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RTCP CRAHN: A Renovated Transport Control Protocol for Cognitive Radio Ad Hoc Networks

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Abstract: Cognitive Radio networks take into consideration about the users to transmit in the licensed spectrum bands, as long as the capability of the licensed User's band is not degraded. Meanwhile, variation in vacant spectrum with time and frequent spectrum sensing undertaken by the cognitive radio users has a noticeable effect on the upper layer protocol capabilities, such as at the transport layer. During the allotment of unlicensed users there occurs a scheduling problem which increases the delay. This paper investigates the scheduling problem, and proposes RTCP CRAHN, a TCP-friendly protocol. A scheduling algorithm is being proposed to decrease the delay and increase the throughput. An analysis of the expected throughput in TCP CRAHN is provided, and simulation results reveal significant improvements by using our approach.

Keywords**:** *Cognitive radio, scheduling, licensed user, spectrum sensing, TCP*

1. INTRODUCTION

New wireless technologies are rapidly permeating all aspects of commercial and social life, thus ever increasing the demand for higher bandwidth availability under heavy traffic loads. These technologies must co-exist in the same RF spectrum in a non-interfering manner. The prevailing policy for managing this co-existence of multiple wireless technologies in the RF domain is to statically allocate the available spectrum. A static allocation separates different RF services in frequency, for the purpose of alleviating interference and contention, while providing quality of service. All useful spectrums from 3 KHz to 300GHz are already licensed for exclusive use to various entities with only a very small portion of it left for unlicensed use. Because the spectrum is already allocated, new wireless technologies find it increasingly hard to operate in unlicensed bands, where they face significant contention and interference from other services. This situation is typically termed as spectrum scarcity, referring to the unavailability of any useful spectrum bands that can be allocated.

However, studies of the spectrum scarcity problem by various regulatory bodies around the globe, including the Federal Communication Commission in the United States of America and Of Com in the United Kingdom have shown that this problem is the artifact of the spectrum management policy. Further, these studies indicate the under utilization of the already allocated spectrum. In fact, according to the FCC, the temporal and geographical variations in the utilization of the assigned spectrum range from 15% to 85% the signal strength distribution over a large portion of the wireless spectrum. Defined radios, also known as Cognitive Radios, named due to their sensing and adaptability capabilities. According to a CR is a radio that can change its transmitter parameters based on interaction with the environment in which it operates.

By this definition, a CR should have the following capabilities Cognitive capability: This refers to the ability of the CR to sense and capture spectrum-related information such as the set of frequency bands that are not in use by the PUs. This capability requires sophisticated techniques which capture the temporal and spatial variations of the radio environment and typically involves (a) spectrum sensing, (b) spectrum analysis, (c) spectrum decision, and (d) spectrum sharing. During spectrum sensing, the CR monitors the available spectrum bands to detect if they are in use by the PU and hence detect free channels. Through spectrum analysis, the characteristics of the free channels that are detected through spectrum sensing are estimated and then a channel that best meets the SU’s communication requirements is selected. In spectrum decision, once the CR determines the transmission mode, data rate, and bandwidth required for transmission, it determines the spectrum it will use for transmission. In spectrum we can see that most frequency bands are underutilized whereas some frequency bands are under heavy use. Hence, to address the spectrum underutilization and spectrum scarcity problems, regulatory bodies have suggested allowing unlicensed users to opportunistically access licensed bands when these bands are not occupied by their primary holders. In this architecture, licensed users are typically referred to as Primary Users and the opportunistic users are typically referred to as Secondary Users. The FCC mandates that the licensed spectrum can be accessed by SUs only if it is not in use by PUs. Essential to meeting this regulation is the ability of the SU devices in recognizing the portion of the spectrum that is idle. This operation termed as spectrum sensing, is realized by intelligent software sharing, the available channels are shared in a fair manner between all the Secondary users.

In cognitive radio networks, the arrival of a licensed user interrupts data transmission. Also, spectrum sensing causes temporary disconnections that lead to TCP time-outs. Unfortunately, TCP assumes that these time-outs are caused by congestion in the path. Hence, a TCP sender unnecessarily decreases the rate at which it sends segments to the receiver. TCP is employed to work in cognitive radio networks. In addition to the events that lead to the reduction of sending rate, in the previous section, there are other new events. Suppose the sender is transmitting at rate, and a PU arrived. The sender then has to look for another channel and resume transmission. However, TCP always starts transmission at a slower rate. Hence, arrival of a PU leads to the reduction of the sending rate. Therefore, frequent arrival of PUs will lead to frequent reduction of the sending rate. Another event that leads to reduction of sending rate is when the receiver is engaged in spectrum sensing. Therefore assumed that the receiver is using a single transceiver; therefore, it alternates between sensing mode and transmission mode. In sensing mode, it cannot participate in transmission; hence the sender will experience a temporary disconnection which will lead to timer expiration. Unfortunately, the TCP sender will assume that the timer expired because of congestion and it will reduce its sending rate.

Therefore, we assume that information flows from one layer to another. We will assume that TCP relies on the lower layers for spectrum sensing and spectrum decision. The lower layers notify TCP about which channel to use for transmission and which channel to move to when a PU arrives on the current channel. Therefore, TCP does not have to make any decision regarding which channel to sense. To prevent the reduction of sending rate due to PU arrival and due to engagement of the receiver in spectrum sensing. The sender can also go into sensing mode, therefore, to prevent the sender from reducing its sending rate when transmission resumes.

2. TCP CRAHN: A TRANSPORT PROTOCOL FOR CR AD HOC NETWORKS

TCP CRAHN comprises of the following 6 states. They are:

a) Connection establishment,
b) Normal,
c) Spectrum sensing,
d) Spectrum change,
e) Mobility predicted, and
f) Route failure.

a) Connection Establishment State:

TCP CRAHN renovates the three-way handshake in TCP newReno therefore the sender can receive the sensing scheduled nodes in the transmission path. Initially, the sender sends out a Sync packet to the destination. An intermediate node, say i, in the routing path follows the upcoming datum to the SYN packet: 1) it's ID, 2) a timestamp, and 3) the tuple. On obtaining the SYN packet, the destination sends a SYN-ACK message to the source. The sensing information which was collected for each node is piggybacked over the SYN-ACK and thus, the sender knows a node in the path that shall undertake spectrum sensing and its duration. The final ACK is then delivered by the sender to the receiver completing the handshake.

b) Normal State:

The normal state in TCP CRAHN is considered as the default state and it resembles the classical process of the classical TCP new Reno protocol. Our protocol enters this type of state when 1) node in the path is not currently committed in spectrum sensing, 2) no connection breaks due to licensed users arrivals, and 3) impending route failure is not signaled.

c) Spectrum Sensing State:

TCP CRAHN changes to spectrum sensing by 1) during sensing buffer overflow prevention for the mediatory nodes i.e., flow control and 2) scheduling the time of sensing to meet the required throughput demanding the goal of TCP CRAHN to adapt the mechanism of flow control.

d) Spectrum Change State:

When node i want to search for a new channel, it should prevent interference to itself and primary users. It sends an explicit pause notification to the source and freezes the protocol. It waits for a new channel CHN message to resume the transmission.

e) Mobility Predicted State:

In order to address the problem of delayed route failure notification a mobility prediction framework based on Kalman filter-based estimation, which uses the Received Signal Strength information from the link layer. The set of Kalman equations similar to the disposition is used for calculating sensor location. But for a simpler scalar case, a single dimension of the received power value is calculated.

The nodes of the path monitor the connectivity to their next hop downstream node by measuring the RSS of the ACKs and the periodic beacon messages. At each epoch, the prediction value is compared with the minimum RSS required for receiver operation. If the condition of possible link failure is predicted in the next epoch, the destination is informed, which then sets the Mobility Flag in the outgoing ACKs. The source responds to this by limiting the cwnd to the ssthresh and the congestion avoidance phase is never initiated. The aim of this adjustment, cwndssthresh, is to limit the number of packets injected into the route which has a possibility of an outage, as the CR specific function of the nodes may delay the arrival of the actual link failure notification. If no ICMP message is received at the source subsequently, signaling that a route failure has indeed occurred or the incoming ACKs do not have the MF flag sent, the mobility prediction state is cancelled and TCP CRAHN reverts back to the state.

f)Route Failure State:

The node i sends a destination unreachable message in the form of an ICMP packet if

1) The next hop node ‘i – 1’ is not reachable based on link layer retries,

2) There is no ongoing spectrum sensing based on the last known schedule, and

3) No EPN message is received at node ‘i’ signaling a temporary path disconnection due to PU activity.

At this stage, the source stops transmission and a fresh connection needs to be formed over the new route by TCP CRAHN.

3. SCHEDULING ALGORITHM

CR Ad Hoc Networks that do not have a centralized entity for obtaining the spectrum usage information in the neighborhood, or external support in the form of a spectrum broker that enables the sharing of the available spectrum resource compared to infrastructure-based networks, relying on local decisions makes the problem of node-coordination and end to-end communication considerably more involved. The mobility of the intermediate nodes and the inherent uncertainty in the wireless channel state are the key factors that affect the reliable end-to-end delivery of data in classical ad-hoc networks. The periodic spectrum sensing, channel switching operations, and the awareness of the activity of the Primary Users (PUs) are some of the features that must be integrated into the protocol design ad hoc networks, involving end-to-end communication over multiple hops, is still in a nascent stage. Propose a window-based, TCP-like spectrum-aware transport layer protocol for CR ad-hoc networks, called TCP. CRAHN that distinguishes between the different spectral specific conditions, it has to undertake state-dependent recovery actions. At the transport layer in classical wireless ad hoc networks, the main challenge lies in distinguishing 1) congestion, 2) channel-induced packet drops, and 3) mobility based packet losses. In the first case, the packet experiences greater queuing delay in the buffers of the intermediate routes, thereby increasing the Round Trip Time (RTT). Consequently, TCP suffers from timeout events if the RTT exceeds a given threshold.

In the second case of channel related losses, such as those caused by fading or shadowing, the dropped packets are mistaken by the source as a congestion event. Mobility-related losses are mostly permanent, and if the sender already has a large number of in flight packets, then all of them are likely to be lost. Though these loss-inducing factors are also applicable to CRAHNs, there are additional unique considerations: the observed RTT may increase if an intermediate node on the route is engaged in spectrum sensing and hence, unable to forward packets. Also, the sudden appearance of a licensed or primary user may force the CR nodes in its vicinity to cease their transmissions, leading to an increase in the RTT.

In such cases, the network is partitioned until a new channel is identified and coordinated with the nodes on the path. Spectrum sensing, then for that duration, it is unable to send or receive packets, resulting in a virtual disconnection of the path. Consequently, the data packets in node 1 and moving toward D and acknowledgments (ACKs) in node 3 for the source S oth experience greater queuing delays. If a timeout indeed occurs, the source is immediately penalized and the rate of sending data is drastically reduced. Similarly, consider the case in which the spectrum used by node 4 is reclaimed by the PUs, and it must immediately cease transmission. There is a finite time duration in which node 4 must identify a new spectrum, switch its transceivers, and coordinate this choice with its neighbors. Thus, in both the above cases of spectrum sensing and switching, the source may mistake the increased RTT (or timeouts caused by this increase) for congestion. In TCP CRAHN, we rely on the intermediate nodes periodically piggybacking their spectrum information on the ACKs, or in times of a sudden event like a PU arrival, explicitly notifying the source the goal of TCP CRAHN is to retain the window-based approach of the classical TCP, and at the same time introduce novel changes that allow its applicability in CR ad hoc networks. To mention the main merit of this paper lies in the theoretical design of a transport layer. The actual implementation on real software defined radios is currently limited by the lack of implementations for link layer and end to end network layer protocols. Thus, there are many practical issues that exist today, which make it difficult to demonstrate.

TCP CRAHN running on such radios, those rapid advances will soon make this feasible. Note that our approach involves making several assumptions of the underlying protocol operation, which may not hold in practice in the eventual standardized implementations.TCP CRAHN protocol requires close coupling with the underlying link and network layers, especially during channel changes and during mobility induced route outages. The Cognitive Radio's futures have to work on in wide range frequencies. There are number of various factors which show our schedulers importance:

1. A small amount of hardware spectrum switching delay means more costly CR equipment. The put forward scheduler fulfills the need to have a small amount of hardware switching delay. Hence this plays a major role in reducing the price of the Cognitive radio devices. Since cost will be the vital factor when Cognitive Radios appear in the market, having a cleverer scheduling algorithm such as our projected algorithm, which makes use of less luxurious devices. This way, Cognitive Radio equipment manufacturer can increase their earnings. Since a less cost Cognitive Radio device will enable more users to exploit Cognitive Radio devices, our projected algorithm will also have a bang on increasing the market diffusion of Cognitive Radio's when they first come into existence.

2. In order to achieve lesser delays in the network, spectrum with smaller switching delay needs more filter designs in the hardware hence it is called heavier CR equipment. To achieve small switching delay in a spectrum sensing with reasonable tools weight is a challenge. Since our proposed algorithm for band switching delay is robust to changes, it eliminates the need to have spectrum with lesser switching delay. Therefore, with our proposed algorithm in the software, it helps the manufacturers to use minimum amount of filters and still it can attain higher throughput.

3. CR device weights can also be reduced with the help of our proposed algorithm by considering the need to achieve spectrum with lesser switching delays and by using lesser amount of filters in the hardware. Spectrum with lesser switching delay increases the device dimensions because more number of filters is being used and it occupies more space.

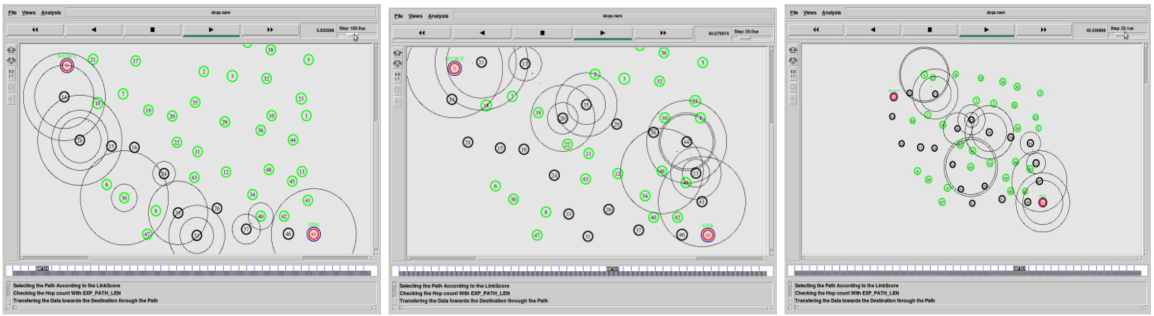
4. In order to achieve more reliable device sizes for future CR devices, it is must to avoid using large number of filters for obtaining lesser switching delay. This criterion is achieved in our proposed algorithm. In wireless networks, the schedule for an event to be occurred are typically made for little duration where the network conditions are fairly stable.

5. In CRNs, the duration which takes to process an event depends on main users or primary users (PU) activities. The scheduling period can be reduced by promptly changing PU activity and spectral environment since the transmission parameters of cognitive radio devices like power and rate should be modified more quickly so that PUs will not be disturbed. In this paper, we take a time period as 100 ms, which is suitable for gradually changeable spectral environments. In other words, the impact of switching delay can be significant even in a gradually changeable spectral environment where a 100 ms of time period are sufficient.

6. The spectral environment varies more frequently, time periods have to diminish and hence, the spectrum switching delay increases. Every CR devices will have its own switching delays and so different CR users may choose for CR devices with dissimilar spectrum switching delay. The units which are used for executing the scheduling algorithm generally cannot command the CR users to choose the specific device. For example, in a centralized CRN where the cognitive base station (CBS) is responsible for limiting the secondary users (SUs) in its service area, where the scheduler rests at the CBS. If some CR users have devices of lower cost with high band switching delay and the CBS operator uses scheduling algorithm which does not think about switching delay, it may accidentally provide poor quality of service to these CR users, who are the CBS operator customers. Some customers may even starve in terms of throughput without the CBS operator planned to do so.

4. SIMULATION RESULTS

Figure 1 a) Transmission and Reception of Primary Users: It explains about the data transmission that takes place in the primary users b) Alternative routes to reach the destination: It shows the alternative path for the secondary users to reach the destination in accordance with the energy consumption. c) Secured transmission and reception of Secondary users after scheduling: It explains about after the scheduling process in order to decrease the delay and traffic, a secured way of transmission takes place in secondary user.



Selecting the Path According to the LinkScore
Checking the Hop count With EXP_PATH_LEN
Transfering the Data towards the Destination through the Path

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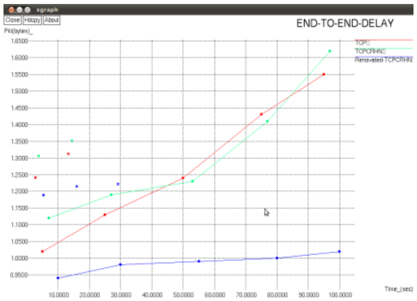
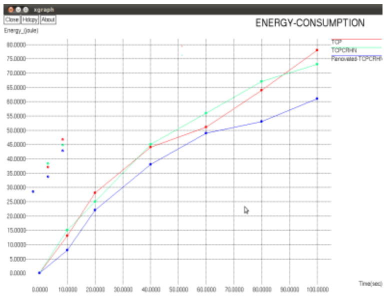
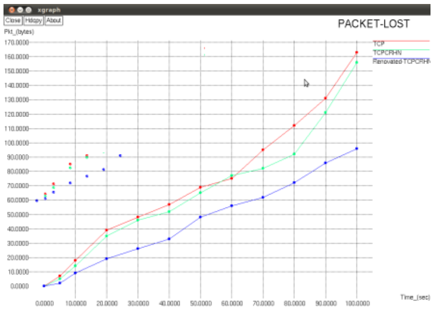
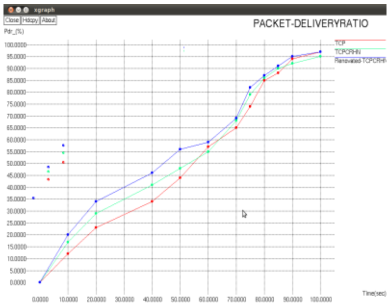
Figure 2 **a)** End-To-End Delay Vs Time: The graph explains about the delay comparisons between TCP, TCP CRAHN and Renovated TCP CRAHN. **b)** Energy Consumption Vs Time: This comparison graph explains about the comparison of energy consumption. Renovated TCP CRAHN consumes less energy when compared to the other both.





c) Packet loss Vs Time: This comparison graph denotes about the less no of packet loss that happens in Renovated TCP CRAHN. **d)** Packet delivery ratio VS Time: This comparison graph explains about the maximum packet delivery ratio in Renovated TCP CRAHN when compared to others. This would also enhance the throughput.





5. CONCLUSION AND FUTURE SCOPE

Thus the switching delay aware algorithm was projected and included in the transport control protocol for the Cognitive Radio Ad hoc Networks which solves our delay problem and increases the overall throughput. Hence by designing the protocol that will be suitable for the Cognitive Radio Ad hoc Networks will increasingly produce high throughput. This also makes the network to work on in an effective manner and all the unlicensed users will be benefited.

REFERENCES

[1] A. Capone, L. Fratta, and F. Martignon (2004), "Bandwidth Estimation Schemes for TCP over Wireless Networks," IEEE Trans. MobileComputing, vol. 3, no. 2, pp. 129-143.

[2] Akyildiz.I,Lo.B, and Balakrishnan.R, "Cooperative spectrum sensing in cognitive radio networks: a survey," Physical Commun., vol. 4, pp. 40–62, 2011

[3] K.Divya, D.Nisha, M.Surya (2014), "Performance Analysis of Transport Control Protocol for Cognitive Radio Ad Hoc Network", IJARCCE vol. 3, Issue 4, April 2014.

[4] K.Divya, M.Surya (2014), "Modified Transport Control Protocol for Cognitive Radio Ad Hoc Network", IJERT vol. 3, Issue 4, April 2014. ISSN : 2278-0181.

[5] A.O. Bicen and O.B. Akan (2011), "Reliability and Congestion Control in Cognitive Radio Sensor Networks," Ad Hoc Networks J., vol. 9, no. 7, pp. 1154

[6] Ganesan.G and Li.Y, "Cooperative spectrum sensing in cognitive radio networks," in Proc. 2005 IEEE DySPAN, pp. 137–1431164, Elsevier.

[7] G. Holland and N.H. Vaidya (1999), "Analysis of TCP Performance over Mobile Ad Hoc Networks," Proc. ACM MobiCom, pp. 219-230.

[8] I.F. Akyildiz, W.Y. Lee, and K. Chowdhury (2009), "CRAHNs: Cognitive Radio Ad Hoc Networks," Ad Hoc Networks J., vol. 7, no. 2, pp. 810-836, Elsevier.

[9] Jing.T, Chen.S, Huo.Y, and Cheng.X, "Achievable transmission capacityof cognitive mesh networks with different media access control,"in Proc. 2012 IEEE INFOCOM, pp. 1764–1772

[10] J. Liu and S. Singh (2001), "ATCP: TCP for Mobile Ad Hoc Networks," IEEE J. Selected Areas of Comm., vol. 19, no. 7, pp. 1300-1315.

[11] K. Chen, Y. Xue, and K. Nahrstedt (2003), "On Setting TCP's Congestion Window Limit in Mobile Ad Hoc Networks," Proc. IEEE Int'l Conf. Comm. (ICC), pp. 1080-1084.

[12] K.R. Chowdhury, M. Di Felice, and I.F. Akyildiz (2009), "TP-CRAHN: A Transport Protocol for Cognitive Radio Ad Hoc Networks," Proc. IEEE INFOCOM, pp. 2482-2491.

[13] L. Brakmo and L. Peterson (1995), "TCP Vegas: End to End Congestion Avoidance on a Global Internet," IEEE J. Selected Areas in Comm. vol. 13, no. 8, pp. 1465-1480.

[14] M. Di Felice, K. Chowdhury, W. Kim, A. Kassler, and L. Bononi (2011), "End-to-End Protocols for Cognitive Radio Ad Hoc Networks: An Evaluation Study," Performance Evaluation, vol. 68, no. 9, pp. 859- 875.

[15] M. Di Felice, K.R. Chowdhury, and L. Bononi (2009), "Modeling and Performance Evaluation of Transmission Control Protocol over Cognitive Radio Ad Hoc Networks," Proc. 12th ACM Int'l Conf. Modeling, Analysis and Simulation of Wireless and Mobile (MSWIM '09), pp. 4-12.

[16] Mishra.S,Sahai.A, and Brodersen.R, "Cooperative sensing among cognitive radios," in Proc. 2006 IEEE International Conf. Commun., vol. 4, pp. 1658–1663.

[17] Mitola.J III and Maguire. G. Jr.,"Cognitive radio: making software radios more personal," IEEE Personal Commun.,vol. 6, pp. 13–18, 1999.

[18] S. Floyd and T. Henderson (1999), The NewReno Modification to TCP's Fast Recovery Algorithm, IETF RFC 2582.

[19] S.M. Kay (1993), Fundamentals of Statistical Signal Processing: Estimation Theory. Prentice - Hall.

[20] T. Dyer and R. Boppana (2001), "A Comparision of TCP Performance over Three Routing Protocols for Mobile Ad Hoc Networks," Proc. ACM MobiHoc, pp. 256-266.

[21] W.Y. Lee and I.F. Akyildiz (2008), "Optimal Spectrum Sensing Framework for Cognitive Radio Networks," IEEE Trans. Wireless Comm., vol. 7, no. 10, pp. 3845-3857.

[22] Xin.C,.Song.M, Ma.L, and C.-C. Shen, "Performance analysis of a control-free dynamic spectrum access scheme," IEEE Trans. WirelessCommun., vol. 10, pp.4316–4323, 2011.