Thanks

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Dedication

We dedicate this humble work

To our parents who did their best to be able to Succeed in our study

and in our families.

I would also like to thank ilyes Naeji and Sabra ben alia for their support

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To our friends (kacem,youcef,madjid,oussama)

To our other friends

For all the people who helped us improve our knowledge

We provide information and advice

Thank you so much

Abstract

Internet objects "IoT" aims to place each object on the Internet (for example, Sensors, cameras, and vehicles) and thus generate large amounts of data it is likely to exceed storage systems and data analysis applications.

So the researchers used it in the field of electric power and get what is known as the smart grid it is the traditional network with Internet of things, also The electricity network became more efficient and allows the Internet objects to monitor the electrical network and to know information on its customers and generators, also thanks to the Internet objects with the electric network, We were able to: economy Electricity consumption (consumption only as needed through a Two-way communication between the service provider and Customer), dependence on renewable energies in generating electricity such as solar energy, etc., knowledge of the damage in a fast time, also storage energy to be used in the event of damage.

The goal of our system is a system that allows the control and control of the smart grid.

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General introduction

The electrical power system which has served humanity efficiently for a century must now evolve to meet changing requirements: increasing renewable energy sources, decreasing fossil fuel use, managing greater total demand, using electricity to fuel transportation, enabling more customer control of both demand and supply, dealing with security threats, and adapting to disruptive technologies. This evolution electrical power grid called the smart grid. Smart Grid concept has been discussed since the end of the last century [54], Smart Grid will allow consumers to participate in the grid action; seamlessly integrated with any sort of energy generation and storage systems; install new electrical equipment, services and new trading event; be more reliable in power quality for industry; be more efficient and reduce power losses and cost; estimate and respond for disturbing and enhance the system self-healing capacity; prevent the grid from physical and cyber-attack [55]. IEA (International Energy Agency) denotes Smart Grid as "an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users" [56].

In basic terms, it consists of a network that integrates communication technology with electric power infrastructures, a smart grid plays an important role in a smart city by modernizing power systems, efficient energy usage, and providing reliable integration of distributed and renewable energy resources. These roles make smart grids invaluable for smart cities. AMI is a fundamental component of the smart grid, allowing two-way communication between electric, gas, and water meters and city utility companies [54]. A smart meter is the

basic component of a smart grid AMI Networks. A smart city uses digital technology to improve the overall productivity, optimize the usage of resources like Electricity, Gas, and Water. This document consists of four chapters, the first chapter talks about the overview of the smart grid, the second chapter consists of two parts, part of the Internet of things, the second part talks about integrating Internet of things into the smart grid, Chapter 3 discusses the system's perception of smart grid control. Chapter 4 discusses the implementation of our system and the programming tools to achieve our system.
The goal of each project is to create a simulation system that allows for intelligent control of the network and know the customer number and the amount of energy consumption. As well as the number of generators, generators, and energy control.

Chaptre 1

Smart grid

1.1 Introduction

The traditional power grid worked very well from its inception in 1870 until 1970 [1]. Even though the consumers' demand for energy grew exponentially, it was still rather predictable. However, there has been a dramatic change in the nature of electrical energy consumption since 1970, as a load of electronic devices has become the fastest growing element of the total electricity demand and new sources of high electricity consumption have been developed, such as electric vehicles (EVs). The power grids endure a significant wastage of energy due to a number of factors, such as consumers' inefficient appliances and lack of smart technology, inefficient routing and dispensation of electrical energy, unreliable communication and monitoring, and most importantly, lack of a mechanism to store the generated electrical energy [2]– [4]. Furthermore, power grids face some other challenges as well, including growing energy demand, reliability, security, emerging renewable energy sources, and aging infrastructure problems to name a few. In order to solve these challenges, the Smart Grid (SG) paradigm has appeared as a promising solution with a variety of information and communication technologies. Such technologies can improve the effectiveness, efficiency, reliability, security, sustainability, stability and availability of the traditional power grid [5]. SG solves the problem of electrical energy wastage by generating electrical energy which closely matches the demand [2]–[4]. SG helps to make important decisions according to the demand of energy, such as real-time pricing, self-healing, and power consumption scheduling and optimized electrical energy usage. Such decisions can significantly improve the power quality as well as the efficiency of the grid by maintaining a balance between power generation and its usage [6].

1.2 Definition SG

Smart grid technology is an extended form of analog technology that has also been introduced for controlling the use of appliances by employing two-way communication. However, the prevalence of Internet access in most homes has made the smart grid more practically reliable to implement. Smart grid devices transmit information in such a way that enables ordinary users, operators, and automated devices to quickly respond to changes in smart grid condition systems.[7] The smart grid is equally advantageous for enterprises, retail stores, hospitals, universities, and multinational corporations. The entire smart grid system is automated for tracking the electricity consumption at all the locations. Grid architecture is also combined with energy management software for estimating energy consumption and its associated cost for a specific enterprise. Generally, electricity prices increase along with demand. By providing consumers with information about current consumption and energy prices, smart grid energy management services help to minimize the consumption during high-cost, peak-demand times.[7]

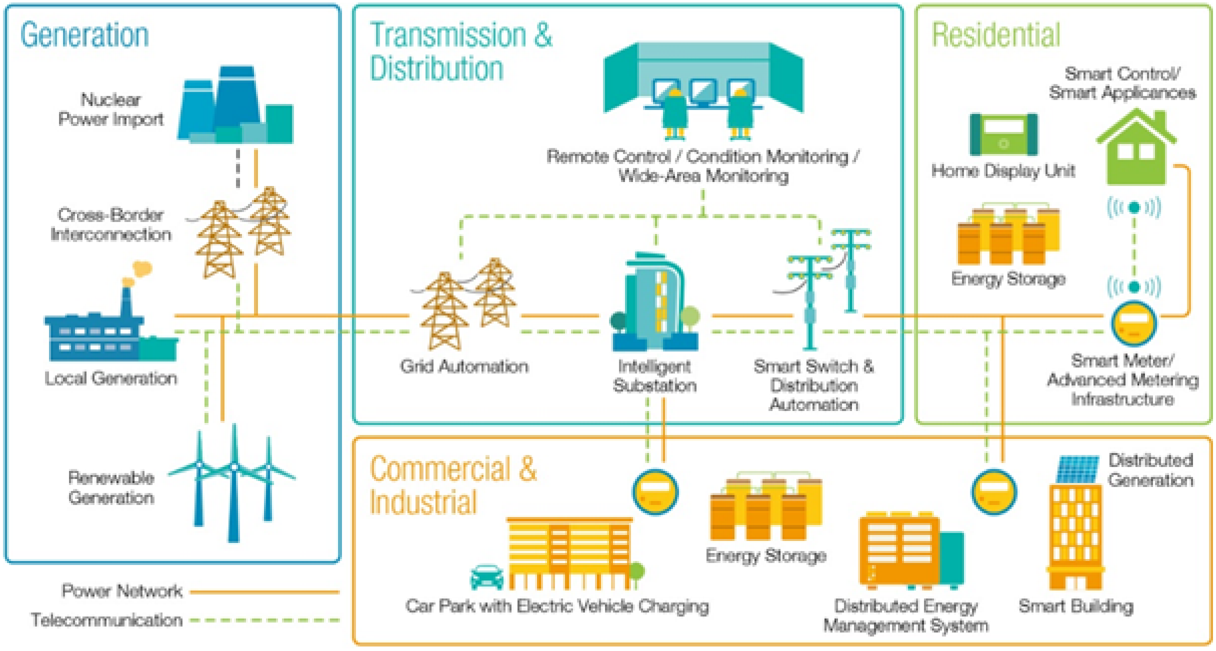


Figure 1.1: Overview of smart grid.

1.3 Smart grid Components

To achieve a modernized smart grid, a wide range of technologies should be developed and must be implemented. These technologies generally grouped into the following key technology areas as discussed below:

1.3.1 Intelligent appliances

Intelligent appliances have capable of deciding when to consume energy based on customer pre-set preferences. This can lead to going away along toward reducing peak loads which have an impact on electricity generation costs. For example, smart sensors, like temperature sensor which is used in thermal stations to control the boiler temperature based on predefined temperature levels. [8]

1.3.2 Smart power meters

The smart meters provide two-way communication between power providers and the end user consumers to automate billing data collections, detect device failures and dispatch repair crews to the exact location much faster. [8]

Figure 1.2: Smart meter.

1.3.3 Smart substations

substations are included monitoring and control non-critical and critical operational data such as power status, power factor performance, breaker, security, transformer status, etc. substations are used to transform voltage at several times in many locations, that providing safe and reliable delivery of energy. Smart substations are also necessary for splitting the path of electricity flow into many directions. Substations require large and very expensive equipment to operate, including transformers, switches, capacitor banks, circuit breakers, a network protected relays and several others. [8]

Figure 1.3: Smart substations.

1.3.4 Super conducting cables

These are used to provide long distance power transmission, and automated monitoring and analysis tools capable of detecting faults itself or even predicting cable and failures based on real-time data weather, and the outage history. [8]

Figure 1.4: Super conducting cables.

1.3.5 Integrated communications

The key to smart grid technology is integrated communications. It must be as fast as enough to the real-time needs of the system. Depending upon the need, Many different technologies are used in smart grid communication like Programmable Logic Controller (PLC), wireless, cellular, SCADA (Supervisory Control and Data Acquisition), and BPL.Key Considerations for Integrated Communication. [8]

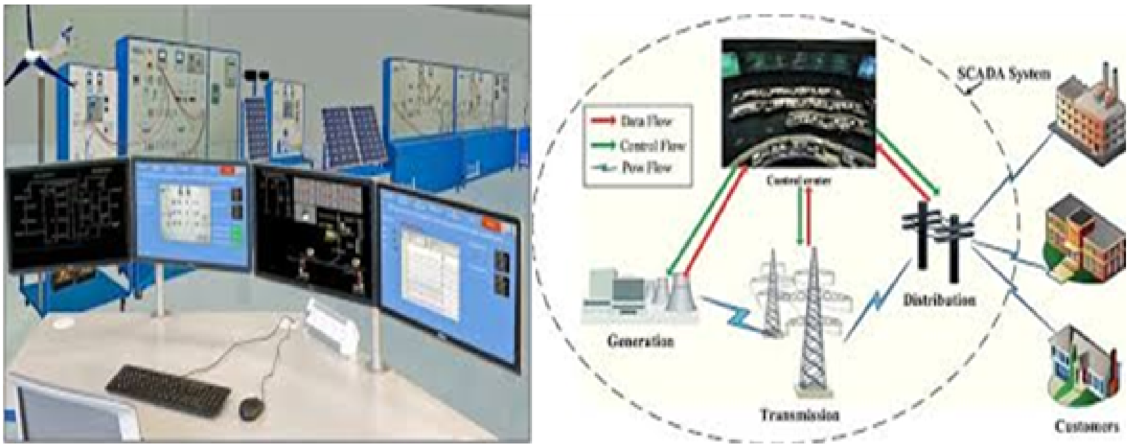


Figure 1.5: SCADA(Supervisory Control and Data Acquisition Systems).

1.4 Architecture of smart grid

1.4.1 Conceptual model of SG

Various efforts have been made regarding the standardization of smart grid communication. A number of organizations that are working on this: IEEE, International Electrotechnical Commission (IEC), and the National Institute of Standards and Technology (NIST). [10] NIST has published standards include NIST 1108 (describes, among others, smart grid interoperability and requirement of communication networks); and NIST 7628 (describes smart grid information security issues). NIST has also proposed the Smart Grid Conceptual Model which gives the characteristics, uses, behavior, and interface requirements standards of the

SG. [11]

This concept of smart energy encompasses a wide range of research issues: Distributed control, fault detection, prediction, grid stability and stability, data and communication, demand response. Thus Smart Grid is a multidisciplinary area showing many challenges. The next section is dedicated to one of these challenges: the communication infrastructure. [10]

Smart Grid is a large ”System of Systems” According to Smart Grid Interoperability Standards Roadmap proposed by NIST the American National Institute of Standards and Technology, the conceptual architecture for smart grid is composed of seven big domains [12]:

1 Bulk Generation

2 Transmission.

3 Distribution.

4 Customers.

5 Operations.

6 Markets.

7 Service Providers.

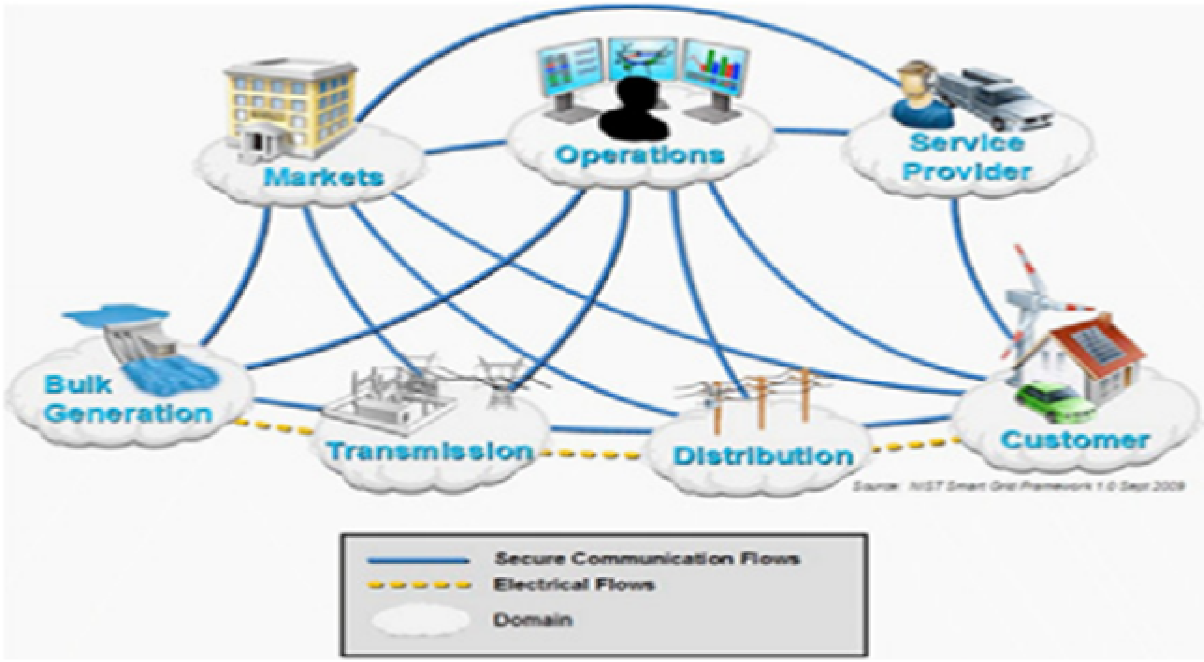


Figure 1.6: Conceptual model of Smart Grid (source IEC).

All these functional domains have different inter and intra domain communications

- Consumer domain is the user of electricity domain such as domestic, industrial, commercial or utilities
- Market domain refers to power market operators.
- Operation domain deal with power supply management.
- Service provider points service utilities companies providing customers with electrical power.
- Bulk Generation, Transmission and Distribution refers to generation, storage, transmission and distribution of power to customers.

One of the key elements of smart grid's successful operation is the interconnection of these seven domains

1.4.2 Smart Grid Electrical Network Architecture

Smart grid compose of three principal domains (see figure 1.7), we mention them respectively in terms of their source and role in SG :

Production domain : of a mixture of nuclear, solar, coal, wind or hydro power plant.[13]

Transmission domain :managed by huge number of network operating centers and substations, a large number of power lines deliver the electricity to distribution domain.[13]

Distribution domain :sum of complex networks topologies delivers electrical power to residential areas, rural farms, metropolitan areas, and industrial areas for consumption.[13]

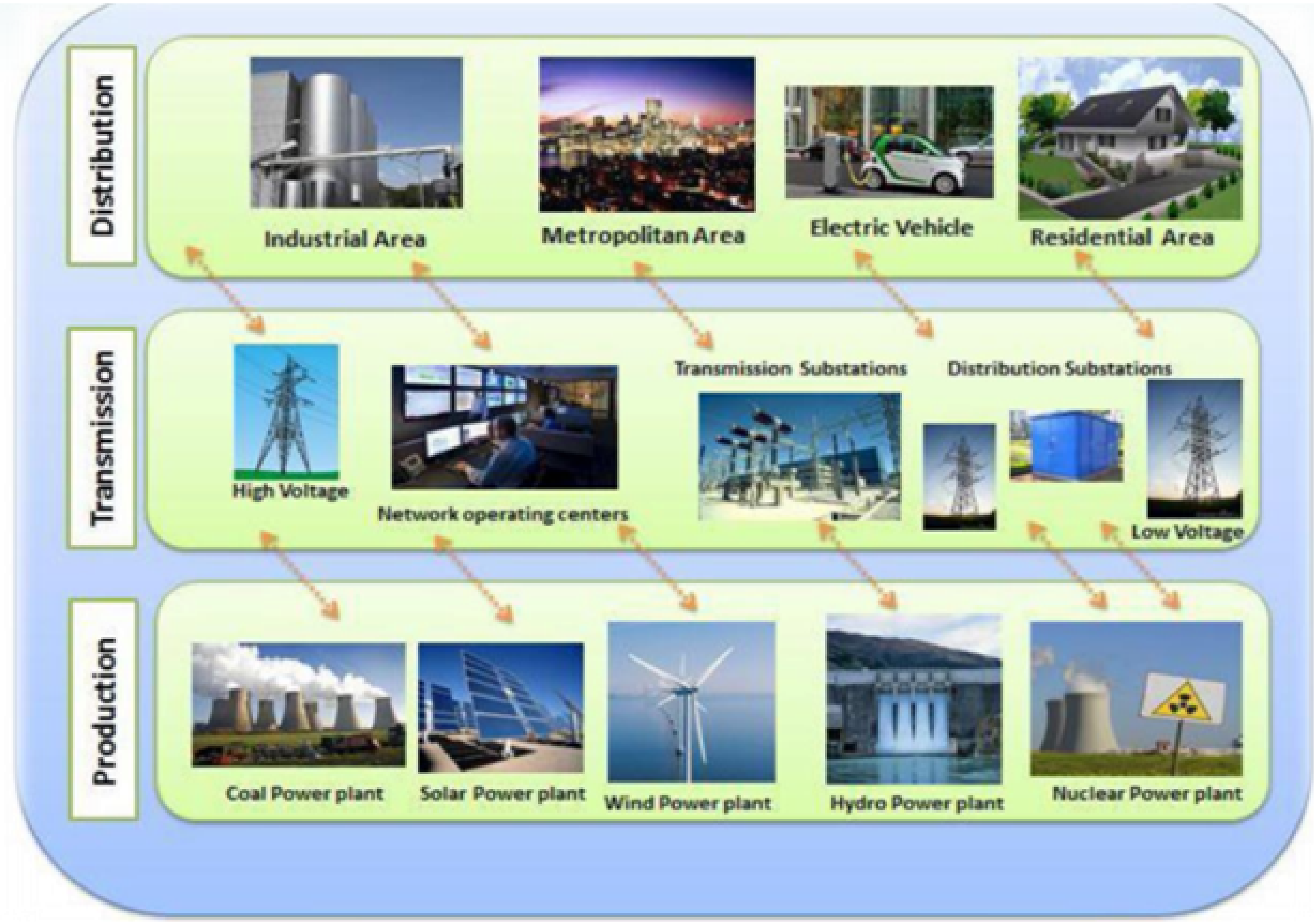


Figure 1.7: Grid Electrical Network Architecture.

1.5 Smart grid communication

Applying ICT to the grid is not obvious because it must deal with constraints that did not exist in automating the telecommunications network. Unlike the communications network, which routes packets of information, the electric grid routes power flows that have many constraints. [10]

A Smart Grid communications infrastructure enables utilities to interact with devices on their electric grid as well as with users, distributed power generation and storage facilities. [10]

In order to satisfy the full concept of the Smart Grid, the communications structure has to be designed as a multilayer architecture that extends across the whole SG.[10]

It has also to cover large geographical areas, consequently, the communications infrastructure of the SG should connect a large set of nodes of the entire region and utilities need to use and accept several networks: [10]

- ✓ **WideAreaNetwork**(**WAN**) for automation, distribution and for covering long-haul distances by providing communication links between the NANs and the utility systems to transfer information.
- ✓ **NeighborhoodAreaNetwork**(**NAN**) for connecting multiple HANs to local access points.
- ✓ **Homeareanetwork**(**HAN**) extends communication to end points within the end-user home or business.

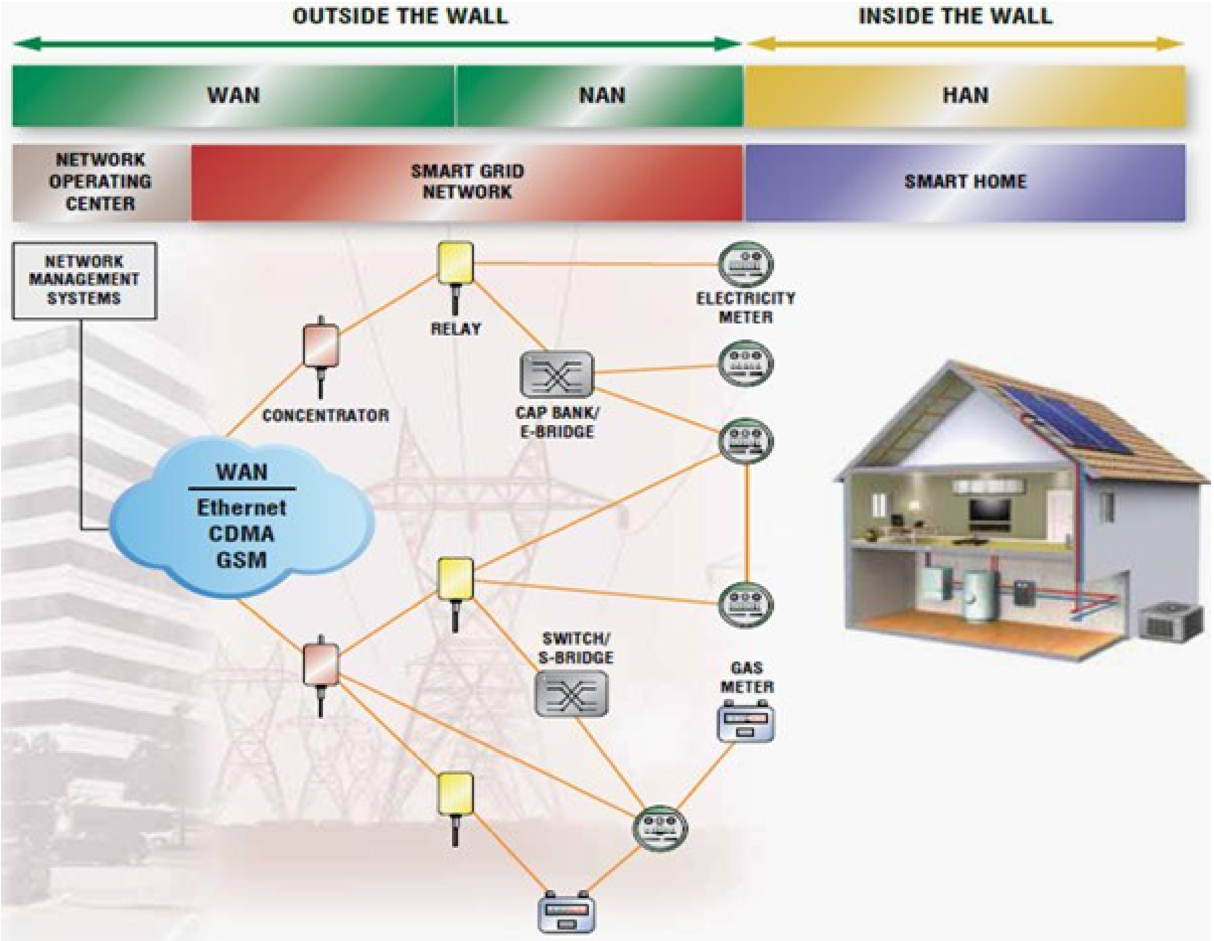


Figure 1.8: The smart grid communications architecture.

Each of the three networks is interconnected through a node or gateway: a concentrator between the WAN and NAN and an e-meter between the NAN and HAN.

Each node communicates through the network with adjacent nodes.

1.6 Different betweenTraditional Power grid and Smart Grid

Smart grid today is Electricity revolution of the world because solve many problem of traditional grid and Many benefits are mentioned in the following table :

Characteristics	Traditional Power grid	Smart Grid
Technology	**Electromechanical** : Traditional energy infrastructure is electromechanical. This means that it is of, relating to, or denoting a electrically operated. The technology of this manner is typically considered to be “dumb” as it has no means of communication between devices and little internal regulation.	**Digital** : Smart grid employs digital technology allowing for increased communication remote control and self-regulation.
Distribution	**One-Way Distribution** : Power can only be distributed from the main plant using traditional energy infrastructure.	**Two-Way Distribution** : While power is still distributed from the primary power plant, in a smart grid system, power can also go back up the lines to the main plant from a secondary provider. An individual with access to alternative energy sources, such as solar panels, can actually put energy back on to the grid

Generation	**Centralized:** With traditional energy infrastructure, all power must be generated from a central location. This eliminates the possibility of easily incorporating alternative energy sources into the grid.	**Distributed:** Using smart grid infrastructure, power can be distributed from multiple plants and substations to aid in balancing the load, decrease peak time strains, and limit the number of outages.
Sensors	**Few Sensors** : The infrastructure is not equipped to handle many sensors on the lines. This makes it difficult to pinpoint the location of a problem and can result in longer downtimes.	**Sensors Throughout** : In a smart grid infrastructure system, there are multiple sensors placed on the lines. This helps to pinpoint the location of a problem and can help reroute power to where it is needed while limiting the areas affected by the downtime.
Monitoring	**Manual:** Due to limitations in traditional infrastructure, energy distribution must be monitored manually.	**Self:** The smart grid can monitor itself using digital technology. This allows it to balance power loads, troubleshoot outages, and manage distribution without the need for direct intervention from a technician.

Restoration	**Manual:** In order to make repairs on traditional energy infrastructure, technicians have to physically go to the location of the failure to make repairs. The need for this can extend the amount of time that outages occur.	**Self-Healing:** Sensors can detect problems on the line and work to do simple troubleshooting and repairs without problems intervention. For related to infrastructure damage the smart grid can immediately report to technicians at the monitoring center to begin the necessary repairs.
Equipment	**Failure and Blackout** : As a result of aging and limitations, traditional energy infrastructure is prone to failures. Failure of infrastructure can lead to blackouts, a condition where the end customer is receiving no power to their unit causing downtime.	**Adaptive and Islanding** : Using a smart grid system, power can be rerouted to go around any problem areas. This limits the area impacted by power outages and can do it on a per residence level.

Control	**Limited:** Using traditional power infrastructure, energy is very difficult to control. After leaving the power plant or substation, companies have no control over the energy distribution.	**Pervasive:** With the increased amount of sensors and other smart infrastructure, energy companies have more control than ever over power distribution. Energy and energy consumption can be monitored all the way down the line; from the moment it leaves the power plant, all the way to the consumer.
Customer Choices	**Fewer** : The traditional power grid system infrastructure is not properly equipped to give customers a choice in the way they receive their electricity. Alternative energy sources, for example, have to be separated from power plants and traditional grid infrastructure. This is also part of the reasoning behind the establishment of electric companies as a public utility.	**Many** : Using smart technologies, infrastructure can be shared. This allows more companies and forms of alternative energy to come on to the grid allowing consumers to have more choice in how they receive energy.

Table 1.1 : Benefits of smart grid compared with traditional grid [9].

1.7 Disadvantage and challenges of smart grid

It is true smart grid solved many problems of traditional grid, but it is contains many problem as :

- ✓ Biggest concern: security and privacy.
- ✓ Some smart meters can be hacked which can be used to increase or decrease the demand for power.
- ✓ Continuous communication network should be available.
- ✓ During emergency situation, network congestion or performance are big challenges in smart grid system.
- ✓ Cellular network providers do not provide guaranteed service in abnormal situations such as wind storm, heavy rain and lightning conditions.
- ✓ It is expensive to install smart meter compare to traditional old electricity meter (cost).
- ✓ Volatility arising from dynamic pricing might cause catastrophic rate spikes. Think User's 'surge pricing'.
- ✓ Complicated rate structures might not incentivize efficiency if customers do not understand what their current rates are.
- ✓ Customers adopt risks of participating in such open markets. Currently, customers are shielded from adverse market conditions somewhat by utilities with the workforce and expertise.
- ✓ Emergent behavior: Does individual assets/customers acting in their own self-interest always lead to optimization of the utility's cost function? Conversely, would striving for global maxima always guarantee benefits to me as an individual owner?

1.8 Applications of Smart Grid

Smart grid plays an important role in modern smart technologies. Following are the most common applications of smart grid technology.

Future Applications and Services	**Real Time Market**
Business and customer care	Application data flow to/ from end-user energy management systems
Smart charging of PHEVs and V2G	Application data flow for PHEVs
Distributed generation and storage	Monitoring of distributed assets
Grid optimization	Self-healing grid: fault protection, outage management, and dynamic control of voltage, weather data integration, centralized capacitor bank control, distribution and substation automation, advanced sensing, automated feeder reconfiguration.
Demand response	Advanced demand maintenance and demand response, load forecasting, and shifting.
AMI (Advanced metering infrastructure)	Provides remote meter reading, theft detection, customer prepay, mobile workforce management

Table 1.2 : Applications of Smart Grid.

1.9 Simulation of SG

There is plenty of software to deal with power system issues for researching on network operation and expansion planning. Building and simulating electrical models in a computer environment is necessary as a convenient and less costly way to analyze the power grid. Understanding the part of the power system and the grid as a whole could be developed via modeling and simulation. [14]

Electrical network simulator capabilities need to be promoted or rebuilt to achieve simulating Smart Grid issues which would never happen in the conventional power systems.

For example, with an increasing number of consumers participating in the power system, how should the system be operated in the most efficient way? If there is a cyber-attack "noise" injected to the communication channel, how could the smart gird detect the attacking "noise" and prevent the network from damaging?

1.9.1 ISSUES OF SMART GRID SIMULATION

The smart grid simulation requirements, but what we can do in simulation to address the smart grid events. A communication network would be employed to transfer the energy consumption and storage level data into the Control Centre. Industry standard PC and Ethernet would be applied in a smart grid to communicate between substations and Control Centre. Universal monitoring and controlling which is installed inside the control Centre would fully be responsible for energy generation, storage, and utilization. It will regulate the renewable energy generation and energy storage and consumptions according to the fluctuating generation forecasting (especially the renewable energy) and dynamic energy load curve. Besides, new algorithms would be built into the control and monitoring device. For instance, the micro-gird energy management system needs to be more intelligent to deal with the uncertainty and variability of demand and generation. Computation Algorithm (CA) is one of the intelligent algorithms that can update information during the system operation. When simulating a scenario of the smart grid, the topology of the power system and communication system should keep the same. Communication devices or monitoring and controlling equipment would be placed in every critical point to sense the information signal and transfer to the control Centre.

1.9.2 CURRENT POWER GRID SIMULATORS

Current Power grid simulators usually focus on a certain professional domain which is very narrow and less connection with any other field. Basically, there are 5 areas for current power grid simulators.

(1) Operation models are designed to estimate the reliability and normal, abnormal operation scenarios for current power system.

(2) Expansion models are used for assess when new technologies or network expansion, the system operation under normal and abnormal scenarios to estimate the policy feasibility.

(3) Contingency analysis is employed into system modeling to discover inherent risk when load is changing or post fault operation.

(4) Power market models research on market activities between stakeholders from generators to customers under competition environment.

(5) Specific models are designed for critical assessment when system is suffered from various disturbances [14]. Data cannot be exchanged among the models in real-time, integration is impossible to both market research and operation research on the same model. Communication network does not exist in current simulator. Additional communication channel needs to apply into power system by cooperating with communication network simulation. Unnecessary obstacles such as synchronizing discrete network with continuous network need to be addressed. [15]
Is presenting SCADA cyber security problems by co-simulating Power World Server with a network emulator. Protection devices are limited in the power system simulators.

1.9.3 FUTURE SMART GRID SIMULATOR

In terms of smart grid functions, power grid models need tosimulate three general dimension scenarios as a whole, namedoperating, system expansion and disruption. In operation scenario, besides the basic functions such as load flow calculation and stability analysis, smart grid simulator is required to do contingency analysis and optimization in power system operations. For instance, power flow calculations aim to minimize the power losses, minimize the cost or minimize load shedding need to be presented. Post fault load flow need to be done in order to power transfermargins or inherent risk inside the power system.
In addition,power system market operation simulation behaviors betweenstakeholders and market participants [14].
System expansion simulates the new technologies appliedinto existing grid for assessing power system operation. Researching on scenario feasibility is modeled to meet the future task. For example, to meet the target on renewable energy 30 penetration in 2030, variability and uncertainty of renewable energy need to be simulated and analyzed in a virtual but realistic environment before applying so many wind and solar energy conversion systems in practice. Last but not least, dimension is to simulate unwanted disasters and malicious physical and cyber-attacks. This kind of modeling needs to integrate power system and communication system together for stochastic events. Generally, power system modeling is continuous while communication system is discrete. The two systems can be synchronous with limited time scale.[16] employs a global scheduler to synchronize two systems implicitly to simulate the failure on primary protection and remote protection devices.

1.10 Conclusion

A revolution in the energy domain is underway, namely the Smart Grid. Smart Grid is the owner as well as user-friendly technology. But there are many challenges to be solved, and thus the current research to integrate the Internet of things with a smart grid to overcome the challenges of the smart grid.

Chaptre 2

Internet of things in smart grid

Part 01 : internet of things

2.1 Introduction

The next wave in the era of computing will be outside the realm of the traditional desktop. In the Internet of Things (IoT) paradigm, many of the objects that surround us will be on the network in one form or another. Radio Frequency Identification (RFID) and sensor network technologies will rise to meet this new challenge, in which information and communication systems are invisibly embedded in the environment around us. This results in the generation of enormous amounts of data that have to be stored, processed and presented in a seamless, efficient, and easily interpretable form. This model will consist of services that are commodities and delivered in a manner similar to traditional commodities.

Smart connectivity with existing networks and context-aware computation using network resources is an indispensable part of IoT. With the growing presence of Wi-Fi and 4G-LTE wireless Internet access, the evolution towards ubiquitous information and communication networks is already evident. However, for the Internet of Things vision to successfully emerge, the computing paradigm will need to go beyond traditional mobile computing scenarios that use smartphones and portables and evolve into connecting everyday existing objects and embedding intelligence into our environment. The term Internet of Things was first coined by Kevin Ashton in 1999 in the context of supply chain management [17]. However, in the past decade, the definition has been more inclusive covering a wide range of applications like healthcare, utilities, transport, etc. [18]. Although the definition of 'Things' has changed as technology evolved, the main goal of making a computer sense information without the aid of human intervention remains the same. The radical evolution of the current Internet into a Network of interconnected objects that not only harvests information from the environment (sensing) and interacts with the physical world (actuation/command/control), but also uses existing Internet standards to provide services for information transfer, analytics, applications, and communications. Fueled by the prevalence of devices enabled by open wireless technology such as Bluetooth, radio frequency identification (RFID),Wi-Fi, and telephonic data services as well as embedded sensor and actuator nodes, IoT has stepped out of its infancy and is on the verge of transforming the current static Internet into afully integrated Future Internet [19]. The Internet revolution led to the interconnection between people at an unprecedented scale and pace. The next revolution will be the interconnection between objects to create a smart environment.

2.2 Iot elements

We present a taxonomy that will aid in defining the components required for the Internet of Things from a high-level perspective. Specific taxonomies of each component can be found elsewhere [20–21]. There are three IoT components which enable seamless ubicomp : (a) Hardware—made up of sensors, actuators and embedded communication hardware (b) Middleware—on-demand storage and computing tools for data analytics and (c) Presentation—novel easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications.

2.2.1 Radio Frequency Identification (RFID)

The RFID technology is a major breakthrough in the embedded communication paradigm which enables the design of microchips for wireless data communication. They help in the automatic identification of anything they are attached to acting as an electronic barcode [22, 23]. The passive RFID tags are not battery powered and they use the power of the reader's interrogation signal to communicate the ID to the RFID reader. This has resulted in many applications, particularly in retail and supply chain management. The applications can be found in transportation (replacement of tickets, registration stickers) and access control applications as well. The passive tags are currently being used in many bank cards and road toll tags which are among the first global deployments. Active RFID readers have their own battery supply and can instantiate the communication. Of the several applications, the main application of active RFID tags is in port containers [23] for monitoring cargo.

2.2.2 Wireless Sensor Networks (WSN)

Recent technological advances in low power integrated circuitsand wireless communications have made available efficient, lowcost, low power miniature devices for use in remote sensing applications. The combination of these factors has improved the viability of utilizing a sensor network consisting of a large numberof intelligent sensors, enabling the collection, processing, analysisand dissemination of valuable information, gathered in a varietyof environments [24]. Active RFID is nearly the same as the lower end WSN nodes with limited processing capability and storage. Thescientific challenges that must be overcome in order to realize theenormous potential ofWSNs are substantial and multidisciplinaryin nature [24]. Sensor data are shared among sensor nodes and sent to a distributed or centralized system for analytics. The components that make up theWSN monitoring network include:

(a) **WSN hardware-typically a node** (WSN core hardware) contains sensor interfaces, processing units, transceiver units andpower supply. Almost always, they comprise of multiple A/Dconverters for sensor interfacing and more modern sensornodes have the ability to communicate using one frequencyband making them more versatile [24].

(b) **WSN communication stack-the nodes** are expected to be deployed in an ad-hoc manner for most applications. Designing an appropriate topology, routing and MAC layer is critical forthe scalability and longevity of the deployed network. Nodesin a WSN need to communicate among themselves to transmitdata in single or multi-hop to a base station. Node drop outs,and consequent degraded network lifetimes, are frequent. Thecommunication stack at the sink node should be able to interactwith the outsideworld through the Internet to act as a gateway to theWSN subnet and the Internet [25].

(c) **WSN Middleware-A mechanism to combine cyber infrastructure with a Service Oriented Architecture (SOA) and sensor networks** to provide access to heterogeneous sensor resources ina deployment independent manner [25]. This is based on theidea of isolating resources that can be used by several applications. A platform-independent middleware for developing sensor applications is required, such as an Open Sensor WebArchitecture (OSWA) [26].
OSWA is built upon a uniformset ofoperations and standard data representations as defined in theSensor Web Enablement Method (SWE) by the Open GeospatialConsortium (OGC).

(d) **Secure Data aggregation—An efficient and secure data aggregation method** is required for extending the lifetime of thenetwork as well as ensuring reliable data collected from sensors [26]. Node failures are a common characteristic of WSNsthe network topology should have the capability to heal itself. Ensuring security is critical as the system is automaticallylinked to actuators and protecting the systems from intrudersbecomes very important.

2.3 Architecture of Iot

Internet of things is known for many architecture but in this paper to discuss but two architecture, three layered architecture in this part and the four layered architecture in second part.

2.3.1 Three layered architecture

We will explain the three-layer architecture, as shown in Figure 2.1

The perception layer

consists of two-dimension code tags and readers, RFID tags and readers, cameras, GPS, all kinds of sensors, sensor network, Machine to Machine (M2M terminals, and sensor gateways, etc. Perception layerincludes perception control sub-layer and communicationextension sub-layer. Perception control sub-layer realizesintelligent perception of the physical world, informationacquisition and processing and automatic control; whilecommunication extension sub-layer connected the physical things to the network layer and the application layer with communication terminal module directly or through theextension network composed by the terminal modules.[27]

The network layer

consists of converged network formed by all kinds of communication network and the Internet. The concept of network layer has been widely accepted due to its mature technologies. Besides, the PIoT management Centre and information Centre are parts of the network layer. That is to say, the network layer can not only operate the network, but also can operate the information. Network layer mainly realizes information transmission, routing and control, including the access network and core network. The network layer can rely on industry-specific communication networks as well as the public telecommunications networks.[27]

Application layer

is a combination of IoT technologies and industry expertise to achieve a broad set of intelligent application solutions. Application layer includes application infrastructure/middleware and a variety of applications of IoT. Application infrastructure/middleware provides information processing, computing, and other common basic services, capacity and resources interface for IoT. The key issue of the application layer is information sharing and information security. Through the application layer, IoT can achieve deep integration of information technology with the industry. It will have great effect on economic and social development.[27]

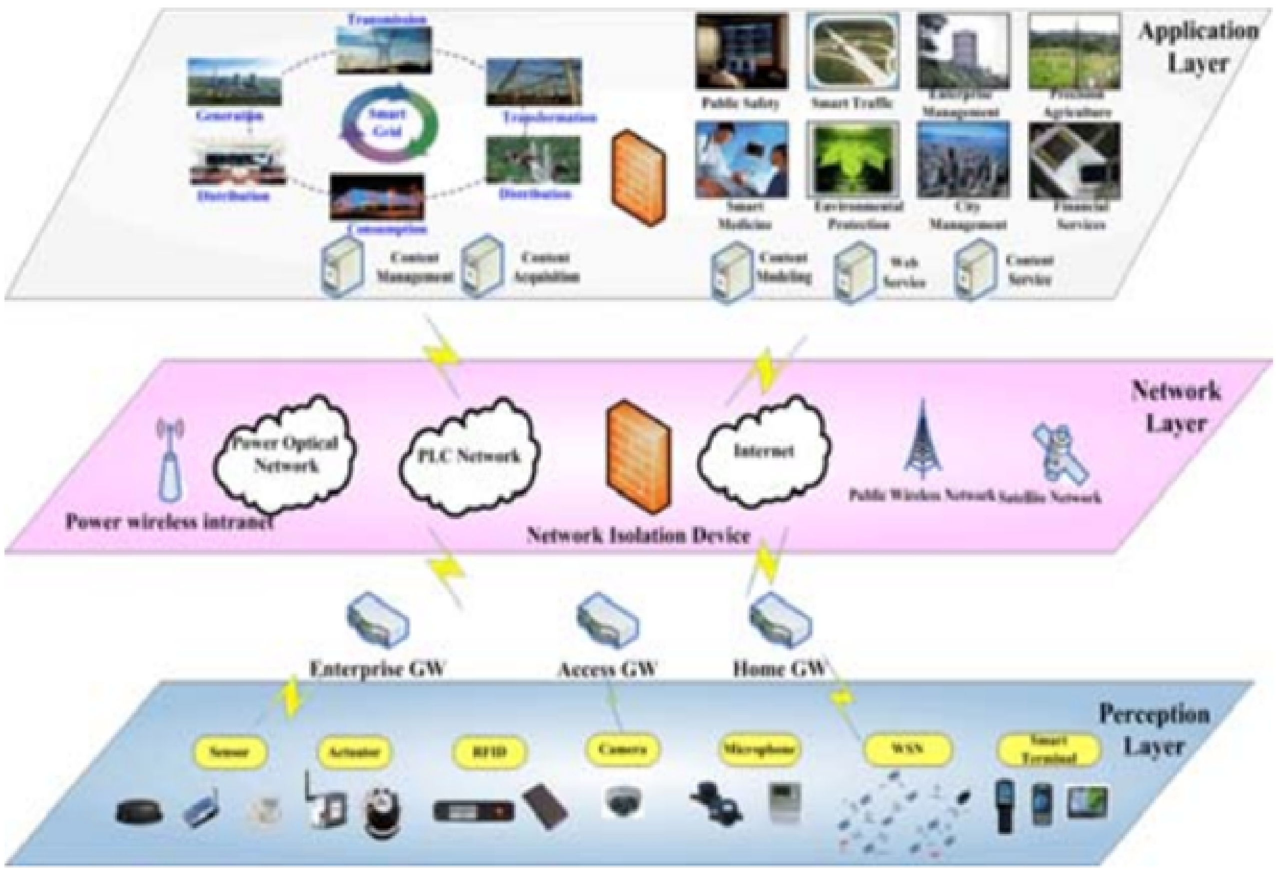


Figure 2.1: Architecture of IOT.

Part 02 :Internet of things in smart grid

2.4 Iot in smart grid

Internet of Things (IoT) is a large network consist of all kinds of information sensing devices such as radio frequency identification (RFID) devices, infrared sensors, global positioning system (GPS), laser scanners and the Internet. IoT employs a variety of smart devices to sense and identify physical world. Based on Internet and communications networks, it utilizes computing facilities and software systems for information processing and knowledge digging. By using IoT technology, we can achieve human-thing and thing-thing information exchange and seamless linkage of information flows, thus accomplishing real-time control, accurate management and scientific decision-making of the physical world.[28]

Power Internet of Things (PIoT) is the application of IoT in smart grid. PIoT can achieve reliable information transmission through wired or wireless communication network and smart information processing in power grid system. PIoT can be widely applied in every aspect of smart grid, such as power generation, transmission, transformation, distribution and consumption.

Overhead high-voltage transmission lines are vulnerable to weathers (such as wind, snow, etc.), resulting in damage to power transmission line, influence in security operation of power transmission facilities, paralysis of large area power supply, and significant loss of the national economy. Wind vibration and wind deviation are common pitfalls of overhead high-voltage transmission lines, and are the main reasons of transmission line broken. Once conductor galloping caused by strong wind, it usually lasts for several hours and will bring great damage to the high-voltage.

Transmission lines. The rainy and snowy weather may cause icing to transmission line, and the asymmetric pulling force will lead to leaning of the transmission tower, which is the potential risk to the safety of transmission line. [29]

2.5 Architecture of Iot in smart grid

The Internet has entered things in many areas including Smart Grid. We will now talk about the architectural architecture of the smart grid and we will talk about the added layers

2.5.1 The four layered architecture

A four-layered architecture (see figure 2.2) for IoT-aided SG systems based on the characteristics of SG information and communication systems was proposed in [30]. This architecture is comprised of a terminal layer, a field network layer, a remote communication layer and a master station system layer. According to the three-layered IoT hierarchical model, the terminal and field network layers in this architecture correspond to the IoT perception layer, the remote communication layer corresponds to the IoT network layer, and the master station system layer corresponds to the IoT application layer.

The terminal layer

is comprised of IoT devices deployed in various SG functions, such as power generation, transmission, distribution and utilization. The IoT devices include remote terminal units, information collection devices, smart meters, smart devices and intelligent electronic devices. This layer collects information from IoT devices and transmits the collected data to a field network layer.

The field network layer

can be wired or wireless. Depending on the type of IoT devices, the appropriate communication network is used. As an example, ZigBee is used by sensor nodes in order to transmit the collected data to a remote communication network layer.

The remote communication network layer

can also be wired or wireless. It is comprised of various communication networks which provide connectivity to the Internet, such as 2G, 3G, and LTE as wireless networks, and optical networks as a wired network. This layer serves as a middleware between IoT devices and the master station system layer.

The master station system layer

is the control and information system of a SG. It controls and manages all the SG functions. It can also be considered as an interface to the IoT-aided SG applications.

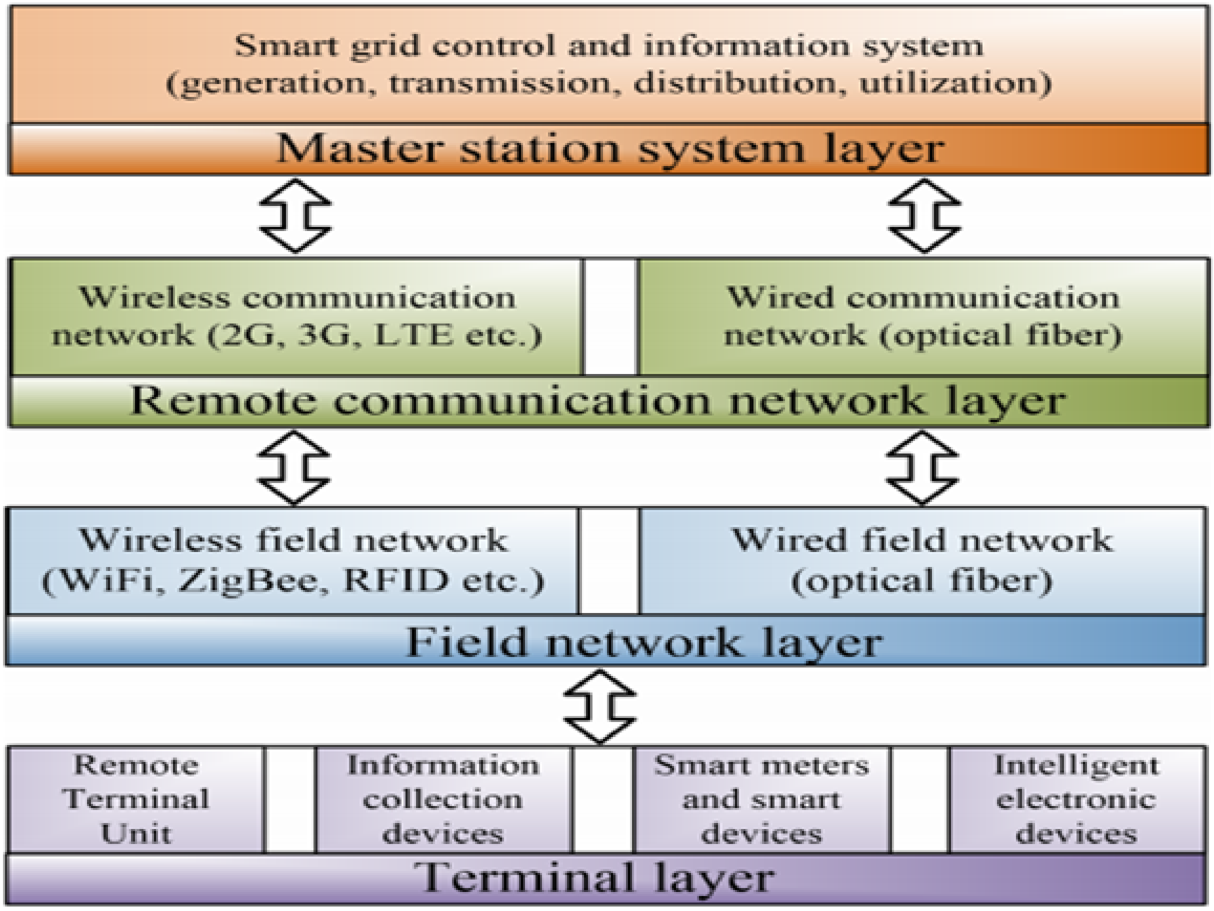


Figure 2.2: Four-layered architecture .

2.6 Key technologies of Iot

The key technologies of applying IoT to smart gridinclude:

2.6.1 Sensor technology

Sensors can be considered as the “sense organs” of the material world, and provide the raw information for information processing, transmitting, analyzing and feedback, including heat, power, light, electricity, sound and signals.[31] Sensors can be divided into various types in terms of materials, output signal types, and manufacturing technologies, etc. Recently, nanotechnology has been utilized to provide high performance sensitive material and new sensor production methods, such as Micro Electro Mechanical Systems (MEMS) technology which greatly extends the application field of sensors and promotes the development of sensor industry.[31]

2.6.2 Information and communication technology

Based on information and communication technology,the transmission and collaboration of the perceptioninformation can be realized, thus the state of the power griddevices can be sensed. According to the range oftransmission, information and communication technology can be divided into two categories: short range communication technology and wide area communication technology.[32] In wide area communication network, IP basedInternet, power line carrier, Optical Fiber Composite LowVoltage Cable (OPLC), power information wireless network,public 2G/3G mobile communication network, TimeDivision Long Term Evolution (TD-LTE) 4G network, andsatellite communication network can achieve long-distanceinformation transmission. For short range communications,IEEE 802.15.4 (ZigBee), Bluetooth, and Ultra Wideband(UWB) represent the mainstream technology. Due to thecharacteristics of low-power, low-rate and short-distance,ZigBee is suitable for the IoT devices with constraint ofcomputation and storage capacity.[32]

2.6.3 Data fusion technology

The resources for IoT terminals are usually limited, including battery capacity, processing ability, storage capacity and bandwidth. In the process of gathering information, it is not appropriate to send all data to the cluster node because it would waste bandwidth and energy. In order to keep the efficiency of information gathering, data fusion technology can be utilized to collect data thus more effective and useful data can be combined.[33]

2.6.4 Reliable communication for smart grid under the complex application environment

There are several requirements of IoT applications indifferent environments, such as reliability, self-organization,signal penetration, hybrid communication technology and Self-healing. Since the performance of IoT highly relies onthe actual environment, IoT technology needs to be carefullydesigned to overcome the adverse environmental factors.[34][34]

Forexample, when a small portion of devices fails to transmitdata, the route and transmission strategy would be reelectedby self-healing technology, thus the reliability of the wholenetwork would not be affected.[34]

2.6.5 Power acquisition technology

Due to the energy of IoT devices are usually supportedby battery, power acquisition problem is very essential forthe application of IoT, such as the power transmission line monitoring system, various sensors, backbone nodes andvideo cameras set up in the transmission lines and thetransmission towers. If the energy supply problem of IoT can be solved, the applications of IoT in smart grid would begreatly extended.[35]

2.6.6 Environment compatibility with high-voltage and strong-electromagnetic

Since IoT terminals are often deployed in outdoor powertransmission lines, substations, and even more severeelectromagnetic environment in smart grid. In order toprolong the lifetime of the sensing terminal under the above severe environments, the sensor and its chip manufacturingprocess need to embed new technologies, such as waterproof,dustproof, anti-vibration, anti-electromagnetic, anti-hightemperature, anti-low-temperature and others.[36]

2.6.7 Information security technology

Information security technology can be utilized in threelayers to avoid information leakage and loss, and protect thesafety operation of the applications. Security should beconsidered not only in the data transmission process, but alsoin the process of data storage and management.[37]

2.7 Based online monitoring system of power transmission line :

Power transmission line monitoring system is one of themost important applications of IoT in smart grid, particularly,disaster prevention and mitigation for power transmissionlines. In recent years, natural disasters bring about manychallenges to high-voltage power transmission facilities,including security, stability, and reliability. Moreover,current power transmission line monitoring operations aremainly realized by manual operations which face the problems of low efficiency, low accuracy, and longoperation period.[38]

At present, a number of monitoring systems of powertransmission line have been put into operation. Thesesystems often use wireless public network such as 3G orother wireless communication networks for datatransmission of each sensor, but there are some problemssuch as high operation and maintenance cost, incompletenetwork coverage, low data transmission rate and complexnetwork maintenance, which will restrict the development ofpower transmission line monitoring system, hinder theimprovement of power transmission efficiency and constrainthe progress of patrol of power transmission line. In order to achieve real-time online monitoring of powertransmission lines, wireless sensors about conductorgalloping, micrometeorology, wind vibration, icing, andconductor temperature are deployed on the 220kV, 500kVhigh-voltage power transmission lines in the experimentalarea The power transmission line monitoring system iscomposed of two parts. One part is installed along with thepower transmission lines to monitor the status of theconductors; the other part is installed on the transmissiontowers to monitor the environment and the states of thetowers. The communication between the IoT devices on thepower transmission lines and the transmission towers isusually based on short-range wireless communicationtechnology. The IoT based online monitoring system of powertransmission lines can transmit the information fartherthrough multi-hop relay communication network, which canensure effective information transmission for the large spanand long distance power transmission facilities. According to different application scenes of power transmission line, thesystem network topology can be cluster-chain type, where several cluster networks form a chain network to cover thepower transmission line.

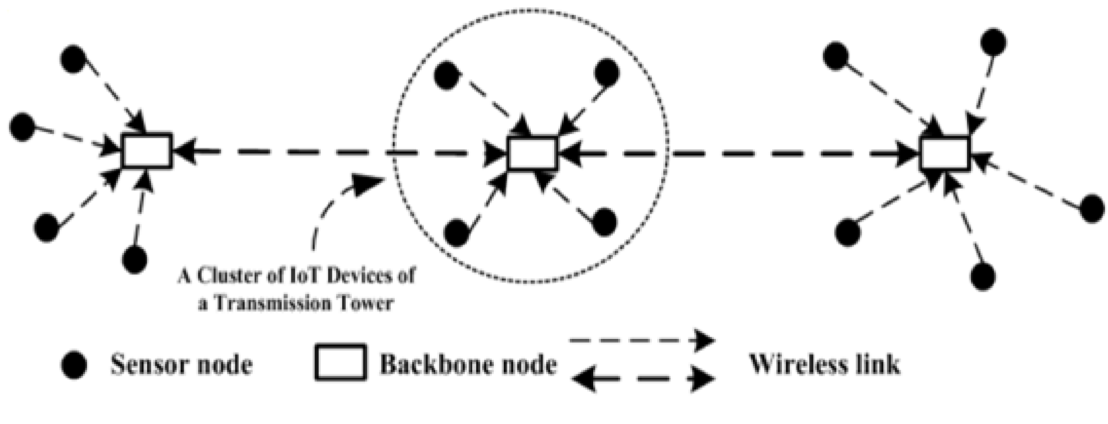


Figure 2.3: Network topology for online monitoring system of power transmission line.

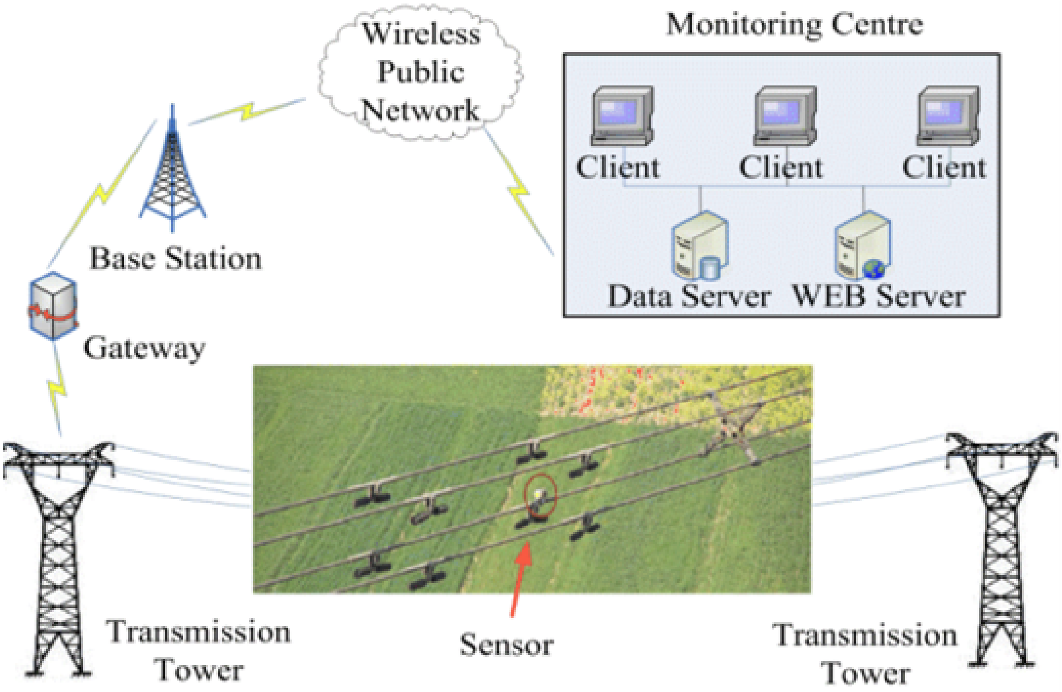


Figure 2.4: Data transmission network.

Each sensor can communicate to the nearby backbone node directly, and the communication links between the sensors and the backbone nodes are generally unidirectionallinks; each backbone node can communicate to at most 256 sensors. The distance between the backbone nodes is several hundred meters, and the communication link between the backbone nodes is bidirectional link. Parts of the backbone nodes are able to access to the public network through 3G, TD-LTE or power optical network. The specific monitoring contents are as follows [38] :

(1) **Transmission tower leaning :** The leaning sensor transmits the status of thetransmission tower to the nearby backbone node, whichmerges the data from several leaning sensors together toform the information of transmission tower leaning andrealize real-time monitoring and early warning.

(2) **Conductor galloping :** According to the calculation and analysis of theacceleration of the monitoring point, the number of verticaland horizontal half-waves of galloped

conductor can beanalyzed and the motion track can be calculated. Thuswhether the conductor is in galloping danger can bedetermined, and the discharge between phase conductors andtower collapse can be avoided.

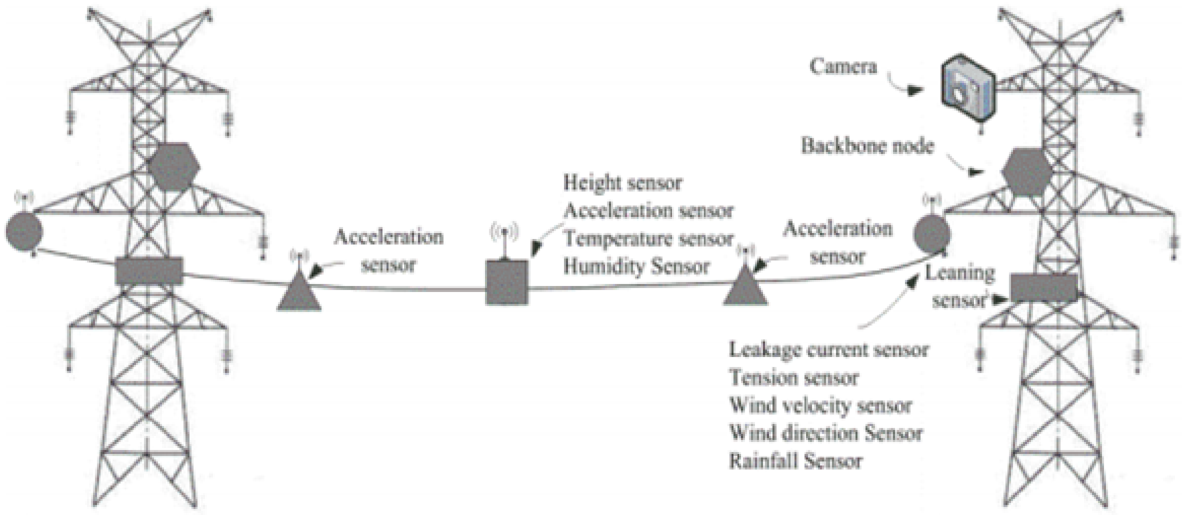


Figure 2.5: The sensor deployment scheme of the power transmission line and tower.

(3) **Wind deviation :** The wind deviation can be calculated by the threedimensional acceleration sensor deployed on the conductors. The wind deviation data results from the wind velocity sensor and the acceleration sensor can provide the field test data for the wind deviation verification of the conductor. The operation personnel can take reasonable measures to resist the wind deviation and find the discharge point.

(4) **Micro-meteorology :** The temperature, humidity, wind velocity, sunshine, and rainfall can be recorded by the wireless sensors along the conductor or on the tower.

(5) **onductor icing :** Conductor icing can be determined according to the result of the micro-meteorology sensors and the tension sensors. The data analysis system at the monitoring Centre analyzes the information collected by the sensors and makes the early warning decisions. Thus the ice flashover can be alleviated or avoided.

(6) **Wind vibration :** The acceleration sensors are used to detect the vibrationof the

conductor caused by wind. The vibration frequencyand amplitude can be recorded and analyzed; the wind velocity, wind direction, environment temperature, humidityand the fatigue life of the conductor can also be analyzed.

(2) **Conductor temperature :** The operating temperature of conductor can be collectedby the wireless temperature sensors along the conductor.

2.8 EXISTING APPLICATIONS OF IOT-AIDED SG SYSTEMS

There are many existing applications of IoT-aided SGsystems, and many more have been proposed, as represented in Figure 14. In this section, we discussexisting applications of IoT-aided SG systems in the literature [39], [40], [41].

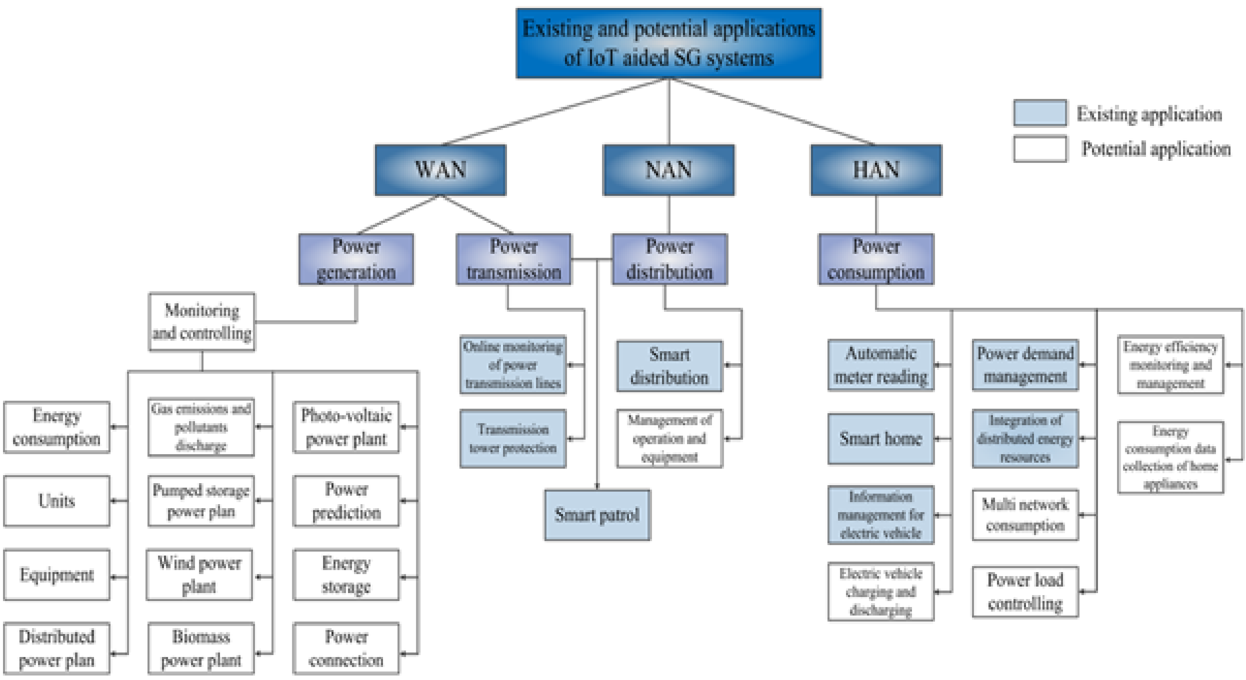


Figure 2.6: Existing and potential applications of IoT-aided SG systems classied into WAN, NAN and HAN.

2.8.1 HAN Applications

(1) **Automatic Meter Reading :** Traditionally, power consumption information was collected manually on site at specific time intervals. This practice inevitably led to inadequaciesin terms of accuracy and timeliness. IoT enables AutomaticMetering Infrastructure (AMI) [42] or remote meter readingsystems based on WSN, PLC and Optical PLC (OPLC) byusing public or private communication networks. An AMIsystem is one of the most important functions of the SG,collecting the real-time electricity consumption data with highreliability, processing this information and hence providingreal-time monitoring, statistics and power consumption analysis. The importance of this system lies in the timeliness,efficiency and accuracy in the power consumption data. Byusing this system, IoT technology could help users to savemoney by adjusting their electricity usage behavior based onthe analysis of their power consumption [43].

(2) **Integration of Distributed Energy Resources (DERs):** Today's power grid. They have recently attracted considerableattention in SG studies due to climate changes and environmental pressures. Renewable energy has a positive impacton the global environment by generating electricity without carbon emissions [44]. Reducing or holding back the annualincrease in greenhouse gas emissions contributes to limitingthe Earth's increasing temperature. In the past few years,governments and organizations have installed a substantialnumber of solar cells and wind turbines to satisfy part of their power requirements [45]. Power generation patterns of renewable energy sources (solar and wind), which are distributed over the grid, are intermittent in nature and dependenton location and climate, so they pose significant challenges for the predictability and reliability of the power supply. Such problems are addressed using the seamless interoperability and connectivity provided by the IoT technology. Furthermore,the IoT technology uses sensors to collect real-time weather information which helps in forecasting energy availability in the near future. A Kalman Filter-based state estimation and discrete-time linear quadratic regulation method for controllingthe state devia-

tions is proposed in [46], utilizing IoT aided SGsystems. It uses IoT technology and WSNs to sense, estimateand control the states of DERs. Furthermore, a web of things based SG architecture is proposed in [41] for the remotemonitoring and controlling of renewable energy sources.

(3) **Power Demand Management :** Power demand management, also known as demand-side energy management, is defined as the change in the energy consumption pro?lesof consumers according to the time-varying electricity prices from utility companies [47], [48]. It is used to minimize theconsumer's electricity bill, and to reduce the operational costof the power grid and energy losses, as well as to shift the demand load from peak times [49]. IoT devices collect the energy consumption requirements of various home appliances and transmit them to the home control units. Subsequently,the SG control unit schedules the energy consumption of homeappliances based on the users' defined preferences so that eachconsumer's electricity bill is minimized. Demand-side energymanagement can be performed at different levels of the SG. For instance, it can be performed at a home-level to maintainconsumers' privacy. It can also be performed at higher levels tonot only benefit the consumers but also the utility companiesby generating a more effective scheduling plan [**?**].

2.8.2 NAN Applications

(1) **Smart Distribution :** Smart distribution is based on advanced automated IoT technology and is one of the importantcomponent of SG [51]. It is the component that is directly connected to users in smart grid. Smart distribution gridconsists of communication system, power distribution remoteunit, master unit and station unit [51]. With the help ofIoT technology, the smart distribution grid can immediatelyidentify the faults in case of any disorder and can overcome the fault instantly. IoT technology helps smart distribution gridby providing various types of sensors for collecting data abouttemperature, humidity, noise etc. which ensures monitoringand secure opera-

tion of distribution grid [52]. The ?rstdemonstration of smart distribution by using IoT technologyin distribution network of smart grid was performed in Henan Hebi IoT demonstration project in Hebi, China [52]. It usestemperature, noise and tower tilt sensors, as well as ZigBee,GPRS, 3G and power fiber. It realizes online monitoring,online inspection and life cycle management. This projectwas performed using 10 kV underground and overhead layingmixed line which covers 45 utility distribution transformers,68 units of surge arresters, circuit breakers on 20 pillars, aring counter, and four cable branch box. Readers are referred to [52] for detailed description and results of this project.

(2) **Smart Patrol :** The patrolling of power generation, transmission and distribution used to be mainly a manual task,performed regularly at specific time intervals. However, due to climate conditions and both human and environmental factors,the quality and quantity of patrolling is not always as desired.Furthermore, it is usually not easy for power workers to patrolunattended substation equipment. The IoT technology offersa promising solution to this problem by introducing Smartpatrol [39]. Smart patrol is comprised of WSN and RFIDtags which are connected to the power substation with thehelp of IoT technology, and are used to locate the powerequipment in order to improve the quality of patrolling, as wellas to enhance the stability, ef?ciency and reliability of a powersystem and its supply. Smart patrol can be used for a numberof applications, such as patrol staff positioning, equipment status reports, environment monitoring, state maintenance andstandard operations guidance [39].

2.8.3 WAN Applications

(1) **Transmission Tower Protection** An integral part ofpower transmission, the transmission tower protection is a WAN application of IoT-aided SG systems, developed toenhance the safety of transmission towers from physical damage by plundering of components, natural disasters, unsafeconstruction and growing trees under the foun-

dations [40].Burglary and intentional damage by people are the majorcauses of transmission tower damage. Natural disasters, suchas typhoons, strong thunderstorms and global warming affectsalso can cause transmission towers to collapse. Additionally, key infrastructure projects, such as highways and high speedrailways, are often constructed near the transmission towersand must sometimes cross high voltage transmission lines. Often the construction companies are not fully aware of the risks involved in operating near high voltage transmission towers. They use a number of large construction machines which notonly pose serious dangers to their crew, but can also damagetransmission lines and towers. Such construction contractors sometimes do not inform the relevant power transmissiondepartments which makes it impossible for power transmissionemployees to inspect and monitor all the power transmissionfacilities, which could lead to risks to transmission towers. Currently, the main method of transmission towers protection is manual patrol by the staff. However, regular manualpatrol of high voltage transmission lines and towers by staffis very dif?cult due to manpower realities, divisions of responsibility and the level of knowledge of the staff. Furthermore,some transmission towers are dif?cult to approach due to theirphysical positioning. Hence, the patrolling quality cannot beguaranteed. The patrolling period varies from 1-10 weeks,which means insuf?cient monitoring and higher security risks. While it is true that some equipment, such as cameras andinfrared alarms, are installed on transmission towers to monitorburglary and other potential damage, the accuracy and stabilityof this equipment is not yet satisfactory [40]. With the help of WSNs, IoT technology can provide remotemonitoring in addressing these security threats. The IoT-aidedtransmission tower protection system contains various sensorswhich generate early warnings of threats to high voltagetransmission towers, enabling quick responses. The sensorsinclude vibration sensors, anti-theft bolts, a leaning sensor anda video camera. These sensors and the sink node form a WSN [40]. The sensors detect any threat, and send the relevantsignals to the sink node. The sink node receives these signalsfrom the sensors, processes them into data and transmits thedata to the monitoring center through the Internet or any otherpublic/private communication network.

(2) **Online Monitoring of Power Transmission Lines** online monitoring of power transmission lines is one of themost important applications of the IoT in the SG, speci?callyfor disaster prevention and mitigation. In recent years, naturaldisasters have highlighted the challenges of security, reliabilityand stability inherent to high voltage power transmissionlines. Traditionally, high voltage transmission line monitoring has been performed manually. Sensors measuring conductor galloping, wind vibration, conductor temperature, micro meteorology and icing can now be used to achieve real-time online monitoring of power transmission lines [43]. This newonline power transmission line monitoring system is comprised of two parts. In the ?rst part, the sensors are installed onthe power transmission lines between transmission towers tomonitor the states of power transmission lines. The secondpart has sensors installed on the transmission towers in orderto monitor their states and their environmental parameters. IoTenables the communication between the power transmissionline sensors and the transmission tower sensors.

2.9 Conclusion

IoT has been considered as the third revolution in thedigital technology after the computer and the Internet.Currently, the power grid is transforming towards smart gridin world, the requirements of automation andintellectualization would lead to deep integrations of IoT with smart grid [53]. Up to one trillion RMB market would bebrought by smart grid, which brings great challenges for IoTtechnology to become more practical for industrialapplications in smart grid. The mature wirelesscommunication theory and network optimization theory havebeen paved the way for theoretical basis of IoT.Through the IoT technology, the operation parameters ofthe power transmission line and tower, such as the micro meteorology, conductor galloping, wind deviation, conductortemperature, icing and tower leaning can be visuallydisplayed at the monitoring Centre. Thus real-timemonitoring and early warning of disaster can be realized,which will effectively resist or reduce the damage of themajor natural disasters to the power grid. In our future work,the cost of our power transmission line monitoring systemneeds to be reduced and the reliability of our system alsoneeds to be enhanced.

Chaptre 3

Conception

3.1 Introduction

Communication in the smart grid is critical and is of great importance to the efficiency of the smart grid, so you must define a well-defined definition of architecture, so the goal of our project is to simulate and control the smart grid.

In this part, we will talk about the roles and responsibilities of actors in the smart grid, as well as the operations applied to the smart grid.

3.2 Global architecture of system control smart grid

In this paragraph, we presented a general view of your system

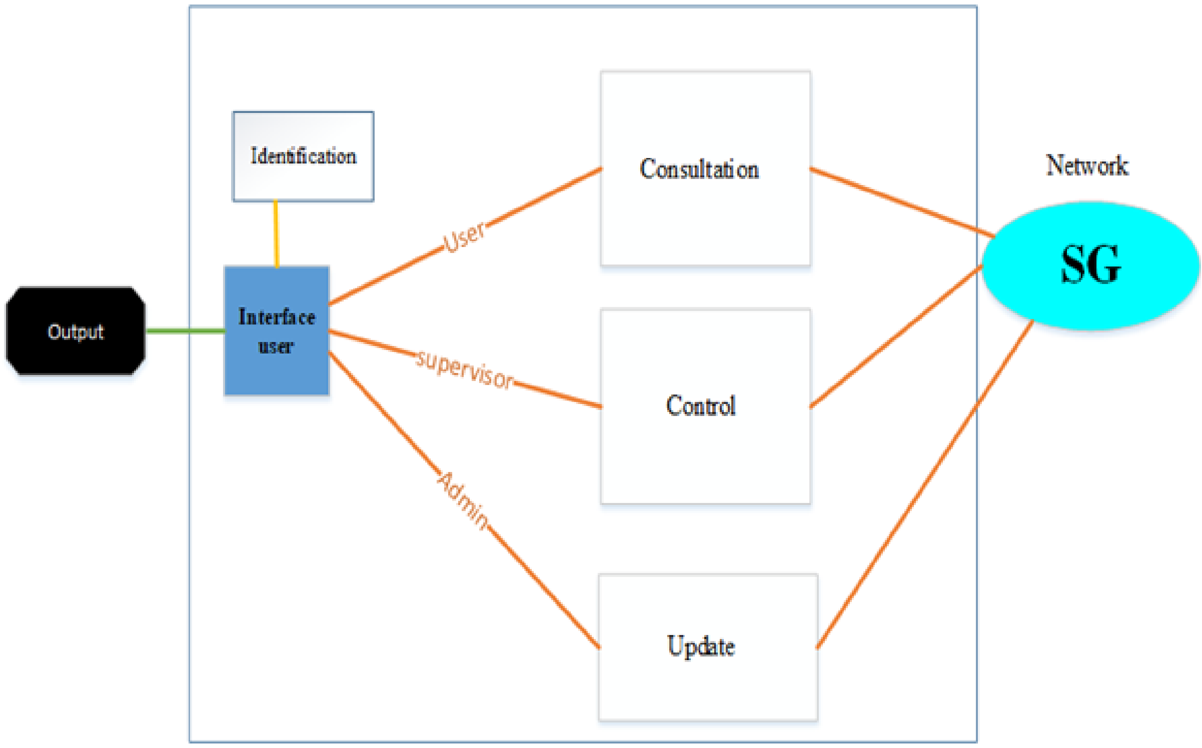


Figure 3.1: Architecture global of system control smart grid .

In this architecture (see figure 3.1), we know the actors principal for system control smart grid also, the architecture enhances the efficiency of information exchanged in the smart grid, the direct physical exchange which is the electrical power in the network.
And allows to perform many operations on the network, such as: knowledge of consumption of customers and the power generated by generators and the status of line transmission, etc.

3.3 Detail architecture

In this paragraph we have presented the architecture detail, also presented each operations by an active actor in the smart grid

3.3.1 Consultation

This process (see figure 3.2) allows the user or the customer to see his energy consumption and see his status active or not. He also informs you by the service provider if the network is damaged due to natural phenomena such as storms.

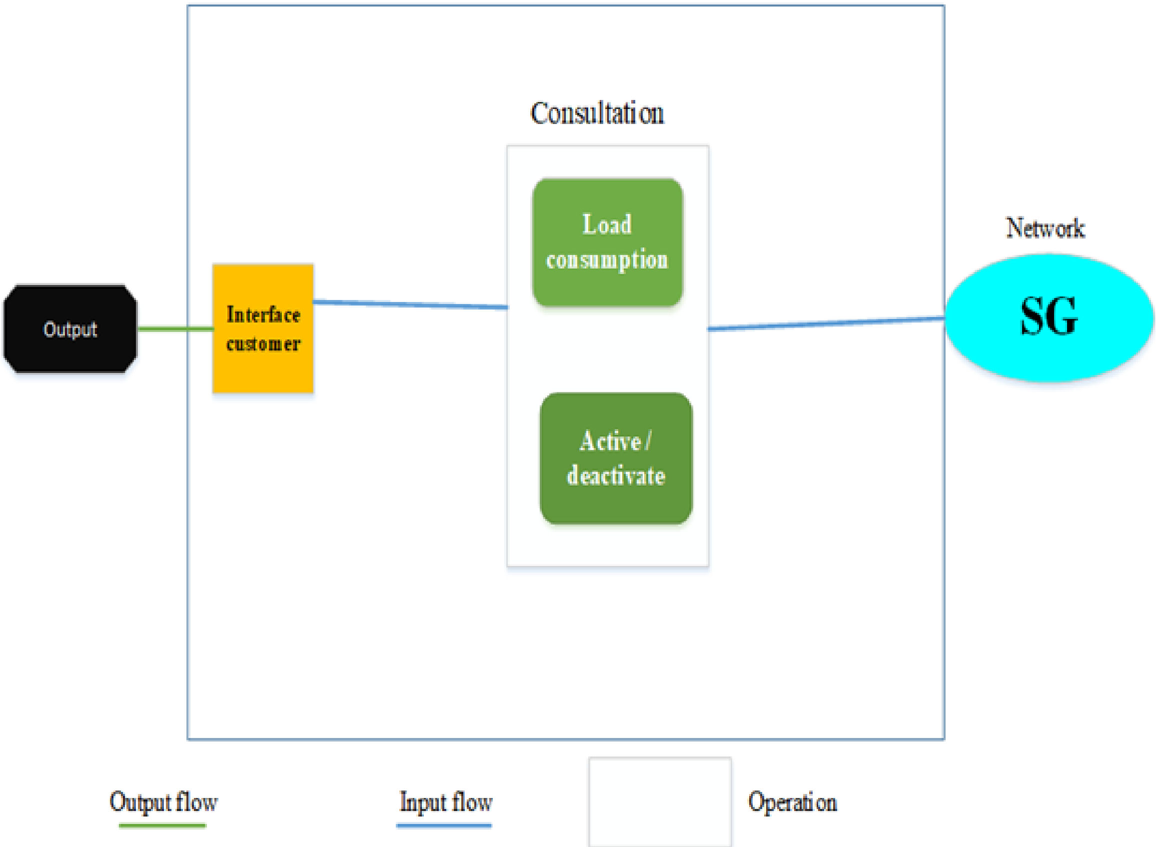


Figure 3.2: Overview of architecture for consultation operation .

3.3.2 Control

This operation (see figure 3.3) allows to supervisor to see all load consumption customers and know the state of the customer active or not, and see power generation from a generator and know the status of the generator working or not.

Also, see the status of transmission lines if it is damaged due to natural phenomena such as storms

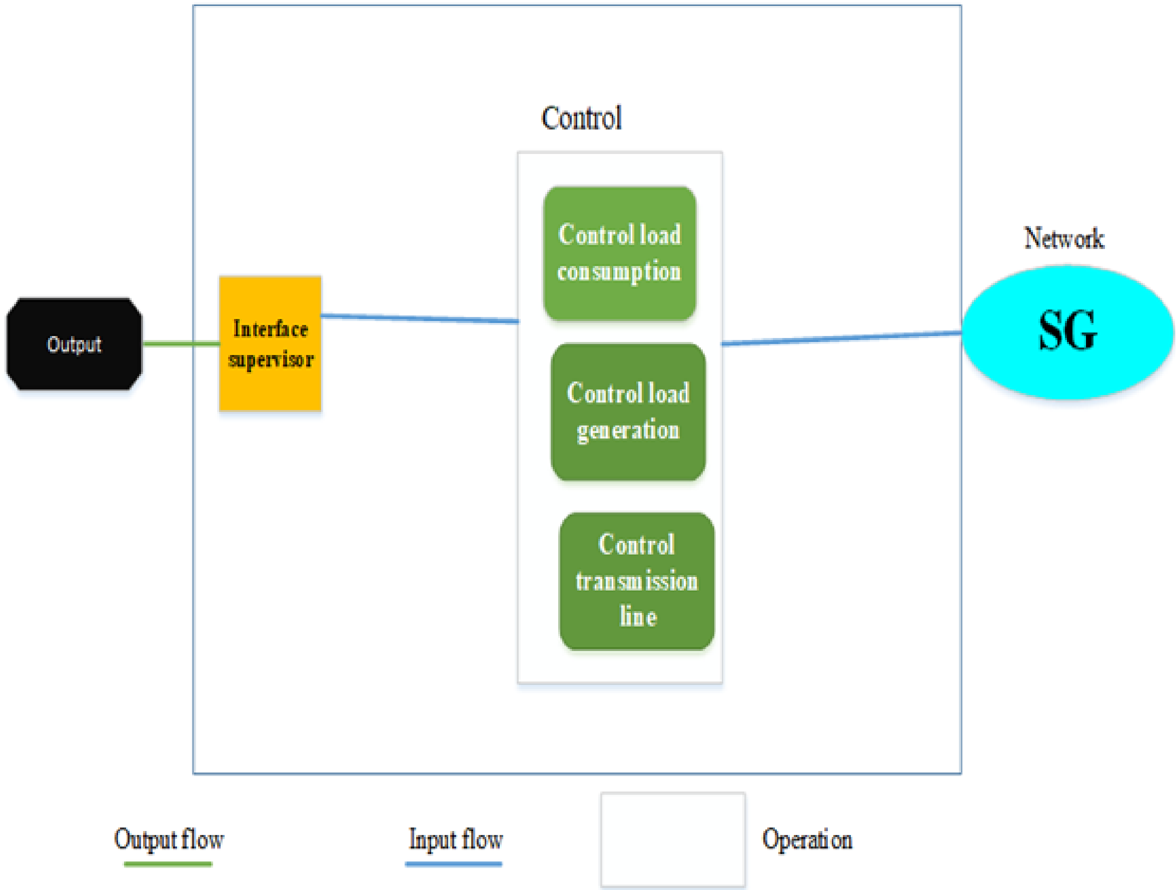


Figure 3.3: Overview of architecture for control operation .

3.3.3 Update

This operation (see figure 3.4) allows to admin see load consumption customer and enable or disable customer, and see power generation from the generator and turn on or turn off the generator.

Also see status of transmission lines and cut line for example for maintenance..etc

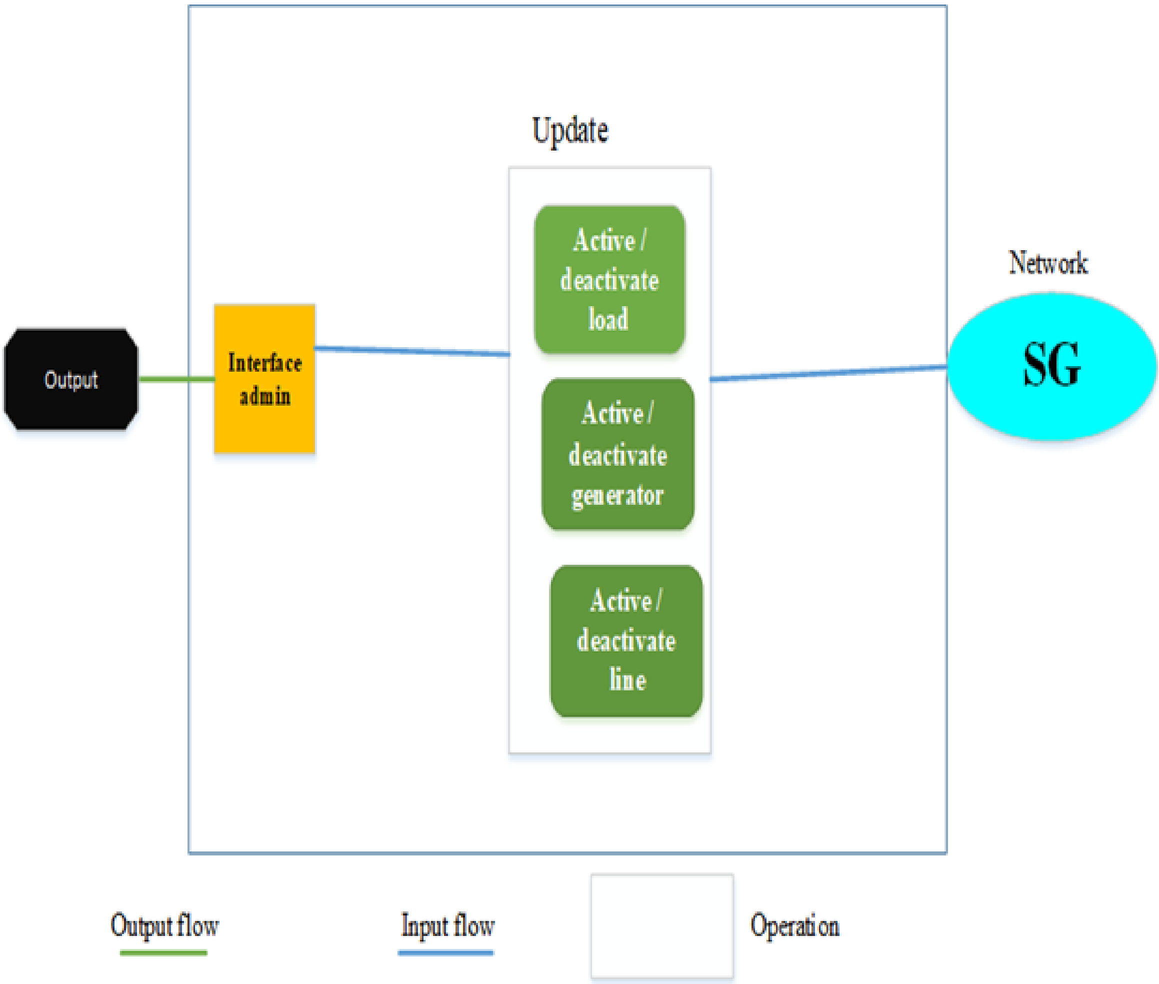


Figure 3.4: Overview of architecture for update operation .

3.4 Actors active in system control smart grid

This part is presented as the specification of the application that we're going to realize but a good analysis is the development start of effective software. A well-designed system that is easy to perform, maintain and understand. Although it can work properly, on the other hand, a bad system designed, will often be expensive to maintain, difficult to test and unreliable. The sentence of analysis is, therefore, the most crucial phase of the development process of a software.

To program an application, it is not appropriate to launch head down in writing the code: one must first organize one's ideas, document them, and then organize the realization by denying the modules and the steps of the realization.

It is this approach before writing that is called modeling, its product is a model. We chose to model by a diagram of sequence UML (Unified Modeling Language).

3.4.1 User

The user or client plays a key role in the system because it represents consumer energy and the user can know the amount of energy consumption and status whether active or not andKnowledge in case of network damage; like his operations in Figure 3.5

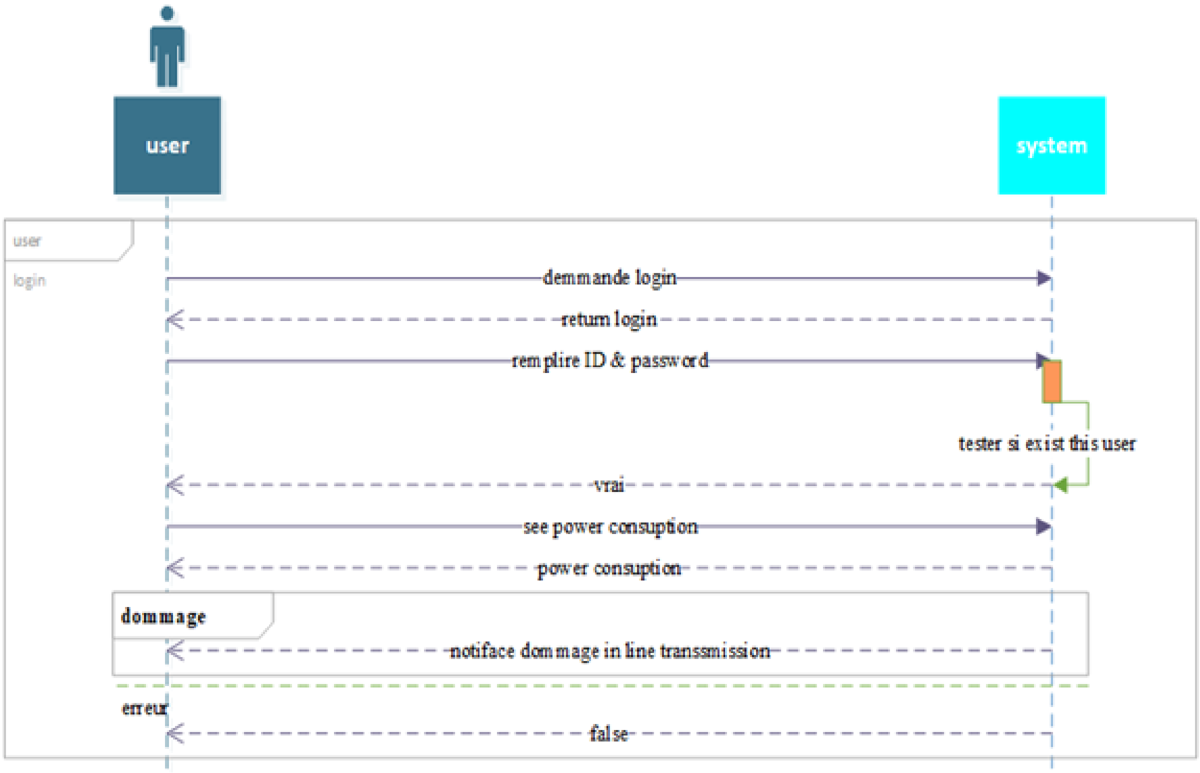


Figure 3.5: diagram sequence of user .

3.4.2 Supervisor

The supervisor plays a key role in the system because it monitors the status of customers, their energy consumption status, and the status of the generators, the amount of power generation and their condition, as well as monitoring the status of the transmission lines in case of damage to the maintenance team to repair damage in a short time. Like that in Figure 3.6

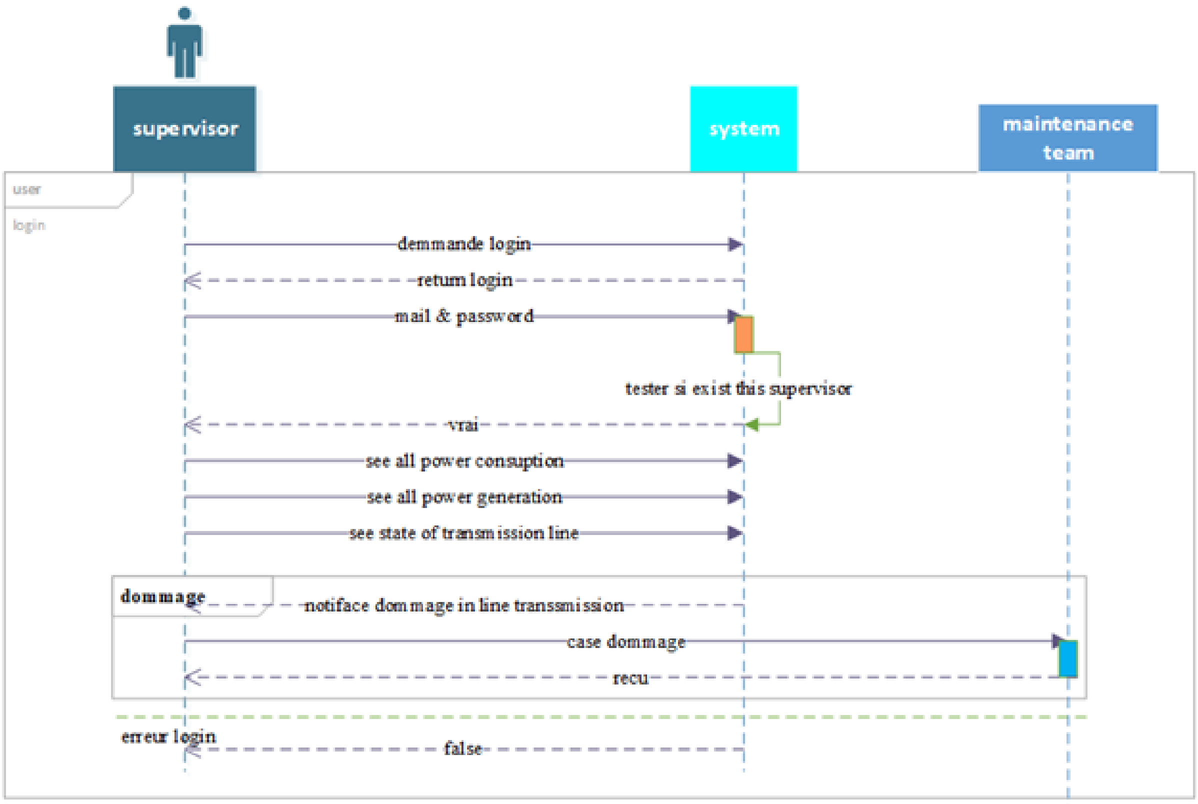


Figure 3.6: diagram sequence of supervisor.

3.4.3 Admin

The administrator plays an important role in the system because it monitors customer status, power consumption status, generator status, power quantity and status, as well as monitoring the state of the transmission lines, as well as the possibility of performing many operations on the network to disable or activate the client, Operation, as illustrated in Figure 3.7

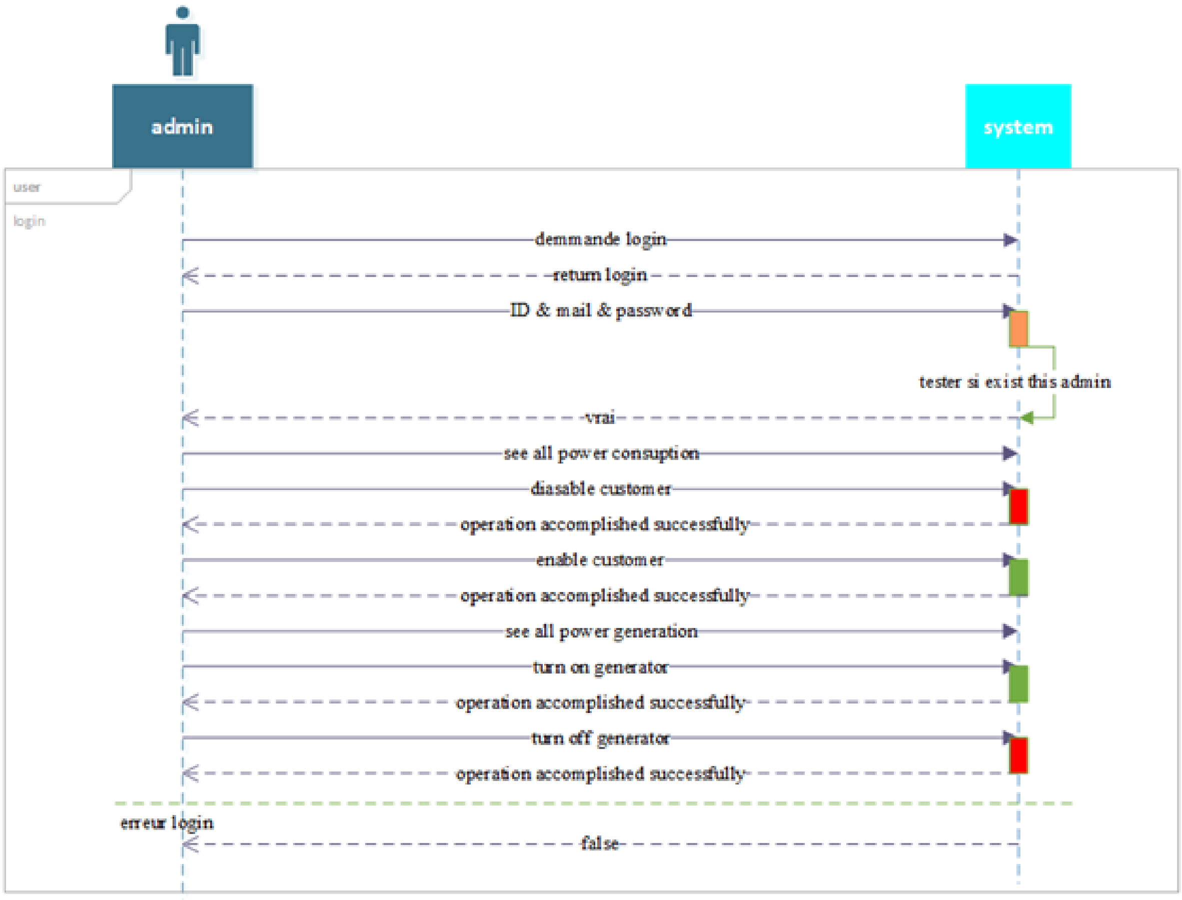


Figure 3.7: diagram sequence of admin .

3.5 Detail case 14

3.5.1 Definition

Is the energy flow data for the IEEE 14(Institute of Electrical and Electronics Engineers) test case, which is a simple and customizable code used by researchers to simulate the smart grid for its development and increase its efficiency

Structure case

The case file consists of input data and output data:

Input data

These data are described by the matrix, there is customer information (see Figure 3.8), and information related to generators(see Figure 3.9).

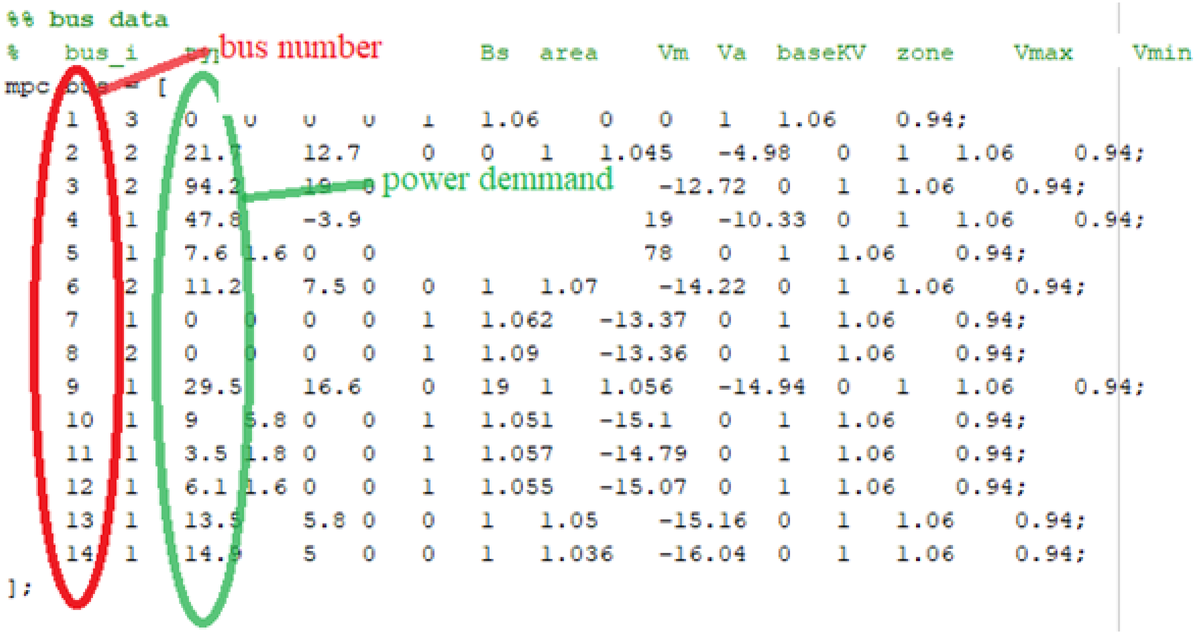


Figure 3.8: matrixof bus data .

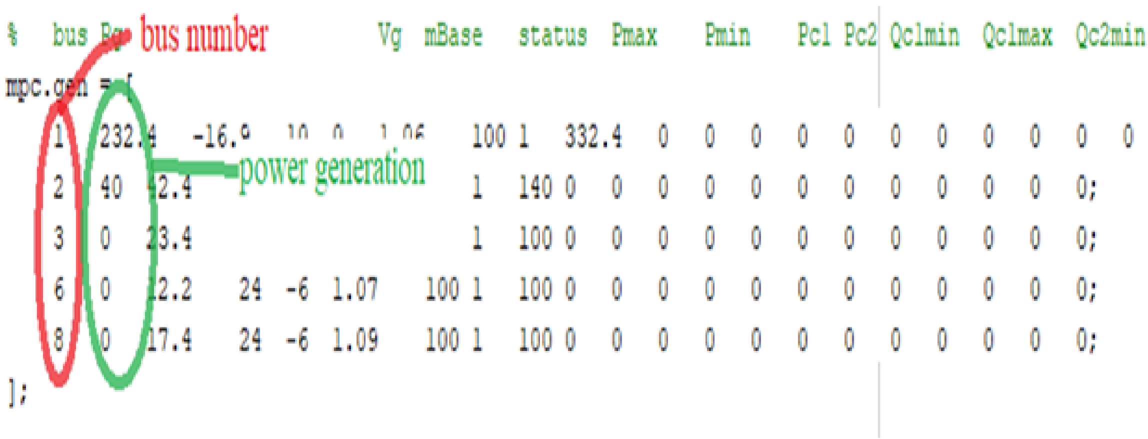
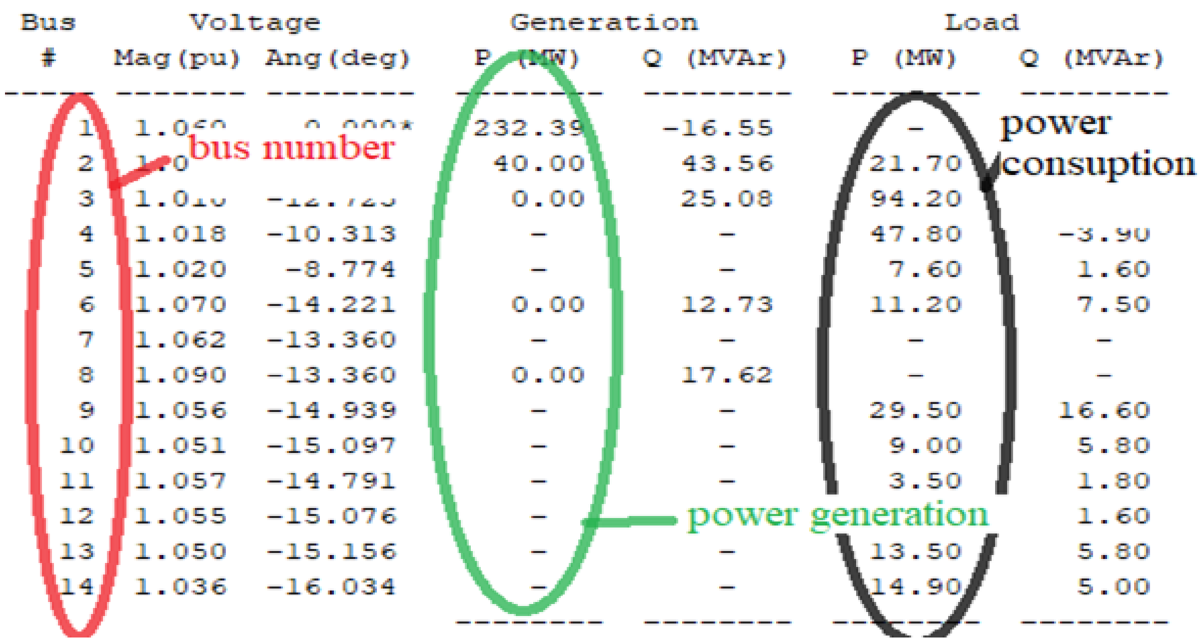


Figure 3.9: matrix of generator data .

Output data

Running the case results in a matrix (see figure 3.10) that contains the energy information consumed and the energy generated.

Also, transfer energy through transmission lines



Bus	Voltage		Generation		Load	
#	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	[illegible]	[illegible]	232.39	-16.55	-	[illegible]
2	[illegible]	[illegible]	40.00	43.56	21.70	[illegible]
3	[illegible]	[illegible]	0.00	25.08	94.20	[illegible]
4	1.018	-10.313	-	-	47.80	-3.90
5	1.020	-8.774	-	-	7.60	1.60
6	1.070	-14.221	0.00	12.73	11.20	7.50
7	1.062	-13.360	-	-	-	-
8	1.090	-13.360	0.00	17.62	-	-
9	1.056	-14.939	-	-	29.50	16.60
10	1.051	-15.097	-	-	9.00	5.80
11	1.057	-14.791	-	-	3.50	1.80
12	1.055	-15.076	-	[illegible]	[illegible]	1.60
13	1.050	-15.156	-	-	13.50	5.80
14	1.036	-16.034	-	-	14.90	5.00

Figure 3.10: matrix results of output data .

3.6 Conclusion

In this section were analyzed and model our system, and defined global architecture, also roles and responsibilities of the actor's active in the system by sequence diagrams.

In the next section, we will begin the realization of system simulation to control the smart grid.

Chaptre 4

Implementation

4.1 Introduction

In this section, we will talk about the purpose of this project to a system simulation that allows control smart grid

So we will apply the model that they are involved in conception section

4.2 Programming tools

To create any project, you'll need software for libraries, a computer, so we'll mention what we've used in this project

4.2.1 working environment

In this project, I used a laptop Dell i3-3217U CPU @ 1.80 GHz, RAM: 4.00 GB, Hard Drive: 500 GB, Operating System: Windows 10 64 bit.

4.2.2 Programming programs

Matlab : (MATrix LABoratory) is software for scientific computing, oriented towards the vectors and lists of data. Matlab is an interpreted language, each line of a Matlab program is read, interpreted and performed. All these functions are defined by default in MATLAB in a specific programming language that we will call ... MATLAB. This language includes many predefined functions for matrix calculation, but not only. As a result, the fields of application are extremely varied, and there may be mentioned, for example :

- ✓ The numerical computation in the body of reals or complexes.
- ✓ Calculation of probabilities or statistics.
- ✓ Integral calculus or derivation.
- ✓ Signal processing.
- ✓ Optimization.
- ✓ Image processing.
- ✓ Automatism.

4.2.3 Programming libraries

Matpower : Matpower is a package of Matlab® M-?les for solving power ?ow and optimal power ?ow problems. It is intended as a simulation tool for researchers and educators that is easy to use and modify. Matpower was initially developed by Ray D. Zimmerman, Carlos E. Murillo- S´anchez and Deqiang Gan of PSerc1 (Power System Emerging Research Center) at Cornell University under the direction ofRobert J. Thomas. The initial need forMatlab-based power ?ow and optimal power?ow code was born out of the computational requirements of the PowerWeb project2.

Many others have contributed to Matpower over the years and it continues to be developed and maintained under the direction of Ray Zimmerman.

Installation : Installation and use of Matpower requires familiarity with the basic operation ofMatlab, including setting up your Matlab path.

Follow the download instructions on the Matpower home page7 .Youshould end up with a ?le named matpowerXXX.zip, where XXX depends onthe version of Matpower..

Step 2 : Unzip the downloaded ?le. Move the resulting matpowerXXX directory to thelocation of your choice. These ?les should not need to be modi?ed, so itis recommended that they be kept separate from your own code. We willuse ¡MATPOWER¿ to denote the path to this directory. Step 3: Add the following directories to your Matlab path .

Step 3 : Add the following directories to your Matlab path:

- ✓ $\langle MATPOWER\rangle$ –core Matpower functions
- ✓ $\langle MATPOWER\rangle$/t –testscriptsfor Matpower

4.3 Presentation system

In this section we presented interfaces of our system :

4.3.1 The main interface

Through this interface (see figure 4.1), the user selects the process he or she performs on the smart grid.

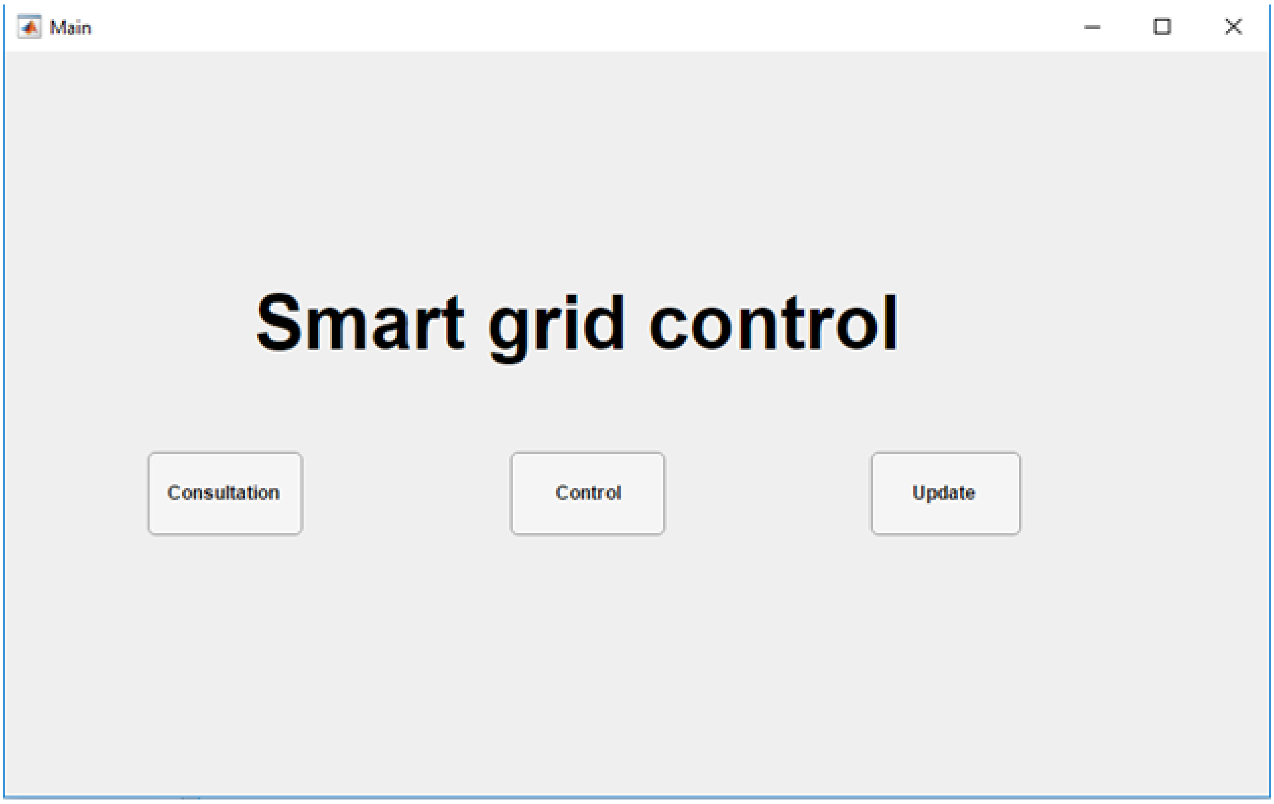


Figure 4.1: The main interface of our system.

4.3.2 Admin interface

The admin can perform many operations through this interface (see figure 4.2), for example, disable customer or turn off the generator

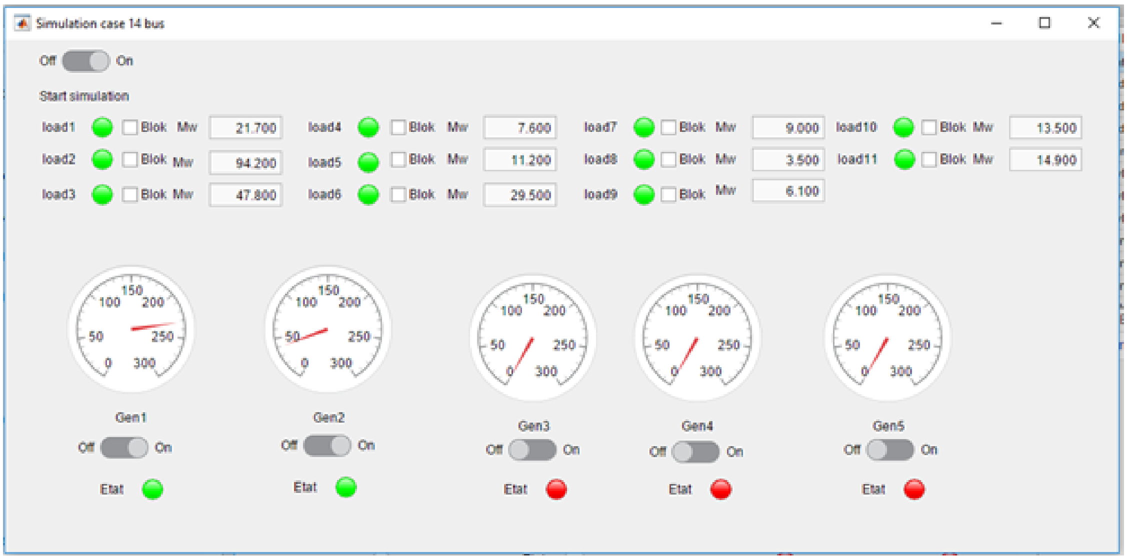


Figure 4.2: Admin interface in our system.

For example disable customer 1 :

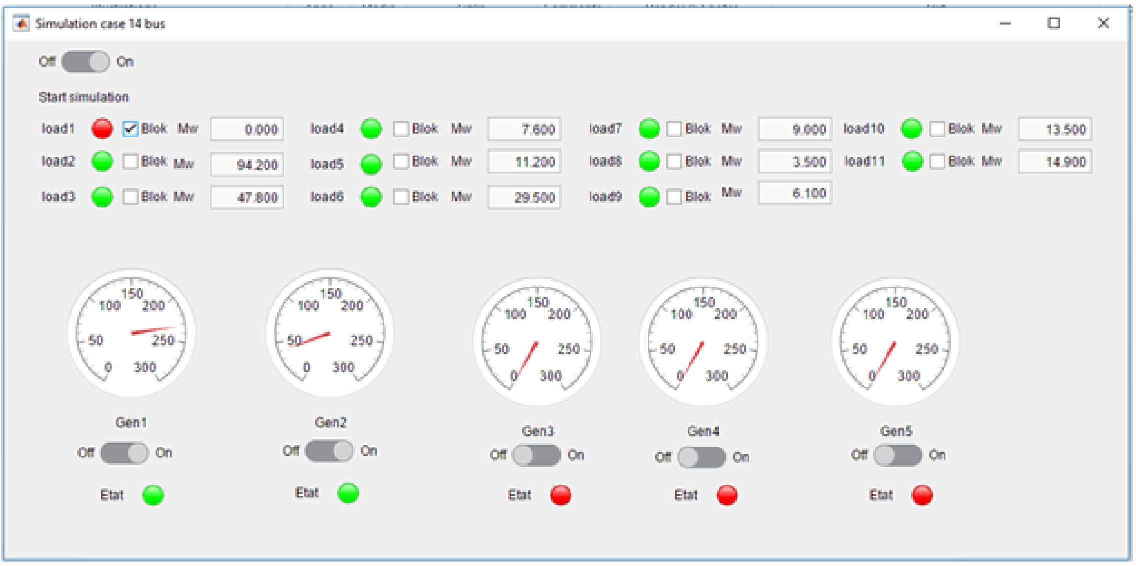


Figure 4.3: Admin interface disable customer.

Instruction code :

```
function khalil

define_constants
mpopt = mpoption('verbose', 2);
casefile = 'case14';
mpc = loadcase(casefile);%charge network


mpc.bus(2,PD)=0;

% run power flow
results=runpf(mpc,mpopt)

khalil = results;
```

block bus 2 by value 0

Figure 4.4: Code block user customer.

Result run code disable customer 1 :

#	Mag(pu)	Ang(deg)	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
1	1.060	0.000*	209.58	-11.68	-	-
2	1.045	-4.351	40.00	35.11	0.00	12.70
3	1.010	-12.161	0.00	25.04	94.20	19.00
4	1.018	-9.812	-	-	47.80	-3.90
5	1.020	-8.318	-	[illegible]	[illegible]	1.60
6	1.070	-13.751	0.00	[illegible]	[illegible]	7.50
7	1.062	-12.867	-	-	-	-
8	1.090	-12.867	0.00	17.61	-	-
9	1.056	-14.450	-	-	29.50	16.60
10	1.051	-14.612	-	-	9.00	5.80
11	1.057	-14.313	-	-	3.50	1.80
12	1.055	-14.604	-	-	6.10	1.60
13	1.050	-14.683	-	-	13.50	5.80
14	1.036	-15.552	-	-	14.90	5.00

block customer 1

Figure 4.5: matrix result of block customer 1.

4.3.3 Supervisor interface

Through this interface (see figure 4.3), the supervisor monitors the state of the smart grid, customers consumption, and generators status.

Figure 4.6: Supervisor interface .

4.3.4 Customer interface

Through the client interface (see figure 4.4), the customer can know the power consumption and its condition is activated or disabled

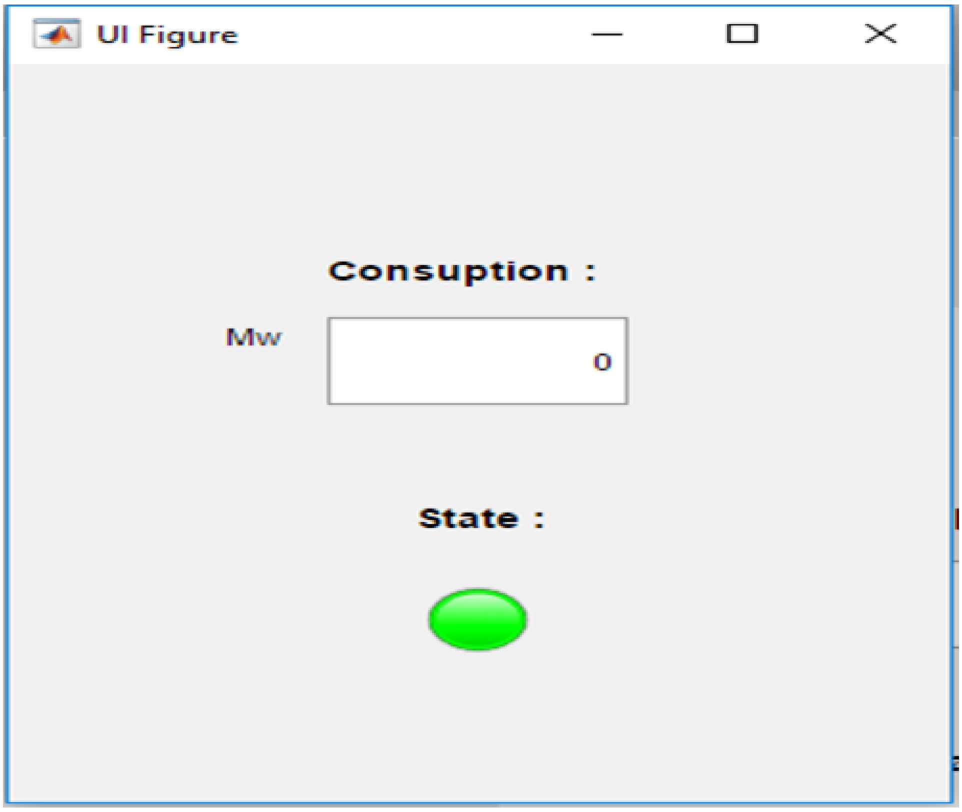


Figure 4.7: Customer interface.

4.4 Conclusion

In this chapter, we introduced our system to simulate and control the Smart Grid, and we implemented many processes in the Smart Grid.

We also explained the actors and their roles in the smart grid.

General conclusion

The smart grid gave a strong boost in different sectors of the power grid, different Communication technologies are applied to meet Specific requirements that are unique. In power Part transmission, wire communication Power lines or optical cables are supported to ensure the Durability of the spine. However, in power Piece distribution that provides direct power to End users, both wired and wireless Communications should be considered.

In order to achieve cost-effective and flexible Monitor and monitor end devices, effective Dispatch power, and dynamic integration of Distributed energy resources with the power grid, Wireless communications, and networks the functions must be embedded in different electrical equipment. Wireless capability Communication between different electrical equipment is one of the key techniques that drive an assessment is a Traditional power distribution network in SG.

In this paper, we applied a simple example of intelligent grid control. We wanted complete control of the smart grid with the possibility of adding clients or generators, but we found many difficulties in this project, including a lack of help in the smart grids, because of a first Project in a department Informatique in smart grids Developers and researchers work on developing SG mean radical Change in energy use and management. Users will Become an active participant in energy management you will be able to control their consumption. On the other hand, utilities will be able to control Peak demand and efficient network management Generation Distribution.

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