Green Communication Networks Challenges, Opportunities and Future Role

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Abstract —The increase in network communication is rapidly nowadays. This increasing involves several issues that can affect the performance of the entire network. Many studies adopted the concept of green communication as a solution to the environmental problems in communication networks, especially in the section of reducing the CO_2 emission. In this paper, a study of the challenges of green communication in the smart grid has been reviewed. Moreover, cognitive networks and network coding in the last ten years are presented. The study also produces the opportunities of green communication as a solution to overcome the environmental communication problems.

Index Terms—Smart grid, network coding, cognitive network, CRPS, NGERS.

I. Introduction

In modern communication systems with the increasing of the soaring data and energy cost, environmental problems and a series of energetic came from high energy consumption. The green communication introduced to solve these problems. The main aim is to improve the efficiency of energy. On the other hand, efforts should be taken by operators to build the data center and mobile network to reduce CO_2 emission and energy consumption. These are requirements to meet the challenges of 3G technology. The reason for that is the consumers' needs a telecommunication network that cannot find in 2G. New functions of 3Gwill serve well. Enhanced infrastructure for the 3G communication network is consequently required. The wireless bandwidth has continually grown with the popularity of smartphones such as the iPhone and other smartphones. These smartphones need to access the internet to form their platform. By applying green communication technology, the problems could be solved. The contribution of human needs and environmental products which are caused by human demand for connection and data and the high cost of energy will be balanced by using green communication [1].

In this research, we first analyze the green communication challenges. The second thing is to elaborate on several green communication techniques. The covered methods are a smart grid, network coding, and cognitive network. Finally, prospects green communication research trends.

II. Technology Used with Green Communication

New ICT techniques need to be studied, and the advantages of these techniques need to be evaluated in aspects of energy efficiency and their related benefits in minimizing the effect of ICT. the aim of studying the green technology can be summarized as following [2]:

1. Minimization of energy usage.
2. Energy efficiency enhancement.
3. Consideration of the environmental impact of elements of the network from design to use.
4.The integration of the network components and services plays an essential role since this integration integrates different systems into one network.
5. AN intelligent network would be more efficient since it will require less power and responsive.
6. Compliance with regulatory reporting requirements; for example, the National Greenhouse and Energy Reporting System (NGERS) and the proposed Carbon Pollution Reduction Scheme (CRPS).
7. Promotion of a cultural shift in thinking about how we can reduce carbon emissions.

The green communication technique is focusing on the solutions in network coding, cognitive network, and smart rig. The paper will briefly discuss these techniques taking into account the studies in the last ten years.

A. Cognitive Network

The green spectrum resources consider a significant part of green communication. The use of cognitive network technology can efficiently enhance spectrum resource utilization and network transmission efficiency.

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Moreover, according to the equipment environment of cognitive radio, the optimal dynamic control of the spectrum resource and energy consumption could be fulfilled. The software radio is the base of cognitive radio. The idea of cognitive radio summer is transmitted against the expanded radio sector because it is exciting and multidisciplinary. The Waveform perception, network awareness, position awareness, spectrum sensing, and observation are cognitive radio elements. Most individuals are concerned about local business, language, customer needs, state, and data protection among spectrum sensing. Among other radios, the most striking characteristic of intelligence is cognitive radio. Cognitive radio responds to any scenario, depending on the goal-driven construction. It is also can take action according to the network condition. That implies that it can react to any changes in the operating system setting through both dynamic self-adaptation and self-configuration mechanisms. Different companies have studied and proposed the development of cognitive radio of the wireless network such as Virginia Tech and Motorola. The automatic learning and self-awareness are the two primary functions of self-configuration. The capability of operators can be maximized depending on the wireless cognitive network [3]. The essential role of the network is how to explore the smart cognitive wireless with radio as its Cognitive node radio plays a key role in improving the effectiveness of radio spectrum usage and the performance of wireless communication systems. It is also performed as artificial intelligence and develops technology for digital signal processing.

Furthermore, many studies have been dealt with in cognitive networks. Through the domain of sensing spectrum, Zhang, Mallik *et al*. (2008) [4] have reviewed the cooperative spectrum sensing in which can optimize the sensing performance. The research study suggested a rapid spectrum sensing algorithm for an extensive network requiring fewer numbers than the entire amount of cognitive radios for cooperative spectrum sensing. Rabbachin, Quek *et al*. (2011) [5] presented a new theoretical model for aggregating cognitive network interaction about capturing cognitive network interference statistical performance. The model accounted for the sensing operation, secondary spatial reuse protocol, and environmental circumstances such as loss of path, shadowing, and channel fading. Additionally, the common use of cognition and collaboration methods invoked to improve the energy efficiency of cellular networks was explored by Later Zhu and Zou et al. (2016) [6].

The research concentrated on the collaboration between TV stations (TVs) and BSs in communicating to UTs acting on opportunistic exploitation of the TV spectrum, where the unused TV spectral band is opportunistically utilized, depending on whether or not it is found to be idle. Finally, Zhang, Chen *et al*. (2017) [7] Proposed HCRSN resource allocation approach to attain range sensor efficiency and also to preserve information sensor power. The research showed power usage could be considerably lowered while maintaining the spectrum carriers ' efficiency. From the input mentioned above, it has been concluded that the rising number of radio communication services and application systems will lead to a rapid decline in spectral resources. Environmental monitoring is necessary for Cognitive Radio Networks (CRN) to achieve practice-based resources. Also, the implementation of Cognitive Radio presents three critical problems that can be analyzed [8]:

- The difficulties of the RF front end -transceiver
- ADC and DAC challenges
- Baseband challenges

B. Network Coding

The new idea presented by Yueng Wai Haw, who is a professor at the Chinese University of Hong Kong, it's called Network Coding [9]. It is considered one of the green communication methods working on redundant paths to enhance the network's performance. In the event of general routing information, data conflict should be prevented in intermediate nodes that are accountable for transmitting data; network engineering can create intermediate nodes by getting the role in the information and handling it in multicast cases. This enhances bandwidth utilization [10], [11]. This enhancement counts as one of the changing development types. It will afford the simple management of information and transmission of messages. The straightforward web collaboration repeater cannot solve the energy problem with many nodes in wireless networks. The best alternative is to use the self-adapting adaptive routing technology as it can decrease transmission space and power consumption. Multi-source broadcasting, network coding adopt a spread asynchronous algorithm. This algorithm operates by first implementing the network coding technology by monitoring a cyclic subset. This procedure reduces the difficulty of coding and decoding, improves the use of links and saves the network's bandwidth. This was not achieved by the prior technology based on the random routing algorithms they used, which is why network coding technology thrives. When [9] brings forward the concept of network scheduling, it becomes one of the brightest study subjects in several areas, both scholarly and commercial. The potential of network coding applications is growing over the moment. Many problems were immediately fixed by using this technology, such as problems with circuit network coding, various input-output issues and optimizing transmitting of ultra-large communication information. Many studies that are connected to network encryption technology are accessible these days. Some instances of this study are Min cut, and Max flow bound that the main objective is to assist the broadcasting communication network with multiple I/O. Other studies advanced the concept of Outer Bound[10] because it could pick up the shortcomings of the previous technique. Multimedia information needs a wide transmission range, as it most likely involves a big data

device capability [12]. In the most popular case, the network coding application only reaches the optimization transfer speed when the source information is compressed and coded [13]. The maximum transmitting speed stream could reduce customers [14]. The exceptional variety is an important metric to measure the wireless channel signal performance. This implies that the use of network coding in a distributed antenna system can decently enhance the antenna system's exceptional variety [15]. Network coding technology ensures a significant business lead based on regular maturation. Microsoft Corporation's key technology is network coding, and they developed Avalanche's prototype software. The Avalanche download speed ranges from 20% to 30% quicker than the common Bit Torrent. With this technology, device safety will be strengthened because the possibility of hacker appeal with network coding decreases [16].

The problem of network coding has been addressed in many types of research. Several research papers reviewed and studied the lifetime of the network by considering I duty cycle, (ii) network coding, and (iii) duty cycle and network coding combinations. The impact of improving the energy of the bottleneck area has been researched by Rout and Ghosh *et al*. (2013) [17] , which contributes to a general enhancement in the life of the network by contemplating a duty-cycled WSN. The research proposed an effective communication paradigm was taken by mixing the duty cycle and network coding in the bottleneck area.

Rout and Ghosh *et al*. (2014) [18] Proposed energy efficiency (integrated information aggregation approach using network encryption) (ADANC) enhancing power effectiveness in a cluster-based duty-cycled WSN. The suggested ADANC approach offered a decrease in congestion within a bunch, thereby improving the bottleneck zone's energy efficiency.

Jiang, Xu *et al*. (2015) [19] focused on the energy-efficient multicast communication aiming at multi-hop wireless networks. The approach suggested a random distribution for the network nodes and using network coding to improve network throughput.

Chen, Zhao *et al*. (2016) [20] developed a clustered Spatio-temporal compression scheme by (1) integrating network coding (NC) (2) compressed sensing (CS) and (3) Spatio-temporal compression for correlated data. The study constructed a new optimization model of reconstruction of the error for the clustered Spatio-temporal compression scheme. The distributed algorithm is developed to determine the optimal solution iteratively.

Wang, Zhang *et al*. (2019) [21] investigated the problems associated with minimizing the total energy consumption used by all devices when recovering their missing packets. The study accomplished by applying network coding based on the selection of the transmission rates in a device-to-device network.

C. Smart Grid

The smart grid is focused on a mixture of fresh computers, equipment, and application technology. There is only one aspect to the smart grid, and it is never restricted. Intelligent system technology includes automatic technology for monitoring, energy and electronic equipment, superconducting technology, sensor technology, storage technology, IT and modern communication technology. All these techniques are combined to provide advanced energy equipment for a conventional system. This facility could be the tasks of assessment, protection, tracking, and control. The traditional design of the enhanced network is less costly, more efficient and more environmentally friendly. These techniques are used to assist in smart grid applications. They used continuous char compensator (SVC) and Thyristor-Controlled Sequence Compensator (TCSC) to be sure of the power transmission characteristics. Moreover, they used a Wide Area Measuring Scheme (WAMS) and a phasor measuring device (PMU) to monitor scheme stabilization. Automation and automatic meter reading (AMR) are used to optimize network delivery procedures. And to enhance the large wind power inside the network and electronic power quality of the grid active power filter (APF) and Static Var Compensator (SVC) is used.

In addition, several studies have been worked on the smart grid. s Qiu, Su *et al*. (2012) [22] Focused on low-power safe PMU and SM interaction, experimentally researched the cellular detector systems to demonstrate the two competing device requirements — security of communication and small power consumption.

Wang, Zhang *et al*. (2015) [23] Established a market for renewable / green power trading for smart grid customers. The research suggested a market model for green energy trading, with proven effective reward algorithms and actual trace tests under different efficiency criteria.

Mahmood, Javaid *et al*. (2015) [24] presented a comprehensive review of Wireless Communications Technologies (WCTs) for the implementation of the smart grid in a systematic way.

Erol-Kantarci and Mouftah *et al*. (2015) [25] the Offered an extensive study of smart grid-driven methods in energy-efficient systems and data centers and interaction between smart grids and information and communication infrastructure. The paper presented the open problems of smart grid-driven ICT solutions and highlighted some significant study strategies such as integrated renewable energy generation capability-coupled communications infrastructures, optimal energy-efficient network architecture for the smart grid setting, and the effect of green communication methods on rel.

Hossain, Madlool *et al* (2016) [26] presented a review paper which attempts to investigate the role of smart grid in renewable energy. The study covered the concept and availability of renewable energies, renewable energy power calculation formulae, smart grid concepts, and feasibility; the case studied as performed by different researchers around the world, discussion and future recommendations and finally the conclusions from the study.

Rehmani, Reisslein et al. (2018) [27] produced an overview of recent efforts that aim to integrate RERs into the SG. The approach outlined the integration of RERs into the SG along with their supporting communication networks, discussed ongoing projects that seek to integrate RERs into the SG around the globe, and finally outlined the future research directions on integrating RERs into the SG.

Tchuisseu, Gomila *et al*. (2019) [28] focused on dynamic demand control (DDC) by introducing a method including communication among DDC devices that are belonging to a given group, such that they can coordinate opposite actions to keep the group demands more stable. The approach showed that, with minimal information exchange, our method reduces the number of pending tasks by factor 10 while large frequency fluctuations are significantly reduced or even completely avoided.

The supporting system technology can be categorized into four kinds, [29] Based on the definition of state-of-the-art energy technology which can be concluded as follows:

1) The technology of integrated communication

A smart grid should set up with high speed to make a super communication network [30], fully integrated, and full-duplex communication frameworks. These features will create the smart grid the greatest alternative for vibrant communication, power exchange, and information systems in real-time [31]. The smart sensor network can be implemented by entering a communication scheme to ensure a secure plug-in and game atmosphere. It will also be a protective system, monitored core and monitored device for the consumer [32].

2) Measurement, sensing and metrology, and techniques

The smart grid contains multiple technologically advanced detectors. From the client-side, the energy state is monitored by two forms of surveillance and communication scheme intelligence tools. The smart grid offers the basic tasks of financial and secure handling based on network security and machinery circumstances [33].

3) Advanced grid equipment

The effective function of sophisticated grid appliances in transporting characteristics, consists of a superconducting power cable, a composite conductor, a fault current limiter and a robust AC transmission system. [34]. Advanced devices for energy storage, developed transformers, distributed generation systems and, advanced control systems are also included in advanced system applications [35].

4) Advanced controlling means

The power grid issue happens when the energy scheme is automatically controlled. When power cuts or electric networks collapse unexpectedly, the great response scheme provides monitoring information collection by grid equipment when information is sent to be evaluated for computing. This operates to determine the issue and to propose alternatives [36]. Moreover, there are three methods for advanced monitoring. These are the following methods [37].

- Analyzing tool (high-speed computer and software algorithm).
- Multi-agent system
- Run applications like SCADA.

The scheme should be configured with elevated velocity, real-time, two-way and embedded interaction device setup in an attempt to understand the smart grid. Without this system, any smart grid function cannot be used because of information acquisition, regulate and security [38]. This is designed to help all communication scheme requirements. This is the first step to implement the building of such a scheme. Every forming of a household should have spared two locked networks, the power grid, and the communication scheme. Only in this manner could the primary feature and purpose of the intelligent grid be achieved [39].

Although there has been a lot of work to turn the present energy scheme into SG, There are still three significant difficulties facing utilities or other SG members. These difficulties include maintaining normal interoperability, accessing the unlicensed spectrum in a cognitive manner and enhancing cybersecurity [40].

III. Challenges of Green Communication

When processing the upgrade of communication devices, some communication problems are also enhanced and optimized. Green communication now needs high-energy equipment to manage the updating method. In order to accomplish emission decrease and energy conservation, communication equipment can be treated by two steps in order to attain energy reduction. The first is the development of optimization by-products, such as compressing the embedded level of the chipset and optical-electronic systems. Another alternative is to decrease PCB single disk density and generally dense PCB board size. By optimizing the circuit design, it can be performed. By enhancing heat dispersion, the energy can be decreased. Moreover, using lower equipment, power can be decreased by adopting a new design. The second key factor is to reduce the appliances ' energy usage Because these systems consume the majority of the energy of the product. The difficulty here is how to produce a fresh structure that balances low-energy and power chips. In order to expand, the next phase of communication systems should advance towards fresh techniques to change the protocols used. In addition, to have a secure and efficient sustainable communication network, the effectiveness of skilled facilities and the production of energy use services should be improved [41]. The protocols that are using in nowadays' communication system do not support these things. To ensure about the background of the Internet of things over energy optimization. Mobile network security. Spectrum resources of comprehensive utilization. Streaming media transmission by qualified service [42].

Spectrum efficiency represents the throughput of the system. It is another important issue that needs careful consideration [43], [44]. On the other hand, Some of the difficulties the cognitive network faces. Some of the issues of poor spectrum utilization in certain services occur because a set part of the spectrum is provided. In addition, some of the licensed parts of the spectrum may not be used geographical zones at moments. The transmission rate is directly equal to the quantity of transmitting energy and bandwidth required . This is according to Shannon's capability formula. I am controlling the transmission power to make the communication green would impact the data rate.

Characterization of this trade-off considering practical hardware constraints is key to the success of such solutions.

IV. Conclusion

The demand for green communications is increasing drastically with the development of information and communication technologies. Green communications not only reduce the energy requirements, but it also helps to reduce the emission of CO2 that is a threat to the environment and human health. There are many studies highlighted considering different inherent challenges and opportunities. Though the existing studies deal with several issues, challenges of energy/ cost, spectral efficiency, and bandwidth requirements still are the bottlenecks, and further research is needed to address these open issues effectively. Network security and secure power optimization is also an aspect that needs to be considered for future green communications due to the enhanced level of device connectivity and data sharing. In this review paper, the p summary of the green communication systems new generation has been presented. It began by incorporating the evolving energy, improving communication machinery and upgrading communication technologies. It also presents network coding, smart grid, and which are the three primary related green communication methods. The cognitive network must be used to optimize the wireless network's present resource information. This is used to encourage effectiveness in the use of spectrum resources. Network coding should also be implemented to improve the efficiency of the communication network. In order to enhance transmission, the smart grid supports green communication.

Conflict of Interest

The authors declare no conflict of interest".

Author Contributions

Mustafa Maad Hamdi, Lukman Audah Have prepared and analyzed the data ; Sami Abduljabbar Rashid, Sameer Alani has reviewed the research ; Mohammad A. Al-Mashhadani has modified the paper organization and outline; Ahmed Shamil has proofread the english language. all authors had approved the final version.

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