

An Effective Spectrum Handoff Scheme for Cognitive Radio Ad Hoc Networks

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ABSTRACT- *Cognitive Radio Networks is the main key technology in telecom industry to overcome the disadvantages of static spectrum allocation share and enhance the spectrum utilization through Dynamic Spectrum Access techniques(DSA). One important topic of the development of CRNs is spectrum handoff, which ensures the uninterrupted communication of Secondary Users also called SUs. Two types of spectrum handoff approaches exist, namely the proactive and the reactive spectrum handoff. When the Primary User also called Pus,traffic is high the proactive spectrum handoff approach is more suitable whereas the reactive handoff on light PU traffic achieves better performance. In my thesis I evaluate the use of proactive and reactive spectrum handoff policies in CRNs. Simulations are conducted using NS-3 simulator software tool. To the extent of our knowledge, an extensive CRN simulation regarding spectrum handoff on NS-3 simulator has not been carried out. Furthermore, we implemented a hybrid spectrum handoff scheme that selectively uses either reactive or proactive handoffs, based on PU traffic intensity. In Additionally my scheme adjusts dynamically the SU frame size throughout SU communications, to minimize collisions. Simulations show that the proposed hybrid scheme performs better than the proactive and reactive handoff types. Moreover, the dynamic adjustment of the frame size on cognitive nodes enhances performance noticeably in certain scenarios.*

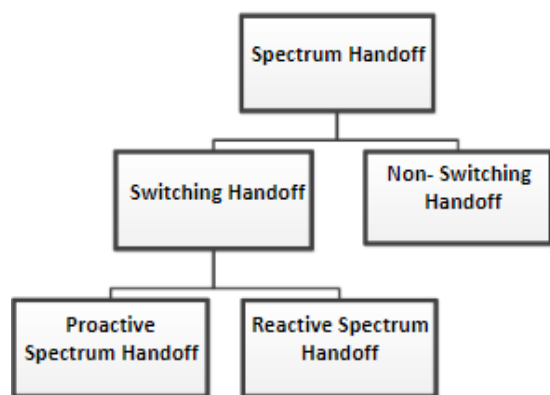
Keywords—*Cognitive Radio Networks; Spectrum Handoff; Frame Size; Primary Users; Secondary Users; Dynamic Spectrum Allocation; Cognitive Radio Ad hoc Network.*

1. INTRODUCTION

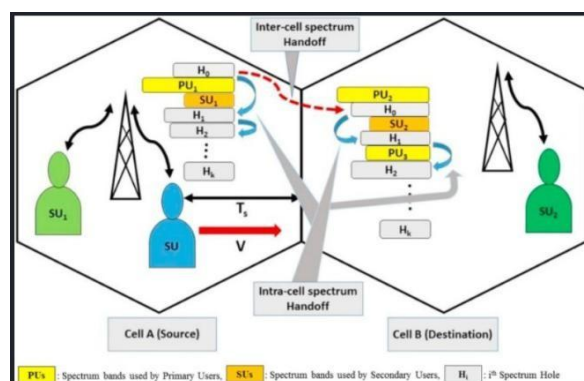
The increasing demands on higher data rates, as well as, the limited availability of radio spectrum have led to the development and continuous research of Cognitive Radio Networks (CRNs). The way radio spectrum is utilized nowadays through fixed licensing via governmental agencies seems to be inefficient and suboptimal. As a result, portions of the radio spectrum, which could be dynamically used to enhance network performance, or deploy more networks in the same geographical area, remain unutilized. To this end, cognitive radio networks using advanced Dynamic Spectrum Access (DSA) techniques are used to overcome fixed spectrum assignments disadvantages. The development of such dynamic networks is possible via the Cognitive Radio (CR), an intelligent network technology that can alter its transmission parameters based on the operating wireless environment. Nodes with CR radios, are Secondary Users (SUs), whereas the licensed Primary Users (PUs) have priority over SUs for accessing the radio spectrum.

Cognitive radio, primary user and secondary user

Cognitive Radio (CR) is one of the technologies that has the potential to alleviate the spectrum scarcity by improving the spectrum utilization and network performance. This is achieved by allowing the Secondary Users (SUs) to access the underutilized licensed spectrum opportunistically. PUs can preempt the SUs any time during the transmission, soon arrival of PUs, SUs have to vacate the current channel.



Classification of Spectrum Handoff



Spectrum Handoff from Cell A to Cell B

2. LITERATURE REVIEW

J. Mitola and G. Q. Maguire, in this study the software radios are emerging as platforms for multiband multimode personal communications systems. Radio etiquette is the set of RF bands, air interfaces, protocols, and spatial and temporal patterns that moderate the use of the radio spectrum. Cognitive radio extends the software radio with radio-domain model-based reasoning about such etiquettes. Cognitive radio enhances the flexibility of personal services through a radio knowledge representation language.

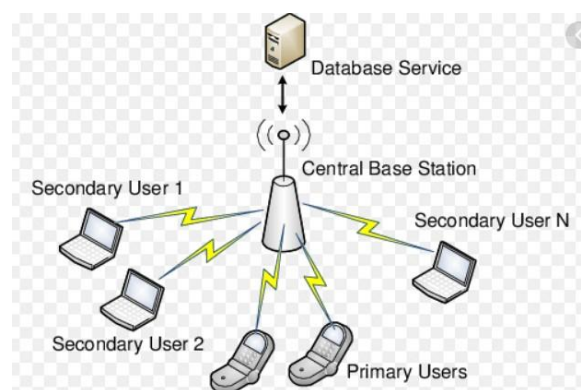
C. Wu, C. He, L. Jiang, Y. Chen, and Q. Shi, We study the frame structure for spectrum handoff in the Rayleigh fading channels and formulate the CSS design problem as a sequential decisionmaking

problem. Considering the secondary link maintenance probability during a frame, we design the optimal CSS length to achieve the maximum energy efficiency/throughput or the minimum energy consumption.

F. Sheikholeslami, M. Nasiri-Kenari, and F. Ashtiani In this thesis, we propose a probabilistic approach in determining the initial and target channels for the handoff procedure in a single secondary user network. To characterize the network, a queuing theoretical framework is introduced, and “stay” and “change” handoff policies are both addressed. The performance of the secondary user in terms of average sojourn and extended service times for secondary connections is analyzed, and convex optimization problems with the objective of minimizing those times as well as analytical solutions are presented. Simulation results confirm the validity of our analytical approach.

3. CENTRALIZED CRN AND TIME SLOTS

Several spectrum handoff approaches have been proposed in the literature. Some of these approaches consider centralized CRN architectures while others CRAHNS.



Centralized CRN architectures

Spectrum Admission Control is investigated by Wu et al. in. SUs form Secondary User Groups (SUGs). DSA is coordinated amongst SUs within the boundaries of a SUG. A SUG base station is also used in this co-operative approach to co-ordinate

further the SUGs with each other. In , an optimal channel sensing sequence scheme is considered for channel selection, to minimize the spectrum sensing overhead of the spectrum handoff procedure. The optimal sequence is determined using dynamic programming with the objective to maximize energy efficiency and throughput. A similar approach is also used in, where optimal probabilistic channel selections are considered to improve spectrum handoffs.

Proposed method

In this paper, I adopt the assumptions using common channel hopping. More specifically, we assume that K SU pairs try to opportunistically access M licensed channels. The co-ordination between the SUs for accessing the available channels is accomplished without the need of a dedicated common control channel (CCC) using common channel hopping. The Request to Send (RTS)/ Clear to Send (CTS) mechanism of IEEE 802.11 wireless networks is used by SUs to access the channels. Additionally, system channels are modeled as ON-OFF sources, where an “ON period” denotes a busy channel and an “OFF period” implies an available channel.

4. DYNAMIC SU FRAME TIME-SLOT

In this section, we describe the dynamic SU FTS scheme proposed for CRAHNs. It has been noted that in cognitive systems, the optimal SU FTS size depends on PU activity and collisions. In particular, it is implied that when PU traffic is low, i.e. OFF periods are frequent and last longer, large frames increase the SU throughput. On the contrary in case of high PU traffic, large frames deteriorate SUs performance since the probability of collisions increases. Accordingly, smaller frames tend to have better probability to pass through the scarce white spaces that are available when PU traffic is high.

Due to the fact that PU traffic intensity is time-varying, a dynamic mechanism dynamically adjusting the FTS size taking into account the traffic intensity of PUs is required.

Consequently, in our model an algorithm is designed and implemented on SUs adapting the FTS length

periodically according to the available PU traffic. In this way, the available radio spectrum is utilized more efficiently.

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Input:  $FTS_{cur}$ ,  $sh\_num$ 
Output:  $FTS_{new}$ 

Calculate TNH using formula (3).
Calculate THR1, THR2 using formulas (4, 5).

If  $sh\_num < THR1$  then
     $FTS_{new} = FTS_{cur} + fts\_add$ 

else if  $sh\_num > THR2$  then
     $FTS_{new} = FTS_{cur} - fts\_sub$ 

else
     $FTS_{new} = FTS_{cur}$ 
end if

if  $FTS_{new} > fts\_max$  then
     $FTS_{new} = fts\_max$ 

else if  $FTS_{new} < fts\_min$  then
     $FTS_{new} = fts\_min$ 

end if
  
```

Algorithm 1 pseudocode

5. HYBRID HANDOFF SCHEME

In this section the proposed hybrid spectrum handoff scheme for CRAHNs is described. In proactive spectrum handoff approaches are evaluated against reactive handoff ones. The obtained results show that in case of light PU traffic, proactive policies have negligible performance gains which sometimes are slightly worse than some reactive approaches. This is explained by the fact that some spectrum handoffs can be falsely triggered, thus resulting in underutilized spectrum holes, affecting negatively SU performance.

Based on the above the hybrid handoff algorithm dynamically determines the spectrum handoff policy that will be followed by SUs depending on the PU traffic.

The algorithm is invoked each time the FTS length is updated. The pseudo code for the handoff scheme policy is shown in Table II. The algorithm is quite

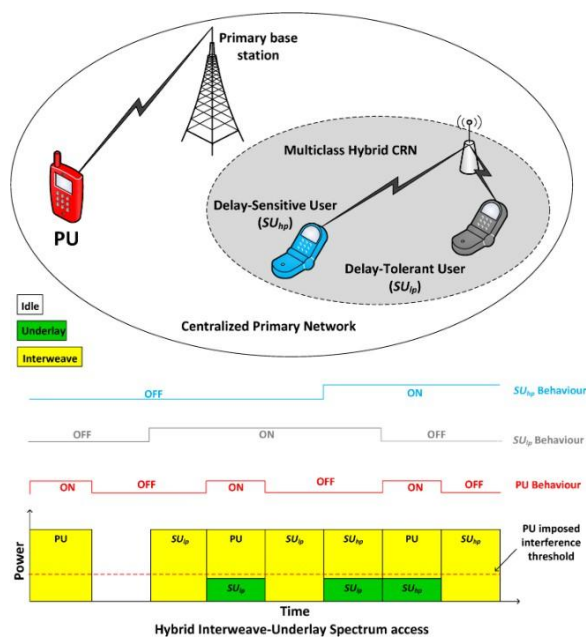
straightforward taking as input parameter the FTSnew value obtained from Algorithm 1.

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Input:  $FTS_{new}$ 
Output:  $sh\_policy$ 

If  $FTS_{new} > hybrid\_thr$  then
     $sh\_policy = reactive\_spectrum\_handoff$ 
else
     $sh\_policy = proactive\_spectrum\_handoff$ 
end if
  
```

It must be noted that in case the algorithm is triggered during an ongoing spectrum handoff, the current handoff is completed based on the previous policy. The new spectrum handoff approach is followed at the next spectrum handoff.



Hybrid Interweave Underlay Spectrum access

6. SOFTWARE USED

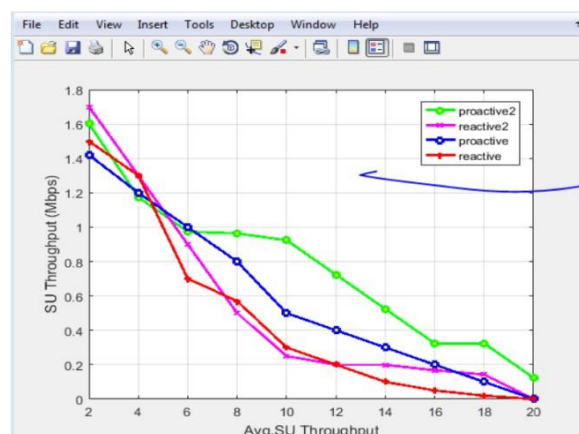
MATLAB

MATLAB is an immoderate-overall performance language for technical computing. It integrates computation, visualization, and programming in clean-to-use surroundings wherein troubles and answers are expressed in acquainted mathematical notation. MATLAB stands for matrix laboratory, and become written first off to offer smooth get entry to

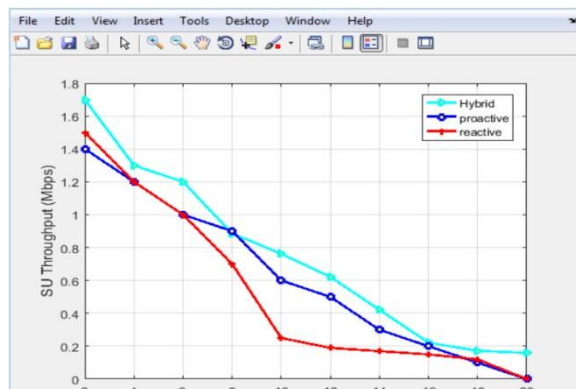
to matrix software application advanced by using LINPACK (linear system bundle) and EISPACK (Eigen system package deal deal deal) responsibilities.

MATLAB is consequently constructed on a basis of sophisticated matrix software program application in which the important element is array that does not require pre dimensioning which to resolve many technical computing issues, especially people with matrix and vector formulations, in a fragment of time. MATLAB talents a own family of programs specific answers referred to as toolboxes. Very important to most customers of MATLAB, toolboxes permit analyzing and utilizing specialised era. These are complete collections of MATLAB features (M-documents) that growth the MATLAB environment to remedy unique commands of problems. Areas in which toolboxes are available embody sign processing, manipulate device, neural networks, fuzzy appropriate judgment, wavelets, simulation and plenty of others.

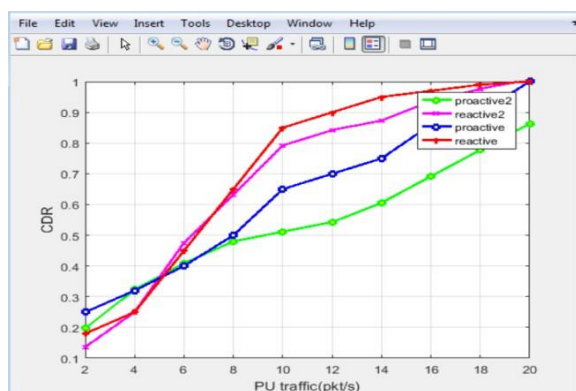
7. SIMULATION RESULT



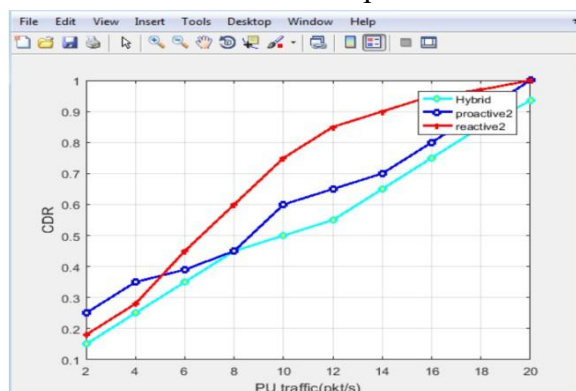
Avg. SU Throughput



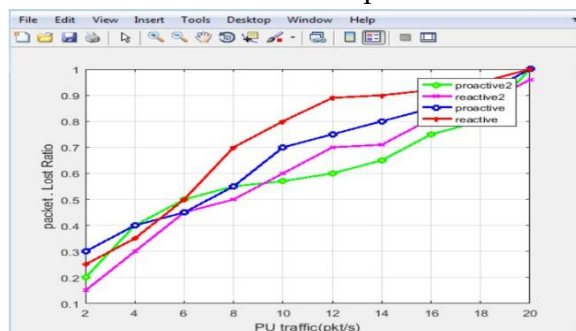
PU Traffic



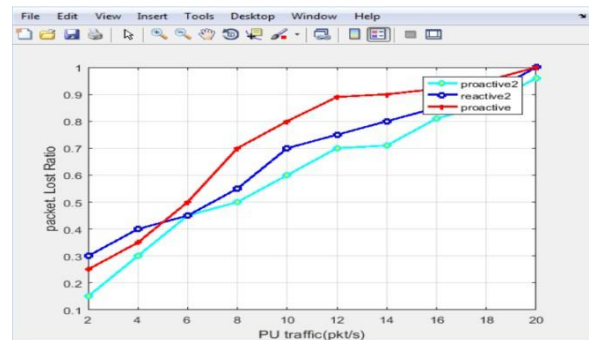
Communication Disruption Ratio



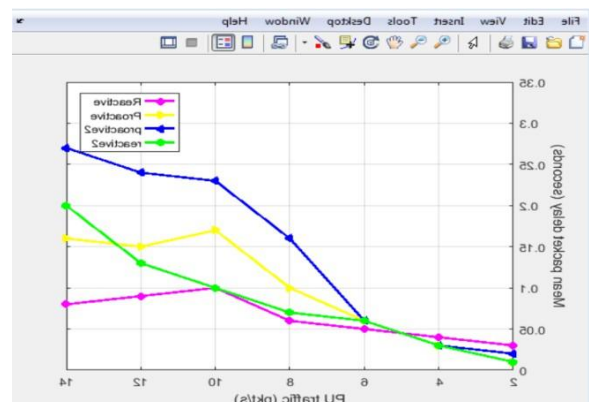
Communication Disruption Ratio



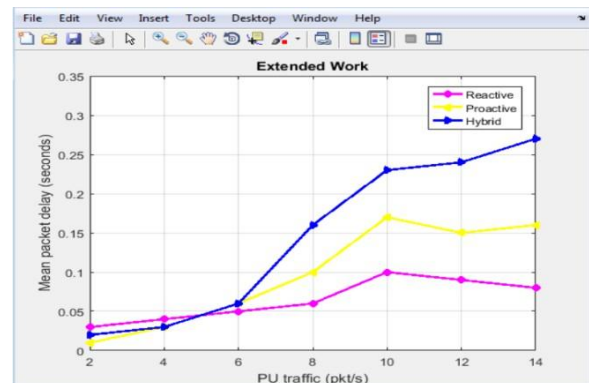
SU Packet Loss Ratio



SU Packet Loss Ratio



SU Mean Packet Delay



SU Mean Packet Delay

8. CONCLUSIONS

In this thesis, we propose a hybrid handoff scheme for CRAHNS which takes into account the varying PU traffic intensity. The proposed hybrid handoff scheme adaptively uses the best handoff scheme, i.e. reactive or proactive, as well as updates the SU frame timeslot periodically, considering the PU traffic

intensity. Simulation results show that the new handoff scheme improves the achieved SU throughput, as well as minimizes communication disruption ratio. This makes spectrum handoff interruptions less noticeable to SU nodes. Also the introduced network latency remains at an acceptable level, considering the increased PU traffic and the existing time varying spectrum opportunities.

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