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Implementation of IEEE 802.22 Cellular Networks for Mobility Management

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***Abstract*—Cognitive radio (CR) networks have been proposed as a solution to both spectrum inefficiency and spectrum scarcity problems. However, they face several challenges based on the fluctuating nature of the available spectrum, making it more difficult to support seamless communications, especially in CR cellular networks. In this paper we use Disaster Information Network, because it solves single wireless network problems like characteristics of wireless frequency or congestion form the use of same radio frequency. However, even if Disaster Information Network consisted of Cognitive Wireless Network, some of wireless node might be broken after severe disaster is happened. Therefore, it is necessary to consider about additional functions which the system never die. We also introduce Satellite System for optimal transmission control method in Cognitive Wireless Network in order to consider with severe disaster. Proper wireless link and route selection is held by AODV value methods for optimal transmission control in Cognitive Wireless Network.**

In the simulation, ns2 are used for the computational results to the effectiveness of the suggested transmission methods in the hybrid system of cognitive wireless and satellite network system.

Index Terms—Cognitive radio, spectrum pool, handoff, inter cell resource allocation, spectrum mobility management, user mobility management, AODV

INTRODUCTION

Wireless spectrum is currently regulated by governmental agencies and is assigned to license holders or services on a long-term basis over vast geographical regions. Recent research has shown that a large portion of the assigned spectrum is used sporadically leading to under utilization and wastage of valuable frequency resources. To address this critical problem, the Federal Communications Commission (FCC) has recently approved the use of unlicensed devices in licensed bands. This new area of research foresees the development of cognitive radio (CR) networks to further improve spectrum efficiency. The basic idea of CR networks is that the unlicensed devices (also called CR users) share the licensed spectrum without interfering with the transmission of other licensed users (also known as primary users). If this band is found to be occupied by a licensed user, the CR user moves to another spectrum hole to avoid interference, which is referred to as spectrum mobility.

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This concept has been widely investigated to solve the exponential data traffic growth in the current cellular network. The main difference between classical and CR cellular networks lies in spectrum mobility, which gives rise to a new type of handoff in CR cellular networks, the so-called spectrum handoff.

IEEE 802.22, the first CR standard for CR networks, maintains a backup channel list so as to provide the highest probability of finding an available spectrum band within the shortest time. In [8], an algorithm for updating the backup channel list is developed to find the idle spectrum bands fast and reliably by cooperating with neighbor CR users. However, recent research mentioned above has mainly focused on spectrum mobility, but does not consider the effect of mobile users across multiple cells.

Disaster Information System needs a robust Never Die Network (NDN) [1] which will be unaffected by any changes in environment after severe disaster. In order to solve this problem, we introduce the Combination of Cognitive Wireless Network (CWN) and Satellite System for Disaster Information System. CWN is consisted of combining with multiple LANs with different transmission characteristics such as IEEE802.11, IEEE802.16, and cellular network. These wireless links are selectively switched by the distance between the wireless network nodes, power density, transmission frequency and their cover area, network transmission speed, and so on. Also, suitable communication environment can be provided even though the communication environment has been changed. IEEE 802.22, the first CR standard for CR networks, maintains a backup channel list so as to provide the highest probability of finding an available spectrum band within the shortest time [3]. In [8], an algorithm for updating the backup channel list is developed to find the idle spectrum bands fast and reliably by cooperating with neighbor CR users. However, recent research mentioned above has mainly focused on spectrum mobility, but does not consider the effect of mobile users across multiple cells.

The CR cellular network is supposed to be deployed in several ways. First, it can be applied to the unused TV spectrum bands, the so-called TV white spaces, as the FCC recently allowed unlicensed devices to use them [5], [14]. Second, while the ultra broadband cellular technology such as 3rd Generation Partnership Project (3GPP) Long-Term Evolution-Advanced (LTE-Advanced) requires up to 100 MHz per channel [15], the amount of wideband spectrum is limited. The CR technology enables bandwidth aggregation by sharing spectrum owned by other cellular operators, or opportunistically utilizing unused spectrum bands licensed to other services such as digital TV, and public safety [16].

A unified mobility management framework is defined so as to support diverse mobility events in CR networks, consisting of intercell resource allocation, spectrum mobility management, and user mobility management functions. Through intercell resource allocation, each cell determines its spectrum configuration to improve mobility as well as total capacity. To support spectrum mobility while maintaining maximum cell capacity, the spectrum mobility management function determines a proper handoff type and target cell for CR users experiencing PU activities by considering both spectrum utilization and stochastic connectivity models. On the other hand, user mobility management mainly focuses on spectrum heterogeneity in space, and offers a switching cost-based handoff decision mechanism to minimize service quality degradation in mobile users.

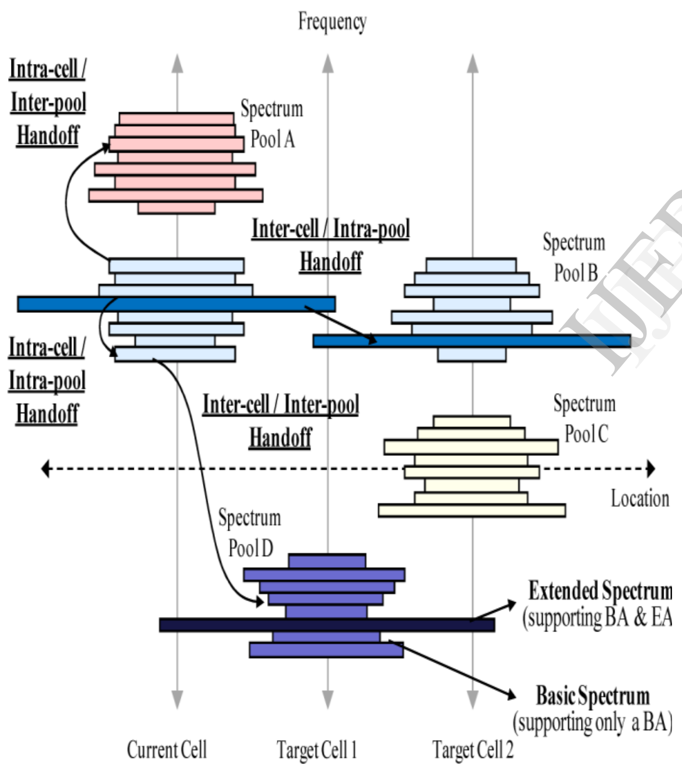

Fig. 1. Different handoff types in CR networks.

Handoff Types

Mobility management in classical cellular networks is closely related to user mobility. However, CR networks have another unique mobility event, the so-called spectrum mobility. By taking into account both mobility events based on the proposed network architecture, we define four different types of handoff schemes as shown in Fig. 1:

- **Intracell/intrapool handoff**. The CR user moves to a spectrum band in the same spectrum pool without switching a serving BS.
- **Intercell/intrapool handoff**. The CR user switches its serving BS to a neighbor BS without changing the spectrum pool.
- **Intercell/interpool handoff**. The CR user switches its serving BS to a neighbor BS, which has a different spectrum pool.
- **Intracell/interpool handoff**. The CR userchanges its spectrum bands from one spectrum pool to another within the current cell. Each handoff type is related to different mobility event, and its performance is mainly dependent on both network and user conditions, such as resource availability, network capacity, user location, etc. Thus, CR networks require a unified mobility management scheme to exploit different handoff types adaptively to the dynamic nature of underlying spectrum bands. In the case of user and spectrum mobility events, CR networks decide on a proper handoff type for their mobile users by performing user and spectrum mobility management functions, respectively. According to the decision, CR users need either to select a target cell (cell selection) or to determine the best available spectrum (spectrum allocation).

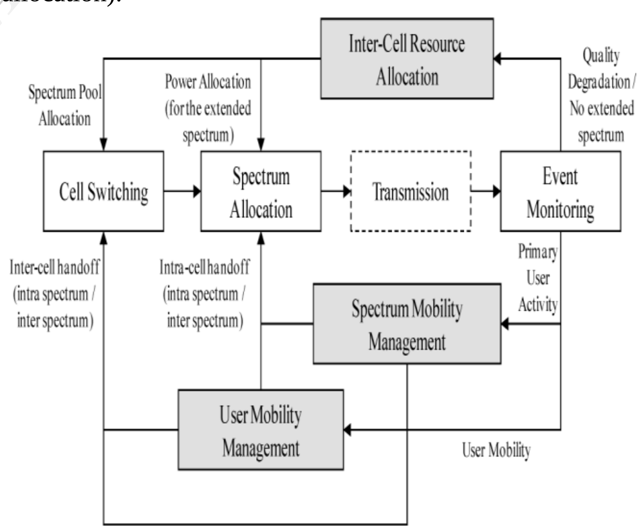

Fig. 2. The mobility management framework.

Spectrum Handoff Modeling

According to the mobility events, each handoff scheme necessitates different strategies as follows:

Proactive handoff. When CR users detect handoff events, they perform handoff procedures while maintaining communications. After CR users make all decisions on the handoff, they cut off communication channels and switch to a new spectrum band or a new BS. User mobility and cell overload are the examples of proactive handoff events. Most of classical handoff schemes are based on the proactive approach.

Reactive handoff. CR users should stop the transmission immediately in the reactive handoff event. Then, they make decisions and perform the handoff. As a result, this handoff has an additional handoff delay, unlike the proactive approach.

SPECTRUM MOBILITY MANAGEMENT IN COGNITIVE RADIO NETWORKS

Spectrum mobility is the unique characteristic in CR networks. When primary users appear in the spectrum, CR users generally change its spectrum band without switching the BS. However, since CR networks have time varying spectrum availability, each cell may not have enough spectrum band to support current users. To solve this problem, an admission control scheme is proposed in [27]. However, in the proposed architecture, CR users can have another option, cell switching, because of the hierarchical spectrum. Here, we propose a spectrum mobility framework by considering both spectrum and cell switching methods. When the PU activity is detected in the cell, the BS needs to check if it has enough spectrum resource for intracell/intrapool handoff. If the cell has enough spectrum resource, the BS performs the intracell/intrapool handoff for all users requiring new spectrum bands (Type 1). Otherwise, some of current users are forced to move to the neighbor cells. If the PU activity is detected in the extended spectrum, all users in EA need to perform intercell/ interpool handoff (Type 2) regardless of current spectrum resource since they cannot find other available spectrum bands for switching in that area. After the user selection, the selected users need to find the proper target cell. Unlike the classical handoff, CR users cannot observe the signal strength from other neighbor cells while maintaining the connection to current cells.

Method used:

As the previous research [2], the cognition cycle is introduced to our proposal method. The cognition cycle is consisted of three stages; the observation stage, the decision stage, and the acting stage. Each stage is continuously cycled in order to perform link or route configuration.

A. Observation Stage

Network data is continuously observed through each layer at this observation stage. Wireless network condition varies depending on the movement of nodes or radio interference. Therefore, CWN needs to parse these stimuli to select the available solution for providing the performance from user requests. In this paper, our supposed system observes application types in order to decide user policy which is depending on the specific services or media. Also, physical characteristics like coding, PER, throughput, delay, jitter, BER, and electric field strength are observed. Those parameters are used for understanding stimuli from user environment.

B. Decision Stage

Decision making is held to maintain QoS in this decision stage. When the network condition is changed, the proposal system will seek the suitable link and route by the calculating from the values of network characteristics like user policy, throughput, BER, and so on. We introduce AHP for the calculation of link, and extend AODV for the decision of suitable route.

1) Link Selection

AHP is one of multi-attribute decision making and structured techniques for dealing with complex decisions. It was developed by Thomas L. Saaty in the 1970s [6]. By structuring a decision problem hierarchy, AHP provides us quantifications of its elements and evaluations of alternative solutions. For example, when the suitable link between neighbor nodes is solved by AHP, the hierarchy of the problem is first structured. That is, goal (To decide suitable link of wireless node), criteria (network characteristics such as delay, PER, throughput, and so on), and alternatives (wireless links such IEEE802.11b, IMT2000, and satellite network, and so on). Then, paired comparisons of criteria and alternatives are calculated for the priority value on AHP. IEEE802.11a is selected for suitable wireless link.

2) Route Selection

Our proposed system would change network route if the suitable link is not found or minimum requirement for user is not satisfied. When a network route needs to change, we introduced extend AODV with Min-Max method for the decision of suitable route. We propose to add the link values by AHP for RREQ,and those are set in the routing tables. When RREQ packets reaches to a destination node, routing table with AHP values is listed. RREQ packets collected within certain time in order to make possible routing list, and Min-Max method is used for the selection of suitable route. Minimal values of AHP are firstly selected within each possible route, and then a max value of those minimal values is selected as a suitable route. RREP packet is returned through this selected route, and suitable route is selected and reconfiguration is held in acting stage.

C. Acting Stage

After the decision making of the suitable link or the route, a link or route will be changed in the acting stage. In the proposed system, a control wireless link is assumed to use for a transmission of the control information. A control link is set to the lowest frequency bandwidth, and a node sends the information with a suitable link to the next node through the control link. Then, both nodes act the link change at the same time. A route change also acts as the same way of a link change.

The cognition cycle goes back to the observation stage after the acting stage, and it works to a link or route change relatively examined to evaluate the effectiveness of our suggested method. IEEE802.11a, IEEE802.11b, IEEE802.11g is used as the wireless links, and Satellite System of Ground- Satellite Link as ns2 prepared is used as the control link. The number of wireless nodes is set to two, and every node has the same wireless links. Then, only a source node moved with the same speed, and video data were transmitted from the source node to the destination node. During the simulation, access points were stopped and alternative satellite transmission is held until connection is recovered.

Conclusion

In this paper, Never Die Network with combination of Cognitive Wireless Network and Satellite System is proposed. In case of our proposed Disaster Information System, this combination is supposed to be effective because data transmission keeps even after severe disaster happened. Wireless links are selectively switched by user policy. Also, suitable communication environment can be provided even though the communication environment has been changed. To realize these functions, extend AHP with Min-Max method and extend AODV with GPS method are proposed for wireless link and route selection in this paper. Also, we proposed that Satellite System provides the function of checking wireless nodes' alive and their locations, reconstructing the topology, and alternating data transmission if there is no possible activate nodes.

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