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A Novel Approach to Optimize Cognitive Radio Network Utilization using Cascading Technique

H Venkatesh Kumar*[1], MN Giriprsad[2]
[1]Nagarjuna College of Engineering and Technology, Department of ECE, Bangalore, India
[2]JNTU College of Engineering Anatapur, Department of ECE, Andhra Pradesh, India
e-mail: venkateshkumar.h@gmail.com

Abstract

The cognitive radio experiences lack of channels. The Unlicensed clients (UU) acquire channels from the licensed users (LU). But, when the LUs need them, the UUs need to stop their transmission and handle the channel back to the LUs. This outcome is delay in transmission of information by UUs. We proposed an algorithm basically centering to meet the delay, by utilizing a data cascading strategy where the information of the UUs are stored in the intermediate nodes so that even if the transmission is interrupted, the data is not lost. The experimental results demonstrate that proposed framework is superior to other existing frameworks.

***Keywords**: cognitive radio network, delay, data cascading*

1. Introduction

A cognitive radio is an intelligent radio that can be customized and configured dynamically. Here the radio distinguishes the channel by itself and accordingly changes its parameters [1]. Parameters like routing, frequency etc. are balanced by the cognitive radio as requirement. Cognitive radios continuously controls its own particular action and focus the radio frequency environment, channel conditions, link performance, and so forth and alters the settings to deliver the required quality of service subject to an appropriate combination of user requirements, operational limitations, and regulatory constraints. It has the capacity to perceive the outside environment and uses artificial intelligence to learn from environment, and makes its inner state adjust to the measurable changes of receive wireless signals by changing some parameters in order to acknowledge high reliable in any place and the powerful utilization of spectrum resources [2]. A Cognitive Radio consolidates numerous sources of data, decides its present working settings, and collaborates with other cognitive radios (CR) in a wireless [3]. The promise of cognitive radios is enhanced utilization of spectrum resources, reduced engineering and planning time, and adaptation to current operating conditions. Qualities of cognitive radio systems:

- Determine their own environment and react.
- Provides robust services
- Operational state languages influence general network architectures.

In a cognitive network the radio spectrum spaces is really scare and are need to be reused. The users with the channels are called as licensed user (LU) and those without license is called the unlicensed user (UU). The unlicensed user waits for the channel to be free from the licensed user. Ones it is free the cell that is responsible for supplying channels to the UUs inform them about its availability [4]. The cells undergo group formation until it achieves Nash stable condition [5]. When it reaches this condition it can become independent enough to serve its UUs with the channels. But during the channels being used by the UUs, if the LUs appear again then, the UUs have to switch from the licensed channel to other unlicensed channel. Hence the continuous data transmission is interrupted and results in delay [6] [7]. In this paper we have proposed a model that will meet the delay by means of cascading techniques.

The remaining paper is described as follows .Section 2 describes the literature survey followed by the proposed system in section 3. Section 4 tells about the system model followed by the experimental results in section 5. Finally the paper is concluded by section 6.

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2. Literature Survey

In [1], intrinsic properties and current research challenges of the CRAHNs are presented. First, novel spectrum management functionalities such as spectrum sensing, spectrum sharing, and spectrum decision, and spectrum mobility are introduced from the viewpoint of a network requiring distributed coordination. A particular emphasis is given to distributed coordination between CR users through the establishment of a common control channel.

In [2], they have identified and addressed three fundamental challenges encountered specifically by mobile SUs. First they modeled channel availability experienced by a mobile SU as a two-state continuous-time Markov chain (CTMC) and verify its accuracy via in-depth simulation. Secondly to protect primary/incumbent communications from SU interference, they introduced guard distance in the space domain and finally derive the optimal guard distance that maximizes the spatiotemporal spectrum opportunities available to mobile cognitive radios.

Fan [6] explores the overheard information, including data request and data reply, to optimize cache placement and cache discovery. To the best of knowledge, this is the first work that considers the overhearing property of wireless communications in data caching. This proposed system was able to reduce the message cost and also the access delay.

In our previous work, we have focused on group forming scheme in cognitive radio for spectrum sensing. At the point when the data should be transmitted consequently then in such cases cognitive radio system is utilized. The transmitters in the subjective systems are signaled such that they can consequently recognize the accessible channels and pass signal through them. In such a circumstance accessibility of channels assumes the essential part. As channels are generally limited so they need to be shared among the participating users. The user who own channels they could call their own are named as Licensed Users (LU), and those does not possess channels they could call their own, need to utilize channels claimed by the authorized clients are called unlicensed clients (UU). Cells can give restricted support of its UUs, in light of the fact that a single cell is capable just for a little number of LUs. So to give exact data in regarding to the channel accessibility the cells need to take in the insights of the considerable number of LUs. So there is a requirement for cells to group forming with one another and structure a gathering to share the data of the considerable number of LUs.

3. Proposed Work

The contributions and significance of this work are:

a) Channel Sensing
b) Group forming
c) Nash stability

Channel availability is characterized as the likelihood of an authorized channel being accessible for the correspondences of unlicensed clients. Channel availability is a key parameter for an effective design of channel determination methods and additionally routing in cognitivetive radio systems. In static situations, the availability of a channel depends only on the primary user′s activity. In mobile scenarios, the availability of a channel dynamically varies in time due to the changes of the users′ relative positions. Figure1 shows the workflow of channel availability [8].

For finding the profit-loss state in cognitive radio spectrum sensing, a group forming approach is presented here in Figure 2. This approach is based on the 'group' concept. Initiated cognitive radio creates structure different 'groups' as per some criteria. Every gathering comprises of a head node, some gateway nodes and normal nodes. During detection stage, nodes sense channels and arrange the channel and slot assignment; during information transmitting stage, every node has the capacity correspond with its neighbor nodes in assigned channels during given time slots [9]. Thus, nodes can be associated together to frame a system without basic channels and the system network is made strides. This study introduces the group forming procedure including neighbor node detection, node communication, group formation, time opening task and time slot assignment.

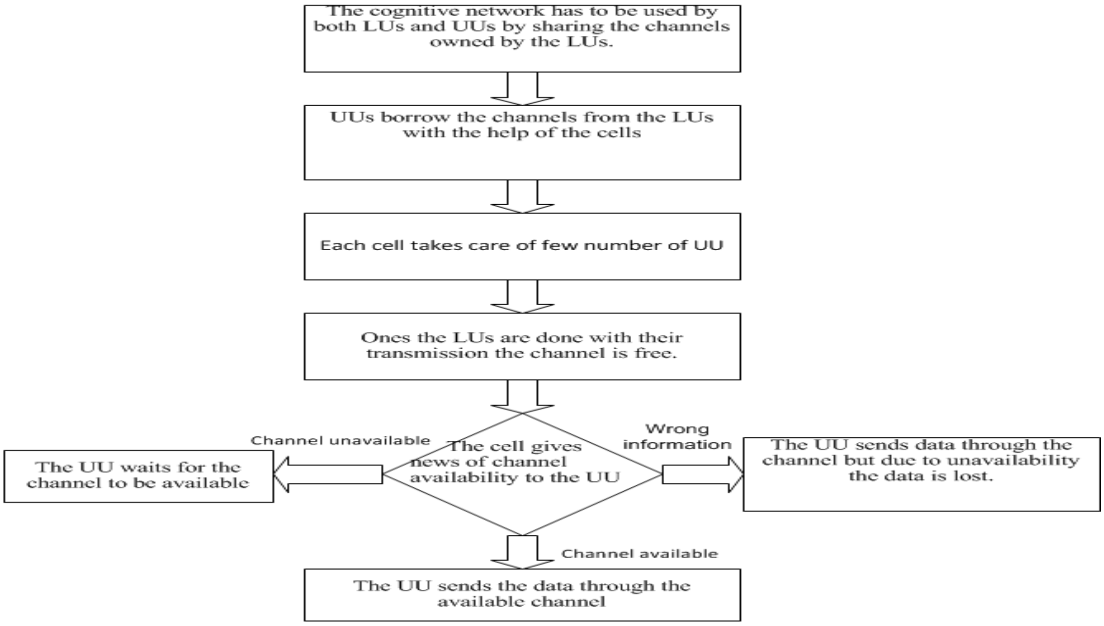

Figure 1. Availability of channel

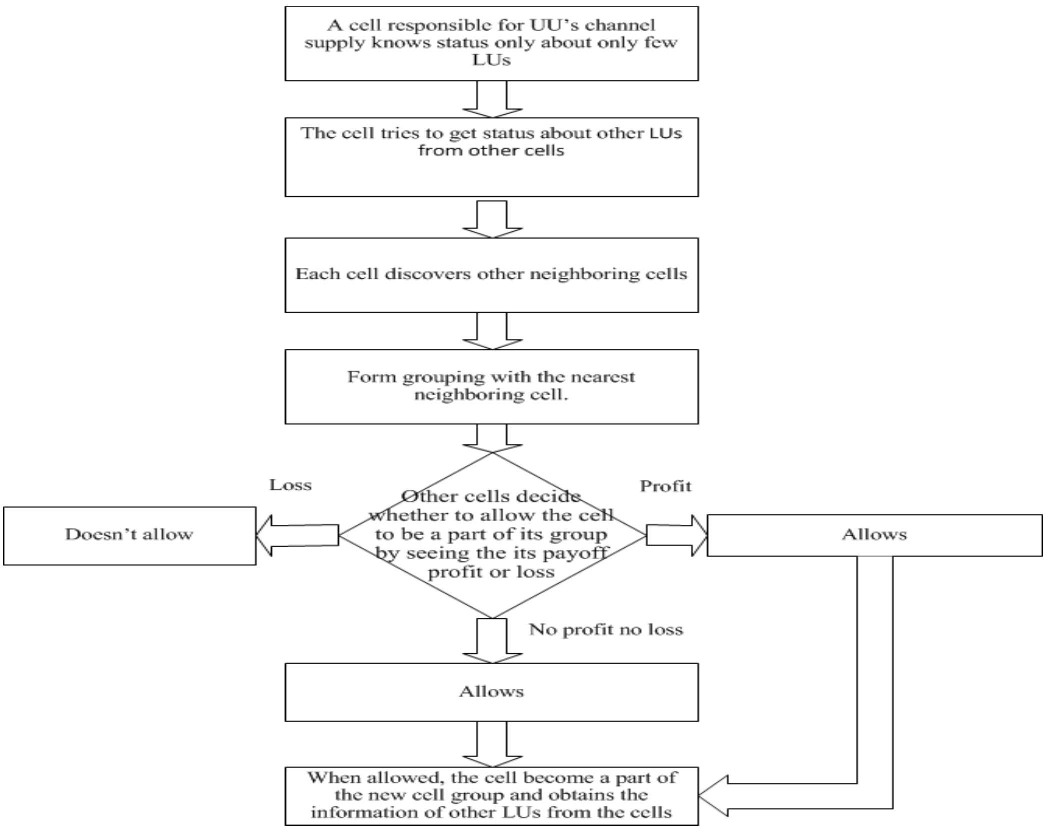

Figure 2. Group forming in cognitive radio for profit –loss state

Figure 3 represents achieving the Nash stability using group formation. This situation utilizes a non-cooperative game model to concentrate on the opposition among primary users with the Nash Equilibrium (NE) as the best arrangement. The primary users first set the bid techniques including the spectrum size and the cost, and after that present their bids to the auctioneer. After gathering all the data from the primary users, the auctioneer gives feedback to every primary user. An iterative calculation is utilized which permits every primary user to maximize their revenue by updating their bid from the joining of the NE. The cost of the NE point can be viewed as the true spectrum value.

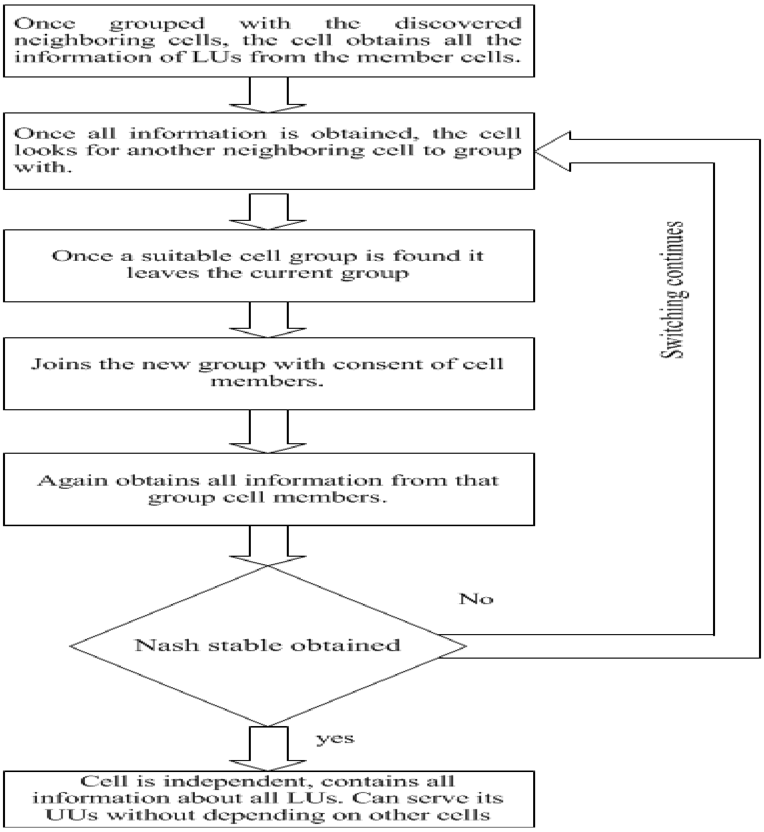

Figure 3. Nash Stability

The Network is used by its users in transmitting and receiving of data among them through the channels. A channel is a route from a transmitting user to a receiving user. All the users do not have a channel of their own, they need to be shared. The channel holder users can any time use the channels to transmit and receive their data. The users without their own channels have to borrow the channels from the channel holders. In our discussion we have named the channel holder users as the licensed users (LU) and the users without channels as the unlicensed users (UU). Ones the channel is free from the use of the channel holder, it can be used by the non-channel holders. Each cell is responsible for servicing a few number of non-channel holders. The cells provide information to the non-channel holders about the availability and non-availability of the channels. Any cell is capable of providing information only about few of the channel holding users. In order to obtain the information of all the users the cells need to share the knowledge of other cells too. For that the cell tries forming group with other cells. It is the personal decision of other cells whether to allow the cell to group with it or not. For each grouping the cells make sure that the addition of the new cell should not bring it to any kind of loss. For every grouping the particular cell that seek friendship from other cells make sure that its payoff increases each time it groups with other cells. So whenever a channel is free the cell tells its respective non-channel holders about its availability.

If the information is true then the non-channel user uses the channel for transmitting its data. If the information is false then the non-channel user transmits its data and the information gets lost. So the cell keep on forming groups until and unless it will reach a situation where the cell will be having the information regarding all the users having channels. Thus a situation arrives where the cells become self-dependent and are able to serve its UUs without any ones help. This ultimate situation is called as the Nash stable state. Ones the cell is Nash stable coalition formation is ended and the cell is able for supplying of the channels to the UUs without grouping with other cells [10].

The UUs while using the channels suffer delays in transmitting their data due to the appearance of licensed users. So in order to avoid the disturbance in the channel traffic, whenever any licensed user again needs to access the channel spectrum then the unlicensed users have to vacate the spectrum and let it free for the licensed user to use the channel for transmitting its data [11].

For using the channel always the licensed user gets the first preference because they are the registered users for the channels or they own the channel. Since because of the sudden appearance of the licensed user the unlicensed user has to surrender the channel for the licensed user. In doing such the ongoing data transmission by the unlicensed user leads to some kind of interruption. As a result the continuous flow of the data is lost. The loss of the continuous data transmission results in some kind of delay. Thus the transmission delay will be significantly increased. The delay constraints in cognitive network are tough to meet. Our main concern in this paper is to meet this delay constraint. Delay with respect to the fading is that when a signal travels in all directions & meets the receiver antenna, the antenna will get the same signals from different paths. So as a result of this some signal which are received after some fraction of second, will have some delay. So all the combined affect is the cause of the signal fading.

Those that receive the signals lately are called the delayed candidates. To avoid this delay difficulty we represent the occurrence of the LUs in a continuous chain. Applying cascading will result in controlling the data access delay.

4. System Model

Our cognitive network consists of L set of total l number of licensed users and U set containing u number of unlicensed users.

Let Ca_n be the set of cascading nodes. The data is transmitted from the source to the receiver through the cascading nodes. The transmission cost is given as $rN(g)$. Where r is the traffic rate, g is the transmission graph and $N(g)$ is the total edges in g.
The entry cost is given as

$$\sum_{n2} Pro_{n2}TdRT_{n2} \tag{1}$$

where Pro_{n2} is the data entry probability for node $n2$,RT_{n2} is the round trip cost from $n2$ to a cascading node and Td_{n2} is the roundtrip delay from node $n2$ to the cascading node next to it.
For a node $n2$ the delay constraint is given by

$$Pro(Ed_{n2} \leq \mathbb{B}) \geq \mathbb{A} \tag{2}$$

WhereEd_{n2} is the entry delay for node $n2$. $\mathbb{B}$ is the threshold for delay, and $\mathbb{A}$ is the level of trust.
The delay constraint problem can be minimized by minimizing the total delay i.e.

$$\sum_{n2} Pro_{n2}Td_{n2}RT_{n2} + RrN(g) \tag{3}$$

where R is a cost ratio, and focusing on
$Pro(Ed_{n2} \leq \mathbb{B}) \geq \mathbb{A}$ for all nodes.

Delay approach:

Let SP_{n1n2} be the shortest path between any two nodes. The data entry delay from $n1$ to its next cascading node is $2minSP_{n1n2}$

The time taken by the source to receive the request is the shortest path, SP length.The disabled nodes are useless during the transmission of the request from the requester to the source. Suppose we have to transmit a request from node 1 to node 6 where node 3 and 4 has no direct channels since those channels are being used by the LUs. So nodes 3 and 4 becomes useless, since it does not help in the transmission to reach to the node 6.

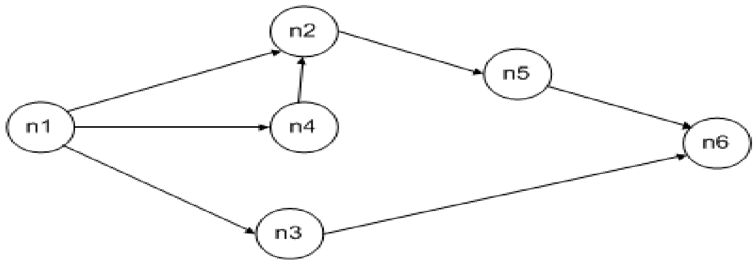

Figure 4. Links between the user nodes during transmission

The various states from n1 to reach n6 are as follows:
State1 → n1, n2
State2 →n1, n4
State3 →n1, n3
State4 →n1, n4, n2
State5 → n1, n2, n5
State6→ n1, n3, n6
State7→ n1, n2, n5, n6
The shortest time for which the request is reached at the node 6 is called the shortest length path. Let us consider the shortest path length from the requester node n1 to the source node n6 be SP_{n1n6}.

$$SP_{n1n6} = \min\{t\} \geq 0: D(t) = {}^{p_n}/_{D(0)} = p_1 \quad (4)$$

If $X(t)$ is a function of SP_{n1n6} such as

$$X(t) = Pro(\, SP_{n1n6} \leq t) \quad (5)$$

$$X_m(t) = 1 - \sum_{j=0}^{m} \left(1 - \gamma_j\right) e^{-yt} \, (yt)^j / j \quad (6)$$

$$\widetilde{X_m}(t) = \gamma_m - \sum_{j=0}^{m} \left(\gamma_m - \gamma_j\right) e^{-yt} (\gamma_m - \gamma_j) e^{-yt} \, (yt)(yt)^j / j \quad (7)$$

Where γ_j is the (1, n) th element in jth power of yth element.

To find the SP from the requester to different cascading nodes, i.e. if the intermediate node n5 is a cascading node and if n5 and the source node n6 both receives the request from the requester, then it is ended and then the state for the source node will be obtained by merging all the states into one final state.

State1 → n1, n2
State2 →n1, n4
State3 →n1, n3
State4 →n1, n4, n2
State5→ n1, n2, n5, n6

The shortest path will give us the value of the entry delay because Entry Delay = 2(shortest path).
Thus the entry delay reduces to

$$Pro(2SP \leq \mathbb{B}) \geq \mathbb{A}\ ) \quad (8)$$

where $\mathbb{B}$ is the delay threshold limit and $\mathbb{A}$ is the level of trust

$$X(\mathbb{B}/2) \geq \mathbb{A} \quad (9)$$

5. Experimental Result

In the proposed model we have considered a network topology including 15 licensed users transmitters and 15 licensed user receivers and about 72 unlicensed users. There are 9 cells included which share the cognitive network. Here after the spectrum optimization in order to deal with the delay effect we have used the cascading technique. The results obtained from the new proposed technique are plotted as shown in Figure 5.

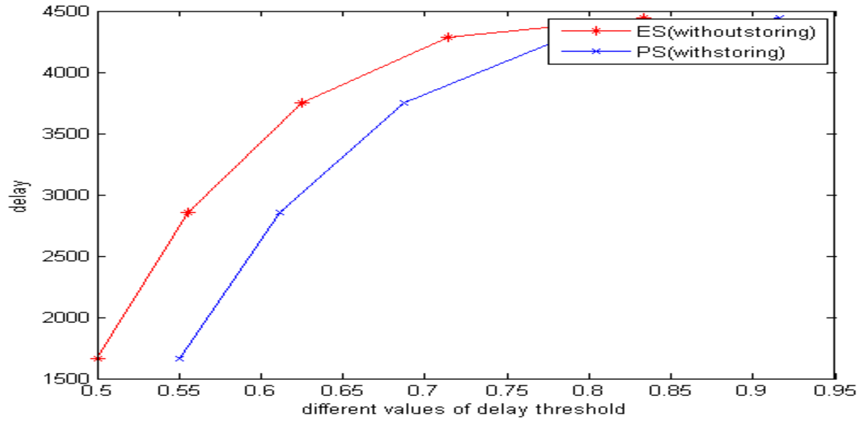

Figure 5. The delay responses for the proposed system vs. the existing system

The Figure 6 describes about the delay change comparison in the Existing system without the cascading technique with the proposed system where the data has been saving in the cascading nodes. Thus from the graph it is seen that the system where the cascading technique is involved suffers low delay then the one without the cascading technique

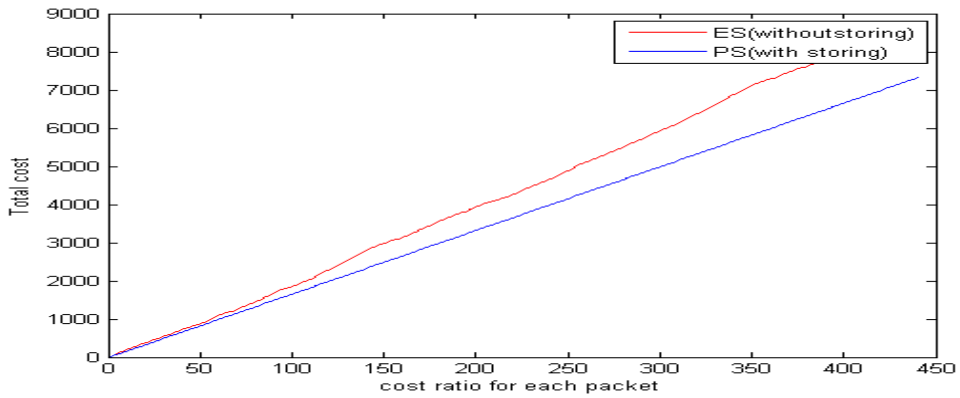

Figure 6. Total cost including the entry cost and the transmission cost for both PS and ES

The Figure 7 describes about the total cost of transmission in bits per second for both with cascading as well as without cascading technique that includes the starting transmission cost and the total transmission cost [12]. Here from the graph it is clear that the transmission is costlier in the existing system i.e. the system without the cascading technique than the proposed system i.e. the one with the cascading technique involved.

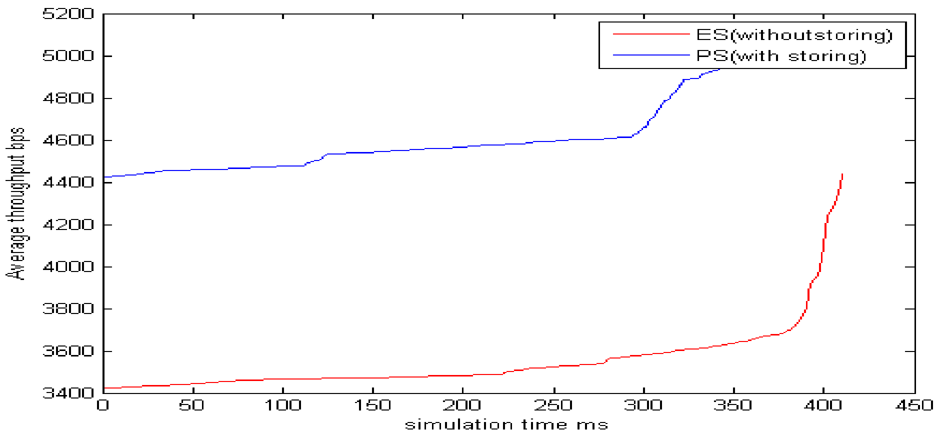

Figure 7. Throughput vs. simulation time

The final graph describes about the comparison of the average throughput of the proposed system and the existing system [13]. Here also the proposed system with cascading technique gives better result in case of throughput than the existing system without the cascading technique.

6. Conclusion

The interferences faced by the channel users in a cognitive network are tried to minimize in this paper. The problem is mainly suffered by the unlicensed user to stop their transmission and handle the channel to licensed user. Since the licensed users are registered to the channels so they always get the first priority in using the channels no matter even if the unlicensed user's transmission needs to be interrupted. This results in delay in transmission. Our paper proposed a cascading node algorithm where the data is stored and reduces the lost and delay. It is better than the other standard systems.

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