ABSTRACT
In this research paper Interference Model for Scheduling Algorithm in Cognitive Radio Networks (CRNs) is designed. In the advancement of 4G it plays vital role. [1]. The first phone call over a cognitive radio network was made on Monday 11 January 2010 in Centre for Wireless Communications at University of Oulu using CWC's cognitive radio network CRAMNET (Cognitive Radio Assisted Mobile Ad Hoc Network), that has been developed solely by CWC researchers. Two types of CDMA based wireless networks are Cognitive radio networks (CRNs), and Cooperative communication networks.[5] Same spectrum is shared in all instantaneous transmissions in the networks and interferes with one another. In Cognitive radio, spectrum is inadequate resource in wireless communications. Currently, fixed spectrum slices are licensed to each wireless service technology. Recent studies [6] [8] have discovered that more than 80 % of spectrum is unutilized in rustic areas.

General Terms
Interference model, Cognitive Radio Network, Scheduling Algorithm.

Keywords
Equal Speed Allotment, Proportional Speed Allotment, CRN, Interference Threshold

1. INTRODUCTION
Radio Resource Management (RRM) plays imperative part in CDMA Based Wireless Networks [3]. In such a system users may transmit their signals concomitantly in the same frequency band. Each transmitter is consigned a dedicated spreading code, which can be reproduced at the intended receiver to regenerate receiver to regenerate the transmitted signal. The cross-correlation of different spreading codes is ideally zero, so that desired signal can be recovered and other interfering signals can be removed at the receiver [4]. In a practical system, the radio channel can be nonlinear and the spreading codes may not be orthogonal to one another. If additional users are there in the system and the higher power they transmit then the more interference they generate to one another. A number of novel ideas have been projected to provide more flexible and resourceful usage of the spectrum. The concept of dynamic spectrum access (DSA) or open spectrum is discussed in [9], which endeavors to dynamically manage spectrum access and spectrum sharing by using new technology and standards, in place of the current static band allocation. The key enabling technology of the projects mentioned above is the cognitive radio (CR), first presented. [7]. Cognitive radio is a paradigm for wireless communications in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently without interfering with the licensed users. This alteration of parameters is based on active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behavior and network states. From learning the wireless environment, the cognitive radio terminal will tune to the under-utilized spectrum and make its own transmission without notice to the primary users (PUs). We first jointly consider the resource allocations in both the primary and the secondary networks, and study the optimum transmission power and rate allocations for supporting best effort traffic in the CRN.

2. SCHEDULING IN COGNITIVE RADIO NETWORKS
Classy scheduling schemes are desirable to allocate resource competently and fairly among the users in a CRN. Compared to the scheduling in traditional wireless networks, scheduling in a CRN is more complex due to the opportunistic nature of the networks [11] [12] [13]. Our work is focused on applying graph theory to spectrum allocation and traffic scheduling problems. Optimum spectrum allocation is solved for CRNs by constructing an interference graph. In [14], the unused licensed channels are allocated opportunistically to a set of cognitive base stations so that the percentage of channel usage is maximized. The joint spectrum allocation and scheduling in cognitive radio networks is studied in [12] using the proposed novel Multi-Channel Contention Graph (MCCG) to exemplify the impact of interference.
3. OPTIMUM SCHEDULING IN COGNITIVE RADIO NETWORKS.

In a CRN with spectrum underlay, the secondary links can transmit at the same spectrum as the primary links as long as the interference that the secondary links cause to the primary links is below a pre-negotiated interference threshold. The effect of setting different interference thresholds on the transmission rate of the secondary links and how the secondary transmissions affect the transmissions of the primary links is studied.

3.1. System illustration
CDMA-based cellular network is primary network, where different frequency bands are used in the uplink and the downlink. Instead of communicating with the base station (BS) directly in the primary network, some mobile stations (MSs) near one another may form an ad hoc CRN and communicate directly with one another. The secondary transmissions share the same spectrum as the uplink of the cellular network through spectrum underlay, and cause interference to the uplink transmissions in the primary network. If the primary and secondary networks are tightly coupled, the CRN can share the same control channels with the primary network. The primary BS can monitor the secondary-to-primary interference and centrally control the CRN as in [17] and [20]. This is not a problem if the primary network has relatively light traffic load, which is most likely the case when a secondary network is allowed and INTh is set to be reasonably high, then the control channel in the primary network has low traffic load and can be well used for the secondary network as well. An alternative way to provide the common control channel in the CRN is that the CRN can lease several mini-slots in both the uplink and downlink in the primary network for transmitting control signals. The mini-slots in the uplink channel are used for the secondary devices to report the link and interference conditions to the controller, and the mini-slots in the downlink are used for the controller to broadcast information related to admission control and packet transmission scheduling to the secondary devices. In addition, the CRN can seek out-of-band control channel as done in [21], and the control channel can be in the license-free band.

Since only the uplink is considered for the primary network, the transmitters are the MSs, and they share the same receiver, which is the BS. Mp and Ms respectively, are the number of primary and secondary links. Each link has a strict signal-to-interference-plus-noise ratio (SINR) requirement at the receiver, which should be above γp for the primary links and γs for the secondary links after the signal is despreaded. There are two interference models for measuring the interference level at the primary receivers. The first is to monitor the noise and total interference from all the secondary and the primary transmitters. This measured interference is then compared with the interference threshold, and the result is used to regulate the secondary transmissions. In this way, the interference at the primary receiver caused by the secondary transmissions is not detected separately. This model does not require a priori knowledge of the RF environment, and consequently does not need to distinguish the licensed signals from the interference and noise. The second model requires that the aggregate signal strength coming from the secondary transmitters is measured at the receiver of a primary link and compared with the interference threshold. In this case, interference caused by the secondary transmitters should be separated from that caused by primary transmitters in order to calculate the interference level. Below we formulate the power and rate allocation problem in the primary-secondary scenario based on these two interference models.

A CDMA-based system is typically interference-limited. In such a system users may transmit their signals simultaneously in the same frequency band. Each transmitter is assigned a dedicated spreading code, which can be reproduced at the intended receiver to regenerate the transmitted signal.

4. INTERFERENCE THRESHOLD
From the secondary links, a higher interference threshold allows higher transmission power and can potentially increase the transmission rate of the secondary links. On the other hand, as the secondary links increase their transmission power, they cause more interference to the primary links. As a result, transmission power of the primary links should also be increased. The mutual interference effect eventually reaches a balance, and then neither the primary nor the secondary links can increase the transmission power. Secondary-to-primary interference is maximized when at least one MS in the primary network reaches Ps,max. Consider that homogeneous traffic is carried out by the primary links. Then for all represent the aggregate noise and interference that the ith primary link experiences from all other primary links and all secondary transmitters. With perfect power control, the actual SINR for the primary link at the BS receiver input is equal to and all the primary links have an equal received power at the BS [22].

\[
P_{p,i} = \frac{P_{p,i}}{g_{p2p,ii}} \leq P_{p,max}
\]
That’s why,
\[ I_{p,j} \leq \frac{G_p P_{p,max} g_{p,2p,ii}}{\gamma_p} \]  \hspace{1cm} (1.2)

If, \( i=1, 2 \ldots \text{MP} \), then,
\[ I_{p,max} = \min_i I_{p,i} = \min_i \frac{G_p P_{p,max} g_{p,2p,ii}}{\gamma_p} \]  \hspace{1cm} (1.3)

The transmission power of the second links is limited by INT, to satisfy the SINR requirements of the primary links.

\[ Pr \left\{ g_{p,2p,ii} \leq \frac{y_{p}^*}{G_p P_{p,max}} \right\} = \int_{0}^{\frac{\beta x}{\ln \left( \frac{y_{p}^*}{G_p P_{p,max}} \right)}} f_d(z)dz N \left( 0, \frac{\alpha}{\ln \left( \frac{y_{p}^*}{G_p P_{p,max}} \right)} \right) \]  \hspace{1cm} (1.10)

\[ f_d(z) = \]  
\[ Pr \left\{ g_{p,2p,ii} \leq \frac{y_{p}^*}{G_p P_{p,max}} \right\} = \int_{0}^{\frac{\beta x}{\ln \left( \frac{y_{p}^*}{G_p P_{p,max}} \right)}} f_d(z)dz N \left( 0, \frac{\alpha}{\ln \left( \frac{y_{p}^*}{G_p P_{p,max}} \right)} \right) \]

5. SIMULATION RESULTS
We first show the results based on the first interference model, then compare the results based on the two Interference model.

\[ E\left[ I_{p,\text{max}} \right] = \int_{0}^{\infty} \left( 1 - Pr \left\{ I_{p,\text{max}} \leq y \right\} \right)dy \]  \hspace{1cm} (1.8)

The distribution of \( g_{p,2p,ii} \) can be found as
Figs. 2 and 3 demonstrate that when the interference threshold is below a certain value, the secondary link transmission rate increases with the interference threshold for both ESA and PSA. Ahead of this range, further increasing the interference threshold does not affect the secondary transmission rate anymore, since the transmission of the secondary links is limited by the primary link’s SINR constraint and the mutual interference between primary and secondary networks. To sustain the SINR, the primary links will increase their power too. Once the maximized interference limit at the primary receiver is reached, the secondary users cannot further increase their transmission rate even if the interference threshold is not reached. It is also observed from both Figs. 2 and 3 that increasing the number of the primary or secondary links results in lower secondary link rate due to that more links are competing for the network resources. Comparing the two figures we can find that using PSA can achieve a lot higher transmission rate for the secondary links than using ESA, since the former can take better advantage of good channel conditions of individual links.

From fig 4. It is observed that as $D_{max}(m)$ increases, interference to primary links reduces. Table 3 elucidate us that $INT_{max}$ reduces as ESA decreases and PSA increases.

### Table 1. Secondary Link Transmission Link, for different values of $N_p$ and $N_s$

<table>
<thead>
<tr>
<th>$N_p=5$ &amp; $N_s=10$</th>
<th>$N_p=10$ &amp; $N_s=5$</th>
<th>$N_p=5$ &amp; $N_s=5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20000</td>
<td>14000</td>
<td>22000</td>
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<tr>
<td>38000</td>
<td>15800</td>
<td>28000</td>
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<tr>
<td>50000</td>
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<td>39000</td>
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<tr>
<td>60000</td>
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<td>60000</td>
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Table 3. $INT_{max}$ for PSA and ESA related to cell size

<table>
<thead>
<tr>
<th>$N_p=10$ &amp; $N_s=5$</th>
<th>$N_p=5$ &amp; $N_s=10$</th>
<th>$N_p=5$ &amp; $N_s=5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000</td>
<td>6500</td>
<td>145000</td>
</tr>
<tr>
<td>10000</td>
<td>13500</td>
<td>180000</td>
</tr>
<tr>
<td>15000</td>
<td>18500</td>
<td>265000</td>
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<td>20500</td>
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Fig 4: Highest interference vs. cell size
6. CONCLUSION AND FUTURE WORK

In this research work, we have simulated and designed interference model for scheduling algorithm in CDMA based CNR. The actual average interference at the primary link is also shown for ESA and PSA, respectively. Results indicate that there is a limit on the interference threshold beyond which the secondary link transmission rate cannot be increased by increasing the interference threshold. Also, the increase of the secondary user transmission rate will consume additional power from the primary user, and the same amount of power increase from the primary users can support higher rate of the secondary links using proportional rate allocation, compared to using equal rate allocation among the secondary links.

From fig 5 and fig 6 we can articulate that, in disparity, PSA does not encourage the secondary links with poor SINR to transmit as high rate as the links with good SINR. When INT$_{th}$ is small, using the second interference model achieves much higher transmission rate than using the first interference model, since in the latter case, noise and interference from the primary network can dominate the interference threshold, while in first interference model, the secondary transmissions can take advantage of all the interference allowed by INT$_{th}$. As INT$_{th}$ increases, the secondary transmission power increases and eventually is limited by their mutual interference and SINR constraints, but not by INT$_{th}$.

At this point, the two interference models result in about the same transmission rate at the secondary network. This work is based on specified transmission rate requirements for the traffic. Further work can be done for supporting variable rate traffic, maximizing a certain system utility function, such the throughput, subject to providing the users with a certain fairness, supporting user mobility, etc.

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8. REFERENCES


