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ADVANCEMENTS IN SMART GRID TECHNOLOGY USING Fi-Wi ARCHITECTURE

[1]Gande Kiran Kumar, [2]Devavarapu Sreenivasarao, [3]Dr V S Giridhar Akula

[1]Student, IT, MallaReddy Institute of Engg.& Tech., Hyderabad,
kirangande92@gmail.com

[2]Associate Professor ,Dept. of CSE/IT, MallaReddy Institute of Engg.& Tech., Hyderabad,
sreenivasaraodevavarapu@gmail.com

[3]Principal &Professor ,Dept.of CSE/IT, MallaReddy Institute of Engg. & Tech.,Hyderabad,
akulagiri2002@yahoo.com

***Abstract*— The main objective of this paper is to provide a detailed study regarding the application of Fi-Wi architecture in smart grids. Fiber-wireless technology, known in short as "Fi-Wi," is a combination of optical-fiber-based network and wireless network. Fi-Wi has recently come forward as one of the emerging future network technologies. The smart grid is a newer, more efficient and cleaner version of our current electric grid system, which is wasteful, expensive and a huge source of pollution. Smart grids are in constant communication with the grid to devise the cheapest, most efficient way to operate .The combination of these two technologies leads to an efficient way of energy consumption.**

***Index Terms*—Smart Grid, Fi-Wi , Wireless Fiber, Wireless Grid.**

I. INTRODUCTION

Technological evolutions gave rise to new demanding applications and services that copper based access networks cannot support efficiently. This has led many providers to seek alternative mediums and infrastructures that would be able to provide such large capacities in the access network .Optical technology was adopted by many providers to seek alternative mediums. Apart from fixed optical networks, wireless broadband networks have attracted a great deal of attention due to their low implementation costs and mobility support. Optical networks offer a huge capacity but with high implementation cost while wireless network offer mobility with low rates and via error prone channels. This idea of combining these two networks is very attractive since it would allow exploitation of complementary benefits of both the technologies .This idea lead to Fi-Wi network proposal where optical and wireless technologies form a common integrated infrastructure capable of supporting upcoming applications and services.

II. METHODS

A. *Network Architecture for Fi-Wi Based P2P Communication:*

In a Fi-Wi network, passive optical network consists of an optical line termination (OLT) at the communication company's office and a number of optical network units (ONUs) near end users. Typically, up to 32 ONUs can also be connected to an OLT through Remote Note (RN). An ONU is connected to the mesh clients through wireless mesh routers.
A peer-to-peer (P2P) communication in such network can be carried through the wireless-optical-wireless mode in which the traffic is sent from the source wireless client to its nearest ONU, which is then sent to the closest ONU of the destination wireless client through the PON sub network, and then traffic is delivered to the destination wireless client. For the traffic route to the Internet, the traffic is sent from mesh client to nearest ONU through the closest wireless mesh router, then sent to OLT, and afterwards the traffic is sent to Internet from OLT. For example, a mesh client would like to communicate with mesh client, traffic will be routed from mesh client to its nearest ONU through wireless mesh router, then to the OLT from the nearest ONU through RN, then the OLT broadcasts the traffic back to ONUs, and the ONU which is the closest to mesh client can send the traffic to client through the nearest wireless mesh router. Figure shows a typical Fi-Wi network architecture that allows such P2P communications.

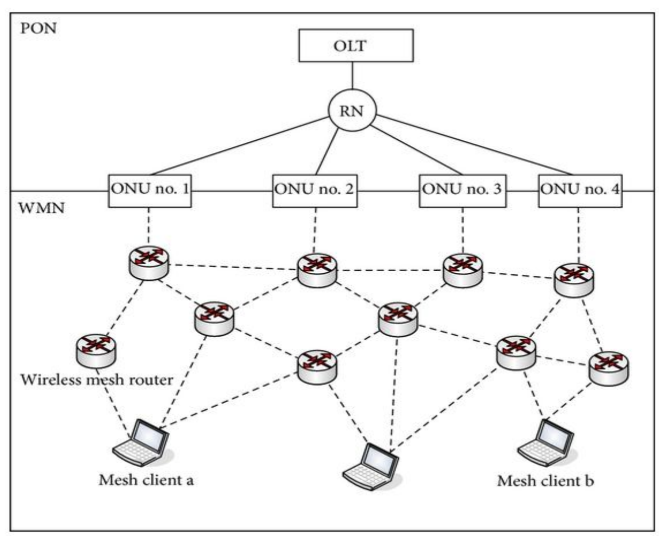

Fig.1: Network architecture that allows such P2P communications

Two approaches are investigated for the integration of optical and wireless network under Fi-Wi concept.

- Radio over Fiber(RoF)
- Radio and Fiber(R&F)

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A. RoF (Radio-over-Fiber):

In RoF Wi-Fi networks, radiofrequencies (RFs) are carried over optical fiber links between a central office (CO) and multiple low-cost remote antenna units (RAUs) to support variety of wireless applications. RoF networks provide transparency against modulation techniques and are able to support various digital formats and wireless standards in a cost-effective manner. These networks use optical fiber as an analogue transmission medium between a central control office and one or more RAUs (radio antenna units). The CO is in charge of controlling access to both optical and wireless media .Figure shows a sample RoF Wi-Fi access network architecture that can be used within a Fi-Wi network.

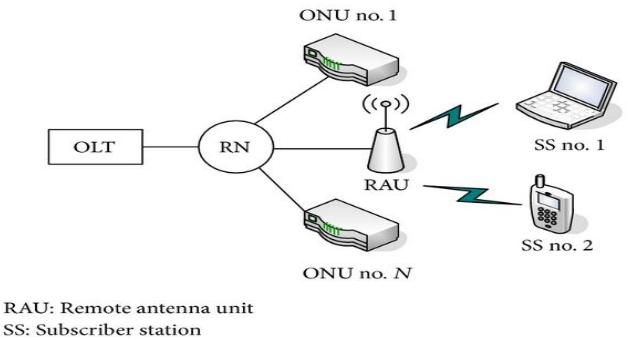

Fig.2: RoF Wi-Fi access network architecture: PON and its wireless extension RAU**.**

B. Radio and Fiber(R&F):

In R&F, discrete optical and wireless networks are merged in order to form one single integrated network In general, R&F networks make use of different protocols in the two parts of the network and therefore the access control of clients is done separately. This means that traffic generated from users communicating only in the wireless network does not have to be propagated towards the optical network as happens with RoF technology. Thus, distributed MAC protocols, e.g. IEEE 802.11b, avoid the fiber's extra propagation delays that degrade their performance. This feature removes a possible limitation regarding the length of the deployed fiber while it adds a degree of resiliency to the system since local wireless traffic can be served even when connectivity with the optical segment is lost.

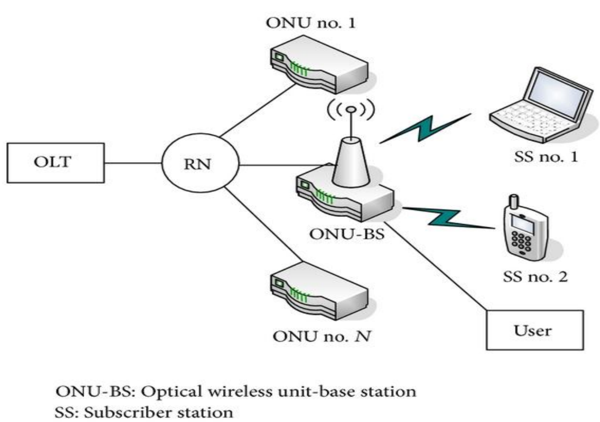

Fig.3: R&F Architecture.

C. Application Areas of Fi-Wi:

The strategies of the network throughput and the gateway deployment in wireless mesh sub network play significant roles .One of the key area of applications of Fi-Wi network architecture is in Grid Technology.

D. Smart Grid:

The electric smart grid is the vast network of transmission lines, substations and power plants that deliver electric power to our homes and business. It is one of the great engineering feats of the 20th century.Grid amounts to providing an Internet Protocol (IP) address to every device that is connected to the electricity grid. A smart grid allows for a two-way street, adding computer intelligence and communications to the electricity distribution network and much of what's connected to it, from solar panels, to smart appliances, to plug-in cars. It holds great promise for cleaner, more efficient power, healthier air and lower greenhouse gas emissions.

It is important to move from normal grid to smart grid. The world as we know it entirely depends on oil. Since it is a limited resource, renewable energy resources will take a bigger place in our daily life also in order to be environmentally more sustainable.

III. EXISTING SYSTEM

The current electric grid is composed of the following main subsystems: generation, transmission, substation, distribution, and the consumer. Generators transmit high-voltage electricity over the transmission lines. Substations are connected to several distribution networks, where it connects a large number of consumers. Over the years, Supervisory Control and Data Acquisition (SCADA) systems were deployed to realize sophisticated supervisory systems such as the Energy Management System (EMS). Real-time data management systems called Remote Terminal Units (RTUs) were installed at substations and at generators. Typically, an RTU sends data about voltage, current, breaker status and other power network parameters every 2 seconds. Several failed attempts have been made to extend the scope of this data flow to reach the consumer. Up to date, only experimental projects have been made. Current power utilities don't have any visibility into distribution networks beyond substations, where most of the opportunities for energy efficiency and integration of distributed generation can be found.

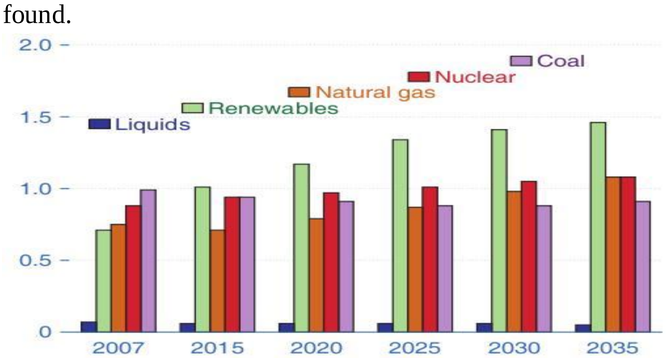

Fig.4: The graph which depicts amount of nonrenewable sources of energy.

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The electric grid must change for several fundamental reasons. The upcoming exploitation of renewable energy resources such as wind generators, where the energy produced depends on the climate and varies over time, has a big impact on the overall power generation. As depicted in Fig.4, the electricity generation from renewable sources is expected to significantly increase over the next few years. Consequently, the electric grid will increasingly work with various types of heterogeneous generator. Meteorological conditions vary minute-by-minute. Also, energy storage systems such as batteries in plug-in electric vehicles (PEVs) add a new component to the overall power grid. Sophisticated two-way and end-to-end communications between all the power grid elements, including the consumer, must evolve to create a new power grid: the smart grid.

A .Vision of smart grid:

The smart grid will be able to deliver not only energy but also information about every aspect of electricity generation and consumption directionally, i.e., in both directions from and to each customer. The smart grid will be instrumental in addressing growing concerns about climate change and carbon gas emissions by exploiting renewable energy sources and controlling power consumption more efficiently, whereby homes will play a key role for the following reasons.

Over 50% of the generated electricity is currently consumed in homes.

- PEVs will be charged mostly at homes after returning from work.
- Homes will be the location of the largest number of distributed power generation devices, e.g., wind turbines and solar panels, also known as distributed energy resources (DERs).

The presence of an IP address enables a two-way communication mechanism between consumers and providers. Roughly speaking, the smart grid will:

1) Reduce blackouts
2) Promote renewable energy usage
3) Give families more control over their energy diet.

IV. PROPOSED SYSTEM

Given the huge number of homes, smart grid solutions must be scalable and use low-cost and future-proof broadband access technologies. Different implementation and business models can be used to leverage on the benefits arising from the utilities' right-of-way and possible infrastructure sharing. A conservative business model might follow the traditional concept of vertical integration, whereby the network owner, network operator, and service provider are the same entity. Vertical integration has been the model applied by the vast majority of incumbents for decades. By applying this model, a utility could exploit its right-of-way and would leverage on the security and maintenance benefits of a private network, but would face significant investments to provide full coverage in its service area. However, the future access network infrastructure business will be more divided in terms of ownership and operation, capitalizing on trust relationships between new alternative operators and incumbents. A promising approach to provide full coverage at reasonable costs is to jointly implement and share a common network infrastructure for both smart grid communications and broadband access, giving rise to what we refer to as the Smart grid-FiWi network.

A. Broadband access networks:

We currently witness that fibers are being pushed ever closer toward the home and end user. Optical fibers offer huge bandwidth capacity, longevity and low maintenance and observe a trend where coppers are replaced with optical fibers instead of coppers. Optical and wireless networks are complementary and will most likely coexist together as depicted in Fig.5. Future broadband access networks will be hybrid combining the high capacity and longevity of optical fibers and the mobility and ubiquity of wireless networks.

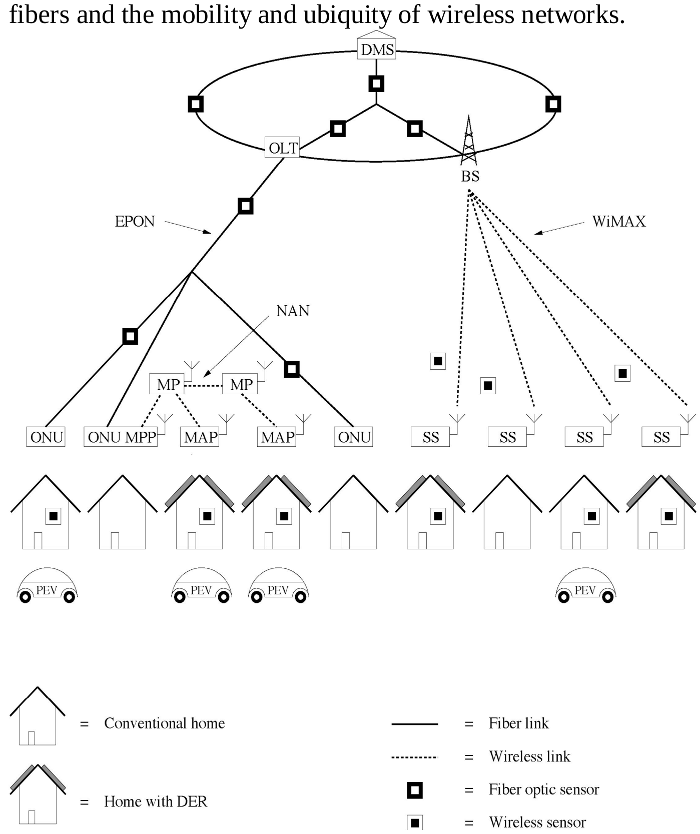

Fig.5. Fi-Wi network connecting homes, PEVs, and DERs to the distribution management system

B. Sensors:

Advanced sensors will play a major role in the future smart grid. At present, sensors are installed in power delivery systems and are limited to voltage and current for protection and control. Thus, the overall monitoring of the power grid is currently not possible. Sensors should be deployed in diverse terrain in order to control, monitor, and store fine-grained information about the overall power grid. There exist a lot of benefits of deploying sensors on a large scale such as safety to prevent risk of failure, maintenance to take action only when needed based on data from sensors, increase utilization depending on the condition of equipment, diagnostic analysis when events occur, adjust the power distribution in order to

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cope with intermittent renewable energy sources, etc. Thus, wireless and optical sensors will play a major role in the future smart grid, transforming FiWi networks into Fiber-Wireless Sensor Networks (Fi-WSNs).

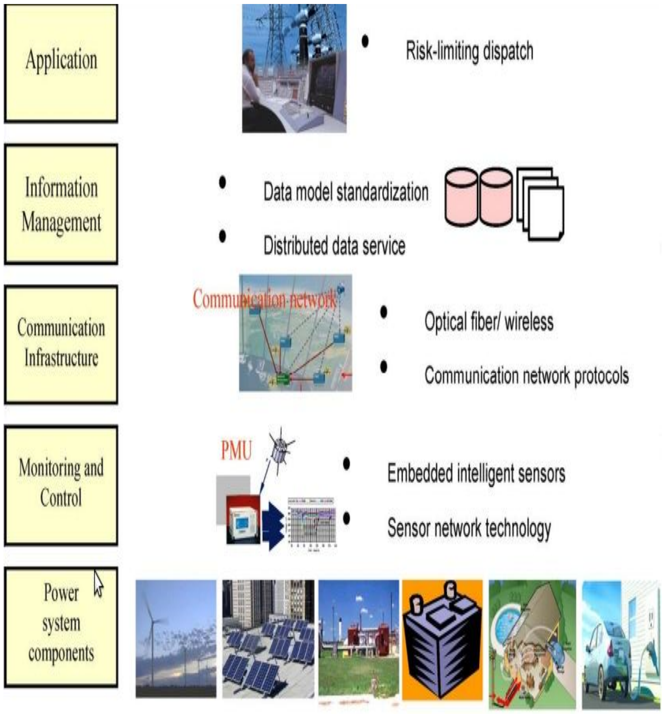

Fig.6: Future smart grid.

V. RESULTS

The smart grid will be decomposed in 5 main components, as shown in Fig. : Applications used by operators, information management systems which regroup and model a huge quantity of data, Fi-Wi networks enhanced with advanced sensor devices, and power systems.

A. Data flow:

Several investigations have to be carried out concerning the nature of the data, rate, and quality attributes used by smart grid communications over Fi-WSNs. Presently data flow in smart grid is being done using Fusion Theory (not discussed here).

B. Communications infrastructure:

By now there is no consensus concerning the equipment and protocols that will be used to deliver data for the smart grid Smart grid has the potential to support high levels of distributed generation (DG); however the current standards governing the interconnection of DG do not allow the implementation of several applications which may be beneficial to the grid.

C. Quality-of-Service (QoS):

Sensor components provide real-time information, which will use the same communications architecture used by several other applications.So the quality of service for these sensor networks is high compared to the present ones.

D. Energy Consumption:

Optimizing the current power grid should be at least as effective concerning the energy consumption. The energy used by this communication infrastructure is very limited.

E. Routing:

Since there are several subsystems in the smart grids, efficient routing mechanisms in terms of utilization, end-to-end delay and throughput must be used. Braided Path Routing can be used in smart grid computing. Experimental Smart grid system (ESGS) combines Watt Deppot,Eco wizard wireless sensors and enables to test custom algorithms for the Smart Grid over a real networking infrastructure. ESGS is written in Java.

VI. CONCLUSION

Global companies like IBM, GE and Siemens are putting their full effort behind the "build-out" that will consolidate all of America into a single, integrated, communication-enabled electric delivery and monitoring system, collectively called Smart GridProponents of Smart Grid claim that it will empower the consumer to better manage his or her power consumption and hence, costs. The utility companies will therefore be more efficient in balancing power loads and requirements across diverse markets.

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VIII. AUTHOR'S PROFILE

Mr.Gande Kiran Kumar is presently pursuing B.Tech. in IT branch at MallaReddy Institute of Engineering & Technology, Hyderabad. He published 1 paper in International Journals. His areas of interest is Computer Network,

Mr.Devavarapu SreenivasaRao is presently working as Associate Professor at MallaReddy Institute of Engineering & Technology, Hyderabad. He has 14 years of teaching experience and published 5 papers in International Journals. His areas of interest include Network Security, Digital Image Processing and Fuzzy logic.

Dr.V.S.Giridhar Akula is presently working as Professor and Principal in MallaReddy Institute of Engineering & Technology, Hyderabad. He received B.E, M.Tech and Ph.D.degrees in Computer Science and Engineering from JNTUA. Dr Giridhar wrote 08 text books and published 50 above papers in many national and international journals. He is acting as an editor and reviewer for many national and Inter national journals. His areas of interest include Digital Image Processing, Computer Networks, Computer Graphics and Artificial Intelligence