A REVIEW OF COGNITIVE NETWORK WITH ASYNCHRONOUS WIRELESS ENERGY HARVESTING

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***Abstract*: Due to increasing number of Internet connected devices like machine to machine communication type networks, such as the Internet of Things (IoT) big challenges in terms of, connectivity, accessibility and security and is naturalized by random transmissions of short packets. In this paper, Asynchronous channel access model performed by a primary ad hoc network underlay with cognitive secondary wireless- powered by an ad hoc network. Particularly, we consider power grid are connected to the primary transmitters, whereas the cognitive secondary transmitters have radio frequency (RF) energy harvesting capabilities and their time switching based asynchronous channel access is recognized based on definite energy and interference based criteria. The sporadic channel traffic is modeled by time-space Poisson point processes and we provide an analytical framework, based on stochastic geometry, for the performance of this asynchronous system.**

Index terms - IoT, cognitive radio, asynchronous channel, sporadic transmission, time space Poisson point process.

INTRODUCTION & RELATED WORKS

The IoT is enabled by the most modern development in Radio frequency identification tags, smart sensors, communication technologies, and Internet protocols. The vital idea is to have smart sensors work together directly without human participation to bring a new class of applications. The recent revolt in Internet, mobile, and machine-to-machine (M2M) technologies can seen as the primary segment of the IoT. In the coming years, the IoT is expected to bridge diverse technologies to enable new applications by connecting physical objects together in support of intelligent decision making [1]. (IoT) is disturbing how businesses, governments, and consumers interact with the world. Cumulatively, almost $5 trillion is estimated to be spent by companies by 2021 on IoT in a wide variety of industries like manufacturing, industry and finance [2]. So it´s possible define IoT as a network of interconnected things, on which anything can communicate with anyone at any time. The aim of the IoT is learn more, and serve better the users[3].

Restricted power in IoT is the mainly difficult barrier to IoT security. Because of any further security module, whether software or hardware, it wants more energy to perform. But IoT systems, especially the wireless systems, are always expected to be energy efficient [4]. Energy Harvesting (EH) is a mature solution to extend the short lifetime of many wireless sensor nodes and IoT devices. However, miniaturizing EH devices to supply low power and small form factor IoT devices is still challenging and not always effective. In fact, EH from the miniaturized is more challenging due to strict constraints in terms of size, weight, and cost. Among other technologies, wireless power transmission is growing of popularity due to the fact that it can be controlled and it is less unpredictable than environments sources [5].

Significant efforts have been devoted to study of wireless power transmission(WPT), where devices are wirelessly powered by harvesting energy from electromagnetic radiation. While in WPT the electromagnetic beams are clearly directed in the direction of the device to power up, in Electromagnetic Energy

Harvesting (EEH) the main concept is to gather electromagnetic waves from the air and convert them into DC energy[6] . WPT the RF-to-DC energy conversion efficiency is sometimes quite mild for low values of power been delivered to the rectifier circuit. This is mainly due to the fact that the Schottky diodes do not have a 0V threshold voltage, which limits the turn on of the diode and impose a minimum value of RF energy wasted to put the diode operating. One solution that can be used to improve this is to use the approach followed in[7]. The author in [8] and [9] said in order to maximize the harvest energy use multiple antennas at transmitter for energy beamforming. The author in [10] introduce the protocol " harvest then transmit" protocol users first harvest the wireless energy broadcast by the hybrid access point (H-AP) in the downlink (DL) and then send their independent information to the HAP in the uplink (UL) by time-division-multiple-access (TDMA) . The author in [11] and [12] applied same protocol, where author maximize throughput by optimal power allocation by balancing the time duration between the wireless power transfer phase and the information transfer phase, while satisfying the energy causality constraint, the time duration constraint, as well as the quality- of-service constraint (i.e., the symbol error rate is lower than a target value). The optimization problem can be solved by an optimal time allocation.

The author in [13] analyze the performance of a battery-free wireless sensor powered by ambient RF energy harvesting using a stochastic-geometry approach. The author in [14] propose two new online approaches where goal is to minimize the non-renewable energy consumption for enable energy trade in cellular networks with non-cooperative energy harvesting base stations (BSs) ,

Another challenges in IOT is spectrum allocation, here spectrum allocation problem is overcome by cognitive radio (CR) network , where several type of devices with different application establish communication by sharing a common medium. For spectrum allocation CR network is promising solution since they allow secondary user to share primary user spectrum by Dynamic spectrum access (DSA), a piece of spectrum can be allocated to primary users (PUs); they have higher priority in using it. new users, which is referred to as secondary users (SUs), can also access the allocated spectrum as long as the PUs are not temporally using it or can share the spectrum with the PUs [15]. Authors in [16],[17] and [18] observe that SUs spectrum access with PUs is deal with the spectrum congestion, which is overcome by spectrum sensing from cognitive transmitters in order to decide whether spectrum access of SUs will not significantly affect the PUs network . The author in [19] works cooperative spectrum sensing to improve the sensing performance in cognitive radio by using Opportunistic Feedback method. The author in [20] propose the random and prioritized spectrum access for CR network with primary cellular networks and they show that energy harvesting used with CR transmission provide sufficient QoS without degrading primary network performance . Furthermore, the work [21] consider the same energy harvesting approach for CR secondary network , primary transmitter assign guard zone to protect its receiver from which occur in CR network. Under specific outage-probability constraints, the author also obtain optimal transmission power and density of secondary transmitters to maximize the secondary network throughput.

The study of WPCN applied in CR networks, communication frameworks research peoples focus on coordinated and slotted transmissions by assuming perfect synchronization. But this approach is not suitable for large scale M2M networks environment[22]. In the way massive machine type networks, like low power device employs sporadic transmission, which is transmission of short packets[23]. Point processes is closely related to stochastic geometry, Point processes are random collection of points that are localized in space or time. Poisson point process (PPP) which is valid when the movement of nodes in a mobile network is uncorrelated or when nodes are deployed randomly in a fixed wireless network[24]. The authors in [25] adopt the TS-PPP and they use tools from stochastic geometry to provide the coverage probability for non-slotted Aloha wireless ad hoc networks. In addition, a similar approach is followed by the work [26], where an analytical framework of asynchronous large scale full-duplex networks is derived

II. ASYNCHRONOUS COMMUNICATION MODEL

We consider a primary ad hoc network underlaid with a cognitive secondary ad hoc network i.e., all nodes establish communications over the same channel. Both networks consist of a random number of transmitter-receiver pairs. Due to the low-power nature of the devices, pairing is achieved if the intended pair is located within a maximum distance [20]. We assume a worst case scenario, where each transmitter is separated by its paired receiver by a distance d, which is common and fixed for all the pairs. The channel access is considered to be uncoordinated and asynchronous (e.g. un- slotted Aloha protocol [25],[31])and each transmitter accesses the channel for a duration T_I. Note that, the transmitted packet length determines T_I [25]. The primary transmitters are connected to the power grid and transmit with constant power P_1. Their operation consists of two phases: an idle phase (i.e. sleep phase) and an active phase (i.e. channel access phase). The randomness, both in time and space, is modeled for each network by an independent homogeneous TS-PPP [25]. We denote by $\Phi_1 = \{(x,t_x)\}$ the TS-PPP of density λ_1 modeling the primary transmitters, where $x \in R^2$ is the location of the transmitter that initiates a transmission at time t_x. It is worth mentioning that the TS density, describes the sporadic channel traffic for a given area and time period, i.e., defines the number of nodes which are active at some random time and location [26]. The secondary transmitters have RF energy harvesting capabilities and take cognition-based decisions regarding their operation. Therefore, while a primary transmitter's operation has two phases, a secondary transmitter undergoes three phases: an idle phase, an awake phase (i.e. RF harvesting/cognition phase), and an active phase. Specifically, during the awake phase, a secondary transmitter does the following: a) harvests RF ambient energy for a duration T_E, b) if the harvested energy exceeds a predefined threshold, the transmitter switches to active if an interference based criterion is satisfied (see Sections II-C and II-D for details). The active secondary transmitters transmit with power P_2 which is a function of the harvested ambient RF energy. We denote by $\Phi_2 = \{(y,t_y)\}$ the TS-PPP of density λ_2 modeling the secondary transmitters, where $y \in R^2$ is the location of the transmitter that enters the second phase at time. Fig. 1 schematically depicts our considered network model.

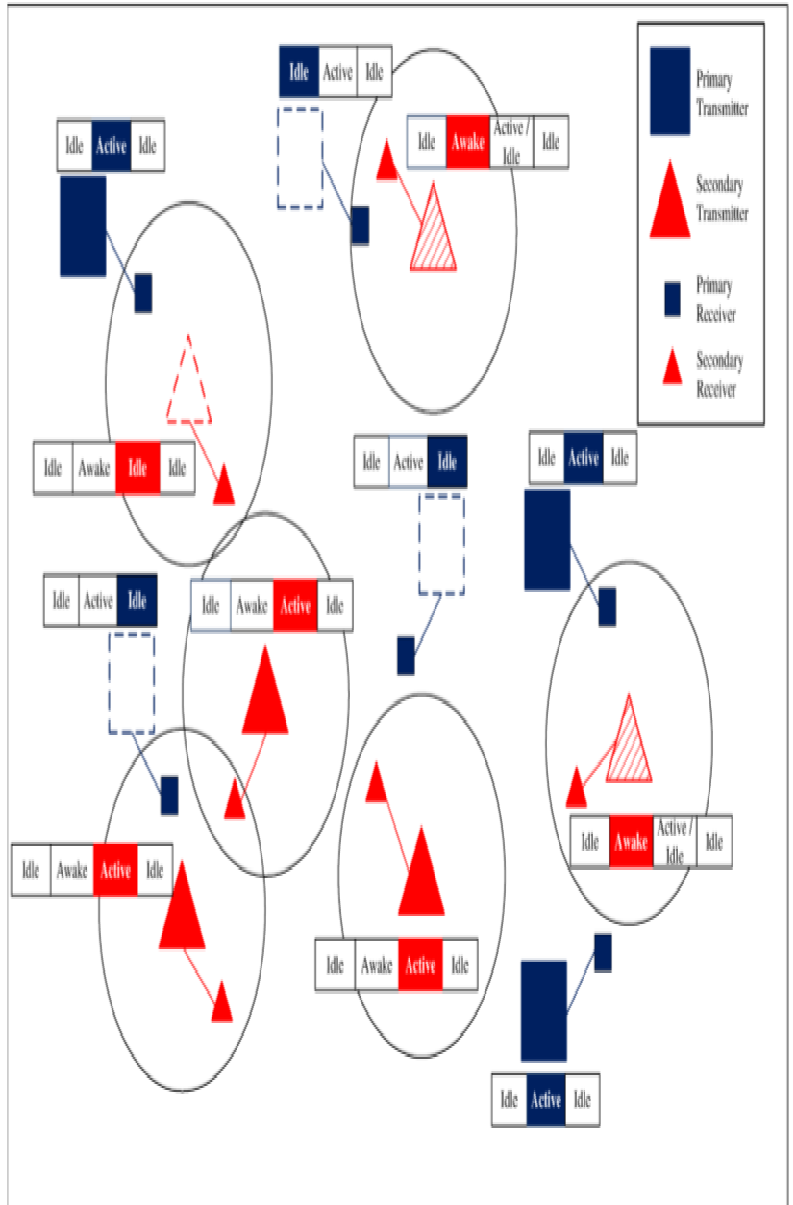

Fig. 1. The primary ad hoc network underlay with the secondary ad hoc network. The transmitters are captured along with their phases overtime where the shaded ones indicate their current phase; circles represent the guard zone of the cognitive secondary transmitters.

II.WIRELESS POWERED SECONDARY NETWORK

In this section, we derive the probability πs that a secondary transmitter is in active mode i.e., the energy and empty guard zone requirements are satisfied and thus the channel can be accessed by the secondary transmitter.

Energy Coverage- We will now derive the energy coverage probability of a secondary transmitter. For this purpose, we will calculate the total harvested energy by taking into account which primary transmitters are active during the energy harvesting period i.e., the transmitters that initiated a transmission before the secondary transmitter switched to the awake mode, along with the transmitters that switched to active during the harvesting period. Consider a secondary transmitter located at the origin during the interval [0,TE] i.e., during the awake phase

Guard Zone- In this section, we will obtain the probability that no active primary receiver is located within a secondary transmitter's guard zone. A secondary transmitter, by the end of the energy harvesting period, returns to the idle mode if there is not sufficient energy, otherwise it decides whether to initiate information transmission to its paired receiver based on the locations of the active primary receivers. If an active primary receiver is located within a distance higher than ρ from the secondary transmitter then the transmission begins. Note that, the decision is considered to be taken instantaneously right after the energy harvesting period. That is, the decision takes into account the active primary pairs which have already initiated their transmissions by the end of the harvesting period.

III. COGNITIVE RADIO NETWORK

One of the challenges that has been daunting researchers and industry personnel is how to bootstrap security associations among nodes in IoT. As we observe throughout our discussion in this article, many security protocols are being designed to secure communications in the IoT, but without specifying how the required cryptographic keys are configured in the intervening devices, in the first place. The security association includes attributes like cryptographic algorithm and its mode, the cryptographic key and other network parameters, required to establish a secure connection.

Dynamic spectrum access (DSA) is an another strategy to permit the radio spectrum to extra efficiently to be used . In DSA, a portion of spectrum can be allocated to one or more users, which are called primary users (PUs); however, the use of that spectrum is not exclusively granted to these users, even though they have high priority in using it. new users, which are referred to as secondary users (SUs), also access the allocated spectrum as long as the PUs are not temporally using it or can share the spectrum with the PUs as long as the PUs' can suitably be protected. By doing so, the radio spectrum can be reuse in an opportunistic method or shared all the time; thus, the spectrum consumption efficiency can be significantly better.

IV. INTERNET OF THINGS

The IoT is the convergence of the cyber and physical worlds, with the goal of creating an open and global network to connect people, things, and data. Simply put, an IoT network is made up of a great number of heterogeneous devices and technologies, produced by different vendors and for different purposes, also characterized by different capabilities. These devices have multi-faceted constraints in terms of processing capability, memory, power supply, communication capability and user interfaces. However, there may also be constraints on networks that are largely independent of those of the nodes. These constraints include high packet loss, low achievable throughput, lack of advanced security services and highly asymmetric links, among others. The main challenge is to adapt such networks to operate in the conventional Internet, and the integration of Wireless Sensor Networks (WSN) with the Internet communications infrastructure is a required and strategic step in the right direction. one of the challenges that has been daunting researchers and industry personnel is how to bootstrap security associations among nodes in IoT. Many security protocols are being designed to secure communications in the IoT, but without specifying how the required cryptographic keys are configured in the intervening devices, in the first place. The security association includes attributes like cryptographic algorithm and its mode, the cryptographic key and other network parameters, required to establish a secure connection.

V.CONCLUSION

In this paper, we studied an ad hoc cognitive secondary network which is wirelessly powered by ambient RF signals and is underlay with an ad hoc primary network. We considered asynchronous channel access from both the networks in order to capture the sporadic channel traffic in IoT environments. For this purpose, the two networks were modeled by TS-PPP and by exploiting tools from stochastic geometry. It can be observed that cognitive radio in IOT applications are not secure and privacy in future work is to improve the data security of IOT .

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