East West University

RF Mesh System for Smart Metering

An Internship Report Submitted to the Dept. of Electronics & Communications Engineering of Electronics and Telecommunication Engineering (ETE) program, East West University and Dhaka Power Distribution Company Limited (DPDC) in partial fulfillment of the requirement for the degree of Bachelor of Science in Engineering (B.Sc. Engineer.)

Submitted To

Academic Supervisor

Mr. Sarwar Jahan
Assistant Professor
Dept. of Electronic and Communication Engineer.
East West University
Dhaka, Bangladesh

Industrial Supervisor

Engr. Mohammad Emdadul Haque
Manager (ICT)
ICT Development Circle
Dhaka Power Distribution Company Limited
Dhaka, Bangladesh

Submitted by:

Md Nazmul Houqe Nayem

ID:2019-1-55-015

Department of Electronics and Communications Engineering.
Electronics and Telecommunication Engineering (ETE) program
East West University, Dhaka, Bangladesh

LETTER OF TRANSMITTAL

18th January 2023

Sarwar Jahan

Assistant Professor

Department of Electronics & Communication Engineering

Subject: Submission of the Internship Report.

Dear Sir,

I am writing to submit my internship report on the topic of "RF Mesh System for Smart Metering." I had the opportunity to work with Dhaka Power Distribution Company and gain hands-on experience in the field of wireless communication and smart metering.

The internship report includes an overview of the smart metering industry, the current challenges and limitations, and the potential of RF Mesh technology as a solution. I have also discussed the design and implementation of RF Mesh systems for smart metering and the benefits it can provide. The report also includes my observations and findings during the internship period.

I would like to express my sincere gratitude to you for providing me with the opportunity to undertake this internship and for your valuable guidance and support throughout the duration of the internship. I would also like to thank Dhaka Power Distribution Company for giving me the opportunity to work with them and gain valuable experience.

I hope that the report will be informative and useful for you. I would be more than happy to discuss the report with you and answer any questions you may have. Thank you for your time and consideration.

Sincerely,

Md. Nazmul Houqe Nayem

ID:2019-1-55-015

Authorship Statement

I do, hereby, declare that the internship report is done by me in partial fulfillment of the requirements for the Degree of Bachelor of Science in Electronics and Communications Engineer. (ECE) from East West University. It is not plagiarized, and the interpretations put forth are based on my reading and understanding of the original texts. The other books, articles, and websites, which I have made use of are duly acknowledged at the respective places in the text.

Date: **18th January, 2023**

Signature

Md Nazmul Houqe Nayem

Acknowledgments

It is my pleasure to acknowledge the extra-ordinary supervision, invaluable suggestion, and proper guidance of my supervisor **Mr. Sarwar Jahan** Assistant Professor Department of Electronic and Communication Engineer and respectable trainer **Engr. Mohammad Emdadul Haque**, Manager, ICT Development Circle, Dhaka Power Distribution Company Limited (DPDC), from whom I have been very much benefitted throughout the course of my training. I express my humble gratitude to him. Without his kind cooperation and help the internship report would never have been possible.

I am also thankful to my honorable teachers of the Department of Electronic and Communication Engineer (ECE) at East West University (EWU) and well-wishers for their valuable suggestion during the period of my internship work.

Finally, I would like to express my indebtedness to my parents for their constant support and inspiration to accomplish the job.

Date: 18th January 2023 Md. Nazmul Houqe Nayem

DECLARATION

I officially certify that I completed my independent study project. The reference lists any materials that other researchers have discovered. No one had ever completed and submitted this research work for a degree before.

Signature of the Supervisor. Signature of Author

Abstract

This paper describes the RF mesh system design and ongoing project in DPDC for advance metering infrastructure and its performance. This system is based on Neighborhood Area Lan (LAN). Its operating band is 920-925 MHz and is based on the frequency hopping spread spectrum. The deployment scenario's geographic model serves as the foundation for the performance evaluation, which uses geographical routing and the appropriate models for radio transmission. It ensures accurate and error free billing. Further, we conclude that the RF mesh system supports us for smart metering and create transparency to customers and DPDC.

Keywords: Automatic meter reading, geographical routing algorithm, RF mesh systems. Advance metering infrastructure (AMI).

Table of Contents

CHAPTER 1 Introduction

1.1.The opening section provides a basic overview of the topic being discussed.

The use of RF mesh-based metering systems has become prevalent in several regions around the world, including North America. Dhaka Power Distribution Company Limited (DPDC) in Bangladesh recently adopted this system. The organization has 36 Network Operation and Customer Service (NOCS) branches, with one NOC in particular adopting the RF mesh-based metering system as their Advanced Metering Infrastructure (AMI). The aim of this system is to allow for automatic meter reading, capture interval data, and facilitate Demand Response (DR) programs through fast and continuous two-way communication between the meter endpoint and the head-end system (HES). DPDC initially deployed 10,000 smart meters in one NOCS branch (Paribag-Division, Dhaka) and based on the success of this pilot, 90,000 smart meters were later deployed throughout the entire DPDC region.

1.2. The background information sets the context for the study.

The capability of RF mesh technology to create on-demand communication links between neighboring network nodes makes it a suitable choice for use in smart meter applications. This is because communication can traverse multiple hops from one node to another, thus increasing the communication range. This way, even if one path in the mesh is obstructed, the system can still work effectively. Furthermore, the requirement for reliable links between communicating nodes is met by RF mesh, making it a better choice compared to other RF solutions such as point-to-point or point-to-multipoint systems. RF mesh-based smart meter systems usually operate in unlicensed ISM bands like the 920-925 MHz range, which is regulated by the FCC Part 15 regulations. The lower frequency in this band offers increased range and better penetration through objects and walls compared to higher frequency ISM bands like 2.4GHz. Today, most RF mesh-based smart meter systems use frequency hopping spread spectrum (FHSS) for collision avoidance and proprietary frequency shift keying (FSK) modulation techniques. FHSS offers a smaller channel bandwidth and a more sensitive receiver, making the link budget stronger, and therefore increasing the range. Additionally, FHSS reduces the risk of interference in shared ISM bands. Systems using FHSS can transmit at 30dbm power levels under the FCC Part 15 regulations, and by combining 6dbi antenna gains, a total EIRP of 36dbm can be achieved. In contrast, systems that do not use frequency hopping are subject to stricter regulations. Currently, the IEEE 802.15.4g SUN work group is working towards standardizing RF mesh-based smart meter systems, although this process may take some time.

1.3. The object of study is defined and described.

The purpose of a smart meter is to collect and send information on a consumer's energy usage to the energy grid, enabling bidirectional communication. The RF mesh technology is employed to connect all of the smart meters in the grid and provide a comprehensive overview of the energy consumption. The primary objective of the RF mesh network is to ensure that every smart meter is linked and updated regularly.

1.4 The importance of the study is emphasized and explained.

In the realm of facilities management, monitoring and measuring systems are key components for success. These systems furnish significant understanding of facility and equipment performance, leading to improved energy management and reduced expenses. Smart meters collect comprehensive data on energy consumption and enable consumers to comprehend their usage patterns and make changes for cost savings and lower carbon emissions. Though definitions may vary, smart meters generally possess some form of two-way communication between the household meter and the utility company to effectively gather data on energy utilization. Some smart meter systems also gather additional information through web-based data and customer feedback through SMS text messages or display screens. The challenge in implementing a smart meter system lies in providing a reliable and cost-effective communication network. Once collected, AMI data goes through a process known as "meter data management system" for verification, editing, and processing before being utilized for billing and analysis.

Chapter 2

Background and Literature Review

2.1. The section discusses the concept of a Smart Meter

2.1.1 The purpose of having a Smart Meter is outlined.

If a Consumer has a Prepaid Metering system installed, the Retailer is not obligated to issue a Tax Invoice, as the Consumer pays for the electricity and distribution services before they are consumed or supplied. Instead, the Retailer will estimate the Distributor's Charge included in the amount received from the Consumer. A Smart Meter is an advanced technology that monitors and records electricity consumption in real-time. The system allows the utility company to set varying tariffs based on the user's characteristics, and helps create more precise cash-flow projections. By operating remotely, it also reduces labor costs for utilities. Smart Meters consist of various components, such as Data Concentrators, which communicate with the concentrator's meters, Meters for calculating energy, a Head End System (HES) that acts as a bridge between the Meter and Meter Data Management (MDM) and serves as a connection to the Meter as per utility guidelines, and MDM which stores meter information such as Load profile, events, and temper using HES.

2.1.2. The necessity of implementing Smart Meters in Bangladesh is highlighted.

In Bangladesh, there is a large number of electricity consumers due to the high population density. In one building, there are different types of users with different tariffs. Unfortunately, some users are not loyal, and there is a shortage of meter readers at the utility company, making it challenging to accurately measure electricity usage. By installing smart meters for every user, the utility company will be able to get an accurate profit and the consumers will be satisfied with the company's services. This will make the billing process more transparent for the users and help to build a positive relationship between the users and the company.

2.1.3. The different types of prepaid meters are categorized.

There are two types of smart meter

1. Token based smart meter.
2. Smart card meter.

2.1.4. The communication network used by Smart Meters is explained.

Home Area Network (HAN)

To manage energy consumption, a HAN is used to collect sensor data more effectively from a range of home-based devices and transmit control information to these devices.

Neighbor Area Network (NAN) or Fan Aria network (FAN)

A NAN It is the WAN concentrators' and SMs' communication network. It gathers data from numerous homes in a community and sends it to WAN.

Wide Area Network (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. The flow of data in Smart Meters is described.

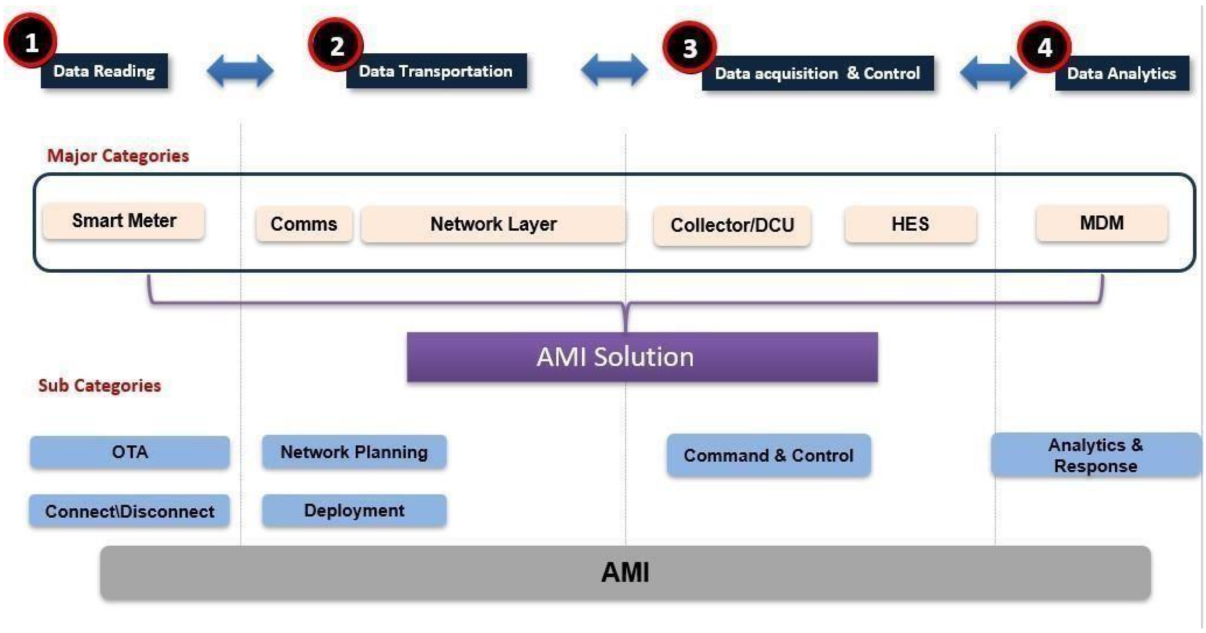

Figure 01

2.1.6. The communication technologies utilized in different layers are analyzed.

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

Figure 02

2.1.7 The features of Smart Meters are enumerated.

The personalization options and other features of smart meters have made our daily lives easier. Instantaneous current, voltage, pick voltage, and current measurement are the most prominent features. Accurate measurements of RMS value, power factor, and system frequency are also possible. This meter has the ability to sound an alarm in any situation. The network interface card (NIC) works to maintain its online status and provide it a distinct identity.

Smart prepaid meter also can be customized.

1. Set default value into meters for
   - Emergency Balance
   - Friendly Time

- Low Credit
- Credit Amount Limit
- Holiday
- Zero Balance

2. Generate Tokens for

- Emergency Balance
- Friendly Time
- Low Credit
- Credit Amount Limit
- Holiday
- Clear Balance
- Tariff Tokens
- Load Management Token

3. Customization Steps

- Add new NOCS, feeders and transformers
- Add Meters
- Add Customers
- Map meter with customer
- Open the new card
- Customize the Meter with Management Tokens
- Put the new card into meters slot
- Hand over the card to customers

2.1.8 The applications of Smart Meters are listed.

- Interval consumption measurements
- Register Reads
- Meter Health/Status
- Voltage Sags and Swells
- Temperature sensor alerts
- Meter Last Gasp
- Tampering alerts

2.1.9 The communication and flexibility of Smart Meters are discussed.

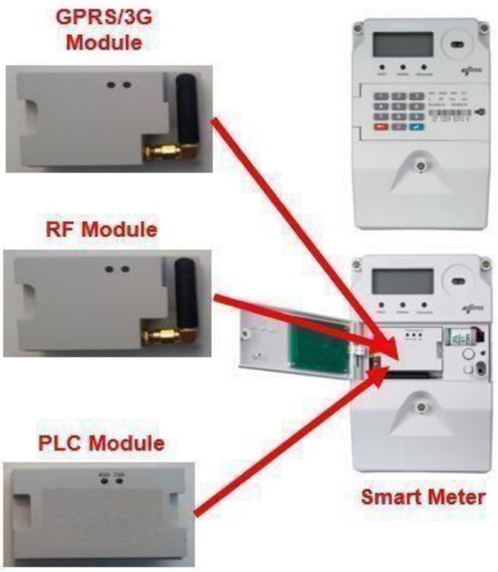

Figure 03

Figure 04

2.1.10 The concept of Power Down Event is explained.

An electronic meter that properly measures energy information and a communication module that sends and receives data are the two major parts of smart meters. The advanced metering infrastructure (AMI) system, which includes smart meters, a communication network, and an IT application to manage the network and provide the necessary meter data and events to the utility's various IT systems, including its outage management system, includes smart meters as part of its advanced metering infrastructure (AMI) system (OMS). OMS enables a utility to manage power outages and restoration events more effectively, as well as cut down on the length and expense of outages.

2.1.10.1 The impact of a single phase outage event on Smart Meters is described.

When there are issues with the service in their homes, customers frequently phone their electric service provider. Some of these calls arise from a more significant outage or utility issue. There are numerous additional calls for single-client outages where the meterside issue is with the consumer. Without a smart meter, these "no lights" situations are frequently fixed over the phone with the client or, more frequently, during a visit to the customer's home. Smart meters help the utility determine if the outage is due to a fault with the utility service or a problem on the customer's property. The utility can then take the appropriate action to address the issue quickly and affordably. Power status data is automatically and upon request provided by smart meters. The "power fail" and "power restoration" indications are included in the automatically generated information when power is lost or lost. Since installing smart meters, a midwestern utility has noticed a significant benefit for this capacity. It almost eliminated all pointless no-light journeys and facilitated quicker problem-solving for clients.

Average annual no-light calls represent 1.5% of all customer calls, and up to 30% of calls from a single customer were found to not be an outage occurrence. For instance, a typical utility with a million subscribers might have 15,000 single no light calls year, which translates to 4,500 non-utility-related outages annually.

2.1.10.2 The effects of multiple outage events (such as storms) on Smart Meters are outlined.

Multiple outage events come in just about every size and shape, from a single fuse to a massive outage caused by a major event such as a hurricane or an ice storm. All such outages have a negative impact on customers. Performing timely repairs and restoring service is a top priority for utilities. To restore power as efficiently as possible, the first step is to understand the scope of the current power outage. Most utilities use OMS to leverage all available information, such as customer phone calls, to define the number and location of affected customers.

Prior to smart meters and more advanced technology, the only input to OMS was the customers' phone calls or the utility's inspection crews. Customers' phone calls will always be important, but in general, less than 20 percent of affected customers will report an outage for a variety of reasons, e.g., not being home or assuming that the outage has already been reported. As AMI gathers and sends data, OMS processes and analyzes it using the tracing and prediction analysis functions of a real-time distribution network model to determine the impact. OMS will make a prediction for the outage location and the extent, and dispatch appropriate crews to restore service based on the information available.

Smart meters send a last gasp message to the utility's OMS system before the meter loses power. Not all last gasp messages make it, but usually enough messages are received to help the utility adequately determine which customers are affected. Smart meter outage data can increase the accuracy of outage predictions and help utility personnel to react to problems readily and accurately. The end result is that customers' power is restored more quickly, and utilities operate more efficiently and decrease costs. Another benefit of smart meters is verification of power restoration. Restoration verification is accomplished when a meter reports in after being reenergized. This will provide automated and positive verification that all customers have been restored, there are no nested outages, and associated trouble orders are closed before restoration crews leave the areas. This reduces costs, increases customer satisfaction, and further reduces outage duration.

During a major event and prior to smart meter technology, it was common for utilities to dispatch crews to restore service to a customer whose service had already been restored. Utilities maximize the value of smart meters for service restoration through automated integration with AMI and OMS. This integration provides utility personnel the ability to visualize the full scope of damage and perform service repairs efficiently.

2.1.10.3 The benefits of improving power outages for Smart Meters are summarized.

Utilities can use smart meters to determine if an outage is within the utility's infrastructure or at a private residence, they can reduce unnecessary and expensive truck rolls. By gathering data from smart meters, utilities can quickly locate and repair utility-side problems. They use smart meters to find nested problems often caused by severe weather events. Benefits include a reduction in traveled miles, especially during severe weather, which improves worker safety and reduces vehicle carbon emissions. Smart meter data can help utilities visualize, analyze, and efficiently manage repairs, reducing outage times and costs while quickly and accurately verifying service restoration.

Outage Avoidance

Utilities, their customers, and their regulators all want to reduce the number and duration of power outages. Tools that reduce the number of sustained outages include trimming trees, maintaining the grid, and deploying automation to restore service. Smart meters report many abnormal events, such as momentary outages on a per-customer basis, which are often a precursor of a grid failure. This information can help a utility predict where a future sustained outage might occur and be better prepared when it does occur.

Auto reclosing equipment, such as circuit reclosers, track the operation count, but it is often difficult to correlate these counts to the number of actual events and problems. By collecting detailed momentary outage data on a select number of meters, utilities can identify the number of events and pinpoint locations where there is a lot of activity. By mapping momentary data, utilities can determine where additional tree trimming might be needed or where some equipment may be defective. Utilities can then take corrective action to eliminate the problem and prevent a possible sustained outage.

If a utility is looking to improve its outage avoidance capabilities, then it must add mapping and analytical applications to maximize the value of smart meter data. These mapping and analytical applications are currently available, but not yet widely deployed for this application.

Accurate Mapping

A benefit of smart meters working with mapping and analytical tools would be to verify the electrical phase to which a single-phase smart meter is connected. Smart meters' data can then be used to verify and correct the utility's electrical maps in its OMS. It is essential that the relationship between a smart meter and its electrical circuit is correct to ensure that the OMS predicts the scope of the outage correctly. Accurate understanding of the phase a meter is connected to will also improve the singlephase loading. This leads to better asset utilization.

Outage History and Reliability Metric

Smart meters timestamp all power up and power down events. Thus, precise outage times and durations can be calculated. Utilities can use this information for a more accurate calculation of their reliability metrics (SAIFI, CAIDI, SAIDI, etc.), identifying the overall performance as well as the best and worst performing circuits. Utilities can then develop the most cost-effective action plan for future grid modernization investments.

Smart meters reduce power outage and restoration time and are beneficial for single and multiple events. Smart meter data can be used with mapping and analytical applications to help prevent future power outages and ensure that the electrical maps in the OMS are correct for the most accurate predictions. Grid resiliency, energy efficiency, and operational optimization have always been strong drivers for utilities. When integrated with distribution automation and grid reliability programs, investments in AMI will enable utilities to further reinforce and strengthen critical utility infrastructure before and during storms, reducing restoration costs and minimizing customer outages.

2.1.11 The solution architecture for Smart Meters is presented.

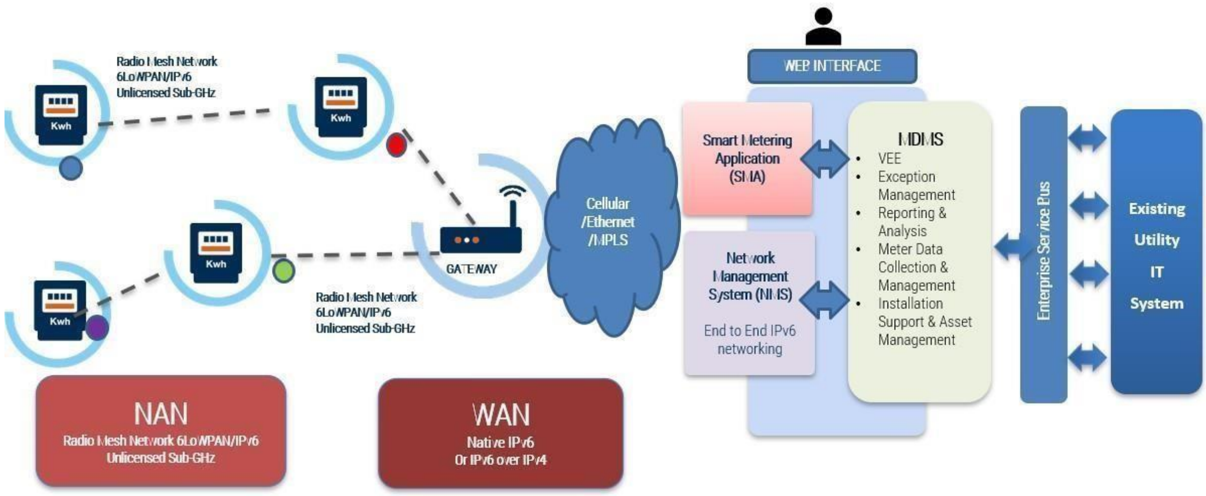

Figure 05

Chapter 3 RF Mesh System

3.1. The architecture of an RF mesh system is described.

RF mesh technology is suitable for use in smart metering applications because of its dynamically form ad-hoc communication links between neighboring nodes. RF mesh technology basically a layered system architecture in which electricity meter are mashed together in the last layer. In middle layer router are interconnects with the meter mesh below and routes to a collector gateway which link to the upper Wide Area Network (WAN) layer where the traffic is backhauled to the Utility's HES. WAN is control by utility companies. The company uses different IP addresses using GPRS, 3G,4G, WiMAX or fiber network and collect real time data from the user.

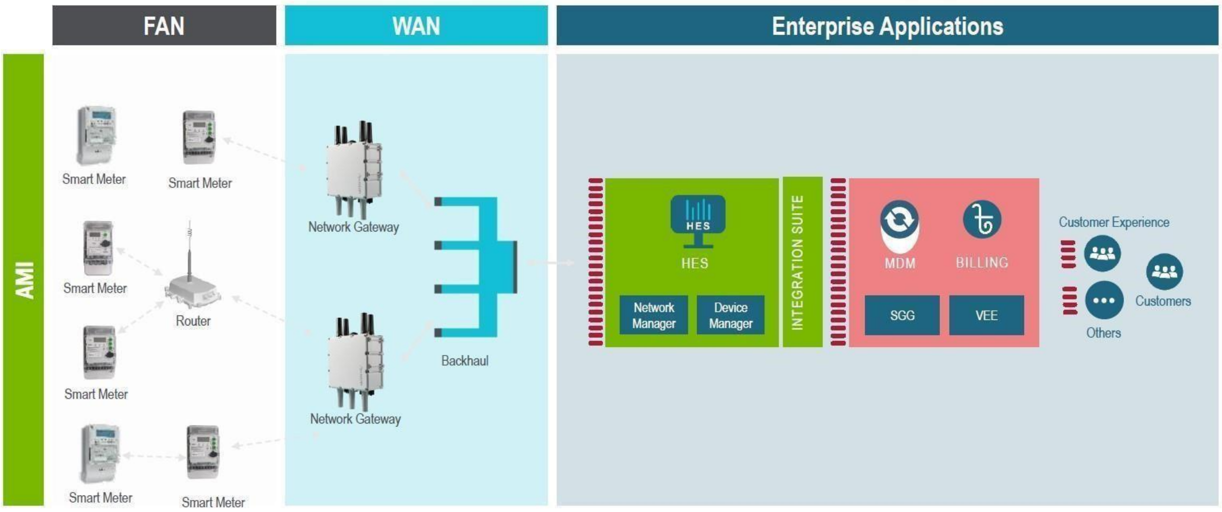

Figure 06

3.2. The concept of retransmission is discussed.

Once a transmitting node has determined its neighbors, it sends its frame to the chosen neighbor using the routing technique outlined above and during the time slot allotted to it. When no immediate acknowledgment is received within the allotted time, the node assumes that the communication link with this neighbor has failed. The next retransmission attempt is then sent to a different neighbor. Up to a set retry limit, this operation is repeated. In practice, this turns out to be more effective than repeatedly retrying with the preferred neighbor because, if that link is down for some reason, like an obstruction, it tends to stay down for a longer period of time than the number of retries allowed while a different neighbor is always available.

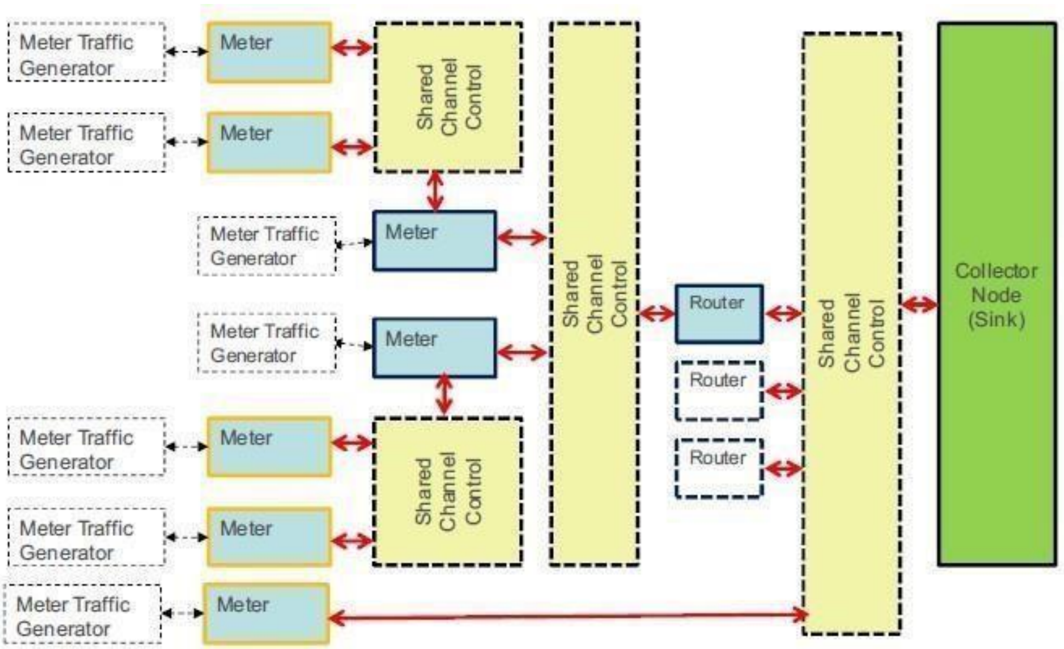

Figure 07

3.3 The process of meter reading and demand response is outlined.

Although this can happen as frequently as every 5 minutes, meters normally gather metering interval data every 15 minutes. A push mechanism is used to convey this data every four hours over an RF mesh network. Through a GPRS connection, the collector is linked to the company's HES and can have metering data transfer scheduled or maintained on a regular basis.

Figure 08

3.4 The process of outage detection in an RF mesh system is explained.

Meters are able to detect and report power loss as well as any changes to the conditions of the line. To ensure that these outage detection notifications are effectively relayed to the

HES, the power meters, router nodes, and collectors all have super capacitors.

3.5. The security measures implemented in an RF mesh system are described.

RF mesh system used public key infrastructure (PKI) based security architecture to protect the network nodes from cyber-attack. Keys are installed between metering point and HES point. Which blocks the critical massage and firmware downloads. Command is securely transmitted to the DPDC so they can take necessary action.

3.6 The process of firmware upgrade in an RF mesh system is explained.

The process of standardizing the smart grid is still in progress, and it is likely that standards will change during the course of the deployment of the deployed meters and networking nodes. The firmware protocol stacks must consequently be able to be upgraded remotely via the air interface. Such firmware changes are supported by the RF Mesh System in a safe and controlled manner. The nodes will only take authenticated firmware images, and these must be sent using the Utility HES. The network nodes that need the upgrade are inundated with new firmware or propagated over the metering population. The network as a whole switches to the new protocol stack in a time-coordinated fashion.

3.7 The features of an RF mesh system are listed.

Meter is communicated with neighbor meter and bult a mesh system which learn to each other in the end communicate with end point. End point router communicate with neighbor router for further communication. The router smartly made a link budget for better connectivity. Though the internet is easy to access now a days the router and meter synchronize easily. If one route is faulty the router finds another route for its connection to

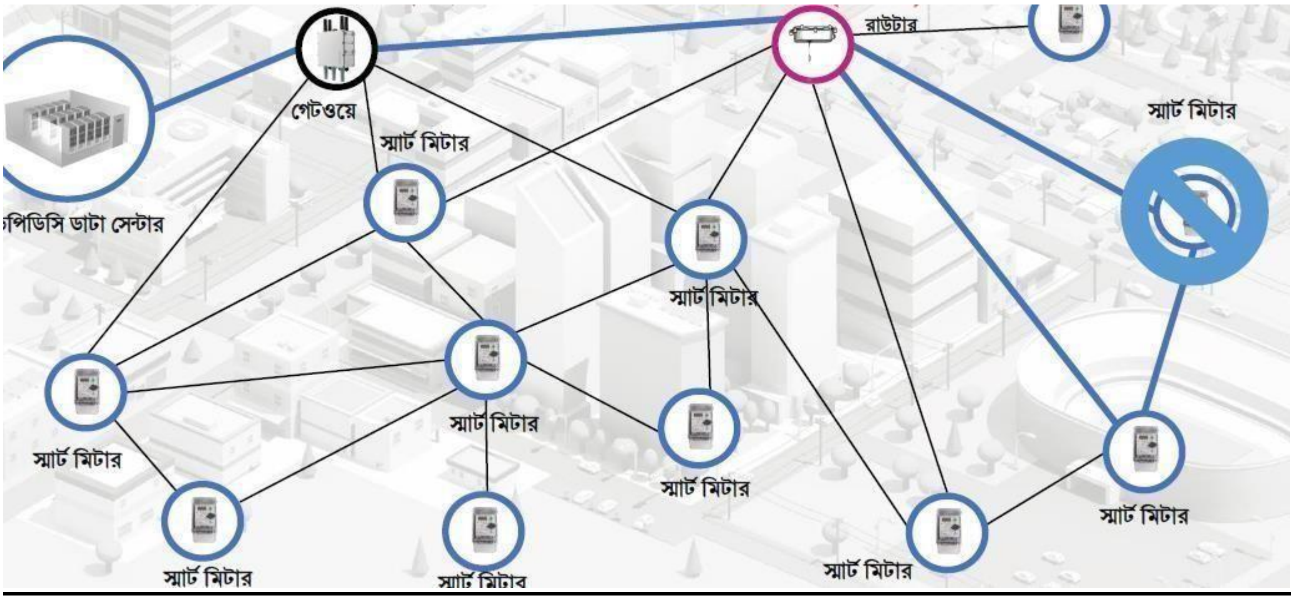

Figure 09

datacenter of DPDC.

3.8. The advantages and disadvantages of an RF mesh system are evaluated.

3.8.1. Advantage

1. Error free billing.
2. Consumer can pay bill using internet and mobile.
3. Consumer can track their meter data using mobile apps and web portal.
4. Consumer can recharge their meter balance in friendly hour, weekend and other government holiday and get uninterrupted electricity.
5. Though ,24/7 they are connected to system so any technical problem can find easier, and solution will be faster for better service.
6. Consumers can show consume load immediately so they can control their load easily.
7. AMI artificial intelligence is using different analytics for that meter tampering and unusual uses of electricity will be zero. In that case company will get hundred percent electric bill.

3.8.2. Disadvantage

1. This system is too costly to install.
2. Monitoring and operate this system are not easy as like other method of electricity connection.

Chapter 4 Methodology

METHODOLOGY Starting with the topic selection and ending with the writing of the final report, the study is carried out in a systematic manner. Identification and data collection played a crucial role. To identify the key points, they were then categorized, examined, explained, and presented in a systematic way. The overall technique used in the study is described in more detail.

Selection of the topic: The study's topic was given to me by my supervisor. Before the topic was assigned, it was thoroughly explored to enable the creation of a well-structured internship report.

Sources of Data

Primary Sources: From the practical deskwork, primary data was derived. In addition, my boss at DPDC assisted me in getting information directly from the business.

Secondary Sources:

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

External source: Different websites related to RF mesh system and online resources.

Classification, analysis, interpretations and presentation of data: Some diagrams and tables were used in this report for analyzing the collected data and to explain certain concepts and findings more clearly. Moreover, collected data were analyzed more precisely. **Findings of the study:** The collected data were analyzed well and were pointed out and shown as findings at the end.

Final report preparation: The final report is prepared after valuable suggestions and advice of my honorable advisor.

Chapter 5 Discussion

5.1. The RF mesh system is discussed in detail.

RF mesh system is generally a system where every meter is always in online. Consumer can access their consume data every moment and built a fair communication and faithful connection to consumer and DPDC. RF mesh system connected every meter with a radio frequency and all meters are connected in a router and router are connected to DPDC data center.

5.2. The benefits of an RF mesh system to a utility are described.

1. Commercial Benefits:

- Automated Meter Reading – Improvement in Billing Efficiency
- Remote Disconnection – Improvement in Collection Efficiency
- Improvement in Data Analytics – Improvement in hit rate in Tamper Detection
- Capturing Maximum Demand - Improvement in revenue through SAC & Fixed charges

  36
- Reduction in Ad-hoc readings - leads to save time & resource
- Faster Detection of Dead Meters - Real Time Energy Audit Reduction in Revenue •

  Billing Cycle time

2. Operational Benefits:

 DT Meters on same Canopy leads to identify the Asset Utilization / Overloading etc.

- Removal of Manual Disconnection / Reconnection
- Faster Outage Detection
- Real time Power Quality Monitoring 3.**Consumer Benefits:**
- Less Outages
- Error Free Bills due to no Manual Intervention
- Option to choose – Prepayment
- Better usage visibility through Mobile app
- Enablement for Renewable Integration
- Incentive for maintaining PF>0.85

5.3. The challenges faced in implementing an RF mesh system for smart metering in Bangladesh are outlined.

Bangladesh is a highly dense country and people are not too much familiar to new technology. In the beginning people are not ready to accept this technology and they have trust issue. On the other hand, electricity provider company also have leakage of skillful worker in that sector. For dense people proper link budget also a challenge.

The design challenges in realizing the smart meter are multi-faceted. One of the first challenges is clear definition of features, as Smart meters for Home and Utility occupy different spectrum of feature sets with minimal overlap. Clarity in the definition of requirements by user community can optimize the cost of the Smart meter by use of optimal hardware and software components. Some of the features which can impact the cost and modularity of the design are listed below:

i. **Communication Protocol:** It is important that specific communication protocols to be implemented are specified/mandated by central body for Smart Meters to ensure that proprietary protocols do not find way into the Smart Meter. ii. **Communication Security:** Communication security in an AMI/ Smart Grid environment will be a prime requirement as remote-control features are enabled and sensitive revenue data is transmitted. It is important that the specific sections of the standards (IEC 62351) to be incorporated in the Meter Firmware are specified which are compatible to the AMI and MDM systems.

iii. **Interoperability:** The control commands and other data formats used in smart meters should be ensured that they are interoperable with the existing AMI infrastructure.

iv. **Meter Data:** Different Consumers (Utilities, Industry and Home) require different measurement parameters. Standardization parameter requirements across consumer segments is a must.

v. **Communication ports:** Since the Smart meters will be provisioned with Ethernet, optical Ethernet other than the Serial connector and USB. Specification of the ports will help optimize the case design and upgradeability.

vi. **Communication:** There is a varied choice of communication modes available for the smart meters like wireless (Zigbee, WiFi, LowPowerRF) or power line. It will be desirable to define the choice of these modes as focused study, analysis and implementation can be carried out.

vii. Standardization of Smart meter size and footprint would also be an important consideration.

viii. **Power Quality Requirements:** The specification on the type of power quality measurements required across different consumer segments will need to be defined for higher order harmonic distortions, Sag, Swell, Outages, dips, transients recording, duration of records. Clear specification on these requirements will optimize the cost of the smart meter as it will impact use of Digital Signal processors and high-speed memories for implementing the Power quality measurement feature.

5.4. The limitations of an RF mesh system for smart metering in Bangladesh are discussed.

RF mesh need high frequency radio signal. There is building everywhere for this the signal will reflect and scattering too much and the signal will destroy. The link budget more challenging for high dense structure. The cost of router and meter will be high and the sever maintaining also will be costly.

Figure 10

5.5. The author's experience as an intern at the DPDC is shared.

One of Bangladesh's biggest power distribution firms is Dhaka Power Distribution Company Limited (DPDC). DPDC wants to use the advantages of Advanced Metering Infrastructure (AMI) to raise the bar for power quality and reliability as it travels the path of making power distribution smarter every day. Considering this, DPDC has created a bold plan for the implementation of advanced metering infrastructure. RF mesh is one of them.

As an intern of DPDC we learn a lot of from them. Their organogram, culture and working environment are very good. Our inter teacher and other teacher and employee are success to tech about their working policy. Every site visit is enjoyable and effective to their effort and hospitality. I will recommend other to take participate in their inter program to learn something with a corporate vibe.

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) Introduction of electricity supply, gradual formation of PDB, REB, DESA, DESCO and DPDC by the Government under the Power Sector Reforms 1

(b) Power supply system at DPDC.

(c) Network Operations and Customer Service (NOCS) activities at DPDC. (d) Activities of supporting offices of NOCS (eg: HR, Finance, ICT, Audit, Planning, Development, Metering, System Protection, Grid, Tariff and Energy Audit).

(e) Activities of Training and Development Department of DPDC.

(f) Inspection of 132/33 KD GIS Substation and 33/11 KV Substation.

(g) Inspection of SCADA System, Workshop, Meter Testing Lab, Central Warehouse, Medical Center of DPDC. Page | 38

5.5.1 The author's visit to a site is described.

Figure -Dhanmondi Sub-Station

Figure-NOCS (Network Operation & Customer Service) Narinda

Figure-Grid Sub-Station (Shahjahanpur)

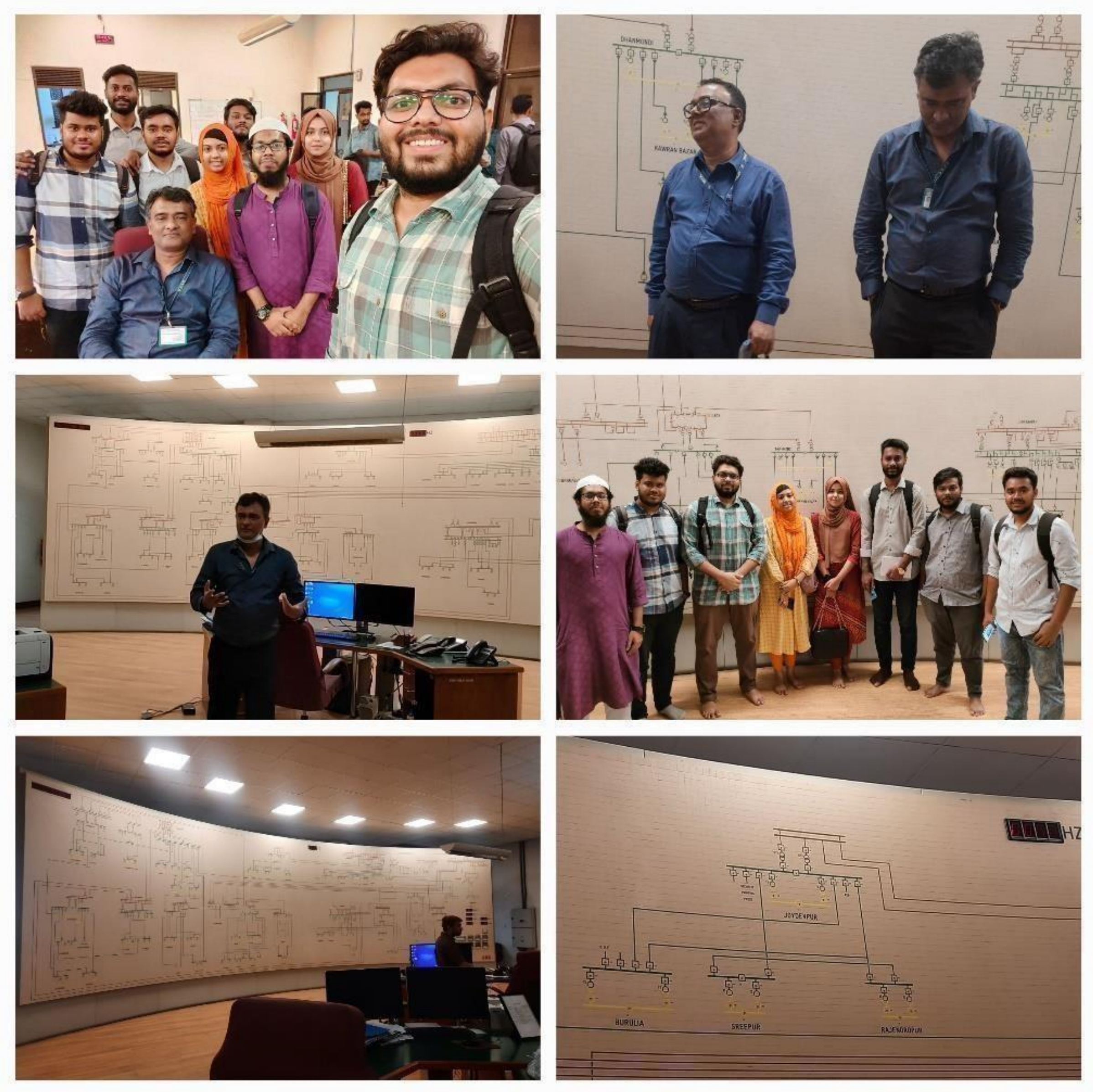

Figure-SCADA (Supervisory Control and Data Acquisition)

HR, Finance, ICT Division, 132/33 KV GIS

DPDC Library

5.6. The ongoing projects of the DPDC are highlighted.

Designing, supplying, establishing, installing, testing, commissioning, operating, and maintaining the Advanced Metering Infrastructure (AMI) for customers with Single Phase and Three Phase Whole Current meters is the scope of the project. The DPDC plans to install the AMI system throughout the DPDC territory (225 Sq.km). In the 36 NOCS zones of DPDC, 100,000 metering nodes from 3 different meter manufacturers are part of the project's initial stage of smart metering. The three distinct meter producers must come from at least two separate nations. 8,50,000 smart meters will eventually be covered by the smart metering, or AMI, project. For these meters, the AMI system will be developed and scaled up for 2 million meters.

The goal of this project is to set up the AMI system for all Distribution customers, with the following features included but not limited to: I. The ability to access AMI meter data on a regular basis, provide all the necessary information on a single console in an integrated manner, and provide remote network control capabilities to improve operational efficiency.

II. The contractor must set up a network platform using RF communication technology that can accommodate numerous applications, such as AMI, GlS, and DMS, on a single communications platform.

III. The contractor must set up a network platform using RF communication technology that can support numerous applications, such as AMI, GIS, DMS, Street Light Management, and HAN, among others, on a single communications platform.

IV. To connect with field devices, the network canopy that will be built using RF communication technology will need intermediary network components such routers, repeaters, collectors, gateways, data concentrators, access points, etc.

V. At the areas where the meters will be installed, the contractor must install smart meters and build an RF communication canopy.

VI. The contractor will provide, install, configure, and commission all necessary hardware (Data Center & Disaster Recovery Center) and software (HES, MDM, Database, Application Server, Mobile Apps, etc.) for efficient AMI administration.

The project must be able to accommodate all signals from the DPDC distribution network, which consists of a 5,213 km power line, a 228 km 132 KV transmission line, a 390 km 33 KV line, a 4431 km 11/0.4 KV line, 19000 no. of distribution transformers, and an initial 100,000 no. smart meter. Within the whole DPDC region, future phases of smart metering must be able to accommodate 8,50,000 metering nodes, which is why the proposed AMI The 8.5% average annual growth rate of customers and related infrastructure should be considered while designing the communication network, control center, data center, and AMI system. This adds up to a total cost of 2 million (approximately) AMI meters after installation and implementation have been completed.

In order to collect data on power consumptions and remotely connect and disconnect the power supply, technology embedded in the communications system for smart meters should enable the configuration-less formation and self-restoration of communication networks that can scale up to the required level for AMI applications. Additionally, the system ought to offer users value-added services such in-depth, visually appealing power usage reporting. According to the agreement between DPDC and the bidder, the network's design and technology should allow for the connection of a greater number of communication devices by adding more components at each level of the RF network canopy and IT infrastructure.

Achieving device level interoperability is another goal of DPDC, which has chosen RF communication technology and a variety of smart meter manufacturers. That is, the manufacturers of numerous meters must adhere to the RF Network Interface Card (NIC)/RF Communication module/chip with plug-in facility requirements of the RF canopy vendor and utilize the same communications technology, RF mesh.

Major items discussed in the following sections of this text are described in terms of their required functional and technical specifications. The bidder will oversee making sure that all systems, subsystems, and equipment/devices adhere in every way to high standards of engineering, design, and workmanship and are able to perform continuously commercial operations in accordance with the current and foreseeable future requirements of the DPDC.

Chapter 6 Conclusion & Future Work

Conclusion:

Radio frequency (RF) mesh systems have emerged as a promising technology for smart metering applications. They allow for the remote collection of electricity, gas, and water consumption data from a large number of meters and provide a reliable and cost-effective solution for utilities to improve their operations and customer service. RF mesh systems operate by using a network of nodes that communicate with each other and transmit data over the air. They are self-healing and can operate in harsh environments, making them well-suited for smart metering applications.

In North America as well as other parts of the world, RF mesh-based metering systems are frequently used. The Dhaka Power Distribution Company in Bangladesh was the first to employ this method (DPDC). DPDC has 36 Network Operation and Customer Service (NOCS) entities. One NOCS is putting an RF mesh metering system into place as part of its AMI. An RF meshbased metering system's main objectives are to make automatic meter reading possible, collect interval data, and offer a Demand Response (DR) program. which require regular, prompt twoway communication between the meter end point and the head-end system (HES).

In one NOCS, DPDC first installed 10,000 smart meters (Pari bag-Division, Dhaka).

Based on estimates, 90,000 smart meters were placed in the DPDC region.

Future Work:

There are several areas where further research and development could be beneficial for RF mesh systems in smart metering applications. Some potential directions for future work include Improving the efficiency and reliability of RF mesh systems: There is still room for improvement in terms of the energy efficiency and reliability of RF mesh systems. Researchers could work on developing algorithms and protocols that can optimize the performance of these systems and reduce the power consumption of nodes.

Integrating RF mesh systems with other technologies: RF mesh systems can be integrated with other technologies, such as power line communication (PLC) or cellular networks, to provide additional connectivity options and improve the coverage of the network. Research could focus on developing solutions that can seamlessly integrate RF mesh systems with these technologies Developing new applications for RF mesh systems: RF mesh systems can be used for a wide range of applications beyond smart metering. For example, they could be used for remote monitoring and control of industrial equipment, or for asset tracking in logistics and supply chain management. Further research could explore the potential of RF mesh systems in these and other areas.

Exploring new deployment scenarios: RF mesh systems can be deployed in a variety of scenarios, including urban, suburban, and rural environments. Research could focus on identifying the most effective deployment scenarios for RF mesh systems in different contexts and developing solutions that can adapt to the specific needs and constraints of each scenario. RF mesh systems are networks of nodes that communicate with each other wirelessly using radio frequency (RF) signals. Each node in the network acts as a router, forwarding data from other nodes to its destination. This allows for the creation of a self-organizing and self-healing network, which can operate even if some nodes fail or are temporarily unavailable RF mesh systems have several advantages that make them well-suited for smart metering applications. They can cover large areas with relatively few nodes and can operate in harsh environments such as underground or in areas with high levels of interference. RF mesh systems are also relatively low cost and easy to install, making them a cost-effective solution for utilities looking to upgrade their metering infrastructure.

In smart metering applications, RF mesh systems can be used to remotely collect consumption data from a large number of meters. This data can be used by utilities to improve their operations and customer service, by enabling them to more accurately track and bill for energy usage, detect leaks and outages, and provide real-time usage data to customers. RF mesh systems can also be used to remotely control and manage meters, allowing utilities to remotely turn them on and off, or change their settings.

There are several areas where further research and development could be beneficial for RF mesh systems in smart metering applications. For example, researchers could work on developing algorithms and protocols that can optimize the performance of these systems and reduce the power consumption of nodes. They could also explore the potential of integrating RF mesh systems with other technologies, such as power line communication (PLC) or cellular networks, to provide additional connectivity options and improve the coverage of the network. Additionally, researchers could investigate the potential of RF mesh systems for other applications beyond smart metering, such as remote monitoring and control of industrial equipment, or asset tracking in logistics and supply chain management. Finally, research could focus on identifying the most effective deployment scenarios for RF mesh systems in different contexts and developing solutions that can adapt to the specific needs and constraints of each scenario.

References

[1] wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/RF MESH METERING.

[2] "Smart_Metering_Systems_Based_on_gprs," researchgate, [Online]. Available: https://www.researchgate.net/publication/327389488.

[3] dpdc, [Online]. Available: https://dpdc.gov.bd/site/page/816191d7-0196-4e00-aa594e3cf6a400a4/-.

[4] "Dhaka_Power_Distribution_Company," wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/.

[5] "gprs system-for-smart-meter-networks," eetimes, [Online]. Available: https://www.eetimes.com/gprs system-for-smart-meter-networks/.