

ANNUAL REPORT

STAKEHOLDER VERSION

YEAR 3

AUGUST '15 – SEPTEMBER '16

CITYPULSE

Annual Report 2016



CityPulse annual report 2016 authors:

The CityPulse consortium

Production:

Michelle Bach (editor)

Susanne Brøndberg (proof reading)

Graphic design and layout:

Stine Sandahl, www.sandahls.net

Illustrations:

Stine Sandahl, www.sandahls.net

The CityPulse Annual Report provides an overview of the CityPulse project, contract number CNECT-ICT-609035 for the period September 2015 to September 2016. This report has been partially funded by the European Commission's 7th Framework Programme.



Creative Commons

Intro

- 6 Welcome to CityPulse. Introduction by Payam Barnaghi
- 8 Meet the CityPulse partners
- 10 The CityPulse framework and its tools

City stakeholder interviews

- 12 Aarhus
- 14 Vienna
- 16 Brasov
- 18 Stockholm

Numbers

- 20 Key figures

Scenarios and components

- 22 Github repository
- 28 Scenarios reviewed by stakeholders

Outro

- 34 The progress in CityPulse

The European Commission is proud to contribute to two thirds of the financing of the CityPulse project. Indeed, its research focus is at the cornerstone of the Internet of Things, which itself has the potential to bring profound changes to the way we organise our society.

The Internet of Things provides impressive capacity to gather data from various kinds of sensors, analyse it based on ever-growing intelligence, and act on its environment. By doing so, it allows to include citizens' preferences in crowd-sourced decisions. It is therefore an ideal tool to enable transparent, citizen-inclusive management of smart cities.

This is why European research projects like CityPulse matter: real-time analytics of streams of data from smart city sensors are a key to deliver many different concrete applications to citizens. Working at European level is necessary to ensure that EU academies and industries are at the top of this field, and that EU-wide solutions are interoperable. The spirit of opening data to find synergies is precisely about avoiding fragmentation, both by sector and by geography.

European projects like CityPulse are making the Internet of Things real.

Eric Gaudillat

Programme Manager at the European Commission

Oversees the CityPulse project

WELCOME TO CITYPULSE, YEAR 3

Dr. Payam Barnaghi, project coordinator of CityPulse reflects on the innovative smart city project.

We are living in an increasingly interconnected world, in which technology allows us to access information and services which enable us to interact with people, physical objects and devices remotely. Citizens and communities are becoming stakeholders in an empowered, connected, society in which information and services are used to tackle some of the key challenges faced by our communities, such as traffic, pollution, waste management, clean water, natural disasters and emergency response, crime prevention and control, healthcare and elderly care. We need to find effective solutions to make our living environment more sustainable and efficient. Network and communication technologies, and in particular, the Internet of Things, combined with data analytics and machine learning techniques, have been among the key enablers in developing communities and cities that are more connected, more informed and smarter.

However, access to technology-enabled solutions and services in cities should be developed in a challenge-led and end-user involved way in order to make a significant impact on the livelihood of the citizens. It is also important to consider the economy and sustainability of the proposed solution. The cost of development, deployment, operation and maintenance of new solutions and enhanced services should not overtake their benefits. Connected communities and smarter city solutions should not contribute to the creation of a new digital gap. These essential and beneficial services should be designed in such a way that they should be applicable and accessible to citizens of all demographic groups.

The EU FP7 CityPulse project started 3 years ago in 2013 with the aim of creating a set of software enablers, analytical methods and tools that can work on existing networks and data collection infrastructures in cities. The aim was to create a framework of open-source tools and components to provide large-scale analytics for smart city data. With the help of its key city partners, the City of Aarhus in Denmark and the City of Brasov in Romania, the project group began to identify the requirements and use-cases for smart city applications and services and their grand challenges. The work was led by the Alexandra Institute, with the help of all the partners, and resulted in the definition and publication of the 101 Smart City Scenarios (<http://www.ict-citypulse.eu/scenarios>). These scenarios were developed with the involvement of large groups of stakeholders in cities including Stockholm, Vienna and Osnabrück.

Using the 101 scenarios, which are based on a scalable design for the smart city data analytics framework architecture, our technical team identified a set of challenges and necessary software components. The industrial and research teams at Ericsson, Siemens, the Alexandra Institute, the University of Applied Sciences in Osnabrueck, the National University of Ireland in Galway, the University of Surrey and Wright State University developed a comprehensive set of open-source components and tools with several demonstrators that use these components. These demonstrators, enabling tools and software are open-source and all are available on the CityPulse Github (<https://github.com/CityPulse>). Some of these solutions, such as the 3D smart city map, have already

become part of commercial tools or demonstrators that are offered by the project's industry partners.

We hope that the open-source software, demonstrators, datasets, scenarios, documents, presentations, papers and reports that are available on the project website (<http://www.ict-citypulse.eu>) will not only encourage the development of smarter and more enhanced data-driven and analytical applications and services, but that they will also make these applications more cost-efficient, agile and easier to test and try.

CityPulse uses several ideas, models and architectures from previous European Research Framework collaborative projects. This project owes its progress and success to the many individuals and research groups who paved the way for us to start with a strong base of collaboration, support and, more importantly, with a clear vision. We would like to thank the European Commission for their support for this project. Our sincere thanks to Gérald Santucci, who was one of the early pioneers of the Internet of Things research at the European Commission, Peter Friess who managed the IoT Research Cluster for several years, Bernard Barani, Thibaut Kleiner and many others at the European Commission who have always been supportive. Our project officer at the European Commission, Eric Gaudillat, was incredibly supportive and encouraged us throughout this project. The reviewers of the project and our extended colleagues in other projects helped us with their feedback, comments and suggestions.

Last but not least, our sincere thanks to numerous citizens from different cities across the continent and

to our project team and their colleagues who have all contributed to building this project and delivering the results.

On a personal note, this has been one of the best experiences in research and collaborative working in my career. I will always have good memories of our meetings and of the laughter, enthusiasm and optimism of our team while overcoming the technical challenges of the project. I am grateful to all my colleagues and friends in the project and thanks to the European Commission for supporting this wonderful collaborative project.



MEET THE CITYPULSE PARTNERS

We set out to ask the CityPulse partners what is the best part about the CityPulse project?



DANIEL PUSCHMANN
Researcher, University of Surrey

"The recent progress in sensors, networking technologies and in collecting real-world data on a large scale has allowed for new forms of real-world services and applications. This development is known under the name Internet of Things (IoT). Sensors deployed in urban environments constantly produce very large amounts of data. However, raw data by itself cannot solve the problems that citizens and city planners are facing in areas such as transport, energy, water and waste management. CityPulse provides a framework for application developers to develop intelligent solutions that can alleviate the challenges of the citizens and the city stakeholders and improve their lives and productivity."



CATALIN FRANGULEA PASTOR
Program Manager, Brasov Metropolitan Agency

"We live in a global world, where making friends across the globe or communicating with someone in an office in another country has never been easier. Our society is surely changing into a community of "digital natives". CityPulse is one of the first steps in Brasov to develop the digital environment in which we would further evolve. The use of ICT will forever change the paradigm of human existence. As the CityPulse project has been implemented, local stakeholders envisage more and more application of ICT in everyday life to improve communication, urban mobility, the way we interact with the public administration, the way we conduct ourselves or do business, etc. Basically, CityPulse started the ball rolling towards adopting the new technologies and embedding them into our city."



THORBEN IGGENA
Researcher, Lab for Mobile Communications
Faculty of Engineering and Computer Science
University of Applied Sciences Osnabrück

"Our integrated components for Reliable Information Processing enable the CityPulse framework to deal with incorrect or faulty information. The ability to rate incoming stream data for their quality of information and the restoration of missing values ensure a continuous user experience for the residents of a smart city. Developing these components and bundling them into the CityPulse framework together with modules of our European partners has been a great experience."

ANETA VULGARAKIS FELJAN
Senior Research Engineer in the data analytics field,
Ericsson, Stockholm

"By participating in the CityPulse project you influence on the cities of the future and be part of the development of several smart city services that address a wide range of urban issues, such as transportation, traffic and energy. These services will improve the citizens' entire way of living!"



AZADEH BARARSANI
Senior Research Engineer in the data analytics field,
Ericsson, Stockholm

"The CityPulse project provided me the chance to meet a great community of academic and industrial professionals in the area of smart city development."



DANIEL KÜMPFER
Researcher, Lab for Mobile Communications
Faculty of Engineering and Computer Science
University of Applied Sciences Osnabrück

"CityPulse uses knowledge that can be collected by various existing data sources of the city to simplify the everyday lives of citizens. Our components ensure the validity and trustworthiness of gathered information, which leads to a highly reliable framework. Furthermore, it gains security, whilst providing privacy through reasoning of information and the detection of events out of manifold data streams."

THE CITYPULSE FRAMEWORK AND ITS TOOLS

What is the CityPulse Platform and why is it necessary for smart cities?
Dr.-Ing. Ralf Tönjes reflects on the outcomes of CityPulse.

What does it take to become a smart city?

Today, cities are facing many economic, ecological and societal challenges. The key to address these challenges better is information and closer cooperation between the involved stakeholders by sharing information. This means smart technology and smart organisation. Technology is getting cheaper and smaller and is embedded into the infrastructure of the cities and the citizens' smartphones connecting the Internet of Things with people. However, the heterogeneity of the different data sources and missing integration platform hinder the uptake of innovative cross-domain smart city applications. Moreover, the provided information (e.g. transportation timetables) is mainly static not reflecting the dynamics in a city or often just not found. CityPulse tackles these issues in order to help municipalities and developers create better city services.

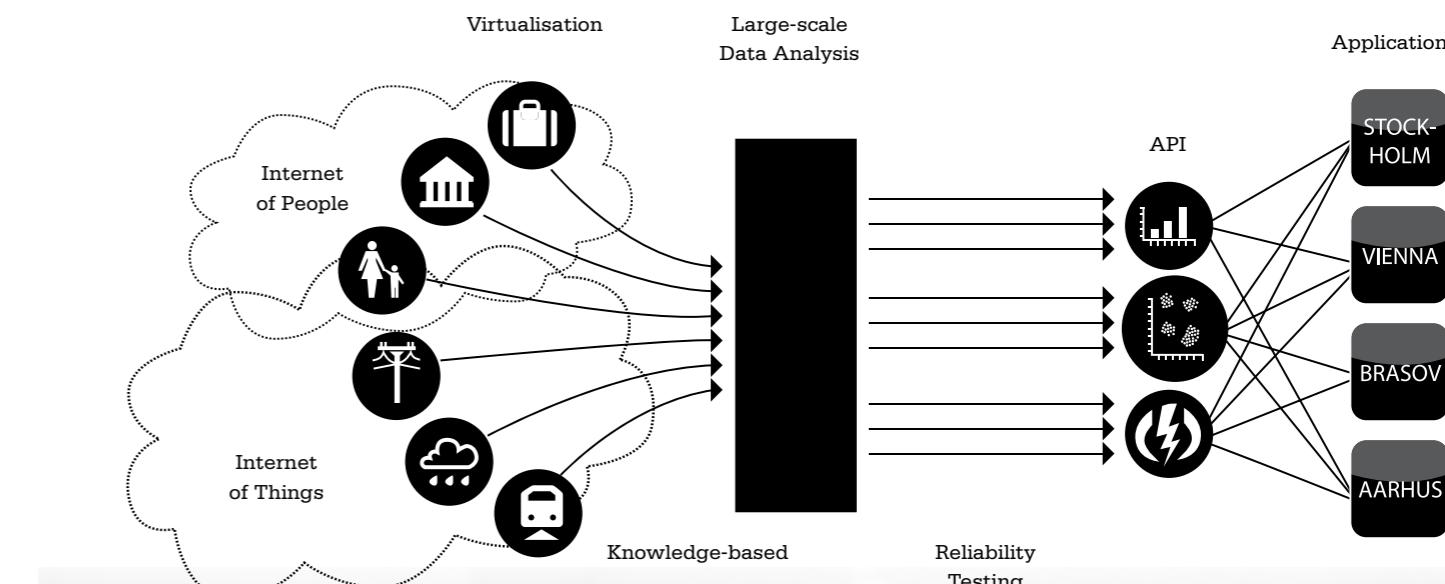
What are the CityPulse innovations for smart cities?

Today cities collect large amounts of valuable data and sensor measurements. However, these raw data streams are meaningless and hinder discovery and extraction of automated information for smart city services. To overcome this semantic gap, CityPulse

annotates the data streams and employs a knowledge-based approach to interpret the data streams. The challenge is to analyse large amounts of data in real-time. Therefore the CityPulse architecture splits into a very efficient large-scale data analysis pipeline and a real-time intelligence, which is fed by domain knowledge to control the data analysis in an iterative and dynamic way. Real world data is often unreliable and incomplete. CityPulse continuously monitors the quality of the information and utilizes domain adaptable spatial and temporal models to improve the reliability. This also allows the detection of faulty sensors and malicious sources.

What is the CityPulse framework?

The CityPulse framework supports smart city service creation by means of a distributed system for semantic discovery, data analytics, and interpretation of large-scale real-time Internet of Things data and social media data streams. The framework comprises (1) annotation and aggregation modules adapting automatically to the changes in the input sources in order to minimise information loss, (2) data federation modules automatically finding suitable data input sources at run time according to the user's specifications, (3) complex event processing modules extracting



CityPulse brings together the Internet of Things and the Internet of People, i.e. social media, thus allowing a better understanding of the dynamics in the city and providing more accurate information that meets people's needs.

information, (4) quality monitoring modules applying machine learning to assess the quality of the data provided by input sources, (5) contextual filtering modules that constantly monitor the user's current activity to automatically select relevant events, (6) decision support modules that combine semantic technologies and Answer Set Programming to provide an expressive and scalable decision support solution, and (7) powerful visualisation tools. All these modules are provided as open source.

How can cities and companies benefit from it?

CityPulse supports an open data approach making data available to citizens thus fostering the development of innovative applications according to people's needs. CityPulse also provides reference data sets to benchmark different algorithms. The CityPulse framework provides developers and city authorities with reusable tools for development and provision of real-time cross-domain smart city services. These services will ease urban living processes like, for example, parking space finding or multimodal transport. We have developed several innovative services in cooperation with the city authorities in Aarhus, Brasov and Stockholm.

"CITYPULSE HAS PROVIDED US WITH CONCRETE DATA USE CASES"

AARHUS:

Birgitte Kjærgaard, Project Manager of Open Data Aarhus and Line Gerstrand, Consultant, Smart Aarhus

How has CityPulse affected your city?

Birgitte: In Open Data Aarhus (ODAA) we strive to gather data and publish them on a portal free for everyone. ODAA was a new project when we became part of CityPulse, so we have grown together. CityPulse has been a project from which we could learn. Now we have a better and deeper understanding for how to use Open Data e.g. the demand for dynamic data vs. static data.

Moreover, CityPulse has provided us with concrete use cases which have helped us in showcasing the value of Open Data, which is very valuable when we are in dialogue with municipality data owners – they need to see good and concrete use cases to understand the many possibilities of opening their data.

On the other hand, we have given input to CityPulse on how to collect and make data available based on the challenges we face in our daily contact with municipality data owners and by being a project in a large political organisation.

What value has your city gained from CityPulse?

Birgitte: CityPulse has done a tremendous job in bringing people together, motivating them and providing them with a platform to start building a smart city. Some of the more concrete initiatives have been our many networking events – Aarhus Data Drinks, a series of informal events to bring the whole value chain of Open Data: - data providers,

politicians, end users such as SMEs and students as well as citizens together to discuss open data.

What have you learned by being involved in a large-scale European project like CityPulse? And what do you think CityPulse and other projects like CityPulse can learn from you?

Line: By being involved in CityPulse together with cities such as Brasov, Vienna and Stockholm together with leading organisations we have learned to think big-scale and internationally.

Birgitte: We have also been able to share our experiences with using the CKAN platform for sharing data, which means that Brasov is now ready to use the same portal. This is just a small – but important – step to connect European cities and create scalable projects and use cases.

Furthermore, we have also been able to share how it is to represent the public sector in an EU project with many partners from the research field. Running a research and development-driven project inside a socio-political environment, i.e. a city, means a lot of hard work. Agendas may change very quickly which makes planning a difficult task. Developing platforms for cities rather than only an application that solves a single problem requires organisational changes, new ways of thinking and deep commitment in both operational and strategic terms.

Which recommendations would you give to other cities?

Birgitte: We have learned that you need to find the real data sets – those showing dynamics and which can be turned into value for the city hall, the employee, the developer and the citizens. This is exactly the case for the data sets in the utility companies. Highly expressive, highly dynamic and in huge quantities – the data show the pulse of the city. So for a city it is important to work closely together with the utility companies.

Finally, you need to expose the data properly – do not make big data dumps. Give people the option to access live streams whenever possible.

Line: The smartest thing a city can do in relation to this topic is to develop an ICT strategy. I.e. moving from a complete silo mentality – each department in the city has its own budget and IT infrastructure. We do this gradually via our Smart Aarhus initiative – where we gather the different departments of the city – but also very importantly the companies and organisations in the area – to discuss smart city issues and collaborate on various smart city projects. One of these is Open Data Aarhus for example.

Where were you before CityPulse in terms of becoming a smart city and where are you now?

Line: On an overall level, we see CityPulse as one of many smart city projects in the City of Aarhus' strategic smart city work.

We have gained experience on how to navigate in the complex culture of EU projects and we are now even more keen on large-scale international projects.



"THE CITYPULSE FRAMEWORK IS A VALUABLE ADDITION TO OUR PORTFOLIO OF SMART CITY SOLUTIONS"

VIENNA:
Herwig Schreiner, Head of Business Analytics and Monitoring of Corporate Technology, Siemens Austria



How has CityPulse affected your city/organisation?

Siemens is convinced that smart cities are the basis for a future of sustainable living, with higher use of renewable energy sources, lower CO₂ emissions, and better quality of life. For more than a decade, Siemens has been committed to develop solutions to achieve these goals and is involved in a number of smart cities projects, covering a wide range of domains such as energy, mobility, buildings, and citizen engagement.

The CityPulse project addresses timely topics in the scope of smart cities, such as dealing with real-time – sometimes faulty – data, as well as making sense of the sheer amount of information and making sure the citizens do not suffer from information overload, but rather get only relevant updates at the relevant time. CityPulse's outcome of a modular and flexible framework is of high relevance in different scenarios and its components can contribute not only to existing Siemens solutions towards smart cities, but also to follow-up projects.

More recently, the city of Vienna has increased its efforts towards smart city initiatives, with projects on open data, modernisation of old urban areas and services to help citizens on their daily activities. Siemens Austria is committed to one of the largest urban development projects in Europe – the urban-lake-side district of Aspern, Vienna. The project, a joint initiative between Siemens Austria, Wiener Netze (a Power Grid operator), Wien Energie

(an energy supplier), Wirtschaftsagentur Wien, and Wien 3420, offers as testbed a "living laboratory" which is being created in there. In this testbed, Siemens and its partners are developing state-of-the-art-solutions for an energy-optimized city district, by having power suppliers, building systems, intelligent power grids, and information and communication technologies (ICT) interacting in an optimal manner. Here there is also a potential to apply CityPulse's outcomes to improve data management and quality monitoring solutions, as well as to provide real-time, on demand, notifications for citizens and for building and power grid operators.

What value has your organisation gained from CityPulse?

The benefits from CityPulse are manyfold. As stated earlier, the framework's components are a valuable addition to the Siemens portfolio of smart cities solutions. In addition, the collaboration with fellow project partners has been very fruitful. Siemens has a long history of collaboration with research institutions, and they have proven to be a great mechanism to tackle emergent topics and advance the state of the art. With CityPulse it has not been different. The project has excelled in delivering its promised goals, which would not have been possible without full commitment of its partners. The legacy of CityPulse is not limited to its components and deliverables. Solid research exchange has been established and it is likely to continue in future follow-up collaborations, both at regional and European levels.

What have you learned by being involved in a large-scale European project like CityPulse? And what do you think CityPulse and other projects like CityPulse can learn from you?

CityPulse marks the first participation of my team in a large-scale European project. After being involved in a number of other research projects of different scales, I can tell that while having a group of lead expertises in different areas provides a solid basis for a project, it cannot alone guarantee the project's success. Equally important is the leadership of the project's coordinator and work package leaders, as well as a strong commitment of the project members to work together. CityPulse has been one of the most enjoyable projects to work on. Its consortium consists of extremely talented people with the motivation to work as a group. This synergy is reflected in the number of high quality publications, open source code, demonstration apps, and participation in events. Partners are also committed to the legacy of the project, which is quite helpful when implementing future follow-ups of the work carried out within CityPulse. All the components are available for download and are well-documented.

I am now convinced that European projects provide a perfect setup for researchers in industry and universities to come together. This exchange is beneficial for both sides. Besides the technical know-how from my research group, I believe that my contribution to the project has also been on sharing the overall vision and goals of Siemens towards smart cities, and how they align with the project's ideas and planned results.

Although this of course has been one of the expected contributions of our role as industry partner it was a pleasure to see how the research institutions could use that information to steer their research direction towards a path which can have a higher impact not only in current technologies but also in supporting future trends, e.g. in mastering urban life in mega cities.

Where were you before CityPulse in terms of becoming a smart city and where are you now?

As mentioned before, Siemens has already been involved in a number of smart city projects, both internally or in collaboration with external partners. The business analytics and monitoring group in Vienna, which I am head of, has a recent history of smart city initiatives, mostly within the country, with the Aspern development and a few other nationally funded research projects. Within CityPulse we have had the opportunity to explore and develop technologies which we have not pursued in previous smart cities initiatives, such as the ability to deal with heterogeneous, faulty data through the use of Semantic Web technologies and machine learning techniques, as well as real-time adaptive contextual filtering using reasoning. The project has contributed greatly in extending our view of smart cities solutions and I am confident that we are now much better equipped to provide state-of-the-art smart cities consulting and tailor-made solutions to our customers.

"THE IDEA OF A SMART CITY IS NOW MORE VISIBLE AMONG OUR LOCAL STAKEHOLDERS"

BRASOV:
Gabriela Vlad, Head of the IT Office, Brasov City Hall

How has CityPulse affected your city?

CityPulse has brought up on the public agenda the entire smart city concept and it shed light on what "smartifying" the city actually means. It allowed for various local stakeholders to participate in the public debate that was stimulated by our participation in CityPulse. One of the most visible results has been the Brasov – smart city conference organized on the 9th of May 2015 where professionals from Romania and from abroad shared their experiences and opinions about the smart city future of Brasov.

What value has your city gained from City-Pulse?

The added value of the project is that it has managed to shift the smart city concept from a distant idea for future development to an actual working concept that is currently used to improve the projects that are

developed both locally as well as in the metropolitan area of the city of Brasov. One of the tangible results is the CKAN platform that will allow us to upload streams of data for public access, thus opening the path for app developers to aggregate these data into new usable information about the city and to its inhabitants.

What have you learned by being involved in a large-scale European project like CityPulse? And what do you think CityPulse and other projects like CityPulse can learn from you?

Being involved in this project together with leading cities such as Aarhus and Vienna and leading players in the research field such as Siemens allowed us to go beyond thinking "small-scale". It has changed the local mindset from being a "follower city" towards becoming a leader in the implementation of the smart city concept.

Where were you before CityPulse in terms of becoming a smart city and where are you now?

Before the project, the city of Brasov was already on its way to become a smart city, being receptive to any innovative idea that could improve the citizens' quality of life. As the project activities unfolded, the smart city idea got more and more visibility among the local stakeholders; the local community leaders adopted this concept and as a result, a new organization emerged – an NGO called Smart City Brasov which is dedicated to bringing the newest technologies to Brasov and making sure that they are embedded in the urban fabric. Currently, we are on a clear path toward ensuring that the smart city concept is represented in every local development project implemented by the public authorities. Also, the public administration is developing new project ideas to support the implementation of the smart city concept.



"UNDERSTANDING FUTURE NEEDS OF A CITY IS IMPORTANT"

STOCKHOLM:

Elena Fersman, PhD. Research Manager, Management and Operations of Complex Systems, Ericsson Research, Stockholm

How has CityPulse affected your organisation?

Ericsson has a broad number of engagements with cities as part of industry and society projects related to intelligent transportation systems, utilities and public safety. Understanding the future needs of cities is important for such engagements and was the main reason for Ericsson to join the project. The project has contributed with insights as well as possibilities for researchers at Ericsson to verify relevance of research ideas with partners.

What value has your organisation gained from CityPulse?

The main value of CityPulse for Ericsson has been in working with concrete challenges that cities are facing, such as semantic interoperability,

federation of heterogeneous data streams as well the need of increased innovation coming with increased digitalization of city infrastructures.

What has your team learned by being involved in a large-scale European project like CityPulse? And what do you think CityPulse and other projects like CityPulse can learn from you?

Working closely to city partners has been beneficial for Ericsson with respect to working with concrete challenges such as semantic interoperability, and large-scale stream processing. Ericsson technologies such as IoT framework and experience in large-scale data analytics were beneficial to the project.

Where were you before CityPulse in terms of having smart city related projects and where are you now?

Ericsson has a number of engagements with smart cities, both on commercial and research level. Projects such as CityPulse allow vendors like Ericsson to deepen the understanding of future needs of cities and to develop relevant technologies in order to address these needs.



KEY FIGURES

9
PARTNERS IN CITYPULSE:

35
TALKS AND PRESENTATIONS GIVEN:

3
INDUSTRY-PARTNERS PARTICIPATING:

2
COMMERCIALIZED ITEMS:

101
SCENARIOS CREATED:

15
OUTREACHING EVENTS:

6
PHD'S EDUCATED:

19
COMPONENTS CREATED:

1 SME'S:

2
CITIES PARTICIPATING:

FROM
6
EU COUNTRIES

4
HIGHER EDUCATION AND
RESEARCH PARTNERS:

335
TOTAL EFFORT:
PERSON MONTHS

The CityPulse framework can be regarded as building bricks consisting of several components, which can analyze, visualize and homogenize different sorts of data.

The outcome of the CityPulse framework is open APIs, which can be used in various smart city scenarios.

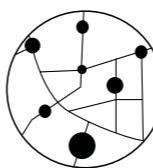
SCENARIO

COMPONENT



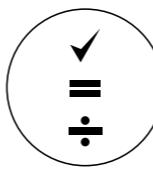
SEMANTIC VALIDATOR

This web application allows ontology developers to validate their data that are based on the SSN ontology. Users can input their data either by uploading a file or directly by inputting the data in the textbox. The application also provides a tag cloud that illustrates the popularity of the terms that are used by all the data that have been submitted for validation.



DATA QUALITY EXPLORER

The Data Explorer gives a graphical user interface to monitor the quality and the trust of the data sources in real-time.



ATOMIC DATA QUALITY MONITORING/ COMPOSITE DATA QUALITY MONITORING

This component shows the quality of the data sources that are used in the CityPulse platform – e.g. the correctness of data and if some information is missing. If a city has no exactly planned infrastructure it is a complex process to determine, which sensor measurements are correct in case of contradictory information. This component predicts the plausibility of events by pursuing a monitoring approach that analyzes sensor values of related sensors of different kinds.



SOCIAL MEDIA ANALYZER

The Social Media Analyzer is a component where the user can visualize events extracted from social media streams such as Twitter.



EVENT DETECTOR

The Event Detector component in the CityPulse framework provides a generic tool for processing the annotated as well as aggregated data streams to detect events occurring in the city. This component is highly flexible in deploying new event detection mechanisms, since different smart city applications require different events to be detected from the same data sources.



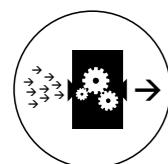
CITYPULSE 3D MAP

The CityPulse 3D Map provides a 3D visualization of cities and different geo-located events provided by the CityPulse platform.



KNOWLEDGE ACQUISITION TOOLKIT

The Knowledge Acquisition Tool (KAT) is a software component that implements state-of-the-art machine learning and data analytic methods for sensors data. The algorithms and methods implemented in KAT are used for processing and analysing the smart city data in the CityPulse project.



IOT FRAMEWORK

A mechanism for converting data points stored in the IoT Framework into semantically annotated data. This can be used for searching and accessing raw sensory data in a smart city data analytics framework.



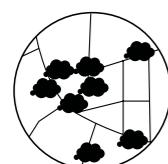
CITYPULSE TOURISM PLANNER

This scenario combines sources of data related to events and points of interest (PoIs) in the city of Stockholm and generates a schedule to explore the PoIs that the users select. The schedule is created based on the opening times of each PoI as well as the user's budget, travel period, and type of transport.



CITYPULSE PICKUP PLANNER

The Pickup Planner scenario aims to provide a travel service for users located around Stockholm. Users specify pickup location, destination, arrival time constraints and preferences in travel requests, from which the system devises a pickup path to be used by vehicle(s) in delivering users to their intended destinations.



CITYPULSE GEOSPATIAL DATA INFRASTRUCTURE

The Geospatial Data Infrastructure (GDI) component is used by a number of other CityPulse components to tackle geo-spatial tasks.



CITYPULSE DYNAMIC BUS SCHEDULER

This scenario introduces a reasoning mechanism capable of evaluating travel requests and generating bus timetables with reduced average waiting time for passengers. Furthermore, the system has the potential to detect traffic flow and make adjustments to the regular path of each bus, so as to decrease the waiting time which is a result of traffic congestion.



STREAM DISCOVERY AND INTEGRATION MIDDLEWARE

This component is responsible for discovering the most appropriate IoT sources for the application and integrates data from multiple heterogeneous IoT data sources.



CITYPULSE TRAFFIC PLANNER

The Traffic Planner is an Android application for citizens that can be used for obtaining user-oriented travel and parking recommendations.



CITYPULSE BRASOV BUS

The CityPulse Brasov Bus is an Android application that allows citizens and visitors in the city of Brasov to search for bus routes between two points. The app suggests routes and monitors the user's location. Users can also report traffic incidents in their vicinity, which will be forwarded to other users on bus routes affected by the incident.



EVENT TESTING

An Android application for reporting events and an application for web browsers to show and inspect events generated by the application and the Event Detector.



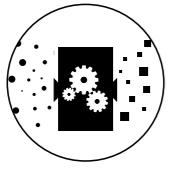
CITYPULSE CITY DASHBOARD

The CityPulse City Dashboard supports visual analytics for the different relevant datasets registered in the CityPulse platform.



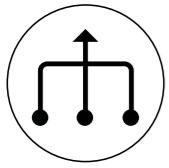
FAULT RECOVERY

The Fault Recovery component ensures the continuous and proper operation of the CityPulse enabled application by generating estimated values for the data stream when the quality drops or it has temporally missing observations. When the quality of the data stream is low for a longer time period, an alternative data source has to be selected.



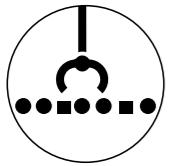
DECISION SUPPORT AND CONTEXTUAL FILTERING

This component utilises contextual information to provide optimal solutions of smart city applications. The component continuously identifies and filters critical events that might affect the optimal result of the decision making task.



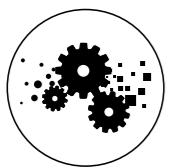
RESOURCE MANAGER

The Resource Manager component is responsible for managing all smart city data sources. Each source is described in a Data Wrapper. A Data Wrapper is a software bundle that connects to the remote data sources in order to fetch and interpret new sensor observations. During runtime an application developer or the CityPulse framework operator can deploy and manage new Data Wrappers to include data from new data streams.



STREAM PROCESSING BENCHMARK

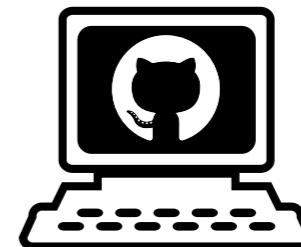
This benchmark has been designed using CityPulse reference datasets and it provides a configurable benchmark to evaluate RDF Stream Processing engines using smart city applications.



DATA STREAM GENERATOR

This is a tool for generating data streams. A data stream is a sequence of measurements from a sensor or other sources, over time (for example temperature data, a car's tire pressure, level of fuel on an aircraft, etc.). It is meant to be used as a tool for testing the performance of systems designed to gather and process large amounts of data from different sources (e.g. IoT middleware). The CityPulse framework uses this component to run some of the demonstrators.

TO LEARN MORE
ABOUT OUR DIFFERENT
PROTOTYPES AND
SOLUTIONS PLEASE VISIT
OUR GITHUB



[WWW.GITHUB.COM/CITYPULSE](http://www.github.com/citypulse)

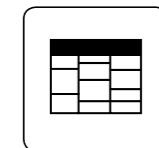
CITYPULSE – IT'S ALL ABOUT THE SMART CITY USE CASES!

In CityPulse we have created a number of different prototypes and solutions based on the CityPulse framework; hereby showcasing the broad variety and possibilities of smart cities.

We have asked citizens which of our smart city prototypes they like the most and how they can be relevant in their daily lives.



CITY: BRASOV
NAME: MEDEEA PETROVAN
PROFESSION: SENIOR CONSULTANT
– ICEBERG CONSULTING



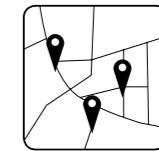
THE CITYPULSE
REFERENCE DATASET

Being involved in the establishment and development of the IT&C cluster of Brasov, I was directly connected with the local IT community, without being a professional in this field myself. I have noticed the growing trust and collaboration between specialised companies and the local authorities in openly sharing knowledge and information

for the direct benefit of the community and the citizens of Brasov. The CityPulse Reference Dataset is a good example of a platform that reunites different types of open data coming from different sources, offering wide opportunities for the developers to create smart city applications that can make our life in Brasov more active and colourful.



CITY: AARHUS
NAME: JESPER ALGREN
PROFESSION: CONSULTANT, SMART REGION,
CENTRAL DENMARK REGION



EVENT DETECTOR

We have already seen several applications where citizens can get an overview of the traffic. I like the idea of an application that collects all Open Data sources related to traffic and parking. This will be the best and easiest way for citizens to get information. I believe that the Event

Detector could be useful in connection with major events or major cultural happenings. In this case, I will know where to park my car and find a toilet nearby, but this requires more data sources.



CITY: VIENNA
NAME: DR. JULIA GIRARDI-HOOG
PROJECT MANAGER, MA 25,
CITY OF VIENNA



CITYPULSE
TRAFFIC PLANNER

The EU-funded project "Smarter Together" focuses on smart urban renewal in a neighbourhood southeast of the city centre. The aim of the project is to prepare neighbourhoods which were planned and built in the post-war period for the future. This includes infrastructure such as electricity, heating and lighting, as well as buildings, mobility, IT infrastructure and most importantly the "users" of the city. CityPulse has an interesting approach, as it is based on several kinds of data, including data produced by users. Especially for mobility purposes, it is interesting to integrate data produced real-time by users

in the neighbourhood. Also for future energy planning and energy saving, the possibility to aggregate and visualise energy production and consumption data is important.

For "Smarter Together" we chose a neighbourhood with a population that has a rather low level of formal education, a high percentage of foreign nationalities and low income. It will be crucial to find ways to integrate these users into projects like CityPulse. Certainly, the possibility to switch between language settings increases the usability of such projects.



CITY: UPPSALA
NAME: NDEY ISHA JOBE
PROFESSION: TEACHING ASSISTANT AT UPPSALA UNIVERSITY



CITYPULSE
PICKUP PLANNER

The CityPulse Pick-up Planner is great and quite essential. It solves problems usually associated with friends (or a group of people) travelling to the same destination and at the same time wanting to reduce the cost of the trip. Uppsala, being a student city, would benefit from such a service, since students frequently need to travel to the airport to catch flights. Instead of posting on social media to inquire if their friends would like to make the same trip and consequently share the taxi cost, the students would

simply register for the pickup service and include their preferences in the requests submitted to the system.

Additionally, the service would be a great help to tourists arriving at new places and who want cheap and shared trips to various destinations. In my opinion, the best feature is the way the application optimises the route for drivers based on the users' requests. I would definitely recommend it to any person.



CITY: AARHUS
NAME: MATTI BUGGE
PROFESSION: CONSULTANT



CITYPULSE 3D MAP

As a citizen of Aarhus, I see a huge potential for the 3D tool developed by CityPulse, mostly because of the city's own ambitions of becoming smarter and more sustainable. It is amazing to see how the tool can show 3D rendered real-time updated information on traffic congestions, parking availability or even pollution in the streets.

With the right development, I imagine the tool could be very useful for both authorities and citizens to interact with their city in a smarter way. Furthermore it is open source so someone just has to come up with the right idea!



CITY: VIENNA
NAME: PROF. DR. THOMAS EITER
**PROFESSION: PROFESSOR OF COMPUTER SCIENCE/
HEAD OF THE KNOWLEDGE BASED SYSTEMS GROUP/
HEAD OF THE INSTITUTE OF INFORMATION SYSTEMS**



CITYPULSE
TRAFFIC PLANNER

Travel planning and mobility are issues of growing demand and importance, and for smart city environments among the core problems that need attention. The increasing availability of real-time sensor data as well as, on the other hand, more dynamic background information opens up new possibilities for travel planning that consider semantic constraints, user preferences and needs, as well as multi-modal transport in order to find the best solutions. It has shown in the traffic planner demo how the framework developed in the project can be fruitfully used to

meet these problems. Based on the experience of our group at TU Wien in intelligent route planning, we see that CityPulse provides a powerful platform that by its architecture, the interfacing of Open Data, the use of semantic technologies, and the support of advanced information management and event detection, can serve as a promising tool to obtain the best solutions for travel planning tasks at increasing complexity levels. Combined with monitoring and optimisation from a global perspective this is thus right on target to enable smart cities of the future.



CITY: ATHENS
NAME: DIMITRIOS GEORGIOPoulos
PROFESSION: BUS DRIVER



CITYPULSE
DYNAMIC BUS SCHEDULER

Traffic is one of the major factors that affect the normal schedule of public transportation, especially in over-populated cities with huge numbers of private vehicles and lack of cycling infrastructure. As a bus driver, I usually receive complaints from unsatisfied passengers, when the bus does not reach its destination at the predefined time. So far, there is no solution to this problem since bus routes include the most popular roads, where traffic density is usually high, and bus drivers are obliged to follow the predefined routes, even if they might be aware of alternative and less time-consuming ones.

Based on my experience, using an application like the Citypulse Dynamic Bus Scheduler, which is able to monitor the levels of traffic density and make adjustments to the predefined bus routes, would prevent the bus vehicles from getting stuck in traffic and reduce the corresponding delays. Moreover, there would be another reason for passengers to be satisfied, since the application generates the timetables and estimates the number of operating vehicles according to their requests. And the more satisfied the passengers are, the less worried the bus driver is.



CITY: AARHUS
NAME: ANNA KATRINE MATHIASSEN
PROFESSION: COMMUNICATIONS SPECIALIST



SOCIAL MEDIA ANALYSER

The Social Media Analyser gives a clear and easy way to overview activities in the city. The tweet-map is in fact a new type of news feed just as a visualisation, and this has higher impact on users. Imagine you want to go out but you do not know where and if something interesting is happening. With this tool, you can get inspired. By choosing between the different categories, it is easy for

the user to sort and locate the activity by category or area. It is also useful for event planners who can use it to create awareness about their event.

I find the Social Media Analyser highly relevant and exciting and it is an excellent opportunity for the citizens to become part of the city's pulse.



CITYPULSE
TRAFFIC PLANNER



CITY: VIENNA
NAME: UNIV.-PROF. DR. AXEL POLLERES
PROFESSION: HEAD OF THE INSTITUTE FOR INFORMATION BUSINESS AT WU WIEN (VIENNA UNIVERSITY OF ECONOMICS & BUSINESS)

With the traffic data analysis demo based on its platform, CityPulse provides an extensible tool that allows integrating locally fixed sensor streams and their data with other data such as mobile sensors, citizen sensing, etc. As a platform, the system – being based on Linked Data and Semantic Web technologies – uses and relies on open standards, which guarantees transparency and extensibility, plus the potential to provide and integrate Open

Data, which is at the moment one of our main research interests at the Institute of Information Business at WU Vienna. We see the potential of the combination of Open Data and Big Data – facilitated through platforms like CityPulse – as one of the future trends of data-driven economies and communities.



CITY: UPPSALA
NAME: DANIEL LLATAS
PROFESSION: COMPUTER SCIENTIST



CITYPULSE TOURISM
PLANNER

sometimes the information is inaccurate. I might use the Tourism Planner as a reference. It would be accurate and it can provide me with a good starting point if there is not much time to walk about in a city.

THE PROGRESS IN CITYPULSE

A significant part of the CityPulse project has been to meet our stakeholders. Throughout the three years the project has lasted, we have participated in several conferences and seminars, and hosted hacklabs and information meetings. We have been in continuous contact with citizens, city stakeholder, SMEs and companies to highlight and evaluate our solutions.

Furthermore, we have held many internal meetings to plan, discuss and execute the technical progress as well as engaging activities. We have developed several components to the CityPulse framework and based on this created a series of smart city scenarios.

Below is an overview of some of our many activities.

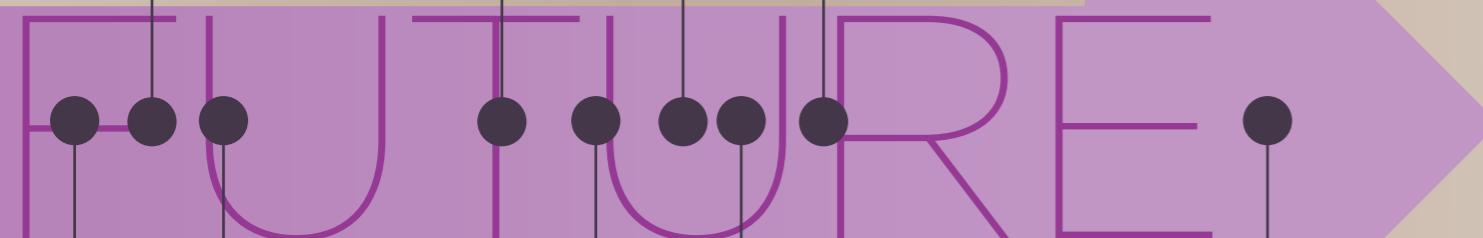


Some of the 101 scenarios developed by the CityPulse partners were refined as project ideas and were included in the Brasov Metropolitan Area's development strategy to be implemented during 2016-2023

CityPulse is part of the City of Aarhus' smart city portfolio, which means it is continuously presented to other city authorities and public organisations

A hackathon is proposed to take place in Brasov during the spring of 2017; it will make use of the data that will be made available through the CKAN platform by the city hall and the 101 scenarios for the development of new smart city apps

Academic and research groups will continue the research and experimentation towards higher impact and will design/publish training and research material to showcase the results of the CityPulse project and present further opportunities and developments



During Internet Week Denmark in spring 2017 in Aarhus the City of Aarhus will present the scenarios for a large audience at DOKK1, the main library in Aarhus

SMEs in Aarhus, Brasov and Vienna will be presented to the CityPulse Framework and scenarios in a hands-on workshop. Some will start to further develop and work on the material that is freely available on Github

The industrial partners will use the results in the future demonstration and ongoing product and service design



Want to follow the next steps in CityPulse? Please, visit the CityPulse website:
www.ict-citypulse.eu

Based on the CityPulse project a new project is taking its form. This project will focus on... large ecosystem of data-driven applications and innovations for smarter cities and connected communities. Fundamental research on key challenges such as large-scale IoT information search and retrieval and IoT stream processing and information extraction will be also considered