A Survey on Cluster-based Architecture in Cognitive Radio Ad-hoc Network

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ABSTRACT
Cognitive radio is a promising technique for efficient spectrum utilization in wireless systems. In this paper, Clustering algorithm for ad hoc network is specified. This is the method to build and maintain hierarchical addresses in ad hoc networks where the spatial variations of spectrum opportunities are considered for clustering. Each cluster consists with a set of free common channels, which benefits smooth shift between control channels. A set of cognitive radio nodes are grouped into the same cluster if they sense similar free channels and are within the communication range of the leader node called cluster head. Whenever cluster head move out of cluster then secondary cluster head takes the charge of cluster head. Proposed clusters adapt themselves dynamically with respect to spectrum availability, and the high mobility of the nodes.

Keywords
Cognitive radio networks, Ad-hoc networks, Cluster-based network, Re-clustering.

1. INTRODUCTION
With the appearance of new wireless systems, demand for radio spectrum is increasing and the scarcity of this resource is becoming obvious. Radio spectrum management to ensure the efficiency of radio communication equipment and services is necessary. The generation of radio waves is strictly regulated by the government in most countries, which is coordinated by an international standards body called the International Telecommunications Union (ITU). Different parts of the radio spectrum are allocated for different radio transmission technologies and applications. In some cases, parts of the radio spectrum is sold or licensed to operators of private radio transmission services (for example: cellular telephone operators or broadcast television stations). Ranges of allocated frequencies are often referred to their provisioned use (for example: cellular spectrum or television spectrum, broadcasting, mobile radio or navigation devices etc). To ensure the efficient management of radio spectrum new policies and technologies are necessary.

Cognitive Radio (CR) is one way to improve the efficiency of the radio spectrum utilization. Actually, CR finds unused spectrum to insert a SU(Secondary User) transmission without interfering with PU(Primary User). Cognitive radio network is a promising wireless network where smart devices are able to exploit the spectrum holes and optimize the overall radio spectrum use. Thus this technology can solve the problem of the unused spectrum and it can be used in many others applications: emergency communications services, broadband wireless networking and multimedia wireless networking. In these cases, the Cognitive Radio system can make decisions about its own behavior and operations according to its working environment to improve the quality of service. Clustering is basically defined as a group of multiple nodes. A novel cluster-based architecture for an ad-hoc cognitive radio network is proposed, where the spatial variations of spectrum opportunities are considered for clustering. Cluster formation includes arranging network nodes into logical groups, while upholding the network connectivity. Clustering is one of the most widely investigated solutions for scaling down ad-hoc networks. The specific objective of the grouping process generally depends on network characteristics and application requirements. For example: in a dynamic environment, cluster formation seeks to abstract the network topology into a simpler, more stable form so that local changes which improves the efficiency of network functions such as routing and multi casting.

Each cluster consists with a set of free common channel which provide benefits smooth shift between control channels. Set of cognitive radio nodes are grouped into the same cluster if they sense similar free channels and are within the communication range of the leader node called cluster head. The selection of cluster head is based on a parameter called Cluster Head Determination Factor (CHDF), considering re-clustering issue for mobile node. Secondary cluster-head takes charge of a cluster whenever a cluster-head moves out from the cluster. The clusters adapt themselves dynamically with respect to spectrum availability and the high mobility of the nodes. Cognitive Radio Network (CRN) has received keen interest to the researchers of communication networks in the last few years because of the flexible and dynamic behavior of spectrum usage over other ad-hoc technologies. This paper proposes a dynamic cluster-based architecture for CRN where the spatial variations of spectrum opportunities are considered for clustering. In this scheme, selection of cluster head is based on a parameter called Cluster Head Determination Factor (CHDF). Apparently, to reduce re-clustering in mobility enabled nodes, secondary cluster-head in each group is proposed which takes charge once the cluster-head moves out. The cluster components of the proposed architecture are Cluster Heads, Secondary Cluster Heads, Cluster Members and Cluster Gateways.

2. RELATED WORK
In [1], authors published the concept of cognitive radio first time in 1999. They proposed a novel approach in wireless communications, which is described as the point in which wireless personal digital assistants (PDAs) and the related networks are sufficiently intelligent about radio resources. Also in related work computer-to-computer communications in order to detect user communication needs was done. They

provide radio resources and wireless services most appropriate to those needs as solution. Cognitive radio enhances the flexibility of personal services through a Radio Knowledge Representation Language (RKRL) which supports automated reasoning about the needs of the user. Here, they have suggested the importance of cognitive radio and determine the approach of cognitive radio as software radio provides which is an ideal platform for the realization of cognitive radio. Authors proposed that CR provides a standard language within which such unanticipated data exchanges can be defined dynamically.

In [2], authors proposed fundamental of ad hoc network which is becoming popular because there is no central administration with simple infrastructure. Ad hoc wireless networks eliminate the complexities of infrastructure setup and administration enabling devices to create and join networks “on the fly" anywhere, anytime, for virtually any application. The decentralized form of any wireless network is considered as wireless ad-hoc network, which is a self configuring network. Various type of clustering is specified in this paper and hierarchical topology related with it. Other aspects of ad hoc networks such as message broadcasting and quality-of-service from network are determined.

In [3], UWB technology is proposed by authors to transmit control information in, the use of ISM bands for control in CRNs. While essentially the entire frequency spectrum is allocated to different application, observations provide evidence that usage of the spectrum is limited; particularly in bands above 3 GHz is specified by authors. A cognitive radio approach for usage of Virtual Unlicensed spectrum (CORVUS), a vision of a CR based approach that uses allocated spectrum in a opportunistic manner to create “virtual unlicensed bands" that is bands that are shared with the primary (often licensed) users on a non-interfering basis is proposed. Dynamic spectrum management techniques are used to adapt to immediate local spectrum availability is specified by author. A Dynamic cluster-based architecture for Ad-hoc cognitive radio network is presented where spectrum awareness for clustering is not considered.

In [5], authors addressed the problem of CCA (Control Channel Allocation) in CRNs and clustering problem into instances of a bipartite graph problems, also showed that this mapping allows for a graceful trade of between the cluster size and the set of common channels in each cluster. Hence, they proposed a control channel rotation mechanism that enables control channel migration in case of PR activity; inter cluster communication and adaptation to the temporal variations of spectrum availability.

In [6], the authors proposed that transmitter/receiver pairs randomly in different bands and decide on a common hopping sequence, called the rendezvous channel, until their data exchange is completed. One limitation of this design is that hopping coordination occurs over licensed channels without considering possible interference to PUs. The research is incompetent for cognitive radio networks as the works are based on defined control channel. A cluster-based architecture in considers nodes mobility but the architectures suffers from the frequent re-clustering problems. The latest architectures suggested by authors meet many critical issues for the development of cognitive radio networks. However, a robust architecture for CRN considering spectrum awareness and nodes mobility is still due.

In this paper, re-clustering of various unit in order to save time and bandwidth which provide best solution for proper utilization of radio spectrum is specified. Due to this energy saving concept is invented in cluster based architecture [7].

Ad-hoc network architecture in CRs is self-organize in nature. The network is ad hoc because it does not rely on a preexisting infrastructure such as routers in wired networks or access points in managed (infrastructure) wireless networks. Without allowing each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. Ad hoc networks can use flooding for forwarding data. The spectrum is divided into non-overlapping orthogonal channels. PU's licensed spectrum is accessible to SUs if PU's transmissions are absent. SU can detect PU's and can measure available spectrum by sensing idle frequency bands using methods such as energy detectors, cyclostationary feature extraction or Eigenvalue-based feature extraction. The proposed clustering mechanism is independent on any particular primary user activity model. However, in order to provide an analytical evaluation of the clustering performance, here consider Semi-Markov ON-OFF model, where PU traffic on a given channel is modeled after a semi-markov ON-OFF. Process where the state of a channel is either busy (ON) or idle (OFF).

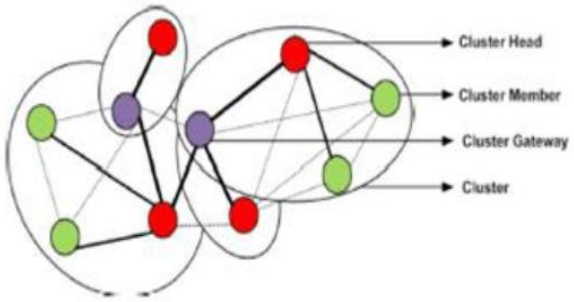

Figure 1: Proposed Cluster Based Cognitive Radio Architecture

When forming an ad-hoc cognitive radio network (CRN), one of the fundamental tasks is to determine the neighbors of each node and channels that can be used to communicate among neighbors. Specifically in CRN, not only the network is multi-channel but the channels available at different nodes may be different. In order to exchange information regarding spectrum availability, CR's need to discover their neighboring network topology that is usually done during the neighbor discovery phase. With the deficiency of a global common control channel, CR's need to alter different

3. CONCEPTS OF CLUSTER BASED ARCHITECTURE IN WANET

Channels to discover the neighbors. In the given protocol, CR's use the PU's signal to obtain a common time reference to be synchronized. In the neighbor discovery phase, time slots are longer enough to be able to discover all the neighboring nodes that are operating on the same channel. Once all CR's sense the free spectrum and prepare the accessible channel set, CR's need to arrange the channels according to the specified orientation. According to architecture, node needs to reshuffle the channels for transmission to even-odd basis, where the next least valued even channel follows every odd value channel.

The definition of a neighbor discovery strategy suitable for multi hops CR networks. The cluster-based architecture that allocates different channels for control at various clusters in network. The clustering problem is formulated as bipartite

graph problems, for which a class of algorithms is suggested that provide different tradeoffs between two confecting factors: number of common channels in a cluster and the cluster size. The clusters are guaranteed to have a desirable number of common channels for control which facilitates for graceful channel migration when primary radio (PR) activity is detected without the need for frequent re-clustering. Once the neighbor discovery is completed, nodes exchange their accessible channels set based on the sensed spectrum availability and generates its neighbor list. Afterwards the cluster formation phase starts. Cluster formation is defined as a maximum edge biclique problem. At first, based on neighbor list and accessible channels set, every CR's creates an undirected bipartite graph.

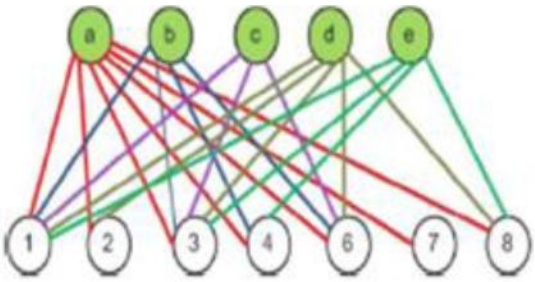

Figure 2: Biclique Graph Constructed by Node A

4. RESULT ANALYSIS

In the dynamic environment, number of clusters varies with varying number of nodes as shown in Fig.3. For a 7-node network, 2 clusters are formed in the dynamic cluster based architecture. With a growing number of 500 nodes, 23 clusters are constructed. It shows that number of constructed clusters for the architecture depends on the nodes in the network.

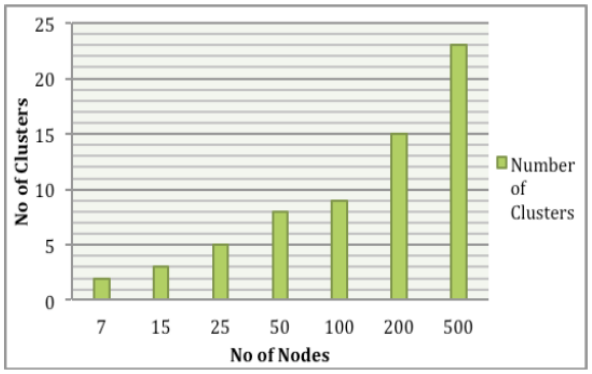

Figure 3. Clusters number with respect of number of nodes

5. CONCLUSION

The non cluster architecture cannot protect against failures caused by viruses, software corruption or human error. Single hop system where the multi hop communication is absent. The energy competence CRN architecture presented in proposes a link between the coordinator and the Geo locater, where the Geo locater limits the architecture to be immobile. The specified architecture breaks the CRN ad-hoc architecture into clusters. Nodes in the network are considered as dynamic. So that the energy efficiency can be achieved. A Server cluster provides high availability by making application software and data available on several servers linked together in a cluster configuration. Suppose one server stops functioning a process called fail over automatically shifts the workload of the failed server to another server in the cluster & the fail over process is designed to ensure continuous availability of critical applications and data.

6. REFERENCES

[1] J. Mitola and G. Maguire, "Cognitive Radio: Making Software Radios More Personal", IEEE Personal Communications, Vol. 6, pp. 13-18, 1999.

[2] Y. Chen, A. Liestman and J. Liu, "Clustering algorithms for ad hoc wireless networks", IEEE Conference on communications (ICC'97), Vol.1, pp. 114-128, June, 2004.

[3] D. Cabric, S. Mishra, D. Willkomm, R. Brodersen & A. Wolisz, "A Cognitive Radio Approach for Usage of Virtual Unlicensed Spectrum", 14th IST Mobile and Wireless Communication Summit, 2005.

[4] I. Akyildiz, W. Lee, M. Vuran and S. Mohanty, "Next Generation Dynamic Spectrum Access/Cognitive Radio Wireless Networks: A Survey", Computer Networks, Vol. 50, no. 13, pp. 2127-2159, 2006.

[5] Sisi Liu, Loukas Lazos and Marwan Krunz, "Cluster-based Control Channel Allocation in Opportunistic Cognitive Radio Networks" IEEE Conference on Sensor and Ad Hoc Communications and Networks (SECON), Rome, Vol. 20, pp. 479-492, June, 2009.

[6] A. C. Talay and D. T. Altilar, "United nodes: cluster-based routing protocol for mobile cognitive radio networks", Communications, IET Vol.5, Issue:15, pp. 529-542, April, 2011.

[7] Nafees Mansoor, A.K.M.Muzahidul Islam, Mahdi Zareei, Sabariah Baharun, and Shozo Komaki, "Spectrum Aware Cluster-Based Architecture For Cognitive Radio Ad-Hoc Networks", 2nd International Conference on Advances in Electrical Engineering, ICAEE, Vol. 9, pp. 181-185, December, 2013.