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Cache Based D² CARP Routing

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Abstract

D^2 CARP exploits spectrum diversity by establishing multi-channel reverse routes in RREQ phase. The existing technique is modified by introducing a concept of cache. Here the last utilized channel by PU will be remembered and the PU will firstly opt for the same channel. If the channel is not available then it proceeds normally. The proposed process reduces the delay as shown in by the simulation results. The simulation results confirm the better performance of the proposed algorithm as compared to existing algorithm.

Keywords: *D^2 CARP, Cognitive Radio Network.*

1. Introduction

Cognitive Radio (CR) techniques are recently gaining more and more attention. The fixed spectrum allocation policy allows only licensed users to access the allocated frequency band(s). However, spectrum usage census exhibits a large variation in both temporal and spatial dimensions. This inefficient usage can be overcome by a new communication paradigm, CR techniques. CR or dynamic spectrum access technologies opportunistically utilize spectrum holes or white spaces, which mean frequency bands that show a lack of activities of licensed users. A CR station is capable of switching between bands (or channels) in the environments of dynamic spectrum usage by measuring the propagation characteristics, signal strengths and transmission quality of different bands. Research efforts on CR networks cover a wide range of areas, including spectrum analysis, channel estimation, spectrum sharing, medium access control (MAC), and routing [1].

CR technology will have significant impact on upper layer performance in wireless networks, particularly in mobile ad hoc networks (MANETs), which enable wireless devices to dynamically establish networks without necessarily using a fixed infrastructure. Certainly, issues in non cognitive MANETs in general are still of interest in the CR paradigm. However, some distinct characteristics of CRs introduce new nontrivial issues to CR-MANETs [2]. Although some efforts have been done to the medium access control (MAC) layer issues, routing is still one of the particularly important networking issues in CR-MANETs. From a routing perspective, it is expected that data packets are routed via a stable and reliable path to avoid frequent rerouting problems since frequent rerouting may induce broadcast storms to the network, waste the scarce radio resources, and degrade end-to-end network performance such as throughput and delay. Compared with classical MANETs, a path in CRMANETs is particularly unstable since it is affected not only by the mobility of CUs but by the interference to PUs as well.

Cognitive Radio Ad-Hoc Network (CRAHNs) [3] is a new developed technology of wireless communication. The difference to traditional wireless networks is that there is no need for established infrastructure. Since there is no such infrastructure and therefore no preinstalled routers which can, for example, forward packets from one host to another, this task has to be taken over by participants, also called mobile nodes, of the network. Each of those nodes takes equal roles, what means that all of them can operate as a host and as a router. Traditional wireless networks are need some improvement due to some factors such as security, power control, transmission quality and bandwidth optimization. To solve problems like maintenance and discovery of routes and topological changes of the network is the challenge of Ad-Hoc Networking. We have formed cognitive radio adhoc network by using user nodes and communication channels as shown in figure 1.

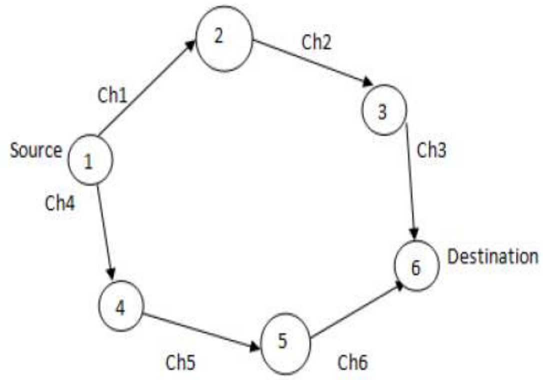

Figure 1: Cognitive Radio Ad-Hoc Network [3]

Cognitive radio (CR) paradigm proposes to enhance the spectrum efficiency by allowing unlicensed users, referred to as cognitive users (CU_s), to utilize dynamically and opportunistically the spectrum assigned to the primary users (PU_s) when it is temporarily not used. To reach this aim, CU_s must be able to change their transmission and reception parameters to communicate with each other without causing interference to the PU_s.

The uncertain availability of the spectral resource imposes unique challenges in cognitive radio networks (CRN_s). Specifically, in cognitive radio ad-hoc networks ($CRAHN_s$), the distributed multi-hop architecture, the dynamic network topology and the spectrum availability varying in time and space are some of the key distinguishing factors. Due to these factors, one of the critical issues in CRAHNs is to counteract the performance degradation experienced by CUs because of the activity of PUs. Since such an activity varies both in frequency and space domain, incorporating diversity techniques in routing can provide an effective solution to address this issue [4].

2. Existing Solutions

1. A path-diversity routing protocol operating only on infrastructure-based network.
2. Another path-diversity based routing protocol is for underlay CRNs. In this, solution we assume a specific distribution of PUs and CUs in the network, which is not reasonable in CRAHNs.
3. A source-based routing protocol with path diversity for CRNs, but its application in CRAHNs is not reasonable due to high packet header overhead.
4. Another protocol, referred to as cognitive ad-hoc on demand distance vector (CAODV) exists. In this work, it exploits individual path and spectrum-diversity.

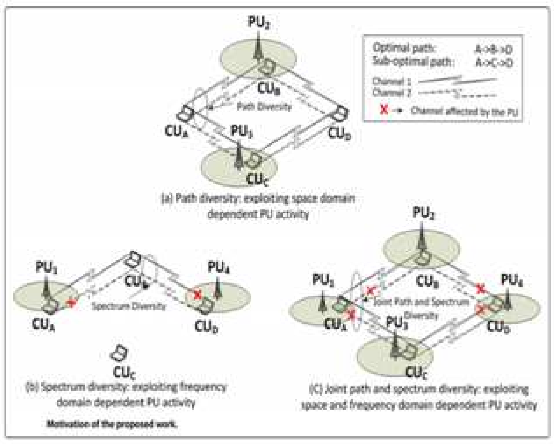

Figure 2: Motivation of Proposed work

2.1 Path Diversity

Path diversity allows CU_s to switch dynamically among different paths for communicating with each other in presence of space-domain-dependent PU activity.

Figure 1a shows how the PU activity can affect a routing process whenever it varies in space domain. Here, CU_B and CU_C are under the transmission range of two different PUs. By exploiting the path diversity, CU_A can reach CU_D through the optimal path a $CU_A \rightarrow CU_B \rightarrow CU_D$ (when PU_2 is not active); or the sub-optimal path $CU_A \rightarrow CU_C \rightarrow CU_D$ (when PU2is active but PU3is not), without the need of a new route discovery process.

However, by only exploiting path diversity, CU_A cannot reach CU_D when the effect of PU activity varies in frequency domain, as it is depicted in Figure 1b.In this example, CU_A must be able to establish paths through different spectrum bands to communicate with CU_D. Clearly, this requires to exploit spectrum diversity, as it will be described in Section “Spectrum diversity”. Therefore, such an example shows that the performance degradation due to the activity of PUs can not be counteracted by the only exploitation of path diversity.

2.2 Spectrum Diversity

Spectrum diversity allows CUs to switch dynamically among different channels for communicating with each other in presence of frequency-domain-dependent PU activity.

Figure 1b shows how the PU activity can affect a routing process whenever it varies in frequency domain. Here, CU_A and CU_D are partially affected by two different Pu_s on channel 2 and channel 1, respectively. By exploiting the spectrum diversity, CU_A can still communicate with CU_D through the optimal path composed by link $CU_A \rightarrow CU_B$ (on channel 1) and $CU_B \rightarrow CU_D$ (on channel 2) without interfering the PU_s. However, the performance degradation due to the activity of a PU, which fully affects a path, can not be counteracted by the only exploitation of spectrum diversity [5].

2.3 Joint Path and Spectrum Diversity

Path diversity cannot counteract PU activity that varies in frequency domain, whereas spectrum diversity cannot counteract PU activity that varies in space domain. Differently, joint path and spectrum diversity can provide a promising solution that can solve both the above mentioned limitations.

In fact, joint path and spectrum diversity allows CU_s to switch dynamically among different paths and channels for communicating with each other in presence of frequency- and space-domain-dependent PU activity.

Figure 1c shows how the PU activity can affect a routing process whenever it varies in both space and frequency domain. Here, the existing work assume that CU_A, CU_B, CU_C and CU_D are under the transmission range of four different PUs. More in detail, CU_A and CU_D are partially affected by PU_s on channel 2 and channel 1, respectively, and CU_B CU_C are fully affected by $PU_2$and PU_3,respectively. Due to the benefit of jointly exploiting path and spectrum diversity, CU_A can communicate with CU_D through the optimal path composed by link $CU_A \rightarrow CU_B$ (on channel 1) and $CU_B \rightarrow CU_D$(on channel 2) when PU_2 is not active; or the sub-optimal path composed by link $CU_A \rightarrow CU_C$ (on channel 1) and $CU_C \rightarrow CU_D$ (on channel 2) when $PU_2$is active but $PU_3$is inactive.

Thanks to both the path and spectrum diversity, CU_A can now reach CU_D counteracting the effect of PU activity. Dual diversity cognitive ad-hoc routing protocol Dual diversity cognitive ad-hoc routing protocol (D^2 -CARP) is a routing protocol designed for CRAHNs, which takes into account the local observations of PU activity. The main feature of D^2 CARP is to jointly exploit the path and spectrum diversity in routing. This feature allows CUs to switch dynamically among different paths and channels accounting for the local route decisions during the data forwarding time. As a consequence, D^2 CARP is able to adapt to dynamic scenarios caused by PU activity

CARP starts with a Route REQuest (RREQ) packet broadcasted by the source to neighbors on each channel not affected by a PU activity, and it ends with one or several routes set up after the reception of Route REPlies (RREPs) from the destination. At the end of the route discovery procedure, the source can take advantage of joint path and spectrum diversity by means of multi-path and multi-channel routes. In a situation, where PU occurs while the channel is occupied by a CU, it vacates the channel and looks for another available channel for continuing the communication with its neighbor. If there is no free channel for its neighbor then CU recalls the route discovery process.

3. Proposed Algorithm

The existing technique is modified by introducing a concept of cache. Here the last utilized channel by PU will be remembered and the PU will firstly opt for the same channel. If the channel is not available then it proceeds normally. The proposed process must reduce the delay i.e. enhanced performance. The routing algorithm is defined below:

1. Node A receives RREQ from node B through channel c.
2. **if** channel c is free from PU **then**

3. **if** it is the first RREQ for A **then**
4. create a reverse route through the channel c broadcast RREQ through the channels free from PU and cache the route;
5. **else if** it is additional RREQ from B but on different channel then create a reverse route through that channel;
6. **else if cache route available then** transmit data using the cache route.
7. **Else If** it is the new or better RREQ **then**
8. update a reverse route through the channel c;
9. **end if**
10. **if** A receives RREQ from multiple paths **then**
11. if cache route available then transmit RREQ using the route
12. else A discards the RREQ;
13. **end if**
14. **If** A has valid route for destination **then**
15. Send reply using the cache route

End if

The proposed technique is implemented in NS-2.35 Simulator in Linux environment. Nam is a Tcl/TK based on animation tool for viewing the network simulation and the packet traces it supports topology layout and the packet level animation and data inspection tools. In Network Ani Mator (NAM) began at LBL it has evolved substantially

Table 1: Performance Comparison of Existing Protocol for different Nodes

No. of nodes	PDR	E2E DELAY in ms	Throughput (kbps)
10	84.3762	0.527	1246.40
20	36.1744	0.361	8912.36
30	14.1103	0.568	17514.72
40	11.5124	0.467	15272.56
50	39.7018	0.155	11951.14

Table 2: Result for Proposed protocol for different Nodes

No. of nodes	PDR	E2E DELAY in ms	Throughput (kbps)
10	94.4772	0.407184	1946.40
20	46.2754	0.241276	9672.36
30	15.2113	0.446516	18244.82
40	21.6134	0.365294	15972.76
50	49.8028	0.23591	12654.34

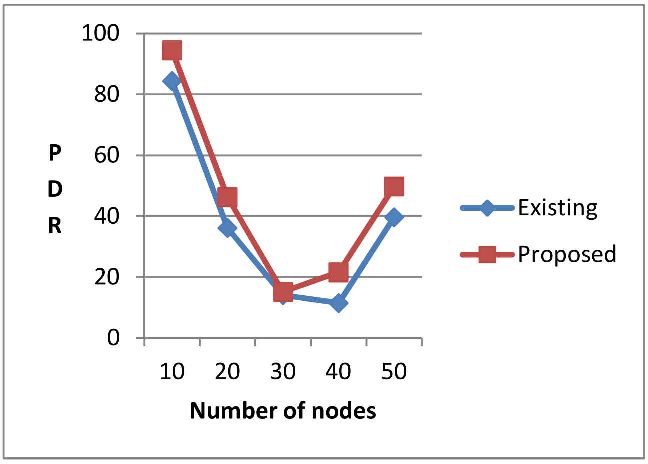

Figure 3: Comparison OF PDR

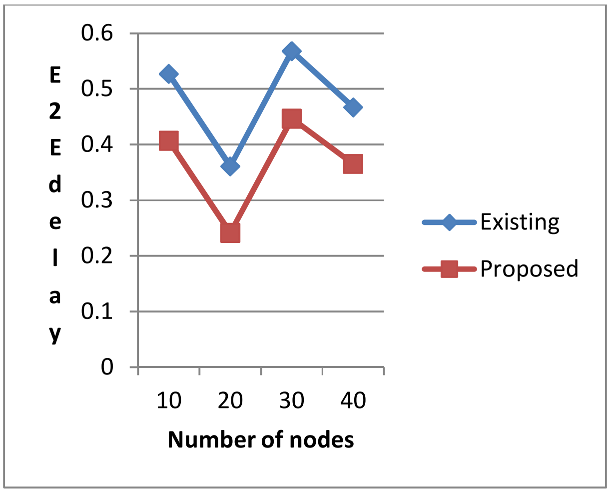

Figure 4: Comparison OF E2Edelay

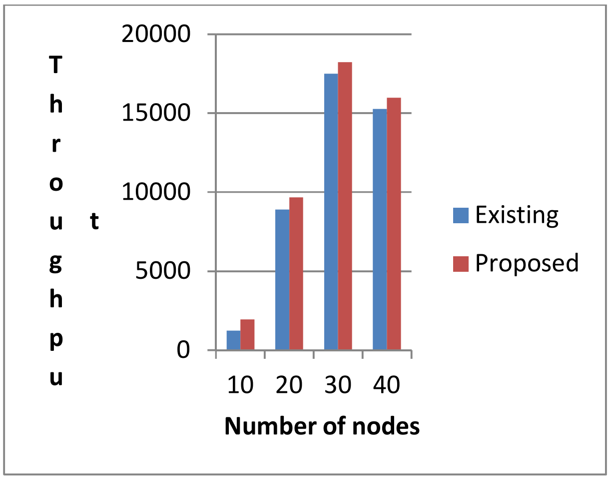

Figure 5: Comparison OF Throughput

The graphical and the tabular comparison show that the proposed protocol has increased PDR for the 10, 20, 30,40 as well as for 50 nodes than the existing protocol. The decrease in end 2 end delay and normalized routing load is also analyzed. This performance shows the effectiveness of the proposed protocol as compared to the existing protocols.

4. Conclusion

The paper modified existing technique by introducing a concept of cache. Here the last utilized channel by PU will be remembered and the PU will firstly opt for the same channel. If the channel is not available then it proceeds normally. The proposed process reduces the delay as shown in by the simulation results. The simulation results confirm the better performance of the proposed algorithm as compared to existing algorithm. In future, the algorithm can be extended in terms of security.

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