SHORT-TERM SCIENTIFIC MISSION (STSM) FINAL REPORT
ON

Development of Availability and Cost Models Based on Realistic Data

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1. PURPOSE OF THE SHORT TERM SCIENTIFIC MISSION

Network providers are facing new challenges due to the always changing number of customers and services and new trends like Software Defined Networking (SDN) and Cloud Computing. Quality of Service requirements are getting stricter and the competition is getting tougher. In times like this, the proper modeling of the availability and cost has utmost importance.

However, a reference (general) availability model containing vendor and product independent – real data based – availability numbers is not accessible. Therefore, the main purpose of the STSM was to discuss a development of such an availability model based on realistic data, which could provide a new platform not only for researchers but for the industry, too.

2. DESCRIPTION OF THE WORK CARRIED OUT DURING THE SHORT TERM SCIENTIFIC MISSION

During the STSM (5days), two main topics were discussed in detail with the Host research group (the Techno-Economic research unit of the Internet and Data Lab – IDLab-TE, part of both Ghent University and imec, including researchers Prof. Sofie Verbrugge, Marlies Van der Wee, PhD, Bram Naudts and Jonathan Spruytte): the topics of the ***Development of an Availability and Cost Model Based on Realistic Data*** and the ***Smart Grid Communication Infrastructure.*** In this section we shortly summarize the main findings of these discussions.

2.1. DEVELOPMENT OF AN AVAILABILITY AND COST MODEL BASED ON REALISTIC DATA

2.1.1. MOTIVATION

The availability of the network including the services they deliver has become important. Services themself become unavailable as soon as one of their components becomes unavailable. Just few years ago in September 2010, Virgin Blue's airline's check-in and online booking systems went down, because of a hardware failure. The outage (subsequent outage) interrupted the Virgin Blue business for a period of 11 days affecting around 50,000 passengers and 400 flights [12].

The outages can happen because of variety of reasons and can be caused by different network layers:

- Hardware failures
  - cable cuts by digging works, OXC failures by defective power supply or fire in the building, etc.
- Software failures
  - Design errors, Faulty implementations
- Malicious failures or attacks

Especially the availability of the transport networks is critical [5,6,7] as a huge amount of services and connections are grouped together in the core of those networks. Therefore, when performing network planning and dimensioning studies, availability information is essential.

Nevertheless, an availability model containing vendor and product availability numbers is not available. One of the main reasons is that it is not an easy task to obtain the availability numbers, as they form business critical information for vendors.

However, we aim to create such a platform with the help of other RECODIS actors.

2.1.2. CURRENT STATUS

The fundament is given in the paper [1] of Prof. Sofie Verbrugge. It covers an availability model including optical layer equipment as well as IP and SDH equipment. Furthermore, a comprehensive availability analysis of the network interconnected with such nodes is included. However, the paper is outdated and needs to be updated (this is the long term goal of the cooperation).

Our intentions are not only to obtain the availability numbers and create a model, but to integrate this data into the ECMN (Equipment Coupling Modeling Notation) and extend the set of available network equipment models.

ECMN [14, 15] is used to visualize the components of modular network equipment, but yet it lacks any availability data and has a limited set of network equipment models.

2.1.3. STEPS TO BE TAKEN

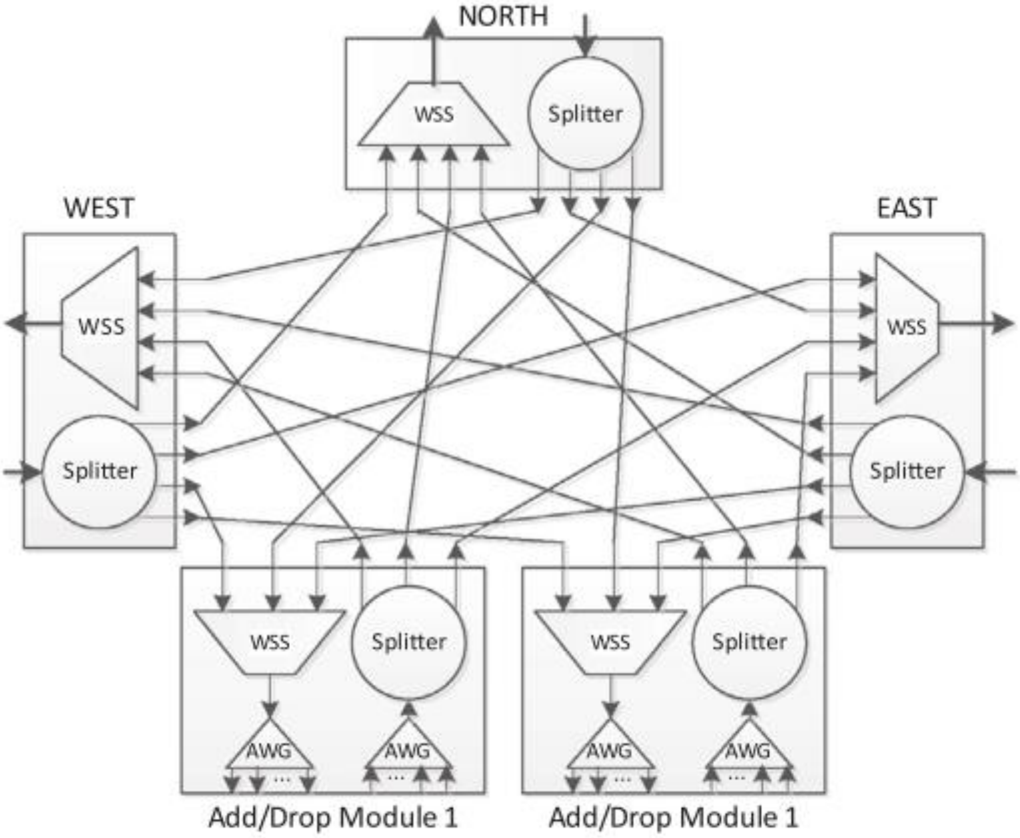
In order to realize our goal, we have to narrow down what kind of equipment we are focusing on. The set of nodes has to be representative for nowadays technologies (we plan to survey several vendors). We not only aim to update the paper [1] but to extend it with more availability data on links (different types of links). The goal is to create an availability reference model and a base data set for research purposes. The granularity of the availability model should focus first on equipment level, after that the component level can be targeted.

The availability data (MTTF - Mean Time To Failure, MTBF - Mean Time Between consecutive Failures, MTTR - Mean Time To Repair) should be integrated into the ECMN and if feasible the BEMEs[14] tool (BEMES: http://bemes.atlantis.ugent.be:8080/editor/) should be extended with an availability layer in long term (i.e. a layer representing the structure and the dependencies of the components).

To reach this goal, the cooperation with several network operators and maybe with vendors is required. Both parties will use their connections to obtain a representative set of the data. Hopefully, RECODIS partners like Deutsche Telecom will support our effort.

In order to extend the set of network equipment models in ECMN, ECMN-related thesis topics will be offered at BME in collaboration with ID Lab-TE. We recommend that other universities join to the effort as well.

During the STSM, I got familiar with the main concept of BEMES and ECMN, in order to be able to provide support for ECMN-related student (thesis) topics. The topic is already submitted on the corresponding page of BME: http://iw.tmit.bme.hu/education/studenttopic/TMIT2017-164



1. Example architecture: ROADM node using WSS [13]

2.2. SMART GRID COMMUNICATION INFRASTRUCTURE

During the meetings, the mutual interest towards smart grid came up. The research group of ID Lab-TE has a starting project with an industry collaborator in order to investigate the possible future telecommunication infrastructure that supports the smart grid concept. Because of my background (power engineering BSc.) and some smart grid related thesis topics, we decided to pursue a collaboration.

2.2.1. MOTIVATION

The smart grid is a modern electric power grid infrastructure for enhanced efficiency and reliability. This can be achieved with automated control, modern communications infrastructure, sensing and metering technologies, and modern energy management techniques (i.e. demand respond) [2,3].

However, smart grid is not an option anymore, it is a necessity because of the shift towards distributed energy resources. In order to enable a smooth shift, new communication infrastructures are needed which enable the new smart services.

Note that, in case of smart grid, the communication and the power grid are relaying even more on each other. This means cascading and disaster related failures have to be considered even more strictly.

2.2.2. THE OBJECTIVE OF THE COLLABARATION

The goal of the project is to investigate the smart grid related potential of different technologies and evaluate them in context of given smart (grid) service related requirements. The design of smart grid communications infrastructures according different QoS requirements [3, 8] is also an objective.

The requirements will depend on the industrial partner (starting project), but of course several scenarios independent of the partner can be considered.

The first step is to investigate the suitable technologies, to fully understand the benefits and drawbacks of them.

Of course, some work on this subject is already published, for example in [2] the communications technologies for smart grid were investigated and several technologies were compared (see Table 1). The goal is to extend the already existing research in order to provide a good foundation for the network design step.

When planning a network, certain requirements have to be satisfied, like bandwidth, delay and availability (Table 2) .These requirements depend on the services you want to provide [9, 10,11]. The goal of the project is to investigate which technologies can satisfy given smart grid related requirements, which topologies could be implemented, and how the availability requirements of smart services affect the network design (technology and topology).

Technology	Spectrum	Data Rate	Coverage Range	Applications	Limitations
GSM	900-1800 MHz	Up to 14.4 Kpbs	1-10 km	AMI, Demand Response, HAN	Low date rates
GPRS	900-1800 MHz	Up to 170 kbps	1-10 km	AMI, Demand Response, HAN	Low data rates
3G	1.92-1.98 GHz 2.11-2.17 GHz (licensed)	384 Kbps-2 Mbps	1-10 km	AMI, Demand Response, HAN	Costly spectrum fees
WiMAX	2.5 GHz, 3.5 GHz, 5.8 GHz	Up to 75 Mbps	10-50 km (LOS) 1-5 km (NLOS)	AMI, Demand Response	Not widespread
PLC	1-30 MHz	2-3 Mbps	1-3 km	AMI, Fraud Detection	Harsh, noisy channel environment
ZigBee	2.4 GHz-868-915 MHz	250 Kbps	30-50 m	AMI, HAN	Low data rate, short range

1. *table Technology comparison [2]*

In order to support the project, both universities will offer thesis topics related to smart grid communication infrastructures.

Function	Bandwidth	Latency	Availability
Smart Meter (AMI)	10-100 Kbps	2-15 sec	99-99.99%
Demand Response	14-100 Kbps	500 msec - several minutes	99-99.999%
Wide Area Situational Awareness	600 Kbps - 1.5 Mbps	20-200 msec	99.999-99.9999%

2. *Table Requirements [2]*

Student topic link: http://iw.tmit.bme.hu/education/studenttopic/TMIT2017-163

3. FUTURE PLANS

We foresee a long term co-operation with possible conference and journal publications. An STSM where a researcher from ID Lab-TE visits our research group in Budapest is also a possibility.

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