COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA15127
STSM title: Fog-cloud computational offloading and resource allocation
STSM start and end date: 19/08/2019 to 26/08/2019
Grantee name: Dr. Pavle Skocir

PURPOSE OF THE STSM:

The aim of this STSM at Internet technology and data science lab (IDLab) is to continue the work started during Thibault Degrande's visit to University of Zagreb Faculty of Electrical Engineering and Computing (UniZG-FER) in the topic of fog-cloud computational offloading and resource allocation. During the first phase at UniZG-FER common research interest was found in the area of smart grids and smart metering. In this STSM the focus was on analyzing communication technologies most adapt for smart metering use case, and to see how other applications in the smart grid environment can benefit from fog-cloud offloading. Additionally, the plan was to explore how can fog-cloud offloading mechanisms help in creating resilient communication network for applications in smart grid environments.

During this STSM the plan was to visit IDLab's HomeLab, a standalone house offering a unique residential test environment for IoT services. Since I have done research in the smart home area, it was planned to see their demo environment, exchange information about current projects and experiences, and analyze the possibilities for future colaborations.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

During the 5-days stay in Gent we continued the work on paper with working title *Analysis of smart metering solutions and their potential*. The analysis of communication technologies for connecting smart meters with the grid was carried out according to the following parameters: scalability, range, coverage, deployment, cost efficiency, battery life, Quality of Service (QoS), payload length, and latency performance. Requirements for communication resilience were analyzed according to specific smart grid applications, as smart grids contain more applications than just smart metering. These applications include demand response management, outage management and cyber security.
We defined the following as main contributions of the paper: it will present the fog-cloud offloading mechanism that can increase resilience of smart grid networks, and it will analyze strategies that can be applied to enable fog-cloud offloading mechanism in chosen areas (EU, Belgium, Croatia).

The main requirements for fog-cloud offloading mechanism have been defined. It will be needed to decide where to compress and decompress data (gateways or centralized servers), and to analyze the metrics for specific applications, e.g., tolerable latency and amount of data transferred. Additionally, it was agreed to analyze how the fog-cloud mechanism can upgrade network resilience in post-desaster scenarios for smart metering and demand response management applications.

Regarding already started activities on techno-economic analysis during Thibault's visit to Zagreb, related work was examined in more detail in this area. Relevant studies include models for deploying smart meters (e.g., in-house development, taking over communication technology companies, developing solutions in partnerships with other companies), costs of deploying smart meters according to their functionality and number of households in the area, etc. Additional information about current smart metering deployments in Croatia were tried to be found, as well as plans for the forthcoming years.

During a visit to Home Lab, I met Jelle Nelis, and we exchanged our research backgrounds. I was shown around UGent's standalone house equipped with the latest technology in smart home domain. We asked for additional information about the installed smart meter, showcasing the current trend in smart metering in Belgium, which will be important for the work on our research paper.

The former and current projects in which HomeLab is involved were discussed. These projects include ambient assisted living application, air quality measurements, lighting control, which are the applications with the similar focus as the ones we have developed at IoTLab at my institution. We were given the possibility to test some of the deployed service using commercially available technology (Google Home, Amazon Alexa, Philips Hue). Furthermore, common interests were identified in the area of publish-subscribe brokers. HomeLab uses Orion context broker by Fiware, while CUPUS broker was developed at UniZG-FER.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

During the visit to HomeLab we obtained information about the electricity smart meter deployed on premises. The meter is based on open standards and uses NB-IoT for communication with utility provider. It contains two local ports: first for providing basic consumption feedback, especially about energy withdrawn and injected at the connection port, while the second one provides raw data based on which advanced calculations can be made allowing for very detailed consumption feedback. Additionally, the second port can also be used for local command and control applications. The electricity smart meter at HomeLab is wirelessly connected to a gas meter. Other types of meters can also be connected. The electricity meter collects data from the other meters and sends the readings to utility providers.

A detailed analysis of communication technologies in the smart grid environment revealed NB-IoT as one of the best options. One of its most significant advantages includes the possibility to offer coverage in deep underground spaces where smart meters are often placed.

To analyze the communication resilience needs in smart grids, it was needed to take into account specific applications and their requirements. Widely mentioned applications in the smart grid environment include remote metering, demand response management, outage management and cyber security. Remote metering is defined in literature as resilient if data from some percentage of meters is always delivered to the utility within a bounded time, while percentage and time are dependent on utility-specific requirements. Demand response is resilient if required load is always curtailed within a bounded time, while load and time are dependent on utility-specific requirements. Outage management is resilient if the utility can always identify and recover from outages within a bounded time, while time is dependent on utility-specific requirements. Cyber security component protects the smart grid against attacks and failures and ensures integrity, availability and confidentiality services for the smart grid. Cyber security component is resilient if it always detects and responds to security threats before performance and security requirements of other functions are violated.

To test the resilience in smart metering, it was decided first to set up a simulation environment to check latency and throughput of NB-IoT communication link to see if it can meet the requirements of chosen applications in the smart grid area. The applications that will be analyzed are smart metering and demand response management. The setup would include 5 subnetworks with 10.000 meters and one base station in each subnetwork. Fog-cloud mechanism was agreed to be developed enabling storage, compression and decompression of data on gateways and central servers. Storage on gateways should prevent data loss when connection to central servers or connection to end devices are unavailable. The mechanism will be tested for disruptions in different parts of the network (on a group of smart meters, on base stations or on the centralized storage location) to analyze the network resilience in disaster scenarios.

Exact information about current smart metering deployment in Croatia was proved to be unreliable (multiple sources were found with contradictory information). It was decided to investigate this issue in more detail. Unofficial information was found revealing that only about 7% of all meters were upgraded to either smart meters or only meters with remote reading capability. Future plans include mainly deployment of meters with only remote reading capability by using Power Line Communication (PLC), without the possibility to receive information from the grid.

In techno-economic analysis we agreed to analyze two strategies: to deploy advanced meters with only reading capability (Advanced Meter Reading – AMI) or meters with additional capability – to receive information from the grid (Advanced Meter Infrastructure – AMI). In Croatia the model for smart meter deployment is partnership with a number of communication companies.

FUTURE COLLABORATIONS (if applicable)

We will continue to work on the paper on smart metering. The most challenging part will be the development of fog-cloud offloading mechanism, simulation of communication parameters in NB-IoT network, and testing the mechanism on different disaster scenarios.
Provisional costs to deploy the meters will be estimated in the future stages of the work on the paper. A strategy will be proposed for upgrading smart metering infrastructure in Croatia and Belgium to reach the goals defined by European commission.

Interesting possibilities arose from the visit to HomeLab. Common interests were identified in the area of smart city applications and publish-subscribe brokers. The possibility for future collaborations in the aforementioned areas will be regarded. Some of the projects developed at IoTLab@UniZG-FER could be tested in the smart home environment at HomeLab. The most suitable service for that would be *lighting control based on user preferences*. One financing possibility might be through open calls of Fed4FIRE+ project in which HomeLab takes part.