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# CITY PULSE

Annual Report 2014



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What you hold in your hands right now is knowledge and experience. Primarily on smart cities and smart city data streams. On how to make use of real-time data from different Internet of Things devices and create smart city applications. But it is also about how to collaborate and bridge the gap between diverse professions. On how to share knowledge internally among different partners as well as external stakeholders.

The annual report is written by the entire CityPulse consortium that brings together people from diverse fields of knowledge, from research to technology as well as city stakeholders. In the project it has been vital for us to be able to combine our different fields of expertise.

In the report you will find interviews on the technical aspects of the smart city, for example how the project has an integrated approach to Internet of Things and Internet of People (page 8-11). You can read about the architecture of the project (page 28-29), and how you convey knowledge about a project of this nature (page 52-53). Last but not least, you can read about how big the impact of CityPulse is for city stakeholders (page 32-49).

But all in all, this report aims to give you a 360-degree introduction to CityPulse from all the different perspectives in the project. We would also like to show that it is as much a technological project as a cultural change project.

And who might you be, you who are holding this annual report in your hands? You might be working as an urban planner in a city implementing a smart city strategy, or as a head of IT or a business strategist. You might also be working in an IT and development company. Or you might be a researcher looking into data streams or data management, IT or even user studies.

No matter who you are, the most important thing is that you are curious. Curious about Internet of Things,

real time data streams, smart cities. But also curious about how to carry out such a project and how to disseminate knowledge about a complex phenomenon.

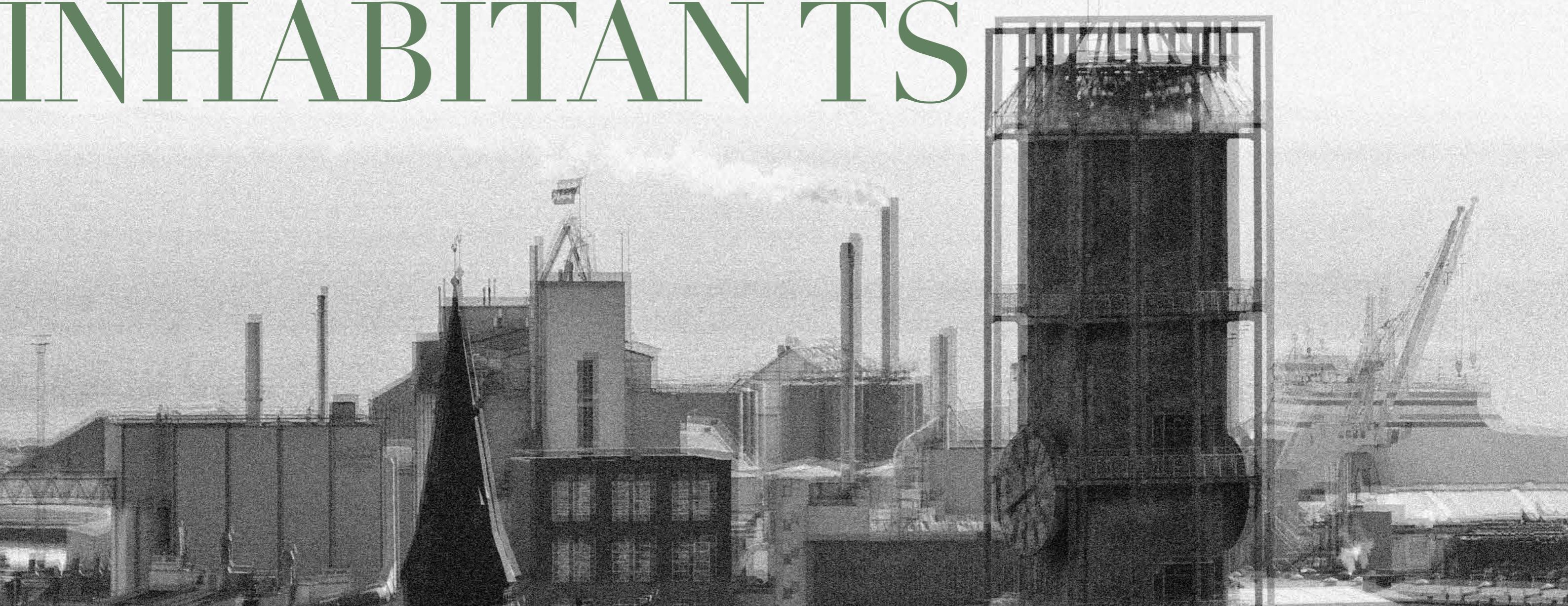
Please pass on this annual report and share our knowledge. And share your own knowledge too. Get in touch with us. After all, that is what a smart city is about. Thank you.

Many thanks to all of you who have contributed to the report and helped make it a reality. Your contributions are immeasurable!

**Michelle Bach**  
**Editor**



SMART CITIES  
ARE ONLY AS SMART  
AS THEIR  
INHABITANTS



# WELCOME TO CITYPULSE

- a project on innovative smart city applications.  
Introduced by Dr. Payam Barnaghi, project leader of CityPulse.

Our world and our lives are changing in many ways. Communication, networking and computing technologies are among the most influential innovations that shape our lives today. In this digital age, multiple technology advancements and widely available hardware and software products have provided a unique opportunity for voice and multimedia communications that allows us to stay connected anywhere at any time and connect almost any physical object into the communication networks. Digital data and connected worlds of physical objects, people and devices are rapidly changing the way we work, travel, socialise and interact with our surroundings and have a profound impact on different domains such as healthcare, environmental monitoring, urban systems, and control and management applications, among several other areas.

Communication networks and data have become an essential part of our lives. In addition to traditional voice and multimedia communications, data can now be collected and communicated manually or automatically to represent observations and measurements from the physical world, report events and incidents, share our thoughts and social events. Cloud platforms, information management systems and analytical tools provide means to process these large volumes of data in order to extract information and insights related to our surrounding environments, personal life and activities, on both local and global scales.

Two years ago, we discussed some initial ideas for a potential new collaborative project under the EU FP7 programme. We had previous works and research experience of communication networks, data analysis, semantic technologies and Internet of Things and several other relevant areas. The idea was to find out how to leverage our skills and expertise to create novel solutions and develop new technologies that can have an impact on people's everyday lives while at the same time supporting innovation and

commercial exploitations. We discussed applying our expertise and skills to develop scalable data analytics solutions for smart cities. Big Data, high performance computing and Internet of Things are among the most discussed technologies in recent years. A lot of interesting work is already available in this area with several platforms, solutions and open or commercial services and applications.

We were seeking an integrated approach to develop a set of interconnected solutions that enable collection, publication, annotation and query of smart city data streams. The idea was to create test and reliability mechanisms as well as quality analysis and enhancement solutions to make the uncertain, noisy and unreliable real world observations and measurements suitable for information extraction of sufficient quality to be used by higher-level services and end-users.

CityPulse was born out of these ideas and out of several brainstorming sessions and discussions with the project partners. The City of Aarhus, Denmark, and the City of Brasov, Romania, also agreed to join the consortium, which provided us with an excellent opportunity to work with real data and to attempt solving real problems in the cities.

'Smart city' is a complex and multidisciplinary domain. We are aware that cities and urban environments are complex social systems, and no technology solution alone can solve their problems. However, our main efforts are focused on providing an open and scalable framework that will facilitate the processing of sensory data and real world data streams so that we can extract information and actionable knowledge for management and decision making systems, and thus provide feedback and intelligence to citizens regarding their city environment and services. There are major opportunities in smart cities if we integrate small pieces of information provided by various distributed sources; the key challenge is how to integrate multimodal, mixed quality, uncertain and in-

complete data to create reliable, dependable information and how to optimise data processing techniques to achieve various goals, such as energy, network and computation efficiency for providers and quality of information and quality of experience for end-users.

The large volumes of heterogeneous data require new ways of communication, aggregation, processing and mining to extract efficient and actionable information from large volumes of raw data. Physical, social and personal data can also be processed to provide insights and knowledge that can be fed into automated decision support systems, business applications, and control and monitoring applications. The large volumes of real world data require effective solutions for processing and interpretation in timely, scalable and flexible ways. Among the key challenges in dealing with smart cities are: data privacy, trust, security issues as well as developing adaptable machine learning and intelligent methods to access, collect, store and process the data and to extract business intelligence and actionable information from huge amounts of raw data that are provided by dynamic resources.

This annual report summarises our design and use-case definition activities as well as research and development efforts within the first year of the project. In the first year, our main work has focused on defining a relatively large set of real world use-cases by collaborating and brainstorming with the city partners, the stakeholder group and experts in the field; selecting and ranking the use-cases; designing a detailed architecture for a smart city data analysis framework; developing an initial set of software components and APIs as well as adaptable machine learning and data analysis techniques for processing and information extraction from large volumes of dynamic data in smart cities.

Our aim is to enrich data streams from physical and virtual sensing devices with semantic annotations, enabling adaptive processing, aggregation and fed-

eration of data. Functionalities for aggregation and federation using linked data and mash-up techniques will enable the development of a scalable framework for processing large-scale Internet of Things data streams in smart city environments.

Reliability testing provides performance evaluations and contributes to more reliable and scalable solutions for dynamic smart city environments. The results of the project will be deployed as pilot projects in the partner cities and will be adapted by the industry partners with the aim of developing new services and products. Our plan is to make the software and APIs developed in the project available for public users to develop their own services and applications using the CityPulse framework.

I hope you will enjoy reading the first Annual Report of the CityPulse project. Please send us your feedback and any suggestions that will help us to improve the project and the report.



# CITYPULSE – FROM BIG DATA TO MEANINGFUL INFORMATION IN REAL-TIME

**Introduction to CityPulse by Ralf Tönjes, Prof. Dr.-Ing. at University of Applied Science Osnabrück.**

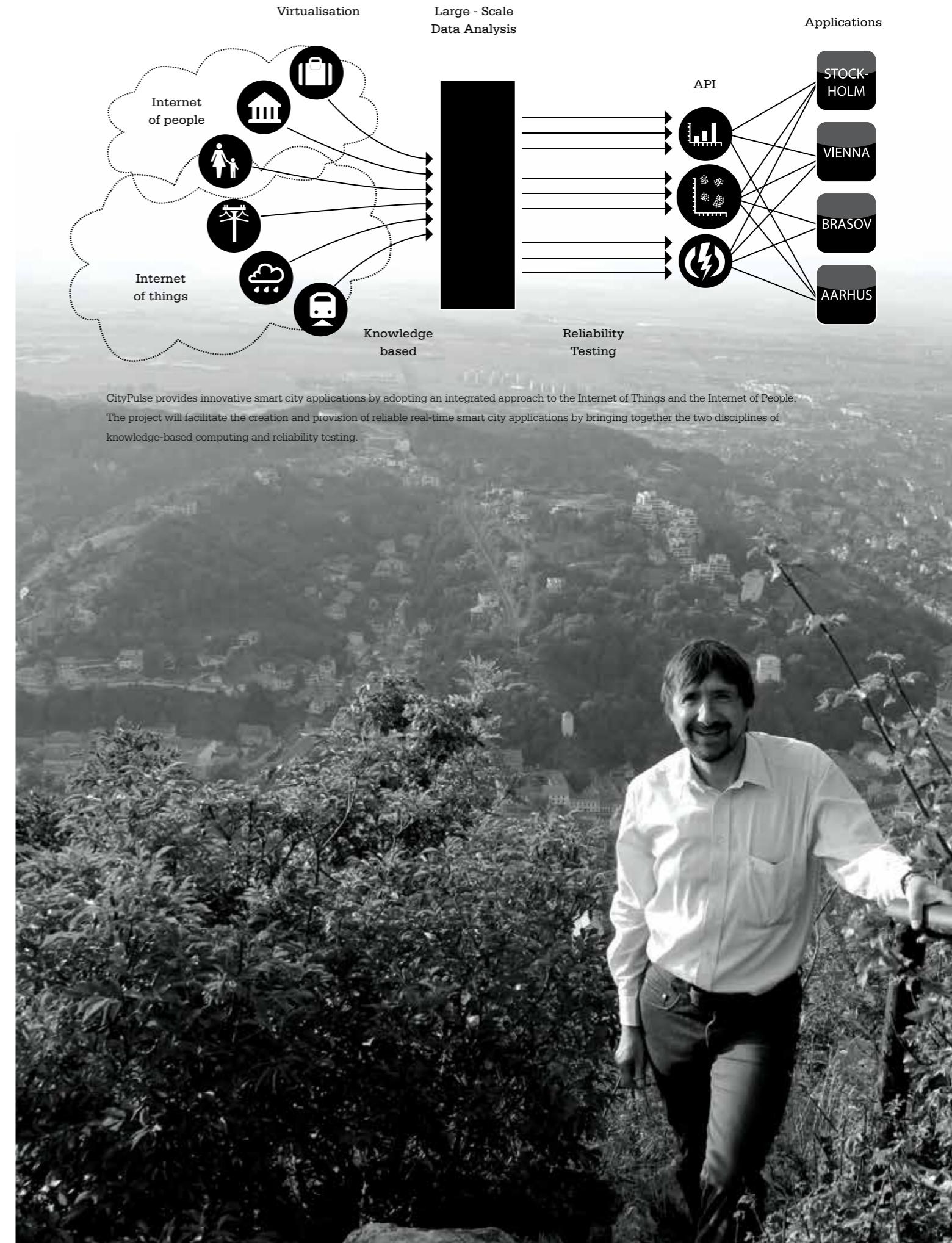
Today cities are facing many economic, ecological and social challenges. In addition, there is an increasing demand for providing better services to citizens and businesses, closer interaction with citizens and attraction of new companies. To address these challenges, many cities have started to introduce new information and communication technology (ICT) enabled services. However, the activities have resulted in a plethora of solutions that differ from organisation to organisation and department to department. Hence, the heterogeneity of the various data sources and missing integration platform are an obstacle to the uptake of innovative cross-domain smart city applications. Many opportunities are missed because the data is heterogeneous, too static or old, not manageable because of volume, or simply just not found. These are the obstacles that CityPulse tackles to enable viable smart cities for citizens, city authorities and businesses.

Our approach is to abstract from the heterogeneity of the numerous data and information sources through virtualisation providing common interfaces. But important data might still not be found. Therefore, data will be annotated with semantics to enable automated detection and later knowledge-based processing. Moreover, the amount of data in cities is increasing rapidly. To ensure scalability, our approach foresees a specific architecture that distinguishes very efficient processing units for big data and very flexible intelligent decision units that employ real-time reasoning and control the big data processing units. Data acquisition in the dynamic environment of a city is prone to errors. Therefore, particular methods will be developed to monitor accuracy and trust and to resolve conflicting

information. All the components will be designed in a way to ensure maximum reusability for different domains and applications. A major effort will be put into visualising the requested events and situations in the city for decision-makers and easy use by citizens.

To achieve these objectives, the CityPulse consortium builds on a strong competence in ICT, data analytics, complex event processing, semantics and knowledge-based approaches, testing and platform engineering. Together with the city partners, the consortium has identified and documented more than a hundred usage scenarios for CityPulse, which were very well acknowledged. The requirements, agreed upon by the partners, derived from the scenarios guided the development of the CityPulse framework. Together with the city partners, large data sets were collected. The idea is to compile complex reference data sets that can be shared with the research community to initiate a competition on developing the best smart city analysis tools. Up to now, the availability of suitable data sets has always been a problem. The emerging CityPulse reference data sets will foster the development of efficient smart city tools. The project has made good progress to address the scientific and technical challenges, which are in particular: scalability, reliability and reusability in different domains. Advanced tools are under development by the individual partners, and a first integrated demonstration for a selected scenario is already in progress and will be presented at the end of the first year.

I hope that you will enjoy reading the first annual report and that you will find lots of interesting information.



# PARTICIPANTS AND ROLES

CityPulse consists of different partners from the field of research, IT and development and municipalities. You can meet them here.

## Research partners:



**University of Surrey (United Kingdom):** Centre for Communication Systems Research (CCSR) at the University of Surrey is the largest academic research centre in the UK specialising in information and communications technology. Our research in the CityPulse project is mainly focused on intelligent processing of dynamic IoT data, large-scale analysis and information extraction from real world data. CCSR is also coordinator of the CityPulse project.



**University of Applied Sciences Osnabrück (Germany):** The University of Applied Sciences Osnabrück (UASO) is a self-governing public foundation. With around 12,000 students, it is one of the largest universities in Lower Saxony, Germany. Close co-operation with business and industry and scientific know-how combined with practical experience in more than 80 laboratories guarantee innovative research results relevant for practical solutions in business and industry. UASO's part in the CityPulse project mainly focuses on reliable information processing in smart city infrastructures. It focuses on computation and assessment of information quality for smart city data streams to help applications to find the best data sources. UASO provides the data source for fault-detection and -recovery mechanisms. Furthermore, monitoring and testing solutions ensure continuous reliability and resilience.



**National University of Ireland/DERI (Ireland):** INSIGHT at NUIG is a leading research institute in Semantic Web and Linked Data, with a strong expertise in developing infrastructures to facilitate scalable storage and reasoning, and active participation in a number of standardisation activities in the area of Sensor Networks, Linked Data and Stream Processing. Being part of CityPulse is a key opportunity for extensive deployment of our core technologies in real-world scenarios.



**Kno.e.sis (USA):** The Ohio Center of Excellence in Knowledge-enabled Computing at Wright State University conducts world-class multidisciplinary research in Semantic Web, Semantic Social Web, Semantic Sensor Web, Physical-Cyber-Social Computing, Smart Data, Personalized Digital Health real-world applications that have significant scientific, social and economic impact. Our research in CityPulse involves development of technology for integration of and reasoning over IoT/sensor and social Big Data to power advanced smart city applications.

## IT and development partners:



**The Alexandra Institute (Denmark):** The Alexandra Institute is a Danish company that works with applied IT research, development and innovation. The CityPulse project is a strategic international project in which we work on new services and applications for smart cities using real-time data streams.



**Ericsson (Sweden):** Ericsson is the world's leading provider of technology and services to telecom operators. Ericsson is the leader in 2G, 3G and 4G mobile technologies, provides support for networks with over 2 billion subscribers and has the leading position in managed services. In the CityPulse project we are working on bringing Ericsson's vision of a Networked Society to life by looking into technologies such as analytics and knowledge management in the context of Smart Cities combining the Internet Of Things with the Internet of People.



**Siemens (Austria and Romania):** Siemens AG is a global powerhouse in electronics and electrical engineering, operating in the fields of industry, energy and healthcare as well as providing infrastructure solutions, primarily for cities and metropolitan areas. Siemens is one of the world's largest providers of environmental technologies and strongly engaging in sustainable solutions. With nearly 7,000 employees worldwide, Corporate Technology (CT) plays a key role in R&D at Siemens and works closely with Siemens' Divisions and Business Units. In response to the global megatrends – climate change, urbanisation, globalisation, and demographic change – CT focuses on innovations that have the potential to change the rules of the game over the long term in business areas that are of interest to Siemens. In CityPulse Siemens is active with two CT research teams located in Brasov (Romania) and Vienna (Austria). Both teams perform joint research in the areas of semantic streams, event driven models for urban context as well as constraint-based configurations and stream dependencies in given contexts. In addition, Siemens supports the use cases developed for Brasov and provides an active link to Smart City initiatives of Vienna, mainly to one of the largest European development projects: Vienna Seestadt Aspern.

## City Stakeholders:



**City of Aarhus (Denmark):** The city of Aarhus is the second largest city in Denmark. The City works with smart city solutions via the Smart Aarhus initiative and provides CityPulse with an open data platform collecting all data of the city. An international project like CityPulse that puts the data of Aarhus into use will provide the citizens of Aarhus with new services and solutions that add value to society.



**City of Brasov (Romania):** The Brasov Metropolitan Agency is an association of public bodies from the Brasov City region, Romania. The actions of the Brasov Metropolitan Agency are directed towards planning the social and economic development process as well as providing assistance to the local administrations in their development endeavors. Our participation in the CityPulse project is an important step for our commitment to transform Brasov into a Smart city. The ideas developed within the project framework will allow us not only to explore an untapped potential of existing data but will also provide us with the next specific steps that we need to take based on the best practices presented by other cities in the project.

An aerial black and white photograph of a dense urban area, likely a European city. The scene is filled with numerous buildings, mostly multi-story houses with tiled roofs. A prominent feature is a church with a tall, light-colored tower featuring a clock face. In the foreground, there's a large, open square or plaza with a grid pattern, possibly a market square. People can be seen walking on the streets and squares, and some cars are parked along the roads.

A DYNAMIC  
URBAN LIFE  
REQUIRES SMART  
CITY SOLUTIONS

# OUR METHODOLOGY IS 101-2-21-2-11. READ ON TO CRACK THE CODE!

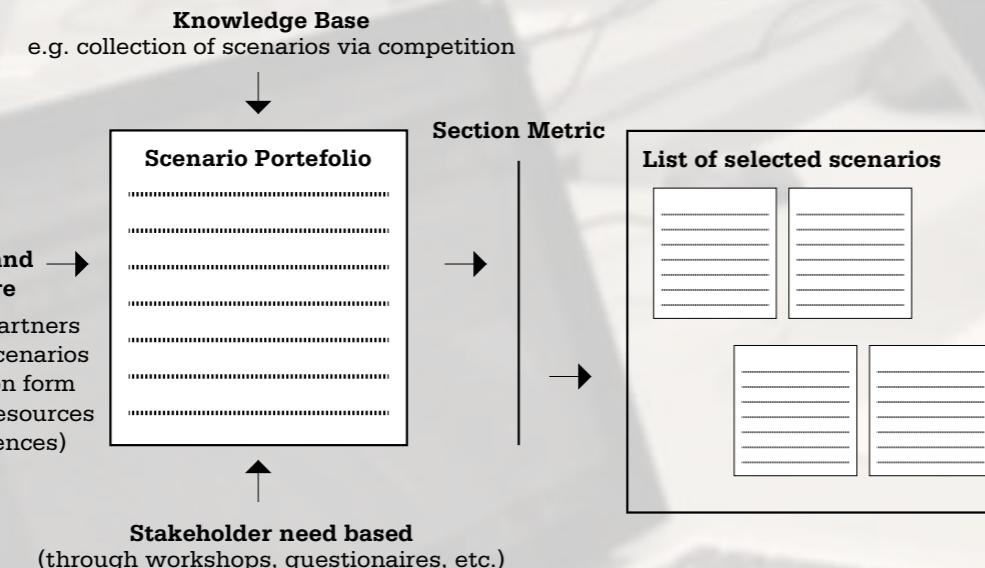
Interview with Mirko Presser, Head of Smart City Lab at The Alexandra Institute on the work with tangible scenarios.

Mirko Presser is responsible for WP6 which create smart city scenarios that are to be implemented in the cities at the end of the project.

**You have created a lot of hypothetical smart city scenarios. Why have you done that?**

An important part of the CityPulse project is to create scenarios that are to be carried out and implemented in the cities of Aarhus and Brasov later on in the project. This is the very tangible part of CityPulse, because here we are concrete and visualise how a

city really is a smart city and how different people in the city will experience it. How will people who work in the city government benefit from IoT and data streams? Will they be equipped with new smart city tools that enable them to offer better and more efficient services to citizens, thus increasing their efficiency and improving their job satisfaction? Will shops, companies and industry be able to interact more cleverly with the citizens? And will citizens and tourists experience an increase in quality of life? We hope to show this via the scenarios.



## Describe the approach in the creation of scenarios:

The CityPulse project has created a total of 101 narratives about applications used by an end user in a smart city. They are all very different, depending on sector, usage and complexity.

The scenarios have been created from three sources:  
1) Crowd sourced: Through a competition that was not very successful to be honest – one submission – but of good quality.

2) Projects and literature: We carried out research and used much of the work of the [iotcomicbook.org](http://iotcomicbook.org).

3) Workshops with city stakeholders: A key resource in the project.

At first, the 101 scenarios were ranked by the CityPulse consortium, which consists of different partners, including city stakeholders, IT professionals and researchers. The scenarios were evaluated based on the parameters shown in figure 2. This gave us an internal ranking list where we ended up with a top 10.

## What is the next step?

We are now working on publishing the scenarios on an online smart city evaluation tool website. There it will be possible for everyone to evaluate the scenarios – citizens, city stakeholders and people with a professional interest. In this way we will get more engagement in the ranking process. It will be available at <http://ict-citypulse.eu/scenarios/>, and you are welcome to try the evaluation selection.

Figure 2: Evaluation metric:

User diff. (1)	City relevance (1)	Data streaming (2)	Decision support (2)	Big data (2)
How strong is the expected impact on providing value (e.g. economical, societal, etc.)?	Is the scenario culturally relevant?	Is the data accessible (pull/push/subscribe/broadcast)?	How complex is the scenario?	Is the data available?
What is the expected uptake?	Is the scenario relevant for citizens?	Does this scenario use live stream?	How many data modalities are used?	Is the scenario scalable?
What is the expected attractiveness and usability?	Is the scenario generally applicable in other cities?	Is there capability in the network to deliver this data stream?	Are there control loops in the scenario? (Yes/No)	What level of privacy consideration does the scenario require?
Is the required data ready and available with the necessary quality and granularity?	Is the scenario relevant for municipalities?	Does the scenario require security (e.g. encryption)?	Is automation included in the scenario?	
	Does the scenario increase public safety?	Does the scenario require reliability (e.g. data loss)?	Is actuation included in the scenario?	



By participating in the evaluation, you can have an influence on what scenarios the CityPulse project is to work on in the near future. After some time, we will have enough evaluations to rank the scenarios with the highest score from the evaluators. Here we will end up with 11 scenarios ranked according to what external stakeholders find relevant.

Ultimately, we will end up with 21 scenarios based on both an internal and an external ranking system. Afterwards, the process in year two will be to implement the concrete scenarios. In the CityPulse consortium we will choose 11 scenarios for actual prototyping, development and implementation in the cities. The final choice will depend on what is possible in terms of e.g. technology or data being available.

So this is how we will go from 101 scenarios to 21 scenarios to 11 scenarios that are to be implemented in the cities.

#### **What are the benefits and challenges of your approach?**

To work with scenarios is a very good way to visualise a project – first via an open approach where everything is possible, and then we narrow it down to a selection of more specific and realisable scenarios. For some, the term smart city can be a bit vague. By having these scenarios you have a tool to explain what it means when IoT and data streams are embedded and used in a smart city.

The benefits of this approach are that we have been able to gather scenarios from various sources and that we have involved both internal and external stakeholders to a very great extent to create relevant use cases for the future end users. It can be hard to

crowdsource – you never know what you get, or if you get any contributions at all. We experienced that with the competition, but on the other hand we expect to get a lot of feedback from the evaluation tool. By presenting the scenarios online where everyone can participate, you really engage with your stakeholders.

#### **What can other smart city projects and stakeholders learn from your method?**

Other projects and organisations working in the smart city field can learn how to actively use their city stakeholders and external stakeholders. They can also learn that it can be hard to crowdsource, and that it takes time and needs prioritisation.

By visiting the online scenario tool, they can obtain inspiration from different smart city scenarios. The evaluation of the scenarios will be public, so if you are interested in developing and implementing IoT in the city, you get a free, online ranking of what citizens, city stakeholders and IT professionals regard as important to them and what they find relevant in a smart city.

Go to the IoT comic book here:



Visit the smart city evaluation tool here:



# A SMART CITY APPLICATION IS A MASH UP OF TECHNOLOGY SERVICES AND IOT SOLUTIONS

Interview with Dr. Šefki Kolozali, Research Fellow, Centre for Communication Systems Research and WP3 leader on the importance of large scale data analysis and importance of seamless integration of data sources.



## **What is a 'smart city'? And what is a smart city application?**

Smart cities refer to cities that aim to improve its citizens' living standards – not only by developing a new infrastructure but also by utilising information technology and available IoT solutions. These solutions will bring services closer to the community and favourably play a role in environmental surroundings, which will help to build a sustainable city.

A smart city application is a mash-up of technology services and IoT solutions that address a wide range of issues relating to traffic, energy and water management, urban mobility, street lighting and public safety.

## **What is your work package about? And how does it relate to the project and the other work packages?**

Our work package is about enabling seamless discovery and integration of heterogeneous sensory resources in a smart city environment. It focuses on providing solutions to aggregate, summarise and create abstractions that can lead to machine-interpretable and human-understandable observations from raw streaming data. The data aggregation and abstractions should be expressive enough to enable the development of effective search, discovery and integration of data.

Advancement of this kind of techniques will allow other work packages and similar projects to manage

large volumes of multi-modal streaming data and to provide knowledge extraction and event detection techniques through open and common frameworks. This will also ease the publication and description of IoT streaming resources and their data in a smart city environment.

## **What have you developed and experienced so far – and what will be the next step(s)?**

Although the project still is in its initial stage, we have developed and integrated a set of key components in the system. Some of these components are already available online. During the past few months, most of our work has been focused on developing integrated and flexible metadata, and semantic annotation frameworks for IoT streams. We noticed that although there are several existing models in the IoT domain, metadata extraction as well as having flexible and optimised annotation frameworks are still open issues in his field.

## **Were there any challenges? How did you overcome them?**

Of course, we encounter many challenges in the acquisition of thoroughly reliable and complete data, as it is often the case in other research fields. Considering the fact that smart city is a very broad research concept and may involve diverse data types and various providers, it is likely to be a typical problem for each and every researcher who works in this field. Some of the common challenges that must be addressed are for example: heterogeneity

(e.g. multi-modal data), inconsistency and incompleteness (e.g. uncertainty, errors, missing values and broken links), scale (e.g. volume of large and rapidly increasing data), timeliness (e.g. real-time processing to summarise what is to be stored), and privacy and data ownership (e.g. to prevent inappropriate use of personal data).

We focus on these issues by utilizing institutional datasets provided by the City of Aarhus, Denmark, and the City of Brasov, Romania. For instance, we have some datasets provided by the city of Aarhus that involve real-time traffic, waste and public library transaction information from the city. Furthermore, we have developed our system based on semantic web technologies in order to overcome heterogeneity issues. We also aim to apply data aggregation, abstraction and federation techniques in an effort to cope with the timeliness and scale of the available data. Additionally, other challenges are under investigation by our partners.

## **Can other projects or companies learn from your experience?**

Other projects or companies can certainly learn from our experience. We have provided a semantic annotation framework and a set of stream publications on energy-efficient data aggregation and abstraction techniques on sensory data that cut down the information loss: companies and organisations that want to publish and describe their data can benefit from using these technologies and solutions.

## **What do you expect will be the outcome of CityPulse? How will it affect the cities of Europe?**

In a city the essential computations in several cases ought to be done in real-time. The remedies and technologies developed in the CityPulse project will play a role in smart cities in several cases, for example:

- intelligent transportation (through analysis and visualisation of live and detailed road network data)
- environmental modelling and energy saving (by means of sensor networks and unveiling patterns of use)
- event detection/management for cities (through the IoT and social media data analysis)

Needless to say that the outcome of these studies will be of benefit to citizens and city.

# WE ARE OPTIMISING CITY INFRASTRUCTURES BASED ON KNOWLEDGE COLLECTION

Interview with Daniel Kuemper, M.Sc. from Lab for Mobile Communications, University of Applied Sciences Osnabrueck on how information validation is a critical task in IoT and smart city environments.

## **What is a 'smart city'? And what is a smart city application?**

A smart city uses the knowledge that can be collected by various information sources to simplify the everyday lives of citizens. This can be achieved by presenting complex information in an easy-to-understand way and by optimising city infrastructures based on the knowledge collected.

Smart city applications use the collected information to improve life in a smart city and help to make the city become more sustainable. There are two sorts of smart city applications:

The first enables citizens and visitors to make everyday decisions based on processed information that couldn't be used manually. They combine and process various data sources to present a high-level view of current events and offer decision guidance to the user.

The second is used by city employees or businesses involved in city infrastructures like a bus company. They use smart city applications for planning, optimisation and organisation of transport, civil services, waste disposal and other challenges related to infrastructure.

## **What is your work package about? And how does it relate to the project and the other work packages?**

The main objective of WP4 is reliable, consistent and fault-tolerant processing of information. The processing techniques facilitate smart city applications to access

and apply information that is continuously verified for plausibility, correctness and trustworthiness. This type of information validation is a critical task in IoT and smart city environments due to the various sources that provide information, such as city infrastructure sensors (e.g. parking), worldwide information brokers (e.g. weather forecast) or citizens that use their smartphone to report data or inject information into social media.

Information reliability will be ensured through:

- continuous monitoring of correlating city data virtualised by WP3
- validation of the provenance and reputation of information issuers
- enabling conflict resolution and fault recovery strategies for failing information sources to enable optimised stream selection in WP3 and WP5
- testing smart city applications of WP6 based on reference datasets collected in WP2

The assessment of data reliability requires an analysis of real-time sensor data obtained in WP3 in terms of Quality of Information (QoI). The QoI describes various attributes of a data source including the precision of information, the plausibility that the information in its precision range is valid and the trustworthiness of the delivering data sources that are under the control of diverse stakeholders. WP4 develops algorithms and homogeneous metrics for in-depth analysis of heterogeneous data sources.

Applications have different reliability demands to data sources. The 'Reliable Information Processing' work package develops techniques for real-time monitoring

of heterogeneous data streams to detect reliability violations and adapt data acquisition accordingly. WP4 develops solutions for autonomous fault recovery based on the combination of soft constraints, hard constraints, preferences and multi-criteria ranking of conflicting information. For this purpose, the inconsistent or contradictory data and multi-criteria conflict resolution algorithms are used.

WP4 is also implementing a set of testing functions to evaluate data availability, consistency and correctness as well as the functionality and feasibility of applications. While monitoring addresses runtime issues, the testing of smart city applications is applied at design-time to verify feasibility and performance.

## **What have you learned and experienced so far – and what will be the next step(s)?**

We have learned that there has not been any sophisticated approach to annotate information quality of smart city data streams in the past. Therefore we have developed an ontology to annotate the information quality of various data streams. Currently, we are evolving information processing models to gain an optimal assessment and selection of information sources. These models are evaluated by correlating data sources that we are monitoring to find contradictory information (e.g. Aarhus traffic data compared to global traffic information sources such as those provided by Microsoft Bing).



## **Were there any challenges? How did you overcome them?**

Finding correlating information sources that use a comparable level of detail is a huge challenge. Organisationally we see CityPulse as a big opportunity to find comparable/correlating data sources by technically overcoming their heterogeneity and collecting them in a joined infrastructure.

## **Can other projects or companies learn from your experience?**

Having common models and processing components to describe quality of data streams and the reputation of their issuers can lead to an increase in the reuse of external data streams. This will simplify the creation of smart city applications at both technical and organisational level.

## **What do you expect will be the outcome of CityPulse? How will it affect the cities of Europe?**

CityPulse will advance the usage of smart city knowledge and enable easier access to validated data sources that can be reused by private individuals, companies and municipalities. It will also enable automatic concepts for conflict resolution and fault recovery so that application developers do not have to individually implement these strategies in their applications. The framework will provide application access to information without the user having to handle the administration and maintenance of myriads of data sources.

# PEOPLE WANT ANSWERS, NOT NUMBERS

**Interview with Dr. Alessandra Mileo, Research Fellow and Project Leader at INSIGHT Research Center at NUIG and WP5 leader about contextually relevant smart city services.**

## **What is a 'smart city'? And what is a smart city application?**

A smart city is a city that can identify, understand and react to changes. A fast growing torrent of data created in modern cities by:

- service providers (energy consumption, telecommunications networks, transport infrastructure, etc.)
- city administrators (urban planning, traffic management, etc.) and
- private users (social networks, mobile phones, smart homes, healthcare devices, etc.).

This unprecedented shift in the available quantity and quality of data is opening new challenges but also tremendous new opportunities and will be a smart-city driver of change. Smart city applications that can properly exploit this data deluge represent a tool for stakeholders to leverage such opportunities.

## **What is your work package about? And how does it relate to the project and the other work packages?**

What it means is to exploit the data is what is hidden in the 'smart' concept. People want answers, not numbers. More precisely, people want timely answers. Providing those timely answers requires that we go from data to actionable knowledge, identifying what is relevant and when. Technically speaking, the digital infrastructures of smart cities must move from batch-like to near real-time approaches to data processing at all levels from data sources to the answers stakeholders need.

The materialisation of this vision in modern cities would determine their success in addressing sustainability and improving quality of life, as well as balancing social, economic, environmental and technological growth.

The 'Real-time IoT Intelligence' Work Package (WP5) aims at enabling such a processing shift and enables the development of user-centric, dynamicity-aware and adaptive smart-city applications. The outcome of other work packages is crucial in that the WP5 outcome depends on the ability to discover, abstract and integrate available data stream sources (from WP3) and on continuous assessment of the reliability of available data (from WP4).

## **What have you experienced so far – and what will be the next step(s)?**

There are two main aspects included in WP5 that make the large-scale real-time infrastructure for city applications 'smart', namely:

- taking into account the context, and
- dynamically adapting to it

Users of smart city applications should be provided with answers that take into account their (changing) individual needs and usage patterns to provide better decision support, and this has to be our goal. We will thus focus on the concept of 'unexpected events', which is everything that might change the context of a user or her needs and requires some sort of adaptation to this change.

We currently cater for one type of adaptation that is tailored to continuously find the streaming sources of best available quality. Future development of WP5 will cater for events that might change the output of a smart-city application from the user perspective, and we will provide mechanisms to adapt solutions provided to the user accordingly. There is another very important aspect we will consider in the deployment of applications with decision support capabilities: users have profiles and patterns of behaviour that can be processed and used to answer their questions in a personalised and more effective manner. User-centricity, therefore, is not only relevant for adaptation but also for decision support itself.

## **Were there any challenges? How did you overcome them?**

Scalability is a very important technical challenge in processing real-time information continuously. One of the main focus areas of CityPulse is to address this issue at the technical level. WP5 strongly relies upon the ability to deal with this challenge at a lower level in other work packages and builds upon the outcomes to provide scalable stream reasoning mechanisms. User feedback is a precious input to reduce the complexity (and the scalability) of certain complex tasks that require heavy reasoning to provide smarter answers. Also the ability to design proper visualisation and interaction modules that can showcase the value of the underlying technology is key.

Including these aspects into WP5 requires a complete understanding of users and the integration of different scientific expertise. We will address these issues by continuously involving our stakeholder in the development process and by promoting periodic 'integration days' where the technical team gather to complete the whole processing cycle around specific target scenarios. This has been proven successful at the lower level for WP3, and we plan to do the same in WP5.

## **Can other projects or companies learn from your experience?**

This open communication both at the technical level and with stakeholder is key for continuously checking that we are going in the right direction. The process of defining requirements, constructing use-cases and implementing proof-of-concept applications is not a pipeline but rather a cycle that needs to be continuously reiterated. We don't have to create a problem for which we have a solution ready, but rather find a better solution to existing concrete and measurable problems.



## **What do you expect will be the outcome of CityPulse? How will it affect the cities of Europe?**

Processing data streams and extracting knowledge from the data will have an impact on citizen's day-to-day lives: the answers they will be able to get will be generating awareness on how they can make a difference for a sustainable smart city development. Active engagement of businesses, city administrators and citizens is crucial to achieve these results. Potential impact for stakeholders includes:

- better quality of life for citizens through smart applications for increasing the effectiveness of public services (e.g., transport)
- timely decision support based on real-time data, for example to help city administrators in solving major national and global sustainability challenges such as climate change, energy management, security, well-being, smart transport, thus enhancing quality of life and health.
- reduced interoperability costs for software vendors in making new solutions available on-the-fly for knowledge-driven applications.

# A DYNAMIC URBAN LIFE REQUIRES SMART CITY SOLUTIONS



# THE ARCHITECTURE OF CITYPULSE

Vlasios Tsiatsis, Senior Researcher at Ericsson Research, Internet of Things Architect, on the creation of a general framework for the smart city infrastructure.

A smart city is a city that utilizes ICT in order to:

- a) efficiently manage existing infrastructure and assist in development of new infrastructure,
  - b) provide efficient services to citizens,
  - c) enable efficient organization of city authorities in order to deliver these efficient services to citizens in a fashion that complies to the environmental mandates and
  - d) enable the private and public sector to develop new and innovative businesses that serve the citizens.
- Humans through social interactions also generate city related information that is typically disseminated through social media or the Internet of People (IoP) as opposed to Internet of Things (IoT). Novel services offered to citizens need to combine all the IoT and IoP sources in order to construct a complete view of the current city situation or the “pulse” of the city.

In order for a smart city to become a reality and address the above challenges the general structure of an ICT system supporting a smart city as well as a number of general guidelines about the smart city ICT infrastructure should be provided. This structure and guidelines is what a framework encompasses in the context of the CityPulse project. The main reason for providing a framework as opposed to specific architecture and technology recommendations is basically two fold:

- a) the diversity of the cities in terms of their hard infrastructure and human capital
- b) the ever changing nature and capabilities of tech-

nology. A framework can be adjusted to a small or a big city as well as to the technologies of today and tomorrow to realise the concrete ICT support platform for a smart city. Figure a shows a high-level architecture of the CityPulse framework.

In addition to information coming from sensors or the city information sources, information about the situation in a city can originate from the citizens themselves through the use of social media (e.g. twitter feeds). Therefore these sources are also included as relevant inputs sources for the framework. The difference between these sources and the IoT or City Information Sources is that the former are potentially sources of unstructured information expressed in natural language (e.g. a tweet is a short text written by a human with potentially a link to a website potentially written by a human) while the IoT or City Information Sources produce structured data although not standardized. The Social information Sinks represent social media channels through which cities could potentially push information to their citizens, e.g. a channel for citizens to receive updates on the traffic situation in certain parts of the city.

The CityPulse framework is organised in three consecutive iteratively applied processing layers (shown in Figure b), covering federation of heterogeneous data streams, large-scale IoT stream processing, and real-time information processing and knowledge extraction. To achieve reliability, CityPulse integrates knowledge-based methods with reliability monitoring and testing at all stages of the data stream processing and interpretation. CityPulse will provide solutions for

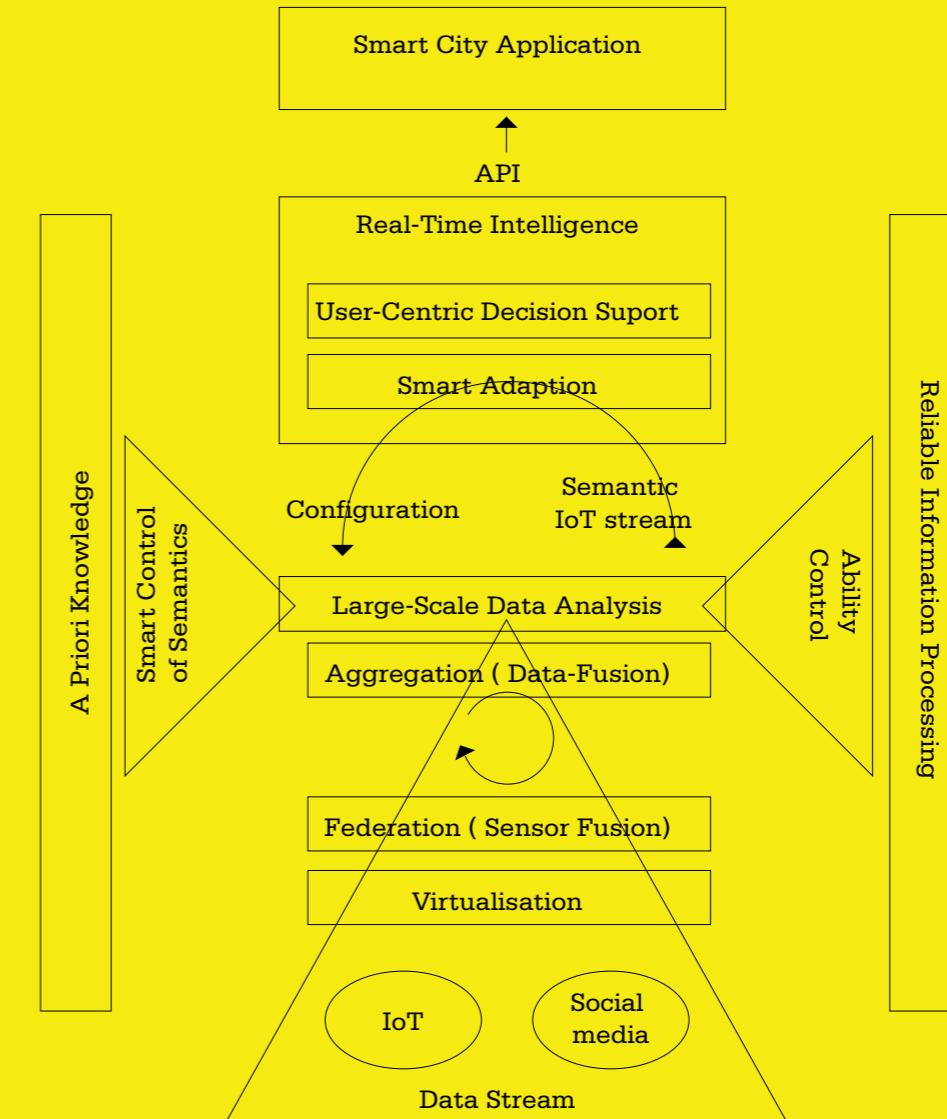


Figure a - smart city framework high level architecture



the different life-cycle stages of data processing and utilisation, supporting application development, i.e. design-time, and application provision, i.e. run-time.

The framework enables:

- Virtualisation: Semantic annotation of heterogeneous data for automated discovery and knowledge-based processing
- Federation: On demand integration of heterogeneous Cyber-Physical-Social sources
- Aggregation: Large-scale data analytics
- Smart Adaptation: Real-Time interpretation and data analytics control
- User centric decision support: Context aware customized IoT information extraction
- Reliable Information Processing: Testing and monitoring accuracy and trust
- Smart City Applications: Application programming interface for rapid prototyping

Figure c shows a functional view of the framework. The outlined boxes represent functional groups (FG) and black boxes showing functional components (FC) that comprise the functional groups. The dotted lines represent the interface between the framework and external systems (Sources, Sinks, Applications). The functional view elaborates on the functional groups and components. The functional view of the framework is an elaboration of the high level architecture that includes more functionality than the high level architecture in Figure a. The main addition (among others) is the introduction of an Actuation Functional group, which covers the functionality of providing actuation services to Smart City Applications.

Actuation services may include public messages to city managed twitter accounts, updating of city information storage media (e.g. updating a road traffic database with the latest statistics from the city road infrastructure) etc.

For the interested readers, the framework is described in more detail here:



Figure b: Main layers in the CityPulse framework

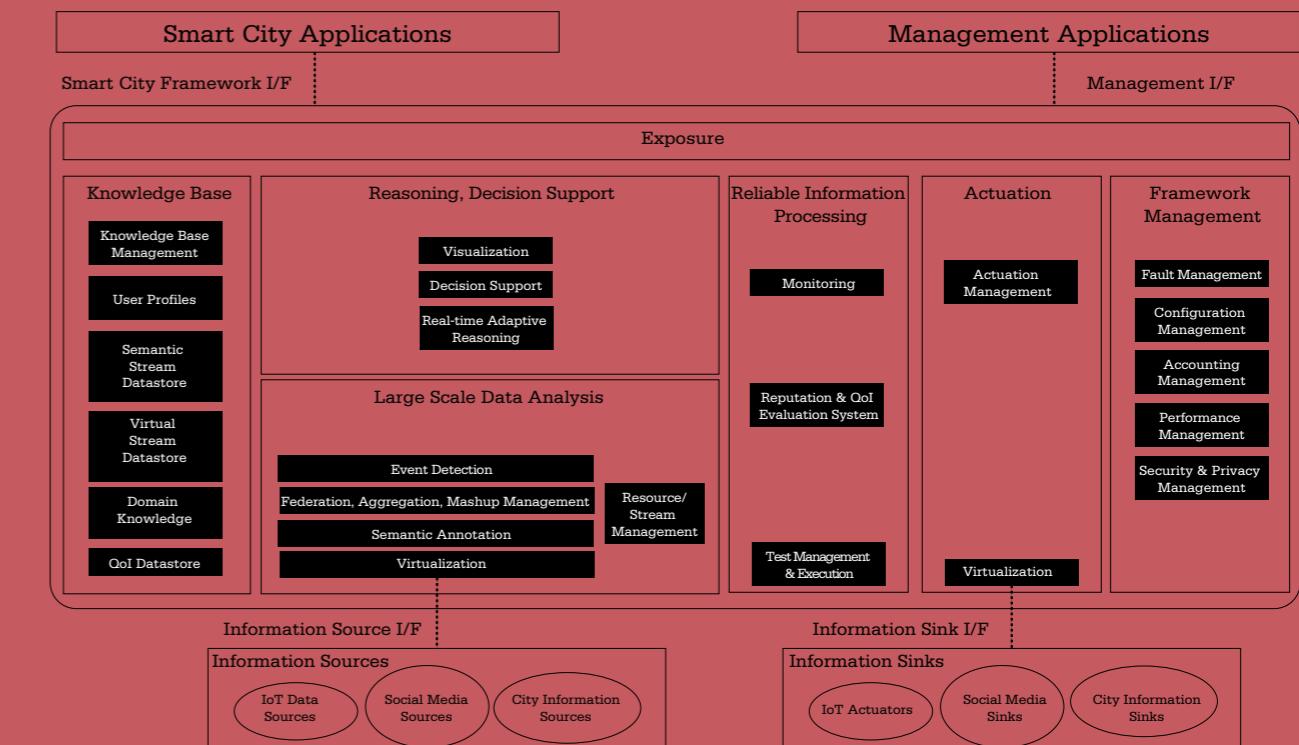
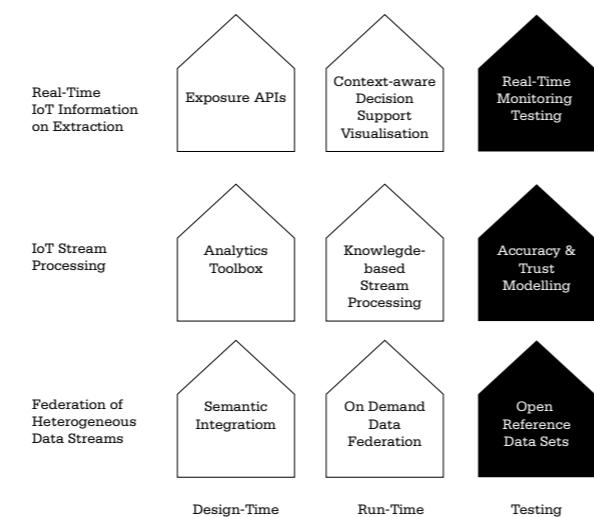


Figure c – Smart City Framework functional view



# OPEN SOURCE + OPEN DATA + OPEN INNOVATION = SMART CITY

**Interview with Bo Fristed, Chairman of Open Data Aarhus, CIO of IT in Aarhus Municipality, Denmark.**

## **What does it mean to be living in a digital age?**

To live in a digital age is the possibility to take a step further into completion than we were able to before. The amount of information we receive today corresponds to what a person in the 15th century received during his or her entire lifetime. With digitisation we have the possibility to reach further, be smarter and do more – better and more efficiently.

To me, there are, however, two sides to the digital age: a positive light side and a darker more negative side. The bright side is of course that technology enables more communication, more and better services, to create devices that can help for example the elderly or sick people. Companies, industries and citizens can now be supported faster, easier and more sufficiently.

On the other hand, technology makes us all more transparent in terms of privacy – now all our routines and habits on the Internet are exposed and used in different contexts. It is very important that we do not give up the right to privacy and that we address these issues. We need to be aware how we behave on the Internet and how the transparency will affect us. We need to be prepared for taking action in the age of transparency towards companies. As a public authority, we have a responsibility in relation to these privacy issues.

Open data is open and freely accessible data cleared of personal information, and especially public data has to be open. It is important to bring the data into play and make it available to start-ups, entrepreneurs, major industries, as well as to research institutes for gen-

erating new knowledge. Last but not least, we must support the idea of democracy by exhibiting openness in public administration and tell the citizens what we do in the public administration.

## **What are your visions for the city?**

I would like Aarhus to become a smart city that supports the needs of the citizens and meets the obligations we have as a municipality and a region in a broader societal perspective. I hope that we can organise our municipality in such a way that we can generate as much synergy as possible. This will only happen if we decide that we want data convergence, open interfaces and that we abstain from using proprietary software. This is the reason why open source and open data are very closely connected. You could add the term open innovation, and then I would say that open source + open data + open innovation = smart city. We have to be open and work across sectors and organisations so that both we and the citizens can benefit from it.

In the City of Aarhus we must learn how to collaborate across departments. In 2015, when we phase out incandescent light bulbs, our department in charge of street lighting might also install wifi and sensors even though their main responsibility is street lighting, because other departments in the City of Aarhus will benefit from it. This will be much more beneficial for all: the city administration as well as the citizens. And this way of thinking can be adapted to different sectors in general.

Aarhus has already started this work through our

Smart Aarhus partnership, which is based on the ideas of partnerships bridging the gap between different sectors and organisations.

## **What will the citizens experience?**

The citizens will experience a city that is ready to meet their needs, and a city that will be able to easily adapt and evolve digitally. We will have the possibility to obtain a lot of detailed information, for example collected via wifi and sensors fitted in the lighting posts in Aarhus. In this way, the citizens will experience holistic services that are better aligned with their needs and demands.

The technology and data will help us to inform the citizens and enable them to make informed decisions when it comes to the environment, culture, healthcare etc.

Opening up data is still a pioneer work, and we have not addressed the whole value chain yet. We still need the perfect business case or the well-used use case. At the moment, the most positive responses come from small start-ups and private developers rather than from the average citizen. We should be better at communicating about open data in general and tell citizens where they meet data in their everyday lives. So actually the citizens experience data and smart city technologies already, but we should be better at telling this story.

## **What is your experience so far?**

As open data is pioneer work, we have experienced that there are many obstacles to overcome before it evolves.

Data owners are very protectionist about data; we are talking about an age-long tradition of saving data for legal and historical reasons – often as a by-product of other processes. We also deal with the fact that some data owners have sold their data for money to hire staff. So our practical experience is that it is as much a cultural change project as it is a technological project.

However, I have also experienced that it is easier to talk about open data on a strategic level than on the practical level, so we need to inform IT personnel about the benefits of open data to make them less hesitant towards open data.

Of course, we also have to address issues regarding how can we make sure that data does not contain personal information, and how do we react if in worst case personal information is leaked or if the press were to publish bad news based on some of the data. But all in all people are positive towards open data.

## **Do you have some good advice if a city or other projects would like to work with open data?**

My advice to other cities who want to become a smart city and work with open data is to first of all ensure broad commitment across different sectors and departments. They will then need to organise the work on open data, after which they can launch a platform. And then they just need to get started. Just do it!

Communication should take place as the project progresses and you have something concrete to show. Do not reinvent the wheel from the beginning each time; use all the great experience that already exists – for example use the free open source-based platforms that are already out there, such as the CKAN platform, on which www.oda.dk is based.

It has proven to be very valuable for the City of Aarhus to be a part of a project like CityPulse. By being involved in the project, we have contributed to an important part of the value chain where data is being put into use in a number of concrete use cases. This may create a positive atmosphere around the project – for example when we talk to data owners. Participation in different local and international events helps to boost the cultural change process. Last but not least, the project facilitates knowledge exchange.

Visit the website of Smart Aarhus here:





# A CITY NEVER SLEEPS

Interview with Mr. George Scripcaru Mayor of Brasov.

**What does it mean to be living in a digital age? How does it feel and how is it expressed to be living in a city in the information/digital age?**

I feel that we are lucky enough to live in such interesting and dynamic times. The characteristics of everyday life change constantly and we can see big differences if we compare today to five years ago or even ten years ago. Cities have evolved tremendously in Romania during the past 20 years. The competitiveness between urban communities has increased, and it is now more than ever important to provide a high quality urban fabric that will bring together people, ideas and businesses. The digital age has generated this process as information technology is one of the competitiveness factors in urban environments.

**What are your visions for the city? What challenges have you seen in the city, and how will you solve them?**

As Brasov strives to become one of the most desirable cities to live in in Romania, we believe that it is crucial to include steps like "sensing" and "actuating" into our everyday lives to give inhabitants and tourists the possibility of connecting, or rather interacting, with the city itself. This interaction enables people to contribute directly to their city's development and to enjoy this development to its full potential.

To paraphrase a famous saying: "A city never sleeps." There are permanent issues that need to be solved in order for a city to function well. The city's functionality is not perceived by the citizens but is a prerequisite for

everyone to achieve his or her personal goals. But if the city does not function right, it will affect the lives of its inhabitants. And that is a loose-loose situation.

Society is ready for more IT, and on our end we try to respond to this situation by bringing as much of the smart city concept into our public services, our road network, public transport, public safety, etc. Through this paradigm shift, we manage to provide everybody with the possibility of "sensing" the city and "actuating" accordingly.

**What will the citizens experience?**

I would ask a different question: "What will the citizens NOT experience?" And the answer is that they will not experience problems in their daily interaction with the city. We strive to provide a user-friendly city environment that increases the quality of life of the citizens. In fact, the citizens will be able to communicate more easily with the smart city if they are provided with real-time information about possible problems in the urban environment. Also, the city will be able to 'peak' to its citizens, allowing them to plan their activities more efficiently. As a result, we hope to be able to attract people and ideas to Brasov, which will ultimately lead to a higher quality of life and further development of the city.

**What have you experienced when data is released and made public? (Or what do you expect to happen)?**

We do not expect resistance to change. In fact, the use



of smart city ideas in the urban fabric seems to be a constant request, especially from young generations. So we expect positive feedback from our citizens and that the city itself becomes more attractive. On the long run, we hope to become one of the centres for innovation and new ideas, as a smart city should be. We are aware that other cities in Europe and around the world are more advanced than we are at this point but based on their experience and lessons learned, we hope to provide all the people in the Brasov City region with a high level of quality of life and to develop a smart city to be proud of.

**What have you learned and experienced so far when striving to become a smart city? And how do you solve your challenges?**

I would say that change is a process. It is not only important to develop the IT infrastructure and embed it in various aspects of the urban environment. It is also necessary to allow time for people to embrace the change. Fortunately, as I mentioned before, the dynamics of urban life are very high so people are rapidly responding to any improvement based on the use of IT. Furthermore, younger generations tend to be first-movers when it comes to asking for and making use of any IT presence in everyday life.

**Do you have any good examples and/or use-cases to explicit anything of the above?**

Our participation in the CityPulse project is one of most obvious examples of our commitment to transforming

Brasov into a smart city. The ideas developed in the project have allowed us not only to explore an untapped potential of existing data but have also provided us with specific steps that we need to take based on best practice presented by other cities in the project.

Visit the city of  
Brasov online here:





# A HIGH QUALITY OF LIFE CAN ONLY BE ACHIEVED WITH INNOVATIVE INFRASTRUCTURE

**Interview with Mr. Reinhard Brehmer** Managing Director of Wiener Netze and Aspern Smart City Research.

**What are the visions for the city of Vienna in relation to smart city and open data? What challenges can you see in the city, and how can they be met?**

Vienna is already Number 1 on UN's "Livable Cities Index" and heading the list of "The Top 10 Smart Cities on the Planet". However, the city still wants to learn how to further reduce its environmental footprint while at the same time enhancing quality of life of its citizens.

An important aspect is to get a handle on what our future energy needs will be. Meeting that goal in a meaningful way calls for an objective determination of its current level of energy efficiency, which is the first step on the road towards measuring improvements over time. It also includes intelligent energy management and smart home solutions, and investigating how conventional solutions such as district heating can be combined with new, decentralised solutions. One challenge is to overcome the problem of big amounts of data being distributed among silos. Information and communication technologies will play an important role in this process, as will data evaluation and analytics. Intelligent IT and networks provide answers to those complex requirements. They are the key factor for the successful management of cities.

**Do you have any good examples and/or use cases showing how Vienna is addressing these topics?**

Vienna is launching a large smart city project at the

lakeside district of Aspern, one of the largest urban development projects in Europe. The vision is to create a world-class research project in a real environment (a "living lab"), where the energy-saving technologies needed for the city of tomorrow can be analysed and optimised.

This district will accommodate around 8,500 flats, 20,000 workplaces, school campuses, an industrial estate and a research centre. In Aspern we have a unique opportunity to carry out research with real data from individual users and entire buildings as well as data from the low voltage network. The goal is to make the whole system "smarter." The power supply, building systems, intelligent power grids, and information and communication technologies will interact optimally. The result will be the most efficient resource management possible, with maximum comfort for residents and users, our future "smart citizens".

In order to reach these ambitious research goals, the research company Aspern Smart City Research GmbH & Co KG (ASCR), a joint venture of Siemens, Wien Energie, Wiener Netze and Stadt Wien, has been launched. Up to 40 million Euros will be invested until 2018.

**What role does data play in the project?**

The goal is to bring more intelligence to the entire system, while taking care of all security and privacy issues. The deciding question is: How can we interpret data from various data sources, e.g. from

buildings, the network or external data, and automatically and wisely connect it? Sensors, for example, can recognise the temperature of a building and know when the building actually has to be cooled down or warmed up again. In this way it is possible to meet the individual heating needs of the building with data and weather reports a few days in advance, thereby operating the building in an energy-efficient way. In Aspern we are treading new paths. We want to contribute to more energy efficiency and higher supply security. For example, an intelligent IT infrastructure that avoids peaks in the electricity network can reduce costs of network construction. In the future, the distribution network for electricity and data hubs will be shared among various players: buildings, power generation, storage, e-mobility as well as citizens and customers.

**How will cities and the lives of their inhabitants change as data from previously separate services is integrated?**

Intelligent cities distinguish themselves through efficient power generation and usage, which is something we want to achieve with the people who live here. "Smart City Vienna" is not a purpose in itself. The central question is whether or not people will see the usefulness in the technology and services we offer and adopt these as something that adds value and comfort to their lives.

Our focus is clearly on the citizens. We want to explore and develop innovative services and customer-friendly applications. At the moment, for example, energy customers are unaware of their actual energy consumption until they receive their annual statements. In the future, users will be offered accurate and dynamic tariff models. If electricity tariffs are cheaper at a given time, users will be able to automatically charge their devices (smartphones, tablets, e-bikes, etc.) at a cheaper rate. The integration of data and real-time information will lead to more user comfort and quality of life.

**What have you learned and experienced so far when striving to become a smart city?**

Cities will have a difficult time asserting themselves in international competition in the future if they do not meet the criteria of a smart city. Efficiency, security, citizen participation and use of modern IT infrastructure are the magic words when you are trying to achieve the vision of a sustainable city. You need technology that is acceptable to customers. You need innovation from which we can generate added value for the location and the customers. Vienna is

a megacity in which many things are already highly developed: the overall understanding of a smart city, renewable energy and energy efficiency, the large amount of combined heat and power generation and public transport. We are going the right way in this respect, and we want to continue.

**Do you personally see a positive future for the cities?**

Sustainable city development and a high quality of life can only be achieved with innovative infrastructure. I believe that our research in Aspern will show how a smart city can really work. The results of our research will bring important findings for the whole world. I am convinced that when modern technology and intelligent IT are used, cities very soon will be able to offer exactly what people expect of them: work, an intact environment, education and culture as well as health-care and retirement benefits.

(Left to right) Gerald Murauer, Head of Siemens Corporate Technology CEE and CEO Aspern Smart City Research, and Reinhard Brehmer, CEO of Wiener Netze and Aspern Smart City Research





# THE CITY HAS BECOME ONE BIG SOCIAL NETWORK

**Interview with Michael Erman, Strategic Planner in the Planning Department of the City of Stockholm, Sweden.**

**What does it mean to be living in a digital age? And how does it feel and how is it expressed to be living in a city in the information/digital age?**

Stockholm is becoming a smart city. Or maybe it already is? This means that it is a connected city where flows are measured and feedback is gathered from devices and the people in the city via ICT and IoT. This is making the city more efficient and hopefully more sustainable.

Personally, I see the development as an evolution. The introduction of the Internet and many sophisticated ICT-devices has changed our lives completely. Not only in terms of technology development but also on a societal level. This means that new possibilities have opened up; the flow of information offers new ways of learning and new ways of interacting.

It has changed the entire way of living. Our lives have become more transparent and connected. You could say that the city has become one big social network. It has given us the possibility to keep in touch with much more people. I believe that the digital age strongly affects us all as human beings, changed our lifestyles and feelings for other people and all of our connections. Now it is easier to be part of other people's lives and share our thoughts and things.

But there is also a flip side to this coin. There is a risk of creating a digital divide as not everyone has access to the digital world – for example because of their age. In 10 years time we might have a group of outsiders who are not connected to other people and the city. There

is also a risk that our personal information and data are abused so we need to address how we can protect ourselves. Finally, some might feel more stressed because of all the obligations and opportunities made possible by the Internet.

**How is Stockholm a smart city? How have you addressed and used new technologies such as IoT and open data?**

Since the beginning of the Internet, there has been a focus on open data and different e-services to our citizens and on the establishment of a powerful and fast digital infrastructure.

We have been one of the leading players in opening our databases, and we have opened up many services and data. One third of Sweden's open municipal data is available in Stockholm. We have looked into what data might be usable for citizens and companies. We have made research in the city, looked into what can be opened and made sure that we have some standards. We have both static data and real-time data as the city of Stockholm is equipped with measuring equipment everywhere, which is open for use. Everyone – private individuals as well as industries – can use the open data for professional and private purposes.

Since 2012 there is an Open Data Award, where everyone is invited to create new web services or applications for smartphones based on the open data of Stockholm. Here we explore what you can do with the data. In general, the ideas and things that are created for the award are very sophisticated – now 33 city apps are available.

The best applications win a prize. The winners of this year created apps about efficient logistics, to find sunny out-door cafes and how to discover nature in the city.

Secondly we now offer over 40 e-services for our citizens, where we try to reach out to as many as possible – both the digital natives but also the digital non-users. In 2013 the e-services of the city were used 1.8 million times.

Thirdly, it has been important for the City of Stockholm to ensure that the infrastructure in the city is the best possible. We have ensured that the city is connected via fibre network, so every building, house, office and home in the city is provided with a high-capacity fibre network. We have ensured that the speed of the network for enterprises is as fast as possible and also that it is rather cheap. This makes a big difference for the city. Both for private companies and their possibility of creating new services and ensure growth, but also for every citizen in the city as we make sure they have access to a fast and stable network. All of this has been made possible because of a strong political will, large investments and administrative capacity to make it happen and actually work.

**What are your visions for the future?**

Through Vision 2030, the City of Stockholm has clarified its long-term ambitions and aspirations. The vision is a world-class Stockholm: vibrant, human and creative. It has an emphasis on partnerships that will be formed to make it happen. The vision – building new housing areas, creating workplaces, constructing new public transport – will take many years to realise but will be an investment for citizens and companies. It spans over an array of sectors, not only addressing climate and environmental issues but covers a range of sectors from education to business, culture and so forth. Vision 2030 also includes important goals on ICT based innovation and growth. It looks into how Stockholm – in the best possible way – can make use of IT infrastructure, ICT and open data to make Stockholm the leading knowledge city.

**What will the citizens experience?**

Citizens experience that Stockholm is a smart city every day, especially when they interact with the city's core services such as the school system, the transport system (traffic, public transport and parking), environmental issues, elder care system and so forth. Actually, they experience the smart city quite often since they are connected to many e-services and apps in their everyday lives. So you can say that the citizens' experience of the smart city is already here.

**What have you learned and experienced so far when striving to become a smart city? And what would you recommend other cities to work with?**

One key is to provide the city with a high-capacity Infrastructure (fibre optic networks and 4 G which already is available in Stockholm), independent of changing political winds. Stockholm's fibre network is owned by a municipal company. This is normally not a core task of a city, but Stockholm did it anyhow. In this, Stockholm is unique. It has proved very rewarding for the city – both in terms of providing the citizens with high-end service solutions and enterprises with a very stable high-capacity infrastructure. The IT infrastructure is just as important as water mains. Furthermore, data should be open to everyone – make sure you have a standardisation for data and digitise it.

Open up data in order to create solutions, innovations – and host open awards. Co-generation: It's simple and delivers brilliant proposals. And in the long run, it will make life easier. For the citizens as well as for the city administration.

And finally when you create e-services for your citizens, make sure that they really address the actual needs of the citizens!

You can read more about Vision 2030 here:



For more information on the Open Data Award:





# TECHNOLOGY IS ONE THING, BUT YOU ALSO NEED TO THINK SMART

**Interview with Søren Kvist, Smart City project manager, Technical and Environmental Department, City of Copenhagen.**

## **What does it mean to be living in a digital age?**

Technology is getting cheaper and smaller. IoT enables units and devices to communicate, and when data is put into use, it turns into value. By combining all of these factors, we can create services to the citizens. This is the idea behind the smart city.

In the digital age that we live in, we have the possibility to use data. Data is interesting when used for creating smart solutions. This means that the solutions are holistic and solve more than one problem at a time. To be working within the smart city field means that we strive to solve challenges on both an organisational and a technological level

And the smart city way of thinking is about bridging gaps and breaking with the silo thinking - this is a main point in the smart city framework.

## **How is Copenhagen a smart city? How have you addressed and used new technologies such as IoT and open data?**

In the project Copenhagen Connecting we have tried to gather different partners from different sectors both from within the city and external partners. They will be an important part of the value chain and help create growth and sustainable solutions. So we are focusing on open innovation in a public-private partnership.

We focus on gathering data not only from various portals within the city, but also from the city grid - sensor

and fibre – as well as via different media layers. It's the big data city flow.

The City of Copenhagen will establish a digital infrastructure that covers the entire city in the same way as roads, heat, water and public transport and will be the main road for the city's data. The digital infrastructure is the future economically efficient and sustainable platform for innovation and growth in a broad sense and embraces several sectors. The Copenhagen City grid will consist of big data on the city flow collected via WiFi units and will create knowledge about the flow of people, cars and bikes in the urban space in real-time. Asset tracking by means of active and passive RFID tags enables tracking of equipment and supplies in the city (such as garbage bins or public bikes) with cheap, wireless and compact units with long battery life. Cheap and wireless sensor platforms (IoT) create data on the city's condition, and cost-efficient data connections enable unified communication.

All of this is Copenhagen Connecting.

Only the sky is the limit when it comes to deciding what this infrastructure can be used for: crime prevention, smarter and smoother traffic, efficient waste management, safety in large public areas and so on.

## **What are your visions for the city?**

In the 17th century, Denmark was a leader in international shipping and trade. In the 18th century, during the industrialisation, Denmark focused on the estab-

lishment of railways, roads and cycle paths. And at the beginning of the 19th century, focus was on being an industry leader through mobility of labour, goods and services. All of this has been crucial for organisations, companies and citizens to experience growth.

Today, we focus on the digital future through the establishment of a visionary digital infrastructure. And in 2020, Copenhagen will be the leader in green growth through data and innovative technology solutions. Of course in collaboration with other cities.

The vision is that Copenhagen is climate-neutral in 2025, so a lot of the activities in the city focus on the climate plan with a diversity of initiatives. Not strictly focusing on green growth but also on the citizens' wellbeing and living standard. The smart city framework enables this vision for Copenhagen.

## **What will the citizens experience?**

The citizens will experience a more transparent and open city as well as a more collaborative city that excels in working together with different partners and within different sectors. The city will have a digital data layer, and innovative clean-tech companies can get access to core services on the Copenhagen City Grid (infrastructure as a service) to build and test bleeding edge clean-tech solutions in the urban space. Copenhagen will be an attractive environment for clean-tech companies, scientists and research.

In the long run, citizens will experience a more climate-friendly city that offers them smart solutions and services.

## **What challenges have you experienced, and how have you solved them?**

The challenge is to inform politicians and other decision-makers about the value of the work with IoT and data streams. The smart city term can be a bit vague to describe for people who are not working with it directly. Furthermore, it is a very long-term project. This means that we have spent the past year on communicating the story and the visions - some of them based on other people's experience and concrete use cases - qualified our solution and raised funding. It is not until now that we can focus on building something concrete.

We also face some challenges when we try to bridge the gap between different sectors. For different historical reasons, people are used to think in "silos". Each sector, administration and industry knows too little about what the others are doing, making it difficult

to realise the necessary cross-sectoral cooperation. The challenge here is that this way of thinking does not necessarily create the best and most sustainable solutions.

It's important to break with the silo thinking that results in disparate smart city solutions, and take on a broader and more holistic approach. It is more complex, but also more beneficial to break down the silos.

Therefore we have focused on the organisational level - to mature the organisation within the smart city field. And it is not only the city – it is also about engaging external private partners. So the main communication challenge has been to communicate that we need to think broadly - that this is the smartest thing to do. We say that it is an 80% organisational and a 20% technological project to make the city smart. Technology is one thing, but you also need to think smart.

Finally, in our newly established Copenhagen solutions lab, we try to combine suppliers, developers and data around solving real city challenges, with tangible solutions, In order to become a smart city.

Visit the project site for Copenhagen Connecting here:





CityPulse has participated in several dissemination activities such as IoT Week 2014 in London and Public Internet of Things, ISSNIP Symposium 2014 in Singapore.

# STAKEHOLDER ACTIVITIES

**Interview with Septimiu Nechifor, dissemination manager in the dissemination activities in CityPulse.**

**Who are you, and what are your tasks as responsible for dissemination in the CityPulse project?**

My name is Septimiu Nechifor, and I represent Siemens Corporate Technology (Romanian branch) in the project. My mission in the project is to actively support, enable and stimulate dissemination of project results to interested smart city communities. Rather than being a 'dry' research action on the European Commission's funding agenda, we want to communicate project results from partners and consortium member cities (well aware of the internal complexity of them).

**What is CityPulse about?**

In order to understand the logic behind the CityPulse agenda, we need to look at the Internet of Things for smart cities as a whole and at the criteria that make up a smart city. We see a megatrend that transforms cities into 'living' and responsive structures, close to citizens, businesses and city management.

CityPulse is addressing this responsiveness with instruments from current data analytics science, aiming at both the deductive and the predictive side. Big data from the city is processed with modern tools to provide meaningful insights, reveal hidden dependencies and trends and actively respond to opportunities and threats in the urban space.

**How important is communication and dissemination in an EU-project like CityPulse?**

Since we are talking about a family of projects and a long-term structured work programme on the European Commission's agenda, this activity is mandatory and necessary. But more importantly, the project team has strong peer relationships with other projects and with worldwide activities, city planners and industry R&Ds in order to disseminate project outcomes to a large potential stakeholders group.

Communication and dissemination play an important role, as we are interested in receiving reality checks from city planners, businesses and academia and of course from all other communities interested in smart cities.

**How have you approached it?**

We have taken a systematic approach, which includes dedicated city stakeholder meetings and being influential at scientific conferences or workshops that address key topics. The first and most visible event was the City Stakeholder Group workshop hosted by Ericsson in October 2013. At the meeting we received valuable inputs from city project partners in Aarhus (Denmark) and Brasov (Romania), but also from interested communities in Osnabrück (Germany), Stockholm and Linköping (Sweden) and Guildford (United Kingdom).

The survey performed covered current status and vision, achievements, public acceptance, plans and pain points. The meeting proved to be very useful for converging the project research agenda with real-life needs and expected outcomes. Relevant meetings

with individual cities were held in Vienna in December 2013 (which also included interaction with the Wien Smart City Seestadt Aspern project, the largest Greenfield development in Europe today on this subject) and Aarhus in April 2014. Both meetings were facilitated by the General Assembly of the project.

**What is the status on dissemination so far?**

In addition to the above-mentioned meetings, CityPulse has been involved in R&D-specific events during the first year of the project. Of course, the project is at a stage where initial concepts reach a coherent form in terms of architecture. At this stage we can talk about dissemination as a valuable community building instrument targeting peer city partners and their agenda.

**Which dissemination activities in CityPulse would you like to highlight?**

Firstly, the Future Internet Assembly in March 2014 in Athens (Greece), where we presented the project concept and vision. Secondly, the IoT Week in June 2014 in London (United Kingdom) where project members discussed and interacted with other ongoing projects on IoT and IoT for smart cities.

Discussions at the event revolved around both specific use cases of all EU-funded smart city activities and their individual agendas.

It is also worth mentioning that project members participate in IERC activity chains.



**Would you like to reach out to other relevant smart city stakeholders?**

Of course, we are open to discuss and synchronise with any interested city. At the same time, we are realistic that we have to demonstrate strong results on a medium term, and our efforts now also need to address existing agendas and use cases of project partners.

**How can they be part of CityPulse? And learn from your experience in CityPulse?**

The project has a City Stakeholder Group as main communication point. Based on project team availability, we can support and provide answers based on experience gained in the project. In addition to information published on the project website, a considerable amount of papers have already been published by project partners, and the future looks promising!



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The CityPulse consortium ready to get their hands dirty at the construction site of DOKK1  
- the new urban media space library in Aarhus, Denmark, when visiting Aarhus in April 2014 at a General Assembly.



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