ercim-news.ercim.eu Number 121 April 2020

ERCIM NEWS

Special theme:

The Climate Action

Mathematics, Informatics and Socio-Economics Accelerating the Sustainability

Fostering Smart Cities based on an Enterprise Architecture Approach

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The concept of smart cities means using data and information communication technology (ICT) to manage a city's resources to create a sustainable environment, benefit the economy and improve quality of life. Unfortunately, the rapid population increase in urban areas has reduced the quality of life for many city-dwellers. Therefore, in the Positive Energy Exchange (+CityxChange) project [L1], we have adopted an enterprise architecture framework to support sustainable smart cities.

The +CityxChange project [L1] is designing an Enterprise Architecture Framework (EAF) to provide data-centric integrated and interconnected smart services. The goal of this collaboration between several organisations is to develop "positive energy blocks"—or areas that can collectively produce more energy than they consume.

The research aims to develop an overall ICT architecture and service-based ecosystem to ensure that service providers of the +CityxChange project can develop, deploy and test their serv-ices through integrated and intercon-nected approaches [1]. For the purpose of this research, a city can be seen as a big enterprise with different departments
[2]. With its ability to model the complexities of the real world in a practical way and to help users plan, design, document, and communicate IT and business-oriented issues, the Enterprise Architecture (EA) method has become a popular domain for business and IT system management. The decision support that it offers [3] makes EA an ideal approach for sustainable smart cities, and it is being increasingly used in smart city projects. This approach allows func-tional components to be shared and reused and infrastructure and technolo-gies to be standardised. EA can enhance the quality and performance of city processes and improve productivity across a city by integrating and unifying data linkages.

The +CityxChange EAF employs a distributed approach that uses loose coupling and stronger integration where necessary in line with EA methodolo-gies in developing an ICT ecosystem that will give partners a better overview of +CityxChange project for integration and thus allows ongoing gap analyses of the state of smart city development. We have adopted a layered EA, where the higher layers address business related concepts and the lower layers address the technical components. The heart of the EAF is centred around a data layer called the +CityxChange DataxChange, to capture the data-centric smart city scenarios. The main benefits of this EAF, compared with other developed EAs, are its capabilities of:

- Capturing the variety of data and data sources that are available for creating value-added services, by data cre-ators, owners and third parties.
- Bringing together the citizens', municipalities', and the business view in the higher layers.
- Describing the collaborative business endeavours that are relevant for creat-ing value-added services.
- Showing the data, its origin and the full context (e.g., owner, format, Application Programming Interfaces (APIs), etc.), how they may be accessed and by whom they may be used to provide value to the citizens.

This includes the overall architecture concepts and diagrams as seen in Figure 1.

Figure 1 depicts the developed EAF for the +CityxChange project. A description of the EAF as shown in Figure 1 includes the architecture layers, stakeholder perspective, and data perspective.

Architecture layers

The horizontal layers of the CityxChange EA are:

- Context layer describes the needs of the citizens and the drivers for the services, which may also be the key performance indicators (KPIs) of the +CityxChange project.
- Service layer describes the value-added services that are offered to users and customers, that bring together a number of service providers, data and applications.
- Business layer describes the different actors and processes that are involved in providing the service. Here the actors would typically be organisa-tional units that need to collaborate to provide the service, referred to as a virtual enterprise.
- Application and data processing layers describe the different applications that support smart city services.
- +CityxChange DataxChange layer describes the data that is available that could be used by various entities to provide smart city services.
- Technologies layer describes the different technologies that support the data exchange and the higher layers of the EAF.
- Physical infrastructures layer identifies the sources that provide the data,

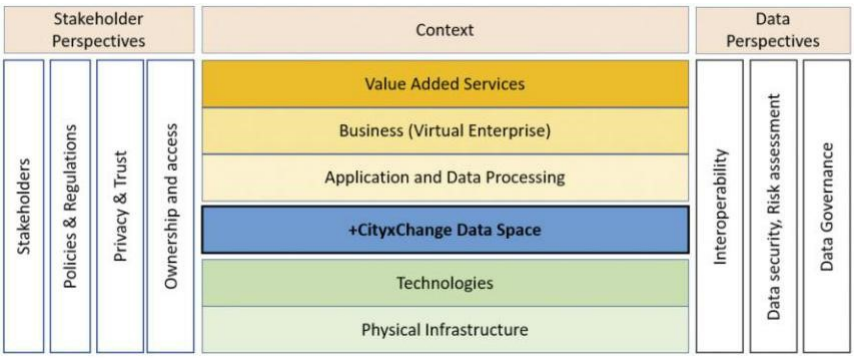

Figure 1: Proposed EAF for the +CityxChange project.

such as IoT devices, mobile phones and social media.

Stakeholder perspective

The stakeholder perspective, as seen in Figure 1, comprises stakeholders that describe the various entities (citizens, service providers, and consumers) involved in the city-wide EA space. Policies and regulations which specifies regulations that are relevant for meeting the objectives of smart city services. Privacy and trust which describe the relevant principles that need to be fol-lowed to respect and protect the privacy of individual people and organisations in supporting a network of trust among the various stakeholders, such as EU GDPR regulations. Lastly, ownership and access, which describe the relation-ships between the stakeholders and the entities that will be represented in city services.

Data perspective

The data perspectives comprise interoperability, which addresses how entities, through all the layers in the EA, could be brought together in a cohesive way to provide value-added services. Data security and risk assessment ensure that the data is handled in a secure and reliable manner. Data governance ensures proper data management processes and data quality and encompasses people, organisations and processes.

In future we plan to apply the proposed EAF to improve smart city services, such as electric mobility as a service and sustainable energy trading in the cities of Trondheim [L2] and Limerick [L3]. Other institutes involved in this project include Maynooth University, Innovation Value Institute (Ireland) and Lero, the Irish Software Research Centre, Ireland.

The project is funded by the European Union's Horizon 2020 research and innovation programme, Grant Agreement No. 824260. It comprises two follower cities Trondheim, Norway and Limerick, Ireland, and is led by Norwegian University of Science and Technology (Norway). The consortium comprises five follower cities (Sestao +Alba Iulia +Pisek +Võru +Smolyan) and a total of 32 project partners.

Links:

[L1] https://cityxchange.eu/
[L2] https://www.trondheim.kommune.no/
[L3] https://www.limerick.ie/council

References:

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[2] Petersen, et al.: "Value-added services, virtual enterprises and data spaces inspired Enterprise architecture for smart cities", PRO-VE, 2019.
[3] Anthony, et al.: "Big data-oriented energy prosumption service in smart community districts: a multi-case study perspective", Energy Inform, 2019.

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Figure1: