SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

Action number: **CA15127** Resilient Communication Services Protecting End-user Applications from Disaster-based Failures
STSM title: **Empowering Critical Nodes in Disaster Activated Smart Communities**
STSM start and end date: **10/12/207** to **17/12/2017**
Grantee name: **Nouman Ashraf**

PURPOSE OF THE STSM/

The main objective of this STSM is to extend our previous work on critical node detection to encompass the smart community specifics. In particular, we envision at exploring how critical node detection is affected not only by the communication network topology but also from the networking services required to sustain the energy management scheme with emphasis of the demand response (DR) methodologies. Critical node detection is vital within the smart community concept as the energy management scheme must guarantee that these critical nodes (CN) are kept alive by offering them adequate power from the scarce energy sources within the community. As the smart community architecture involves interconnected power and communication networks, the effect of critical node failure of the communication network on the smart power management scheme is also explored. In this STSM the following issues are investigated.

(a) Examine how the specifics of the smart community concept, which involves interconnection between the power management network/system with the communication network, affect the spectral partitioning problem. Specifically, the effect of the interconnection on the graph formation are explored and the possibility to use appropriate weighting functions on the Laplacian are investigated.

(b) Explore how the energy management communication mechanism, and in particular the DR mechanism, affect the graph formation and leads to appropriate choices for the weighting functions on the Laplacian matrix where Laplacian matrix is used for representing the topology and connection between different nodes in the graph.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

On the 11th of December, a presentation was given by Nouman Ashraf on the work conducted by the home institution, Frederick University (under the supervision of Dr. Marios Lestas) on Disaster Based Smart Communities. Presentation was attended by the research group, Computer Networks and Computer Communications at host university, University of Passau. In the first part, the talk covered an overview of the Smart community concept as the motivation for Demand Response and the activities to be pursued in the proposed short term scientific mission (STSM). Discussion suggested that the case of a disaster, where major failures will be reported and in such a situation, smart communities can create islands of, probably isolated, networked devices which offer smart power and communication services. Such isolated smart communities, will be characterized by scarce distributed power sources and loads, and so, an effective energy management policy is vital to offer maximal utility services to the community clients. Followed by the discussion on some recent state of the art DR approaches to tackle the problem of limited resources in case of disaster based scenario, a solution for integrating renewable energy sources based of prediction of energy

to be harvested using Markov Chain was presented. An optimization based power allocation approach using Price Based DR programme was presented. Benefits of introducing Aggregators were discussed. An optimization distributed power allocation approach was discussed followed by the power allocation by using aggregators as middle entity. It was presented that the solution of the above optimization problems leads to a distributed feedback based message exchange protocol which is implemented via the communication network. Maintaining a highly connected communication network is vital not only for offering quality communication services but also to be used as a medium with which to implement the smart energy management policies. The communication network can be used for example for negotiating prices for a price based DR scheme which incorporates power aggregators. Hence, both power and communication networks are highly interdependent and the cascading failures problem is significant. i.e. when the communication network is interrupted due to link or node failuers, in what way is power network affected. Throughout the days that followed, daily discussions were made on above mentioned issues including other aspects of Resilient Communication Services Protecting End-user Applications from Disaster-based Failure.
Issue of making a communication network resilient in the case of a disaster and limited resources was also discussed in few meetings and it was decided to explore further that how to allocate resources during limited availability and it was also discussed that how our recently proposed energy management policies can be integrated in this framework.
Members of the host research group presented their ongoing research work related to resource allocation in Electric Vehicles Charging station to maintain KPIs of the grid where they have designed algorithms. In different meetings it was discussed how to proof the stability of those algorithms and it was decided to find the system model for the purpose of establishing stability proofs.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The research (possibly contributing to a paper) aims to calculate the criticality of nodes representing entities which are parts of critical infrastructures and mutually interconnected as well as mutually dependent. The methodological approach of the activity thereby follows a two-step approach: First, the critical infrastructures are modelled as interconnected, weighted network graphs, enabling a criticality rating of nodes through the detection of cut sets. Second, the results will be validated by using a co-simulation approach, where the power grid is simulated with the well-known and open source power flow simulation tool GridLAB-D and the communication delay is calculated using the INET framework, an open-source model suite for wired, wireless and mobile networks within Omnet++.

Indicatively IEEE 14 bus network with hypothetical communication network will be considered and using our CN detection algorithm we will find the nodes which are critical in interdependent networks and for the validation purpose above mentioned simulation approach will be used where different nodes will be removed and effects on the whole network will be observed.

FUTURE COLLABORATIONS (if applicable)

Future collaboration includes (but not limited to):

a) Aforementioned work based on node criticality in interdependent networks.
b) Stability analysis of power allocation algorithms for Electric Vehicle Charging Stations to maintain KPIs at grid, proposed by host institute, subject to availability of system model.
c) To investigate if simulations of DR program proposed by research group of host institute can be performed using co-simulation environment.