A METERING NETWORK FOR A SMART PREPAID SCHEME UNDER AN ELECTRICAL UTILITY ORGANIZATION

By

Syeda Afra Saiara(16321165)

A Thesis Submitted to the Department of Electrical and Electronic Engineering of BRAC University in Partial Fulfilment of the Requirement of the Degree of Bachelor of Science in Electrical and Electronic Engineering

[EEE]
Brac University
June 2020

Declaration

It is hereby declared that

1. The thesis submitted is my own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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Student's Full Name & Signature:

SYEDA AFRA SAIARA
16321165

Approval

The thesis titled “A Metering Network for a Smart Prepaid Scheme under an Electrical Utility Organisation” submitted by

1. Syeda Afra Saiara(16321165)

of Spring, 2020 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Department of Electrical and Electronic Engineering on 30-06-2020.

Examining Committee:

Supervisor:
(Member)

Dr. S. M. Lutful Kabir
Professor,IICT
BUET

Program Coordinator:
(Member)

Dr.Abu S.M. Mohsin
Assistant Professor,EEE
Brac University

Departmental Head:
(Chair)

Dr. Shahidul Islam Khan
Chairperson & Professor, EEE
Brac University

Abstract

The present prepaid metering scheme is connected to server mainly using GSM network. It creates an inherent dependence on mobile companies. Moreover, there is always an operational (recurring) cost to maintain different kinds of information exchange. Therefore, it will be beneficial for the utility organizations if they could develop a low-cost network of their own.

The objective proposed thesis work is mainly to develop a backbone metering network which once installed can be used for information exchange almost free of recurring cost. The establishment cost of the network may be high but it can be justified by the benefit that the utility organization can derive from it.

The backbone may be composed of mixed technologies. Some portion of the network may be established with optical fibre, some may be with copper wire and also some may be wireless. All options and their suitability for different portions will be studies and tested to set up a standard.

The work will finally be tested and the proposed network will be up for suggestion to be implemented in the smart meter networking scheme.

Keywords: Smart Prepaid Meter, Optical Fiber,

Dedication

With immense love and gratitude, I would like to dedicate this work to my parents, friends and mentors whose visionary intellect have inspired me to take up this task, and whose kind words motivated me to complete what I had started.

Acknowledgement

All praises and gratefulness to Allah, the Lord of the world, for giving the strength to proceed and persevere to accomplish our task.

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My gratitude extends to all the staff of the Department of Electrical and Electronic Engineering of BUET and Brac University.

Finally, I wish to remember my family, friends and loved ones one more time for being my pillars of strength.

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List of Acronyms

GSM	Global System for Mobile
	Power Line Communication
PLC	
	Radio Frequency
RF	
GPRS	General Packet Radio Service
EMF	Electro Magnetic Fields
SMETS2	Smart Metering Equipment Technical Specification Standard 2
M2M	Machine to Machine
IPTV	Internet Protocol Television

Chapter 1. Introduction

1.1 Introduction

The present prepaid metering scheme is connected to server mainly using GSM network. It creates an inherent dependence on mobile companies. Moreover, there is always an operational (recurring) cost to maintain different kinds of information exchange. Therefore, it will be beneficial for the utility organizations if they could develop a low-cost network of their own.

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The backbone may be composed of mixed technologies. Some portion of the network may be established with optical fibre, some may be with copper wire and also some may be wireless. All options and their suitability for different portions will be studies and tested to set up a standard.

The work will finally be tested and the proposed network will be up for suggestion to be implemented in the smart meter networking scheme.

1.2 Objective

At present in Bangladesh there are around only 50,000 smart meters in use. While it is the ultimate goal of the government to switch to the smart metering technology, the main obstacle faced by them is the mode of communication that will be used to connect this vast number of devices. While there has been some experimentation done with PLC and RF technology, the majority of these 50,000 smart meters are connected using the GPRS technology.

However, there has been problems associated with this existing system of communication using GPRS technology. These issues will be discussed in greater detail in the following pages. But to state primarily the objective of this thesis is to develop a backbone metering network which will address those difficulties of the previous technologies and try to put forward a new and unique metering network system.

1.3 Motivation

As will be discussed in the upcoming chapters, from the Power Division Ministry of Bangladesh's website, it has been reported that there is almost 5-7% of generated power is lost due to "non-technical losses such as contracting out meter reading and billing, computerized billing and cut-offs and legal penalties."

It is estimated that around BDT. 4000 crore worth of electricity is consumed in Bangladesh per month on an average. Thus, a 5-7% of power loss would account for a massive loss of BDT. 3000 crore per annum.

This study motivated us to do some work in this line to help the utility companies to switch to smart metering scheme so they could prevent this loss from taking place.

1.4 Literature Review

A number of remarkable works has been done on smart meter networking scheme ranging from the design of a simple meter to a master plan for an entire feasible smart grid system for a nation.

In [1] a detailed explanation has been presented of what a prepaid meter is, and some of the drawbacks of the existing prepaid metering system. Furthermore, a framework for a smart metering system is proposed followed by the design of a prototype of the prepaid meter in discussion.

[2] discusses the various Wireless technologies that may be used in a smart meter networking scheme. It presents the various advantages and disadvantages associated with each technology, and was credible and relevant to our research because the write was done in the context of India, which is a similar economy to us in terms of population pressures and resource scarcity.

The main analysis of [3] revolves around the growing popularity of IoT (Internet of Things) and how this technology can be used as the backbone of smart metering network.

[4] brings in light a rather pressing issue of RF and EMF radiation emitted from smart meters, which are well above the permitted figures. This was eye opening to us because we understood from this paper that while designing our scheme, we had to take into account the fact that it must be low emitting and less harmful to the environment.

[5] gives an overall insight into a smart grid system.

1.5 Organization of the Thesis

This book is organised in six chapters which are given as follows:

- Chapter-1 introduces the reader to our work by presenting a brief summary of certain notable related works which have been done in this field by some previous groups, and the objective and motivation behind our work.

- Chapter-2 is divided into three different sub topics; the first explains the basic definition of what a smart metering network is, the latter ones discuss some categories of this network and describes the present scenario of smart metering network in Bangladesh respectively.

- Chapter-3 proposes the mixture of technologies to be implemented in the Smart Grid scheme for Bangladesh as the final outcome of this thesis work.

- Chapter-4 closes with some prospects for future work.

Chapter 2. Some General Discussion on the Topic

2.1 Basic Concepts and Definitions of Smart Meter and Metering Network

A smart meter is an electronic device that records consumption of electric energy and communicates the information to the electricity supplier for monitoring and billing. Smart meters typically record energy hourly or more frequently, and report at least daily. Smart meters enable two-way communication between the meter and the central system.

Since smart meters are still a new concept in Bangladesh, we have looked into the smart metering scheme that is being used in England to explain to our reader the basic working principle of a smart metering network. The case study is as follows:

" A Smart Meter works by measuring the current flow and voltage at regular intervals and then adding this up to calculate the power used in a half hour period. Similarly, for gas the flow is measured at regular intervals. This information can be sent to your In-Home Display and to your supplier. Different communications technologies may be used in different kinds of premises for the Home Area Network to communicate with your In-Home Display, and different technologies will be used in different parts of the country to allow the Wide Area Network to send data to and from the company providing the communications.

As well as measuring energy, meters are constantly monitoring their own performance and environment. For example, they will report if they have an internal memory problem and report if the terminal cover is removed. In these cases, your supplier may send someone to your home after contacting you.

The information from your meter goes first into a communications hub that is usually built into the electricity meter, and then through radio waves to the communications company. In the case of the SMETS2 meters it is the Data and Communications Company (DCC). From there it is sent on to the various DCC Services users who have a need for the data.

A diagram of the network topology is shown below.

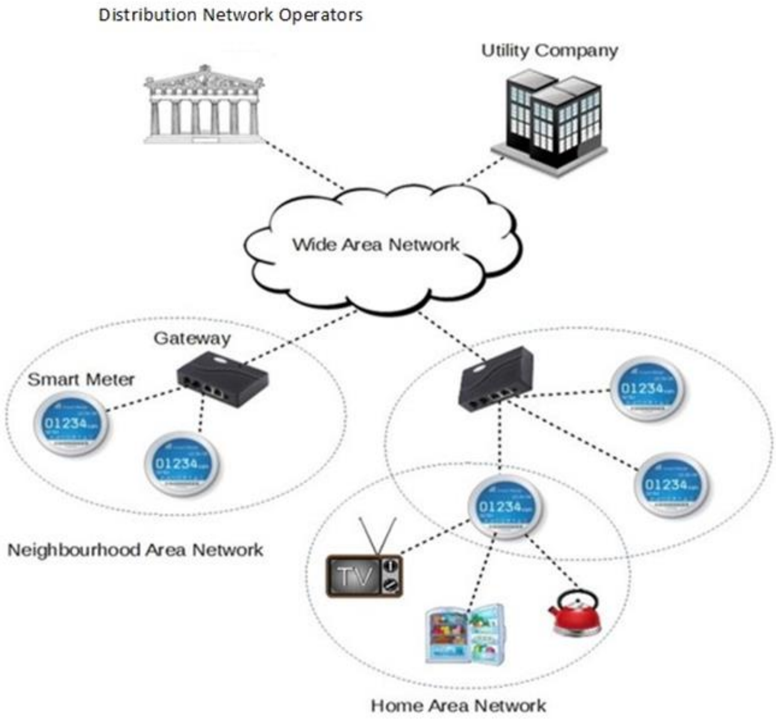

Figure 2.1: Advanced Metering Infrastructure (AMI) Network Architecture.

In your home as an energy customer you will have a smart meter for electricity and a smart meter for gas (if you are dual fuel). Both meters communicate with a communications hub which is normally a part of the electricity meter however it could be separate if your gas smart meter is installed first. To power the communications in the gas meter a battery is used as it would be dangerous to use mains electricity.

In addition, you will have an In-Home Display which is powered though the mains and communicates with the meters through the same communications hub. In the future more gadgets could use the communications hub, provided they have the right security credentials.

To minimise costs for the long-term use of SMETS2 meters the DCC went out to tender for the communications network having split the country into regions for this purpose. So depending where you are you could have one of two companies communicating with your meter, Arqiva Limited in the north and Telefonica in the central and southern regions.

Once received by the DCC the data is processed by the Data Services provider, currently CGI UK Limited. Overall the whole of DCC is facilitated by Capita plc.

From the DCC, the Smart Meter messages can be sent to various Service Users depending on the messages content. Electricity and gas suppliers and distribution network operators will all have a keen interest in the data from Smart Meters. They will use it for the following reasons:

- Suppliers
    - Meter readings - for billing purposes
    - Half Hourly readings - for additional services or sophisticated products

    - Maintenance messages about the health of the meter - such as memory problems
    - Firmware messages - to update the software in the meter
    - Configuration messages - to set up new products
    - Pay As You Go messages - to top up PAYG credit
    - Tamper messages - to detect theft and security attacks
    - Export meter readings - to measure how much electricity your solar cells or wind turbine is passing back to the network for load management and to credit the customer depending on the commercial arrangement.

- Distribution Network Operators
    - Power outage messages - to know when and where outages occur
    - Meter readings - for network billing to suppliers
    - Half Hourly readings - for network load planning
    - Voltage, Current and Power Factor readings - for network operation and planning.
    - Export meter readings - for network operation and planning.

- Other Authorised Parties
    - Meters readings - to analyse and show you your energy usage
    - Half Hourly readings - to analyse and show you your particular energy profile shape. "

2.2 Categories of Metering Network

1. Fibre Optics Network

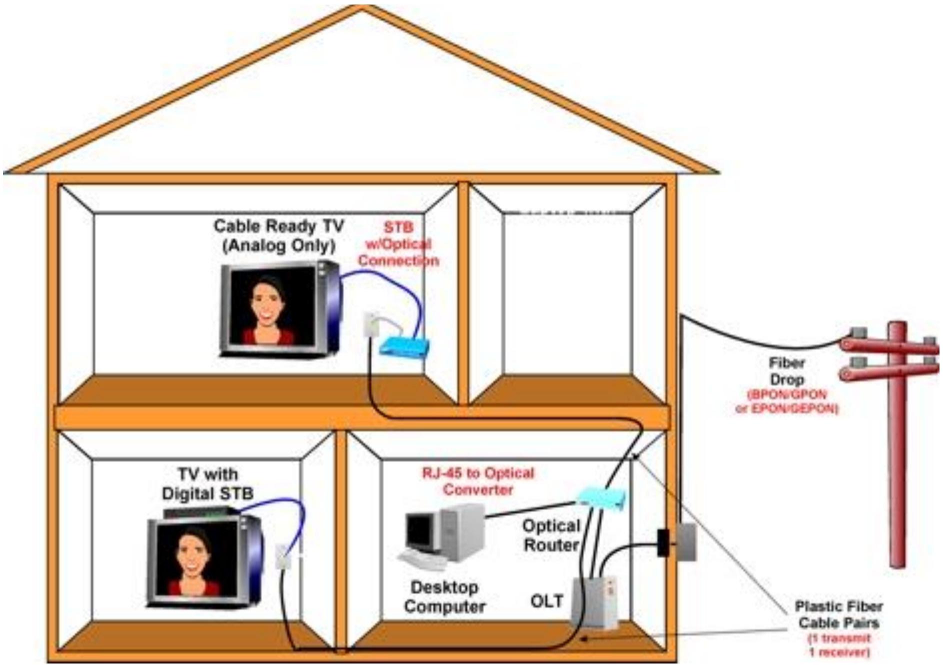

Figure 2.2: A current application of Optical Fiber communication technology for IPTV network..

Optics communication, given the requirements of mission-critical applications and the objective of politicians to get fibre connections as soon as possible to almost all households, fibre optical networks appear to be the preferred solution for Smart Grid. Optical fibre is the fastest and highest bandwidth network available, supporting a wide range of communication protocols and services (Evens et al. 2011). Furthermore, Fibre to the Home (FTTH) networks are future proof. However, this communication infrastructure does not play a significant role in the many broadband markets yet. The low penetration of fibre as an access technology relates to the costs of deploying FTTH-networks. The costs range between € 500 in dense urban areas and € 2000 in rural areas (Casier et al. 2008). Even more intensified cooperation between utilities and telecommunication operators (Tahon et al. 2013) cannot change the expectation that FTTH networks will not be an option in the upcoming years to support end-user oriented Smart Grid appliances to a considerable degree. The same applies to network-oriented appliances in the electricity grid. Here, the network elements (e.g. substations) are usually not equipped with access to optical fibre networks. From a cost point of view, it is far too expensive to deploy fibre networks only for Smart Grid purposes. Looking at the requested data throughputs, one has to acknowledge that the large bandwidth that fibre optical networks provide is simply not needed. A concluding remark refers to the above-mentioned link between national broadband plans and the deployment of Smart Grid (Mayrhofer/Römer 2012). Against the background of the costs of FTTH-networks we can hardly expect an availability of these access networks at locations where typically renewable energy sources feed the electricity grid. Current developments show that wireless technologies like LTE or LTE Advanced using frequencies at 700 MHz (digital dividend part two) are more likely to close the geographical digital divide.

2. DSL (Digital Subscriber Line)

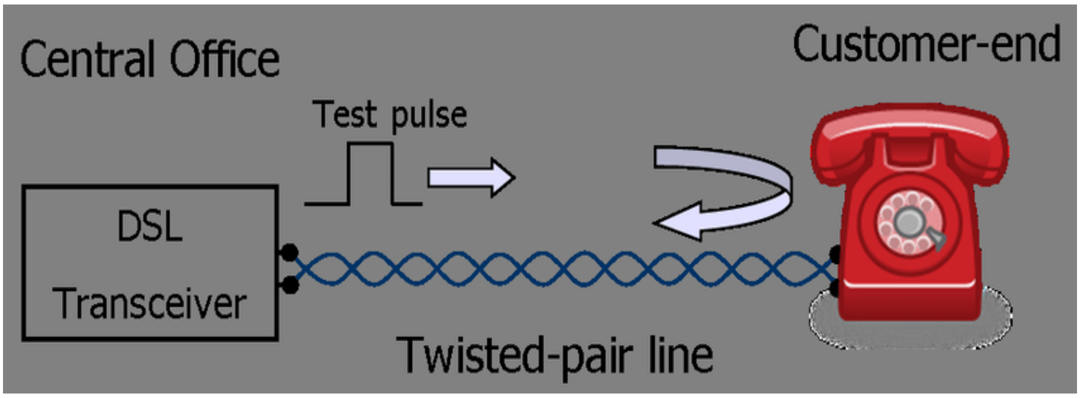

Figure 2.3: A current application of DSL communication technology for wired telephone (TNT) network.

Today the majority of broadband connections are based on DSL, although in some countries cable is growing faster. Access to DSL is available in dense urban areas, whereas in some rural areas the infrastructure is still less developed. At first glance, DSL technologies are viewed to offer low cost services for Smart Grid because the physical infrastructure is already available and the bandwidth required for Smart Grid applications is marginal. However, the use of DSL faces significant challenges in terms of access line regulation, dependence on the customer and installation cost. The wholesale price for local loop unbundling, i.e., the use of copper line to each house, is regulated. If an additional service is offered, a new allocation of costs must be carried out to determine the wholesale price. Smart Grid applications need transmission resources which are comparable to those that retail customers use for voice telephony. Today, even if these retail customers have subscribed only to such limited voice services, they have to pay the full price. According to regulatory considerations, using DSL technology for Smart Grid means first of all to open up the controversial discussion on wholesale prices for local loop unbundling. Because this part of the regulatory landscape is highly disputed, we can expect legal proceedings which can have negative repercussions on the deployment of Smart Grid. In the event, that the regulatory authority is able to re-allocate the costs in a way that the involved stakeholders agree, another challenge remains. What happens to the customer-independent Smart Grid services if the end-customer terminates his DSL contract? In that case, the function of the advanced metering infrastructure will be interrupted. Consequently, from a functional perspective any kind of Smart Grid access must be independent of customer behaviour. DSL will also likely incur higher installation costs compared to power line or certain wireless technologies. Usually, the wired infrastructure needs an additional wired or wireless link to the Smart Meter for which the consent of the owner of the premises is needed. Both the additional infrastructure and the requirement to involve the owner increase the one-time costs of installation. With regard to one’s interest to avoid a lock-in effect, it could be a shortcoming that DSL providers usually offer a product bundle comprising connectivity and IT services, such as data management which is primarily aimed at smaller utilities which do not have their own resources.

3. Power Line Communication

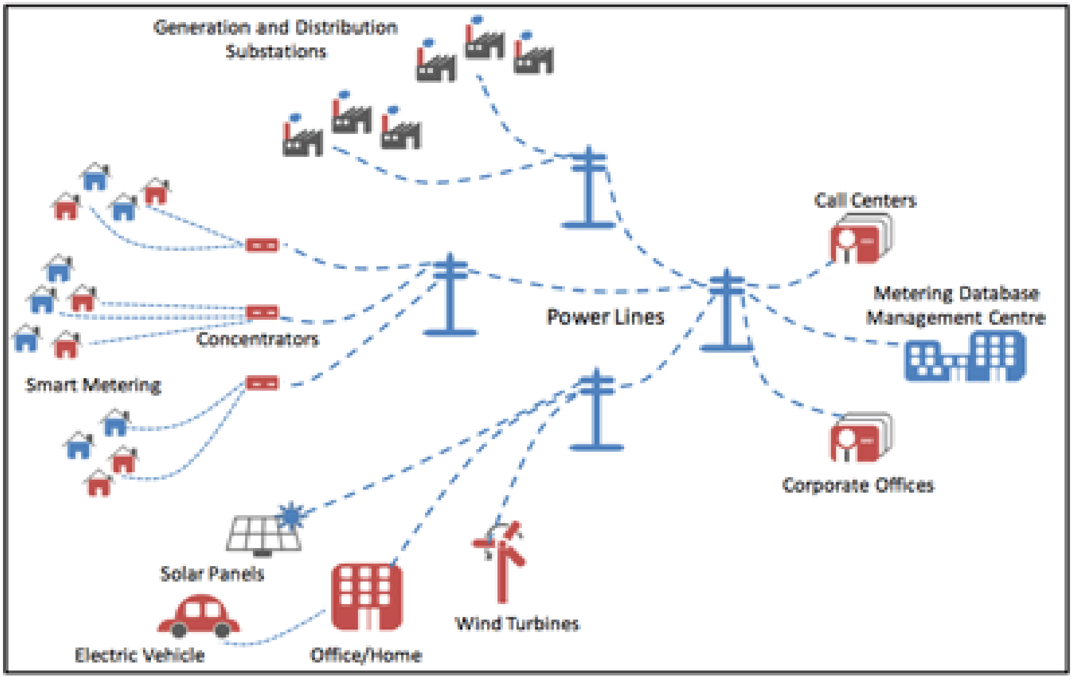

Figure 2.4: Power Line Carrier (PLC) communication is transferring data through power cables.

Power line communication Power line communication is widely used by utilities for remote metering in many countries around the world (Galli et al. 2010). The deployment of power line is motivated by both the shortcomings of commercial offerings and the interest of one to exert control over the communication infrastructure given that they have responsibility for grid operation. The power line technology operates by sending modulated carrier signals on the power transmission wires. Typically, data signals cannot propagate through transformers and hence communication is limited within each line segment between transformers (Wang et al. 2011, Until recently, utilities chiefly deployed single carrier narrowband solutions. Narrowband power line is now being upgraded to broadband systems operating in higher frequency bands. Hereby data rates up to 200 Mb/s can be achieved. Whereas power line technology was not able to compete with wired broadband technologies (e.g., DSL, cable) in the mass market for broadband connections, this is not the case in the Smart Grid giving new market opportunities to this technology. Advocates of power line (Schönberg 2012) highlight the fact that the physical lines needed for PLC already exist. This could lead to lower (operating) costs, although we have to bear in mind that the cost structure depends on the number of connected devices. As mentioned above, due to lower external cost and general line availability, the power line technology is often used in smart meter pilots. Additionally, power line can be used for home area network (HAN) purposes. Furthermore, the data rates required for the different applications are within the broadband power line capabilities. The shortcomings of traditional narrowband power line are as follows: A critical feature of Smart Grid is the capability to transfer data in real-time. That applies primarily to the frequency stability and power flow status in low and medium voltage grids. Here, the office needs reliable data in order to keep the network stable. Pilots revealed that, especially when narrowband power line is used, the technology does not always fulfil this requirement. Another shortcoming of power line relates to interference. In the event that power line technology is used nationwide to connect up to 80 per cent of smart meters, it is not clear how power line will affect radio applicants (e.g., broadcasting services). According to the German security profile defined by BSI, the capacity of narrowband power line is not sufficient to carry the metering traffic with required security features. As a consequence, broadband power line seems to be the more relevant technology for Smart Grid. However, broadband power line uses the same frequency spectrum as in-house power line for LANs and also for some radio applications (i.e., emergency services). Therefore, interference on same grid communications caused by other usage as well as disturbances of other users can occur, especially in the case of an extensive use of broadband power line for smart metering. Since broadband power line uses higher frequencies, the signal attenuation is much higher than for narrow band power line. Furthermore, the regulatory emission limits for the protection of radio applications limits power line operation to relatively small signal levels as a result of which line amplifiers are often required if distances between substations and smart meters are too long. Moreover, the signal coupling between the power line modem and power grid, and thus signal strength, is highly unpredictable because of unknown and time varying impendency of the power grid for higher frequencies. This also can lead to implementation of additional line amplifiers for higher availability. In addition, in the event of an outage, communication over power line is not available, a highly undesirable situation. Consequently, power line is not easily equipped for critical applications in the power grid. And finally, broadband power line is a relatively early stage and non-standardized technology. Choosing broadband power line solutions for smart metering and critical network-oriented applications appears at least risky.

4. Mobile Network

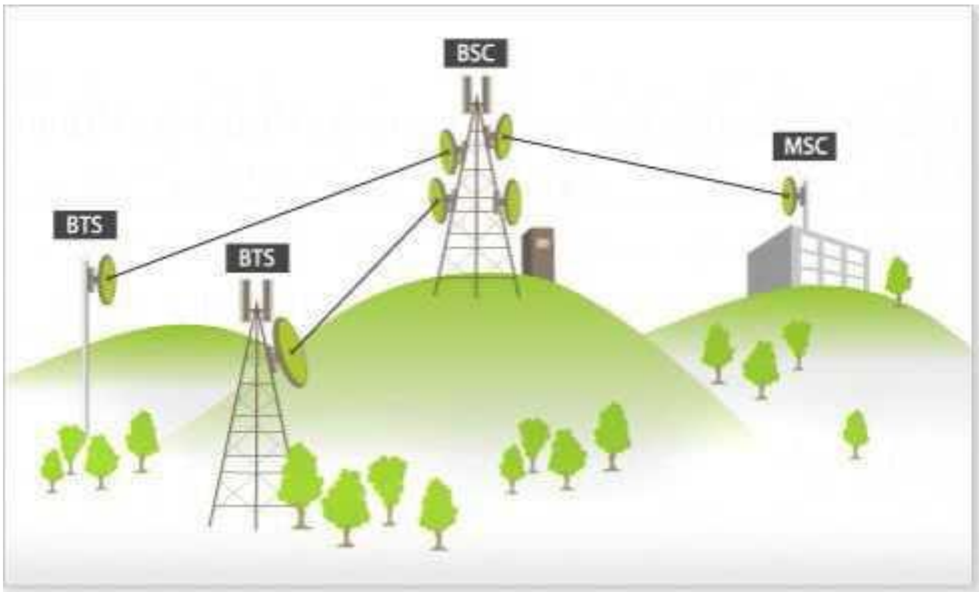

Figure 2.5: A mobile network showing the Mobile Switching Centre (MSC), Base Station Controller (BSC) and Base Transceiver Station (BTS).

The first alternative is to use the services of public, commercial mobile networks, where it is doubtful whether operators can offer a dedicated service with high SLA (Service-Level Agreement) in principle (issue of net neutrality) and at an acceptable price level.

5. GSM (Global System for Mobile)

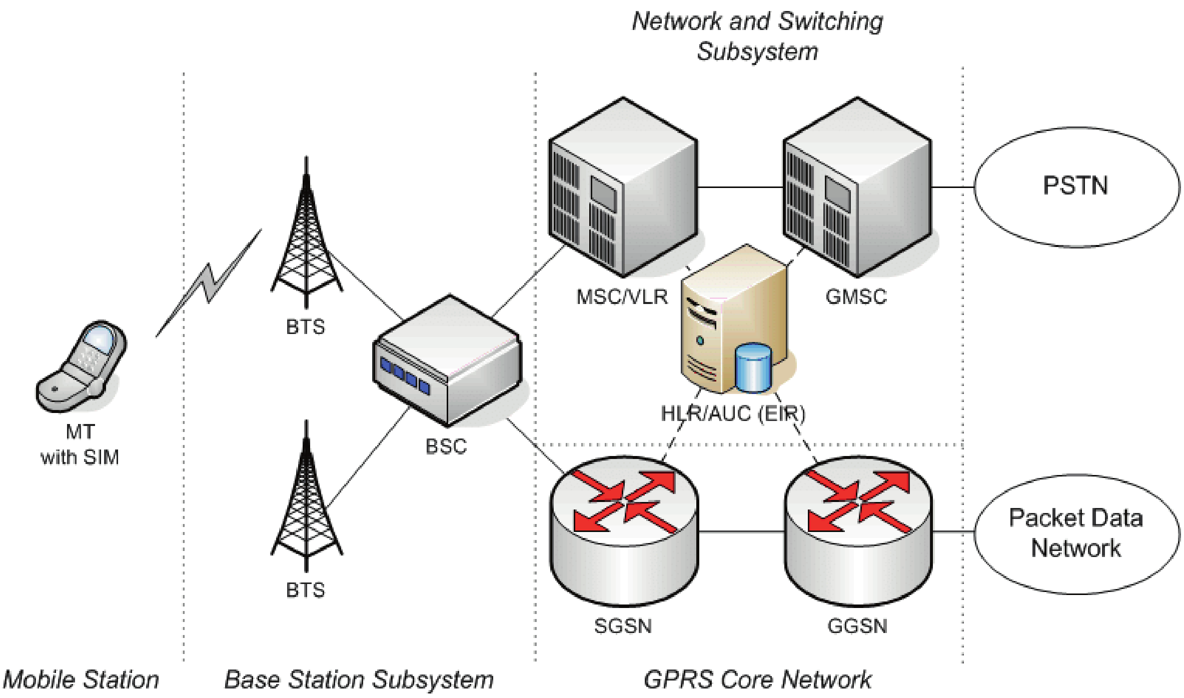

Figure 2.6: The structure of a GSM Network.

Other than GSM/GPRS in the 900 MHz band, the majority of mobile operators have not switched to another technology (like UMTS or LTE). For example, the German mobile operators have constantly repeated that from a short-term perspective GSM/GPRS remains the prevailing technology in this frequency band. Hence, Smart Grid in the 900 MHz frequencies uses GSM/GPRS. Other technologies might be deployed after 2020. Currently, trials in Germany and in other EU Member States use GSM/GPRS as the WAN for the Smart Grid. 9 The use of this technology reflects primarily the fact that GPRS is currently the only mobile technology which is accessible almost everywhere in the country. Furthermore, GSM/GPRS networks at 900 MHz are able to provide reasonable indoor coverage and data services are available at reasonable cost. However, observing the requirements outlined above and taking into account results from trials (Ernst & Young 2013, 49) it becomes obvious that GPRS has some significant limitations; certain performance requirements are not met by GPRS (e.g., latency). The indoor coverage of GSM networks is probably the best of any commercial networks, given its 900 MHz spectrum band and comprehensive area coverage, but pilots have shown that the coverage is often insufficient for Smart Meters. Since in the 900 MHz band all frequencies dedicated for mobile telephony (or mobile access to the internet) have already been allocated, there is no possibility to deploy a private network. As a consequence, GSM/GPRS in 900 MHz is only available as a service on commercial networks with shortfalls in terms of security, control, availability and resilience. Here we have to bear in mind that GSM/GRPS networks have been designed, dimensioned and deployed to offer mobile voice telephony to end users. The networks are ill prepared to handle the signalling traffic of millions of devices which occurs with the advanced metering infrastructure on top of mass market voice services. Service guarantees and dedicated quality of service to ensure priority message delivery cannot be guaranteed by mobile operators. In addition, it is expected that GSM/GPRS will be substituted by other technologies in the midterm which are more efficient. Thus, it can be assumed that mobile operators will not invest in this technology to improve the network quality for just one class of service. In summary, although the use of GSM/GPRS is the simplest alternative available to utilities, as it avoids any further decision on communication solutions and related investments and deployments, there is a mismatch between the utilities' requirements and the capabilities and lifecycle of GSM/GPRS. While GSM/GPRS is dominant in current trials because of its wide availability, it appears that GSM/GPRS is generally seen as an inferior solution when a full-fledged roll-out of the AMI is considered.

6. LTE (Long Term Evolution)

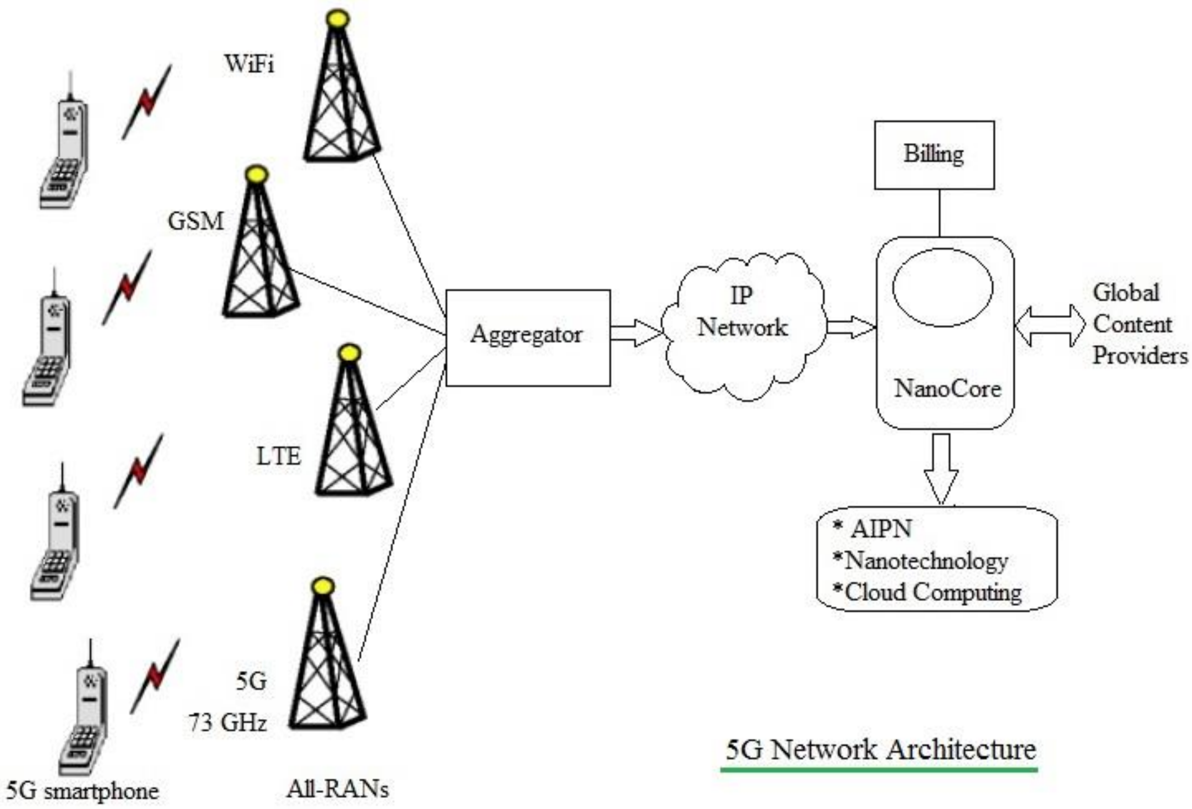

Figure 2.7: The structure of a 5G Network Architecture.

LTE as a new global standard for mobile (broadband) data has attracted considerable attention in the context of Smart Grid (Brown/Kahn 2013). LTE networks are currently operated in the frequency bands at 800 MHz, 1800 MHz and 2,6 GHz. In light of the increasing demand for mobile data services it is assumed that mobile operators will ask for additional frequencies in a mid-term perspective (Kürner 2013). Due to propagation characteristics only LTE at 800 MHz offers the opportunity to provide the necessary indoor coverage in most cases. But, for the time being, LTE at 800 MHz does not provide nationwide coverage in most European countries. Furthermore, in some regions LTE is or will be the only technology which gives access to the Internet. Consequently, network capacity is limited. Although LTE 800 fulfils broadly the performance requirements (e.g., latency), we have to take into account, that LTE 800 is firstly being rolled-out by commercial operators only10 and secondly will not be designed and optimized for M2M traffic. The current use cases of LTE differ significantly from the use case we have identified in Smart Grid. The opportunity costs arising in the event Smart Grid traffic crowds out mass-market applications in the retail market will impact pricing of the Smart Grid traffic making it more expensive. The better LTE succeeds in the market, the higher the opportunity costs which subsequently have to be reflected in the wholesale prices for Smart Grid services. The telecommunication operator has to bear in mind that M2M traffic with a high number of installed devices, like the Smart Meter, uses a large part of network resources. Congestion in commercial networks can only be avoided if the network concerned is operating with sufficient resources in frequency bands below 1 GHz and is optimized for M2M traffic pattern. In summary, although LTE 800 fulfils some requirements there are doubts whether it is technically and economically feasible for mobile operators to enter the market for Smart Gird communication. Furthermore, choosing commercial LTE 800 services for Smart Grid communication faces several of the shortcomings of GSM/GPRS 900: chiefly no control over the network and therefore a lock-in to providers which will first service the mass consumer market for revenue reasons.

7. CDMA (Code Division Multiple Access)

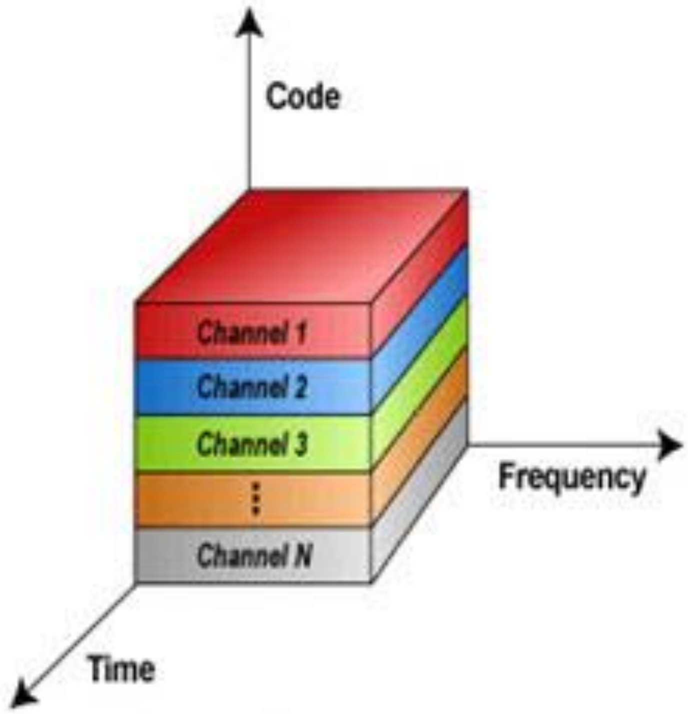

Figure 2.8: CDMA in which each channel is assigned a unique code which is orthogonal to codes used by other users.

The 450 MHz frequency band is available in many European countries (being either underutilized or unassigned) and has in comparison with 800 MHz and 900 MHz a striking benefit: due to its lower frequency range, the propagation characteristics enable much better building penetration than GSM 900 and LTE 800. Moreover, mobile networks in the 450 MHz spectrum require approximately four times fewer base stations than mobile networks at 800 and 900 MHz (irrespectively of the technology deployed), thereby offering much better stand-alone economics. Currently, the standardized CDMA (3G) technology is available at 450 MHz In the mid-term, LTE technology will become an alternative. Standardization of LTE for

450 MHz is on the way and first suppliers have LTE equipment available. It is likely that operators in Brazil will deploy LTE in this frequency band starting in 2014. However, LTE has yet to be optimized for M2M use cases. CDMA EV-DO Rev. A provides a data throughput of 1.8 Mb/s in the uplink and 3.1 Mb/s in the downlink. The latency criteria of network-oriented applications are also met. Existing CDMA450 networks in more than 60 countries and a well-developed supply ecosystem ensure longer term equipment availability. CDMA technology is being further optimized for M2M use by new standard developments such as CDMA 1X Rev F. A recent analysis of the economics of a Greenfield CDMA450 network revealed low unit cost making the CDMA450 solution not only technically superior but also cost competitive with power line and GSM/GPRS (Sörries 2013). In summary, as spectrum is available in many countries, CDMA (or alternatively LTE) at 450 MHz is a valid opportunity for the deployment of Smart Grid communication. Compared to the alternatives of GSM/GPRS 900 and LTE 800, the 450MHz band is not widely used in Western Europe for mass market deployment for mobile services. In many countries the spectrum is either unassigned or currently underutilized, making it available for Smart Grid communication. It is not only technically, but also from a spectrum/network availability standpoint, very well suited for deploying/operating networks that are wholly or partially dedicated to Smart Grid.

2.3 Present Scenario of Bangladesh's Metering Network

Prepaid meter users pay for their energy before they use it - usually by adding money to a 'key' or smart card, which is then inserted into the meter. At present, Bangladesh has around more than 22 lac prepaid meters in use throughout the country. Our country is slowly advancing towards replacing all the electricity meters to prepaid meters. The reason behind this is that prepaid meters benefit consumers in the way that it helps them to manage their resources more efficiently and reduce wastage of electricity. Financially they benefit that there is no minimum charge associated with prepaid meters.

From the Power Division Ministry of Bangladesh's website, we learn that there is almost 5-7% of generated power is lost due to "non-technical losses such as contracting out meter reading and billing, computerized billing and cut-offs and legal penalties." There have also been complaints such as tampering with the readings and illegal connections and so on.

In the post-paid metering system 'meter readers' take readings off the meters on a monthly basis and then an extensive billing process is carried out. This multiplied by the total number of 3 crore 20 lac consumers throughout the country, this surely becomes an overwhelming process. The procedure of manual reading is shown in the picture below.

Figure 2.9: 'Meter Readers' collecting readings off post-paid meters.

Compared to this, on the other hand the scenario becomes much simplified with a pre-paid meter as can be seen in the following picture.

Figure 2.10: A digital Prepaid Meter used by DESCO, being recharged by a consumer.

In prepaid meters, there is no hassle of reading or billing as was in the previous case.

The next technology that follows prepaid meters is the smart meter. Smart" indicates information exchange and/or programmable capabilities. Using smart metering technologies, the utility companies not only can monitor the data of meters (electricity consumption details, demand, Power, Tamper information if any etc.) remotely, but also they can control the meters remotely which includes disconnection of power to any consumer, reduce the permissible load to any consumer or any other relevant programming at consumer end. At present in Bangladesh there are around only 20000 smart meters in use. While it is the ultimate goal of the government to switch to the smart metering technology, the main obstacle faced by them is the mode of communication that will be used to connect this vast number of devices. While there has been some experimentation done with PLC and RF technology, the majority of these 20000 smart meters are connected using the GPRS technology.

Some of the main problems that have been noted by the users of the GPRS technology are that it creates an inevitable dependency of the utility providers on the telecommunication companies. The technology has proven to be quite expensive since the private telecommunication companies charge a high rent. The reliability of this process is also to question because in many rural areas it has been observed that the connectivity is quite poor.

Chapter 3: Results

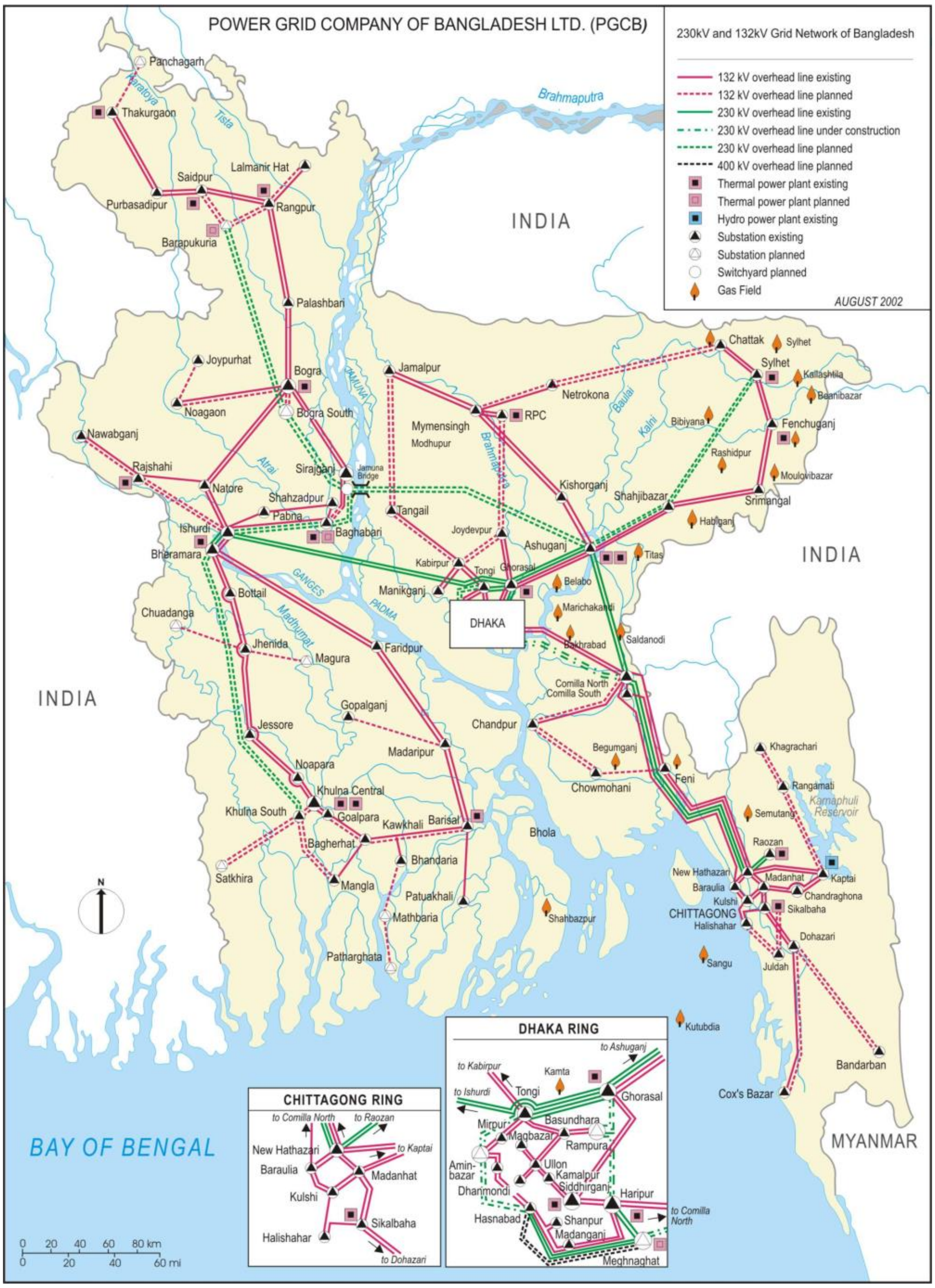

Figure 3.1: Existing Grid Map of Bangladesh prepared by PGCB (Power Grid Company Bangladesh).

The previous figure shows the present grid map of Bangladesh.

Bangladesh is planning to implement Smart Grid scheme in the near future.

At present, there is a nuclear powerplant project ongoing in Ruppur region. The first phase of this project is expected to be ready for operation by 2023. A crucial factor of running nuclear plant is that the frequency needs to be very precise. Currently, Bangladesh manages the frequency at a a range between 48Hz to 52 Hz, with the real value being 50 Hz, with a 2Hz inaccuracy.

However, to operate nuclear power plant, the accuracy may only be allowed up to 49.5 Hz to 50.5 Hz.

This is never possible with manual system. Thus, Smart grid scheme is inevitable.

Under these circumstances, after thorough analysis of the communication technologies, the following mixture of technologies is proposed for the Smart Metering scheme in Bangladesh.

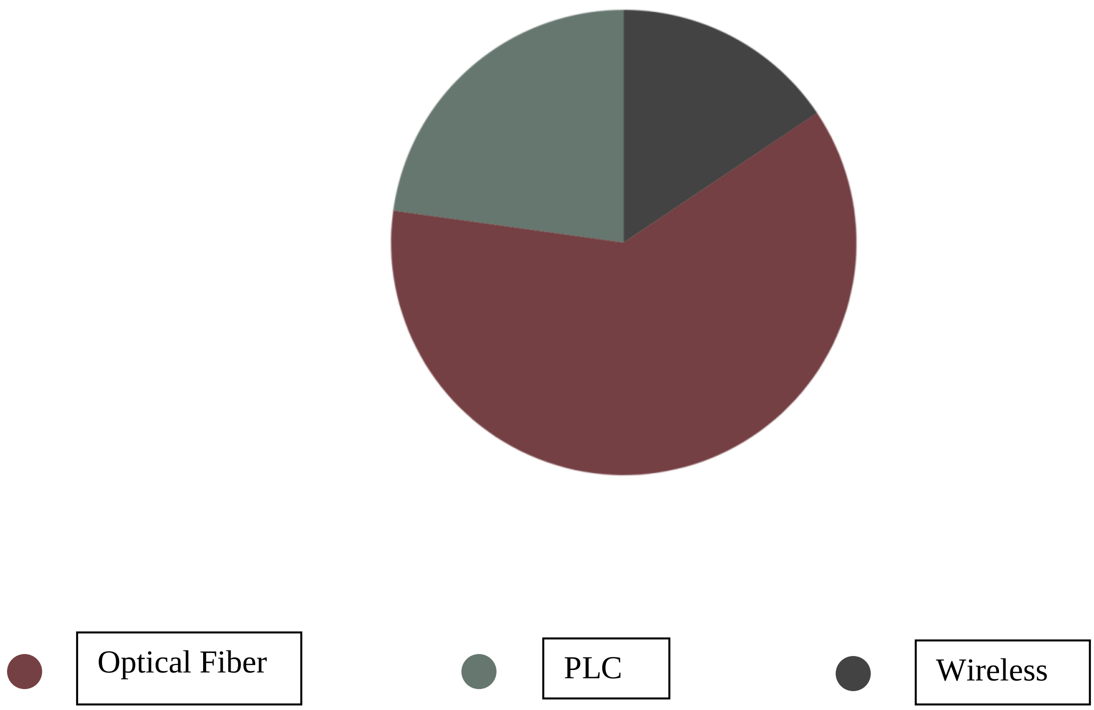

Figure 3.2: Proposed Mixture of technologies for Bangladesh Smart Grid

Chapter 4: Conclusions

Future Work:

While undertaking this work, a rich variety of interesting and significant research areas were revealed which may be pursued as future work.

Since a mixture of technologies will be implemented in the smart scheme, research may be done to find out techniques for better interoperability among the different technologies.

Secondly, research may be done on how to utilize the proposed network structure for other uses like, internet connection, and by all other ministries such as health, education, disaster management, transportation and administrative ministry. New techniques of multiplexing the optical fiber network may be look upon to achieve this.

Lastly, to conclude, the objective of this thesis work was mainly to develop a backbone metering network which once installed can be used for information exchange almost free of recurring cost.

The uniqueness of this was that it would be composed of mixed technologies. Some portion of the network may be established with optical fibre, some may be with copper wire and also some may be wireless.

The outcome of this work proposed that the technology should consist of 70% optical fibre network technology, 20% PLC technology and 10% wireless technology.

The benefits that the users will achieve from this setup are that

- Copper-based Ethernet connections are limited to a data transmission distance of 100 meters when using UTP cable. By using Ethernet to fiber conversion, it can extend link distance up to 80 kilometers or more.
- Electromagnetic interference, or EMI, can cause corruption of data over copper-based Ethernet links. Data transmitted over fiber optic cable is completely immune to this type of noise, ensuring optimal data transmission and network performance.
- Optical fibers allow to convert link speeds from 10 Mbps to 100 Mbps or from 100 Mbps to 1000 Mbps.

So, this idea may be applied in the smart metering network infrastructure. This network can be used for electricity, internet, gas and all other utilities. So, this would prove to be a very cost effective and efficient use of resources for the economy.

Finally, this scheme could realize our much desired plan of creating a ‘Digital Bangladesh’ where every citizen would be connected to each other and the government through a robust and reliable digital means.

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