedicated 4G/5G spectrum in Finland will be 2300–2320 MHz. The first radio licenses in this band are planned to be granted after summer 2020.

A need to lighten the licensing process has been identified in Finland so as to enable 5G development and to promote possible demand for new types of operator models. (Finnish Communications Regulatory Authority, 2016). There is a draft government proposal concerning overall ECSA reform, which should enter into force during the autumn of 2020, including provisions about license requirements. The reform is based mainly on the European Communications Code but also includes national proposals for amendments to the licensing process.[14]

As for frequency bands already allocated for public mobile communication services[15] in Finland, these are shared among the major operators on the market, namely DNA, Elisa and Telia. (Ministry of Transport and Communications, 2018). It should be noted that the frequencies allocated already enable many of the activities pursued within the Neutral Host concept. The new frequency band, 26 GHz, one of three bands identified for 5G at EU level, covers 24.25–27.5 GHz. It will be allocated during 2020. Band 25.1–27.5 GHz will be auctioned for national use as three 800 MHz frequency blocks. The proposed starting price at auction would be EUR 7 million for each 800 MHz frequency blocks.

The lower part of the frequency spectrum, 24.25–25.1 GHz, i.e. 850 MHz, would be excluded from the auction. This spectrum would be reserved for local networks. In the future, local networks could be constructed in ports/harbors and industrial facilities, for example, and companies could use them for remote control, robotization and sensor data collection among other things. The way in which this frequency band will be allocated

13 Id.

14 See the draft Government proposal, available at: https://www.lausuntopalvelu.fi/FI/Proposal/Participation?proposalId=36773abd-fb0b-4593-a36a-0d843e1af094&proposalLanguage=da4408c3-39e4-4f5a-84db-84481bafc744 (Accessed: 25 February 2020).

15 The official term for public mobile communication services is "Terrestrial systems capable of providing electronic communications services".

has not yet been decided at the government level so regulatory amendments are still open with the new frequency band.[16]

However, taking into account 5G networks multiple use-cases, the 26 GHz frequency band is not the only way for Neutral Host to operate while lower frequencies are also applicable to smart city needs. Based on the current legal framework and with these frequencies, Neutral Host could already operate in co-operation with frequency holders (for example, by contracting on access and to the extent this is successful). Within the current regulatory framework, the only long-term solutions are either to have an own network license (if possible for new non-allocated frequencies) or to gain a right of access from current license holders (for allocated frequencies). Ways to cooperate are many in terms of benefits for both parties. (Ahokangas et al, 2018).

6.3.1.3 Obligations and rights of the teleoperator

Regardless of whether the operator works in cooperation or alone, the law imposes some obligations for telecompanies engaged in public telecommunications activities. These obligations need to be taken into account when constructing the Neutral Host. In general, an activity might be free of charge or commercial by nature. Thus, a non-profit entity, such as a city, might also fall under the scope of provisions addressing a telecompany. (See also Traficom, 2019). Obligations are many (chapters 7–10 and 34) and they might target an activity as a whole or parts of it. The main obligations, alongside notification and licensing, are the following:

- paying a fee,
- ensuring technical functionality and data security,
- providing assistance for authorities in emergency situations,[17]
- ensuring consumer protection and other end user rights and catering for basic services,
- safeguarding confidentiality of communications,
- promoting competition, and
- complying with regulation of the use of radio frequencies. (See also Traficom, 2019).

The teleoperator will be monitored by Traficom (sections 302–304). An annual information society fee must be paid to Traficom (section 289). Moreover, Traficom conducts market analyses and renders decisions on significant market power. Thereby obligations are imposed to secure competition in the market. These can include, for example, an obligation to grant rights of access, interconnection obligations, or non-discrimination obligations (sections 52–54, 56–57, 60–64, and 68). According to section 55 ECSA, Traficom may impose obligations to relinquish access rights (section 57) or an interconnection obligation (section 62) as well as other obligations related thereto (sections 67–69, 72, and 74) also based on reasons other than significant market power.

When contracting with consumers, chapter 15 ECSA applies. The law also imposes obligations to the teleoperator regarding data security and confidentiality (chapters 17–19, section 197 and chapters 32, 33 and 40). In addition, chapters 24 and 26 include regulation on marketing. Chapters 29 and 30 ECSA also impose some general quality requirements, for instance, regarding the network and transmitters (e.g. avoiding interference with others or society in general).

16 See the Government Project (LVM045:00/2019), available at: https://valtioneuvosto.fi/hanke?tunnus=LVM045:00/2019 (Accessed: 25 February 2020).

17 See e.g. section 280 ECSA on the obligation of a telecommunications operator to transmit a targeted message from the authorities.

For its part, net neutrality (section 110) also comes into question when tele companies are operating in a 5G network. This means that teleoperators have to treat all internet traffic equally and enable users' right to an open internet. Net neutrality is ensured by Regulation (EU) 2015/2120.[18] Traficom may provide further regulation (section 110), while it is also obligated to cooperate with EU authorities in other telecommunications issues (section 308).

Besides obligations, teleoperators also have some rights concerning the construction of infrastructure for their network. In specific circumstances, a teleoperator is allowed to place equipment, including a telecoms cable, a base station or a radio mast, on third party land or building on certain conditions (section 229). If placement is not agreed with the owner, the municipal supervisory authority decides on the matter [section 229 (3), section 233]. Contracts regarding such equipment are also binding in relation to any new owner or holder of a building or property [section 229 (4)]. If no agreement is reached with the owner, the teleoperator must draft a plan and inform all stakeholders, while the municipal authority may base its decision on this plan (sections 230–233). Teleoperators may also take other measures on third party land or building related to the construction plan (for example, remove vegetation, maintenance) if they are necessary for the placement of equipment (section 236). Resulting from the overall reform of the ECSA, some rights regarding construction of infrastructure may become wider, especially concerning the right to place small-area wireless 5G access points.

6.3.1.4 Ongoing legislative reform

In the context of implementing the new EU provisions (European Electronic Communications Code) amendments have been proposed to the ECSA and related acts in Finland. To begin with, the reform responds to the need to lighten the licensing process. It is proposed that the government-granted network license would not be needed in small-scale public telecommunications services in the case of local activities in a geographically restricted area which is indicated for such use by government decree.[19] Operating in this area would be covered by a radio license. Besides, amendments are also directed to the terms and use of a network license, aiming inter alia to support the common and efficient use of frequencies and investments in the network infrastructure. Proposals concern for example the duration of license, transfer of license and leasing the right to use a license.[20]

Amendments have also been proposed regarding provisions on access and interconnection (see Chapter II European Electronic Communications Code). Amendments include some new obligations to interconnect and to relinquish the right to access concerning both companies with significant market power and based on other grounds.[21] Moreover, the European Electronic Communications Code includes new provisions for companies with significant market power (Chapters III–IV) in areas such as migration from so-called legacy infrastructure[22] as well as co-investments[23] which are being implemented. The draft Government proposal also includes amendments to chapter 28 of the ECSA regarding placement of equipment by telecom operators. Moreover, alongside amendments to the ECSA, amendments to the

18 Regulation (EU) 2015/2120 of the European Parliament and of the Council laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union, OJ L 310, 26 November 2015, pp. 1–18.

19 See section 6 ECSA in the draft Government proposal.

20 See sections 16, 17 a–b, 18 and 20 ECSA in the draft Government proposal.

21 See sections 55 a–e and 56 ECSA in the draft Government proposal.

22 See section 81 c ECSA in the draft Government proposal; Art. 81 (1) of the European Electronic Communications Code: "Undertakings which have been designated as having significant market power in one or several relevant markets in accordance with Article 67 shall notify the national regulatory authority in advance and in a timely manner when they plan to decommission or replace with a new infrastructure parts of the network, including legacy infrastructure necessary to operate a copper network, which are subject to obligations pursuant to Articles 68 to 80."

23 See sections 81 a–b ECSA in the draft Government proposal; Art. 76 (1) of the European Electronic Communications Code: "Undertakings which have been designated as having significant market power in one or several relevant markets in accordance with Article 67 may offer commitments, in accordance with the procedure set out in Article 79 and subject to the second subparagraph of this paragraph, to open the deployment of a new very high capacity network that consists of optical fiber elements up to the end-user premises or base station to co-investment, for example by offering co-ownership or long-term risk sharing through co-financing or through purchase agreements giving rise to specific rights of a structural character by other providers of electronic communications networks or services." See also Recitals 198–201.

Land Use and Building Act[24] (LUBA) have been proposed in order to facilitate the construction of a 5G network.[25] Article 57 of the European Electronic Communications Code includes provisions on the deployment and operation of small-area wireless access points as follows:

> "1. Competent authorities shall not unduly restrict the deployment of small-area wireless access points. Member States shall seek to ensure that any rules governing the deployment of small-area wireless access points are nationally consistent. Such rules shall be published in advance of their application.
> In particular, competent authorities shall not subject the deployment of small-area wireless access points complying with the characteristics laid down pursuant to paragraph 2 to any individual town planning permit or other individual prior permits.
> By way of derogation from the second subparagraph of this paragraph, competent authorities may require permits for the deployment of small-area wireless access points on buildings or sites of architectural, historical or natural value protected in accordance with national law or where necessary for public safety reasons. Article 7 of Directive 2014/61/EU shall apply to the granting of those permits.
> (…)
> 5. Without prejudice to any commercial agreements, the deployment of small-area wireless access points shall not be subject to any fees or charges going beyond the administrative charges in accordance with Article 16."

Related amendments proposed in Finland concern chapter 28 ECSA and section 161 LUBA. If the provisions enter into force, communal authorities would not be allowed to restrict – nor could they require a prior permit for deployment of – small-area wireless access points. Moreover, access to the physical infrastructure (for example, light poles, traffic lights) controlled by public authorities should be allowed for operators to arrange placement of such access points.[26]

The proposed section 55 c ECSA would allow Traficom to impose obligations (based on other grounds than significant market power) regarding the sharing of (passive) infrastructure which is used for provision of wireless electronic communications services or contracting on localized roaming. Obligations may be imposed if they are directly necessary for local (radio frequency-based) service provision and if other companies cannot gain access to comparable infrastructure on fair and reasonable terms. Imposing such obligations would be restricted to situations where there are insurmountable hindrances to market-based deployment resulting in end-users having limited opportunities to access the network or use services.[27]

However, this legislative reform is still ongoing and final amendments are expected to enter into force later in 2020. Therefore, the effect of the proposal on Neutral Host can only be estimated. Despite any direct effect, there is a move towards principles such as non-discrimination and co-operation among telecompanies, which might affect Neutral Host more indirectly.

6.3.1.5 Summary

In general, it is already possible to execute Neutral Host as a concept, that is, even with current (already allocated) frequencies and operators as well as in the current regulatory framework. This would mean a need to cooperate with existing teleoperators (who hold relevant frequencies) and obtain a contract covering the relevant frequencies. Even then, Neutral Host could fall under the scope of legal obligations when regarded as a telecompany providing public telecommunications services.

With regard to relevant frequencies that remain unallocated (26 GHz), the means of allocating them will be crucial. It remains to be seen how

24 Land Use and Building Act (132/1999).

25 See the draft Government proposal.

26 Id.

27 Id.

they are allocated. Additionally, the influence of overall ECSA reform – for example, on the licensing process – remains to be seen. Many open questions remain: whether there is a chance to participate in an auction of new nation-wide frequencies (and a government-granted network license would be needed for operation), and whether in the future a radio license would cover local activities in the case of geographically restricted and small-scale public telecommunication services. The procedure might become lighter in the future, but on the other hand the applicability of the obligations of a telecompany remains to be seen.

6.4 Competition law

The national Finnish Competition Act[28] (FCA) and EU competition law apply to Neutral Host and organizations participating in its activities. Competition (antitrust) law prohibits 1) agreements and other forms of cooperation that restrict competition and 2) abuse of a dominant position. Breaches of these rules may result in administrative remedies (e.g. fines and orders) resulting from investigations by competition authorities (the European Commission or national competition authorities). Courts and arbitrators can also apply competition law and impose remedies for competition law infringements (for example, compensation by way of damages, invalidation of agreements). There can also be other legal consequences (including criminal liability in some countries) and non-legal consequences (such as costs, publicity) for competition law infringements.

Additionally, Finnish and EU competition law requires that 3) certain transactions, including permanent joint ventures be notified in advance to competition authorities (the European Commission or national authorities) and may not be implemented unless the authorities clear the transaction. Below the key rules are outlined and their applicability to Neutral Host discussed.

6.4.1 Finnish and EU competition law

6.4.1.1 Antitrust prohibitions

Section 5 FCA and Article 101 (1) of the Treaty on the Functioning of the European Union (TFEU)[29] prohibit agreements and other forms of cooperation between undertakings that restrict competition in a market.[30] Prohibited practices cover contracts, concerted practices and decisions by associations of undertakings which appreciably prevent, restrict or distort competition. Parties to a restrictive practice can, however, justify the practice by establishing that it improves the production of goods or promotes technical progress, allows consumers a fair share of the resulting benefit and does not allow the undertakings in question to eliminate competition in the market (section 6 FCA and Article 101 (3) TFEU).

Additional rules apply to undertakings that are in a dominant position in a relevant market. Acquiring a dominant position is not prohibited but abuse of that position is (section 7 FCA and Article 102 TFEU). Abuse can comprise, for example, 1) exclusion of rivals from the market, 2) exploitation of customers or suppliers, or 3) discrimination between customers. A dominant position generally requires a relatively high market share (for example, a market share over 50 % supports a presumption of dominance) and barriers to entry or expansion.

The Finnish Competition and Consumer Authority (FCCA) has jurisdiction to investigate

28 Competition Act (948/2011).

29 Consolidated version of the Treaty on the Functioning of the European Union, OJ C 326, 26 October 2012, pp. 47–390.

30 The TFEU prohibitions only apply when there may be an effect on trade between EU Member States but since that threshold is relatively easily reached, the rules will often apply in addition to the national, such as Finnish, competition rules.

suspected infringements of these prohibitions in Finnish and EU competition law (sections 5 and 7 FCA and Articles 101 and 102 TFEU), to impose certain remedies (such as prohibitions) and to propose fines for infringements before the Market Court. Additionally, the European Commission enforces Article 101 and 102 TFEU throughout the EU and national competition authorities in other EU Member States can enforce EU and their own national competition rules. National rules are typically similar to EU rules, but in national law they may be stricter particularly as regards unilateral practices.

6.4.1.2 Merger control

Merger control rules apply to so-called "concentrations", which entail acquisition of control, acquisition of the entire business operation of an undertaking or part thereof, a merger and creation of a joint venture which is to perform all the functions of an autonomous economic unit on a lasting basis (section 21). If the combined turnover of the parties to the concentration exceeds certain thresholds, it must be notified to the FCCA (sections 23 and 24) or the European Commission. If an authority concludes that the concentration would significantly impede effective competition in a relevant market, particularly due to creating or strengthening a dominant position, the concentration can be prohibited or conditions can be imposed on its implementation. (sections 25–27).

6.4.1.3 Other relevant rules

Relevant sector-specific rules also apply to undertakings. In particular, the Act on Electronic Communications Services complements the general competition rules. In particular, the Act can impose duties on providers of certain telecommunications services that have significant market power. They can, for example, be required to allow other telecompanies to use its network or infrastructure (sections 56, 61, 63, and 67 of the Act on Electronic Communications Services).

The Finnish Competition and Consumer Authority secures the balance between the business activities of the private and public sectors (chapter 4a), referred to as "competition neutrality". The aim of these rules is in particular to ensure that public actors do not prevent or distort competition in the market area. These rules may particularly apply if public sector organizations become involved in the market.

6.4.2 Implications of competition law on the practices of Neutral Host operator

Neutral Host and participating undertakings are generally required to evaluate their compliance with Finnish and EU competition law by themselves; no advance clearance by competition authorities is generally possible. Undertakings must, in particular, avoid engaging in cooperation that restricts competition and, if dominant in any relevant market, refrain from practices that amount to abuse of that position. Moreover, transactions such as creation of a permanent joint venture may need to be notified to competition authorities (the European Commission or the Finnish and/or other national authorities) and cleared before it can be implemented. Since competition law limits the practices that can be adopted and establishes duties for undertakings to act in certain ways, competition law also affects which business strategies are attractive for Neutral Host.

6.4.2.1 Competition law analysis of Neutral Host practices

Assessing Neutral Host from the perspective of competition law requires examining all aspects of creating and operating it. Generally, competition law analysis considers:

1. The form and nature of the practice (mergers/acquisitions/JVs, agreements/cooperation, unilateral conduct)
2. Legal and economic context of the practice
   a. Economic: relevant market (rivals), market position of parties, customers, entry barriers
   b. Legal: legal rules affecting competition on the market
3. Effects on competition (reduction of rivalry, or other forms of acquiring, maintaining and exploiting market power)
4. Efficiencies and other justifications: benefits produced that compensate consumers for anti-competitive effects, necessity of anti-competitive practices, no elimination of competition

On some practices there is legislation and case law that sets standards and tests. However, this is not the case for most aspects of the Neutral Host. As regards particularly platforms and data, the legal approaches are still under development in the Member States and at the EU level. For this reason there is uncertainty over how competition authorities and courts would analyze these types of practices. However, authorities, legislators and courts are currently examining these issues, which may clarify the situation in some aspects relevant to Neutral Host in the future.

6.4.2.2 Potential competition law issues raised by Neutral Host

Although the state of the art does not provide standards or tests on Neutral Host practices, it is possible to identify potential competition law issues that Neutral Host might raise in light of the concerns competition generally pays attention to, which are horizontal collusion, vertical restraints, foreclosure of rivals, and exploitation of customers or suppliers.

Relevant aspects for Neutral Host are for example:

1. Formation of Neutral Host operators
   - Joint venture that requires merger notification to competition authorities.
   - Agreements and cooperation that may restrict competition.

2. Connectivity layer: network and facilities
   - Agreements/cooperation – particularly among actual or potential rivals:
     - Is cooperation among telecommunications likely to restrict competition?[31]
     - Can restrictive cooperation be justified on the grounds that it is ultimately pro-competitive and beneficial to consumers?
   - Direct or indirect duties to provide access to NH connectivity facilities to other firms?

3. Data platform: collection and use of data
   - Collection of data
     - Agreements between data collectors/holders and NH?
       - Horizontal aspects: e.g. restrictions between competing data collectors?
       - Vertical issues: restrictions on data collectors or NH that restrict competition?
     - Abusive collection of data (e.g. without consent or under unfair terms)?
   - Use of collected data
     - Packaging of data: data pools, other bundles of data, separate data types?
       - Joint (collusive) selling of data?
       - Bundling: risks of excluding rival data providers?
     - Terms of supplying data to customers:
       - Pricing of data
       - Restrictions/conditions on using the data by customer

31 In the future, these types of competition law issues may become more frequent. First, proposed amendments to network and frequency regulation in Finland would enable broader sharing than is currently the case. Second, greater network densification driven by 5G and also greater emphasis on cost management of small cell networks supports the need for sharing arrangements. (See Body of European Regulators for Electronic Communications, 2018a, p. 95 and Body of European Regulators for Electronic Communications, 2018b, p. 3). In Finland, The Finnish Competition and Consumer Authority (FCCA) has expressed concerns that a joint venture among DNA Oyj and Telia Finland Oyj with Suomen Yhteisverkko Oy, with the parties sharing a mobile network in Northern and Eastern Finland, would restrict competition in the mobile communications market. However, the FCCA accepted commitments offered by DNA and TeliaSonera to address the FCCA's concerns. The commitments include the parties offering virtual and service operators access to their national networks, renting out mast and equipment location sites to competitors and restricting information exchange within the sphere of the joint venture. (See the FCCA's decision in Finnish: Finnish Competition and Consumer Authority, 2015). Also the European Commission has examined network sharing under antitrust rules (Article 101 TFEU) and recently preliminarily concluded that network sharing in the Czech Republic restricts competition. (See European Commission, 2019).

- Use of data
- Disclosure of data
- Other conditions: e.g. duty to provide own data to NH?

- Sharing data within NH (founders/partners) and through NH (to customers):
  - Risks of collusion among those having access to data that can be used to coordinate conduct among rivals
  - Abusive use of data (e.g. to exclude rivals)

- Direct or indirect duty to allow data collectors' access to NH or customers' access to data collected?

4. Marketplace: rules applicable to those willing to provide their products via NH marketplace
   - Rules for operating on the marketplace set by NH
     - Pricing related rules
     - Requirements, conditions and limitations applying to products offered in the marketplace
   - Direct or indirect duty to allow access to firms seeking to offer their products in the marketplace?

These potential concerns have to be taken into consideration when the rules and practices of Neutral Host are planned and built. Consideration also depends on the market position of the parties, the position of their competitors, customers and suppliers, as well as the effects of the practices on competition and consumers. An issue that also needs to be further examined is the implications of the network and spectrum regulation, including conditions set in spectrum licenses, as these may affect the competition law treatment of sharing and renting spectrum as well as sharing infrastructure.

6.4.3 Summary

Finnish and EU competition law prohibit all forms of cooperation that restrict competition and practices that constitute abuse of a dominant position. Since the formation and operation of Neutral Host involves cooperation and agreements with various undertakings, it is important to ensure that the agreements and their specific conditions do not reduce rivalry or can be justified by efficiency benefits (such as cost efficiencies). For example, if Neutral Host activities involve firms that otherwise would have competed (for network access, data, services, and so on), competition between them could be restricted and the parties to the activity must justify it. More permanent structures for cooperation may also require notification to competition authorities under merger control rules. Data sharing and platforms need to be designed in a way that does not include agreements restricting competition or, if Neutral Host were to become dominant in some market (such as data supplier in an area), does not lead to foreclosure of competitors or impose unjustified restraints on customers or suppliers.

6.5 Public procurement legislation

The aim of public procurement legislation is to ensure cost and quality efficiency in the use of public funds as well to maintain competition in the market by providing equal opportunities to provide goods and services. To achieve this, procurements have to be tendered under certain circumstances. The obligation to arrange competitive tendering depends principally on the organization (procurer) as well as the value and type of procurement.

6.5.1 Act on Public Procurement and Concession Contracts

Finnish national legislation on public procurement[32] will be applied and the competitive tender procedure needs to be arranged when 1) the contracting entity is one of those mentioned in the Act and it arranges procurement outside of its organization and 2) the value of the procurement

32 Act on Public Procurement and Concession Contracts (1397/2016).

exceeds the national threshold values defined in section 25 (60 000–500 000 euros depending on the type of procurement).[33]

Contracting entities subject to the duties under section 5 are:

"1. authorities of central and local government and joint municipal authorities;
2. the Evangelical-Lutheran and Orthodox churches of Finland and their parishes and other authorities;
3. state commercial institutions;
4. institutions of a public law character;[34]
5. any party conducting a procurement when it has secured support in doing so from a contracting entity referred to in paragraphs 1–4 amounting to more than half of the value of the procurement."[35]

The competitive tender procedure needs to comply with certain requirements set in legislation. These include, for example, notifications and set timelines for the call for tenders, competency requirements when selecting the service provider and the requirement that the whole procurement process is fulfilled in accordance with the principles of equality and non-discrimination (section 3, chapters 6–11 and chapter 14). As a rule the most economically advantageous tender has to be selected (section 93).

Purchasing bodies can choose among certain procedures and contract types (chapter 5). One method of executing public works or service procurement is to use concession contracts. A concession contract denotes an agreement concluded for financial consideration, whereby the contracting entity assigns – to the supplier – performance of public works, or the provision and administration of services, and the associated operational risk. The consideration for the assignment consists either solely in the right to exploit the works or services, or in that right together with the payment.[36]

Generally, all medium and high value contracts must be awarded through competitive procedures. However, there are some exclusions from and exceptions to this. These include, for example, procurements "whose principal purpose is to enable the contracting entity to make public communications networks available or to maintain them or to provide the public with one or more electronic communication services" (section 8 paragraph 1) and procurements concerning research and development services defined in schedule A (section 9 paragraph 13). Additionally, in some circumstances – when purchasing real estate or where there is only one possible supplier – competitive tendering is not required (section 9 paragraph 1, section 40).

6.5.2 Directive 2014/24/EU on Public Procurement

The EU Directive on Public Procurement[37] requires that if the value of the procurement exceeds the threshold values defined in the directive (2020 threshold values lie between 139 000 – 5 350 000 euros)[38] somewhat stricter requirements as to the competitive tender procedure have to be taken into account[39] and the competitive tender has to be arranged EU-wide. In EU-wide competitive tenders, providers from any Member States which

33 Sections 27 and 28 define how to calculate the estimated procurement value. Dividing or combining procurement artificially in order to evade application of the law (section 31) is prohibited.

34 Institutions of a public law character referred to in paragraph 4 are defined as "a legal person expressly established to satisfy public interest needs that are not of an industrial or commercial nature and: 1) are mainly financed by a contracting entity referred to in paragraphs 1–4; 2) are managed under the regulatory control of a contracting entity referred to in paragraphs 1–4; or 3) of whose administrative, managerial or regulatory organs a contracting entity referred to in paragraphs 1–4 appoints more than half of the members".

35 Unofficial translation by the Ministry of Economic Affairs and Employment.

36 Chapter 13 regulates concession contracts. The national threshold value for concession contracts is 500 000 euros (section 25). EU regulation will be applied if the value of a concession contract is over 5 million euros (Directive 2014/23/EU of the European Parliament and of the Council on the award of concession contracts, OJ L 94, 28 March 2014, pp. 1–64, Article 8).

37 Directive 2014/24/EU of the European Parliament and of the Council on public procurement and repealing Directive 2004/18/EC, OJ L 94, 28 March 2014, pp. 65–242.

38 Article 4. The values are reviewed every two years.

39 Articles 23, 27–31, 42, 50, 51, 59, 61. Stricter requirements include required notifications, longer set periods for tenders and the use of common EU standards and forms as well as more detailed competency criteria for the selected tender. The EU has created, e.g., a common public procurement vocabulary (CPV-codes) which needs to be used when specifying procurement types.

fulfil certain requirements can participate in the call for tenders and are eligible to be chosen as a provider of a service or goods.

The primary organs for reviewing the procedure are the courts or independent review bodies based in the EU country where the tender was published. These processes need to comply with certain requirements. For procurements whose value exceeds the EU threshold limits, the European Commission has jurisdiction to intervene in unlawful acts among Member States.[40]

6.5.3 Summary and implications of public procurement law for Neutral Host

Public procurement rules in Finland and throughout the EU require certain organizations to arrange their procurements through a tendering process. From the perspective of the NH project, public procurement rules raise two particular questions: 1) whether Neutral Host is required to arrange competitive tendering of its procurements or 2) whether another entity that purchases goods or services from Neutral Host has to do so and what implications this has for Neutral Host.

As to the first question, when structuring the Neutral Host it is relevant to establish whether Neutral Host could be regarded as a contracting entity. This mainly comes into question if a public entity (e.g. city) occupies a central role in Neutral Host activities. With regard to the second question, a strategic consideration is that entities purchasing goods and services from Neutral Host may need to arrange procurement procedures required by law. As the applicability of public procurement rules to the customers of Neutral Host depends on the value and object of procurement by the procurer, it is relevant what the object of procurement is, whether goods and services of Neutral Host are acquired as separate components or as one package and what their value is deemed to be. An issue requiring further analysis is to what extent the exceptions applying to "electronic communications services" (section 8 paragraph 1 of the Finnish Act on Public Procurement and Concession Contracts; Article 8 of Directive 2014/24/EU) cover products offered by Neutral Host.

6.6 Concluding remarks

Neutral Host, as an operating model for a digital smart city ecosystem, may open many unforeseen business possibilities that can benefit both citizens and the government. In any case, many legal aspects need to be taken into account when developing the Neutral Host business model. Legal requirements and obligations must be fulfilled, for example, when collecting and using (processing) personal data, operating in a network with the possible new operator model and producing services and applications for the data platform's marketplace. Neutral Host also needs to be organized and operated in a way that meets the requirements of competition law, which in some situations may require notification of planned joint ventures to the competition authorities.

In addition, when evaluating whether digital smart city ecosystems' functions are compliant with the law, it has to be noted that the regulatory environment is new and the legal approaches and praxis are constantly developing. This is why exhaustive answers to all the upcoming questions can be challenging to give. To provide a more precise analysis of the legal framework for Neutral Host, for example, the actors and functions in the ecosystem need to be further clarified. However, as the purpose of regulation is also to enable the development of future smart cities, there is also

40 Council Directive 89/665/EEC on the coordination of the laws, regulations and administrative provisions relating to the application of review procedures to the award of public supply and public works contracts, OJ L 395, 30 December 1989, pp. 33–35.

a need to adjust or lighten certain regulatory procedures and practices that are no longer applicable in the 5G era. The need to update regulation is already recognized at the EU level, as well as in Finland, where ongoing reform of network and spectrum regulation implicates the trend. In the context of digital smart cities, where many new legal concerns will arise in the future, legislators and regulators need to achieve a balance between responsibilities and restrictions and rights and reliefs.

However, the Neutral Host as a concept could already be executed under the current regulatory framework. Current legislation provides a frame where the 5G ecosystem can operate ensuring that, inter alia, the privacy and data protection of citizens is secured, that market balance and fair competition remain and that the elements needed for the digital smart city's function are shared and used fairly and effectively. Looking into the future, the ongoing reforms and proposed amendments can be relevant for the Neutral Host, but their final influence can only be estimated later. Meanwhile, Neutral Host can be further developed by following existing legal mandates and legal requirements.

7 SUMMARY

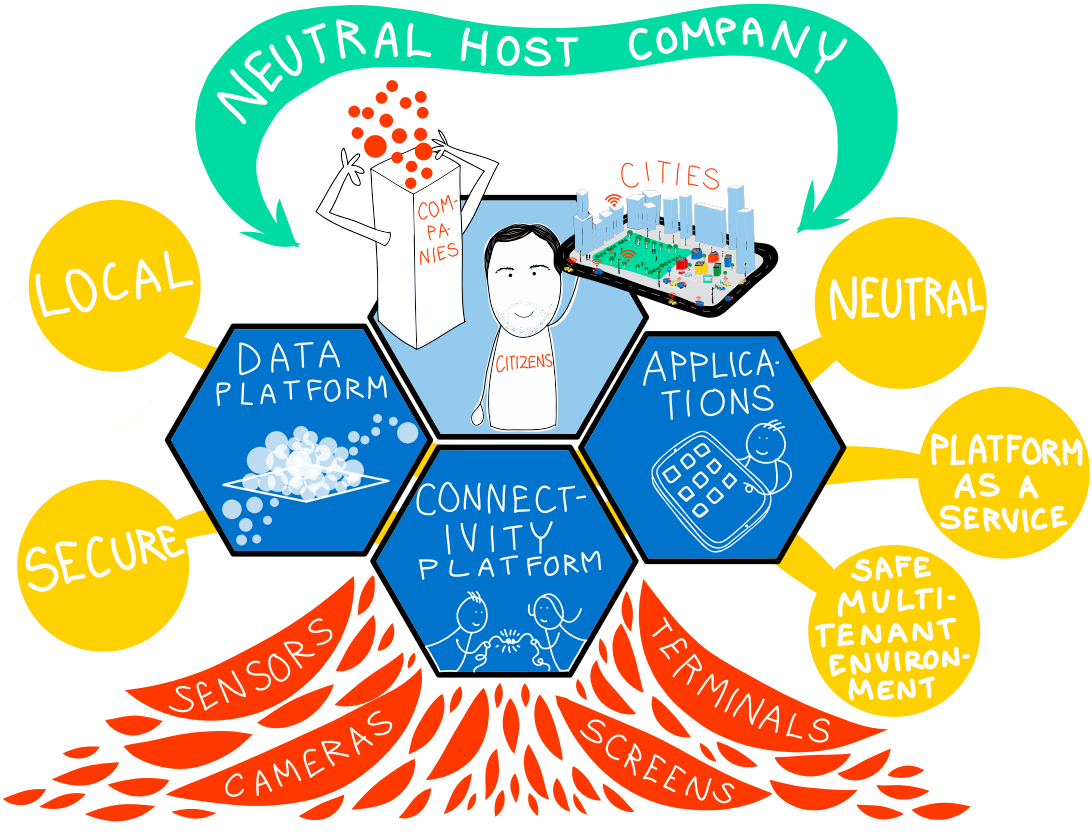


Figure 31 Neutral host company

According to UN reports, 56% of the global population resides in urban areas of the world. Some sources argue that this percentage is significantly higher and that it goes over 70%. Either way, the world's population is inevitably going to increase in the upcoming decades, regardless of some regions struggling with a declining birth rate. The only way for cities to improve the quality of life as the world's population grows at a tremendous rate is to discover and implement new technologies in different sectors. One such type of technologies are the innovations such as Smart cities and Neutral Host networks (NHNs).

In a nutshell, an NHN is a third-party cellular network in charge of providing localised mobile coverage solutions to a wide range of national mobile network operators (MNOs). The NHN itself determines whether their commercial mobile network solutions are paid or free of charge or whether they belong to the MNO's bands or a dedicated NHN-owned spectrum. In European regions, these innovations are expected to be implemented mainly within transportation and mobility sectors to increase functionality and citizen engagement.

One outcome of integrating these technologies would be the reduction of the use of personal cars, as the cities are going to provide more reliable and pleasant public transportation. With improvements to shared mobility, cities are going to benefit in terms of environmental changes and higher satisfaction among the citizens. However, it is important to address that neutral host technologies also play a significant role in various other industries, including media and entertaining, the automotive industry, logistics, safety, drone technology, healthcare industries, and energy, among others.

Neutral host technologies are bound to increase network capacities and processing capabilities, which is going to lead to more advanced data processing systems and thus a higher degree of data collection. As big data continues to develop on a larger scale, technologies such as AI and machine learning will benefit from the increased capacity and data variety. The increase in data processing volume is one of the bases for EU's key strategies including the European Data Economy and the Digital Single Market. As a result, API ecosystems will support data economy development and provide additional data for this cause.

There are many data-driven value propositions worth mentioning, including information and knowledge or a non-data product or service. Data business models expand through various uses, from models for data suppliers and data users to data facilitators and data sharing technologies. Potential value of data will remain untapped as long as data remains fragmented in isolated systems. Opening up the door to this new world of data could solve a variety of smart city challenges the world is currently dealing with. In order to make smart cities a reality, business models must put together a smart city data economy.

This will create a new value from data which will enable new technologies and applications. The currently unusued data storages can significantly boost the speed of smart city development. Other solutions needed for this cause are technologies for exchanging, that is, selling and buying data products. Of course, the implementation of these technologies will require business expertise and funding in order to form the new business models. With data-business and communications-businesses being completely different, a neutral-host business model, if established, would be operating in two separate markets. This could be a potential block on the road, although there are ways to work around it. After all, data and communications businesses, even though fundamentally different, are both platform-based.

Each platform would need a certain volume of customers to cover the costs of the new operations. With that in mind, the geographical location where the natural host would be operating would have to be vast enough to provide the required customer volume.

Moreover, it is important to address the categorization of the ownership structures. There are two extreme ends – one; which is a neutral host or a public stock-listed company, and the other; a non-profit organization that takes care of non-monetary objectives. There are, however, several minor categories between these two. With that in mind, we must take into consideration that the ecosystem will vary if operated by different owner-base-neutral-hosts. The concept of ownership can have a significant impact on the implementation of these categories.

The second categorization implies that certain companies choose similar strategies based on their historical background. This piece of information helps neutral hosts determine how to run a business and which growth path to choose. We have also covered the traits and strategies of neutral host companies in regards to their use of data. The goal behind these reports is to understand how neutral host companies act in their ecosystems. In our research of the given matter, we have discovered that neutral host companies have numerous businesses possibilities that could be beneficial to both citizens and the government in a smart city ecosystem.

As we have discussed in this report, it is important to take into consideration all the legal aspects that go into developing a neutral host business. Collecting and processing personal data of any kind requires compliance with certain privacy laws and regulations. The neutral host company also has to comply with the requirements of competition law, which usually requires each

planned joint venture to be announced to the competition authorities. Throughout the entire process of ensuring that the smart city ecosystem is in full compliance with the law, it is important to keep in mind that legal matters are constantly changing and developing. This makes pinpointing specific questions and answers difficult, as we are dealing with a new legal environment that is constantly evolving.

The purpose behind regulating these activities is to enable implementation of smart cities in the future. To do so, certain regulatory procedures will have to be lightened, as they will no longer be applicable to 5G implementation. This need has already been acknowledged in Finland and at the EU level. There is no doubt that there will be countless new concerns regarding the legal side of enabling smart cities. However, legislators and regulators will have to work together to find a balance between restrictions and potential benefits. As we have for example seen in this report, with regard to relevant frequencies that remain unallocated (26 GHz), the means of allocating them will be crucial. It remains to be seen how they are allocated.

Despite all potential concerns, there is a way for the concept of a Neutral Host to be implemented under the current regulatory framework. According to the current laws, a 5G system can legally operate as long as citizen's data and privacy are fully secured. Another requirement is that all elements needed for bringing a smart city to life are shared and used in the most effective way possible. While we do expect the development of new and lighter reforms that will allow smart cities to function on a larger scale, the influence of the Neutral Host won't be estimated until later on in the future. Until then, Neutral Host can be developed through existing legal framework, as long as all privacy requirements are taken into consideration.

REFERENCES

5G-CITY 2017, 5G City (2017 – 2019), Cellnex Ltd, https://www.cellnextelecom.com/en /projects/5g-city/

Abraham T. 2015, What other cities should learn from Philly's failed municipal broadband effort, Technically Press, viewed 28 January 2020, https://technical.ly/philly/2015/03/04/ cities-learn-phillys-failed-municipal-broadband-effort/

Ahokangas, P., Matinmikko-Blue, M., Yrjölä, S., Seppänen, V., Hämmäinen, H., Jurva, R. and Latva-aho, M. (2018). Business Models for Local 5G Micro Operators. In *2018 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN)* 1 January. Available at: https://research.aalto.fi/files/31560142/ELEC_Hammainen_IEEE_DySPAN_Business_models_for_local_5G_operators_camera_ready.pdf (Accessed: 25 February 2020).

Article 29 Working Party (2017). *Guidelines on Data Protection Impact Assessment (DPIA) and determining whether processing is "likely to result in a high risk" for the purposes of Regulation 2016/679. Adopted on 4 April 2017, as last Revised and Adopted on 4 October 2017.* Available at: https://ec.europa.eu/newsroom/article29/item-detail.cfm?item_id=611236 (Accessed 20 April 2020).

AT 2020, History, American tower, viewed 28 January 2020, https://www.americantower.com/company/history.html

AT-b 2020, Improve Capacity and Coverage in Dense Urban Environments, American tower, viewed 28 January 2020, https://www.americantower.com/us/solutions/smart-poles.html

BAI 2020, Transit Communications, BAI Communications, viewed 28 January 2020, https://www.baicommunications.com/our-services/transit-communications/

BDVA (2019) 'Towards a European data sharing space - enabling data exchange and unlocking AI potential', BDVA Position Paper.

Body of European Regulators for Electronic Communications (2018a). *Study implications of 5G Deployment on Future Business Models. A Report by DotEcon Ltd and Axon Partners Group. 14 March 2018.* Available at: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/8008-study-on-implications-of-5g-deployment-on-future-business-models (Accessed 20 April 2020).

Body of European Regulators for Electronic Communications (2018b). *Report on infrastructure sharing. A Report by BEREC. 14 June 2018*. Available at: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/8164-berec-report-on-infrastructure-sharing (Accessed 20 April 2020).

Breyer, P. v. Bundesrepublik Deutschland (2016) Case C-582/14. ECLI:EU:C:2016:779.

Bu-Pasha, S. (2018). *Location Data, Personal Data Protection and Privacy in Mobile Device Usage: An EU Law Perspective*. Doctoral dissertation, University of Helsinki.

BW, 2018, "Dense Air" The Neutral Host Small Cell Operator, Business Wire, viewed 10 February 2020, https://www.businesswire.com/news/home/20180226006349/en/ %E2%80%9CDense-Air%E2%80%9D-Neutral-Host-Small-Cell-Operator

Caragliu, A., Del Bo, C. & Nijkamp, P. (2011) Smart Cities in Europe, Journal of Urban Technology, 18, 2, 65-82, p.70

CISION 2020, The Global Market for Telecoms Towers 2014 – 2020, PR Newswire, viewed 28 January 2020, https://www.prnewswire.com/news-releases/the-global-market-for-telecoms-towers-2014---2020-276829701.html

CTIL 2020, Join the Future, Cornerstone, viewed 28 January 2020, https://www.cornerstone.network/

Daniel, J. 2008, In-Building 101: A Primer for RF Distribution Technology, Jack Daniel Co., viewed 4 February 2020, http://www.napco.org/Resources/M108-Daniel.pdf

DEA, 2019. 5G Action Plan for Denmark, Danish Energy Agency, visited 10 February 2020, https://ens.dk/sites/ens.dk/files/Tele/5g_action_plan_for_denmark.pdf

DenseAir, 2020. Keeping you connected. DenseAir Ltd. Viewed 10 February 2020. http://denseair.net/

DIF 2020, Investment assets, Digital Telecommunications Infrastructure Fund, viewed 28 January 2020, http://www.digital-tif.com/dif/investment

Dot.econ & Axon partners report (2018) '*Study on Implications of 5G Deployment on Future Business Models'.* Available at: https://www.dotecon.com/publications/study-on-implications-of-5g-deployment-on-future-business-models-a-report-for-berec/. Viewed 15.1.2020

EC (2017) 'Building a European Data Economy', Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, 10.1.2017, COM(2017), pp. 1–18.

Euractiv. (2019). *EU Commission unveils 'European Green Deal' by Frédéric Simon: The key points*. Available at: https://www.euractiv.com/section/energy-environment/news/eu-commission-unveils-european-green-deal-the-key-points/.

European Commission.(2017). *Sustainable Development in the European Union — Overview of progress towards the SDGs in an EU context*. Available at: https://ec.europa.eu/eurostat/web/products-catalogues/-/KS-01-17-796 or https://ec.europa.eu/eurostat/documents/4031688/8461538/KS-01-17-796-EN-N.pdf/f9c4e3f9-57eb-4f02-ab7a-42a7ebcf0748.

European Commission. (2019). *Antitrust: Commission sends Statement of Objections to O2 CZ, CETIN and T-Mobile CZ for their network sharing agreement. Press release, 7 August 2019.* Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_19_5110 (Accessed: 19 March 2020).

European Commission. (2019). *The Future of Cities 2019*. Available at: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities.

European Commission. *Smart Specialisation Platform on Smart Cities*. Available at: https://s3platform.jrc.ec.europa.eu/smart-cities. (Accessed:25 February 2020).

European Commission. *Smart Specialisation Platform: Digital Agenda toolbox in investing in Smart Cities*. Available at: https://s3platform.jrc.ec.europa.eu/documents/20182/137912/Smart+cities2.pdf/880a4ec0-73d4-4d20-8171-71f062a6a5e9. (Accessed:25 February 2020).

European Commission. *KnowSDGs Platform*. Available at: https://knowsdgs.jrc.ec.europa.eu. (Accessed:25 February 2020).

European Commission. (2020). *European Data Strategy, 20 February 2020.* Available at: https://ec.europa.eu/eip/ageing/news/european-data-strategy_en (Accessed: 13 March 2020).

Fildes N. 2019, Vodafone and O2 signal potential sale of mast joint venture, Financial Times, viewed 28 January 2020, https://www.ft.com/content/d31b871e-1ee4-11e9-b126-46fc3ad87c65

Finnish Communications Regulatory Authority. (2016). *Viestintäviraston TAE 2017*, Available at: https://www.eduskunta.fi/FI/vaski/JulkaisuMetatieto/Documents/EDK-2016-AK-78656.pdf (Accessed: 25 February 2020).

Finnish Competition and Consumer Authority. (2015). *Decision dnro 438/14.00.00/2014, 5 November 2015*. Available at: https://www.kkv.fi/globalassets/kkv-suomi/ratkaisut-aloitteet-lausunnot/ratkaisut/kilpailuasiat/2015/kielto--sitoumus--ja-toimitusvelvoiteratkaisut/r-2014-00-0438.pdf (Accessed: 19 March 2020).

Forum Virium, 2019. The most functional smart city in the world, Forum Virium, viewed 10 February 2020, https://forumvirium.fi/en/introduction/building-an-open-and-smart-helsinki/

Fruhwirth, M., Rachinger, M. and Prlja, E. (2020) 'Discovering Business Models of Data Marketplaces', Proceedings of the 53rd Hawaii International Conference on System Sciences, pp. 5738–5747. doi: 10.24251/hicss.2020.704.

FSN 2020, Suomen yhteisverkko, Finnish Shared Network Ltd., http://yhteisverkko.fi/

Garfinkel, S.L. (2015). *De-Identification of Personal Information.* National Institute of Standards and Technology Internal Report 8053. U.S. Department of Commerce. Available at: http://dx.doi.org/10.6028/NIST.IR.8053 (Accessed: 25 February 2020).

GSMA, 2019. *Infrastructure sharing: An overview,* GSM Association [online]. Available at: https://www.gsma.com/futurenetworks/wiki/infrastructure-sharing-an-overview/ (accessed 27 April 2020).

Hadi, M. U. 2015, Extending the benefits of LTE to unlicensed spectrum, 2015 International Conference on Information and Communication Technologies (ICICT) (pp. 1-3). IEEE.

Hall, R.E. (2000). The vision of a smart city. In *Proceedings of the 2nd International Life Extension Technology Workshop.* Paris, France. September 28. Available at: https://webcache.googleusercontent.com/search?q=cache:oygpf30o6rgJ:https://www.osti.gov/servlets/purl/773961/+&cd=1&hl=fi&ct=clnk&gl=fi (Accessed: 28.3.2020).

Helsinki, 2018. Helsinki claims several top positions in 2018 smart city comparisons. City of Helsinki, viewed 10 February 2020, https://www.hel.fi/uutiset/en/kaupunginkanslia/helsinki-claims-several-top-positions-in-2018-smart-city-comparisons

Huttunen, H., Seppälä, T., Lähteenmäki, I., Mattila, J. (2019) 'What Are the Benefits of Data Sharing? Uniting Supply Chain and Platform Economy Perspectives', ETLA Report No 93.

I2CAT, 2019. The i2CAT's NEUTROON solution selected to participate in the tech transfer programme Collider, i2CAT Foundation, viewed 10 February 2020, https://www.i2cat.net/ the-i2cats-neutroon-solution-selected-to-participate-in-the-tech-transfer-programme-collider/

Joyce, A., & Paquin, R. L. 2016. The triple layered business model canvas: A tool to design more sustainable business models. Journal of cleaner production, 135, 1474-1486.

Kamara, I. and De Hert, P. (2018), *Understanding the balancing act behind the legitimate interest of the controller ground: a pragmatic approach*. *Brussels Privacy Hub Working Paper, Vol. 4, N° 12.*

Kibria, M. G., Villardi, G. P., Nguyen, K., Liao, W. S., Ishizu, K., & Kojima, F. (2017). Shared spectrum access communications: A neutral host micro operator approach. *IEEE* Journal *on Selected Areas in Communications*, 35(8), 1741-1753.

Kühne, B. and Böhmann, T. (2018) 'Requirements for Representing Data-Driven Business Models - Towards Extending the Business Model Canvas', in AMCIS2018, pp. 1–10.

Lohan, E.S., Alén-Savikko, A., Chen, L., Järvinen, K., Leppäkoski, H., Kuusniemi, H. and Korpisaari, P. (2018) '5G Positioning: Security and Privacy Aspects' in Liyanage, M., Ahmad, I., Abro, A.B., Gurtov, A. and Ylianttila, M. (eds), *A Comprehensive Guide to 5G Security*. Wiley, pp. 281–320.

LuxTurrim5G. (2019). *Nokia Driven LuxTurrim5G Smart City Ecosystem Extending* [Online]. Available at: https://www.luxturrim5g.com/new-blog/2019/11/4/nokia-driven-luxturrim5g-smart-city-ecosystem-extending (Accessed: 3.4.2020).

LuxTurrim5G. (2017). *Project Summary* [Online]. Available at: https://www.luxturrim5g.com/project-summary (Accessed: 3.4.2020).

Magalhaes, G. and Roseira, C. (2017) 'Open government data and the private sector: An empirical view on business models and value creation', Government Information Quarterly. Elsevier, (August), p. 101248. doi: 10.1016/j.giq.2017.08.004.

Martin De Saulles (2018) Why the Internet of Things needs dynamic data exchanges, The business of data. Available at: https://news.codecademy.com/why-data-structures/.

MBNL 2020, About us, Mobile Broadband Network Limited, viewed 28 January 2020, https://mbnl.co.uk/

Ministry of Transport and Communications. (2018). *Valtioneuvosto myönsi 5G-verkkotoimiluvat* [Online]. Available at: https://www.lvm.fi/-/valtioneuvosto-myonsi-5g-verkkotoimiluvat-987074 (Accessed: 25 February 2020).

Muir, S., Chapin, J., Bose, V., & Steinheider, J., 2006. Distributed antenna systems plus software radio: Range extension and other benefits, In Vanu, Inc., Software Defined Radio Technical Conference, Orlando, FL.

ONTIX 2018, Ontix wins Contract to Deliver 5G-Ready Wireless Connectivity Across Westminster, Ontix Ltd, viewed 28 January 2020, https://www.ontix.co.uk/news-press/ontix-secures-wireless-concession-westminster/

OpendataDK, 2020, Åbne data til dig, Open Data DK, visited 10 February 2020, https://www.opendata.dk/

Osterwalder, A., & Pigneur, Y. 2002. Business models and their elements. In Position paper for the international workshop on business models, Lausanne, Switzerland.

Osterwalder, A., Pigneur, Y. and Tucci, C. L. (2005) 'Clarifying Business Models: Origins, Present, and Future of the Concept', Communications of the Association for Information Systems, 16(July). doi: 10.17705/1cais.01601.

Paglierani, P., et al., 2019. Techno-economic analysis of 5G immersive media services in cloud-enabled small cell networks: The neutral host business model: Providing techno-economic guidelines for the successful provision of 5G innovative services in small cell networks. Transactions on Emerging Telecommunications Technologies, e3746.

Paolino, M., et al., 2019. Compute and network virtualization at the edge for 5G smart cities neutral host infrastructures. In 2019 IEEE 2nd 5G World Forum (5GWF) (pp. 560-565). IEEE.

Perätalo, S., & Ahokangas, P. (2018). Toward Smart City Business Models. *Journal of Business Models*, 6(2), 65-70.

Rasay, S. J. & Shah, S. 2019, Vodafone's cell towers spinoff plans welcomed by analysts, S&P Global, viewed 28 January 2020, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/53314183

Rayal, F. 2013, LTE-Advanced, 3.5 GHz, Small Cells and Neutral Host Services: A Powerful Mix to Abundantly Increase Network Capacity, Frank Rayal Blog, viewed 4 February 2020, https://frankrayal.com/2013/09/16/lte-advanced-3-5-ghz-small-cells-and-neutral-host-services-a-powerful-mix-to-abundantly-increase-network-capacity/

Reinsel, D., Gantz, J. and Rydning, J. (2017) 'Data Age 2025: The Evolution of Data to Life-Critical', Framingham, MA, US: International Data Corporation.

Saeid, M., Rezvan, M. and Barekatain, M. (2018) 'Machine learning for internet of things data analysis : a survey', Digital Communications and Networks. Elsevier, 4(3), pp. 161–175. doi: 10.1016/j.dcan.2017.10.002.

Schroeder, R. (2016) 'Big data business models: Challenges and opportunities', Cogent Social Sciences. Cogent, 2(1), pp. 1–15. doi: 10.1080/23311886.2016.1166924.

Schüritz, R., Seebacher, S., & Dorner, R. 2017. Capturing value from data: Revenue models for data-driven services. In Proceedings of the 50th Hawaii International Conference on System Sciences.

Spiekermann, M. (2019) 'Data Marketplaces: Trends and Monetisation of Data Goods', Intereconomics, 54(4), pp. 208–216. doi: 10.1007/s10272-019-0826-z.

Strohbach, M., Ziekow, H., Gazis, V., & Akiva, N. (2015). *Towards a big data analytics framework for IoT and smart city applications*. In Modeling and processing for next-generation big-data technologies (pp. 257-282). Springer, Cham.

Tan, W. et al. (2016) 'From the Service-Oriented Architecture to the Web API Economy', IEEE Internet Computing. IEEE, 20(4), pp. 64–68. doi: 10.1109/MIC.2016.74.

Tietosuojavaltuutettu. v. Jehovan todistajat – uskonnollinen yhdyskunta (2018) Case C-25/17. ECLI:EU:C:2018:551.

Traficom. (2019). *Mikä on teletoimintaa?* [Online]. Available at: https://www.traficom.fi/fi/viestinta/viestintaverkot/mika-teletoimintaa (Accessed: 25 February 2020).

UK 2018, Forging a full fibre broadband and 5G future for all, UK Government, viewed 28 January 2020, https://www.gov.uk/government/news/forging-a-full-fibre-broadband-and-5g-future-for-all

UN 2016, The World Cities in 2016, United Nations, viewed 30 December 2019, https://www.un.org/en/development/desa/population/publications/pdf/urbanization/ the_worlds_cities_in_2016_data_booklet.pdf

Unabhängiges Landeszentrum für Datenschutz Schleswig-Holstein v. Wirtschaftsakademie Schleswig-Holstein GmbH (2018) Case C-210/16. ECLI:EU:C:2018:388.

Vu, Q. H. et al. (2012) 'DEMODS : A Description Model for Data-as-a-Service', in IEEE 26th International Conference on Advanced Information Networking and Applications, pp. 605–612. doi: 10.1109/AINA.2012.91.

Walravens, N., & Ballon, P. (2013). Platform business models for smart cities: from control and value to governance and public value. *IEEE Communications Magazine*, 51(6), 72-79.

Washburn, D., Sindhu, U., Balaouras, S., Dines, R.A., Hayes, N.M. and Nelson L.E. (2010). *Helping CIOs Understand "Smart City" Initiatives: defining the smart city, its drivers, and the role of the CIO.* Cambridge: Forrester Research, Inc. Available at: *http://goo.gl/4XHk0F* (Accessed: 9.4.2020).

WIG 2020, About us, Wireless Infrastructure Group Ltd., viewed 28 January 2020, https://www.wirelessinfrastructure.co.uk/about-us/

WIG-b 2020, WIG raises £220m to accelerate investment into new neutral-host wireless infrastructure, Wireless Infrastructure Group, viewed 28 January 2020, https://www.wirelessinfrastructure.co.uk/wig-raises-220m-to-accelerate-investment-into-new-neutral-host-wireless-infrastructure/

Wray, Sarah, 2019. Huawei seals smart city deal with Barcelona, SmartCitiesWorld, viewed 10 February 2020, https://www.smartcitiesworld.net/news/news/huawei-seals-smart-city-deal-with-barcelona-4804.

LIST OF FIGURES AND TABLES

Figures

Tables