Dynamic spectrum access for TCP performance improvement in cognitive radio network

A.Senthamarai Selvan*, A.Rajesh, N.Sasikala
Computer Science and Engineering, C.Abdul Hakeem College of Engineering and Technology, Melvisharam, India
***Corresponding author: E-Mail: senselvana@gmail.com**

ABSTRACT

In the late years, researches focus on decay of TCP throughput over wireless connections, and numerous wireless TCP solutions are proposed to manage this issue. On the other hand, trailed by the change of equipment innovation, new system structures and mechanism are proposed to upgrade wireless interchanges, for example, the Cognitive Radio (CR) systems. However this new system architecture causes another issue, which is not solved in wireless TCPs. In this paper, we discuss new issues that affect the TCP throughput over CR systems, which we call Bandwidth Variation and Packet Loss Event and it as concerned with three events such as PU-Interference Loss Event, Mild-Congestion Event and RTT-Variance Event that cause these issues. In view of these three events we proposed three event handlers such as Primary user interference handlers, Fast recovery handlers, RTT adjustment function to boost TCP throughput. A cross layer arrangement is proposed to manage these new issues. We propose an event driven CR-TCP that joins these event handlers, which can be solved with begin of-start-of-art CR-TCP arrangements. Both numerical and simulation results are displayed to exhibit the effectiveness of the proposed arrangement.

KEY WORDS: TCP, wireless TCP, Cognitive Radio, Bandwidth Variation, Congestion Control.

1. INTRODUCTION

In the most recent decade, wireless devices have been broadly utilized for communication, trade, education, diversion and business works. As indicated by popularity of these applications on internet, the distinction of Internet Protocol throughput over wireless connection is widely studied. The information traffics over TCP have throughput issues because of the environmental qualities of wireless connections. Analysts proposed new protocol to conquer the throughput decay issue, known as wireless TCP (WTCP). The three primary issues of WTCP solutions are Random Loss, Burst Loss and Packet Reordering (Ka-Cheong Leung, 2006). Many WTCP arrangements are proposed in recent years (Wu, 2004; Akyildiz, 2002; Biaz, 2005).

The Cognitive Radio (CR) arranges that utilization opportunistic spectrum access (OSA) approach (Poston, 2005). The OSA environment brings distinctive issues from different wireless communication frameworks; for example, channel sensing, management, selection and decision (Ian, 2006). The system architecture and instruments of CR system create new issues, which is not solved by previous WTCP arrangements. One of the new components used as a part of CR device is channel aggregation. Channel aggregation is presented in Discontiguous OFDM technology (Poston, 2005).

The attributes of MAC and PHY layers of CR devices pass on more issues to TCP. The SU's link quality and point of confinement are unsteady, and the spectrum opportunities appear irregular. Another TCP packet loss event in the CR join, which is called "PU-interruption loss," is exhibited in (Issariyakul, 2009). We call this new issues "bandwidth variation", is displayed in (Yu-Chun, 2010), which is the key issue that decay TCP throughput in CR system.

The suppositions of this situation are depicted as take after:

A. CR nodes suffer impedance by various Primary users.

B. CR device use channel aggregation mechanism in uplink transmission.

C. The utilized spectrum is divided into a few nonoverlapping, autonomous channels.

D. A SU's MAC/PHY layer can give historical utilization, complete data transfer capacity limit and real-time availability data to TCP layer.

The rest of this paper is organized as follows: Further discussion and motivation of TCP throughput is described in Section 2. In Section 4, we describe the models, and then the observations from simulation results. The proposed mechanisms and simulation results are shown in Section 5. Finally we conclude the paper in Section 7.

Preliminary and Motivation

Preliminary of WTCPs: Many WTCP arrangements have been proposed in the literature to address different issues in wireless system environment. The four major qualities of wireless connections are: channel contention, signal fading, mobility and limited power (Ka-Cheong Leung, 2006). Issues that TCP appearances are: random loss, burst loss and packet reordering (Ka-Cheong Leung, 2006).

The arrangements of these issues can be inventoried (Ka-Cheong Leung, 2006) as: congestion detection (Akyildiz, 2002), state suspension (Chandran, 2001), response postponement (Biaz, 2005) and hybrid approaches

(Wu, 2004). The congestion detection approaches distinguish packet loss event and attempt to perceive the sort of loss event. The state suspension approaches plan to recover the throughput decay after specific event. The response postponement approaches are recipient side arrangements that sending so as to reduce overhead and conflict event by less ACKs.

Preliminary of TCP over CR network: From related surveys, we discover that bandwidth variation and packet loss event may occur in either channel overlay model (Shao-Yi Hung, 2008) or underlay model (Wu, 2004). Obviously, the reason that bandwidth varies in channel underlay model is due to its dynamic transmit power. The transmit power of CR device adapts to the primary traffic constraint (Wu, 2004) in order not to deal harmful effect to Primary Users. The main objective of CR system is to improve overall spectrum efficiency, and one of the main mechanisms of system is channel aggregation. This mechanism is introduced in OFDM, which can aggregate discontinuous spectrum by switch off unwanted subcarriers and produce a signal with a non-continuous spectrum (Poston, 2005).

Motivation: Fortunately, CR MAC protocol can give some helpful system data to traffic control in the assumptive situation in segment I. The CR MACs should have the capacity to gather the accessible channel data of taking after time period. We are motivated to outline a cross-layer CR-TCP to accomplish higher throughput with the supporting of CR MAC.

Background Work

Spectrum Sensing: In the proposed work, IEEE 802.11a signal has been generated based on the standard specification parameters. The actual data available for transmission is converted from serial to parallel form. The resulted data is modulated using 64QAM. This modulated data is subjected to Inverse fast Fourier transform operation and the preambles are added as per IEEE 802.11a standard. This data is transmitted through awgn channel. Let sig(t) be the transmitted signal, w(t) is the channel noise, sig(t) + w(t) be the received signal, which is given as the input to the matched filter and sig0(t)+w0(t) be the output of the filter. Let the matched filter's impulse response be h (t). It had been proven that, impulse response of the optimum system is the mirror image of the desired message signal sig (t) about the vertical axis and shifted to the right until all of the signal sig (t) has entered the receiver. It should be realized that the matched filter is optimum of all linear filters.

The signal component at output of the filter, at the observing instant tm is given by

sig0(tm) = 1/2π_(s (ω)) 2 (1)

sig0(tm) = E (2)

Hence the output signal component has maximum amplitude of magnitude E, which is nothing but energy of the signal sig (t).Here the transmitted signal is passed through the channel where the additive white Gaussian noise is getting added to the signal and outputted the mixed signal. This mixed signal is given as input to the matched filter. The matched filter input is convolved with the impulse response of the matched filter and the matched filter output is then compared with the threshold for primary user detection.

The threshold of a signal, determined by two possible ways has been discussed here. One way is to estimate the energy of the signal and reduce it to half, fix it as a threshold. Another way is to compute the standard deviation of the signal by computing the mean and use it as threshold. Of the two methods, the former one is theoretically proved to be optimal. In this paper the former is chosen to detect the presence of WLAN signal.

Once the threshold is chosen, presence of signal is determined based on the following decision rule (Ka-Cheong Leung, 2006).

rxd(t) > a : signal present (3)

rxd(t) < a : signal absent (4)

whererxd(t) is the matched filter output given by

rxd(T) = sig0(T)+w0(T) (5)

from eqn.(2)

rxd(T) = E + w0(T) (6)

If there is no primary user signal, then received signal be

rxd(T) = w0(T) (7)

indication of only noise.

2. MATERIALS AND METHODS

Proposed System: As we said in Section 1, the hugest distinction between CR and existing wireless systems is the presence of a PU. In CR concentrates on, the issues of channel use and need issues are taken care of in the MAC and PHY layers. In this way, these issues are not interested in the TCP layer. Throughput is the main concern in this paper. In this subsection, we think about the impacts of specific events that effect TCP throughput in a CR environment. The assumptive CR-MAC convention is the same as (Issariyakul, 2009).

This MAC convention depends on the accompanying suppositions:

- A SU has an altered MAC super-frame size. Toward the starting of every super-frame, a SU examines all channels and chooses which channel to access.

- There are N orthogonal (obstruction allowed to each other) channels for the PU what's more, SU to utilize. A SU can use to 1 to N channels at the same time. The aggregate transfer speed limit of a SU is the total transfer speed of the channels he access.
- A SU can (and should) empty the channels being used at whatever points the PU access to one. A SU vacate all accessed to channels at the point when any of these channels are interrupted by the PU.
- Every channel contains no less than one PU transmitter-recipient pair.
- The MAC layer contains the following data: historical channel use of the PU and constant channel accessibility.
- The MAC layer can recognize the PU's signal from noise (counting another SU's signal).

TCP Events on CR

PU-Interference Loss Event: Since the PU is the highest need client, he can impact a SU's activity by both getting to and leaving a channel. Clearly, the more channels a PU utilizes, the less data transmission limit a SU has. Two events happen when the PU begins and shuts his channel access. To start with, the PU interferences with a SU while he attempts to get to a channel utilized by a SU. As indicated by the attributes of CR-MAC, a SU must not occupy the channel at whatever point the PU gets to it. We call such a case as a "PU-Interference Loss" event In a PU-interference loss event; the TC client might confront a time out condition if the MAC does not recoup collided packets by the due date. Such an event most likely prompts decreased TCP throughput.

Mild-congestion Event: The second event is because of the PU leaves an occupied channel after a SU's activity blockage,). We call this event a "Mild Congestion Event." A congestion event demonstrates that the transfer speed limit is below activity loads on the data path. In this manner, the TCP client declines his congestion window size to decrease movement loads after a congestion event. Be that as it may, in a mild-congestion event, a SU does not have to decline activity loads, for the data transmission capacity increments for the PU to release the channel asset. Since a SU knows the constant channel accessibility [in the assumptive CR-MAC attributes (5)], the TCP client now has a chance not to decrease the congestion window. On the off chance that the congestion window size increments with rising transfer speed limit, TCP throughput can be improved.

RTT-Variance Event: By CR-MAC attributes (2), we realize that a SU"s data transmission limit relies on the measure of accessible channels. That is to say, a SU"s transfer speed limit differs with time []. The transfer speed limit the transmission rate, as well as important data, which TCP client need: RTT. We call the condition at the point when RTT is affected by the changing of data transmission limit in a CR domain a RTT-Variance Event". RTT is utilized as a part of numerous TCP capacities, For example, accessing way limit, controlling congestion window estimate, and associating time-out.

Event Handlers: We outline three handlers to hand-more than three TCP events in CR: PU-interference, mild-congestion, and RTT-variance events. These handlers are activated by the three events in specific conditions. Just the events that affect TCP throughput genuinely trigger handlers. We utilize MAC data [as CR-MAC attributes (5)] to make sense of the specific conditions that handlers should to trigger, which incorporate historical channel usage of a PU and current channel accessibility.

The first we utilize, the PU's historical channel utilization, is perceived as "PU-Activity" data. PU-action shows long term patterns of likelihood that a PU will interface with a SU. This data additionally causes a SU to recognize better channels (which imply less opportunity to be intruded) to access. The second one, current channel accessibility, is perceived as "Transfer speed Capacity" data. Since per-channel transfer speed is all around characterized, a SU's most extreme transmission capacity limit on a CR connection can be driven from channel accessibility.

The proposed three event handlers are deal with the three events: the PU-Interference Loss, Mild-Congestion, and RTT-Variance events. These handlers are named “PU-Interference Handler,” “Faster-Recovery Mechanism,” and “RTT-Adjustment Function,” respectively. The proposed event handler is triggered in some constraints, as shown in Table 1.

Table.1. Triggering Event Handlers

Information Type	Low PU Activity	High PU Activity
High Bandwidth Capacity	PU-I	PU-I, RTT-A
Low Bandwidth Capacity	PU-I, Mild-C, RTT-A	PU-I

PU-interference handler: Since a SU senses (and chooses to access) diverts periodically in every MAC super-frame, the impacted packets in a PU-interference loss event can be retransmitted before all else of the following super-frame as opposed to waiting for other retransmission instruments. On the off chance that a PU- interference loss event happens, the PU-interference handler sends all packets in the congestion window again toward the start of the following MAC super-frame. The starvation, which causes throughput decay, is more genuine when the MAC super-frame is longer. Then again, if the MAC super-frame is short, the impacted packets are conceivably recouped by MAC retransmission.

Faster Recovery Handler: The thought of taking care of a mild-congestion loss event is to restore congestion window parameters in a brief period as opposed to by means of a traditional AIMD system (Yu-Chun, 2010), which is like Freeze-TCP. The expected period after a mild-congestion loss event with certain channel accessibility can be driven from PU movement data. The handler of a mild-congestion loss event is named "faster Recovery Mechanism." The congestion avoidance mechanism is only triggered while the current used bandwidth is larger the congestion threshold BWCT. Otherwise, the used bandwidth will recover to current level soon. The proposed congestion avoidance mechanism, named Faster-Recovery, is shown in Algorithm 1.

RTT Adjustment Function: We are propelled to outline a RTT-adjustment work that can drive a normal RTT from the transfer speed limit data as opposed to from an ACK timestamp. From (Chandran, 2001), the normal RTT estimation of different TCP connections can be composed as:

$Ti=\tau i+1/\mu$ (1)

Where Ti is RTT esteem, τi is propagation delay and μ is bandwidth limit. In the proposed situation, the RTT of the TCP stream, RTTPATH, can be gotten from $RTT_{PATH} = RTT_{VL} + RTT_{SL}$, where RTT_{VL} and RTT_{SL} are the RTT of the CR join furthermore. RTTVL and RTT_{SL} can be gotten from Equation (1), where:

$RTT_{VL}=t_{VL}+l_{VL}/bw_{VL}, RTT=t_{SL}+l_{SL}/bw_{SL}$ (2)

t_{VL} t_{SL} l_{VL}, l_{SL} and bw_{SL} are the propagation delay of RTT_{VL}, the propagation delay of RTT_{SL}, packet length of the CR connect. Since t_{VL} t_{SL} l_{VL} and l_{SL}/bw_{SL} are steady in the proposed situation, the RTT_{PATH} can be composed as:

$RTT_{PATH}=C+L/bw_{VL}$ (3)

Where,

$C= (t_{VL}+t_{SL}+l_{SL}/bw_{SL}), L=l_{VL}$

We can utilize the least squares technique to prepare C and L in Equation (3). Speaks to the i-th passage, C and L can be gotten from:

$L= \sum_{i=1}^{n}(BWi-\overline{BW}) (RTTi-\overline{RTT})/\sum_{i=1}^{n}(BWi-\overline{BW})$(4)

$C=\overline{RTT}-L*\overline{BW}$ (5)

Where

$\overline{BW}=l/n \sum_{i=1}^{n} BW_i, \overline{RTT}-=1/n \sum_{i=1}^{n} RTT_i$

The RTT value after the RTT-adjustment function from C, L and bandwidth information BW, ARTT (L, C, BW), is written as:

ARTT (L, C, BW) =C+L/BW (6)

While the TCP client gets an ACK (and its RTT esteem, RTTi-1), he looks at the present transfer speed, bwi, with the data transmission of the time that the information packet is sent, bwi-1.On the off chance that the data transfer capacity data is equivalent, say bwi=bwi-1, the RTT adjustment component prepares its parameters, say L and C, from the data of RTT and the transfer speed limit from this ACK. On the off chance that bwi!=bwi-1, the TCP process updates the SRTT esteem by the balanced RTT results from ARTT(.) rather than RTTi-1, and he doesn't train L and C by this transfer speed RTT entry. A short time later, the TCP procedure will utilize this RTT/SRTT esteem for its operation.

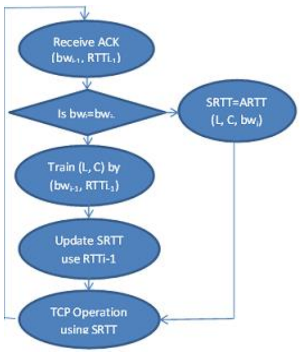


Figure.1. Flow Diagram of RTT-Adjustment

Algorithm Used For Congestion Avoidence

Algorithm 1 Fast Recovery (CST,$\bar{X}$, L)

1: BWCT=CT (CST,$\bar{X}$, $\bar{q}$)

2: CountDown = L

3: Fast-Recovery = OFF

4: While true do

5: t=current -time

6: IF Fast-Recovery = ON

```
If not Congestion Event
CountDown = CountDown-q̄
End if
If CountDown = 0 do
UBW[t] = Backup-Bw;
Fast-Recovery = OFF
CountDown = q̄
End if
End if
If Congestion Event #UBW[t]>ABW[t]
If UBW[t] <BWCT do #UBW recovery
Backup-Bw = UBW[t]
Fast-Recovery = ON
Else
Do Congestion -Avoidance
End if
End if
Sleep (q̄)
End while
```

The congestion threshold of channel condition X[t], CT(X[t]) of channel state, results in the value of q is small and p>0 (The ABW(X(t)) cannot be recover soon and it is easy to collision in the near-future). By giving all possible channel state set, X = {X[t]}, ∀t, and time slot size q, wecan build up the Congestion Threshold Table offline.The parameters of these predictors can be gathered from historical data. That is, the results of congestion threshold can be pre-calculated by given all possible primary utilization combinations. In the runtime, CR nodes only need to do table-lookup in particular primary utilization (background traffic load) to find congestion threshold. In our observation, near-actual values of primary utilization are good enough to find congestion threshold, for this threshold has no huge difference in a near-by range of primary utilization.

Performance Evaluation: CR-TCP is the mix of three events handlers, so CR-TCP enhances essentially in all situations. Concluding the correlation in the middle of WTCPs enhances 10 percent to TCP-NEW RENO.A while later; we progressively change PU activity with time and watch the effect to TCP-NEW ERNO, WTCPs, and CR-TCP. Three situations with various channel bandwidths are introduced. CR-TCP performs far and away superior to the cases with enduring PU-movement proportions, particularly in low-proportion cases. In the event that PU action turns out to be low all of a sudden, TCP-NEW RENO and WTCP will scarcely utilize channel assets adequately (as in a 100^{th} and a 200^{th} of a second). CR-TCP enhances 86 percent and 33 percent over TCP-NEW RENO in Figure 3 of 100kB, 1MB, 2MB, separately.

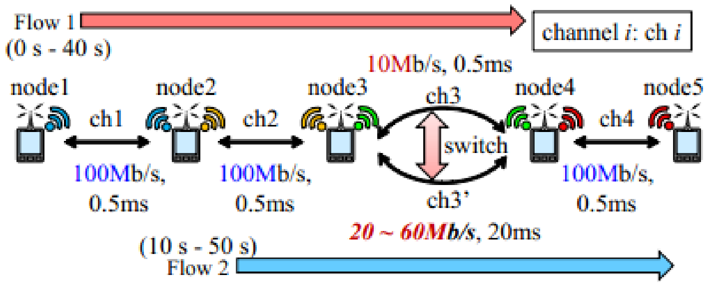


Figure.2. Topology of parameters

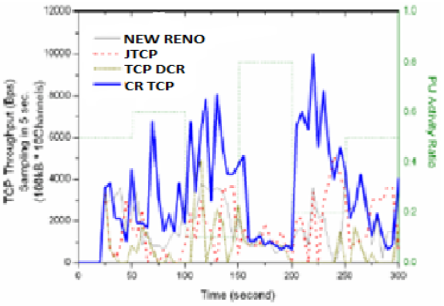
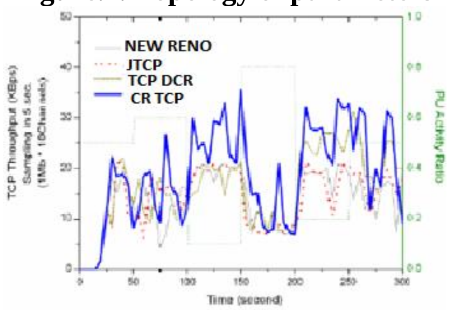
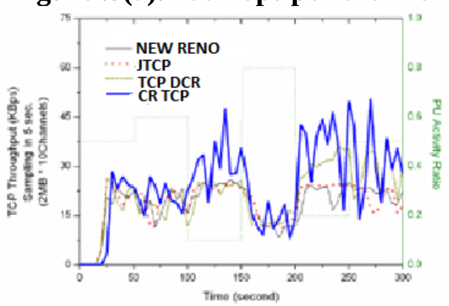


Figure .3(a). 100 kbps per channel



Figyre.3(b). 1 mbps per channel



Figyre.3(c). 2 mbps per channel

3. RESULT

By the generated throughput xgraph it is concluded that throughput is decreased when the packet size increases and the efficiency of TCP protocol outperforms in TCP-NewReno as the proposed CR-TCP environment and throughput is high when compared to all other environment. CR-TCP is the mix of three events handlers, so CR-TCP enhances essentially in all situations. Concluding the correlation in the middle of WTCPs enhances 10 percent to TCP-NEW RENO.A while later; we progressively change packet size with time and watch the effect to TCP-NEW ERNO, Vegas.

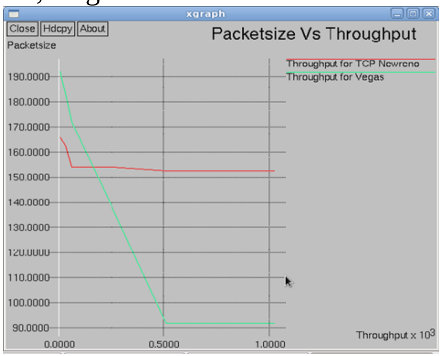


Figure.4.Throughput analysis

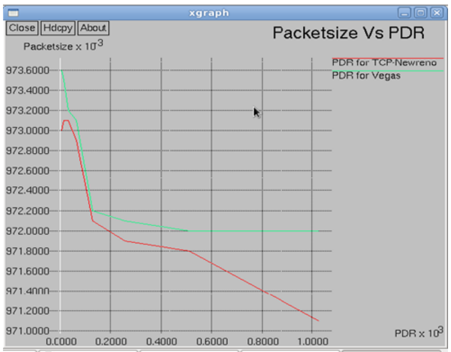


Figure.5.FigurePacket delivery ratio

4. CONCLUSION

In this paper, we introduced a new WTCP issue which happens in CR network environment and defined as three events named as PU-interference loss, mild congestion, and RTT-variance. The proposed three event handlers named as PU-interference handler, faster-recovery mechanism, and RTT-adjustment function to deal with the TCP throughput decay problems. The cause of this problem, say Bandwidth Variation and packet loss event is discussed in section II and we re-build it by proposed say CR_TCP event driven solution generator. We were motivated to design a new solution for several reasons, such as the previous WTCP solutions do not work, are also discussed in section 4. Simulation results of the proposed handlers and CR-TCP solution significantly improve TCP throughput over WTCP solution.

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