# Quality of Experienced based Approach for Power Scheduling in Smart Grids

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**Abstract:** A smart grid is an electrical grid that uses smart meters and other devices to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated manner to improve the efficiency, reliability, economical, and sustainability of the production and distribution of electricity. Smart grid is a new emerging technology which is able to intelligently control the power consumption via network. Therefore, the efficiency of the information exchanges between the power suppliers (or control centers) and power customers are an important issue for smart grid. Moreover, the performance of the smart grid usually depends on the customer satisfaction degree which belongs to the field of quality of experience. Now-a-days, power consumption by the end users has increased a lot, prices of electricity is increasing day by day but the power production is reducing and always there is a scarcity in the required power. To overcome all these problems, smart grid is very helpful. In this thesis, we propose to study and analyze various QoE issues of smart grids for efficient use of power. We aim at proposing QoE aware power scheduling for effective utilization of power.
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**Keywords:** Smart Grid, QoE, Power Scheduling etc.

## 1. Introduction

Smart grid delivers the electricity from suppliers to consumers using digital technology with two way communications to control appliances at consumers home to save energy, to reduce cost and increase reliability and transparency. Smart grid integrates the traditionally used power hardware with sensing and monitoring technological issues and communications to improve the grid performance to the utmost level and gives the better services to the consumers. Power grid infrastructure is very critical and made with heterogeneous interconnected combination of elements like power transformers, generators and distribution feeders that are geographically spread.

The increasing complexity gives the huge number of geographically spread generators and the side effects caused by variable nature and penetration of renewable energy systems makes it vulnerable and requires specific security mechanism [3]. Perhaps the current power system does not give better quality of experience and also a centralized system with unidirectional power flows from the power plants. So the complete handling mechanism was done by central stations and some partial sub stations when required, here almost the loads are passive. So if distributed intelligence is to be provided in local electricity generation, there is a two way flow and achieve reliable, efficient, flexible, economic, secure power supply and usage [4].

So the smart grid technology is a choice for intelligent control of the power consumption with two way communication network. The performance of the smart grid is relatively based on the customer or consumer satisfaction, it can be variable as Quality of Experience. Overall benefits are stated sequentially as improving reliability, improves quality like stable voltages, more energy efficient, allows two way flow of power, provides dynamic pricing and demand side control, and very important one is greater consumer choice.

## 2. Related Back ground work

Under the Energy Independence and Security Act (EISA) of 2007, the National Institute of Standards and Technology (NIST) has been introduced a conceptual reference model [6]. The NIST Conceptual Reference Model is descriptive, and is intended to be high-level. The NIST conceptual Model can serve as a tool for identifying actors and possible communication paths in the Smart Grid. The figure 1 below provides a high-level grouping of what NIST has deemed as the smart grid domain.

The seven Domains in the Smart Grid Conceptual Model include: customers, markets, service providers, operations, bulk generation, transmission and distribution [5]. Here QoE driven power scheduling is most important for smart grid.


Figure 1: Interoperable smart grid technology conceptual model

Perhaps all these requirements may maintain the clear analysis and good Quality of service, along with these the customer satisfaction is also important for the control centers otherwise they may quit the system and it leads to revenue loss. More number of customers are also need to be satisfied and should maintain good quality of service [1] and here is a question that how to define a specific model in the clear context of smart grid. Communication also one of the important key factor for Smart grid communication technology, generally we may find so many wireless technologies with different complexity and flexibility levels to the user, here is a sample analysis of the wireless communication in smart grid shown in table 1 [7] .

TABLE I
SMART GRID COMMUNICATIONS TECHNOLOGIES

| 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-2Mbps | 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 |

We should also study on the wireless communication systems because of its importance in the smart grid power management system. The mainly used wireless techniques in to day's world are GSM, GPRS, 3G, WI-Max, PLC and ZigBee. The performance analysis of these networks also should remind for the most familiar and flexible usage of the service. In detail explanation and analysis of these communication networks are actually beyond of this paper, so pointed out very little important information. So in the next section we clearly defined a relevant system model with smart meters and related equipment for clear customer satisfaction and good quality of experience.

**3. System Design**

The system design is specifically defined in six interrelated elements or domains, and all the domains are connected using two way communication system, which is more crucial for the smart grid power system. The domains of the system model can be defined as Power Management, Demand Response analysis, Energy providers, Power distribution, Smart Meters and Consumer devices; the model design was described in figure 2.

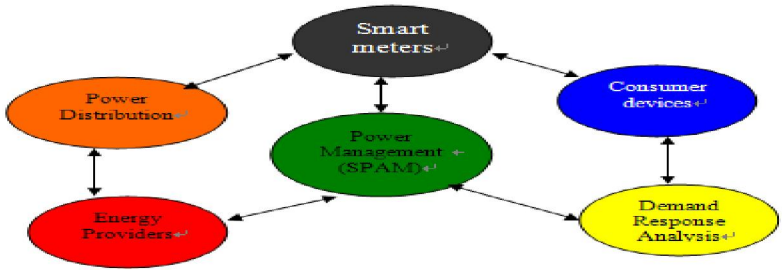


Figure 2. System Design

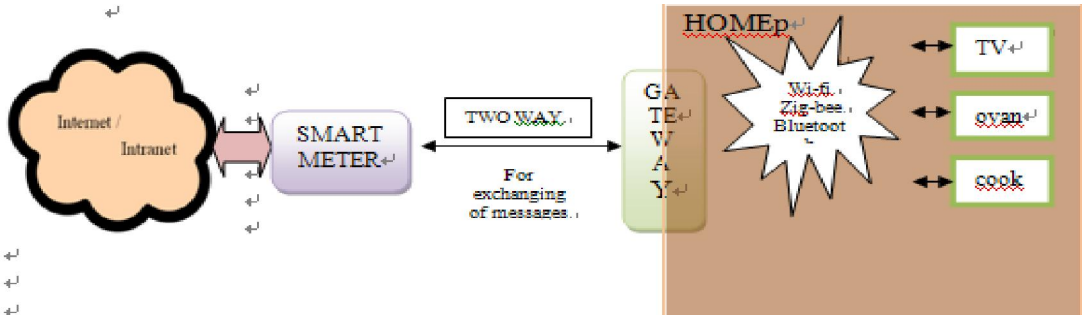


**Figure 2a: Smart grid home energy handling with smart meter and wireless technologies**

**Power Distribution:** The Power Distribution domain takes the crucial role and it distributes the electricity to and from the end customers in the smart grid. The distribution network connects the pecifically designed smart meters and all intelligent field devices, managing and controlling them through a two-way wireless communications network. It may also connect to energy storage facilities and alternative distributed energy resources at the distribution level.

**Smart meter:** the role of smart meter is to grab the power consumption request from the consumers. Two way communications is possible with interval measurements and storage of consumption data. Smart grid technology is actually works in wireless communication so connections should be operate remotely, so smart meters supports remote connection and disconnection. And it supports the variable energy tariffs; it would be very friendly and provides flexibility as well as good satisfaction to the consumers of the smart grid.

The above figure shows the simple outer look of smart grid management with smart meter connected with the gateway using two way communications, used to exchange price, energy, time, support and various types of messages. Smart Meters measure and record at 30 minute intervals that how much electricity a household or business is using. There are different Smart Meter models, but the basic functions are the same. Smart Meters communicate meter readings directly to electricity distributors, eliminating the need for someone to come out and read your meter – whether that is for each quarterly bill, to change your electricity retailer or to reconnect power when you move house. Not only does this reduce fees, but electricity bills will also be more accurate – virtually eliminating estimated bills. Smart meters will also provide consumers with more accurate information and bring an end to estimated billing.

Demand Response Analysis: Demand Response Analysis (DRA) entails the control of energy demands and loads during the peak level to achieve the balance between energy supply and the demand, so good utilization of the available energy at peak times enables the good Quality of experience. Customer can participate in the energy market competition by changing their energy consumption approach instead of being passively exposed to fixed prices, so will get profits for both end users and company [6].

Energy Providers: Energy providers are the organizations who provide energy services to the consumers or electrical users and utilities. This is the main domain to concentrate more on QoE. The energy providers should maintain a good quality of service as well.

Consumer Devices: Consumer devices are the devices which can effectively utilize the power in the sense of consumption and saving. These devices contained by the customers or consumers of electricity, may also store, generate and manage the use of electricity. Traditionally three types of customers are discussed, each with its own domain: Residential, Commercial, and Industrial. The consumer devices may be vary based on the specified customer type and their usage strategy.

Power Management: Power management has the central control of all other domains. This is very crucial for the smart grid to effectively communicate in both the directions. The transmission of electricity over the bulk distances in bulk quantity, and also required to manage the storing and generation of electricity. The SPAM can adjust the transmitting power for DATA/ACK packets as well as signal RTS/CTS packets according to the current network condition in order to reduce the energy consumption whereas the performance of the whole network should not be much sacrificed; hence quality

of service will be increased.

4. QoE analysis on SPAM

The Smart Power Adjustment Method (SPAM) is developed based on the information and its corresponding communication in smart grids. It is very important for smart grids to achieve efficient data communications between various components of smart grids such as energy providers, power distributors, smart meters and consumer devises. With the deployment of SPAM in smart grid, we are in a position to achieve not only power saving data transfer mechanism but also we could develop an efficient power management system due to the fact that SPAM ensures that timely communication amongst various components of smart grids, it would broadly effects on the QoE factor and gets the good quality of service as well.

When we are discussing about QoE on smart grid, we should consider some open issues like hybrid Architecture, and security issues [1] yet to be developed. The proposed system is simulated using NS-2. The simulation parameters are shown in Table 2.

Table 2: Simulation Parameters

| Parameter | Value |
|---|---|
| Number of nodes | 10 |
| Simulation time | 1000s |
| Underlying MAC protocol | 802.11DCF |
| Channel type | Wireless Channel |
| PHY Type | Phy WirelessPhy |
| Max. transmit power | 300 mW |
| Radio range of Max power | 250 m |
| antType | Antenna/OminiAntenna |

Let us see the performance metrics of the SPAM which effects broadly on the Quality of user experience that the delivery ratio and throughput.

**4.1 Performance Metrics:**

**Delivery ratio:** it is ratio of the number of data packets correctly delivered out of the total number of data packets sent. The deliver ratio can broadly impact on the quality of experience and improves the reliability of usage. Quality of experience is assumed as Qe, All the data packets sent assumed as Ts, total data packets received assumed as Tr and total deliver ratio can be as

$$Dr = Tr / Ts$$

The increment value of Dr highly effects on the Qe value, if Qr value is higher then automatically the Qe value will also be higher. Which is the Qr value is directly proportional to the Dr value.

**Throughput:** throughput is the net bit rate of the successful data transfer through a communication channel, expressed in bits or bytes per second. It also implies the performance of network capacity and QoE. The throughput of a communication system is limited by many effects; some of the effects are signal to noise ratio and bandwidth of the received signal. Bandwidth is equal to the communication link maximum throughput. It can be closely estimated by right tools, right protocols and by careful analysis of test data and should consider delays.

**4.2 Simulation Results:**

For measuring the clear QoE, this method has been compared with IEEE 802.11 and BPCMP using NS-2 for delivery ratio, throughput. For measuring the performance of the system we should focus on some wireless networking related issues, which are significantly effects on the performance of the system with heterogeneous power capabilities [8][9]. These results indicate that the proposed method of communication improves the smart grids performance.

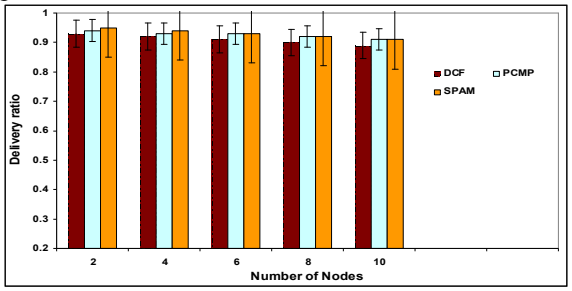


Figure 3. Delivery ratio comparisons

The simulations were carried out for IEEE 802.11 MAC protocol, BPCMP, and for the proposed method, respectively. Figure 3, 4 shows the simulation results of the comparative study of respective protocols. As we said earlier the Qe will be increased with respect to the value of Dr, that is the Qe value is directly proportional to the Dr value.

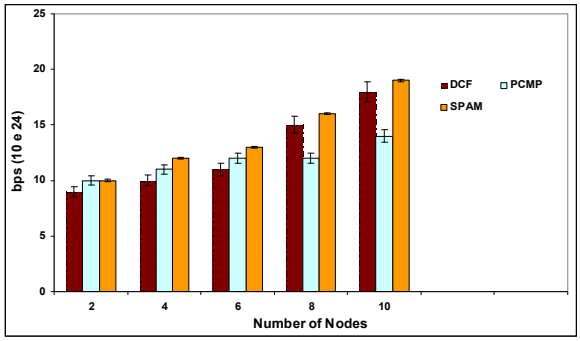


Figure 4. Throughput comparison

The energy saving for the described method is significant when compared to other methods. The SPAM comparatively consumes less energy and help in efficient management of power in smart grids. So the QoE will be successfully achieved when the performance, reliability of the system is more.

**6. Conclusion**

The main focus of this paper is on Quality of Experience based power scheduling on communication system so that we discussed some communication issues which improves the quality of service along with quality of experience. Proposed an analysis on a specific System design which illustrates broad view of domains in relate with the QoE, each and every domain described in this scheme has significant effect on the QoE. For obtaining the QoE requirement, the analyses was performed on the SPAM and on its related methods with specialized metrics are as Delivery ratio and through put were analyzed. And found this method give the better results and higher rate of QoE. To measure the performance of the system we need to consider so many parameters that are existed in wireless two way communications existed in smart grid. So in future scope we can do performance estimation and effective QoE based on many other user related real time factors which are broadly effects on the user under smart grid power scheduling.

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**References:**

[1] Liang Zhou, Joel J. P. C. Rodrigues, Luís M. L. Oliveira: QoE-driven power scheduling in smart grid: architecture, strategy, and methodology. IEEE Communications Magazine 50(5): 136-141 (2012).
[2] Chris Tuppen, "Introduction to Smart Grids and Meters"www.culleninternational.com/ressource/305/0/chris-tuppen-modu.pdf .
[3] Q. Morante, N. Ranaldo, A. Vaccaro, E. Zimeo,"Pervasive grid for large-scale power systems contingency analysis", IEEE ransactions on Industrial Informatics, vol. 2, no. 3, pp. 165-175, Aug. 2006.
[4] M. Liserre, T. Sauter, J.Y. Hung, "Future Energy Systems: Integrating Renewable Energy Sources into the Smart Power Grid Through Industrial Electronics," IEEE Industrial Electronics Magazine, vol. 4, no. 1, pp. 18-37, March 2010.
[5] National Institute of Standards and Technology,"NIST framework and roadmap for smart grid interoperability standards, release 1. 0," N IST Special Publication 11 08, Jan. 2010. [Online]. The document can be available online at this address: http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf.
[6] C. Cecati, C. Citro, A. Piccolo, P. Siano, "Smart Operation of Wind Turbines and Diesel Generators According to Economic Criteria," IEEE Transactions on Industrial Electronics, vol.58, no.10, pp.4514-4525, Oct. 2011.
[7] Vehbi C. Güngör, Member, IEEE, Dilan Sahin, Taskin Kocak, Salih Ergüt, "Smart Grid Technologies: Communication Technologies and Standards," IEEE transactions on industrial informatics, vol. 7, no. 4, november 2011 M.Krunz and A.Muqattash, the Universities of Arizona, Transmission Power Control in Wireless Ad-hoc Networks:Challenges,Solutions and Open Issues IEEE-2004.
[8] N. Poojary, S.V. Krishnamurthy and S. Dao, Medium access control in a network of ad hoc mobile nodes with heterogeneous power capabilities, in: Proc. IEEE International Conference on Communications (ICC 2001), Vol. 3 (2001) pp. 872.
[9] S.Narayanaswamy, V. Kawadia, R.S. Sreenivas and P.R. Kumar, Power control in ad-hoc networks: Theory, architecture, algorithm and implementation of the COMPOW protocol, in: Proc. European Wireless 2002 (February 2002).
[10] R. Ramanathan and R. Rosales-Hain, Topology control of multihop wireless networks using transmit power adjustment, in: Proc. INFOCOM 2000, Vol. 2 (March 2000) pp. 404–413.
[11] Kaushik R. Chowdhary, Nagesh Nadiraju, Pritam C, and Dharma P. Aggrawal, "Channel Allocation and medium access control for Wireless Sensor Networks"Ad Hoc Networks, 2008 Elsevier.
[12]Giuseppe Anastasi, Marco Conti, Mario Di Francesco, and Andrea Passarella "Energy Conservation in a wireless Sensor NetWork: A Survey". Ad Hoc Netwoks, Elsevier 2008.
[13]Feng Zhao and Leonidas J. Guibas "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann Publisher .
[14]Frederic Butler, "A Call to order – A regulatory perspective on the smart grid," IEEE Power & Energy Magazine, April 2009.
[15]S . M. A m in and B. F. Wollenberg, "Toward a s m art grid: pow er delivery for the 21s t century," IEEE Power Energy Mag., vol. 3, no. 5, pp. 34–41, S ep. /O ct. 2005.
[16] E . S antacana, G . Rackliffe, T. L e, and F. X iaom ing, "G etting s m art," IEEE Power Energy Mag., vol. 8, no. 2, pp. 41–48, Mar. /A pr. 2010.
[17] T. F. G arrity, "G etting s m art," IEEE Power Energy Mag., vol. 6, no. 2, pp. 38–45, Mar. /A pr. 2008.

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