Implementation of Smart System Based on Smart Grid Smart Meter and Smart Appliances

Engr. Bilal shahid[+], Zubair Ahmed, Adnan Faroqi and Rao M.Navid-ur-Rehman.

Engineering College University College of Engineering and Technology,The Islamia University of Bahawalpur, Punjab, Pakistan

Abstract. This research paper works on Smart Meter system through networking .This paper will provide the overview about smart networking for Smart House system. This method is very advance and reliable. It will manage whole power consumption and communication between the systems.
A Smart House consists of smart appliances due to installation of smart cards, which act as communication icon between Smart Meter and appliances . Number of such Smart Houses are connected with a Town Server. This Town Server is able to control power, provided by service provider and power generated by Regenerative sources. The connection between Smart Meter and Town Server is via local PSTN and also with Power Line. Now further on, Town Server is bidirectional connected to another town server via power line for power transmission and via PSTN. And also connected with Main Server through PSTN. All the Smart Houses are controlled by Town Server. Town Server also takes reading from meter of each moment record it and sent it to Main Server after each hour and also manage power within its area of control or manage power from other towns for its Smart House .Main Server takes data from each Town Server after every hour and compile a bill up to that reading. This Main Server is directly controlled by service provider. The main advantage of such networking system is, in any case of disturbance to the Main Server , system remains on working , as all the power management, recording and its communication are keep on going by Town Servers.

Keywords: Smart Grid, Smart Meter, Smart Appliances, PSTN

1. Nomenclature

SMATR METER	S.M
SMART HOUSE	S.H
TOWN SEVER	T.S
MAIN SERVER	M.S
PUBLIC SWITCHED TELEPHONE NETWORK	PSTN
LOCAL AREA NETWORK	LAN
REGENERATIVE SOURCE	R.S
TWISTED PAIR CABLE	TPC

2. Introduction

The main objective required by smart power system is to be control the load through networking. The basic idea of a power system is to manage power and active frequency by balancing active power supply and demand. Without this balancing, system might collapse. This balancing could be limited by some Factors which are stability of the generators, transmission line capacity limit and power losses [1,2,3]. If all the generation of the system is unable to fulfill the requirement due to these factors, load shedding must take place in system to avoid the system from collapsing [4,5].As now a days, a new system is introduce based on smart meter and smart grid technology. And this system also uses conventional power generation and transmission system along with latest technology of smart grid. While conventional meters are replaced by smart meters. Previously smart meter communication is carried out by different methods like global system for mobile communication(GSM), Wi-Fi communication, CDMA communication etc. But the major

---

[+] Email: bilal.shahid@iub.edu.pk, malik0861@gmail.com, adnanfaroqi@gmail.com, naveed08es14@gmail.com

problem present in such communication is high power radiations [10]. Which is quite injurious for all the living things specially for human beings. As it breaks the trust of a normal man and make this technology unsatisfying for him. While from service provider point of view, all the proposed technologies have some consider able drawbacks. Like Wi-Fi based communication of smart meter needs to mount repeater pole after a specified distance. And also signal problems are observed specially in bad environment and sensitive areas. GSM based system has more signal to noise ratio while CDMA has less but 40 times larger bandwidth. And both factors increase when the burden of this power system is also added in GSM system and CDMA system. And those proposed systems which use LAN connection between S.H and S.M, TPC have some limitation of distance about 100 meters[12,13]. And also need hub or repeater device after that specified distance to transmit data properly.

On the other hand, previously purposed systems have some management problems, like if the central managing unit or subordinate managing unit goes to link down then all the system will blank out and etc. For such problems of high importance, it is necessary to introduce a new concept, which has some solution of these radiations with effective price and which has some solution of managing problems like one discussed above. And also have as low as possible cyber security risks[11]. Such amazing system is presented in this paper. In this paper, this balancing of power and uncentralized management along with removal of high radiations is done by modifying S.M and by networking. System presented is given name as smart system.

3. Description ad working

There are four Major parts of smart system, which will work together to overcome all those problems which are drawbacks of previous systems. These are

- Smart House System
- Smart Meter
- Town Server
- Main Server

3.1. Smart House System

It consist of all smart appliances, having smart card. The structure of these smart cards is as shown in Fig. 1 Smart card consist of (i) sensor (ii) digital meter (iii) micro controller (iv) LAN card . With these SAs, no need of a smart socket for the appliance to communicate with the SM[6,7]. Sensor is the device to sense the power consumption and decide current status. Digital meter show the consumed unit of power and price .Micro controller is controlling device that control the flow of power and it also knows the power which is required for the appliance and that information is send to the S.M through the LAN card. LAN card is connecting device having Ethernet port, used to connect S.M and smart card by TPC.
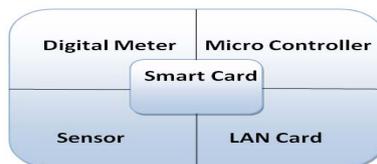

Fig. 1 A smart card consist of four component

3.2. Smart Meter

The basic purposes of S.M system are

- Measuring and power management
- Price and unit measurement
- Communication

3.2.1. Measuring and Power Management

S.M is an intelligent device which takes input from smart grid/power station and have already information about amount of total power required by the smart appliances [8].If power provided by the smart grid/power station is not sufficient, it will try to extract power from R.S to fulfill its requirement and if R.Ss also can not satisfy the power requirement then smart meter send a signal to T.S to provide difference of

power of required power and available power.

If it is the case that provided power by T.S is more than required, it broadcast the massage to T.S that its assigned power is more and T.S can reduce up to a specified level to provide power to another S.H.

3.2.2. Price and Unit Measurement

In this section, S.M measures those units which are provided by service provider for the purpose of price estimation and also measure those units which are extracted from R.Ss and are utilized by service provider to run another S.H .Then it calculates the difference and show the price against this reading up to that time. It will visible to customer[9].

3.2.3. Communication

S.M communicate with T.S to send and receive the message signal .This work is done by Local PSTN. This usage of PSTN removes the factor of high radiation which is present in previous S.M communication systems[10]. This S.M send the number of units and price to the T.S which is to be finally paid by the customer to the service provider. This T.S is also connected to a M.S via PSTN. While S.M is also connected to T.S via power line for the purpose of communication.

3.3. Town Server

A T.S is main unit of management of smart system or in fact it is a complete server and central computer which have all the right to take a decision for all the user under it. This T.S is connected to a M.S of smart system by PSTN for communication purpose only. Because T.S send the calculated power units up to that time to M.S after every one hour so that the data remain save at M.S and T.S keeps information of current month for efficient working. As current month passes it remove its data because M.S have backup of all previous months and of current month up to that time. This duration of one hour is designed to remove the possibility of over loading of bandwidth or reduce the bandwidth to considerably very low level than previous smart systems. The multi-tasking real time operating system and real time software of T.S are designed in such a way that whenever main server goes to link down state, T.S automatically switched to administrative mode in which it behaves like main server for itself and keeps data until M.S again goes to linkup state. All the T.Ss of smart system are connected to each other via PSTN's and via power lines. (See fig: 2). these two links between T.Ss are of key importance because all the management done by T.S is carried out with other T.Ss is based on these two links. As discussed in introduction the drawbacks of proposed system and latest requirements, the one very strong reason for using PSTN is theoretically unlimited bandwidth availability. Shannon's theorem describes the bandwidth equation given below:

$$BPS = BW \log 2(1 + s / n)$$

BPS = Bits per second
BW = Channel bandwidth
s/n= Signal to noise power ratio.
This is a real power ratio and not a dB ratio. And bit per second is given by equation:

$$BPS = Rs \log 2Ns$$

Rs = symbol rate (also bandwidth for QAM)
Ns = number of symbols in the constellation

Let's start from very first point, a S.M send a message signal that its S.H need that much amount of power .And same message will be received by T.S from all of its subordinate S.Ms. At every instant when the requirement of a S.H increase or decrease, it will be informed to T.S . Now it is a case, when a S.M send a message to reduce its power and other S.M wants to increase its power, both broadcast a message signal to T.S then T.S reduce the suggested power of first one and that amount of power is send to second one according to its requirement. If it fulfill requirement of second one, its fine. Otherwise check another S.H whose power is reduced and not assigned to any S.H. If still deficiency remains, it checks its S.Hs those can provide power of their regenerative sources to compensate power deficiency. If no one is there or regenerative power is less then it broadcast a message signal to its nearest T.S to provide power (see fig:3). And if it doesn't have power to donate from its grids then it will borrow power from next T.S for the first T.S.

In any case of problem at M.S end or any/few T.Ss then other T.S will remain working properly as shown in fig:2. This is huge advantage of this smart system over any other systems. Town server may be directly connected with smart grid or conventional power station or both.
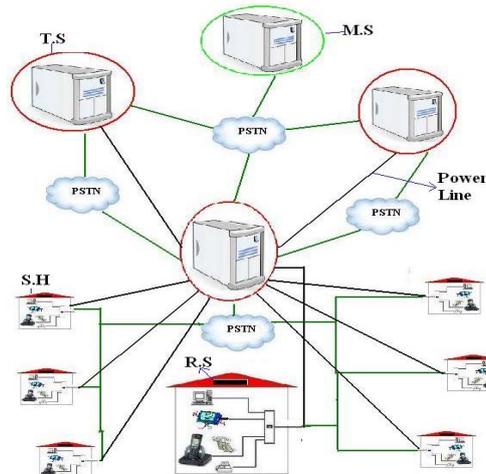

Fig. 2 Topology of smart system; upper part shows way of connection between T.Ss and also with M.S; While lower part shows the way of connection of S.H to T.S through local PSTN.

The connection between smart grid station and town server is as simple as main computer of smart grid is connected in the system.

3.4. Main Server

M.S is basically brain of smart system which keeps record, backups, measurements, bills, costumer record, deals to the customers, topology of division of all the power of smart grids/power stations for relevant smart towns, etc. This M.S is connected with every T.S via PSTN only. As shown in fig: 2. This M.S is operated by head office of service provider .And can start or stop all the working of a particular T.S/S.H in any severe case by some type of commands and passwords .It might be scene that M.S have the ability to stop the working of a T.S if all the systems is operated by different distributions companies under single umbrella .This M.S now generates a complete summary for each T.S and each S.H at the end of the month. It informs the customer by one of their selected media(email, sms, by post, etc.) and broadcast summary of month to relevant T.S.
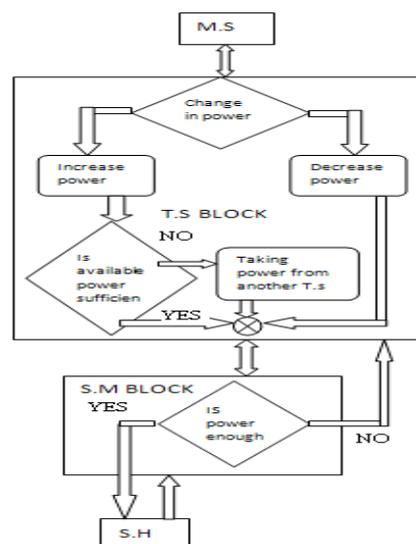

Fig. 3 Basic flow of communication and assigned power of smart system

4. Advantages

This smart system provides electricity to every user every time as managing unit is T.S. Its working is

described above. Using networking in such away as used in this system remove Radiation remarkably and also give user mental satisfaction from radiations. In any case of problem at M.S end or any/few T.Ss, Other T.Ss will remain working properly. Which is huge advantage of this smart system over any other systems. This system is much more reliable and fast than any other smart system. By using PSTN's, it reduce amount of expanses to establish this system. As for present company of communication sector, it has its own and for new power company it can purchase bandwidth at low cost for long duration. As this smart system involves networking through PSTN, networking needs to be secure to encapsulate data and also secure system from viruses or interruption of irrelevant person. While cyber security risks are also less in modern PSTN system.

5. Conclusion and Further Enhancement

This research paper present the idea of T.S as a managing and controlling unit for smart system which can work in case of any problem in any part of the system .This paper discussed the removal of radiation by using local PSTN's and main PSTN's and mutual sharing of power sources between regions and also sharing of power lines of smart systems, in such case also in which system have many generation and distribution companies under single umbrella. While whatever is the case customer will never suffer and this networking and power communication of smart system will fulfill all the requirement of any customer, in any corner of system, in any timing even M.S or few other T.Ss are not working properly. For future enhancement this research paper can bring a power revolution in communication sector by the collaboration of communication sector and power sector so that a customer will have electricity, land line, broadband internet, mobile phone connection and cable TV. Connections from a single system of company. It might suggest to researchers to design a special line which give power transmission and bandwidth communication bidirectionally, both in a single insulated jacket. As PLCs are unidirectional lines or cables.

6. References

[1] Verma, V.; Singh, B.; Chandra, A.; AI-Haddad, K.; , "Power Conditioner for Variable-Frequency Drives in Offshore Oil Fields," Industry Applications, IEEE Transactions on , vo1.46, no.2, pp.731- 739, March-april 2010.

[2] Rajagopal, V.; Singh, B.; Kasal, G.K..; , "Electronic load controlle with power quality improvement of isolated induction   generator for small hydro power generation vol.5, no.2, pp.202-213, March 2011.

[3] Soder, Lennart; , "Explaining Power System Operation to Nonengineers," IEEE, vo1.22, no.4, pp.25-27, Apri12002.

[4] Seyedi, H.; Sanaye-Pasand, M.; , "New centralised adaptive loadshedding algorithms to mitigate power system blackouts," Generation, Transmission & Distribution, lET , vol.3, no.l, pp.99-114, January 2009.

[5] Gungor, V.C.; Bin Lu; Hancke, G.P.;, "Opportunities and Challenges of Wireless Sensor Networks in Smart Grid," Industrial Electronics, IEEETransactions on, vo1.57, no. 10, pp.3557-3564, Oct. 2010.

[6] Moslehi, K..; Kumar, R.; , "A Reliability Perspective of the Smart Grid," Smart, pp.57-64, June 2010

[7] Rozeha A Rashid; Mohd Adib Sarijari; Mohd Rozaini Abd Rahim; Tan Zun Yung;, "Flood Transmission based Protocol for Home Automation System via Power Line Communication," Proceedings of the International Conference on Computer and Communication Engineering, May 2008.

[8] Book : "Getting smart about smart meters answer book for residential customers" By POWER STREAM

[9] M.S.Jaganmohan; K. Manikandan "Challenges in Smart Meter Design" Power system protection and automation conference, December 2010, New Dehli ,India.

[10] Book; by Orlean Koehle ; "The Latest in Bio-Hazard Technology" Information Compiled Fall and Winter of 2010, Printed by ARC Reproductions,Rohnert Park, CA 94928

[11] Book: by Prof. Douglas C Hopkins; Prof. Mohammed Safiuddin. "Power electronics in a smart-grid distribution system" chapter #6.

[12] http://www.windowsnetworking.com/articles_tutorials/copper-glass-guide-network-cables.html

[13] Book: by Todd Lammale "CCNA:Cisco Certified Network Associate Study Guide" 5th Edition pp:33

[14] Document: "56Kbps Data Transmission the PSTN" By: P. Michael Henderson November 18, 1998