

Analysis of Energy Efficiency of Adhoc Cognitive Radio Network

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ABSTRACT: High energy consumption during the communication among the number of users in Cognitive Radio (CR) network is the major issue and it is solved by the suitable spectrum sensing technique. When we integrate the CR into the Internet of Things (IoT), the placement of nodes, data routing and the mobility affect the communication adversely. The major issues in the existing method are dynamic mobility of nodes over the diverse spectrum access and preserving energy under multi-hop criterion. This paper proposes the Sleep Wake Scheduling based Cluster Update (SWSCU) to alleviate the above-mentioned issues in IoT framework. The proposed work includes the cluster formation, cluster update and transmission modules to proceed the energy efficient data transmission. The message Advertisement (ADV) message is broadcasted among the nodes to provide the instant update of energy consumption and provides the alternate way in order to achieve the uninterrupted communication. The comparative analysis between the proposed work with the existing method assures the effectiveness in IoT applications.

KEYWORDS: Cluster Formation, Cognitive Radio, Internet of Things, Sleep-Scheduling.

I. INTRODUCTION

Ethnicity of today's mankind is transformed to a lifestyle that makes it adaptable to face bunch of challenges posed by the hasty urban ambience. Hence, the universal requisite naturally inclines toward an instant elucidation to resolve all sorts of critical issues and here it goes in par with the solution to be explored for a pitfall that occurs with the rapid advancement of the technologies regarding communication. In order to acquire the instigated attainment of a full-fledged smart city, a hefty network is quested in an abrupt manner. Absolutely connected gadgets alone assist the livelihoods of a typical urban environment. Consequently, this aspiration drives on the road to reach the concept of transformation from an ordinary internet to the adequate Internet of Things (IoT).

In general, IoT is a self-motivated auto configuring network framework available globally. It is the unique platform that certainly accommodates the association and connection of virtual as well as real things so as to converse with each other. It actually results in a facilitation of an adorable ambience and an enduring arena for humans to dwell in the near future. For sufficing this need of the hour, the blossoming concept of IoT must serve in a robust manner such that all sorts of technically modern accomplishments are adaptable within resourceful scenario. The practical predicaments prevailing in the realization of a complete IoT infrastructure is,

- Inappropriate utilization of the existing networking services accounting to the technical deterrence
- Lack of interoperability regarding cross domain applications

In order to manage this framework in a proficient manner, an instant remedial measure called Cognitive Radio Networks (CRN) is incorporated with this innovative IoT concept. This CRN is capable of managing the network services available and ant accordingly. The radio spectrum that is readily available for utilization is instantly sensed by the mobility devices formally termed as Cognitive Radio (CR) devices. Utilizable spectrum available is segregated into

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two diverse parts given as licensed spectrum and the unlicensed one. The formerly mentioned licensed spectrum is allocated and utilized only by the registered users likely to be called as Primary Users (PU). The leftover spectrum band accessible is known as unlicensed spectra band and it is to be scheduled and allocated for the CR devices that is the Secondary Users (SU).

This concept is effectually realized by means of deploying the conventional sensor network that tends to serve as a lucrative solution for accomplishing this task. The events that happen in the real-time environment are eventually sensed by the sensors that are deployed in the sensing environment and are properly updated with the CR devices available in an environment where CRN is incorporated with IoT. These CR devices are responsible for sensing the spectrum in search of spectrum holes. The spectrum is typically free from any sorts of allocation at the spectrum holes. Since, these sensor nodes are usually mobile devices, the concept of energy management is to be rigorously trailed in order to accomplish an interconnected network for a prolonged lifetime.

Beyond all these beneficial assistance of the CRN in IoT, some other issues prevailing in the network accounts for resolving the issues regarding the dynamic mobility of CR nodes on behalf of the miscellaneous radio access to the network by incorporation of both cellular as well as broadband technologies. It also strives for preserving energy at the time when a failure of sink node is realized. Multi-hop criterion involved in transmitting the sensed data from the sensed ambience to the predefined destination through CR nodes incurs a great end-to-end delay. Owing to the existence of mobile CR in the presented cognitive network, the assistance delivered by them lacks to a great extent.

Section II presents a description about the previous research works which is relevant to the MANET and trust based MANET. Section III involves the detailed description about the proposed hybrid observation trust models. Section IV presents the performance analysis of proposed and existing methods on network parameters. This paper concludes in Section V.

II. RELATED WORK

Zhou, et al. [1] proposed the security architecture for Internet of Thing (IoT) based on software defined networking (SDN). The result of architecture provide the network security in more efficient and flexible with SDN. The border controller was used to communication between the domains and the border controller was called as special controllers. The advantage of the architecture was to reduce the security issues and the secure SDN based architecture for Internet of Thing (IoT). The SDN architecture included the main disadvantage was Denial of Service (DoS).

Abedin, et al. [2] developed the system model for energy efficient Green-IOT network. The IoT systems were limited in the energy resources so it was extended the capability and life time. The average power consumption was classified into three, such as, on-duty, pre-off duty and off- duty. An energy efficient scheme of green IoT was used in the less power consumption. The green communication was used to validate the energy efficient scheme of IoT.

Hodo, et al. [3] utilized the neural network intrusion detection system for analyzed the IoT networks. The normal and threat patterns on an IoT network were mainly focused in this paper. The IoT network was used to identify the Distributed Denial of Service (DDoS\DOS) attacks. The artificial neural network was evaluated against IoT network and it was provide the good accuracy. Iot network was used to identify the different type of networks and it provides the good performance such as, true and false positive rate.

Srivastava and Pal [4] discussed and suggested the difference challenges, technologies and protocols used by the IoT (Internet of Thing). It was mainly applicable in the medical aids, mobile health care, and electricity grid system to surveillance camera. The Wireless Body Area Network (WBAN) was used to design the architecture of IoT in IEEE 802.15.6 standards. IEEE 802.15.6 network was contained the some layers, such as,

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- Physical layer
- Human body communication layer (HBC)

The physical layer included the two band as, narrow band (NB), ultra-wideband (UWB) and Human Body Communication (HBC).the MAC layer format for the IEEE 802.15.6 or WBAN technology were used in the smart technology networks.

Wang, et al. [5] proposed the generic computation architecture for network data processing in named function networking (NFN). The computation service management (CS-Man) protocol used the NFN. Service discovery and service deployment were the two procedures the IoT network. The network computation was provided by the IoT devices and it was enabled in the scheduling protocol. Service recovery problem was solved by the CS-Man. IoT traffic was delivered the Information Centric Networking (ICN) based approaches. An application layer was designed by the available computation service. Distributed sub service execution and lowering processing cost were implemented in the computing balance.

Rathod, et al. [6] proposed an energy efficient and reliable IoT network for water management. The wireless technologies based datasheets were compared with the Internet of Thing (IoT) in Indian Institute of Science (IISc). The sub-GHz modules were tested in the different environment, such as open ground, straight road, moderately and densely wooded area. The system was tested and applied Indian institute of science.

Le, et al. [7] addressed the critical issues of managing diverse resources in IoT system. The IoT system was represented the IoT resources, edge-to cloud network capabilities, network function, and cloud computing infrastructures. The different data models with various IoT resources were extendable in data information. The end-to-end IoT resources provisioning and configuration were

SWSCU MODEL

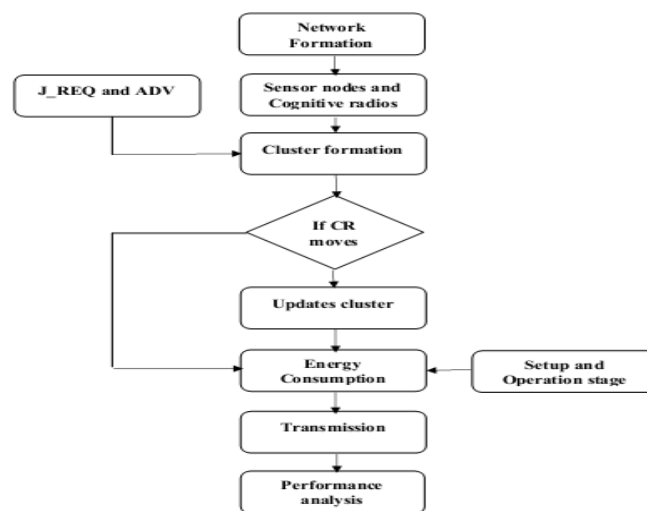


Fig. 1 Overall flow of proposed SWSCU.

The devised CRN based IoT formulation,scores for its effectual sensing with respect to the proficient energy management strategy. The contemplated network model encompasses the sensor nodes, Ad hoc CR devices, and servers for manipulating the information being gathered from the sensing field. The proficient energy management

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policy is accomplished by means of deploying an inventive procedure termed as Sleep Wake Scheduling based Cluster Update (SWSCU). This certainly invokes the Ad hoc CR to get involved in the process of data transmission by disintegrating clusters into subgroups. Meanwhile, the nodes are scheduled on the basis of their energy by means of exploiting the efficient Cluster Update and Subset Formation (CUSF) procedure. This scheduling manipulates each and every subgroup as if a single subgroup is all alone responsible for the data transmission and remaining subgroups are subjected to be retained in sleep mode with respect to the active PU present in the network. The amount of energy incurred for sensing the spectrum is highly mitigated with sensor nodes via deliberation of CR node movement in a recurrent manner at the time of setup stage. Hence, lifetime of the overall network setup is prolonged with an added proficiency.

Network formation with assimilation of CRN and IOT

- Prevailing internet paradigm is stretched out to formulate an utterly associated networking elements such as sensor nodes, mobility gadgets like mobile phones, laptops, tablets etc. and servers. The elementary conceptual structure of internet serves those devices to retain its connectivity in a robust frame. In order to cope with the swiftly varying scenario in which human dwells, the technology surrounding their living ambience must also serve with a cognitive sense. Hence, the necessity for accomplishment of a brainy and intellectual networking environment is growing in a rapid manner. So as to suffice the requisite a collated environment is fabricated by incorporating IOT with the prevailing CRN. This inventive framework holds the responsibility for formulating an indigenously responsible network. The network articulated comprised of diverse set of layers such as recognizing/ retorting layer, Interrelating Layer, Information Layer and facilitating Layer.
- **Recognizing/ Retorting layer-** Both the actions of gathering information from the stipulated environment and providing an apt reply to resolve the abrupt need of particular instant is accomplished by means of this initial layer. All sorts of communicating appliances typically termed as smart devices are associated with this layer with the intention of sensing the environment and reacting accordingly. The key endeavours executed by this layer encompasses (a) recognizing the ambience for its acute as well as modest variations and transmuting those information gathered in a stipulated format so that it is conveyed to interrelating layer (b) act in accordance to the instructions directed from the monitoring layer. The sensors deployed in the physical networking environment factually sense and recognize the variations by means of the augmenting perceived stimuli.
- **Interrelating Layer-** The associating systems such as components residing within the CR system are comprehended in this layer. The components of a CRN consist all sorts of electronic gadgets that are capable of transferring the sensed information to particular destinations by means of getting connected to a prevalent infrastructure.

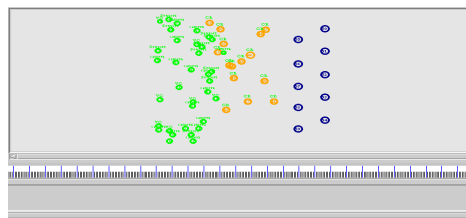


Fig 2. Network formation

The CRN typically decides in getting linked with particular network in accordance with the network traffic available at particular instant of time. There are also many issues that arise on account of getting connected with the CRN such as, immediate recognition of vacant spectrum, impact created by instant mobility of devices, managing the spectrum handoff in a proficient manner. Owing to the inappropriate device mobility, utilization of spectrum is also bit complicated. The spectrum is sensed by the cognitive capability of the CRN components by means of realizing the

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spectrum holes available in the spectrum. Afterward, a process of spectrum hand-off is accomplished in order to utilize the spectrum concerned without disturbing those available Primary users (PU) in the licensed perceptible network. The Secondary Users (SU) are permitted to utilize the unlicensed perceptible network after acknowledging the regular spectrum handoff. At once, when the SU are permitted into the communicating spectrum, they are also capable of interfering to the licensed spectrum of PU with the utilization of its dynamic access. In order to eradicate such a delicate circumstances, the spectrum is scanned by the cognitive network in the initial stage itself and provides authorizations for the SU deprived of causing any sort of illegal access to the available spectrum. In the depicted fig 2 the initially residing nodes possessing bright green color represents the sensor nodes existing in the sensing field, the second set of nodes owning orange colour resembles mobility devices located in the CR networks and the final set of nodes signifies the servers existing in the processing end is coloured in the dark blue.

The area defined the simulation environment as square with the dimensions of 100 x 100 m². The Mobility range for the CR nodes deployed in the cognitive network is 20 m. The number of nodes varied from 50 to 100 in which the 20 nodes have the destination and the routing information tops the destination. The maximum duration accomplished by the CR node for sensing a spectrum is 2ms and the maximum communication range sensed by a CR node is about 20 m.

Cluster Formation

An advertisement (ADV) message in a stipulated format as if illustrated below is broadcasted by the CR nodes. The header field is provided to fulfil the intention of discriminating other control messages from the advertisement messages.

Header	ID	Position	Nodes
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The CR nodes that receives this advertisement usually dwells within the feasible range and in turn, the node which received the advertisement responds by transferring a Joint Request (J_REQ) in a format given below.

N_ID	CR_ID	E_rem	SNR
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N_ID corresponds to the destination's identification number where, CR nodes identification is indicated through C_ID. E-rem resembles the energy encompassed by the CR node probably the energy retained after accomplishment of transmission and SNR points to signal-to-noise ratio of the corresponding CR node.

Multiple CR nodes tend to broadcast advertisements even to a single node and only the CR node that resides in the utmost vicinity gains the opportunity to get associated with. This constraint is rigorously trailed at the time when the nodes tend to form the cluster because; this constraint alone can suffice and assure the least consumption of energy that is acquired for transmitting data.

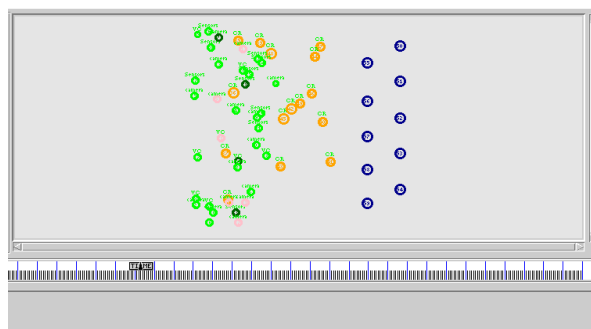


Fig 3. Cluster Formation

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At some sort of specific instance, a node may experience a context in which it comprises of advertisement from the manifold nodes in which all those nodes are positioned in a similar coverage distance. At this juncture, the node concerned opts for bring patched up with the node that comprised of minimal count of nodes being cluster with it. Consequently, this mitigated count of cluster members within a cluster results in abating the waiting time that is inferred for transferring the information sensed from the physical environment. In the fig 3 the nodes resembled in pink color indicates the cluster members in a network while the nodes colored with dark green color signifies the node that encompasses useful sensed information within it.

Updating the Clusters

At once, when the clusters are initiated the data transmission begins within the network. Hence, the sensed information are ready for transmission from the sensing field to the processing end that comprises of servers for initiating the remedial actions. When the information traverses from one node to the other, some of the parameters are deliberated on forming the specific clusters such as cluster locating time as well as the time span acquired for transmitting the data. On the contiguous transmission of data, some sort of interruptions are faced by the traversing clustered sensor nodes. The instances at which the process of updating a cluster happens are,

- Occurrence of alterations in overall count of nodes associated with the CR node
- Modification in the CR node with respect of its location

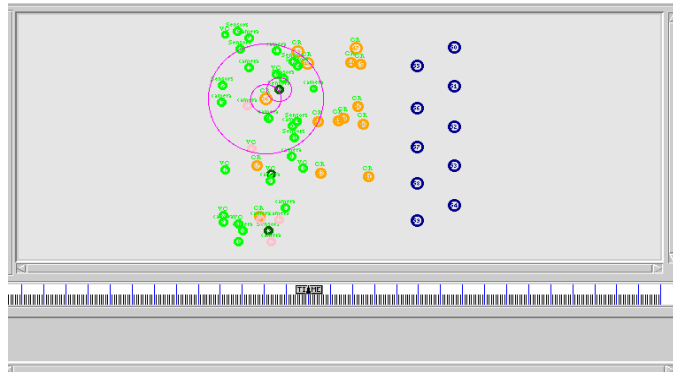


Fig. 4 Updating the clusters prevailing in the network

On realizing such sorts of conditions, the CR concerned holds the responsibility for updating its cluster set patched up with it. On reiterating the process of cluster formation, the broadcast of ADV is initiated and hence, the J_REQ request is sent as response to the CR node concerned by the nodes that are so far not attached to the CR node cluster. A node previously committed into a cluster may also receive the ADV broadcasted and in such an instance, if the newly arrived ADV accounts for a lesser distance then it gets detached from the cluster where it is presently dwelling in by means of sending a leave message to the CR as L_REQ which is formatted as,

N_ID	CR_ID
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Where, N_ID corresponds for the concerned node identity that is planned to leave the respective CR node possessing the cluster identity indicated as CR_ID. Subsequently, the sensor node concerned is relieved from that particular CR node and it gets into the newly framed cluster.

After getting fixed to a single cluster that exists in an optimal distance, the framed cluster is further disintegrated into manifold subgroups on the basis of assessing the energy retained by each and every node existing within the cluster. In order to eradicate the possibility of accomplishing a sensor node failure owing to energy drain, it is deliberated as the crucial criterion for opting a node into transmission procedure. In order to resolve this issue, a nominal overlapping

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criterion is deliberated in the simulated environment. It is computed by means of considering the coverage of a specific node. If the coverage area of the particular node is modestly overlapped with that of the CR nodes then those are marked for clustering as if signified by the pink colored circles in Fig 4. It trails a sequential stages as described below,
Stage I- Initiating node should possess an extreme amount of energy and that is opted for organizing the subgroup formation process

Stage II- Set of sensor nodes that possessed an overlap criterion regarding their coverage area is deliberated and recognized for including into the subgroups. A sensor node with vast amount of coverage area is taken into process

Stage III- The count of nodes residing inline with the subgroups are surged while, the node count in the clusters are certainly diminished

Stage IV- The predefined stages are reiterated until all sorts of clusters are disseminated into subgroups

Transmission between nodes

The resource utilization with the CR nodes are highly mitigated when compared with ordinary sensor nodes transmission. The probable number of subgroups to be framed is designated by means of computing the detection probability for the overall count of CR nodes residing in an IoT environment. This factor holds the absolute responsibility for recognizing the availability of PU signal in the licensed spectrum. This probability value is assessed by means of relying upon the Signal-to-Noise Ratio (SNR) field engraved within the J-REQ message sent by the sensor node as reply for the broadcasted ADV message.

Where the SNR component of the node concerned indicates, signifies the favouring component of the local decision on the basis of energy threshold. Likewise, the fake signal identified by the CR nodes as if the PU signal within an IoT environment is also assessed by means of computing the false alarm probability.

III. EXPERIMENTAL RESULTS

During the simulations in NS 2, the effectiveness is validated through cluster update with minimum energy consumption. The comparative analysis of the formulated SWSCU approach with the existing EESA-RLS approach that does not possess an accurate energy efficient mechanism is presented to assess the performance in terms of throughput, routing overhead, Packet Delivery Ratio (PDR) and end-to-end delay. .

Throughput

The number of data packets sent over the total simulation period refers throughput. The mathematical formulation for throughput is expressed as

$$\text{Throughput} = \frac{\text{Number of data packets sent (bits)}}{\text{Time period (secs)}}$$

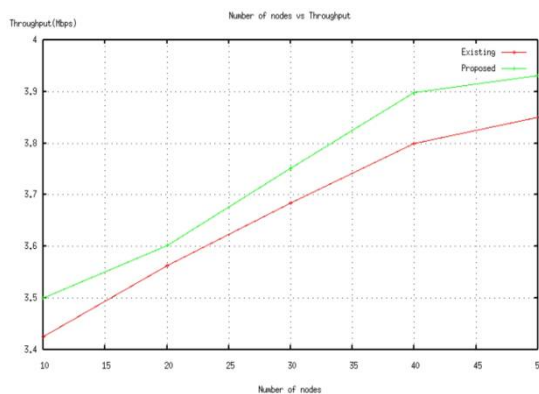


Fig 6 Throughput analysis

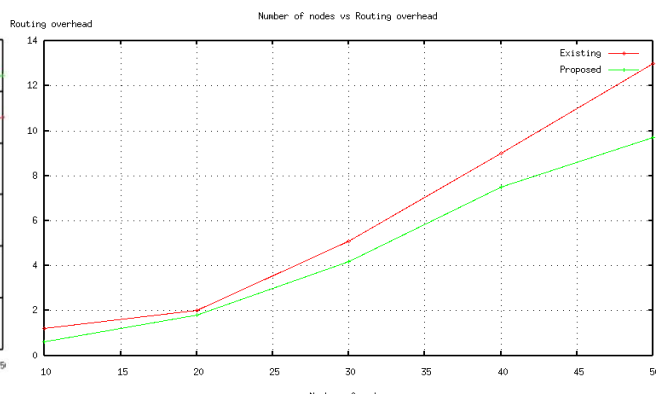


Fig 7 Routing Overhead analysis

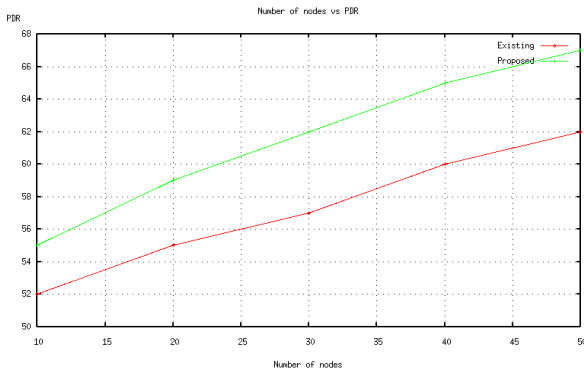


Fig.8 Packet delivery ratio analysis

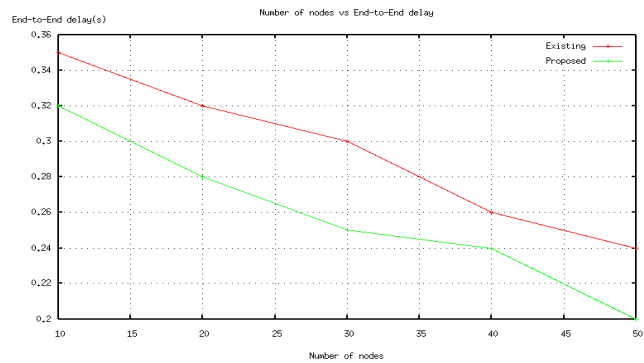


Fig.9 End-to-end delay analysis

IV. CONCLUSION

In this paper, the issues in CR-IoT integration CR into the Internet of Things (IoT) are addressed. The major issues in the existing method are dynamic mobility of nodes over the diverse spectrum access and preserving energy under multi-hop criterion. This paper proposed the Sleep Wake Scheduling based Cluster Update (SWSCU) to alleviate the above-mentioned issues in IoT framework. The proposed work included the cluster formation, cluster update and transmission modules to proceed the energy efficient data transmission. The message Advertisement (ADV) message is broadcasted among the nodes to provide the instant update of energy consumption and provided the alternate way in order to achieve the uninterrupted communication. The comparative analysis between the proposed SWSCU with the existing method assured the effectiveness in IoT applications.

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