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Electrical Engineering

Elixir Elec. Engg. 62 (2013) 17883-17886

ISSN: 2229-712X

# The smart grid concept and the challenges in communication

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**ARTICLE INFO**

**Article history:**
Received: 10 June 2013;
Received in revised form:
28 August 2013;
Accepted: 16 September 2013;

**Keywords**
Smart grid,
HAN,
NAN,
WAN,
Routing protocol, etc.

**ABSTRACT**

The concept of smart grid is a promising issue in the field of energy management. There are lots of researches going on different aspect of this system. One of the major topics that is involved in this concept is the communication constraints. In this paper we have analyzed few aspects of smart grid system. The main focus is on the communication technologies and their threats along with solutions. We have considered different literatures to investigate the overall concept of smart grid and prepared a review on the topic.



## Introduction

The world is heading towards a future with unlimited use of electric appliances and dependency on a complete electric world. In our current system we are using the traditional system for power distribution, transmission and generation. In future we are looking forward for a better solution and in that case the only promising technology is Smart Grid. Already the technologies such as distributed generation and plug-in hybrid electric vehicles are helping us to reduce the harmful effects caused by energy. The concept of smart grid will focus on a two way flow of electricity and information, creating an automated, widely distributed energy delivery network.[1]. In our traditional system the need of communication was designed to meet the needs of a regulated power industry that dates from several decades ago.

These networks are designed to support control operations and interactions between control centers and individual substations.In this paper we want to focus on few suggestions for changes in our current system to get closer to the world of smart grid and also the advantages we can get from the system, as described in the previous literatures.

## Distributed energy generation

One of the important improvements we may get is distributed energy resources (DERs) into the electricity grid on a large scale. The main function of DERs will be to supply electricity to some particular areas when they will be isolated from the main distribution system.

Currently, the supply of energy in this type of emergency situation cost a lot for the distribution network operators (DNOs), as the majority of the energy that is destined for customers is wasted in the form of heat. In the traditional power grid the electricity usually flows from the central power stations to the customers, but with the modern DER it is possible to make the flow in two directions. To implement this type of structure the use of sensors will play the main role. For this type of system we need to have a constant monitoring system at every node so that any irregularities can be detected at a real time response and then the required action can be taken. For our traditional system we are dependent on SCADA for the purpose of communication in the grid. In our case we will need an extended SCADA system that will help to track all the data collected by the sensors.

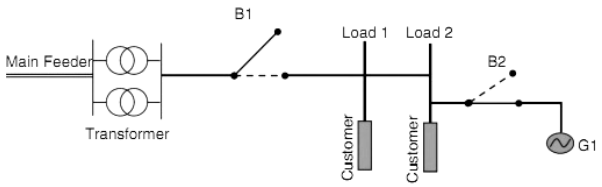


**Fig. 1: Power resupply with distributed generation.**

For this purpose we need to sub divide our grids intro micro grids which will be controlled by Autonomous Intelligent Controllers. This type of improved sophisticated control will remove a certain amount of communication stress from the control room.

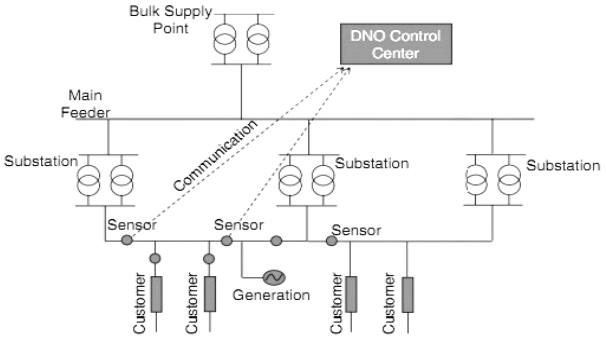


**Fig. 2: Communication in a centralized active control system**

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**Home energy management system**

HEMSs will be used to help the households optimize their lifestyles, rearranging the energy consumption schedule to secure a high quality life while reducing the burden of excess energy bills. This system will make the concept of smart grid more user friendly to the customers and aware them regarding the efficient use of electricity. There are mainly three elements of HEMS:

- The energy management gateway (EMG) that will ensure secure connections
- Energy management unit (EMU) for collecting information about the status of the appliances
- Group of sensors and microcontrollers which will feed the EMU.

A brief overview of this concept can be seen clearly in the following figure.

**Advanced metering infrastructure**

One of the vital components of the smart grid is AMI which will help to optimize business operations. It will used as a way to collect monthly consumption data used for billing and provide load profile, demand, time-of-use, voltage profile, and power quality data. AMI along with HEMS will let utilities implement direct control of demand-side management. To develop this idea we need to have few changes in our communication system to support the real time operations.

A clear concept about this can be found in the diagram below.

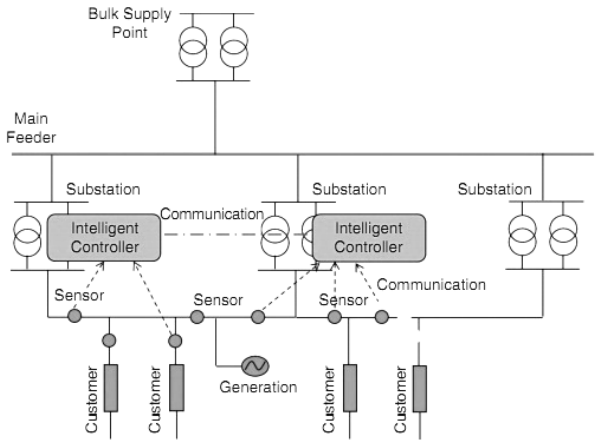


**Fig. 3: Communication in an autonomous active control system**

**Communication In Smart Grid**

The network architecture of smart grid hierarchically consists of three components as described before:

- Home Area Network (HAN)
- Neighborhood Area Network (NAN)
- Wide Area Network (WAN).

As these networks are mostly wireless and shared hence the possibilities of attacks are found in many literatures. These attacks focus on different part of the smart grid network. One of the attack targets the power plants and aims in disrupting or taking over the operation generators.[2]. The power distribution and control system can get attacked with false data injection. This type of attack can potentially cause grid instability and inability in the worst case. The smart meters and AMIs are the next candidates for the attack, which can modify the commands or price signals.

These attacks have also been discussed in many literatures with different categories. In one of the literature [3] these attacks are categorized as vulnerability attack, data injection attacks and intentional attacks.

For all the possible attacks the preventions are also mentioned in their researches. It should be noted that the concept of smart grid purely depends on real time operations hence it is most important to maintain the continuous availability of the network and immediate recovery from any attack. Table 1 below summarizes different types of attacks and corresponding defenses.

**Table 1: Characteristics and Defenses of attacks in Smart Grid**

| Attack Targets | Characteristics | Defenses |
|---|---|---|
| Generation | - Sophisticated and require significant resources - Spectrum of cyber attacks evolves threatening multiple assets | - Include with risk management frameworks, vulnerability-reduction tools, information-sharing programs, etc. [6] |
| Distribution and control | - Threaten monitoring and controlling physical properties of the electrical power grid with false data injection - E.g., false date injection attack, stealthy deception attack, load altering attack | - Adaptive CUSUM algorithm against false data injection attack [7] - Algorithm using the generalized likelihood ratio test against stealthy attack [8] – Setting up passwords, firewalls, and identity authentication against load altering attack [9] |
| Smart meters | - Attack altering commands or price signals - Treats to smart meters, i.e., curious eavesdroppers, motivated eavesdroppers, unethical customers, overly intrusive meter data management agencies, active attackers, and publicity seekers | - Private key encryption or MAC for unicast, and group key management for multicast [9] - Secure key management and authentication protocol for smart metering over PLC [10] - Intrusion detection system (IDS) for AMI [11] |

In one of the other literatures the authors have proposed a new security strategy for a secure and distributed control network [4]. In the paper the author mentioned five levels of a smart grid: Utility Level, Transmission Level, Distribution Level, Neighborhoods Level and Households level.

It has been found that typically there are two types of implementation in the communication network. One of which is dedicated to the substation network and other one is the leasing public communication network. In the second case of leasing public communication network for distribution level power system, the cyber-attack is unique attribute that it can be launched through the entire network from a remote location. Hence it is critical to discover and setup a reliable and secure route for the operating SCADA command. One of the known smart grid communication solution is the so-called

comprehensive MPLS VPN solution. But to implement this feature all the utilities should be subscribed to VPN services.

The proposed system in that paper TQOS(Trustworthiness-based Quality of Service) routing protocol is based on a serial route discovery and setup procedure. This can ensure that every power system operation will be transmitted through a secure route. The detail analysis with simulation result can be found in [4].

**The challenging environments**

In different domains of smart grid communications, different communication technologies are preferred to meet the specified requirements. In order to promote the success of smart grid system, the communication techniques need to satisfy strict requirements [5]. Depending on the demand of energy, we can divide the environment into three main categories: *Mobile Environment*, *Geographical Environment* and *Harsh Climate Environment*.

All these environments reflect high efficiency transmission facility and maintenance to guarantee the normal operations of the grid. The existing solutions to these environments are given in the table below:

**Table 2: Challenging Environments and Existing Solutions**

| Challenging Environment | Challenges | Existing Solutions |
|---|---|---|
| Mobile environment | a. Availability of charging infrastructure b. The communication of electric vehicles' power level and charging request | Wireless communication networks |
| Geographical environment | a. The wiring for isolated areas b. Increased the volatility and reduced reliability | a. Wind farms or solar panels b. Wireless communication networks |
| Harsh climatic environment | a.Real-time power flow impossible b.Expensive repair cost c. Long outage and restoration period | a. Wireless sensing and controlling b. Charged electric vehicle |

After investigating the simulation results of the above mentioned environments a solution has been proposed which is based on CR communication network in the literature [5].

**Conclusion**

Smart grid is the technology which will make the energy generation, distribution and transmission more efficient. For this purpose we need to consider some major changes in the communication system of our traditional power system. In this paper we have focused on some basic functions of smart grid along with few discussions on the communication technologies used in smart grid. There are many researches going on this topic and many literatures had provided some useful solutions. In this paper clear ideas about few suggestions and the possible outcomes have been discussed.

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