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Smart Grid Simulation and AODV routing protocol

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Abstract

The electricity demand increases by the increasing of population which causes several problem in the grid .and the use of conventional resource became a danger on the environment and the humans.

In this case, the use of renewable energy will be very beneficial by integrated in the smart grid.

In this project, we made a simulation to test the performance of the AODV as reactive protocol and DSDV as proactive protocol.

Key words : renewable energy ;smart grid ; energy ; routing protocols,AODV, DSDV .

ملخص

يزداد الطلب على الكهرباء مع زيادة عدد السكان مما يسبب عدة مشاكل في الشبكة ، كما أن استخدام المصادر التقليدية أصبح يشكل خطرا على الطبيعة و الانسان .

في هذه الحالة سيكون استخدام الطاقة المتجددة مفيداً جداً من خلال دمجها مع الشبكة الذكية.

في هذا المشروع قمنا بمحاكاة لتجربة أداء كل من البروتوكول :

DSDV بروتوكول استباقي و AODV بروتوكول رد الفعل .

الكلمات المفتاحية: الطاقة المتجددة , الشبكة الذكية , الطاقة , بروتوكولات التوجيه AODV . DSDV

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..Thank you all for everything

Dedication

To my parent

My sisters "Sara, Fatima"

*My brothers "Saif, Noredine,
mohammed"*

My lovely friends

" YOUCFI Fatima & her twins"

" HATTASSA Mebarka"

To the best colleague "TABBI Amina"

Imane

Dedication

to my loving mother

*to my sister and my brothers "Soumia, Khalil, Haider
and Mokhtar"*

to my cuties brother's daughters "Rinad and Maria"

to my best friends "Fatima, Souaad and Ichrak"

To the best colleague "Sabou Iman"

Amina

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Glossary

A

AMI : **A**dvanced **M**etering **I**nfrastructure.

AODV : **A**d-hoc **O**n **D**emande **D**istance **V**ector.

D

DSDV: **D**estination **S**equenced **D**istance **V**ector.

DG : **D**istributed **E**nergy.

DER: **D**istributed **E**nergy **R**esource.

E

EPRI : **E**lectric **P**ower **R**esearch **I**nstitute.

EMS: **E**nergy **M**anagement **S**ystem.

F

FM: **F**requency **M**odulation.

H

HAN: **H**ome **A**rea **N**etwork.

I

IEC : **I**nternational **E**lectro **t**echnical **C**ommission.

IRENA : **I**nternational **R**enewable **E**nergy **A**gency.

IEA : **I**nternational **E**nergy **A**gency.

M

MW: Mega Watt

N

NAN: Neighbourhood Area Network.

P

PV : PhotoVoltaic.

PMU: Phasor Measurement Unit.

R

RBDS: Radio Broadcasting Data System.

RES : Renewable Energy Systems

S

SG : Smart Grid.

SCADA: Supervisory Control and Data Aquisition.

T

TW : TeraWatt.

U

UK: United Kingdom.

US : United States .

W

WAN: Wide Area Network.

General introduction

The electric power grid is one of the largest and most complex infrastructures ever built by mankind. Modern civilization depends on it for industry production, human mobility, and comfortable living. However, many critical technologies such as the 60 Hz transformers were developed at the beginning of the 20th century and have changed very little since then.

The traditional unidirectional power from the generation to the customer through the transmission-distribution grid has also changed nominally, but it no longer meets the need of the 21st century market energy customers. A move towards a true digital grid is needed. Such a digital smart grid requires a tight integration of the physical layer (energy and power) with digital and cyber information to allow an open and real time market akin to the world of e-commerce. Another major factor that is pushing for this radical transformation are the rapidly changing patterns in energy resources ownership and load flow.

Smart grid (SG) is combination of power resources and communication and information technologies into the electricity grid. Main components of smart grid are sensors, smart meters, monitoring system and data management systems which controlled the flow of information between the different stakeholders. Smart grid represents a huge network of computers, routers, switches, smart meter, house application, wireless sensor, renewable energy resources, and electrical vehicles. Smart grid applications need to communication between heterogeneous environments so they need to use routing protocols to accomplish their work. Ad hoc on demand Distance Vector (AODV) developed initially for Mobile Ad Hoc Networks (MANETs) and after the improvements it used for smart grid applications by selecting the best path between smart grid sensors to exchange reliable data.

In MANETs, communication between mobile nodes always requires routing over multi-hop paths. Since the node mobility may cause frequent link failure, we proposed the nodes are fixed (the smart homes) . in order to Perform a Comparison of AODV, DSDV Routing Protocols.

We start by giving generalities on renewable energy (solar ,wind, thermal) in the first chapter then we introduce the technology of smart grid and it's characteristic ; different component; The security in smart grid.

finally in the third chapter we talked about the implementation and the result that we obtained from the comparison of AODV and DSDV protocol .

Chapter I

Renewable Energy

1.1 Introduction :

this chapter aims to provide an overview of renewable energy systems (RESs) and the underlying issues related to the RES theme such as the energy definition . the different types of renewable energy systems are briefly discussed focusing on their characteristics and giving an examples of the most known power plants in the world. This followed by the answer of why do we need the renewable energy by the most important aspects such as environmental damage and public health . This chapter also discusses the world's most used renewable power sources and its advantages .

1.2 Renewable energy definition

1.2.1 Energy definition

due to **oxford dictionaries** energy can be defined as: “The strength and vitality required for sustained physical or mental activity.” Or: “Power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines.”. From that point we continue the definition of energy by stating its types: it exists two types of energy that have common points such that they are both natural resources but the first is limited, and we name that one **Non-renewable** energy. The second is the opposite unlimited resource, we name it **renewable energy**. [1]

1.2.2 What is renewable energy :

Renewable energies (or renewables) are ways to generate energy from (theoretically) unlimited natural resources. These resources are either available with no time limit or replenish more quickly than the rate at which they are consumed.

Renewable energies are also often referred to as “green energies” or “clean energies”. Still, this doesn't mean that these energies aren't harmful to the environment and have zero impact. Nonetheless, they have a low environmental impact compared to fossil fuels. That's why they're increasingly becoming important elements in companies' CSR strategies in terms of sustainable development.

There are several types of renewable energies that are produced by different sources such as the sun, wind or water. In fact, these renewables' power consumption has been growing over the last year. They have provided 8% of the world's electricity in 2017 and they now cover 1/3 of

the power mix in Europe. At the same time, the energy grid gets 1/4 of the total energy in China and 1/6 in the United States, India, and Japan. Let's learn more about them below . [2]

1.3 Renewable energy types :

1.3.1 Hydropower:

Hydropower represents one of the oldest and largest renewable power sources and accounts for close to 10% of our nation's electricity. Existing hydropower capacity is about 80,000 megawatts (MW – one million watts or one thousand kilowatts). Hydropower plants convert the energy of flowing water into electricity **Figure1**. This is primarily done by damming rivers to create large reservoirs and then releasing water through turbines to produce electricity. Hydropower results in no emissions into the atmosphere but the process of damming a river can create significant ecological problems for water quality and for fish and wildlife habitat. [3]



Figure 1.1: Construction of Hydropower Project

Examples of hydro-electric power in the world :

- The Sihwa Lake Tidal Power Station in South Korea. This is the world's biggest tidal power installation and it has a capacity of 254 MW;
- The Rance Tidal Power Station in Brittany, France, has a 240 MW capacity;
- The Three Gorges Dam in China is the world's largest power station in terms of installed capacity (22,500 MW). [2]

1.3.2 Biomass :

Biomass is second to hydropower as a leader in renewable energy production. Biomass has an existing capacity of over 7,000 MW. Biomass as a fuel consists of organic matter such as industrial waste, agricultural waste, wood, and bark. Biomass can be burned directly in specially designed power plants, or used to replace up to 15% of coal as a fuel in ordinary power plants. Biomass burns cleaner than coal because it has less sulfur, which means less sulfur dioxide will be emitted into the atmosphere. Biomass can also be used indirectly, since it produces methane gas as it decays or through a modern process called gasification. Methane can produce power by burning in a boiler to create steam to drive steam turbines or through internal combustion in gas turbines and reciprocating engines. The largest use of biomass energy in Virginia is the forest products industry. Furniture plants, sawmills, and paper mills usually burn their wood waste to produce heat and electricity. Many homeowners use firewood or pellets for winter heat. [3]

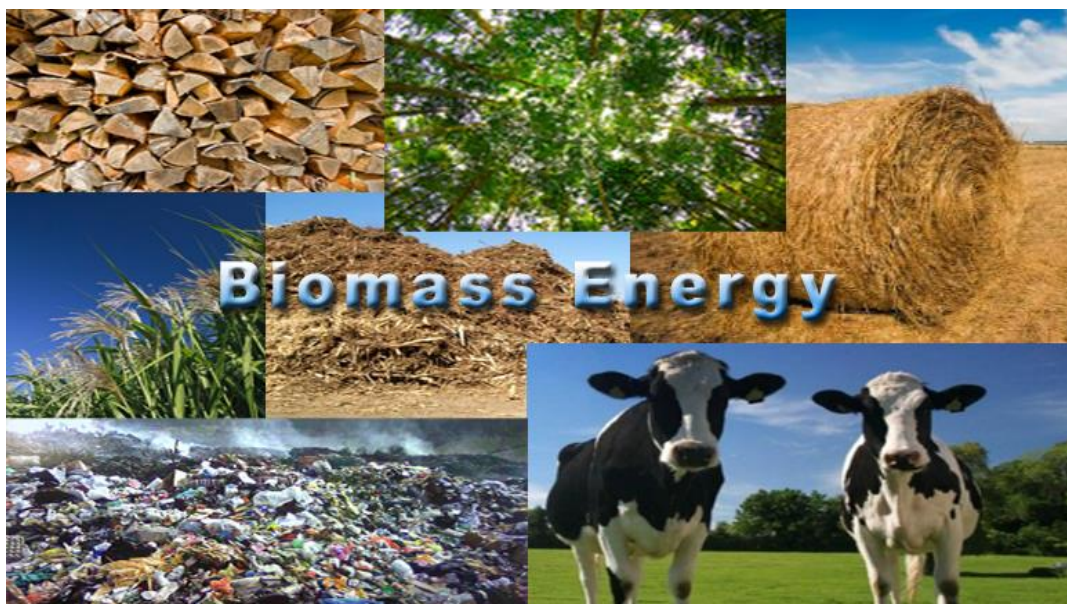


Figure 1.2 : biomass energy

Examples of biomass energy in the world

Some of the most known biomass power plants in the world are:

- The Iron Bridge power station in the UK, with a capacity of 740MW. It uses wood pellets as the main fuel;
- The Alholmenskaft power station in Finland. It has a 260MW energy generation capacity;
- The Polaniec power plant in Poland that uses mainly agricultural by-products and wood residues. It has a 205MW capacity. [2]

1.3.3 Geothermal

Geothermal power plants use high temperatures deep underground to produce steam, which then powers turbines that produce electricity. Geothermal power plants can draw from underground reservoirs of hot water or can heat water by pumping it into hot, dry rock. High underground high temperatures are accessed by drilling wells, sometimes more than a mile deep. In one sense, this geothermal energy is not renewable, since sometime in the future the core of the earth will cool. That time is so far off (hundreds of millions of years) that that we think of it as renewable. Most geothermal power plants are located in the western United States, but some costal regions of Virginia (near Wallops Island) have geothermal power potential. Geothermal heat pumps use compressors to pump heat out of the earth (for winter heating) or into the earth (when running as air conditioners in summer). The energy they pump into and out of the earth is renewable, since it is replaced by the cycle of the seasons. The energy that runs the compressor can either be renewable or conventional. [3]



Figure 1.3 : Renewable Geothermal Energy

Examples of geothermal energy in the world

- The Darajat Power Station in Indonesia has 3 plants with a total capacity of 259MW;
- The Malitbog Geothermal Power Station in the Philippines has a capacity of 232MW;
- The Hellisheidi Geothermal Power Station in Iceland has a capacity of 400MW of thermal energy;
- The Salton Sea Geothermal Plants in the U.S. have a capacity of 340MW . [2]

1.3.4 Solar Energy

Solar energy comes directly from the power of the sun and is used to produce electricity, to produce heat, and for light. Solar-electric power can be produced either by power plants using the sun's heat or by photovoltaic (PV) technology, which converts sunlight directly to electricity using solar cells. PV technology is more practical for residential use.

Systems to use the heat of the sun directly can be either active or passive. In active systems, air or liquid circulate through solar collectors and bring heat to where it is used. In passive systems, buildings are built with windows and heat-absorbing surfaces set up to maximize solar heating in winter. Either technology is suitable for residential use. [3]

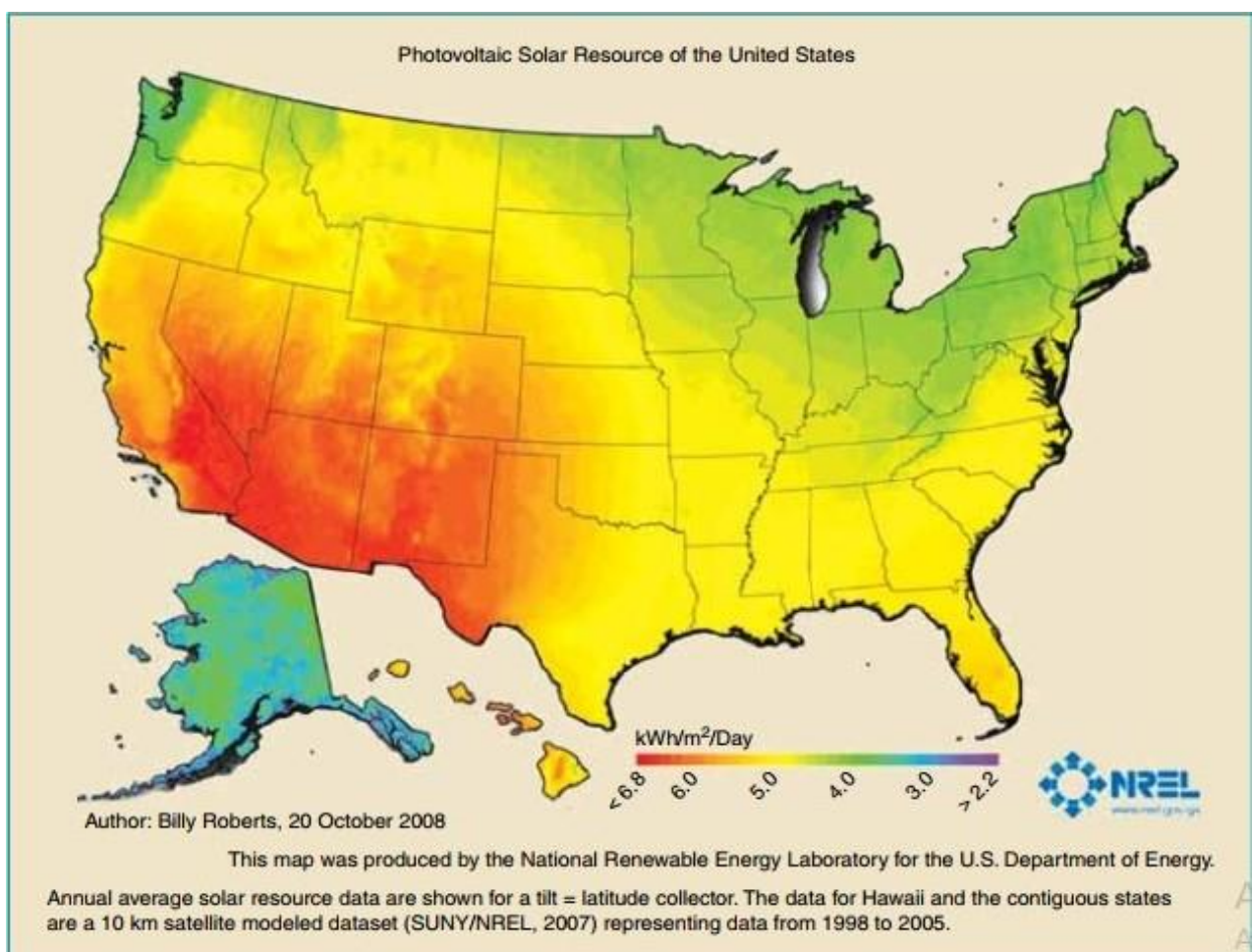


Figure 1.4: Solar energy available in the United States. (Used with permission from NREL.)

Examples of solar energy in the world

It's estimated that in 2017 1,6% of the worldwide generated energy came from solar sources. At the same time, solar power also contributed to 20% of the total energy growth in this same year. Some of the most known sources of solar energy are:

- The Kurnool Ultra Solar Park in India. It has a total generation capacity of 1000MW and over 4 million solar panels installed;
- The Longyangxia Solar Park in China that has a total capacity of 850MW and covers around 25sq km.
- The Kamuthi Solar Facility in India: it has a total capacity of 648MW and covers 10sq km [2]

1.3.5 Wind Power

The wind power is another renewable energy. Here, the wind's kinetic energy makes turbines spin and creates a mechanical movement. Afterward, a generator transforms this mechanical energy into electricity. There are several types of wind renewable energies: onshore wind turbines, off-shore wind turbines and even floating wind turbines. But the operating principles are basically the same for all these types of wind-generated energy. [2]



Figure 1.5 : combining Wind & Water for Energy Production & Storage .

Examples of wind power in the world

Wind power continues has also been growing, In fact, it provided 4.4% of global power generation in 2017. The highest installed wind capacity belongs to China (164GW). At the same time, in the EU, wind power provides 15% or more of the energy generated in several countries such as Germany, Portugal or Lithuania. Some of the most known sources of wind power energy are:

- The Gansu Wind Farm in China. It is still under construction and it will be able to produce 20,000MW of power by 2020;
- The onshore Muppandal Wind Farm in India with a capacity of 1,500MW and over 3000 turbines;
- The Alta Wind Energy Center in the U.S. with a total capacity of 1,548MW that's expected to reach 3,000MW by 2040;
- The Walney Extension in the UK. It has a total capacity of 659MW and it's the world's largest offshore farm. [2]

1.4 Comparative statistic of renewable energy use throughout the world:

This part of the study provides a brief statistic published by The International Renewable Energy Agency (IRENA) on the comparison of renewable energy use in Africa, produces comprehensive, reliable data sets on renewable energy capacity and use worldwide. Renewable Energy Statistics 2020 provides data sets on power-generation capacity for 2010-2019, actual power generation for 2010-2018

The renewable power capacity data shown in these tables represents the maximum net generating capacity of power plants and other installations that use renewable energy sources to produce electricity. For most countries and technologies, the data reflects the capacity installed and connected at the end of the calendar year. Pumped storage is included in total capacity but excluded from total generation. The capacity data are presented in megawatts (MW) and the generation data are presented in gigawatt-hours (GW/h). [6]

Capacity (MW)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Africa	27 330	27 760	28 748	30 945	32 965	35 287	35 287	42 729	46 466	48 446
Asia	387 287	433 478	478 468	551 810	628 524	716 985	808 944	915 183	1 023 860	1 119 265
Europe	264 700	302 632	335 520	358 504	378 444	401 941	423 334	445 800	467 710	497 267
Middle-east	12 133	12 556	13 218	14 092	15 595	6 929	17 773	18 803	20 373	23 137
North America	232 124	242 939	262 768	271 985	285 786	307 701	331 179	348 558	368 956	391 241
South America	146 538	150 982	154 95	160 133	169 268	178 783	193 325	202 301	212 666	220 986

Table 1.1 Totale capacity of renewable energy

Production (GW/H)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Africa	116 683	117 605	120 912	128 329	137 194	141 190	143 010	152 394	160 236
Asia	1 272 708	1 320 815	1 564 260	1 687 988	1 914 705	2 043 364	2 227 197	2 424 481	2 643 589
Europe	899 180	885 307	1 004 14	1 094 101	1 135 631	1 173 180	1 194 346	1 208 734	1 297 883
Middle-east	18 294	21 194	22 268	24 532	21 233	20 899	26 683	26 340	26 605
North America	857 471	971 050	958 087	1 002 811	1 033 620	1 040 559	1 119 942	1 202 235	1 226 317
South America	711 340	758 335	749 796	735 286	736 330	732 966	780 189	783 711	794 164

Table 1.2 Totale production of renewable energy

1.5 Why use renewable energy:

1.5.1 Fossil Fuels Are Limited

The first and main reason for why governments and businesses are keen to move to renewable energies as soon as possible is that fossil fuels are a finite resource. We may or may not have reached peak oil - the point at which demand outstrips supply -and by current figures, many experts seem to agree we did so around 2008 with only external factors creating

fluctuations in demand making it difficult to predict precisely when it will run out. That is another debate entirely that our politicians and economists have argued for decades, and will continue to argue for many years to come. Whichever way we look at it, fossil fuels will run out eventually and it will take some 10,000,000 years to replenish what we have used in around 150 years.

As the human population increases, our *rate* of consumption of these fossil fuels also increases. Geologists and others whose job it is to locate and access these pockets of crude oil are finding it increasingly difficult to locate and extract new sources. Whether we have 1 year or 100 years left of oil, many argue that what is left should remain in the ground because it is not sustainable - it will run out eventually and so we should prepare for a post-fossil fuel world now.

1.5.2 Carbon Emissions & Climate Change

The most immediate problem, particularly in light of the COP21 agreement of 2016, and the changes we have seen to the climate in the last 150 years, is climate change and the carbon emissions that are forcing it. In the last few years especially, no part of the world has been untouched by freak weather conditions. Most continents have recorded record high temperatures in summer, record lows in winter and increased frequency of typhoons and hurricanes, record dry spells, drought and flooding. There is no doubt that these freak weather conditions are affecting every country.

Most renewable energy sources, and the technology used to harness them, are low carbon emission. In most cases, once installed they have minimal or no carbon output and can still provide our energy needs. We can never go fully carbon neutral as it takes resources to make a solar panel, build a dam and so on, but it is a critical and significant reduction of our carbon output. What we do need to do, is to take the steps we can to reduce our carbon footprint for international regulations, to help those in the developing world, and to protect ourselves against the freak weather. We also know that the ice caps are melting and the sea levels are rising which creates food shortages and national instability as well as being an expensive situation for our insurance.

1.5.3 Energy Security

Energy security is a relative newcomer to public perception when we consider the greater need for renewable energy. The beginning of this decade has seen instability in the Middle

East. The Arab Spring swept across Algeria, Tunisia, Libya, Egypt and Syria leading to pro-democracy demonstrations. There are ongoing problems in Syria with the rise and spread of ISIS. Why have these political issues in other parts of the world encouraged the rest of the world to think about its energy plan?

The Middle East is one of the biggest suppliers of oil to the world. South America also produced oil, North America and South America supplies coal and the UK, Russia and other European Atlantic powers mine for gas. New tension between Russia and the west, firstly over Ukraine and secondly over Syria, has led to increased distrust between world powers. Being dependent on other countries for our energy supply is problematic in itself, but when international relations between supplier and supplied sour, increased wholesale prices threatening to destabilize the economy is the least that could happen . If a supply is cut off, then disaster could strike. For this reason alone, we need spare capacity and multiple avenues of energy acquisition.

Energy security will become a much greater factor as fossil fuels begin to dwindle. More than ever before, demands on energy supply often outstrip supply of conventional production forcing prices up . It is expected that increased tension over acquisition and protection of resources could lead to global conflict. Some are already arguing that the crisis in Syria is less about campaign for democracy reform in a major Middle Eastern power, and more a result of ongoing regional climate crisis. Former farmers who have fled to Europe and beyond have cited drought as the major catalyst for the civil war in the country .

The price of oil has fluctuated greatly in the last 10-15 years - from an all-time high in 2012 to 2013 to record lows in 2015 to 2016. Oil prices have a knock on effect for the economy when they are at the extreme and lead to protests .We must remember that oil is a commodity and when prices are erratic, it affects jobs all over the world.

1.5.4 Economic Stability

Related to some of the issues mentioned above, where renewable energy offers a constant and sustained supply (such as hydroelectric, wave power, solar and biofuels), energy prices are likely to remain stable and in turn, keep the economy stable .In many cases, energy produced from renewable sources is already cheaper than that produced by non-renewable means. Mentioned above, Idaho produces a large amount of energy from geothermal sources. Another example is Texas where energy produced from wind power is noticeably cheaper for the state's citizens.

1.5.5 Environmental Damage

As fossil fuel supply gets harder to acquire, and prospectors search for new pockets of oil and have to drill longer and deeper to acquire it, there has been conflict between environmental groups and industry and between governments and both groups when local wildlife and environmentally sensitive areas are threatened. Here in the US, public consciousness and the need to protect our wildlife and natural landscapes means that many new developments are protested with concerns of environmental damage. Ongoing protests against fracking and new drilling in Europe and North America and recent examples. Though some renewables will have an environmental impact, many do not and when built, have no further impact - unlike ongoing drilling.

1.5.6 Public Health

Oil, gas and coal drilling and mining have high levels of pollution that are pumped into local environments and the wider atmosphere, so while protestors attempt to prevent the building of pipelines or new prospecting in virgin areas and wilderness, it is as much about public health as it is about conservation. We have known for decades about the knock on effect of industrial processes for public health. Few renewables are entirely emission-free, but their output is much lower than conventional fossil fuel acquisition and processing. [4]

1.6 The world's most used renewable power sources:

Renewable technologies with exception to traditional biomass are often termed 'modern renewables'. These include hydropower, solar, wind, geothermal and modern biofuel production (including modern forms of waste-to-biomass conversion).

The change & mix of modern renewable consumption over the last 50 years is shown in the chart (figure 6). This is measured in terawatt-hours per year and can be viewed across a range of countries and regions.

Globally, the world produced approximately 5.9 TWh of modern renewable energy in 2016. This represents a 5 to 6-fold increase since the 1960s. Here we see that hydropower remains the dominant form of modern renewables consumption, accounting for almost 70 percent. Despite absolute growth in production, hydropower's share is, however, declining as other renewable technologies grow.[5]

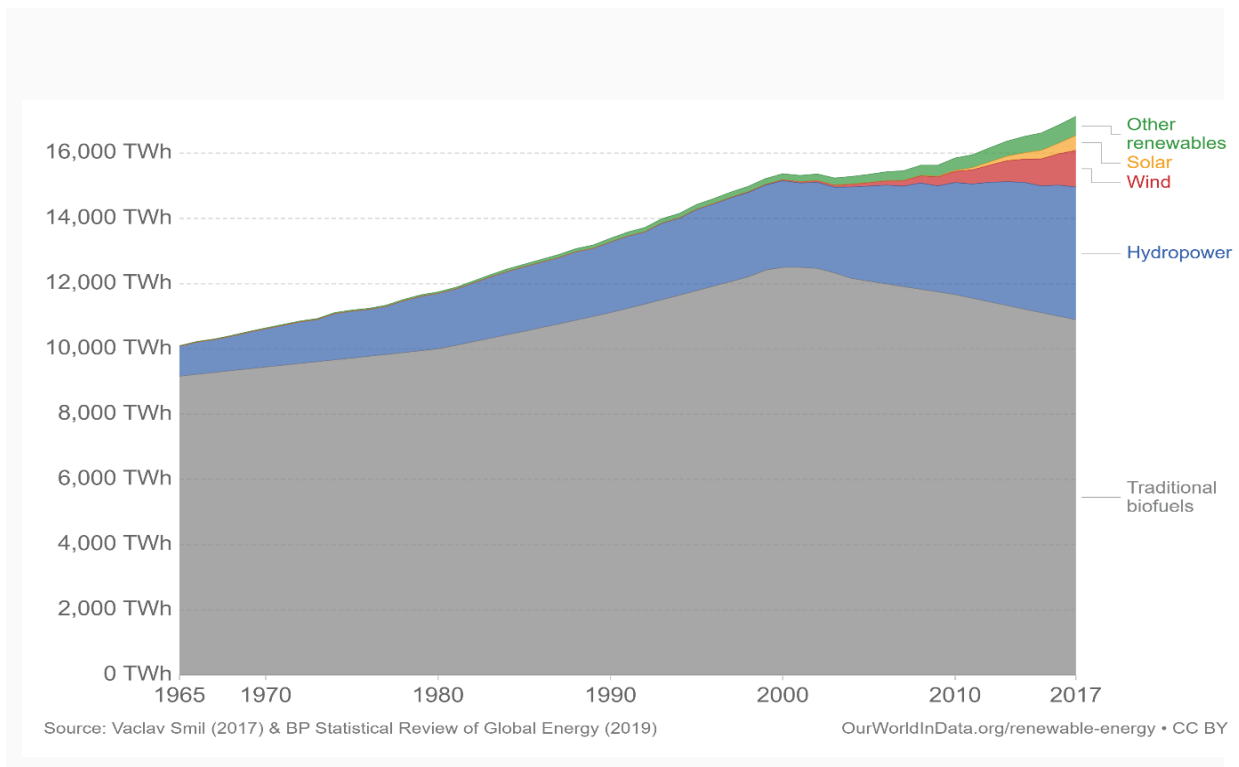


Figure 1.6: Global renewable energy consumption 1965 to 2017

1.6.1 Advantages of Hydropower:

- Hydropower is fueled by water, so it's a clean fuel source, meaning it won't pollute the air like power plants that burn fossil fuels, such as coal or natural gas.
- Hydroelectric power is a domestic source of energy, allowing each state to produce their own energy without being reliant on international fuel sources.
- The energy generated through hydropower relies on the water cycle, which is driven by the sun, making it a renewable power source, making it a more reliable and affordable source than fossil fuels that are rapidly being depleted.
- Impoundment hydropower creates reservoirs that offer a variety of recreational opportunities, notably fishing, swimming, and boating. Most water power installations are required to provide some public access to the reservoir to allow the public to take advantage of these opportunities.
- Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power to the grid immediately, they provide essential back-up power during major electricity outages or disruptions.
- In addition to a sustainable fuel source, hydropower efforts produce a number of benefits, such as flood control, irrigation, and water supply.

1.7 Potential and obstacles for renewable energy technologies :

The potential of renewables to provide all the energy services needed is huge as describe in the Special Report on Renewable Energy Sources and Climate Change Mitigation of the Intergovernmental Panel on Climate Change, published in 2011 (IPCC, 2011). Further developing and exploiting renewable energy sources using modern conversion technologies would enhance the world's energy security, reduce the long-term price of fuels from conventional sources, and conserve reserves of fossil fuels, saving them for other applications and for future generations. It would also reduce pollution and avoid safety risks from conventional sources, while offering an opportunity to reduce greenhouse gas emissions to levels that will stabilize greenhouse gases in the atmosphere, as agreed upon globally. It could also reduce dependence on imported fuels, minimize conflicts related to the mining .

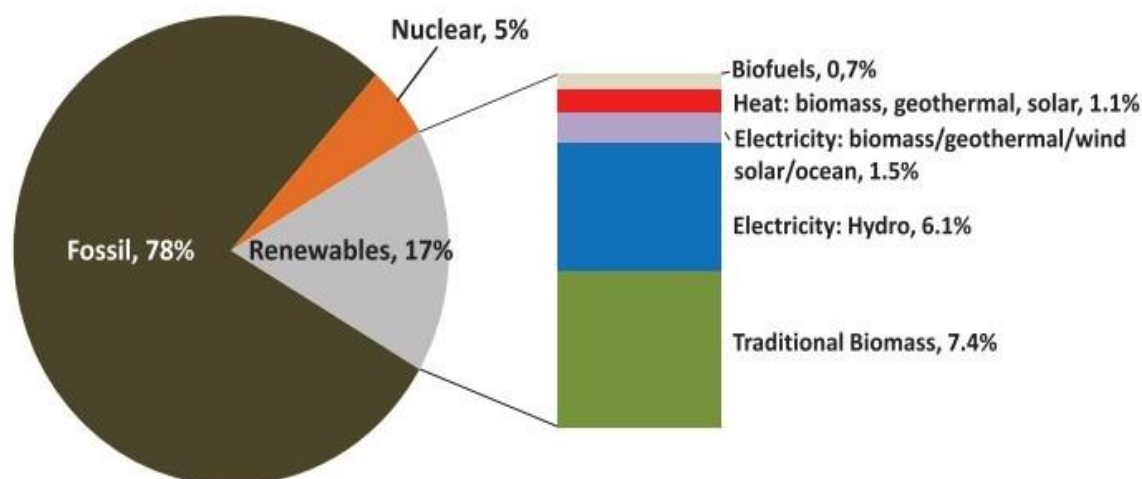


Figure 1.7 Renewable share of primary energy supply in 2009

and use of limited available natural resources, and spur economic development, creating new jobs and regional employment.

But using energy from renewable sources also faces a number of challenges because of their often low spatial energy intensity (J/m^2) or energy density (J/m^3) compared with most fossil fuel and nuclear energy sources, their generally capital intensive installation costs, their sometimes higher-than-desirable operational costs, and a variety of environmental and social concerns related to their development. An additional important issue is the intermittent character of wind, solar, and several ocean energy, requiring backup system investments or other innovations to secure a reliable energy supply.[7]

1.8 Conclusion:

It is clear that there is a strong need to integrate more renewable energy sources into the grid of the future. These kind of energy sources, when coupled with energy storage, can greatly benefit the grid by offering a variety of ancilliary services and daily peak load reductions. Storage technologies will vary according to different renewable energy sources and a greater variety of sources will lead to more grid stability.

All of these things rely on building new and more energy storage systems for renewable energy sources to allow them to be integrated with the grid in many different ways. With the current amount of storage on the grid, renewable energy sources still face a very hard road to full integration with the grid. But it is also worth noting that renewable energy may play a much bigger role in decentralized or distributed power systems (microgrids) than in the gigantic centralized power system we have today.

Chapter II

Smart Grid

2.1 Introduction:

The electric industry is poised to make the transformation from a centralized, producer controlled network to one that is less centralized and more consumer-interactive. Is an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. In this chapter, we presented what is a smart grid and its characteristic. Then we talked about the component of a smart grid. We discuss also about the advantages of the smart grid.

2.2 Understanding the “Grid”:

The term grid itself is a bit confusing in that it typically conjures an image of a linear pattern, like the streets of Manhattan or a page of graphing paper. In fact, when people talk about the **power grid**, what they are actually referring to is a network. This network is made up of generation plants, transmission lines, and transformers -- which convert and distribute high-voltage power into homes.

It is also problematic because "grid" doesn't really describe scale in any specific way. It can, of course, mean a single chain that goes from a power plant into an individual's home. It can also mean an entire country -- or continent's -- power system.

The reality is that the single chain rarely exists anymore. In most places, power from a number of generation plants is carried via a series of transmission lines and transformers and adjusted -- often manually -- to deal with fluctuations in demand and capacity.

Managing this network in a more responsive and efficient way is the goal of the **smart grid**. [8]

2.3 Smart grid definition:

There are yet no unanimous agreement on the standard definition of a Smart Grid, for it is a concept, which is still under development. The definition of smart grid varies from experts to experts.

For example, The European Union has defined a smart grid as “an electricity network that can cost efficiently integrate the behavior and actions of all users connected to it generators, consumers and those that do both in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety”. Electric Power Research Institute (EPRI) website offers the following definition “A SG is one that incorporates information

and communications technology into every aspect of electricity generation, delivery and consumption in order to minimize environmental impact, enhance markets, improve reliability and service, and reduce costs and improve efficiency”.

The International Electro-Technical Commission (IEC) definition states, “The SG is integrating the electrical and information technologies in between any point of generation and any point of consumption”.

International Energy Agency (IEA) defines “A SG is 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. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability” . [9]

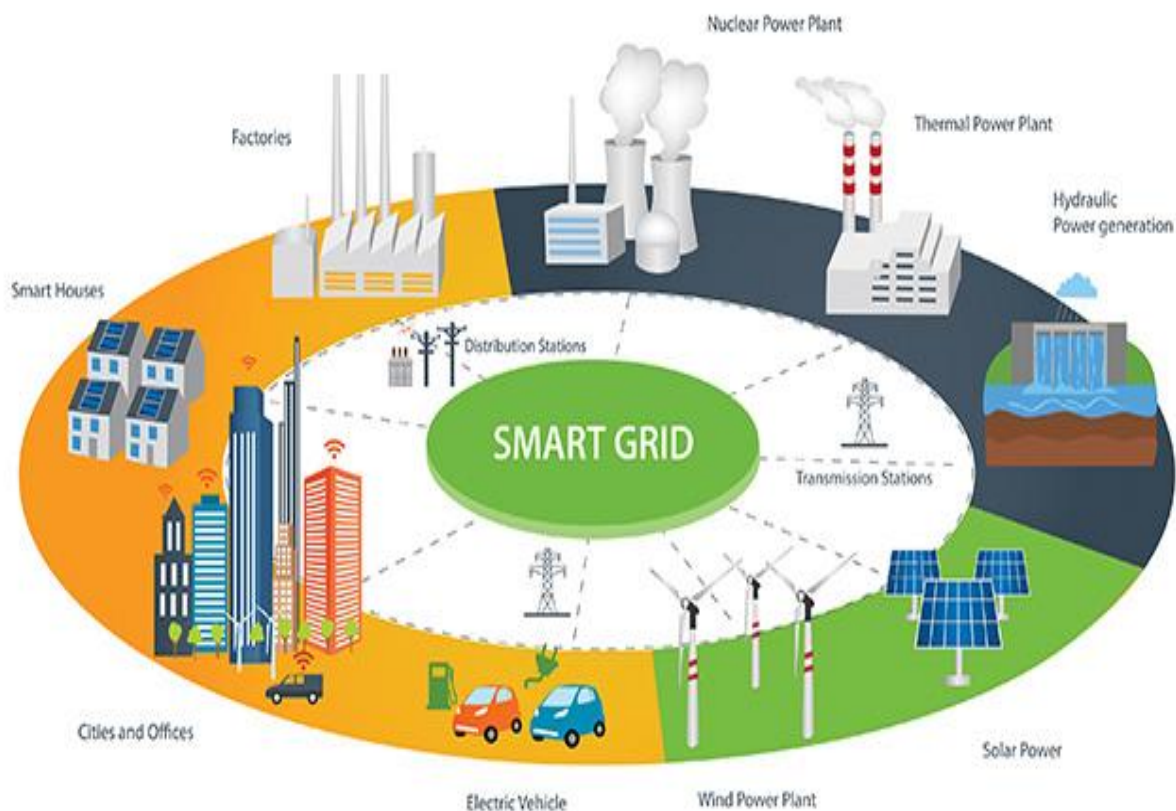


Figure 2.1: The overall smart grid concept

The scope of the smart grid extends over all the interconnected electric power systems, from centralized bulk generation to distributed generation (DG), from high-voltage transmission systems to low-voltage distribution systems, from utility control centers to end-user home-area networks, from bulk power markets to demand response service providers, and from traditional energy resources to distributed and renewable generation and storage, as shown in Figure 2.1 [2].

Figure 2.2 and Table 2.1 can illustrate the transition from the present grid to a smart grid and the key differences between the two. One can see there is a fundamental shift in the design and operational paradigm of the grid: from central to distributed resources, from predictable power flow directions to unpredictable directions, from a passive grid to an active grid. In short, the grid will be more dynamic in its configuration and its operational condition, which will present many opportunities for optimization but also many new technical challenges [10].

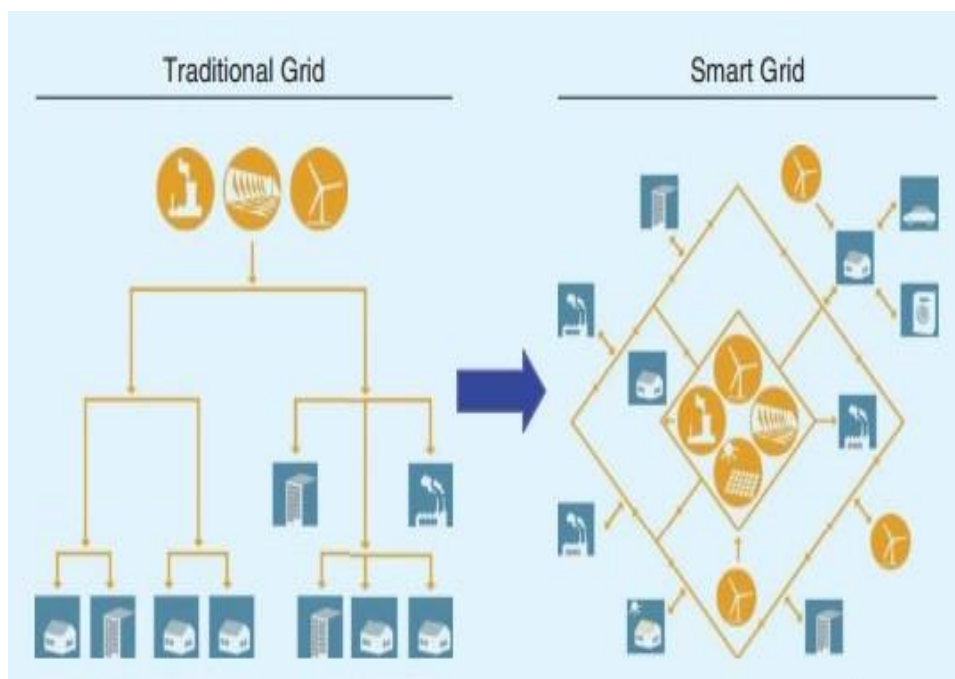


Figure 2.2: Transition from the present grid to a smart grid

Entity	Traditional model	Smart grid
Generators	Centralized generation	Generation everywhere
Power source transaction	Mostly hydrocarbon (natural gas , coal , oil) consumers bought power via energy companies (one direction)	More portion of renewable energy .A direct transaction between generators and consumers (multi direction)
Pricing billing	Determined by government or power company periodic billing (postpaid)	Every generator can set their price prepaid (pay as you need)

Table 2.1: comparison of traditional grid and smart grid

2.4 Smart Grid Characteristics:

A Smart Grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies toward:

2.4.1 Provides the power quality for the range of needs:

Not all commercial enterprises, and certainly not all residential customers, need the same quality of power. A smart grid supplies varying grades (and prices) of power. The cost of premium power-quality features can be included in the electrical service contract. Advanced control methods monitor essential components, enabling rapid diagnosis and solutions to events that affect power quality, such as lightning, switching surges, line faults and harmonic sources.

2.4.2 Enables informed participation by customers :

Consumers help balance supply and demand, and ensure reliability by modifying the way they use and purchase electricity. These modifications come because of consumers having choices that motivate different purchasing patterns and behavior. These choices involve new technologies, new information about their electricity use, and new forms of electricity pricing and incentives.

2.4.3 Accommodates all generation and storage options:

A smart grid accommodates not only large, centralized power plants, but also the growing array of customer-sited distributed energy resources. Integration of these resources including renewables, small-scale combined heat and power, and energy storage – will increase rapidly all along the value chain, from suppliers to marketers to customers.

2.4.4 Enables new products, services and markets:

Correctly, designed and operated markets efficiently create an opportunity for consumers to choose among competing services. Some of the independent grid variables that must be explicitly managed are energy, capacity, location, time, rate of change and quality. Markets can play a major role in the management of these variables. Regulators, owners/operators and consumers need the flexibility to modify the rules of business to suit operating and market conditions.

2.4.5 Optimizes asset utilization and operating efficiency:

A smart grid applies the latest technologies to optimize the use of its assets. For example, optimized capacity can be attainable with dynamic ratings, which allow assets to be used at greater loads by continuously sensing and rating their capacities. Maintenance efficiency can be optimized with condition-based maintenance, which signals the need for equipment maintenance at precisely the right time. System-control devices can be adjusted to reduce losses and eliminate congestion. Operating efficiency increases when selecting the least-cost energy-delivery system available through these types of system-control devices.

2.4.6 Provides resiliency to disturbances, attacks and natural disasters:

Resiliency refers to the ability of a system to react to unexpected events by isolating problematic elements while the rest of the system is restored to normal operation. These self-healing actions result in reduced interruption of service to consumers and help service providers had better manage the delivery infrastructure.

2.4.7 Scalability of the system and devices :

Using open standards for devices and systems to facilitate data exchange and interoperability, ensuring compatibility for wider deployment across the network management systems.

2.4.8 Upgrades to the grid may be delayed or avoided

There are fast and cheap solutions for new connections and provide continuing grid to meet the highest standards of safety and reliability [11].

2.5 Home energy management system :

In a smart grid system, three major parts generation, distribution, and consumption (Figure2.3) have different functionalities, as follows:

a. Power generation:

Generation is composed of different types of power generators (e.g., coalfired, gas, wind-powered turbines, and solar power plants). A generator measures the cost, power demand, and power prices offered by other generators to competitively or cooperatively adapt the power generation strategy (e.g., price and amount of supplied power in a certain time period) to achieve the maximum profit while meeting constraints on demand, capacity, and reliability.

b. Power distribution:

Electrical power is delivered from generators and distributed to consumers through transmission lines and distribution stations. Power distribution has to be optimized such that the loss and cost of transmission are minimized given constraints on the amount of transmitted power and transmission line capacity. The distribution can be adaptive on the power generator and consumer sides.

c. Power consumption:

Consumption is composed of different types of power consumers (e.g., home, industry, and government consumers). The power demand of consumers has to be determined so that the allocation of power supply and distribution can be performed optimally. To achieve such a goal, the smart meters are deployed to quickly and accurately collect the power consumption data. This data can be used to estimate the power demand. The HEMS focuses on the power consumer side in a smart grid in which home appliances (e.g., air conditioner, dishwasher, dryer, refrigerator, kitchen stove, and washing machine) with smart meters can be monitored and controlled by a control center to optimize the power supply and consumption [20].

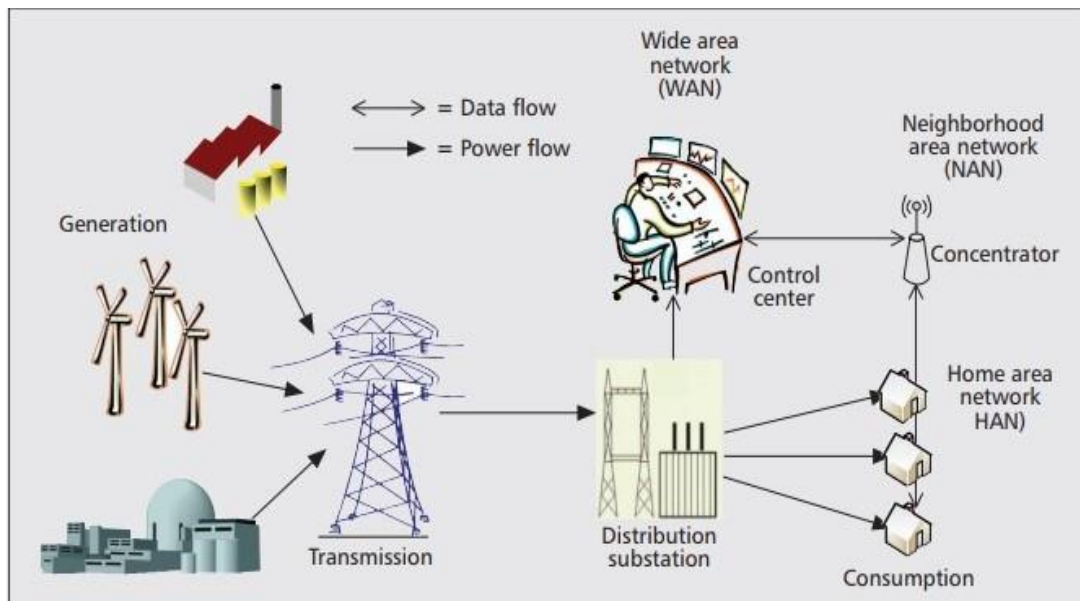


Figure 2.3: A general model of the smart grid

2.6 Components of Smart Grid

The components of a smart grid are a combination of intelligent appliances and heavy equipment that play an important role in the production of electricity as mentioned below. These appliances work in a predefined manner, they are smart enough to understand the incoming power supply and how to utilize it.

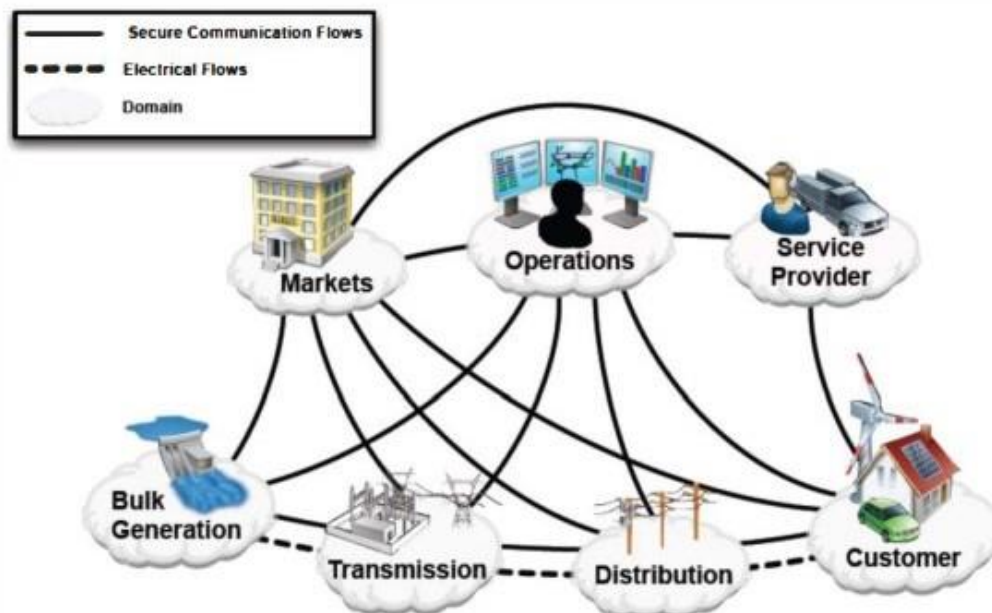


Figure 2.4: Smart grid components

2.6.1 Smart appliances

These appliances are set to consumer's predefined preference level and they have an idea on when to consume energy on what level. These tech appliances have an important impact on the grid generators since they help in understanding the power position and reduce the peak load factors.

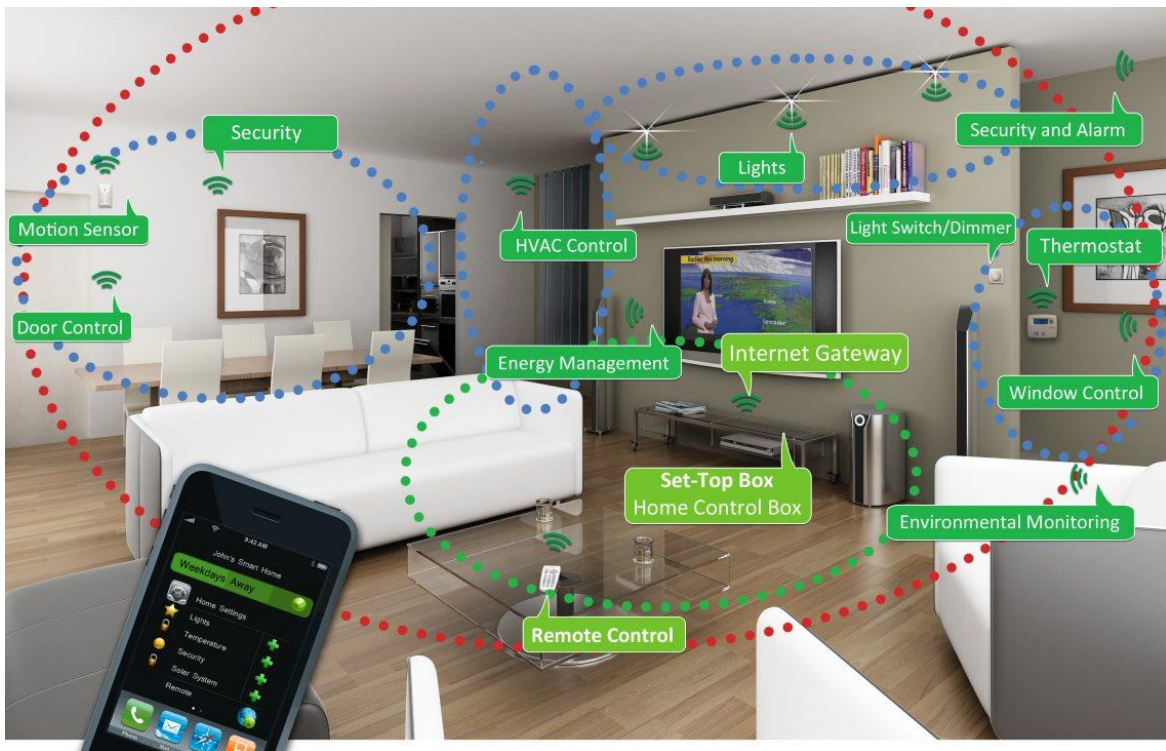


Figure 2.5: Smart home appliances

2.6.2 Smart meters

The smart meters are a two-way communicator that help create a bridge between the power providers and the end consumer. It automates the billing data collection on the very convenient manner, detects system failures and sends repairing teams much faster than before because as soon as a system or a unit fails, the service providers are notified immediately, they look much like the electric meters that are in your home now, but their technology is far more advanced.



Figure 2.6: smart meters

- **Smart meters are safe and secure:**

Smart meters have been thoroughly tested for safety and reliability. They have undergone extensive tests by utilities in USA. Smart meters operate at a level that is much lower (1.4%) than the maximum permissible exposure limits for radio frequency

2.6.3 Smart substations

Substations are located in every region as a sub-branch for their main station. They monitor the performance of the station and control any critical and non-critical data that could be the status of the power, power performance, circuit breakers, security and the operationalization of the transformers.

These are also used to transform voltage at several stations and operational regions and to split the path of electricity into several routes.

Smart grid's substations require heavy equipment and manpower to be operationalized thoroughly. This equipment may include transformers, switches, capacitor banks, circuit breakers and a network protected relay.

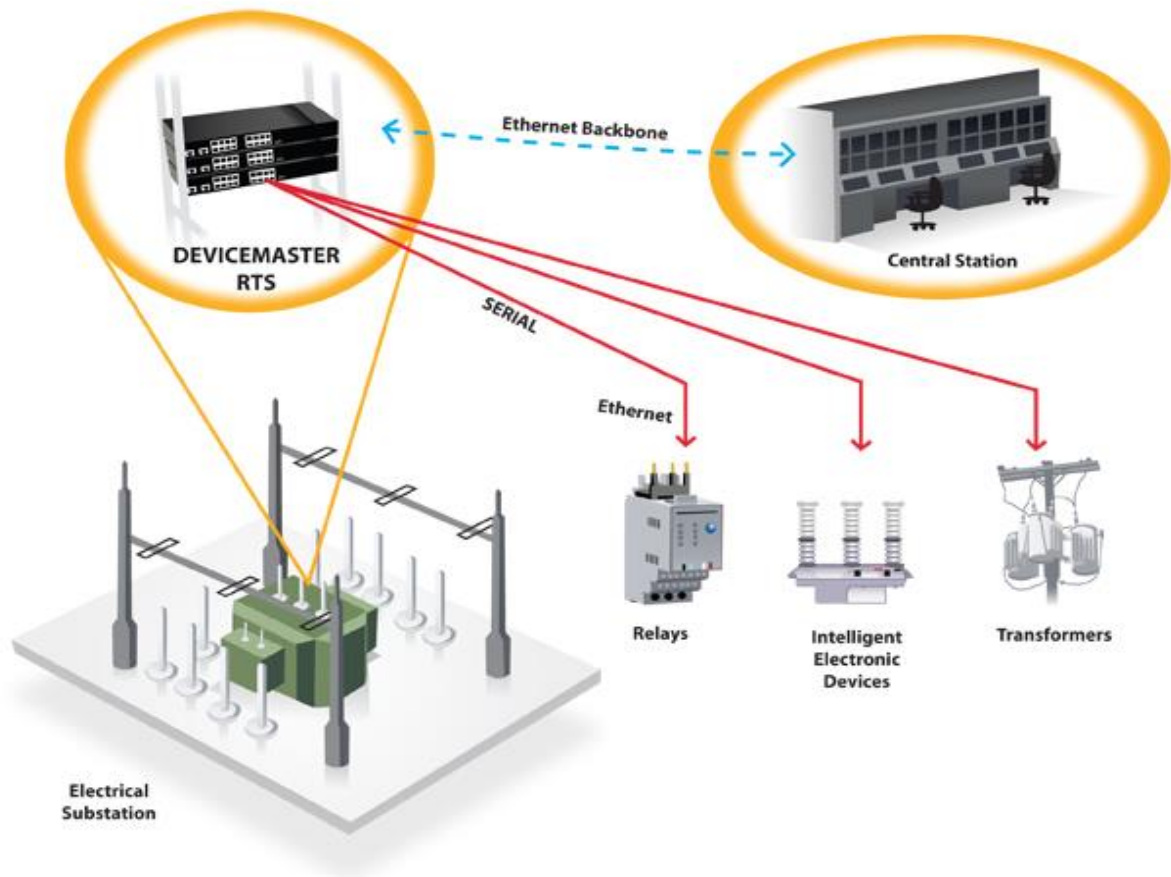


Figure 2.7: Direct monitoring and control of smart grids for several substations.

2.6.4 Synchro Phasors

Recent advancement in **synchro phasor** technology or **Phasor measurement unit (PMU)** has played a key role in the supervisory control and data acquisition (SCADA) and energy management systems (EMS). The most common advantages of phasor measurement technology include:

- Dynamic monitoring of the whole interconnected system
- Post-event analysis
- Oscillation detection
- Island detection

Synchro phasors gather data from various locations of the grid to get a coherent picture of whole network using GPS and transmit for analysis to central locations [12].

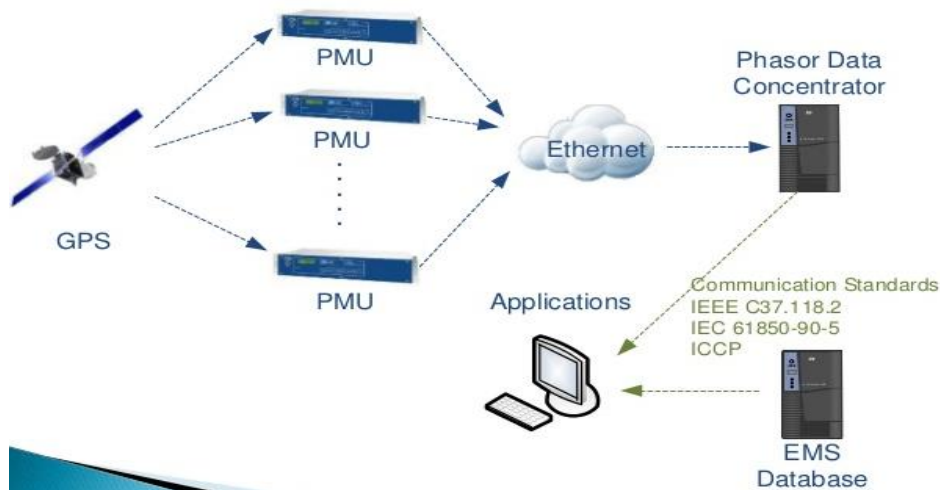


Figure 2.8 : synchro phasor infrastructure

2.7 Advantages of smart grid:

2.7.1 Intelligent

Capable of sensing system overloads and rerouting power to prevent or minimize a potential outage; of working autonomously when conditions require resolution faster than humans can respond...and cooperatively in aligning the goals of utilities, consumers and regulators

2.7.2 Efficient

Capable of meeting increased consumer demand without adding infrastructure.

2.7.3 Accommodating

Accepting energy from virtually any fuel source including solar and wind as easily and transparently as coal and natural gas; capable of integrating any and all better ideas and technologies energy storage technologies, for example – as they are market-proven and ready to come online .

2.7.4 Motivating

Enabling real-time communication between the consumer and utility so consumers can tailor their energy consumption based on individual preferences, like price and/or environmental concerns.

2.7.5 Opportunistic

Creating new opportunities and markets by means of its ability to capitalize on plug-and-play innovation wherever and whenever appropriate

2.7.6 Quality-focused

capable of delivering the power quality necessary – free of sags, spikes, disturbances and interruptions – to power our increasingly digital economy and the data centers, computers and electronics necessary to make it run

2.7.7 Resilient

Increasingly resistant to attack and natural disasters as it becomes more decentralized and reinforced with Smart Grid security protocols

2.7.8 Green

Slowing the advance of global climate change and offering a genuine path toward significant environmental improvement [13].

2.8 Security in Smart Grid

A smart grid is a large-scale system that extends from a power generation facility to each and every power consuming device such as home appliance, computer, and phone. This large-scale nature has increased the possibilities of remote operation of power management and distribution system. With energy being a premium resource, ensuring security against theft, abuse, and malicious activities in a smart grid is of prime concern .

The challenges of ensuring cybersecurity in a smart grid are diverse in nature due to the diversity of the components and the contexts where smart grids are deployed. Deploying a smart grid without strong and diligent security measures can allow advanced cyberattacks to remain undetected, which can eventually compromise the entire system . Inadequate security measures can also compromise the stability of the grid by exposing it to, for example, utility fraud, loss of confidential user information and energy-consumption data The cyber security objectives can be classified into the following three categories :

(i) **Integrity:** Protecting against the unauthorized modification or destruction of information. Unauthorized information access opens the door for mishandling of information, leading to mismanagement or misuse of power.

(ii) **Confidentiality :** Protecting privacy and proprietary information by authorized restrictions on information access and disclosure.

(iii) **Availability :** Ensuring timely and reliable access to information and services. Availability can be compromised by disruption of access to information which undermines the power delivery. Availability and integrity are the most important security objectives in the smart grid from the perspective of system reliability. However, due to the systems interactions with customers, the importance of confidentiality is also growing in this two-way data communication system that interconnects the whole system including meters, collectors, communications network, and utility data centers .

As mentioned earlier, smart grid has introduced new concepts in energy sector such as real-time pricing, load shedding, demand management, and integration of distributed, renewable power sources. It is based on numerous control systems, which can be targeted by the attacker. Furthermore, smart grid has created many more access points and with commands emanating from interfaces in homes and businesses in HAN ; any of these access points can be manipulated by the attackers to penetrate a network, gain access to control software, and alter load conditions to destabilize the grid in unpredictable ways . It is important to note that attack at any point can affect the entire smart grid as it is mostly based on mesh network, and any malignant attack can propagate to the entire grid, as all components in a smart grid can communicate with each other. One particular point of concern in this regard is from a customer meter to the data collector, which can use wireless communication. This can provide an opportunity to the attacker, if security mechanism is not adequate . Smart grid security mechanism should be enforced at several layers including physical and logical layers. Physically, smart grid systems and component must be secured from harm, tempering, theft, vandalism, and sabotage. Examples of physical layer security include installation of fence, video surveillance, and alert system .

Security in the logical layer deals with protecting the digital data. In a detailed discussion on logical layer security mechanisms has been presented; a few of these are highlighted below.

- a. **Encryption :** Data encryption in smart grid, from meter to utility center, is a useful tool to prevent snooping, hence preserving the confidentiality of data. Strong but efficient

algorithms can be used; however, all smart grid devices, for example, meters, collectors, processors, and routers, must be enabled with encryption processing capabilities .

- b. Authentication :** It is the process of determining that a user or entity is, indeed, the same as been claimed. Smart grid applications must have strong authentication capabilities, to detect and reject unauthorized connections between its components, for example, meter and the utility interfaces .
- c. Application Security Controls :** Smart meter applications should be designed and coded appropriately so that cybercriminals cannot access a meter to mount buffer overflow attacks or to embed a malware. Data validation is an example of techniques that can be used .
- d. Security Patches:** It can protect an application from known threats; therefore, codes should be kept up to date with latest security patches.
- e. Malware Removal:** Use of antivirus and antispysware software throughout the smart grid applications can help to detect and to remove malwares from the system [9].

2.9 Conclusion:

The smart grid is the latest development for the electric power system. Although the term “smart grid” does not have a precise, uniformly accepted definition, it is commonly regarded as a digital upgrade of the existing power system. It promotes clean energy, controls energy consumption pattern and brings security to the grid. The future smart grid should enhance the security and reliability of the power system. The implementation of smart grid will be a long continuous process because it involves technological and financial investment. It also involves international effort. The government of each nation will need to develop a policy for implementing smart grid.

Chapter III

Implementation and Result

3.1 Introduction :

In this chapter we will present an overview about routing protocols and communication hierarchy in smart grid, in order to understand the idea of our application. We choose the network simulator (NS2) as an environment to implement a comparison between AODV and DSDV routing protocols, regarding performance metrics which includes various comparison factors like packet delivery fraction, and energy consumption ; throughput as parameters .

The simulation flow shown using NAM (Network Animator) and the results in graphs.

3.2 Classification of ad hoc routing protocols :

Whenever a packet is to be sent from a source node to a destination node by intermediate nodes, routing protocols are responsible for finding paths from source node to destination node. These routing protocols are categorized as follows:

3.2.1 On-demand Routing Protocols :

In this category the routes are established upon necessity. The source node begins a route discovery process whenever it needs to send data towards destination node. When a route or routes are found, the discovery process is considered as complete. When routes are created, the procedure of route maintenance is followed, which maintains valid routes and eliminates invalid routes. Different on-demand routing protocols consist of AODV, Dynamic Source Routing (DSR) etc.

AODV is an on-demand routing protocol. The discovery process is OFF until a route is required. Upon demand, the source node which needs the route, broadcasts a request packet to its neighbors. When an intermediate node receives a request packet and it has an entry corresponding to the destination node address in its routing table, it returns a reply packet through the reverse path to the source node; otherwise, rebroadcasts the request packet to its neighbors. This procedure will continue until an intermediate node can return a reply packet through the reverse path to the source node or the request packet reaches the destination node and destination node returns a reply packet through the reverse path. Next, the source node recognizes a new path and transmits its data through this path to the destination node.

3.2.2 Table-Driven Routing Protocols

This category of protocols holds the routing information from each node to every other nodes in the network, regardless of whether these routes are needed or not. Every node in the network holds a table, known as routing table, where routing information is maintained and assists nodes

to get the route information and establish a path. Different table-driven routing protocols consist of Destination Sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR), etc [15].

3.3 The characteristic of AODV routing protocol :

AODV combines some properties of both DSR (Dynamic Source Routing) and DSDV (Destination Sequence Distance Vector). It uses route discovery process to cope with routes on-demand basis. The protocol is hence seen as a reactive one. However, it adopts DSDV like hop-by-hop routing tables for maintaining routing information. Hence, AODV is a reactive protocol, it doesn't need to maintain routes to nodes that are not communicating. AODV handles route discovery with Route Request (RREQ) messages. RREQ message is broadcasted to neighbor nodes. The message floods through the network until wanted destination or a node knowing fresh route is reached. Sequence numbers are used to guarantee loop freedom (Sec 2.2) RREQ messages cause bypassed nodes to allocate route table entries for reverse route. The destination node unicasts a Route Reply (RREP) back to the source node. Nodes transmitting a RREP message creates routing table entries for forward route.

For route maintenance nodes periodically send HELLO messages to neighbor nodes. If a node fails to receive three consecutive HELLO messages from a neighbor, it concludes that link to that specific node is down. A node that detects a broken link sends a Route Error (RERR) message to any upstream node. When a node receives a RERR message it will initiate a new source discovery process.[21]

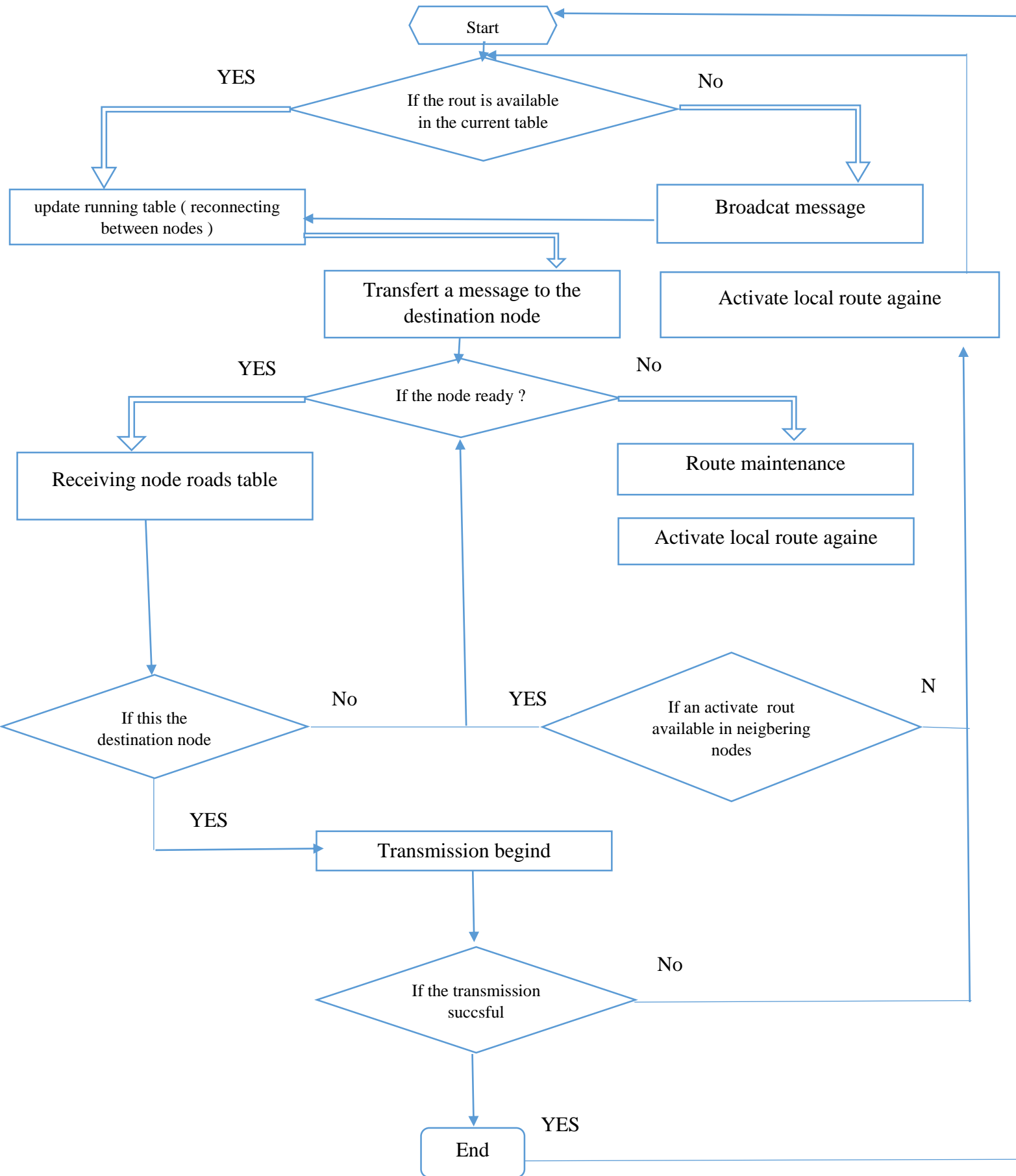


Figure 3.1: the diagram of AODV routing protocol

3.4 Smart grid communication network hierarchy :

Hierarchically, smart grid communication network can be divided into three area networks :

3.4.1 Home Area Network (HAN):

The Home Area Network belongs to the customer domain and comprises of home appliances and sensors. These devices report their power usage information to central home controller or smart meter which in turn forwards it to the central grid. Smart meters also receive electricity instructions from the grid and can turn the appliances on and off depending upon the grid's load. The Home Area Networks spans for area of thousands of square feet and has small data rate requirements in the order of 1 -10 Kbps.

For this particular network, ZigBee is the most preferred communication standard being utilized today. ZigBee is an energy efficient small range wireless standard dedicated for wireless sensor networks. Small nodes density and inter-node distances are characteristics of this network. However, indoor communication is severely degraded from shadowing effects and wall penetrations. Another candidate is WiFi which can also be utilized for inter-communication of home appliances and sensors. These days low power WiFi SoCs are being manufactured which can be utilized for implementing Home Area Networks. Co-existence of ZigBee and WiFi poses problems which need to be addressed.

3.4.2 Neighbourhood Area Network (NAN) :

The main role of Neighborhood Area Network is to make possible the communications of smart meters with backend control center. The NANs are deployed in outdoor environment and may consist of hundreds to thousands of smart meters. NANs connect the smart meters with gateways (collector) to relay the metering data. The coverage area of NANs is in order of 1-10 square miles and has relatively higher bandwidth requirements of around 10 - 1000 Kbps. High node density, large inter-node distances and outdoor communication are characteristics of this network. IEEE 802.11 with multi hop mesh topology is a promising candidate for implementing Neighborhood Area Networks. Electricity meters are powered by main power lines, however, water and gas smart meters are battery operated. Energy efficiency should also be considered when choosing wireless standard for this network. WiFi Mesh network, primarily installed for smart metering, can also be utilized for providing internet access in the whole city.

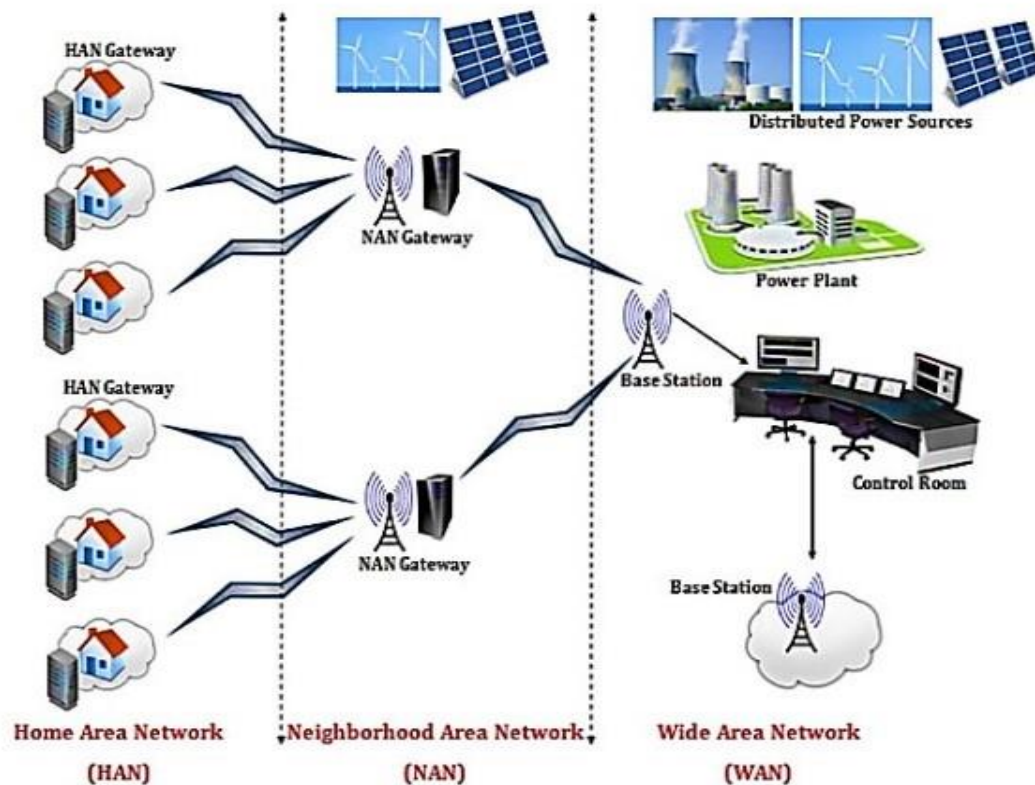


Figure 3.1 : Smart grid communication network consisting of HAN, NAN and WAN.

3.4.3 Wide Area Network (WAN) :

The Wide Area Network connects several NANs with the backhaul network. Gateways or Collection points are located on poles to collect Data from metering nodes of NANs and forward them to the grid control center. The coverage area is much higher in terms of thousands of square miles. Likewise, data rate requirements are in the order of 10-100 Mbps. For this network, optical fibers, WiMAX and Cellular (3G/4G) are competitive technologies due to high bandwidth requirements [16].

3.5 NS2 simulator presentation :

3.5.1 NS definition :

Network Simulators (NS) are a series of open source discrete event network simulators. Most popular among them is NS-2. The latest version is NS-2.36. The core of NS-2 is in C++, with Object-Tcl (OTcl) based scripting. Linux is the most compatible operating system for NS-2. Windows with the Cygwin package supports NS-2. Back-end modeling in NS-2 is very complex and time consuming because of the continuous changes in the code base. Moreover, some protocols have unacceptable bugs. Even though the installation of NS-2 itself

is complex and time consuming, so many well-known protocol packages are available with NS-2 package. It lacks a GUI and user should learn scripting language, queueing theory, and modeling techniques.

Moreover, there is no inbuilt packages supporting UWSN simulation except in NS-2.30. Limited tutorials and sample codes are available on NS-2.30 as it is an earlier version. Also, it is difficult to run simulation scripts written in higher versions of NS-2.30. Hence, we need to model all the underwater channel characteristics and propagation model for simulating UWSN in NS-2.35 and above. Nam is the visualizer of NS-2. Trace file is the output file generated after running a simulation. The trace file has a separate format for wired, wireless, and mobile networks. To analyze the performance of the network, data from the trace file should be retrieved and analyzed. For that, it is required to write .awk scripts of concerned performance metrics.

An open source trace file analyzer software named NS-2 visual trace analyzer is available to analyze trace files.

3.5.2 Basic architecture of NS2 :

Figure given below shows the basic architecture of NS2. NS2 provides users with an executable command ns which takes on input argument, the name of a Tcl simulation scripting file. Users are feeding the name of a Tcl simulation script (which sets up a simulation) as an input argument of an NS2 executable command ns. In most cases, a simulation trace file is created, and is used to plot graph and/or to create animation.

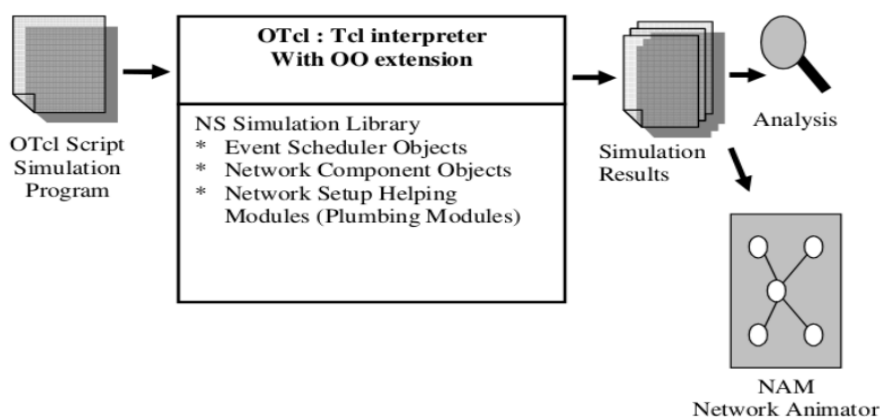


Figure 3.2 : NS2 Architecture

3.5.3 Why does NS2 use two languages :

ns uses two languages because the simulator has different kinds of things to do.

First, It needs a programming language to efficiently manipulate bytes, packet headers etc that run over large data where the run-time speed is more important and turn-around time is less important.

C++ is fast to run and slow to change making it suitable for detailed protocol implementation.

Second, a large part of the network involves quickly exploring a number of scenarios where run-time speed is less important.

oTcl runs much slower but can be changed quickly making it ideal for system configuration [17].

3.5.4 Results visualization :

3.5.4.1 Trace file:

Trace file is written by an application for storing whole information in a network. For generating trace file in NS2, we require the file to be written in OTCL Script.

Generated trace file that is (.tr)

```

M 1.000000 2 (363.00, 287.00, 0.00), (500.00, 300.00), 10.00
s -t 1.000000000 -Hs 3 -Hd -2 -Ni 3 -Nx 210.00 -Ny 271.00 -Nz 0.00 -Ne
50.000000 -NL AGT -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 3.0 -Id 12.0 -It
tcp -Il 40 -If 0 -Ii 0 -Iv 32 -Pn tcp -Ps 0 -Pa 0 -Pf 0 -Po 0
r -t 1.000000000 -Hs 3 -Hd -2 -Ni 3 -Nx 210.00 -Ny 271.00 -Nz 0.00 -Ne
50.000000 -NL RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 3.0 -Id 12.0 -It
tcp -Il 40 -If 0 -Ii 0 -Iv 32 -Pn tcp -Ps 0 -Pa 0 -Pf 0 -Po 0
s -t 1.000000000 -Hs 3 -Hd -2 -Ni 3 -Nx 210.00 -Ny 271.00 -Nz 0.00 -Ne
50.000000 -NL RTR -Nw --- -Ma 0 -Md 0 -Ms 0 -Mt 0 -Is 3.255 -Id -1.255 -
It AODV -Il 48 -If 0 -Ii 0 -Iv 30 -P aodv -Pt 0x2 -Ph 1 -Pb 1 -Pd 12 -Pds
0 -Ps 3 -Pss 4 -Pc REQUEST
s -t 1.000635000 -Hs 3 -Hd -2 -Ni 3 -Nx 210.00 -Ny 271.00 -Nz 0.00 -Ne
50.000000 -NL MAC -Nw --- -Ma 0 -Md ffffffff -Ms 3 -Mt 800 -Is 3.255 -Id
-1.255 -It AODV -Il 106 -If 0 -Ii 0 -Iv 30 -P aodv -Pt 0x2 -Ph 1 -Pb 1 -
Pd 12 -Pds 0 -Ps 3 -Pss 4 -Pc REQUEST
N -t 1.000635 -n 4 -e 49.399025
N -t 1.000636 -n 2 -e 49.399025
N -t 1.000636 -n 0 -e 49.399025
N -t 1.000636 -n 1 -e 49.399025
N -t 1.000636 -n 5 -e 49.399025
N -t 1.000636 -n 10 -e 49.399025
N -t 1.000636 -n 6 -e 49.399025
N -t 1.000636 -n 9 -e 49.399025

```

Figure 3.3 : Trace File Format

3.5.4.1.1 setdest Syntax:

We use another command to create run time environment for NS 2. setdest -n val -M val -P val -t val -x val -y val .

Setdest is a command used to create the runtime environment for NS2. Where :

- n: Numbers of nodes.
- M:speed(Mobility).
- P:pause time.

- t: simulation time.
- x: x coordinate.
- y: y coordinate.

3.5.4.2 NAM file output :

NAM is a Tcl/TK based animation tool for viewing network simulation traces and real world packet traces. Taking data from network simulators (such as ns) or live networks, NAM was one of the first tools to provide general purpose, packet-level, and network animation, before starting to use NAM, a trace file needs to create. This trace file is usually generated by NS. Once the trace file is generated ,NAM can be used to animate it. A snapshot of the simulation topology in NAM is shown in figure 3.4 , which is visualized the traces of communication or packets movements between mobile nodes. [16]

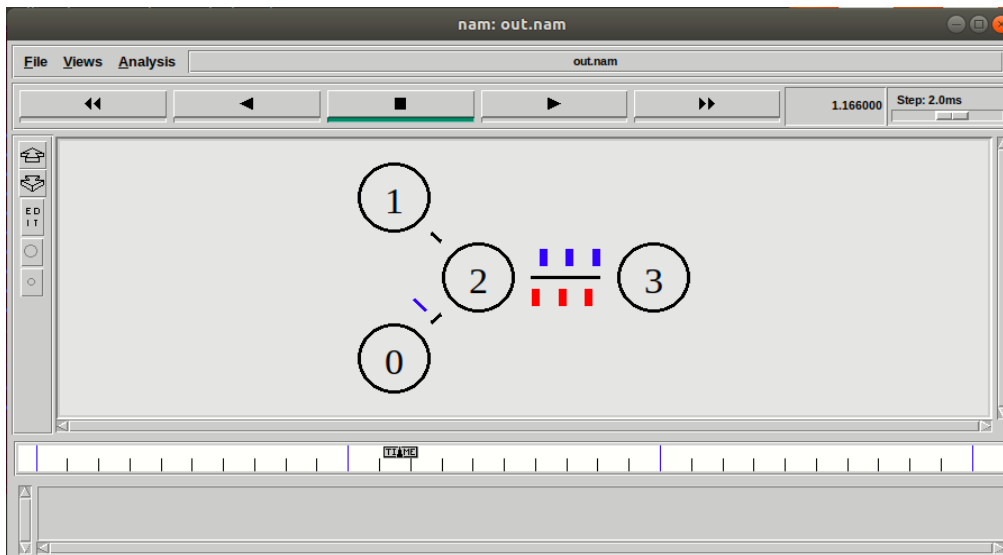


Figure 3.4 : Nam interface

3.5.4.3 Interface XGRAPH:

xgraph in ns2 is used to plot the network parameter characteristics like throughput, delay, jitter, latency .[16].

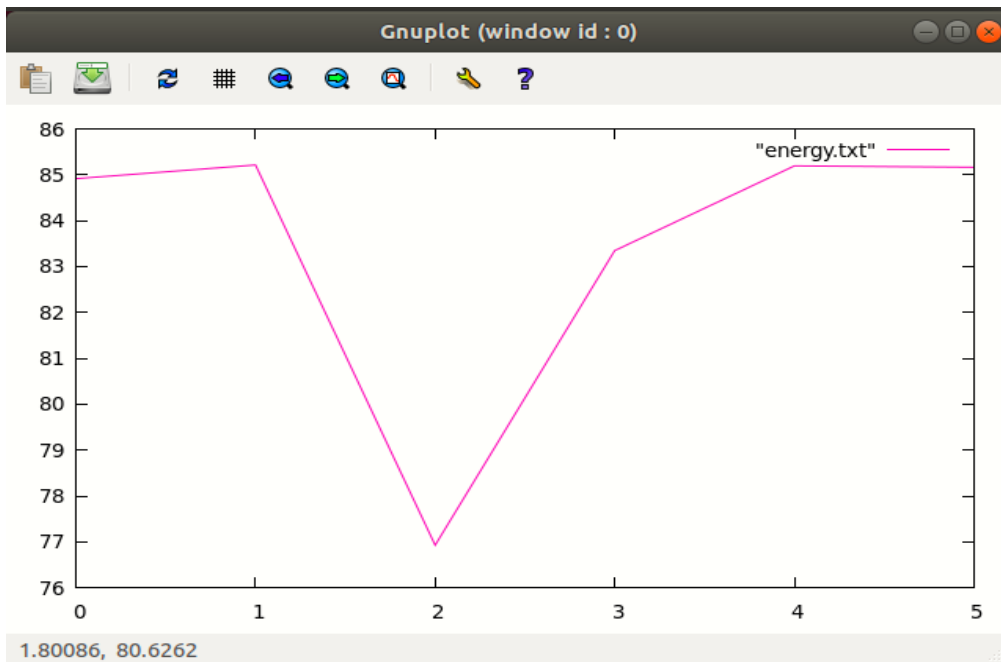


Figure 3.5: XGraph plot .

3.6 scenario of smart homes simulation:

The smart homes introduce a range of techniques from a centralized platform for management and control, intelligence devices in a house and allow owners to organise their house according to their will and therefore improve their lifestyle.

In addition to energy management, a smart house is able to control operations that ease energy distribution, including solar panels and wind turbines. It supports the infrastructure of smart grids in terms of supervision, adjustment and energy loading. in the context of the management of smart grids , AMI has taken mainly responsibility for delivering messages from services for each house, long-distance transmission power or through wired means of communication, as illustrated in Figure 3.6.

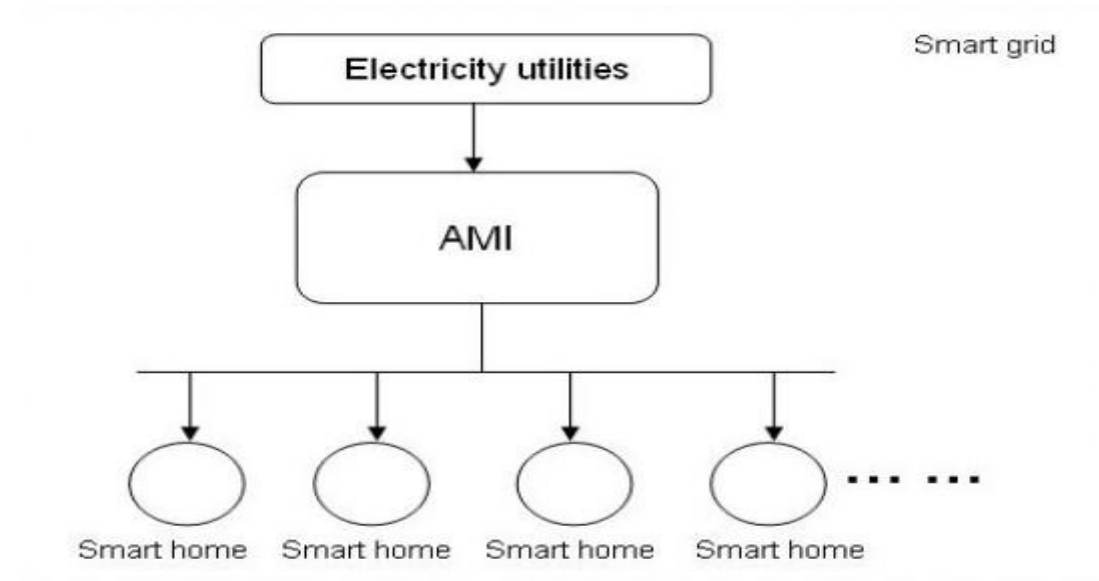


Figure 3.6 : scenario of delivering messages through AMI to smart homes in smart grid

In an intelligent house, a smart meter deployed by the uses (the municipality) keeps a trail of the original message, through AMI and cooperates with the home control centre so as to regulate the use of energy for the different applications based on the preference and pre-configuration of residents.

With the reception of messages sent by the smart meter, the control centre selectively adjusts, energy supplement and consumption, oriented according to use in a house. First of all, it requires accessibility to energy generation and storage ease available at the moment. These facilities will be able to automatically serve to the residences, at each request without intervention by the control centre with the electricity network as a supplement. If there is a need to reduce the electricity surcharge, the controller immediately sends a warning message based on the dynamic price to the machines in each house, including electric cars and hybrid vehicle plug-ins often or simply cut off the course of a couple of machines when it's necessary.

In this example, we took only the AMI connection with the smart houses for message delivery and data transmission.

Frequency modulation (FM) represents a good support for signal penetration through buildings when disseminating data to their destinations. The data broadcasting radio system (RBDS) can be used for the transmission of small packets through the FM channel, which covers most residences and in addition the system is integrated into the package used for smart grids.

In order to evaluate network metrics traffic and energy consumption on the nodes, a model for simulating the network of a smart home, on NS-2 v2.29, was designated and implemented to explore program delivery. The complete model includes an RBDS network as well as in a ZigBee/IEEE 802.15.4 network in an environment of multiple communications between channels, respectively assigned to each network, as shown in figure 3.7 [18].

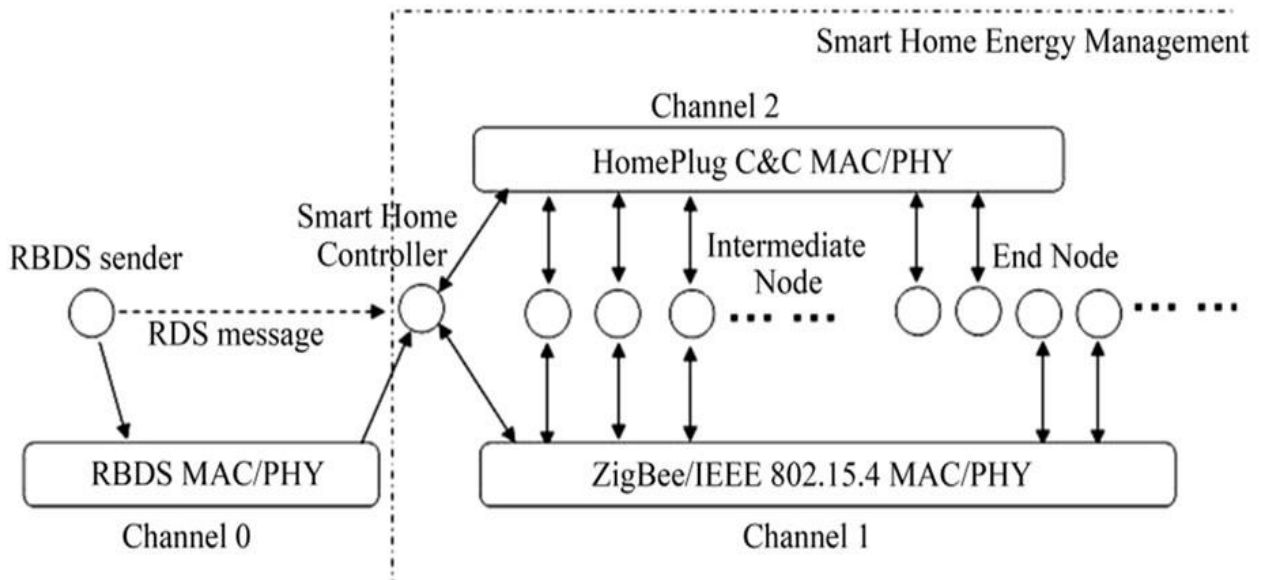


Figure 3.7 : simulation model of the energy control network in smart homes.

3.7 Routing across network :

Generally, data transmission in the implementation of ZigBee or AODV , is categorized into two phases: the establishment of routes to destination nodes and data packet forwarding, as illustrated in the sequence organigram below :

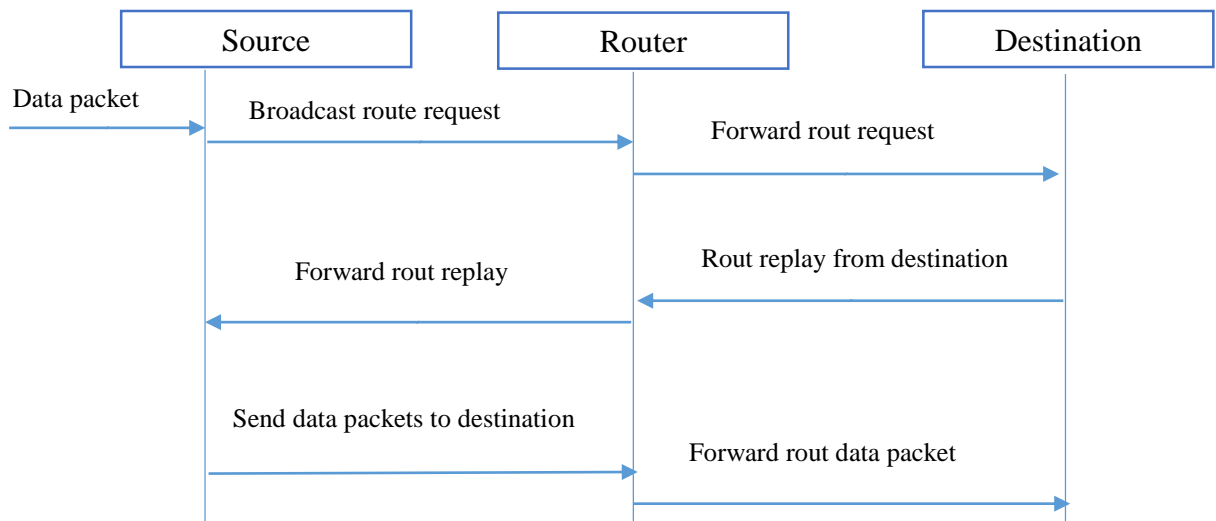


Figure 3.8 : sequence organigram of data transmission

3.8 Simulation analyzes and discussion:

In this part, we focus mainly on analysing the results of the simulation in an effort to assess whether and how dynamic factors influence the network model in terms of performance indicators, oriented towards different protocols, and the routing strategies of our implementation.

3.8.1 node deployment and network parameters:

The smart house is occupied by an individual network. In our case, we took 16 houses a few metres away, which play the role of smart main metres, and each house is equipped with a secondary metre that will communicate directly with the main metre.

The nodes are placed in a grid mode to ensure that each node participating in the associated network is able to receive packets via the wireless link. According to the network deployment model as shown in the figure 3.9.

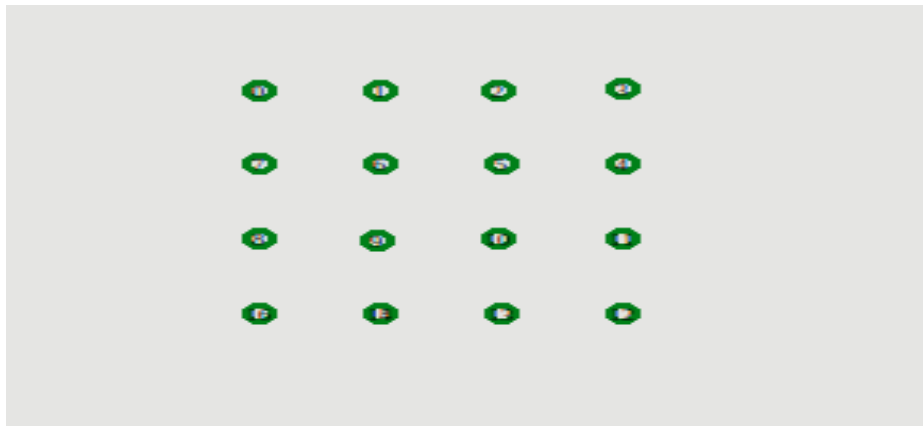


Figure 3.9 : deployment model

The centre controller is at the bottom left of the grid in a smart network. In the default simulation scenario, communication between nodes is done as illustrated in Figure 3.10.

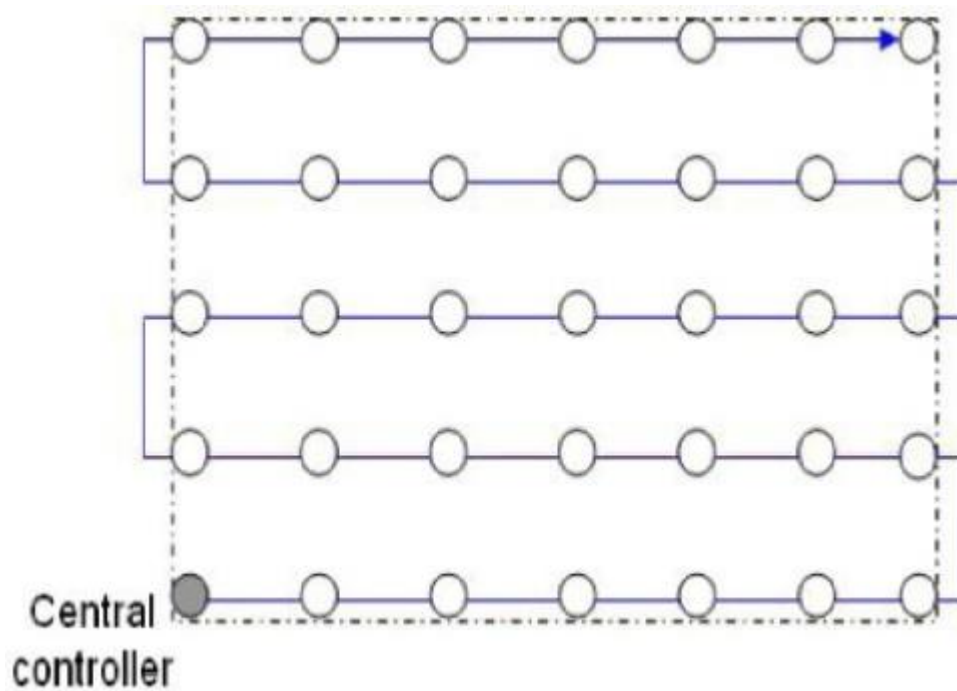


Figure 3.10 : wireless communication by several hops between nodes.

the network parameters are summarized in the table :

X dimension of topography	956
Y dimension of topography	600
Routing protocol	AODV /DSDV
Number of nodes	16
Time of simulation end	25.0s
Channel type	Wireless channel
Antenna model	Antenna/OmniAntenna
Link layer type	LL
Interface queue type	Queue/Droptail/Queue

Table 3.1: simulation configuration .

3.8.2 Metrics and Performances :

A group of measures, used in the analysis of the data produced in the simulations, is chosen in our project to assess the performance of the associated network.

3.8.2.1 Energy Consumed :

The energy consumption of communication systems is becoming a fundamental issue among all sectors, wireless access networks are largely responsible for the increase in consumption. It is very essential to develop a technology to reduce energy consumption in wireless networks in general and smart grids in particular.

3.8.2.2 Packet Delivery Ratio (PDR) :

can be measured as the ratio of number of packets delivered in total to the total number of packets sent from source node to destination node in the network. It is desired that maximum number of data packets has to be reached to the destination. As the value of PDR , increases the performance of the network also increases [19] .

3.8.2.3 Throughput:

In network throughput can be termed as number of successfully transmitted packets from source to destination per second. For good designed network the value should be high and if it is attacked by any attack the value of throughput considerably decrease [19].

3.8.3 Results and Analyzes :

In this work the performance analysis is carried out in an adhoc network with three different metrics (pdr, energy , throughput) while keeping other parameters constant. Two protocols AODV and DSDV are considered for the comparison purpose on the above performance.

3.8.3.1 Energy Consumed :

The main objective of the energy cost is to explore the power consumption situation for all battery powered nodes with a wireless interface.

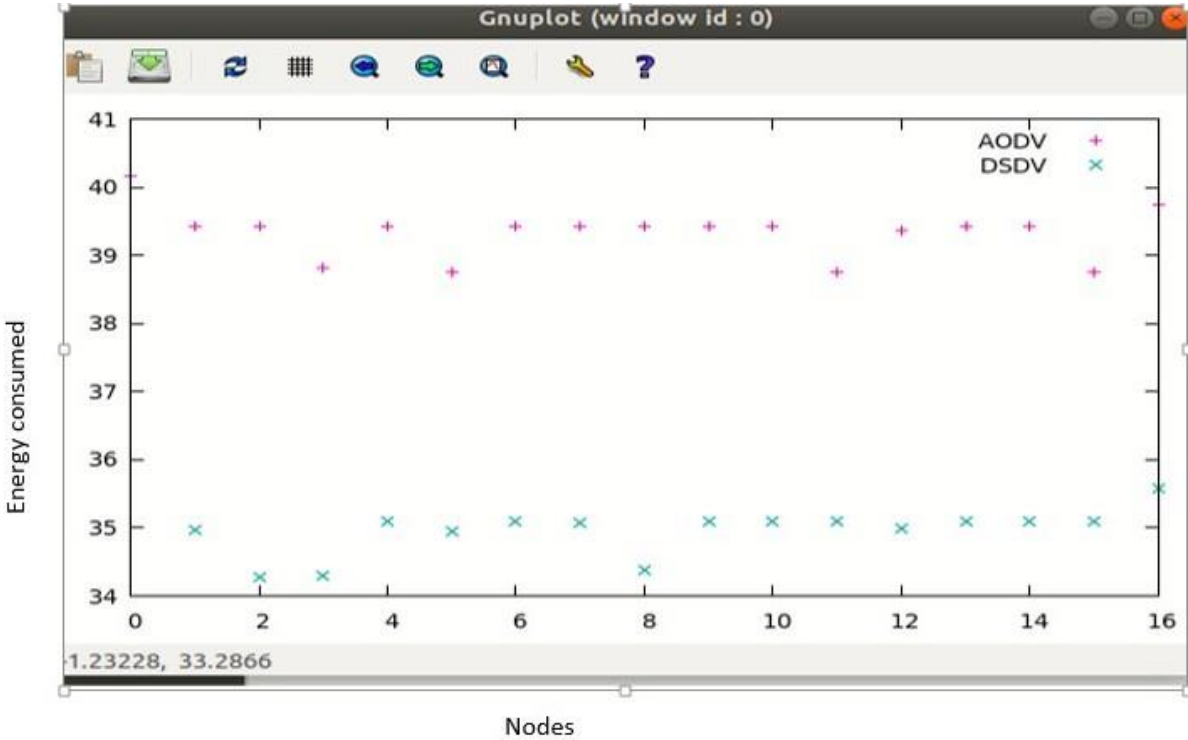


Figure 3.11 : Comparison between energy consumption in each node of AODV and DSDV

the figure 3.11 show traces of the residual energy in each node according to simulation time.in both graph . we notice that the when the use of protocol AODV the node are consumed energy more less than DSDV protocol .

3.8.3.2 Packet Delivery Ratio (PDR):

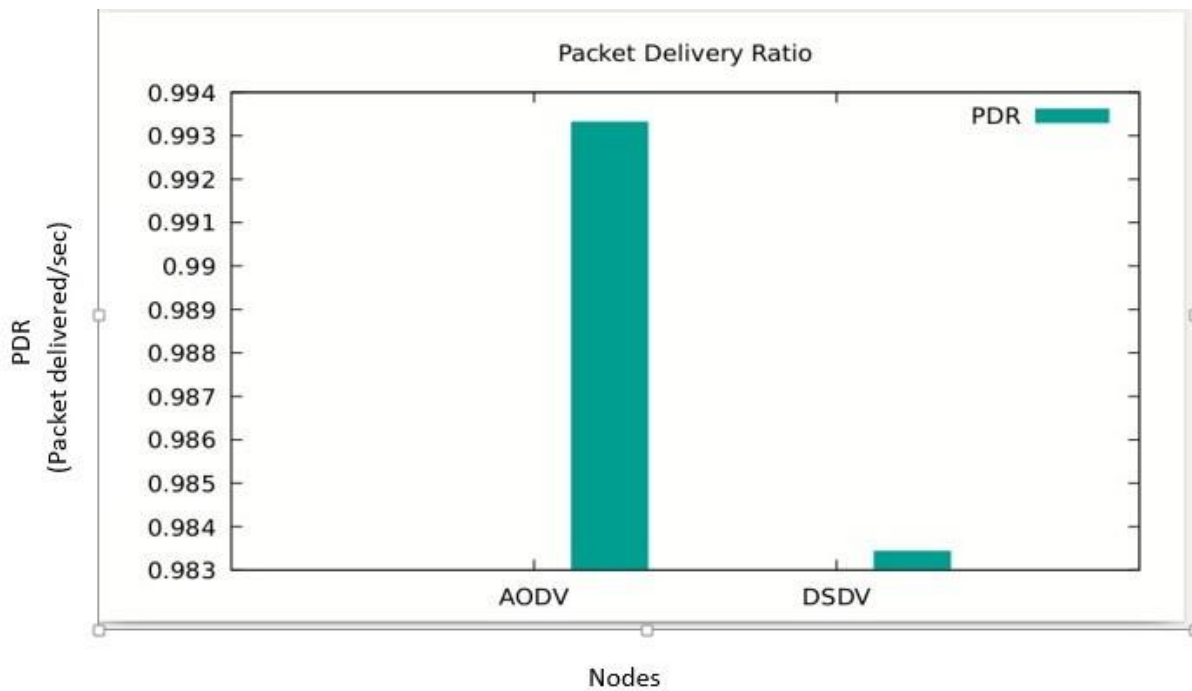


Figure 3.12: Comparison of packet delivery ratio between AODV and DSDV

A comparison shown in figure 3.12 is made with AODV and DSDV in the network. It is observed that the AODV outperforms the DSDV in terms of PDR by increasing the total data bits received.

3.8.3.3 Throughput:

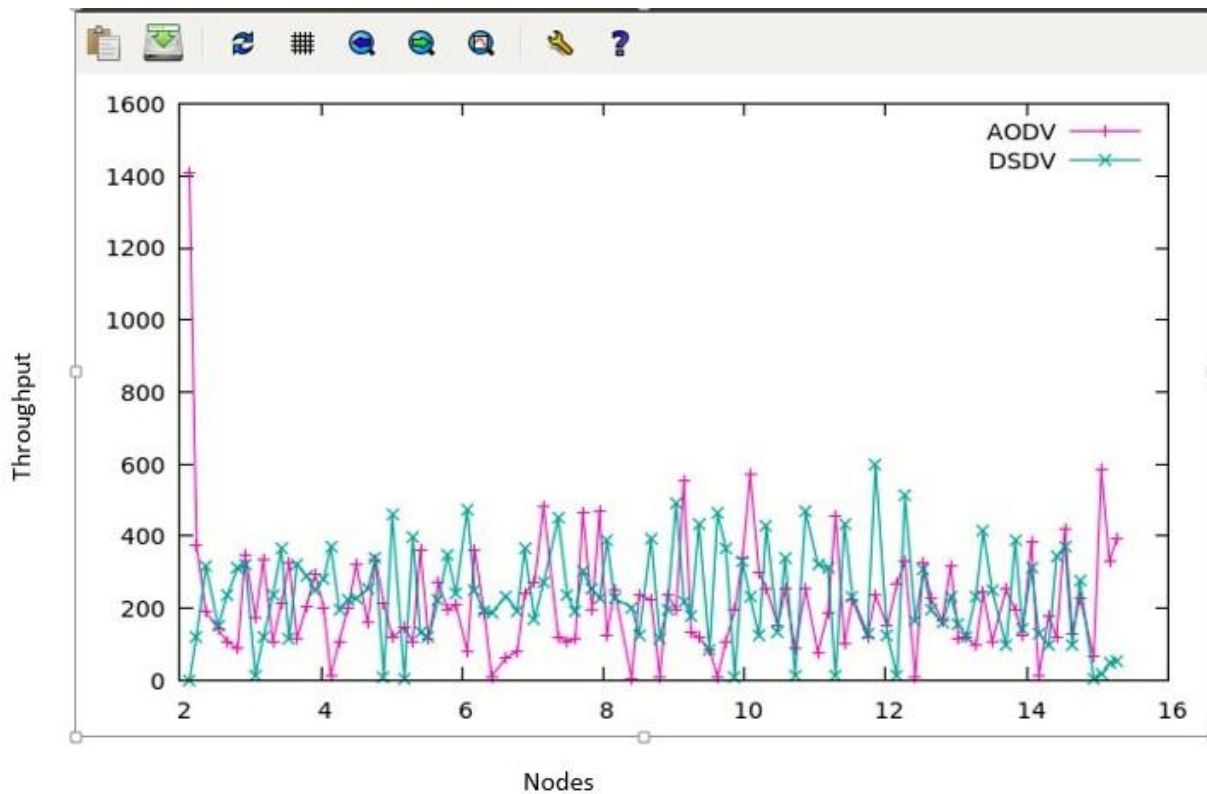


Figure 3.13: comparison of throughput between AODV and DSDV

The comparison shown in figure 3.13 it is observed that The performance metrics obtained from analysis of trace file and study of graph generated by simulation of DSDV and AODV routing protocols, states that :

for 10 nodes AODV performs best in comparison to DSDV.

for the nodes from 10 to 16 DSDV performs better compare to AODV.

3.9 Conclusion:

In this chapter, we presented the performance comparison between Ad hoc on demand distance Vector Routing (AODV) as reactive routing protocols and Destination Sequenced Distance Vector (DSDV) as a proactive routing protocol to precisely determine which protocol is more effective. Network Simulator (NS) version 2.35 has used to evaluate the performance of these protocols in terms of the performance measures . each protocol is having its own advantages and disadvantages and may be well suited for certain scenarios. In the term of energy consumption and average PDR the protocol AODV is the best , and in term of

throughput Thus it states that in case of higher node density, DSDV performs well and is more scalable, but for lower node density AODV performs well.

General conclusion :

Smart grids currently represent production and distribution networks for electrical energy, integrating new information technologies. These systems information can improve overall energy efficiency, by managing both production of electricity than its storage, distribution, and consumption, so effective.

Smart grids are therefore at the intersection of three sectors: energy, information systems and telecommunications. This requires the installation of ICT systems in houses, apartments, offices, but also in energy production plants, etc.

smart grid can be summed up as a combination of infrastructure electrical and on-board intelligence that can be associated with it (software, automation, transmission and processing of information).

This intelligence can be deployed at various levels of the network (production, equipment network, consumption and management). Researchers are now experimenting with smart grid technologies to overcome the shortcomings of the traditional grid.

In our work, we studied an architecture based on fixed nodes which represent smart homes. and the routing protocols used .it would be ambitious to study an architecture integrates mobile nodes representing, for example, electric vehicles. may be fter a lot of improvement in the future .

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