Smart City as a Platform-Based Ecosystem

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Abstract. While for a smart city there is no generally accepted definition, there exists a wide consensus of what a smart city (or country) should bring to its citizens. It is believed that it such smart environment, all required conditions are met for a quality of life of individuals and communities and for sustainable economic growth. In most circumstances, this is associated with the availability of health and social security, the ease of use of public services, efficient mobility, security, job and business opportunities etc. How to achieve that remains a challenge of the 21st century. In this paper, we describe a program of R&D projects that were launched in late 2016 within the Slovenian Smart Specialization initiative as a response to the aforementioned challenge.

Keywords. Smart city, platform ecosystem, smart specialization

1. Introduction

Even though we still don't have any officially accepted definition of what "smart" or "smarter" exactly means in the context of a city, one thing is clear: the word "smart" is broadly used as a synonym of almost anything that can be considered modern and intelligent [1]. Accordingly, it would be expected that smart city has all sorts of smart systems in use to help better manage and govern the city as well as to provide citizens with everything necessary for a quality living. The "smartness" however should not be associated with smart systems and the use of ICT only – a great impact on the "smartness" can also have innovations that are not technology oriented, e.g. innovative business models, organizational solutions, creative design etc. In more wide sense a smart city can be thus seen as a city with an ability to bring together all its resources, to effectively and seamlessly achieve the goals and fulfil the purposes it has set itself [2]. But this again leaves a lot of space for interpretation and contributes to the fact that nowadays we have a number of cities that call themselves smart even though they are very much different in the smartness they provide or use.

Nevertheless, what is becoming more and more evident, is that we urgently need to address social challenges, such as mitigation of costs associated with aging population, increased production and reduced loss of foodstuffs, reduction of GHG emissions, redistribution of wealth and correction of regional inequality, etc), which are becoming a serious threat to the whole society.

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Japan is an example of a country that has made a large step forward in this regard. In CeBIT 2017, they introduced its societal transformation plan, called Society 5.0 [3, 4]. According to this plan, Japanese government aims to tackle several social challenges by going far beyond just the digitalization of the economy (e.g. such as in Industry 4.0) towards the digitalization across all levels of the Japanese society and the (digital) transformation of society itself. This turns to be a huge challenge that needs to be approached with a wide society consensus.

In this paper, we describe how Slovenian government has started to tackle these challenges by setting up the so-called Smart Specialization Framework to boost its digital transformation by considering the societal challenges on one hand and the specifics and maturity of Slovenian economy on the other.

The rest of the paper is structured as follows: in Section 2 we describe the societal challenges that represent an important fact and motivation for efforts in making cities smarter. Next, we describe the Slovenian Smart Specialization (S4), a framework that Slovenia accepted to cope with these challenges and at the same time to boost development in those areas that were identified as having potential for developing innovative and highly competitive products and services. In Section 4, we describe EkoSMART, a program of S4 projects that aim at providing all supporting mechanisms for efficient, optimized and gradual integration of smart city domains into one, unified and coherent system of value chains. Its vision is to establish a business ecosystem for the development of integrated and highly competitive solutions and services in the smart city domain. The paper ends with concluding remarks on lessons learned.

2. Societal Challenges

More than half of the world population is already living in cities. But even more alarming is that this number is expected to grow and reach 5 billion till 2030 [5]. This is a huge challenge for cities' infrastructure and organization and one of the reasons that motivate cities' governments to invest into the use of ICT and smart solutions to be able to cope with these challenges.

The urbanization is however not the only reason for investments in smart management and operation of cities. Even more important are societal challenges.

The economic advancement is bringing many changes that are impacting our lives. We are becoming older (as the society), need more energy and food, the distribution of wealth is becoming severely unbalanced, we are experiencing higher and higher competition, etc. All this is opening many social problems that could have enormous impact on a long turn and thus cannot be ignored. A big expectation is now associated with modern technologies as the means for addressing these problems (Figure 2).
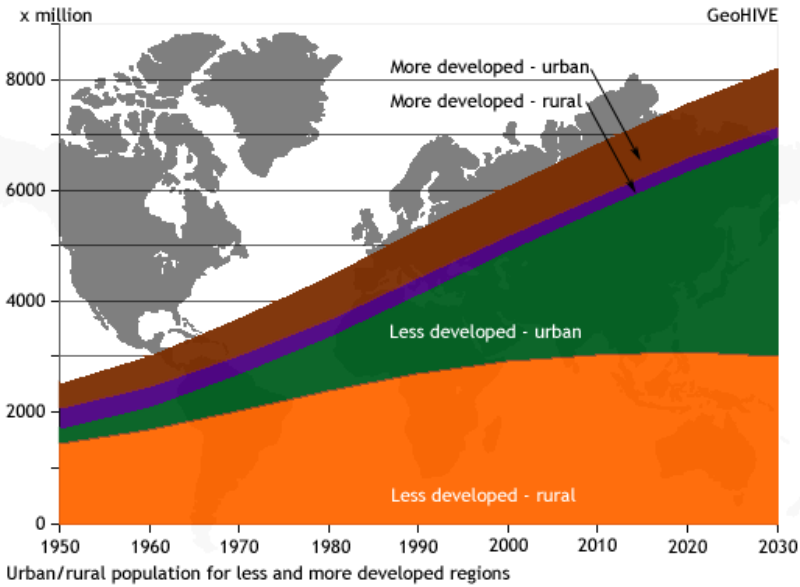
Figure 1. Urban/rural population, source: Global Urban Trends,
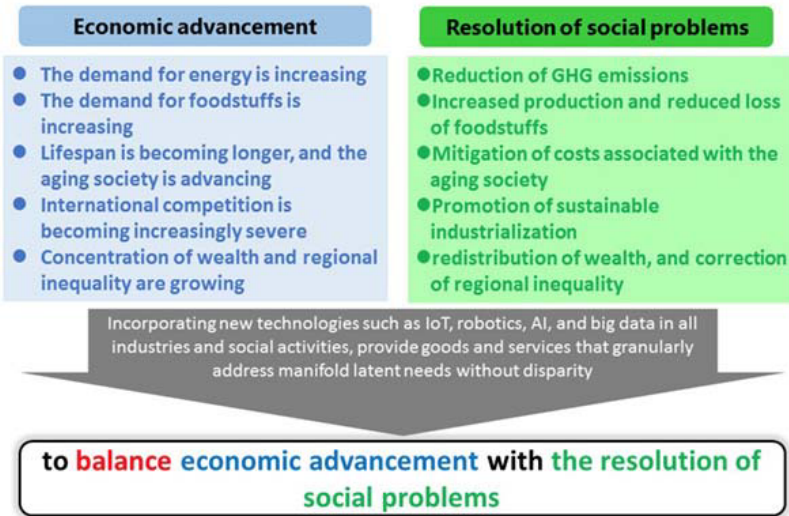https://www.thegeographeronline.net/urbanisation.html

Figure 2. Balancing economic advancement with the resolution of social problems [6]

The need for joint effort in resolving social challenges that result as side effect of economic development has been emphasised also by United Nations. In 2016, world leaders signed an Agenda for Sustainable Development which foresees seventeen goals that universally apply to all nations (Figure 3). According to this memorandum, countries around the world will mobilize efforts to end all forms of poverty, fight

inequalities and tackle climate change, while ensuring that no one is left behind. Again, a smart use of ICT is seen as a promising approach for enacting some of these goals and diminishing associated problems.

Figure 3. Goals of sustainable development (https://www.unbrussels.org/the-sustainable-development-goals-sdgs/)

3. Slovenian Smart Specialization

Slovenia has decided to follow the principles of Society 5.0 with the so-called Smart Specialization Framework (S4) that focuses on sustainable technologies and services for a healthy life.

S4 recognizes 9 domains (health and medicine, factories of the future, smart buildings, sustainable food production, smart cities and communities, etc.) that are associated with the aforementioned societal problems and can potentially contribute in their solution. At the same time, they represent domains where Slovenia recognized potential for developing internationally competitive and innovative high-tech solutions.

Organizationally wide, S4 is developed around Strategic Innovation Partnerships (SRIP) SRIPs are a specific form of collaboration between industry and research partners in the S4 domains.

SRIPs are formed for each of the 9 domains. Their main goal is to prepare and maintain action plans that define most important focus areas of the domain and establish value chains of partners with common interests for the development of new, innovative and integrated services and products.

In the smart city domain, the action plan identified several focus areas: 1) Energy and utilities, 2) Health, 3) Mobility, transportation and logistics, 4) Safety, 5) Urban life quality, and 6) These are further supported by a horizontal SRIP (HM-IKT) that focuses on technology and is common for all SRIPs. HM-IKT joins together partners that have products/services and expertise in different technology areas: 1) Cyber

security, Digital transformation, GIS-T, HPC and big data, Internet of Services, and Internet of Things.

The partnerships are large in terms of the parties involved. In Smart Cities and Communities, there are around 150 members, ranging from start-ups and SME's to large companies, universities, NGOs, and municipalities.

A large share of the subsidies and financial support that is given by the government in terms of supporting of the smart specialization, requires the beneficiaries to be in line with the focus areas and action plans. Memberships in strategic partnerships is however not required and is not a precondition to be involved in any of the subsidy schemes.
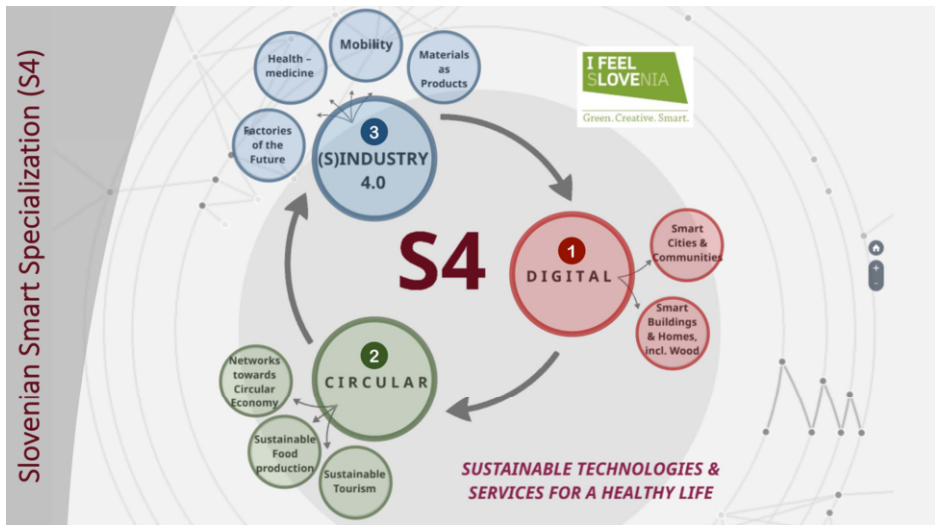

Figure 4. Slovenian smart specialization scheme

4. EkoSmart

EkoSmart is a set of projects that were launched in late 2016 after approval by the government to fit to the Smart city and communities action plan. The main purpose of EkoSmart is to provide companies and other interested entities with supporting mechanisms that are required for an efficient, optimized and gradual integration of smart city areas into one, unified and coherent system of value chains. The vision of the programme is however more ambitious, i.e. to establish a business ecosystem for the development of integrated and highly competitive solutions and services that will also have potential for penetration to foreign markets.

The programme focuses on three key areas for which we identified their digitalisation would bring the strongest individual and synergy effects. Those areas are: Health, Mobility and transportation, and Urban life quality. The programme was intentionally limited to these three areas to avoid complexity that we would be dealing with if targeting all smart city domains at once. In addition, the programme includes a special project that is dedicated to the development of common services to facilitate

interoperability among domains and to allow for the later inclusion of domain that are not covered by the programme.

The programme started in August 2016 and is scheduled to end in July 2019. It involves 26 partners, ranging from private companies, research institutions, public institutions and NGOs. The consortium only involves partners that are strong in terms of their products/services and markets they cover, or in terms of their research excellence. The program amounts to approx. 9 Mio EUR and is partially supported by S4.

In the following we describe specific projects of EkoSMART programme that focus on the aforementioned key areas and some of the preliminary results.

4.1. Health

The ageing of population and increase of patients with chronic diseases are global trends that have been present for several years. OECD health indicators such as the number of chronic patients with chronic diseases, amputations of extremities in adult patients with diabetes, hospitalisations due to chronic heart failure, blindness and increase in the number of dialysis patients, etc. are alarming since they point to unsustainable social and health systems and represent a large social and economic burden. To illustrate the consequences of diabetes alone, Germany carried out a study that established the following shocking facts: every 19 minutes an extremity is amputated, every 90 minutes a patient becomes blind, every 60 minutes a new dialysis patient emerges, there is 2.5 times higher risk of heart attack and 7.5 times higher risk of reinfarction. Financial consequences: 10% of insured persons with diabetes represent 30% of costs for the insurance company [7].
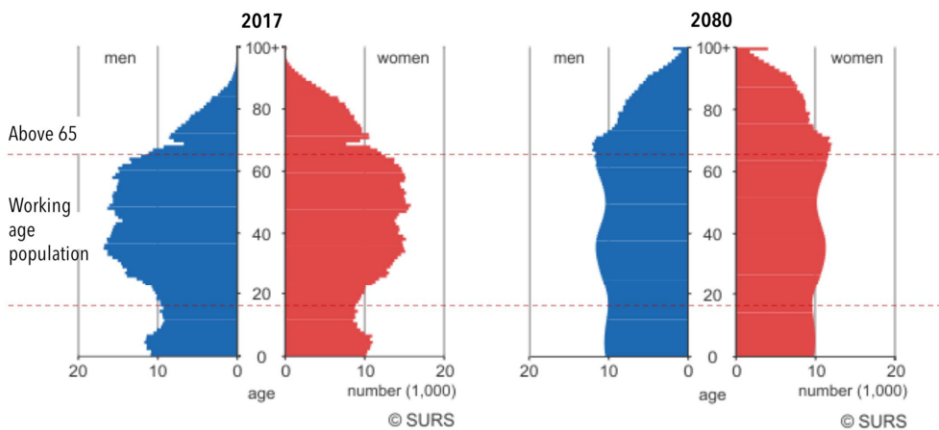

Figure 5. Slovenia population pyramid by age and gender, source: Eurostat database

Beside growing burden of chronic diseases, additional reason for Slovenia to put focus on possible solutions for its social and health care systems is the aging of its population. Despite assumed greater fertility, the population of Slovenia is expected to age. In the next 65 years, the age structure of Slovenia's population is expected to change significantly (Figure 5). In 2015, the elderly (aged 65 or more) stood for 17.9% of the population, while in 2057 this share is projected to be at nearly 31%, and in 2080

at 29%. The share of children (under 15 years of age) is expected to increase for a few more years (2021: 15.3%) and then start to drop and reach its minimum (about 13.4%) in about 20 years. It is then projected to rise again and reach 15.7% in 2080.

EkoSMART programme is devoting a lot of attention to the health area, since it has been proven that appropriate use of ICT solutions can significantly contribute to optimising health care and efficiency of treating (mostly for chronic patients). Countries that have managed to develop and introduce patient treatment based on ICT for individual chronic diseases (e.g., diabetes, heart failure, COPD), have marked positive economic effects (savings both in individual treatments and at the macro level), significant improvements in treatment results and greater patient satisfaction. Due to its large extent, we have covered this area with two projects: Electronic and Mobile Health (RDP4) and Smart System of Integrated Health and Care (RDP5) (Figure 6).
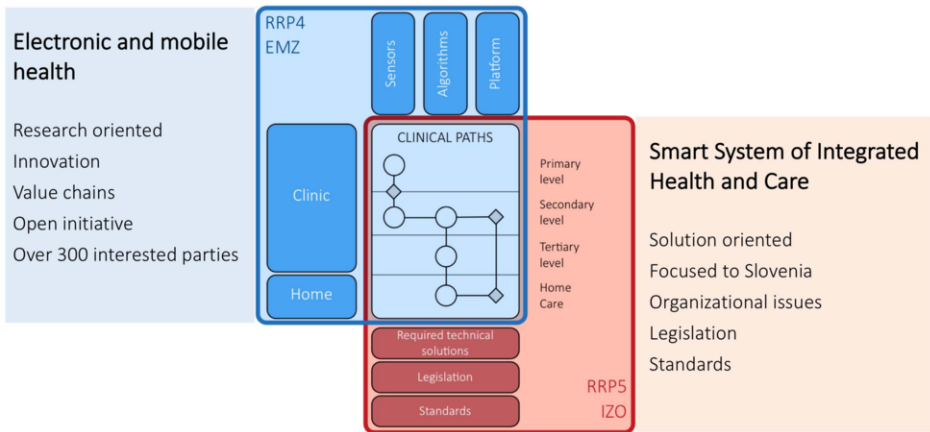

Figure 6. Approaching healthcare challenges in EKoSMART

The two projects are distinguished by their vision. RDP4 is based on an open initiative of electronic and mobile health and already includes over 300 partners. It is research oriented with a focus on innovation. RDP5 on the other hand focuses on a very specific goal, i.e. to introduce telemedicine in Slovenia. It is led by the biggest telco operator and involves many other parties, ranging from medical institutions to government bodies. Its goals are not focused on the technology alone but are mainly concerned with the associated organization, standardization and legislation.

As indicated in Figure 6, RDP4 and RDP5 connect over clinical paths that were modelled for telemedical treatment, specifically for patients with chronic diseases. Innovative products and services that are being developed in RDP4, will be potentially used in the pilot phase of RDP5 if approved by IT and medical professionals.

Central to both projects, RDP4 and RDP5 is telemedicine. Telemedicine can be described as the use of ICT to provide clinical healthcare from a distance. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities [8]. According to several studies, telemedicine has a lot of potential and positive impact on both, financial aspects of health care and the results of health treatments.

The biggest known study so far was performed in the UK. The whole system demonstrator programme (WSD), was the largest randomised control trial of telehealth

and telecare in the world. It was launched in 2008 and took 2 years. There were 6.196 patients involved with different chronic diseases (diabetes, heart failure, COPD) and 238 General Physicians. The data collected was further analysed by 4 major universities in the UK. The indicators of how telemedicine can help were clear. It was shown that if used correctly, telemedicine can deliver: a 15% reduction in A&E visits, a 20% reduction in emergency admissions, a 14% reduction in elective admissions, a 14% reduction in bed days and an 8% reduction in tariff costs. More strikingly they also demonstrated a 45% reduction in mortality rates.

RDP4 already resulted in several interesting and innovative products and services (Figure 7).

Figure 7. Example of products resulted within EkoSMART programme: on the left: Savvy monitor for ECG signal (http://www.savvy.si/en/), in the middle: Vitabits – gateway for medical devices (www.vitabits.eu), on the right: In-life, a smart watch for elderly (https://dis.ijs.si/?p=1937).

RR5 has started the pilot phase which will finish in July 2019. The pilot involves 500 patients with different chronic diseases. Some of the products that were developed within RDP4, will be tested in the pilot.

4.2. Mobility and Transportation

Cities are locations with a high degree of accumulation and concentration of economic activities that are complex in terms of space and related transport systems. The larger a city is, the more it is complex and the bigger challenges and risks are, especially if we do not know how to manage that complexity. Mobility problems are most often connected with urban areas and transport systems that for some reason cannot meet the needs of urban mobility. Efficiency of a city vitally depends on its transport system which enables mobility of its labour force, delivery of goods etc. The vital transport terminals such as airports, ports and railway stations are often located in cities which further contribute to complexity of mobility and its management. The biggest problems of urban mobility are [9]:

- Traffic congestion and parking difficulties: Congestion is one of the most prevalent transport problems in large cities. It is particularly linked with motorization and the increased number of automobiles. Investments in traffic infrastructures were in many cities insufficient and have not been able to keep up with mobility needs. Since vehicles spend the majority of the time parked, motorization has also caused parking problems (especially in city centres). This also increases traffic density (looking for a parking space) and causes congestion.
- Longer commuting: people are spending an increasing amount of time commuting between their residence and workplace. An important factor

behind this trend is related to residential affordability as housing located further away from central areas is more affordable. Therefore, many families decide to move out of cities and commute to work every day. However, commuting also has negative consequences such as social exclusion etc. Public transport inadequacy: Many public transportation systems, or parts of them, are either overused (during peak hours) or underused and therefore financially unsustainable (particularly in suburban areas).

- Difficulties for non-motorized transport: These difficulties are either the outcome of intense traffic, where the mobility of pedestrians and bicycles is impaired, but also because of a blatant lack of consideration for pedestrians and bicycles in the physical design of infrastructures and facilities.
- Loss of public space: The majority of roads are publicly owned and their use is free of cost. Increased traffic has adverse impacts on public activities that once crowded the streets such as markets, parades, processions, games, which are today replaced by automobiles. More traffic impedes social interactions and street activities.
- High maintenance costs: Cities with an aging of their transport infrastructure are facing growing maintenance costs as well as pressures to upgrade to more modern infrastructure. In addition to the involved costs, maintenance and repair activities create circulation disruptions.
- Environmental impacts and energy consumption: Pollution, including noise, generated by more and more dense traffic has become a serious impediment to the quality of life and even the health of urban populations.
- Accidents and safety: Growing traffic in urban areas is linked with a growing number of accidents and fatalities, especially in developing countries.
- Freight distribution: Globalization of the economy has resulted in growing quantities of freight moving within cities. This causes further pressures on the transport infrastructure of cities.

Some of the above problems of urban mobility can be considerably alleviated with the use of appropriate ICT solutions and IoT devices. RDP2 focuses on the traffic flow control and management systems. The aim is to join efforts of several Slovenian companies that offer specific products related to traffic management and, together with research institutions, develop an innovative solution for traffic management.

One of the challenges that the project is trying to solve is related to the optimization of city infrastructure needed for the realization of the smart traffic management. In large cities, the investment into smart traffic infrastructure, such as smart traffic lights, parking sensors etc., quickly exceeds millions of Euros and make decision makers sceptical if there is no clear calculation of the return of investment (ROI). In RDP2, a smart city simulator was developed that is able to calculate where to position smart infrastructure to maximize effect in terms of gas emissions and travel time with a certain size of investment (Figure 8). The simulator is based on SUMO – an open source traffic simulation software (www.sumo.com) that uses OpenStreetMaps for city maps.
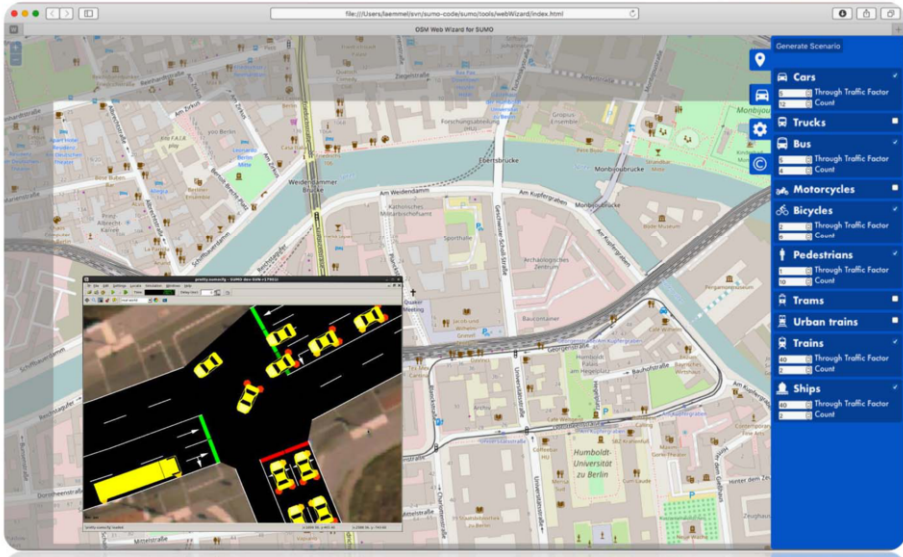
Figure 8. SUMO-based Smart city simulator

4.3. Active Life and Wellbeing

Healthy lifestyle is gaining increasing scientific value and awareness, while preventive practices have an important long- term role in ensuring good health and benefits for the whole society. The family is generally one of the most important communities in a person's life. The lifestyle one has in childhood depends on parents and their choices, since life patterns are developed in a family. Modern lifestyle is closely intertwined with information and communication technologies that can also be used to improve our health. There are very few solutions that focus on a holistic family approach for an active life style, health improvement and well-being. In the programme, we investigate the models of family functioning in a smart city, the scenarios of using solutions for active life and well-being, integration of activity support and connection with other services in a smart city ecosystem.

The leader of RDP3 is a company Mikropis that has a long record in providing applications for active and healthy living. The family of solutions called 24alive has been on the market for many years. In 2018, Mikropis signed an agreement with Mayo clinic, which gives the company access to all healthy life-related material that the clinic has in its disposal.

In the framework of RDP3, a specific focus is given to family as the main target group. The goal is to promote healthy and active life through new product MyFamiliy that will enable families to participate in challenges that encourage an active lifestyle. Together, they will set goals to improve health and well-being tailored to the characteristics, needs, capacity and size of each specific family. By the use of gamification, families will have possibility to compete with each other, which will represent motivation for an active lifestyle of the whole community.
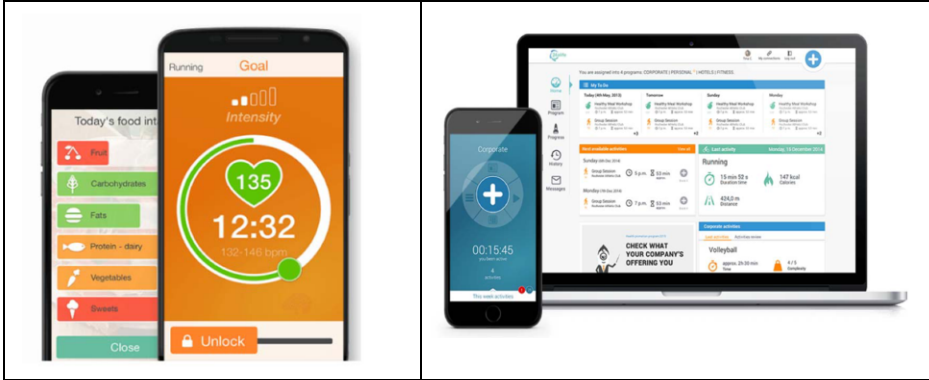
Figure 9. 24alive, https://www.24alife.com

4.4. Platform Ecosystem

As described in previous sections, the EkoSmart programme is addressing specific areas of a smart city. These areas alone are very complex and usually result in solutions that are specific for each individual area. In our case, RDP5 is producing a platform for electronic health, RDP2 is coming out with a family of products for active and healthy living and RDP3 is ending up with a platform for managing traffic flow. One of the objectives of the programme was however to make sure that these areas will not remain isolated but will integrate into a common ecosystem. For this purpose, a special project (RDP1) is dedicated to the development of a joint platform with the following two goals:

a) to implement services that the programme partners have identified as missing in their solutions and could benefit from a central solution (e.g. data lake, big data analytics etc.),

b) to provide mechanisms for sharing data, services, products and ideas across all the involved areas.

Such platform would facilitate interoperability and make possible to support inter-sectorial use cases. One of such scenarios is shown in Figure 10, where the interoperability between health and traffic systems is represented. An elderly person with a chronic heart failure (CHF) is not feeling well, which is detected by the patch she is wearing. This patch is sending ECG signals to telecentre where critical situation is detected and communicated to the Emergency centre. In communication with the Traffic control centre, the route to the elderly is optimized so that the ambulance can get there as quick as possible.

Apart from supporting inter-sectorial use cases, such platform is essential for sharing data and services from the involved areas so that other interested parties including start-ups could reuse them for their own purposes and business ideas.

Figure 11 shows a high-level overview of the EkoSmart platform. For each of the components open source solutions were used and integrated over a common authorization scheme (Identity Management) and search capabilities (Enterprise Search). The main components and their solutions are:

- a solution for sharing services (WSO2 API management),

- a solution for sharing data (CKan),
- a solution for sharing products (Magento marketplace)
- a solution for sharing things (Sentilo platform)
- a solution for ingesting, storing, processing and visualizing big data (Hadoop with Hortonworks distribution).

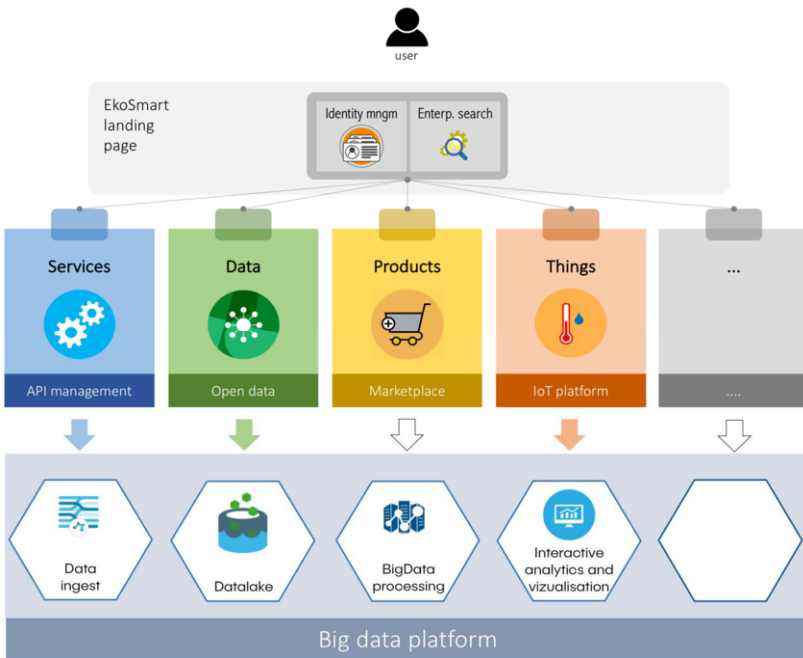**Figure 10.** An example of interoperability between health and traffic systems

Figure 11. High-level overview of the EkoSmart platform

When designing the EkoSmart platform, we followed the principles of the platform-based ecosystems, which are known to have enormous capacity for growth and market capitalization. In such ecosystems, three types of stakeholders are involved (Figure 12): platform owners that take care for the platform, developers who use the platform to market their solutions and finally customers who buy products and services running on the top of the platform. The benefits of being part of the ecosystem are several: a) an opportunity for making long-term partnerships, b) constant innovation, c) higher customer retention, etc. There are many examples of successful platform-based ecosystems, such as: Amazon, Airbnb, Uber, Dropbox, Facebook, Google to name just the biggest.
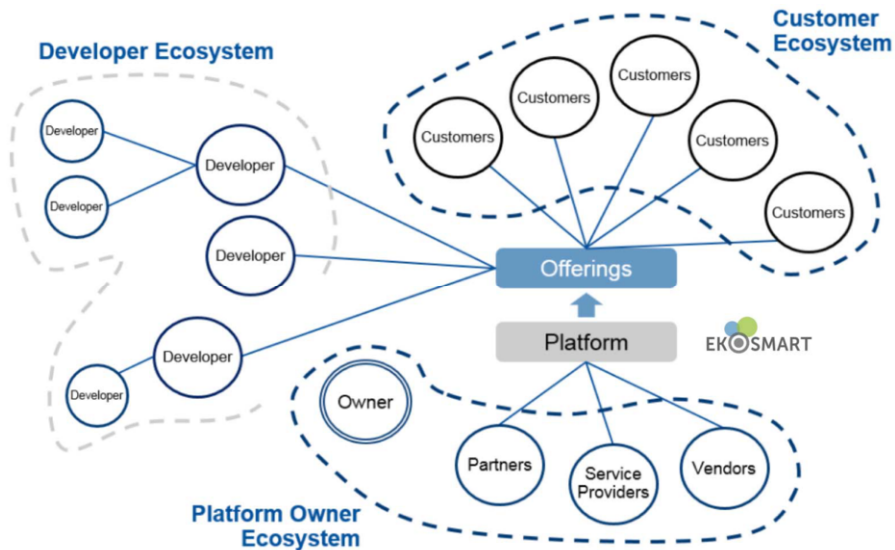

Figure 12. Platform ecosystems and their stakeholders, source: Gartner; January 2016

There are however requirements that have to be met in order for a platform-based ecosystem to be successful [10]. The most important one is to have a clear business model, i.e. a joint vison that all stakeholders believe in and a set of rules to follow. In the case of the EkoSmart platform, this turned to be rather challenging as we are dealing with a number of partners with very different interests. In addition, in the consortium, there are no partners that would have experience "in selling" city-wise platforms; hence they are rather reluctant for accepting this role.

Having a platform that enables cross-sectorial integration, is however very important as it can help in resolving social challenges (Figure 13). In case business incentives for establishing a cross-sectorial platform are not clear or missing, then governments can help with regulations and standardization. An example of this an emergent market of healthcare solutions that was formed immediately after Japan has introduces its "*Next generation medical infrastructure law*" [11].
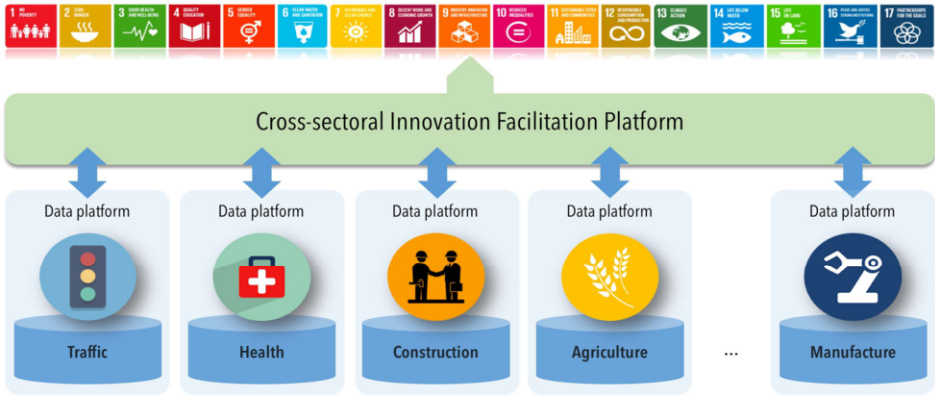
Figure 13. Cross-sectoral Innovation Facilitation Platform

5. Conclusion

Due to rapid urbanization and its forecasts for the future, many cities are trying to take measures that will help them in city management and operations. The urbanization is however not the only challenge that the society is facing. A number of societal problems have emerged as a side effect of the economic growth and development. These are of utter importance and cannot be ignored. A smart use of ICT has proved to have high potential for optimizing city functions and making cities more attractive to its citizens. It seems also that the technology can help in balancing between economic development and associated societal challenges.

In this paper, we described a programme of smart city-related projects that were launched in 2016 as a part of the Slovenian Smart Specialization Framework. In this programme, the focus is on three areas, Health, Mobility and transportation, and Active life and Wellbeing. The paper explains the projects' settings and preliminary results. An important objective of the programme was also to provide a solution for cross-sectoral integration which will foster interoperability and will, hopefully, provide a possibility to address at least some of the societal challenges. In the paper we explained how the principles of the platform-based ecosystem might be suitable for this purpose.

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