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"ENERGY HARVESTING IN WIRELESS COMMUNICATION"

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ABSTRACT

Cognitive radio (CR) enables dynamic spectrum access and offers a promising solution to the impending spectrum scarcity problem. It senses the licensed spectrum and identifies spectrum opportunities which can be utilized by the secondary users (SUs) without disrupting the primary user (PU) transmission. Hence, it improves the spectrum efficiency by opportunistic spectrum access. Power is another critical resource. Recently, a lot of work has been focused on utilizing energy-harvesting techniques to achieve self-sustaining wireless networks. Adding energy-harvesting capability will further enhance the ability of CR systems. In this article we present increasing performance of energy harvesting in wireless communication, Performance measured in some quality of services parameter and result shows better values than the previous work.

Key Words: *Fifth Generation, Energy harvesting, Cognitive radio, Sensor network, Cooperative communications, Quality of services, Internet of things*

I. INTRODUCTION

The Fifth Generation communication (5G) is the research and development focus of the communication industry in recent years and will become the backbone of the communication industry [1]-[3]. In 2012, lots of major countries and regions in the world started research on 5G mobile communication demand and technology in succession [4]. At the same time, the international telecommunication union (ITU) launched a series of 5G work, such as 5G vision, demand, evaluation methods, and formally released the 5G vision in June 2015, which defined the development trend of mobile communication market, users and business applications oriented to 2020 and the future, and proposed the framework and critical capabilities of future mobile communication system [5]. 5G will revolutionise applications in other markets, including industry, automobiles, healthcare and even defence. Due to the Internet of Things (IoT) to contact the increasingly close world, 5G has significant improvements in the speed which is at least ten times faster than 4G, up to 10 GBPS, and the delay which is ten times less than 4G, as low as 1 ms, and the density that is 1 million per square kilometre IoT devices. Thus, 5G will apply it possible for a mass of innovative applications, especially in security, reliability, service quality, efficiency and cost, as well as other essential areas.

Energy is a vital element in the growth of modern society. From a light bulb to outer space missions, we need energy everywhere. Some energy is visible to us, such as light, but most of the existing energies in nature are not visible. Among all these, electric energy is the mostly used form. Due to the high demand for electricity, measures are being taken to convert other forms of energy to electricity. The process which derives energy from external sources is called Energy Harvesting. Converted energy can be stored in a capacitor or battery for later use. Energy harvesters provide power for low energy electronics. Interest in converting ambient vibration energy into power has increased dramatically in the last few years. The goal of such research is to power wireless remote sensors which are usually powered by

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batteries. Batteries have a finite lifespan which creates problems with frequent replacement during emergencies. If ambient energy in the atmosphere can be utilized to harvest energy to power these batteries simultaneously, then most of the existing problems could be solved. There are various transduction mechanisms that can be employed to harvest such kind of energy. One of that is the use of piezoelectric materials to harvest energy from the unused or lost vibration energy of the host structure.

As shown in below figure, 5G will realise the interconnection of goods and services, while "goods" reside in user or enterprise space, while "services" usually reside in the cloud. 5G networks will be able to shred parallel connections flexibly, adjust the level of service required by users, and provide excellent cost and performance balancing solutions.

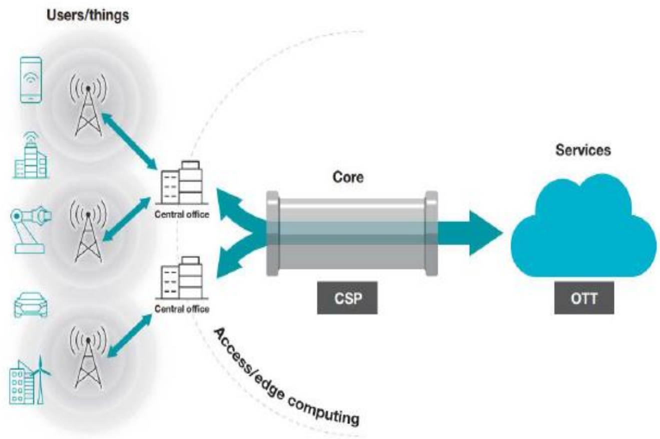

Fig 1: The structure of 5G communication

II. ENERGY HARVESTING MODELS

To design an efficient energy harvesting communication system, one has to model the process of energy harvesting as accurately as possible. Thus energy harvesting models play a significant role in the efficient energy management and performance evaluation of such systems. Based on the availability of non-causal information at the transmitters, the energy models can be broadly categorized into two types, namely deterministic and stochastic models.

Deterministic Models

Such models assumes that the time instant of energy arrival and amount of energy being harvested is fully known non-causally at the transmitters. These models are less practical but they are extremely useful in designing optimal scheduling strategies and providing a benchmark for performance for suboptimal strategies with more practical scenarios involving causal information. However, energy management using such models are only successful, if the energy profile is predicted accurately over a longer time horizon. Thus, deterministic models are suitable for situations, where the energy harvested from the source is predictable and varies slowly.

Stochastic Models

Such energy models are more practical in nature. Here the amount of energy being harvested is assumed to be a realization of a random process. The major benefit of this assumption is that the transmitter doesn’t need to know the information about timing and amount of energy arrival non-causally. Thus, these models are more suitable when the energy arrival process is more unpredictable. The downside is the presence of modeling mismatch as it is hard to fully comprehend the stochastic nature of ambient energy sources. Furthermore, the stochastic models can be subdivided into two categories, namely time-correlated or time-uncorrelated models, based on whether there is any correlation between the amounts of energy harvested from one slot to another. With time-uncorrelated models, it is assumed that the amount of harvested energy is i.i.d over different time slots.

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III. ENERGY HARVEST TECHNOLOGY

With the extensive application of information technology in social production and life, the business volume of mobile communication network shows explosive growth. The continuous expansion of network scale, diversification of base station and other communication equipment, as well as randomization of communication equipment site selection, have brought the sharp increase of the total network energy consumption and the multiple of the difficulty of base station energy supply. The construction of a sustainable and deployable communication network has become a crucial issue. Owing to the flexible deployment and uninterrupted green pollution-free energy providing, energy harvesting (EH) technology has become a particularly potential technology to resolve the difficulty of energy depletion in the future communication structure. Researches into energy harvest technologies initially focused on solar, wind and other renewable energy-powered devices. However, this technology does not only include renewable energy. The energy obtained by communication nodes from the surrounding environment does not necessarily refer to the clean energy such as solar energy and wind energy, but may also refer to the energy sent separately by other devices, similar to wireless charging technology. Using energy access technology in the wireless communication system, attributable to the changes of energy source, the obstacles and constraint conditions of traditional stable grid energy or limited battery power supply are no more applicable, so the algorithm of wireless communication, network protocol and even the hardware of transmission node are redesigned based on the needed energy for technical characteristics. In the wireless communication system actuated by energy harvest technology, the predicament to be dealt with firstly is the randomness of energy acquisition [19]. As a consequence of the unpredictable energy source, the energy collection technology will stack the arbitrary of accessible energy of the system in the light of the original unplanned of wireless communication channel also data arrival, thus greatly increasing the intricacy of the conundrum. The next is the causality, that is, the energy acquired can only be operated at the following time, and the energy consumed by the system cannot exceed the total energy currently acquired and stored. Finally, it is about the effectiveness of energy. Because the capacity of the energy storage device is limited, energy cannot be stored without limit, resulting in limited energy that can be used, and the part beyond the capacity can only be discarded. Meanwhile, different from the traditional power furnish network, the traditional power supply network is not constrained by energy, and its optimization goal is to ameliorate the network service performance, likely improving the throughput of the system and reducing the user's blocking rate. However, in the wireless system based on energy harvest technology, due to the limitation of this technology, the optimization of service quality in the network must be considered on the basis of the optimization of energy use. If it is only to improve the throughput of the system and lessen the blocking rate of it, once the transmission is interrupted because of energy exhaustion, the information cannot be transmitted, which will urgently affect the quality of service. Therefore, the application of energy acquisition technology in wireless communication system must be thoroughly studied. However, considering about the energy harvest at receivers, the energy on the sending end is supplied by the power grid or other stable energy sources, while the energy used by the communication on the receiving end is obtained from the electromagnetic wave sent by the sending end and then used for the transmission of information. Similar to wireless charging technology, it is generally called SWIPT.

IV. EXPERIMENTAL WORK

Recently, there has been much work on using opportunistic RF energy harvesting which is specific to the CR system. The SUs not only utilize the PU spectrum holes for transmission but also exploit the PU busy periods to harvest RF energy from PU transmission. Some authors used the stochastic geometry paradigm to

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analyze the SU transmission probability in an opportunistic RF energy-harvesting CR system. Optimal SU density and transmission power level were obtained to maximize the throughput of the CR network while satisfying the outage probability constraints at the PUs and SUs. A decision-making problem was formulated as a POMDP to decide between the spectrum-access and energy-harvest modes for the SU in each time slot to maximize the SU throughput while harvesting energy for future slots. In a multichannel system with RF energy-harvesting SU, an optimal channel-access policy was derived to maximize the SU throughput by using an MDP framework for the case when model parameters for the SU transmission and harvesting, and PU channel state occupancy were available. An online learning algorithm was proposed for the case when no information was available. In a similar multichannel system with multiple SUs, optimal channel-access policies were obtained for the SUs cooperating in a round-robin and a decentralized manner. It shown that a greater SU throughput can be achieved by considering the hybrid energy-harvesting and transmission modes as compared to that obtained by only operating in overlay mode using ambient energy sources. An RF energy-harvesting CR based device-to-device (D2D) communication was considered to access a predefined channel of a multichannel cellular network in an underlay mode. Stochastic geometry was employed to analyze the outage performance of both the D2D and cellular networks for two different access policies for cellular system, i.e., D2D channel can be selected randomly by the cellular user and the D2D channel can only be used when no other channel is available. In another work on RF energy harvesting underlay CR system, outage probability was derived for different types of power constraints at the PUs and the SU. Additionally, throughput expressions were determined and analyzed for both delay-sensitive and delay-tolerant systems

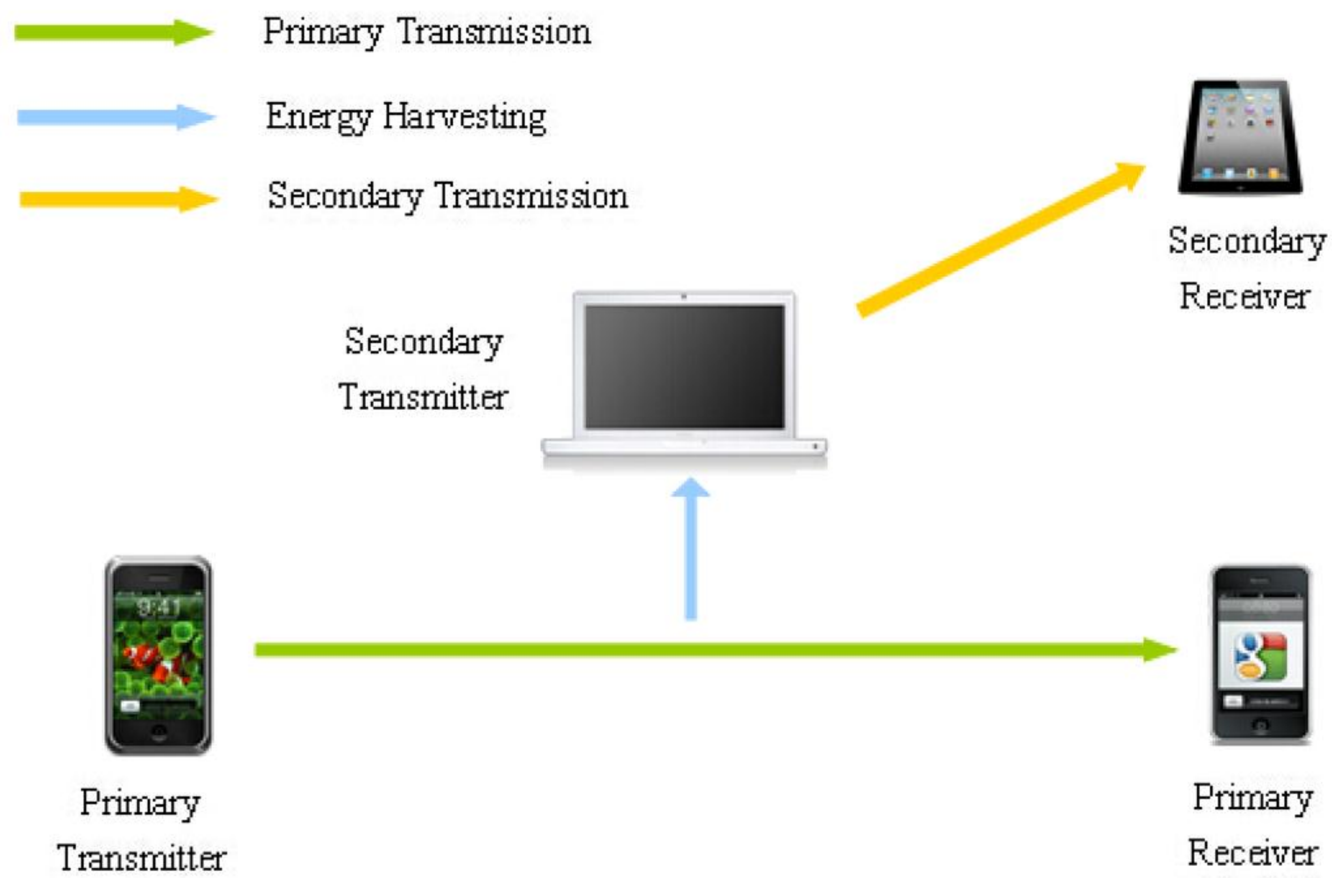

Fig 2: Model of energy harvesting in cognitive radio.

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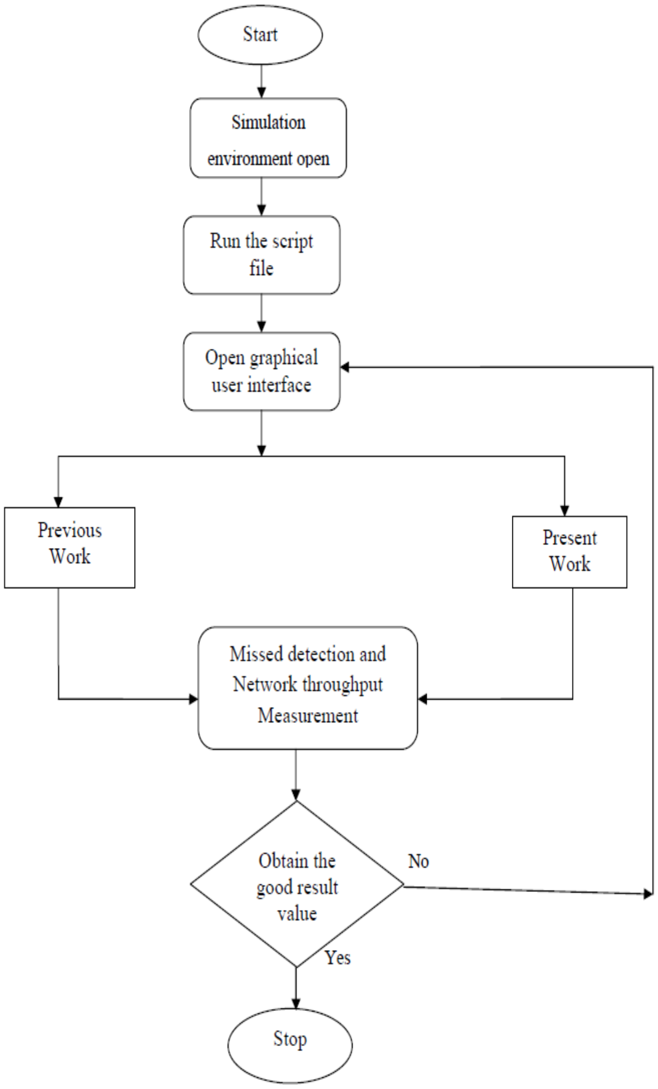

Fig 3: Present flow graph model of energy harvesting in cognitive radio.

Fig 4: Experimental work of energy harvesting in cognitive radio

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V. Conclusion

Unprecedented growth in wireless data services, the demands for power are constantly increasing, leading to a battery depletion problem for wireless nodes/devices. Recent advance in green technology has attracted a lot of attention from both academic and industrial research communities to consider a new paradigm shift of power supply by decreasing the use of fossil fuels while increasing more renewable energy sources in wireless communications and networking. To achieve this, energy harvesting has been proposed as a viable solution that enables wireless nodes to scavenge energy physically or chemically from natural or man-made phenomena. Energy harvesting provides us with many promising advantages and unique features for future wireless communications that cannot be offered by conventional battery or grid power operated communications, including self-sustainable capability, reduction of carbon footprint, truly wireless nodes without requiring battery replacement and tethering to electricity grids, easy and fast deployment in any toxic, hostile or inaccessible environments, etc. Hence, we can expect that energy harvesting in wireless networks is gaining more and more popularity in wide applications ranging from remote environmental monitoring, consumer electronics, to biomedical implants.

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