CITY IoT

CityIoT – IoT Solutions for Smart Cities

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Leverage from the EU 2014–2020
European Union
European Regional Development Fund

Content

Publisher: Oulu University of Applied Sciences, Oulu 2020
ISBN 978-951-597-193-7
URN: http://urn.fi/URN:ISBN:978-951-597-193-7
Editors: Jussi Kangasoja and Pirjo Rousu
Layout: Design Inspis Oy, Oulu

Key Results

- The use of open IoT platform is economically justifiable.
- Reference architecture and implementation that support piloting in the future.
- Utilisation of new digital services continued with commercial terms after successful pilots.
- Companies developed new products.
- With service design companies improved their products from customer perspective.

Summary of the Project

Pirjo Rousu, University of Oulu

CityIoT project “Future Operator Independent Data Integration Platform” belongs to the Six City Strategy (6Aika) projects and was carried out in between 9/2017–5/2020. The project was funded by European Regional Development Fund (ERDF). Funding was coordinated by Helsinki-Uusimaa Regional Council. The project had five participants: coordinator University of Oulu, City of Oulu, City of Tampere, Oulu University of Applied Sciences, and the University of Tampere.

In the Smart Cities of the Future, services are online and based on wireless data transfer and information is utilised efficiently. One of the problems with the Internet of things is that the systems are not compatible. The strength of the Internet is in compatible protocols and other technologies but there is no such a common feature in the Internet of things. That causes difficulties in adding new applications on top of the existing IoT systems. It is also difficult to combine data from several different IoT systems. CityIoT project addressed the need to develop cities’ digitalisation capabilities and to develop solutions to get the data from different operators’ systems to be effectively utilised.

CityIoT reference architecture specification aims to consolidate in the knowledge on key data integration services, functionalities, components and interfaces for the IoT data integration platform for Smart Cities. As a result of the project, a non-commercial, open and operator independent IoT data integration platform was built. Open IoT platform brings an advantage for the cities. They can e.g. ask for bids for information system acquisitions without having to stick with one operator. At the same time open IoT platform enhances especially the small companies’ opportunities to develop new innovative services for the cities.

The project pilots served both cities and companies. The pilots offered cities the opportunity to test new digital services. The companies were able to test and develop products in real environment and to co-develop solutions together with the end user. For the project, the pilots were an essential way to test and develop the FIWARE platform.

In Oulu the pilots conducted with the companies focused on improving the maintenance and lifecycle management of the buildings. In Tampere, the solutions tested were related to urban environment, for example smart street lighting and analysing the conditions of the roads.

The number of companies that participated in the project confirm that building cities’ digitalisation capabilities is an actual topic. Approximately 160 companies were involved in the project and over 40 pilots were conducted. As an outcome of the pilots many of the companies reported they will create a new product and start-ups enhanced their capabilities to develop new products.

Participant's Say

University of Oulu

Especially start-up companies may need support to design services from customer perspective. Service design workshops together with the companies and the end users were proven to be successful. Products in development phase were further developed to meet customer requirements. The companies were encouraged to design scalable services. It was also considered how the data should be processed to the services so that the services could be used in different environments regardless of the technical platform.

University of Tampere

The University of Tampere had an essential role gathering and distributing FIWARE knowledge. The university analysed and tested FIWARE technology using the CityIoT data from the pilots in Tampere. Demo applications were developed based on this data. As an outcome, a reference implementation based on open source code was created. Experiences of FIWARE components, collecting the data and information security were documented.

City of Tampere

Hackathons and over 30 agile pilots were carried out in Tampere. It was delighted to see how the companies were interested to attend the project and test their products and IoT technology in urban environment. Pilots confirmed that currently in the market there are several digital solutions that work technically and have business potential. Conducted pilots proved the cooperation and co-development between the city and companies to be functional. Agile piloting is a good approach to develop data driven city services.

UNIVERSITY OF OULU

Tampereen yliopisto
Tampere University

TAMPERE

City of Oulu

The pilots in Oulu were implemented in public buildings, for example, in schools and day care buildings. The University of Oulu coordinated the cooperation between the companies and the project team and the City of Oulu organised all the preparations and installations needed in the pilot targets. The companies were able to test their products and IoT technology in real environments and get feedback from the end users. The feedback from the companies was positive: agile piloting model worked, and public buildings fit well for research and development.

Oulu University of Applied Sciences

OUAS validated the results of the pilots from the viewpoint of the cities: features examined were attractiveness, functional and economical value, scalability, and usage of the solution after pilot. Together with the companies OUAS studied new business opportunities generated by digitalisation. All the universities involved in the project reported positive attitude towards spin-off businesses.

Digitalisation creates new business opportunities.

OULU

OAMK
OULU UNIVERSITY OF APPLIED SCIENCES

Project Pilots

Jani Nousiainen, City of Oulu

Mika Heikkilä, City of Tampere

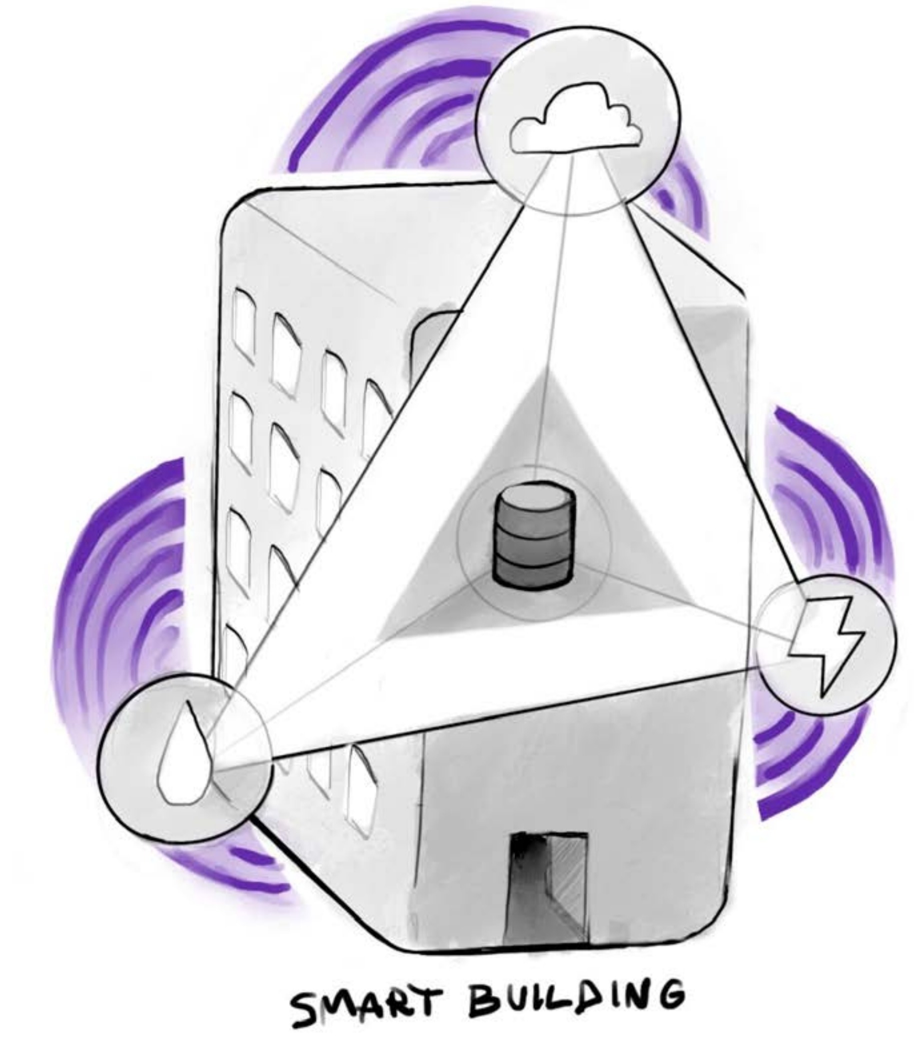
Markku Niemi, Business Tampere

Monitoring the Snow Load on Building Roofs, Oulu

Pilots were carried out in Oulu and Tampere in cooperation with cities, researcher organisations, and companies from different fields. Companies utilised CityIoT pilot environments in their research and development processes. Pilots in Oulu focused on improving the maintenance and lifecycle management of the buildings and in Tampere focus was on city infrastructure. Pilot data was used to develop the operator independent IoT platform.

IoT technology provides an economic and easily scalable solution to measuring snow load on building roofs. In Oulu it is often necessary to drop off snow from the building roofs. Usually, the need is evaluated case-by-case, but this pilot offered an opportunity to base the decision on concrete measurements.

The snow load measurement was piloted by Ramboll Finland Ltd. and Haltian Ltd. provided the sensors. The application was piloted in a day care building and in an indoor ice rink. The measurements were taken from critical spots in the structures measuring the bending of the roof structure. The bending was monitored through Ramboll's application that also sent alarms to a caretaker's phone and email. Although winter 2019 was less snowy than usual the pilot provided promising results.



IoT sensors collect data inside smart building. **Illustrated by Michael Persson.**

Monitoring Indoor Air Quality, Oulu

In the Talvikangas school there was a pilot testing an application designed by Playsign Ltd. The application monitored the indoor air quality of the school building. The air quality data was collected in the CityIoT platform and visualised to the users of the school. Data was collected from different sources: in addition to data from building automation also open weather data and IoT sensor data from the school were utilised. A 3D model consisting of the floor plan and visualisations of indoor air quality measurements was available for users via online application. The data from the school building was visualised so that a user could easily see the air quality in the building. The temperature, humidity, carbon dioxide, noise level, the weather and measurements of volatile organic compounds were collected and presented in an easily approachable way. The users could give feedback of the conditions of the building via the same app and the measured data could be compared with the user experience.

Agile Pilots, Tampere

In Tampere, the pilots mapped the conditions of streets and monitored the slipperiness of the road in real time. Gathering data from different sources to one open platform enhances the reliability and coverage of information. Refined data enables enhancing the traffic safety and maintenance can be targeted where it is most needed. CityIoT project managed to join the companies' solutions to developing the services of the cities. The new IoT solutions have significant potential in urban environment, especially with utilising AI and machine learning in editing stills and video. Part of the pilot implementations have been continued with commercial terms after the project.

Based on these experiences, it can be said that IoT is moving rapidly forward. There are already several prepared solutions that can help cities to make operations more efficient. For example, solutions using AI or machine learning in image or video processing have high potential. IoT solutions can help predict maintenance needs or offer more precise real time information from several different sources to help planning and decision making. This cuts costs and enhances the quality of services for citizens.

The new IoT solutions have significant potential in urban environment, especially with utilising AI and machine learning in editing stills and video.

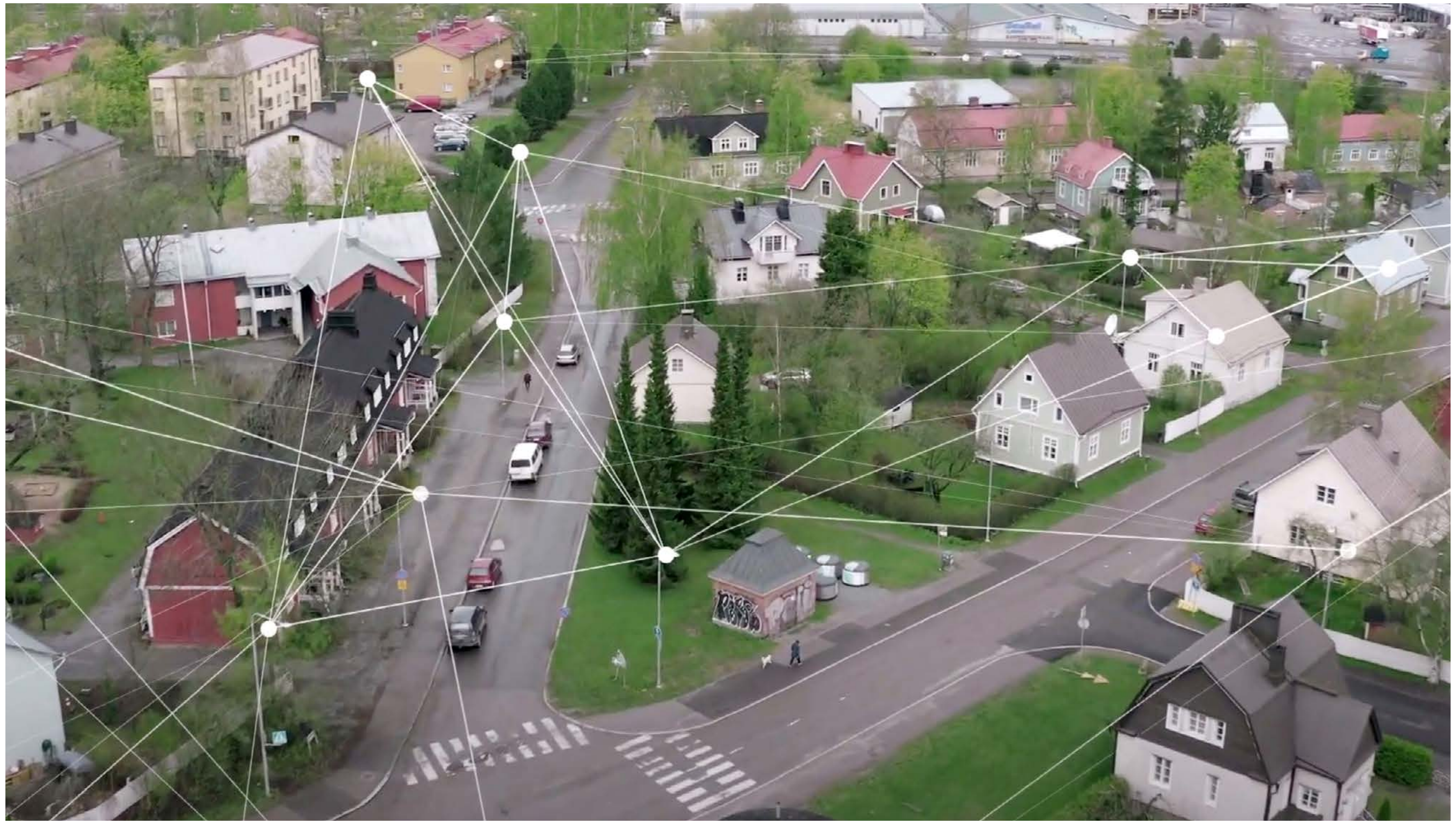
There were 8 rapid testing searches for companies. The pilot received 66 bids from which 30 were chosen.

Smart Light Pilot, Tampere

City of Tampere piloted smart lighting system, which uses open data collected from the environment and from citizens. IoT solution was built in Swedish-Finnish cooperation with Capelon AB and Wirepas Ltd. 400 streetlights in Viinikka turn on and off based on traffic and pedestrian movements. Energy will be saved when the lights are on only when needed. In case of emergency

> 400 streetlights in Viinikka turn on and off based on traffic and pedestrian movements.

the rescue department can switch the lights on in certain area. It is already made possible in Viinikka to control the lights along with the shadows. When a certain area becomes dimmer, it is possible to add light and secure enough lighting in every corner.



Testing area for new smart lightning solution that adjusts to traffic volume.
Image: [from the video of Capelon AB and Wirepas Ltd.]

IoT Platform

Kari Systä, University of Tampere

Operator independent IoT platform was one of the most essential goals of this project. Planning guideline we followed through project was openness towards both the information sources and applications.

Requirements

Requirements of the platform were collected during the project and analysed and sorted in seven categories:

1. Openness.
2. Data collection and recording.
3. Application interface.
4. Architecture, implementation and updating.
5. Safety and privacy.
1. Enabling business opportunities.
2. City-specific implementations.

Reference Architecture

In addition to the seven requirement categories, we mapped the already existing IoT platforms, standards, markets and definitions in Europe to define the IoT platform architecture and standardise and certificate the data platform.

Industry operators and research centres in Europe have formed alliances, for example International Data Spaces (IDS) Association[1] and FIWARE Foundation[2]. As a result of the cooperation, open source code based platform solutions, information models and reference models have been created. Cities are already able to use these models in their own IoT systems. Large commercial operators are also providing their own cloud services and IoT solutions for mass markets.

We decided to use FIWARE technology to build the reference architecture on. Smart cities are one of the most essential FIWARE implementation targets and FIWARE concentrates on data integration and applications. Concerning reference architecture, the most important part of FIWARE are its API interface and information models. We are planning to implement the interface and models in several applications.

Reference Implementation

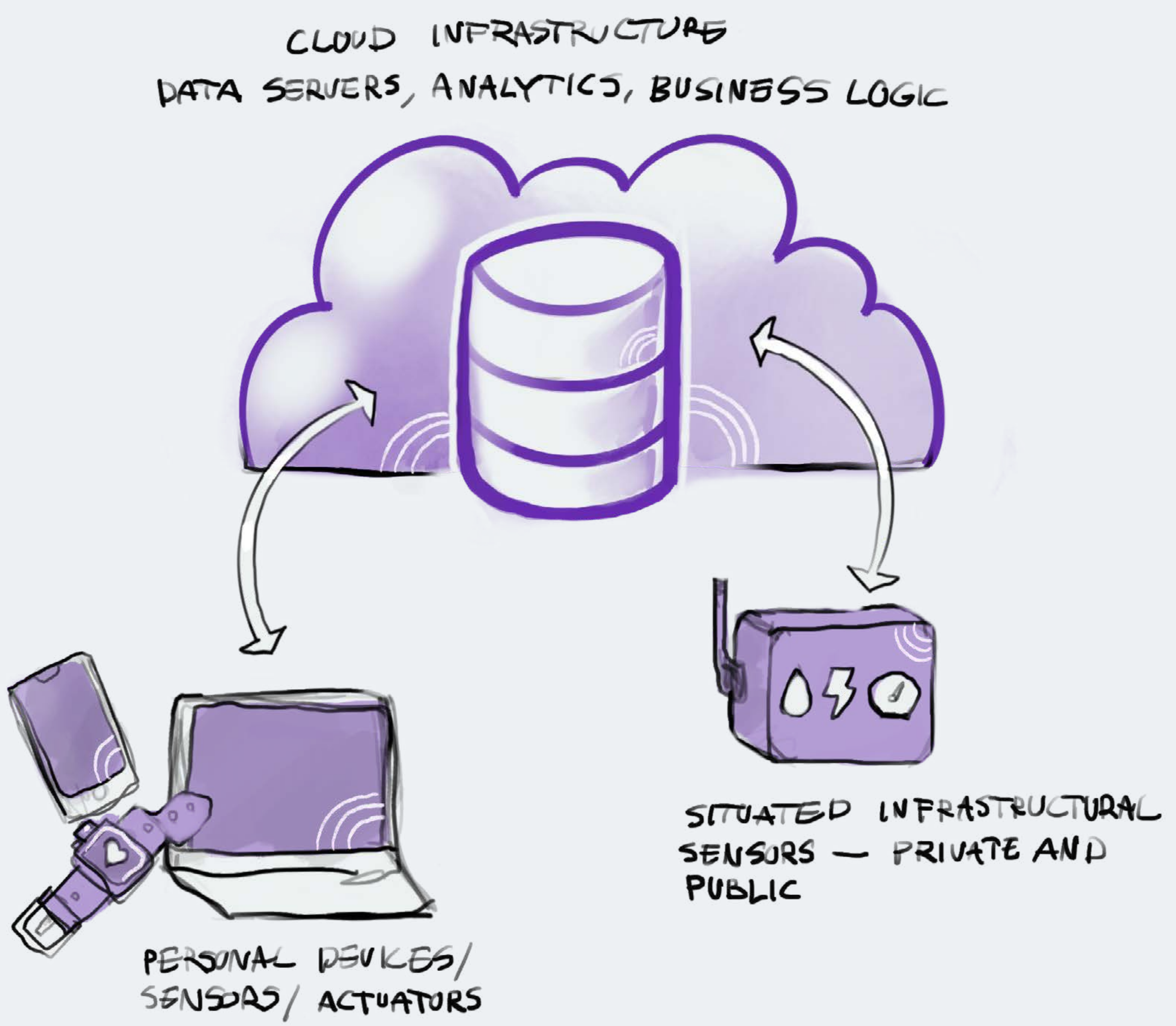
We built reference implementations in the Universities of Tampere and Oulu during the project. The goal of the reference implementation was to test solutions created in defining the architecture, and in part of the pilots, work as an IoT platform.

[1] https://www.internationaldataspaces.org
[2] https://www.fiware.org

Components of the platform

- Broker: updates the measured information of the whole system in real time. FIWARE Orion component implements this operation.
- History archive, which records the changes in the space as a timeline. We have tested both STH Comet and QuantumLeap technologies and recommend the QuantumLeap.
- Interface which allows applications to use information and meets the FIWARE/NGSI2 standard.
- Group of information collectors.
- A system for documenting and publishing data groups, which is based on CKAN[3] technology.
- Graphical tools for visualising, based on Grafana[4] and Wirecloud[5].

The IoT platform and its components are built so that new operators and following projects can easily build similar platform. The source code is open and installation instructions are accessible to everyone.



IoT Architecture. **Illustrated by Michael Persson**.

[3] https://ckan.org
[4] https://grafana.com
[5] https://wirecloud.readthedocs.io/en/stable

Lessons Learned

Jarkko Hyysalo, University of Oulu

Benefits of Digitalisation

Open data integration platform increases openness and visibility and helps to develop applications and services based on open data. The City of Oulu piloted a solution where the gathered data was utilised to create an application to monitor and visualise the indoor air quality.

Data helps cities to invite bids as well as make services more efficient. So far, all the building data has been produced by different building automation vendors and thus is not freely accessible. The rapid development of technology has lowered the prices of sensors and components and enabled the use of open interfaces in data collection. Cheap sensors can be placed more densely, which makes the information more comprehensive.

Constant monitoring provides significant benefit in managing the life cycle of a building. Problems can be acted on immediately and thus avoid permanent damage.

Data Analytics

Data analytics enables formulation of models that analyse what has happened, why it happened and what will happen. Data analysis enables fact-based decision making and preparing for the future.

In Tampere, the pilots focused on city infrastructure, for example, measuring the conditions of roads with real time monitoring of slipperiness. Gathering data from different sources to an open platform enhances the reliability and coverage of information. Refined data enables enhancing the traffic safety and maintenance can be targeted where it is most needed.

Data analysis enables fact-based decision making and preparing for the future.

Benefits of an Independent IoT Platform

An open, operator independent IoT platform enables sustainable development. Utilising the open platform with standardised interfaces and data models enable IoT data to be used to develop new applications and services. Standardised solutions and modularity make it easy to accommodate new needs and solutions. Open FIWARE technology allows developing without expensive licenses.

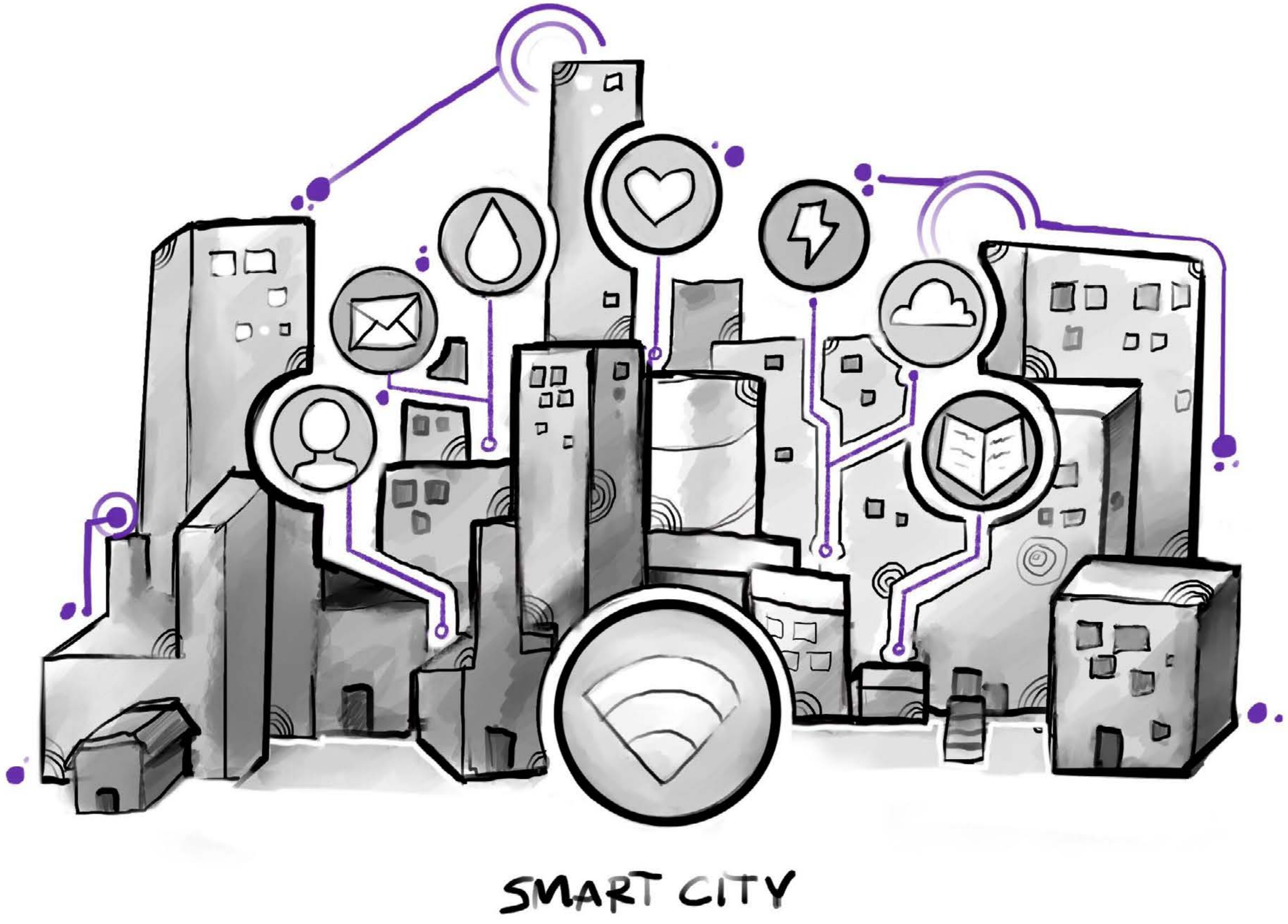
Agile Pilots in Practice

Agile pilots were considered a functional method to create practical solutions for cities. Successful solutions worked also as a reference point for companies.

Testing offered valuable information on how to target investments and future development.

Agile Pilots Checklist:

- Agile piloting requires resources: continuous monitoring, coordinating cooperation and prompting to action.
- Agile piloting needs preparations: electricity, telecommunication connections, premises, security and privacy issues have to be taken care of.



Smart City integrates smart technologies into entities that serve the citizens. **Illustrated by Michael Persson.**

Recommendations

Following viewpoints are to be taken into consideration when purchasing and introducing new digital tools.

Technical Viewpoints

Data ownership. Devices, sensors, and IT systems produce data that need to have an owner. Who owns the raw data? Do the raw data and modified and analysed data have the same owner? Is the system provider the one that controls data integration?

Defining the requirements. Successful purchasing of the IoT devices and systems requires detailed definition of the requirements and specifications. Cities can turn to technical experts to get checklists. Cities are recommended to utilise checklists defined by technical experts.

Piloting environments. It is recommended that cities have their own or have the access to the external piloting environments. Especially small companies need these environments to test and develop solutions.

Open and standardised interfaces enable comprehensive utilisation of the data. Openness enables adding new data sources and applications and the owner of the platform (the city) have full control over that. It is possible to make competing implementations that use the same interface.

The interface must be based on commonly used standards that are independent of provider, platform, and programming languages. The interface consists of three parts:

1. interface to bring the information to the platform
2. interface to use the information
3. data models to ensure consistency of metadata.

Open IoT platform brings business benefits. Open systems support developing city specific agile IoT services. Cities can make IT system acquisitions without vendor lock-in.

However, making system architecture decisions requires considering lifecycle and recourse costs between the open and commercial cloud applications. The cost of system specification, implementation and operation need to be considered.

Developing Smart Cities

Engaging the citizens to service development. The citizens use services and know what they need. Co-development is developing products and services together with their potential end users.

Share and use open data. Open data enables developing innovative services and creates new business opportunities. Using and combining open data from various data sources may create completely new services.

1. Data ownership must be determined.
2. Successful acquisitions require thorough definition of the requirements.
3. Piloting environments support smooth implementation.
4. Open and standardised interfaces enable comprehensive utilisation of the data.
5. Engaging the citizens to service development.
6. Share and use open data.

Recommendations to implementing IoT platforms.

CityIoT – IoT Solutions for Smart Cities

Reference implementation of operator independent IoT platform made it possible to utilise data from different data sources. The City of Oulu and the City of Tampere developed new cost-effective innovative services that were based IoT technology.

www.cityiot.fi

6Aika Helsinki-Uusimaa Regional Council OULU TAMPERE UNIVERSITY OF OULU OAMK OULU UNIVERSITY OF APPLIED SCIENCES Tampereen yliopisto Tampere University