East West University

GPRS System for Smart MeteringNetworks

An Internship Report

Submitted to the Dept. of Electronics & Communications Engineering, East West University and Dhaka Power Distribution Company Limited (DPDC) in partial fulfillment of the requirements for the degree of Bachelor of Science in Engineering (B.Sc. Eng.)

Submitted To

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Approval

The intern report titled "GPRS System for Smart Metering Networks" submitted by Md. Mobashir Hossain (ID: 2019-1-55-009) to the Department of Electronics and Communications Engineering East West University, Dhaka, Bangladesh has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of Bachelor of Science in Electronic and Telecommunication Engineering and approved as to its style and contents.

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Declaration

I declare that our work has not been previously submitted and approved for the award of a degree by this or any other University As per our knowledge and belief, this this contains no material previously published or written by another person except where due reference is made in the thesis itself. hereby declare that the work presented in this thesis is the outcome of the investigation performed by us under the supervision of Zahidur Rahman, Lecturer, Department of Electronics & Communications Engineering, East West University, Dhaka, Bangladesh.

Countersigned

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Zahidur Rahman

Signature

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Authorship Statement

By signing this document, I certify that I have completed the internship report in part fulfillment of the requirements for the Bachelor of Science in Electronics and Communications Engineering (ECE) degree from East West University. The interpretations presented are based on my reading and comprehension of the original materials, and there is no plagiarism involved. At the appropriate locations in the text, the other books, papers, and websites that we used are properly credited.

Signature

Name: **Md. Mobashir Hossain**

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I would like to thank my respected trainer **Engr. Mohammad Emdadul Haque,** Manager of the ICT Development Circle at the Dhaka Power Distribution Company Limited (DPDC), who has been a great help to me throughout my training, as well as our supervisor **Zahidur Rahman,** Lecturer in the Department of Electronics and Communications Engineering at East West University. They have my heartfelt gratitude. Without their kind aid and involvement, the internship report would not have been possible.

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Finally, I would want to thank our parents for their unwavering encouragement and motivation to complete the task.

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Certification

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Abstract

Many Smart Grid installations rely on General Packet Radio Service (GPRS) for wireless communication in Advanced Metering Infrastructures (AMI). In this paper i describe security functions available in GPRS, explaining authentication and encryption options, and evaluate how suitable it is for use in a Smart Grid environment. I conclude that suitability of GPRS depends on the chosen authentication and encryption functions, and on selecting a reliable and trustworthy mobile network operator.

Keywords: Security, GPRS, Smart grid, AMI, Smart Metering

Origin of the Report

The East West University's internship program is a prerequisite for B.Sc. graduates in order to graduate. This report is one of the requirements for the East West University's B.Sc. internship program. The primary goal of an internship is to expose students to the working world. As an intern, the biggest challenge was applying theoretical principles to real-world situations.

The following objectives of the study and the internship program:

- To gather and arrange comprehensive knowledge of the solar system.
- To get experience in a real-world work environment.
- To contrast the situation in real life with the knowledge gained at East West University
- To fulfill the B.Sc. program's requirements.

The result of a three-month internship at Dhaka Power Distribution Company Limited, this report is being written as part of a requirement for the B.Sc. program at East West University (DPDC). I have to submit a report on GPRS System for Smart Metering Networks." The topics covered in this report are DPDC's services and activities, a business overview, and customer services.

Limitations

The DPDC training center and ICT division offices were mostly where I worked. Being a new employee, it was first difficult to understand how the GPRS System worked and how it applied to DPDC. Another concern was time constraints. Analyzing a lot of data was challenging enough because of time constraints. Three months was all that my work lasted. For a complete and understandable study, nevertheless, this amount of time is insufficient. As a result, the report may contain a few unintended mistakes. I made an effort to finish the report despite a number of obstacles.

Table of Content

Chapter 1

Introduction

1.1 Introduction

Possibly the most noticeable feature of the smart grid is smart meters in an Advanced Metering Infrastructure (AMI). Every residence has a smart meter that allows for two-way communication with the distribution service operator or power provider in real time. With the use of AMIs, more precise pricing systems are possible thanks to the automatic collecting of data on energy use. Smart meters may feature breaker functionality, which enables power to be switched off remotely. They can also send signals and alarms to the DSOs. Meters may be linked to home appliances that enable automatic adjustment of power usage based on the current price level. Smart meters communicate with DSOs using several channels, although General Packet Radio Service (GPRS) is a common option in many rural areas. It was introduced as a quicker data transmission service for GSM mobile stations, providing a packet-based data service in accordance with the internet protocol (IP). It introduces a number of new network components, most notably the serving GPRS support node that connects to the mobile station via the currently operational Base Transceiver Station (BTS) and the Gateway GPRS Support Node (GPSN) at the Mobile Station's home operator that connects to the open internet.

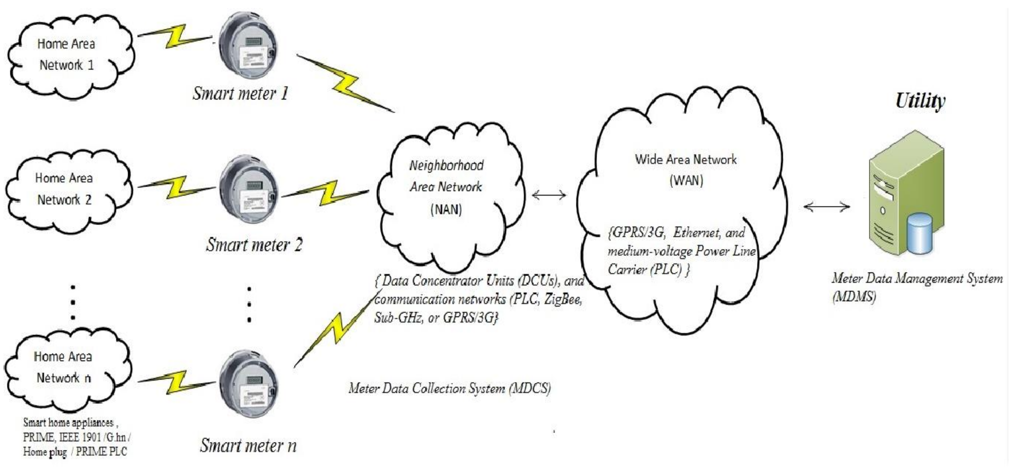


Figure 1. Smart metering infrastructure network

A handset's internet connection will surely be faster thanks to GPRS, but it's still unclear just how much faster the system will be able to go. Several different data channels are combined to make it operate.

Data is divided up into little packets that are then reassembled by the receiving system into their original format, making it possible for this to happen.

1.2 Background

As a result of the AMI's new models and expanded connectivity, there are more risks now than ever before, and DSOs must act quickly to protect customer privacy and cope with these risks.
Identifying vulnerabilities to AMI systems at the interface between a smart meter and the Head End System (HES) at the DSO is the environment in which we are thinking about GPRS communication, as shown in Figure 1. include threats,

Identity theft: Someone may adopt the T2 meter's or the HES's false identities (T1). Communication tampering: A third party interferes with messages transferred between the HES and the meters (T4)

Repudiation: Meter disputes receiving a message (T6) or sending a message (T9). Eavesdropping: Someone listens in on conversations between a meter and the HES (T10) Denial of service: communication is impeded because of an attack on the HES (T18), an attack on one or more meters (T19), or a communication link failure (T20).

For DSOs, it's critical to comprehend how vulnerable GPRS and other potential communication technologies are to such attacks or how well they can fend off failures of the kinds.

1.3 Goal of the study

The goal of the smart meter is to not only measure the consumer's energy usage, but also to broadcast the readings of the meter to the utility office once a week, once a day, once an hour using a GSM module or by uploading them to the cloud.
It can be viewed in two forms:

a. Overarching goal

b. Clearly defined goal

Overarching goal

This internship report was created primarily to satisfy the requirements for the Bachelor of Science (B.Sc.) degree set forth by East West University's Department of Electronics & Communications Engineering.

Clearly defined goal

These components of the study are more specifically:

a. Summary of Bangladesh's position with smart meters.

b. To talk about Dhaka's city's energy usage.

c. Paying attention to the GPRS system to meet people's needs.

d. To pinpoint Bangladesh's GPRS system's opportunities and obstacles for smart metering.

1.4Relevance of the Research

The need for electricity is growing exponentially along with the population. The energy market is hampered by power theft, unpaid bills, and inadequate energy utilization. Because of their low price, gadgets have become more popular, which has affected power quality. Consequently, to improve power consumption efficiency, keep an eye on power quality, and continuously monitor client power usage patterns. Providing two-way communication between clients and the utility is the main objective. Voltage, current, and power factor readings for smart meters can be taken using GPRS technology. The meter uses GPRS to determine the amount of energy used and store the data in the cloud. It offers thorough data on usage to lower electricity costs and raise awareness of the electricity grid's condition, which enhances the grid's functionality and the standard of service provided to customers. The paper includes information on the GPRS system for smart metering scenario in Bangladesh. In order for people to understand the GPRS system's potential and difficulties in Bangladesh, the analysis of the system is the main focus.

Chapter -2

Background and Literature Review

2.1 Smart Meter

2.1.1 How and why humans need smart meters

Defining the smart meter:

The term "smart meter" refers to a digital electricity meter that measures the amount of electricity entering and leaving your home and typically sends the data to the utility at intervals of 30 minutes. A meter reader does not need to visit a smart meter after it is installed. Utility and Meter may communicate back and forth.

Electricity consumption is measured by time repetition with the smart meter, an electrometer. Electricity consumption is measured by time repetition with the smart meter, an electrometer. These meters have the advantage of sending and receiving data and commands to and from the main hub or command center. The smart meter has a feature for two-way communication.

Components of Smart Meter

- Data concentrators: These devices communicate with the concentrator's meters.

- Meters are tools for calculating energy.
- The Head End System (HES), which combines hardware and software as directed by the utility, it communicates with the meter. It functions as a bridge between MDM and Meter.
- Reporting system on meter data; MDM (meter data management). Meter data (Load profile/Event/temper) is stored here via HES.

In Bangladesh, why Smart Meters are Crucial?

- Detection of meter manipulation and theft
- Meter data reading at programmable intervals with scheduled or on-demand load control and load limiting
- Remote Disconnect/Reconnect
- Timing of the day (TOD)/TOU metering
- Alarm/Event notification, detection, and reporting
- Prepaid and net metering
- Accounting and auditing of energy
- updating remote firmware

2.1.2 Why Smart Meter is Essential in Bangladesh

- Watching the transformer for overload
- Potential for instant load management
- To move to a smart grid, smart meters are necessary.
- Accessibility of online vending
- A customer's home computer can display meter status.
- A new tariff and meter firmware can be quickly updated by the utility.
- Meter data reading on demand or on a schedule, at specified intervals
- Online disconnecting and reconnecting

2.1.3 ; Smart Prepaid Meter Customization

What are smart Prepaid Meter

Customizations

• Set up the meter properly at first so that it functions with prepaid features.

• It guarantees the preservation of income
• Boost customer service.

Ways of smart Prepaid Meter Customization

Default value into meters	**Holiday**	**Create tokens for the**
In case of Emergency	Clear Balance	In case of Emergency
Null Balance	Tariff Tokens	Credit Amount Cap
Credit Amount Cap	Load Management Token	Poor Credit

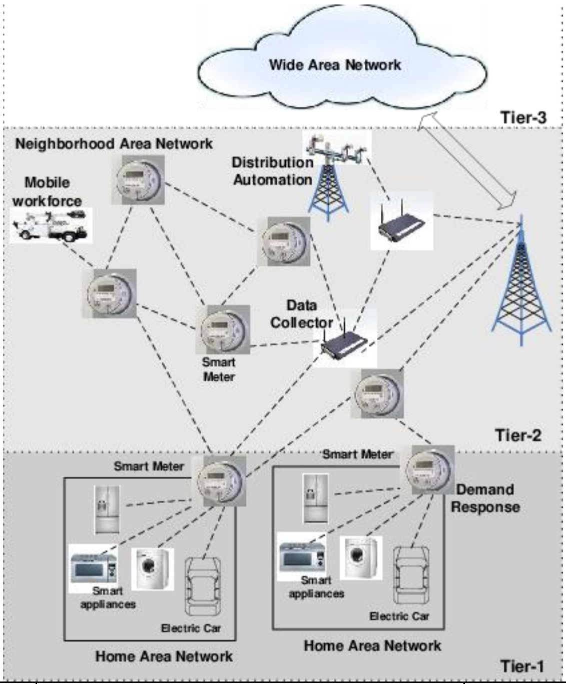
Customization Steps

• Include more NOCS, feeders, and transformers.

Add meters.

- Increase Clients
- Customers and maps
- Click the new card.
- Add management tokens to the meter for customization.
- Insert the fresh card into the meter slot.
- Give customers their cards.

2.1.4 Smart Meter Communication Network



Home Area Network (HAN)	Neighbor Area Network (NAN) or Field Area Network (FAN)	Wide Area Network (WAN)
To more effectively manage energy use, a HAN is used to collect sensor data from a range of devices across the home.	A NAN The SM and WAN concentrator communication network is what it is. It gathers data from a lot of homes in the neighborhood and sends it to WAN.	Data is gathered from several NANs and sent to the utility private network across a WAN. Furthermore, it makes it possible for long-distance communication to occur between various data aggregation points (DAPs) found in power plants, substations, transmission and distribution grids, control centers, etc.

2.1.5 Smart Meter Data Flow

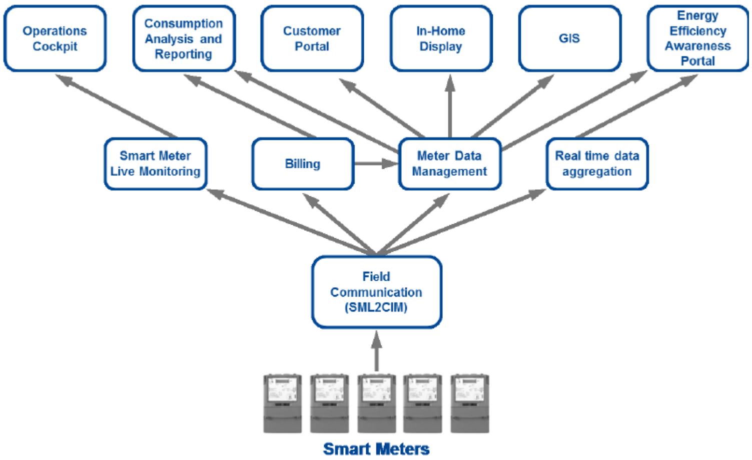


Figure 1: Smart meter data flow

The electrical current flow and voltage are periodically measured by a smart meter, and the power consumed over a half-hour is then calculated using this information. Gas flow is measured similarly at regular intervals. You can send this information to both your supplier and your in-home display. Different communication technologies may be used in various types of premises for the Home Area Network to communicate with your In-Home Display, and various communication technologies will be used in various regions of the nation for the Wide Area Network to send and receive data to and from the communications provider.

In addition to measuring energy, meters are always keeping an eye on their own performance and environment.

2.1.6 Communication Technology in Different Layer

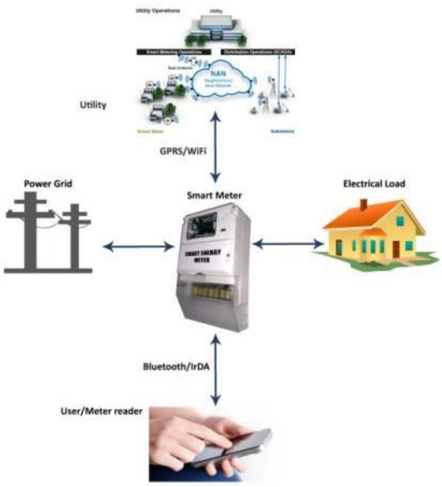
Table 1

Technology / protocol	Home Area Network (HAN)	Last mile/ NAN/FAN	Wide Area Network (WAN) / Backhaul
Wireless	• RF mesh • ZigBee • Wi-Fi • Bluetooth • NFC	• **RF mesh** • ZigBee • Wi-Fi	• **Cellular/GPRS** • Satellite • Private Microwave Radio
Wired	• PLC • Ethernet • Serial interfaces (RS-232, RS-485)	• **PLC** • Ethernet • Serial interfaces (RS-232, **RS-485**) • DSL	• **Optical Fiber** • **Ethernet** • PLC • DSL

In today's climate, wired technologies don't always satisfy corporate needs. For this reason, wireless technologies used in smart metering started to develop and upgrade the initial telecommunications infrastructure. Meters constantly track their own performance and the surroundings in addition to measuring energy.

2.1.7 Smart Meter Features

Main Features



Continuity of	Current Voltage and current peaks
Suddenly Apparent Power	Event, alarm, and alert capacitor
Real Power Available Now	Input/Output Devices
The Power Factor	Current/RMS Voltage

2.1.8 Smart Meter Technology Perspective

- Single and multiple phase metering
- Over-the-Air (OTA) programming
- Firmware revision

- Meter Configuration/Settings
- Data on the meter faceplate
- Point-to-point (using SIM or cellular cards)
- Mesh

2.1.9 Smart Meter Application

- Periodic measurements of consumption
- The Register Reads
- Status/Health of the meter
- Saggy and swollen voltage
- Temperature-related notifications
- The Last Gasp of a Meter
- Alerts for tampering

2.1.10 Communication flexibility in Smart Prepaid Meter

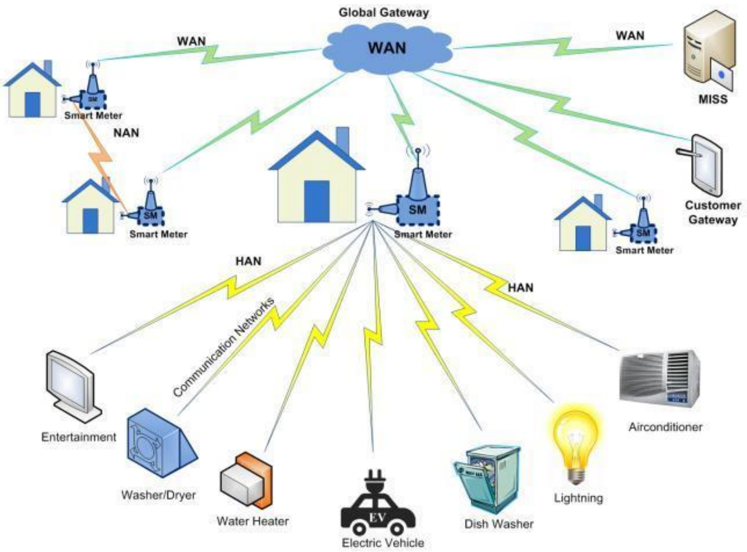
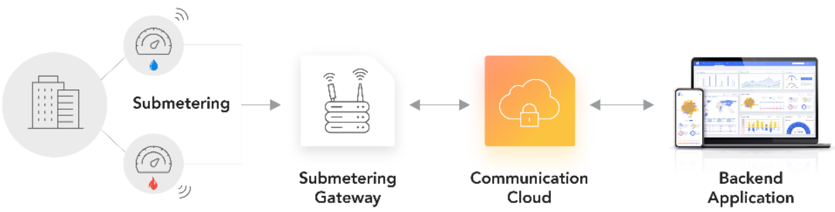


Figure 2

The integration of power engineering and information and communication technology (ICT),



also known as smart grid systems, has led to the development of the next generation of energy.

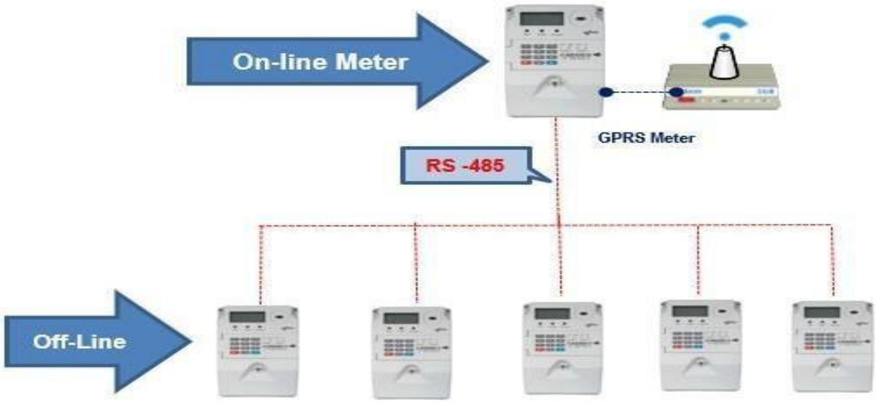


Figure 3

Smart meters are technologies for distributing, consuming, and measuring energy.

2.1.11 Events That Reduce

Power Events Reports

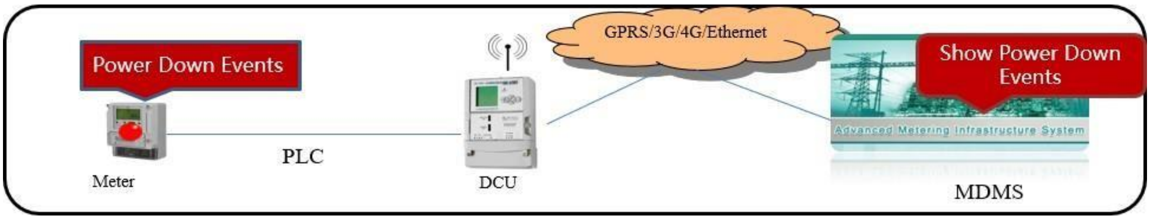


Figure 4

The two major parts of a smart meter are an electronic meter that precisely measures energy information and a communication module that sends and receives data. Smart meters are a component of an advanced metering infrastructure (AMI) system, which also includes a communication network and an IT application for network management and supplying necessary meter data and events to the utility's other IT systems, such as its outage management system (OMS). OMS enables a utility to lessen outage time and expenses while managing power outages and restoration events more effectively.

2.1.11.1 Individual Outage Events

When they experience service issues in their homes, customers frequently contact their electric service provider. Some of these calls are the consequence of an extensive outage or utility issue. There are several such calls for single-customer outages where the issue is on the customer's side of the meter. In the absence of a smart meter, these "no lights" situations are frequently rectified over the phone with the client or, more frequently, during a visit to the customer's home. With the use of smart meters, the utility is better able to determine whether the outage is due to a fault with the utility service or an issue on the customer's property. After that, the utility can take the appropriate action to quickly and cheaply remedy the issue. Power status information is automatically provided by smart meters as well as upon request. The automatically generated data includes the "power fail" and "power restoration" indications for when power is lost and restored, respectively. Since installing smart meters, a midwestern utility has noticed a significant benefit for this capacity. It helped customers resolve issues more quickly and virtually all unwanted no lights trips were removed. An average of 1.5 percent of all calls for no lights are made each year, and up to 30 percent of calls from a single consumer were found to not be an outage event. Consequently, there would be 4,500 non-utility-related outages each year, or 4,500 outage incidents.

2.1.11.2 Numerous Outage Occurrences (Storms)

From a single fuse to a big outage brought on by a significant event like a hurricane or ice storm, multiple outage events come in just about every size and shape. Customers are negatively impacted by all of these outages. Utilities place a high focus on making prompt repairs and resuming service. The first step in restoring electricity as quickly as feasible is to comprehend the extent of the present power outage. The majority of utilities employ OMS to make use of all available data, including consumer phone calls, to identify the quantity and location of affected customers. The only input to OMS prior to the development of smart meters and more recent technology was provided by consumer phone calls or utility inspection teams. The importance of consumer phone calls will never diminish, although less than 20% of impacted customers will often report an outage for a variety of reasons, such as being away from home or believing that the problem has already been reported. OMS analyses and analyzes the data that AMI collects and provides using a Realtime distribution network model's tracing and prediction analysis functions to ascertain the impact. Based on the facts at hand, OMS will forecast where and how long the outage will last. It will then send the right teams to restore service. Before they lose power, smart meters communicate one last message to the utility's OMS system. Even if not all last-ditch messages are sent, the utility typically receives enough to accurately identify the consumers who are impacted. Outage data from smart meters can improve forecasting accuracy and assist utility staff in quickly and accurately responding to issues. As a result, utilities run more cost-effectively and efficiently, and consumers' electricity is returned to them more promptly. Power restoration verification is another advantage of smart meters. When a meter reports in after being reenergized, restoration verification is complete. As a result, before restoration teams depart the affected locations, automated and conclusive verification will be provided that all customers have been restored, there are no nested outages, and all connected trouble orders are closed. Costs are decreased, customers are more satisfied, and the outage length is further decreased. Before the advent of smart meters, utilities frequently did so during significant events. Prior to smart meter technology, it was typical for utilities to dispatch staff to restore service to a client whose service had already been restored during a large event. By automatically integrating smart meters with AMI and OMS, utilities can maximize the value of these devices for service restoration. Utility staff members now have the ability to quickly and efficiently execute service repairs by being able to see the entire extent of the damage.

2.1.11.3 Benefits of Outage Management Improvement

Smart meters allow utilities to distinguish between outages that occur within their infrastructure and those that occur at private residences, which helps them avoid needless and expensive truck rolls. Utility-side issues can be rapidly identified and fixed because to the data that smart meters provide. To locate nested issues, frequently brought on by extreme weather, they use smart meters. Reducing the number of miles driven has advantages, particularly in bad weather, as it increases worker safety and lowers carbon emissions from vehicles. Utilities may reduce outage times and costs by using smart meter data to visualize, evaluate, and efficiently manage repairs, and to confirm the return of service rapidly and precisely. preventing outages Reduced power outages are something that utilities, their clients, and their regulators are all interested in. Cutting down trees, keeping up with the grid, and using automation to restore service are all methods for lowering the incidence of prolonged outages. A grid failure is frequently preceded by a number of odd events that smart meters frequently detect, such as brief outages for each customer. A utility may be able to use this information to anticipate potential future locations for continuous outages and to better prepare for such events. Circuit reclosers and other auto-reclosing devices keep track of the number of operations, but it is frequently challenging to tie these counts to the number of actual events and issues. Utility companies can count the number of events and identify specific areas with a high volume of activity by gathering comprehensive momentary outage data on a small sample of meters. Utilities can pinpoint areas where further tree pruning may be necessary or where certain pieces of equipment may be broken by mapping momentary data. In order to fix the issue and avoid a potential prolonged outage, utilities can then take the appropriate steps. Verifying the electrical phase to which a single-phase smart meter is linked would need working with mapping and analytical tools. After that, the utility's OMS's electrical maps can be checked and updated using data from smart meters. To make sure that the OMS accurately anticipates the size of the outage, it is crucial that the relationship between a smart meter and its electrical circuit be right. The single-phase loading will also be improved by a precise knowledge of the phase a meter is linked to. This results in increased asset usage. Reliability metrics and the history of outages All power-up and power-down events are timestamped by smart meters. As a result, exact outage times and durations may be computed. By determining the overall performance as well as the best and worst performing circuits, utilities can utilize this data to calculate their dependability measures (SAIFI, CAIDI, SAIDI, etc.) more precisely. Then, for upcoming grid modernization investments, utilities can create the most cost-effective action plan. Power outages and restoration times are shortened by smart meters, which is advantageous for both single and repeated situations.

To assist prevent future power outages and guarantee that the electrical maps in the OMS are accurate for the most precise predictions, smart meter data can be used with mapping and analytical tools. Utility companies have long placed a high priority on grid resilience, energy efficiency, and operational optimization. Investments in AMI will enable utilities to further fortify and strengthen crucial utility infrastructure before and during storms, lowering restoration costs and decreasing customer disruptions. This is when linked with distribution automation and grid resilience programs.

2.1.12 Smart meter architecture

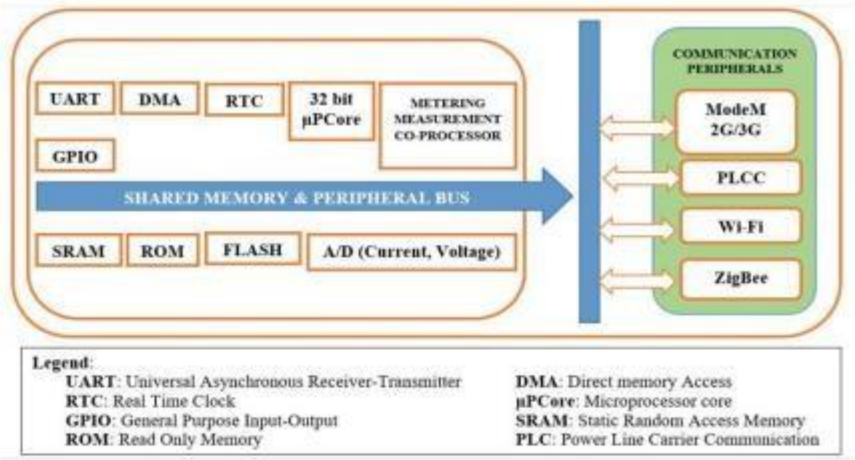


Figure 5

These files are used to load information into a digital form representation and store it in the system's internal memory. These numbers are used to figure out how much energy is utilized and to keep track of outages. Star, tree, and mesh topologies are the most often utilized in communications between smart electricity meters. A silicon-and-chip-based smart power meter's hardware architecture is shown in Figure 3. A metering measuring co-processor, an analog-to-digital converter, a shared memory and peripheral bus, and common peripherals make up its core parts.

Chapter-3

GPRS System

1.1 Architecture of GPRS System

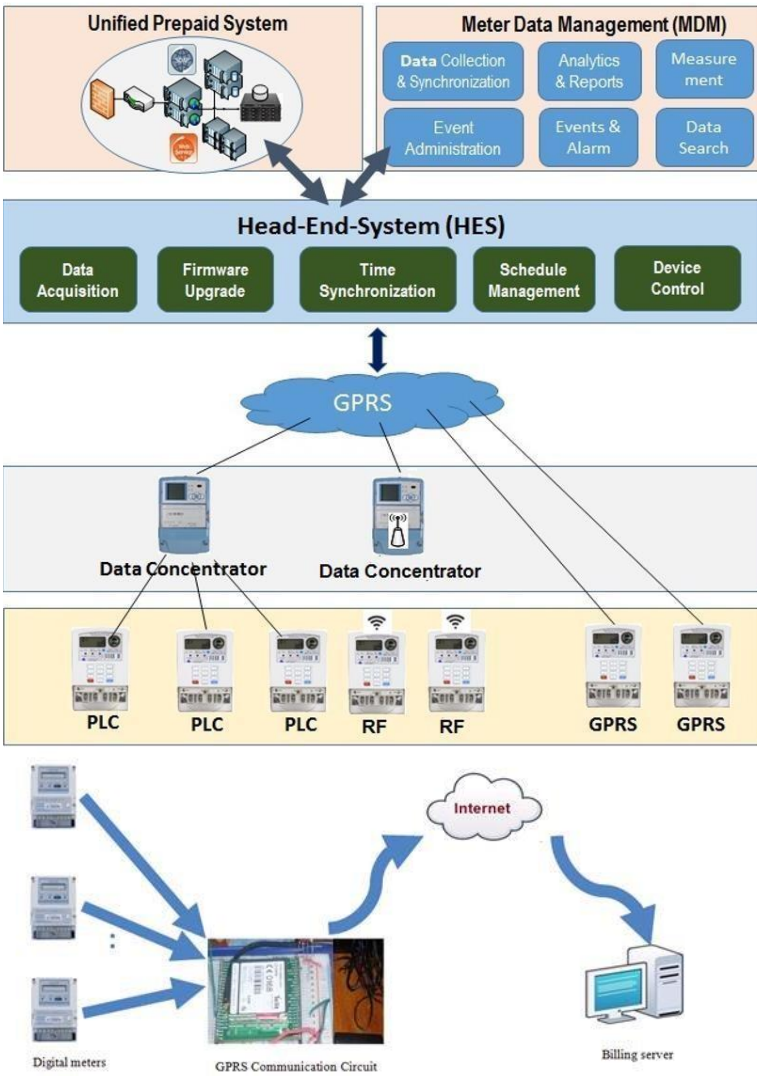


Figure 6

Electricity is now measured using smart meters instead of conventional ones since they are more capable, dependable, and accurate. Smart meters monitor energy use, reload pre-paid electricity credits automatically, and inform customers of the energy usage of their household or commercial equipment. The smart meter system is made up of metering apparatus that is attached to the electrical circuit and measures overall electric usage. It contains a software-based application that handles the data collection and functions as a simple communications gateway. Real-time data from a database is provided by the gateway's mobile user interface. Working Principle of GPRS System

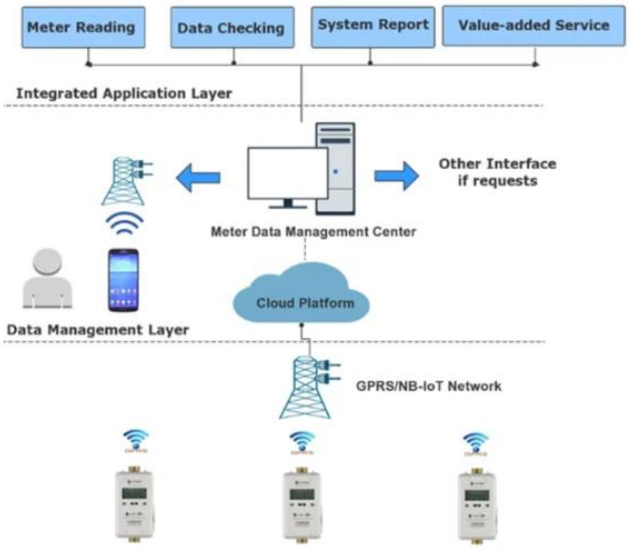


Figure 7

GPRS can be used to make connections with Internet protocols, which provide a range of services, including corporate and enterprise applications. The data is split up into individual packets and sent across radio and the main network before transmission. The receiver's end reattaches the data.

1.2 GPRS Roaming

Operators promoted roaming within Europe and eventually internationally when the common GSM standard was established. The GPRS1 standard has greatly boosted data transmission speeds by allowing transmission over a continuous connection. Mobile carriers had only partially established bridges between their switching networks and data networks prior to the release of GPRS. This study aims to highlight the new architectures required for GPRS roaming and the related cost ramifications.

1.2.1 Mobile operators and GPRS roaming

As a result of the existence of the mobile Internet, mobile operators who may provide their subscribers with Internet access must establish connections with operators from the data sector. Mobile operators occasionally graft themselves onto the current Internet architectures, but, they prefer their own dedicated infrastructures that only open the access to the public Internet when it is necessary, in order to limit the risks to the communication's quality and security. flow. The IP backbone operators' solution, GRXs, was chosen by the operators as their preferred option.

1.2.2 Why GRXs?

The connection between various mobile operators' GPRS/IP networks can be established in a number of ways: directly between mobile operators; indirectly through the Internet; and directly through connections to GRXs (GPRS Roaming exchange).

Direct connection between operators provides the greatest security and the best quality of service

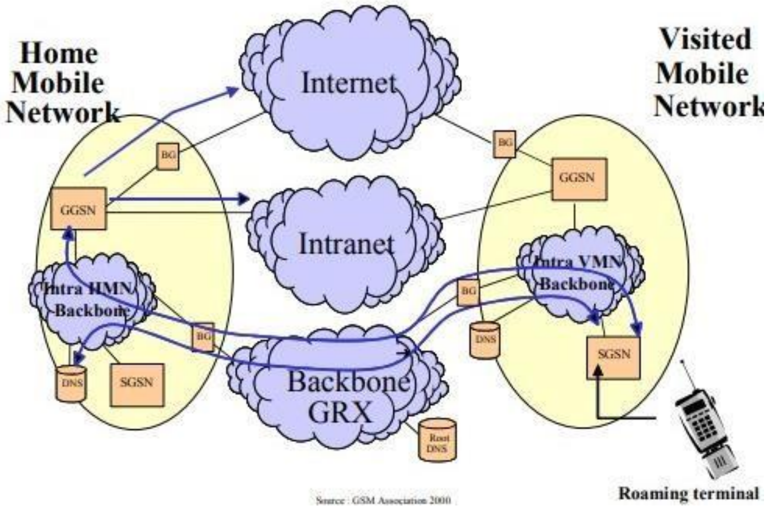


Figure 8

but also the highest expense. On the other hand, an indirect link through the Internet's middleman is less expensive to build but offers subpar security and service. Operator arbitration was so necessary.

They chose the GRX solution because it has the best quality to cost ratio of all the options, balancing security and quality, and installation costs.

1.2.3 The GRX operators: the international GPRS infrastructure

A new group of competitors are GRX providers. They come from different backgrounds, and in 2000 after the GSM Association's move, they first became visible in the open. To enable the global rollout of GPRS roaming, it was vital for this "officialization" to acknowledge a strong relationship with mobile operators. To offer a private Internet that is very significantly distinct from the public Internet, the majority of GRX operators have to address difficult technical issues and maintain their global IP infrastructures.

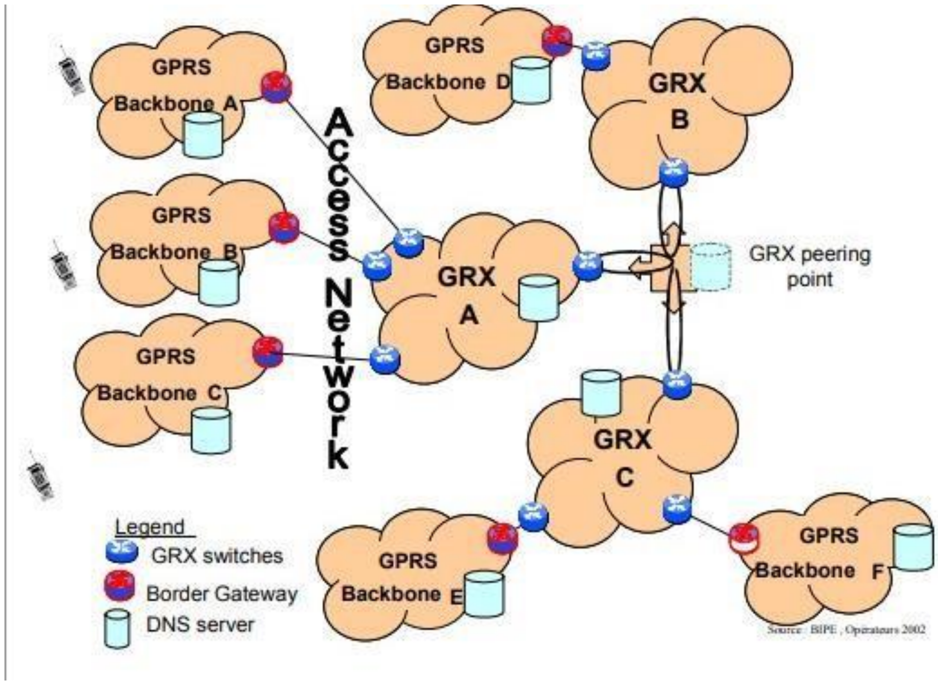


Figure 9:GRX Architecture

The updated way in which the GRX operators interact with their mobile operator clients is very advantageous to all mobile carriers in Europe. In actuality, the GRX operator chosen by the group is usually the common GRX operator, even if the GRX is chosen unilaterally by each of the foreign mobile subsidiaries. The group-wide GRX operator boosts the value of its network through this "option,"

Points of trade between GRXs: The market's immaturity is seen in its small quantity. The GRX operators have established the principle of sites of trade, modeled after those found on the Internet, to circumvent the model's inherent restrictions (with GRX specific features). There is currently only one, called AMSIX, in Amsterdam where 15 GRX operators connect, including Belgacom, BT, Deutsche Telekom, France Telecom, Sonera (with Equant), Telecom Italia, Telefonica Data, Telenor, Telia International Carrier, Cable & Wireless, UUNet, Equant (with Sonera), Aicent, Camphone, and TSI. This point of exchange, which is based on free peering, partially corrects the architectural imbalance that is there by design.

However, at least one additional point from Asia should soon join this one, which is still unique in Europe. However, if we contrast this small number of points with the numerous points of exchange that the public Internet already offers, we can see that is due to the nascency of the national GPRS marketplaces.

1.2.4 The Central DNS Problem

The central DNS, which resolves addresses between the DNSs of the GRX operators, is still an issue, though. The pros and cons of establishing a centralized DNS ("master root DNS") that can handle all address resolves between GRX operators and mobile providers are currently being considered by all the participants. Although the concept is well known, talks are still ongoing because not all parties involved are aware of the benefits of a centralized DNS server; for example, the GRXs that federate several mobile operators are less interested in putting up this structure than their smaller counterparts.

The roaming of content issue is still open, to sum up. The same content is currently available to traveling users as it is to those connected to their home networks. The services that are available when roaming could be limited by this quality. Counterparts.

1.2.5 GRX: infrastructures without traffic flows but ready for the UMTS

The inability of the GPRS roaming traffic flows to fully utilize the installed global infrastructures is the main issue now plaguing all GRX operators. The GPRS service is expected to become popular in 2003, according to forecasters. Because of this, mobile carriers will maintain their dominant position in the GSM industry.

Less significant changes will undoubtedly be made to the core network than those impacting the radio component in order to implement the UTMS. The GRXs are prepared for this evolution, depending on the technology options chosen (migration of the IP networks already operated or installation of ad hoc IP networks for the mobile Internet traffic).

1.2.6 GPRS roaming billing flows: a new model that will develop

GPRS has introduced new players, new procedures, and billing keys. Operators have had to extensively alter their billing systems and related processes as a result of the shift from charging by time to billing by volume (where the kilobyte has replaced the previous reference value). Due to their close connection to the end users, mobile operators, who are at the root of the issue, have implemented cutting-edge billing techniques for roaming. Roaming costs are still deterring, though, for the time being. The dual issues of offering engaging content and their costs are still issues that operators must address.

The financial flows are separated according to whether they are flows between GRX operators (currently based on free exchange) or flows between mobile operators (based on the roaming agreements concluded between them and contain at heart amongst other things the IOT2). The retail prices for roaming, which at present are still prohibitive, may drop as the service develops. Finally, the financial flows destined for the content providers and aggregators using the GPRS havenot yet been perfectly clarified. All these flows between mobile and GRX operators are show in the diagram below:

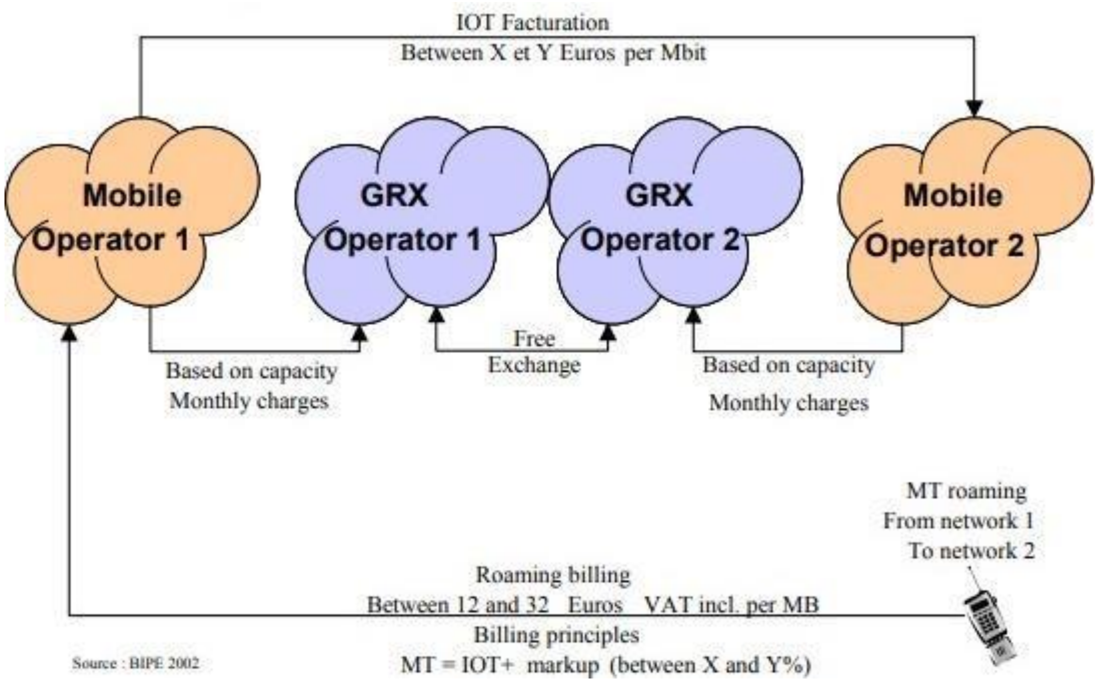


Figure 10: Financial Flows

These financial flows only display the transportation sector and do not forecast the money flows to service providers.

Additionally, depending on which European country is chosen, roaming costs are significant. This makes it more challenging to see clearly how much roaming clients are being charged. In the very near future, clients want consistent costs that don't range from €12 to €32 depending on the country they are roaming in.

1.2.7 Pan-European operators at the center of GPRS roaming.

In this new universe that GPRS's debut has created, pan-European operators will play a key role. They will provide GRX operators the ability to secure a crucial place in the market because they are the primary clients of those companies. Accordingly, a pan- European operator will have a significant competitive advantage in terms of market structuring if all or some of its national subsidiaries choose a GRX operator. Pan-European mobile operators truly do represent major players for the business of GRX operators if we take into account the inherent asymmetry in roaming traffic flows in addition to this competitive advantage.

GPRS traffic flows are currently minimal and are not leading to any major conflicts between the various companies. Due to both the national under-development of GPRS services and the significant pricing differences between countries, users only sometimes use the roaming feature in practice. Pan-European operators could significantly affect the suggested prices in this situation.

1.3 GPRS Security for Smart Meters

3.4.1 GPRS Security Functions

The link between the mobile terminal and the GPRS core network is equipped with security features thanks to GPRS. This section explains that functionality, as well as security functionality that may be obtained by using UICC/USIM in place of SIM cards. Additionally, it offers a succinct overview of GPRS core network security and ways to safeguard data transported from the GPRS core to the DSO across open networks like the internet.

3.4.2 Authentication and key agreement

Users of mobile devices are verified by the network in GPRS. The circuit-switched GSM system and the packet-switched GPRS system both use the native 2G authentication and key agreement (AKA) protocol, but the Serving GPRS Support Node (SGSN) handles the challenge-response process instead of the Visitor Location Register/Mobile Switching Center (VLR/MSC). When there is no differentiation between GSM and GPRS scenarios, we use the term VLR/SGSN to describe those situations. The interface3 functions A3 and A8 are used in the authentication protocol, known as GSM-AKA (TS 43.020 [4]). Operator choice will ultimately determine how an algorithm is implemented, however the GSM Association has a number of example algorithms accessible. According to Fig. 2, which shows the GSM-AKA protocol's two stages:

3.4.2.1 Request from VLR/SGSN to HLR/SGSN and forwarding of triplet (authentication set) from HLR/AuC to the VLR/SGSN (steps 1 and 2)

3.4.2.2 Network-initiated challenge-response (VLR/SGSN - SIM) (steps 3 and 4)

Elements used in the GSM-AKA Authentication and Key Agreement protocol

Table 2

Kc	SIM and HLR/AuC delivered VLR/SGSN a secret calculation they had computed.
Ki	Both AuC and SIM share a secret key.
RAND	VLR/SGSN has chosen a random challenge.
RES	Challenge outcome determined by SIM and forwarded to VLR/SGSN.
XRES	the anticipated outcome of the challenge estimated by HLR/AuC and transmitted to VLR/SGSN

In addition to the AKA algorithms (A3/A8) and the per-subscriber authentication secret Ki, the tamper-resistant SIM card also contains the permanent subscriber identification (International Mobile Subscriber Identity, or IMSI). Since the Ki is a pre-shared secret, the IMSI and Ki are one to one connected. Unlike the Ki, which is only known to the SIM and the HLR/AuC, the IMSI will be known to numerous nodes and networks.

At the request of the VLR/SGSN, the HLR/AuC will generate triplets (RAND, SRES, and KC) and send them. While the signed response is represented by a 32-bit SRES, the (pseudo) random challenge is represented by a 128-bit RAND. A3/A8 are 3 The many Ax, charge functions defined in GSM and UMTS (A3, A5, f1, f2,...) are merely standardized at the interface level, i.e., anticipated input and output is described, but the actual implementation is left to each operator. The GSM Association and 3GPP have documented several sample implementations, however as will be discussed later in this article, many operators use one of them.

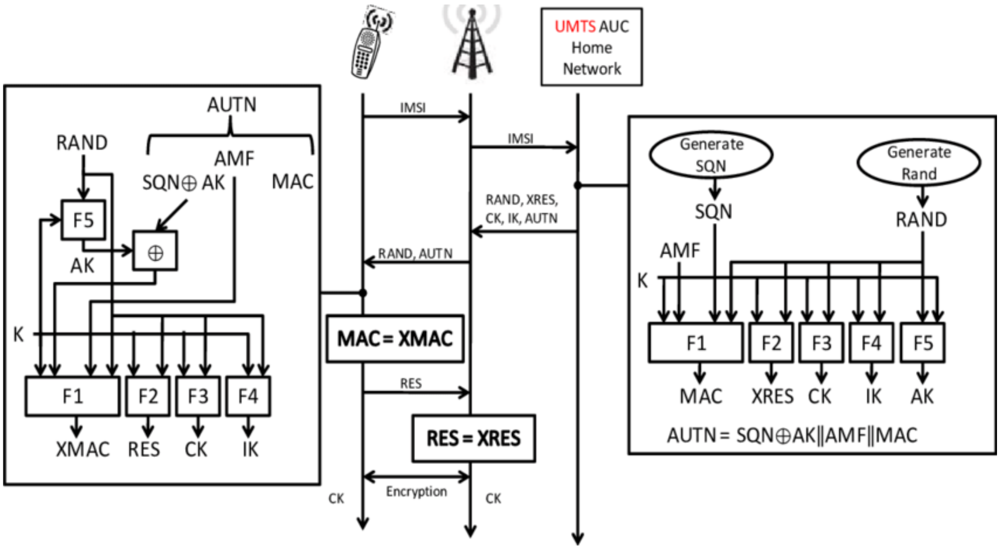


Figure 11: The GSM-AKA Authentication and Key Agreement protocol

When using one-way functions (Fig. 3), it should be impossible for an attacker to figure out the Ki and the KC after seeing the challenge-response exchange in plaintext.

Procedure 4: The triplet is received by the VLR/SGSN, which then challenges the SIM by sending the RAND. The SRES will be transmitted to the VLR/SGSN as the response after the SIM computes the KC and SRES. In response to a request, the SIM will send the encryption key to the MS. The authentication is deemed successful if the HLR/SRES AuC's and the SIM's result match. In the end, the SIM, VLR/SGSN, and KC encryption key are shared. The 64-bit KC key, which is utilized for both GPRS and GSM, is the ciphering key.

In particular, the original "example" method known as COMP128 has some fairly shoddy A3/A8 implementations (completely broken [5, 6]). Also keep in mind that GSM-AKA only creates a 64-bit session key, which is obviously not future-proof given the ongoing advancements in processing speeds for thorough key search applications. We advise using the GSM-Mileages [7] implementation of standard GSM-AKA, which implements the A3/A8 functions by utilizing a set of conversion functions and the UMTS mileages AKA functions.

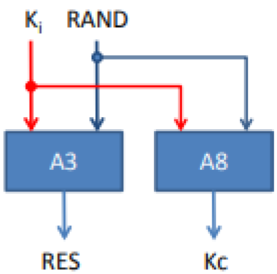


Figure 12: Using the GSM A3/A8 functions to perform GSM-AKA calculations

Notably, it must be computationally impossible to recover Ki even when the attacker may watch numerous challenge-response exchanges, ideally including for chosen plaintext attacks. Even if an attacker were to get access to the entire triplet (including SRES and Kc), recovering Ki should be impossible.

3.4.3 UMTS Authentication and Key Agreement

If the user uses a UICC/USIM module instead of the outdated GSM SIM, it is possible to use the UMTS Authentication and Key Agreement (UMTSAKA) [8, 9] protocol via the "GSM Edge Radio Access Network" (GERAN). Fig. 4 illustrates the functions of the UMTS AKA protocol, which is described in 3GPP TS 33.102 [10]. All the interface functions f1 through f5 require the secret key K and a random challenge, while f1 additionally requires a sequence number SQN and an authentication management field AMF. Here are the outputs that the functions generate:

MAC- a code for message authentication

XRES- Challenge outcome anticipated

CK - For use in later message encryption, use the cipher key.

IK - Integrity is important.

AK - Identity Check (for obfuscating the sequence number in case this exposes the identity of the client) The Authentication Center (AuC) calculates these numbers, and moreover

$$AUTN = SQN \oplus AK||AMF||MAC\text{-}A$$

$$AV = RAND||XRES||CK||IK||AUT$$

The UMTS analogue of the GSM triplet is the Authentication Vector (AV). A detailed list of all the components utilized in UMTS-AKA may be found in Table 2.

Comparable to the GSM triplet is the Authentication Vector (AV). The sequence number is concealed by the AK. The (RAND, AUTN) tuple is part of the challenge from the SGSN. After performing the calculations shown in Fig. 4, the UICC/USIM returns the value of f2 (RES). The SGSN.

the RES from the MS is compared to the XRES from the AV, and if they match, the MS is verified.

Table 3

Acronym	Explanation
AK	The 48-bit Anonymity Key
AMF	The 48-bit Anonymity Key
AUTN	AuC's computation of authentication values
AV	SGSN received the AuC-generated authentication vector (equivalent to the GSM triplet)
CK	Data encryption using a 128-bit Cipher key (Confidentiality key)
IK	The 128-bit Integrity key
K	USIM and AuC pre-share a 128-bit secret key.
MAC-A	an authentication code for 64-bit messages, To verify the challenge, use a "signature"
RAND	Random 128-bit challenge chosen by VLR/SGSN
RES	Result of the challenge, 32-128 bits, calculated by transmitted to SGSN and USIM (default 64 bit)
SQN	The 48-bit Sequence Number
XRES	32–128-bit SGSN received the anticipated challenge outcome from AuC. (default 64 bit)

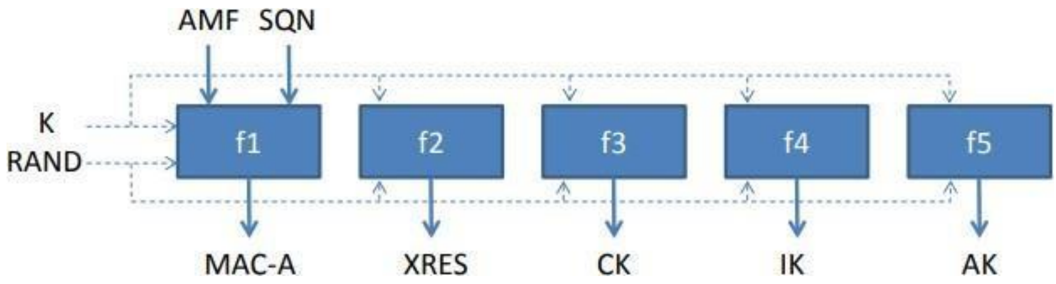


Figure 13 UMTS Authentication and Key Agreement (AKA) functions

An example implementation of the f1-f5 functions is given by 3GPP in the mileages algorithm set [11]. The mileages algorithm set consists of a Rijndael cryptographic core (the algorithm that implements the Advanced Encryption Standard (AES)), as well as a set of constants and parameters to generate independent output from each of the UMTS AKA functions.

3.4.4 GPRS Encryption

Through the wireless interface and all the way from the mobile station to the GPRS core, GPRS encrypts all data and signaling transmission. The GPRS ciphering methods belong to a family of algorithms called GEA (GEA, GEA2, GEA3, GEA4). TS 41.061 [12] defines the GEA interface. We would like to reiterate that, in 2G GPRS, ciphering ends in the SGSN's core network (CN), but in GSM, ciphering ends in the BTS. The A5 family of algorithms (A5/1, A5/2, A5/3, and A5/4), which include the deprecated A5/2 algorithm and the A5/1 method that is now past its prime, are the ciphering algorithms that are equivalent to GSM. With the exception of GEA4 (and A5/4), which uses a 128-bit key, both GSM and GPRS employ the 64-bit KC key for ciphering. The 64-bit architectures of the original GPRS algorithms (GEA and GEA2) are actually rather similar, but the GEA algorithm has been altered to only employ 54 significant bits. The easing of export restrictions allowed the GEA2 algorithm to recoup the 10 lost bits. This is a remnant of the cold war's export laws.

The KASUMI5 block cipher, which in turn uses the Keystream Generator Core (KGCORE) block cipher mode of operation, defines the GEA3 algorithm. Internally, the KGCORE primitive relies on a 128-bit key, and the interface accomplishes this by employing the KC key twice. The GEA4 encryption technique can also be used by GPRS with the KC128 128-bit key. KGCORE is used by GEA4 as well, however there the KC128 key is used directly. The subscriber needs to employ a UICC/USIM and run the UMTS AKA protocol in order to use GEA4 (or A5/4 in GSM).

We point out that although while a 3G/UMTS identification module (UICC/USIM) can be utilized in a 2G device (GSM/GPRS), the cipher function will inevitably need to be compatible with the over-the-air interface. As a result, the UMTS key pair (CK, IK) needs to be transformed into the 64-bit KC key (or the 128-bit KC128 key for GEA4).

The choice of encryption method is made by the mobile station declaring which GEA version(s) it supports, and the SGSN then chooses which version will be used [13]. The link might be broken if they don't support a common algorithm. The SGSN may also choose to forgo encrypting the data.

KASUMI is not an acronym, despite appearances ("mist" in Japanese)

In particular, all data sent over the public internet interface (Gi) from the GGSN is delivered in plaintext because there are no built-in security features in GPRS that guarantee confidentiality or integrity protection beyond the SGSN6. GERAN receives absolutely no integrity protection. However, it is feasible to build up a VPN tunnel from the Gi-interface to an external network using the GGSN's access point names (APNs) configuration feature. Some of these solutions7 are already in use in the business world.

3.4.5 Core Network Protection

In GPRS, the SGSN is where access security comes to an end. Utilizing the GPRS Tunneling Protocol, data traffic is transmitted between the SGSN and the GGSN (GTP). There are multiple GTP versions and a difference between the user plane (GTP-U) and the control plane (GTP-C). Although GERAN may be used for access, a 3G or 4G compliant core network may still be used. There is no security offered by the GTP protocol (in any version) alone. Although it is strongly advised, the 3GPP does not have any explicit requirements for the GTP protocol's cryptographic protection. The Network Domain Security (NDS) section is where IPsec is specifically profiled for usage within 3GPP systems (TS 33.210 [14]). Although the NDS/IP [14] was first created for inter-operator use, it is now being utilized for all IP-based interfaces in the 3GPP system. NDS/IP should be utilized to safeguard GTP, as we firmly advise.

3.4.6 GPRS Closed User Groups

It is possible to set up closed user groups in the cellular networks [15], but as there is no appreciable security provided this can at best serve as a defence-indepth measure. Furthermore, the service is really tailored for circuit-switched calls and is therefore largely irrelevant.

1.4 Comparison of Popular Communication Technologies for Smart Metering – GPRS

Table 4

Advantages	Disadvantages
developed technologies	Except for meter reads, most AMI advantages cannot be obtained.
Standardized and inexpensive communication modules	rapid evolution of technology (2G) to EDGE to 3G to LTE to 4G
The most effective way to collect automatic meter readings from a small number of consumers who are dispersed throughout a big geographic area	Spectrum and scalability limitations High operational costs, with cellular companies paying monthly recurring fees per SIM card
Quick deployment	limited scope (data network is poor in villages)

Chapter -4

Methodology

METHODOLOGY Starting with the topic selection and ending with the creation of the final report, the study is carried out in a systematic manner. The identification and data collection were essential components. To determine the key points, they were then systematically categorized, examined, translated, and presented. Further explanation of the study's methodology is provided.

choosing a subject:

The study's subject was determined by my supervisor. In order to write a well-structured internship report, the topic was thoroughly addressed before being given.

Information sources:

Initial sources:

The practical deskwork served as the source for the primary data. Additionally, I received assistance from my DPDC supervisor in contacting the business directly for information.

Additional Resources:

Internal sources: The organization's files, manuals, and circulars, as well as the various documents provided by concerned officers.

A third-party source:

Various GPRS websites and online resources are available.

Information classification, analysis, interpretation, and presentation:

In this study, some tables and diagrams were utilized to analyze the data gathered and clarify some ideas and conclusions. More precise analysis was done on the acquired data as well.

Research findings: The gathered information was thoroughly evaluated, and the results were highlighted and presented as findings.

Developing the final report: My honorable advisor's insightful recommendations and counsel were used to construct the final report.

Chapter -5

Discussion

5.1 Smart Metering:

5.1.1 The Smart Meter

Electricity consumption is measured by time repetition with the smart meter, an electrometer.

These meters have the advantage of sending and receiving data and commands to and from the main hub or command center. The smart meter has a feature for two-way communication.

5.1.2 Smart Metering Features

- The Utility can remotely turn off all smart meters.
- The meter cover must be opened before changing plugs.
- The timestamp is recorded in the meter.
- Send the command center a quick notification of any crucial events.

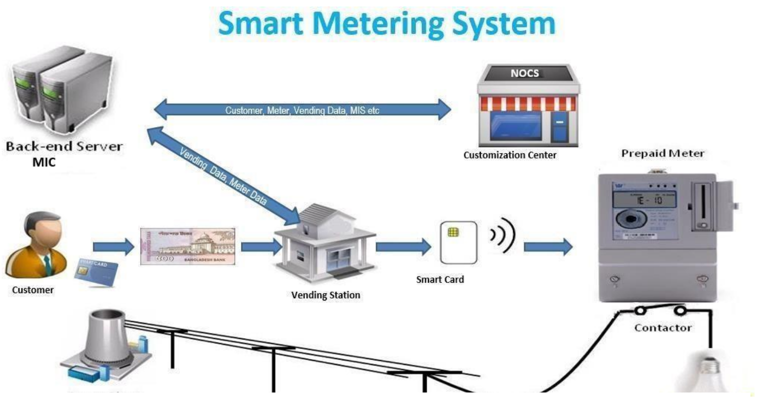


Figure 14

5.2 Benefits to Utility:

1. Financial Gains:

- Improved Billing Efficiency Due to Automated Meter Reading
- Increased collection efficiency upon remote disconnect
- The ability to capture the most demand through improved data analytics, higher hit rates for tamper detection, and increased income from SAC and fixed charges
- Time and resources are saved by reducing the number of ad hoc readings.
- Real-Time Energy Audit Reduction in Revenue Billing Cycle Time and Quicker Detection of Dead Meters

1. Practical Advantages:

- Asset Utilization, Overloading, etc. are identified by DT Meters on the same canopy.
- Disconnecting and reconnecting manually
- More rapid outage detection
- Power Quality Monitoring in Real Time

2. Benefits to the public:

- Fewer outages and errors Due to no manual intervention, bills are free.
- The choice is prepayment.
- more accurate use visibility via mobile app
- Integration of Renewable Energy Facilitation
- incentive to keep PF over 0.85

5.3 Challenges of Smart Metering in Bangladesh

The creation of the smart meter presents numerous design issues. Clear feature specification is one of the initial issues, as Smart meters for home and utility use occupy different feature sets with little overlap. By using the best hardware and software components, a clear specification of the user community's requirements can reduce the cost of the Smart meter. Here are some characteristics that may affect the price and modularity of the design:

i. **Protocol for Communication:** To prevent the incorporation of proprietary protocols into Smart Meters, it is crucial that specific communication protocols be specified or regulated by a centralized agency.

ii. **Safety in communication:** As remote-control functionalities are implemented and sensitive revenue data is communicated in an AMI/Smart Grid context, communication security will become a top priority. It is crucial to provide the precise IEC 62351 standards subsections that will be implemented into the meter firmware and be compatible with AMI and MDM systems.

iii. **Compatibility :** The interoperability of the control instructions and other data formats used in smart meters with the current AMI infrastructure should be guaranteed.

iv. **Statistics from Meter:** Different measuring requirements are needed for utilities, industry, and homes. Consumer segment needs for parameter standardization are essential.

v. **Ports for Communication:** As opposed to the Serial connector and USB, the Smart meters will be equipped with Ethernet and optical Ethernet. Port stipulation will aid in case design and upgradeability optimization.

vi. **Communication:** Smart meters provide a variety of communication options, including wireless (Zigbee, Wi-Fi, Low Power RF) and power line. It would be preferable to specify this choice as allowing for specialized research, analysis, and application.

vii. Another crucial factor to consider is the standardization of Smart meter dimensions.

viii. **Standard for Power Quality:** Higher order harmonic distortions, Sag, Swell, Outages, Dips, Transients Recording, and Recording Duration will all require different types of power quality assessments to be made across various consumer groups. A clear definition of these requirements will reduce the cost of the smart meter by optimizing the use of digital signal processors and high-speed storage for the Power quality measurement feature.

5.4 Challenges of GPRS System for Smart Metering

Most AMI benefits cannot be used, with the exception of meter reads. Technology is advancing quickly (2G, EDGE, 3G, LTE, and now 4G). limits in terms of spectrum and scalability High operating expenses, with telecom providers paying monthly recurring fees per SIM card. restricted scope (village data networks are inadequate).

5.5 Experience as an Intern at DPDC:

At the end of May 2022, some of us students from East West University participated in DPDC's 3-month internship program. The following topics are highlighted in the internship program:

(a) As part of the Power Sector Reforms, the government started supplying power and gradually formed PDB, REB, DESA, DESCO, and DPDC.

(b) The DPDC's power distribution system.

Network Operations and Customer Service (NOCS) tasks performed by DPDC.

Activities of NOCS's auxiliary offices.

(d) (e.g.: HR, Finance, ICT, Audit, Planning, Development, Metering, System Protection, Grid, Tariff and Energy Audit).

Activities of the DPDC's Department of Training and Development

(e). 33/11 KV Substation and 132/33 KD GIS Substation inspections

(f). 33/11 KV and 132/33 KD GIS substations are being inspected.

(g) Examination of the SCADA system, workshop, meter testing lab, central warehouse, and DPDC medical center.

5.5.1 Visiting Sites:

Dhanmondi Sub-Station:

Figure 15

Grid Sub-Station (Shahjahanpur):

Figure 26

SCADA (Supervisory Control and Data Acquisition):

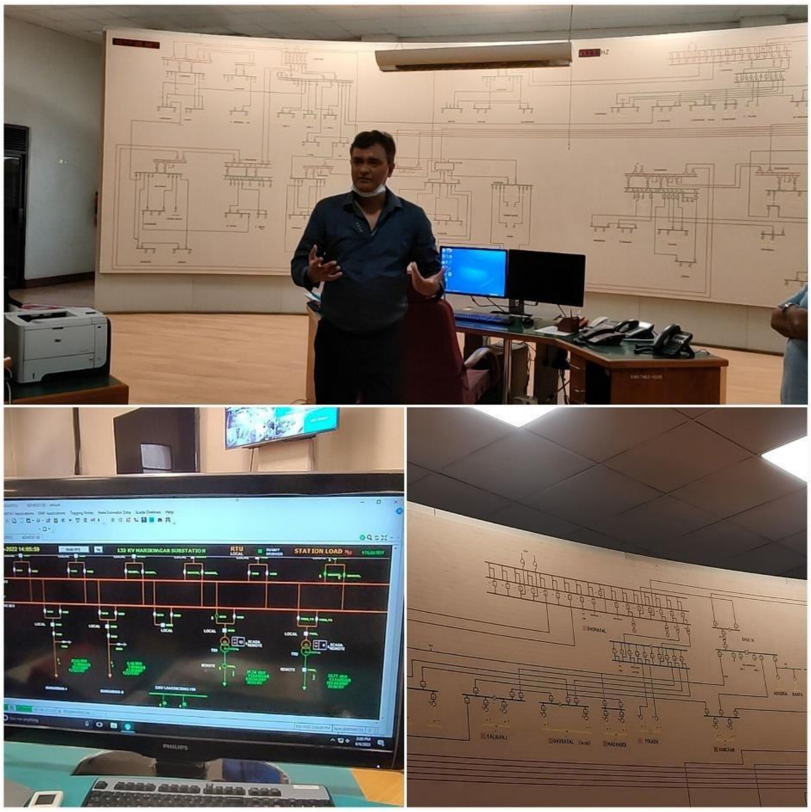


Figure 37

DPDC Library

Figure 48

132/33 KV GIS:

Figure 59

5.6 Ongoing Projects of DPDC

1. Detailed description of self-financed projects

Projects completed in the financial year 2021-2022:

01. Project Name: Design, Manufacture, Supply, Installation, Testing & Commissioning of Smart Pre-Payment Meter at NOCS Kamrangirchar on Turnkey Basis.

Ongoing Projects:

Project Name: Design, Manufacture, Supply, Repair, Service, Installation, Testing and Commissioning of Mohammadi 132/33 KV Grid Substation on Turnkey Basis.

Project Name: Design, Manufacture, Supply, Installation, Testing & Commissioning of Smart Pre-Payment Meter at NOCS Bangla bazar with 03 Years Maintenance Support Service on Turnkey Basis.

2. Projects included in the Annual Development Program (ADP):

Projects completed in FY 2021-2022:

01. Project Name: Construction of New 132/33 KV & 33/11 KV Substation under DPDC.

Ongoing Projects:

- **I.** Project Name: Pre-payment Metering Project for 06 NOCS under DPDC.
- **II.** Project Name: Expansion and Strengthening of Power Distribution System in DPDC Areas.
- **III.** Project Name: Power Distribution System Development Project in DPDC Areas.
- **IV.** Name of the Project: Installation of eight lakh and fifty thousand smart pre-payment meters in the area under DPDC.
- **V.** Project Name: Underground substation construction project at Kawran bazar, Dhaka under DPDC.
- **VI.** Project Name: Construction and Rehabilitation of Substations, Installation of Capacitor Banks in Power System, and Introduction of Smart Grid System in DPDC Areas.

Chapter 6:

Conclusion and Future Work

6.1 Conclusion

To facilitate smart metering, this article has discussed the strategic GPRS system applications over the electrical grid. To understand how GPRS systems might fit in the Smart Metering networks, the history, strong points, and limitations of GPRS systems have been demonstrated. To be able to provide the functionality and performance required for the Smart Grid, these GPRS systems' design and architectural framework must be further developed in the field.

The system choices that were made to enable GPRS systems to adapt to each Smart Metering scenario are detailed in Chapters 2-3. The first thing that needs to be considered is the communications architecture that will be created for the MV and LV grid segments, where the throughput requirements are a crucial factor to be taken into consideration, along with the level of isolation of the GPRS systems used in the MV and LV segments' connection points, or the SSs. The capabilities of the GPRS system used as well as the GPRS signal injection at the SSs will affect the performance outcomes once the architecture has been decided. To wrap up the chapter and given that NB GPRS systems are the most common ones for Smart Metering networks, specific low-level recommendations are made for the MAC layer, with packet size, FEC tactics, and automatic retransmission being the most crucial ones.

The deployment recommendations for NB-GPRS systems are included in Chapter 3. These recommendations should be followed when injecting GPRS signals from system masters into SSs as well as at various locations along the LV grid when signal repetition is necessary because of low SNR. The chapter's multi-transformer situation and the signal injection method's specifics have a significant impact on signal injection strategy (single- or three-phase). With the help of these recommendations, the desired performance outcomes will be achieved.

My time spent as a DPDC intern is also included in this essay. I also spoke with DPDC officials about smart meters there and other DPDC projects.

6.2 Future Work

The difficulties that GPRS systems confront when they adapt to meet the requirements of Smart Grid networks are discussed in the paper's conclusion.

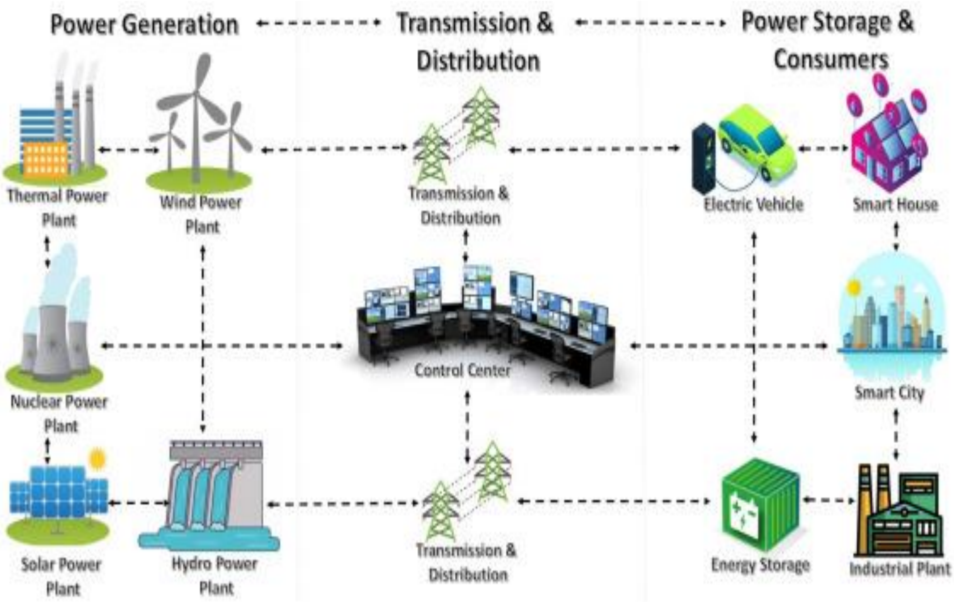


Figure 20

On the one hand, it is emphasized how the current GPRS system needs to be further optimized. On the other hand, it is demonstrated that the interaction of GPRS systems with the grid is a factor that must be leveraged to enhance GPRS system performance as well as to learn more about the grid. GPRS and non-GPRS technology integration is recommended as a potential solution to open the door to smart grids as a final thought.

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