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Development of a Cognitive Access Point Algorithm for proper spectrum management in a High Density Network.

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Abstract

Newer innovations of electronic equipments come with factory fitted wireless network interface cards to enable them to have internet access. Consequently, the recent surge in youths signing up unto social media, file sharing and messaging services in addition to high rate of internet of things currently being deployed also increased the internet dependency rate. The global pandemic also surged the need for data dependency as corporate organisations and schools moved to online meetings and online classrooms. Classroom learning has also been drastically changed through the introduction of virtual classrooms and holograms. This research work studied conventional wireless access point environment through experimental setup of wireless access point scenarios. The effect of distance from the access point on the signal strength and transmission power was determined by setting up so many stations at various distances from the access point and packets transmitted to them while network analyser was used to read up the bandwidth and calculate the time, delay, throughput, and received signal strength. The effect of wireless interference on wireless network transmission within the same area was determined by setting up interfering radio signals to affect normal wireless LAN operations.

Keywords: Cognitive Network, Bandwith

Introduction

The sharp increase in internet dependency has become very pertinent to make internet access very mobile. Wireless network created the possibility for internet mobility. This makes internet access available at every location without any hindering factor like cable connections, etc.

Wireless Access Point becomes a key factor to making internet portability possible. For this reason, in recent years, Wireless Access Point technology has been seen to have a very sharp demand in the market of telecommunications. The technology is having an astronomical growth as the day goes by. Manufacturers of portable internet devices and service providers are raking in millions of dollars daily. All moveable electronic devices for instance, the mobile phones, laptops are now manufactured to have network interface card and adapters. Even now, smart televisions are equipped with internet capability. The icing on the cake of this is that it brought up the cost effectiveness of internet deployment and made data access to be readily available everywhere and at any time. To achieve wireless data sharing, there should be handy Access Points having a direct connection with the internet backbone in order to make available wireless connection to the area that is covered by the wireless network. Making use of a single access point hampers the effectiveness of data access especially in densely populated areas. This is because data service demand is predominantly apparent in crowded areas like conference halls, auditoriums or any other location where people gathered en masse and a great number of wireless devices compete for limited spectrum. Such a congested environment is overflowing with individuals that may have the desire to publish what they experienced through video streaming or share of still photos with associates and friends who are not there present through the use of social media platforms like Snapchat, WhatsApp, Facebook, etc., email and other web browsing platform (Haleh *et al*, 2016). For this reason, a University environment will normally have more than one access points working in tandem to make available the desired data sharing services to the connected tech and data savvy youths within the environment. This is because wireless access points have limited ranges at which its power level could push data successfully. In addition, they also have limited number of clients they can serve at the same time with respect to throughput demand of the users. Consequently, as there has been a remarkable growth in the employment of wireless devices in the everyday life due to constant advancement in wireless technology, it can be seen that in the few years to come, considerable increase in the number of devices connected will be on high rise with regards to general embracing of Internet of Things (IoT) and adoption of Bring Your Own Device (BYOD) by most companies (Meru, 2012). Contemporary WLANs regularly provide service for at least 3 different devices for each individual or up to seventy five devices for each cell. However, the sizes of cells have not been altered in any way. This will in turn push the existing Wireless Access Point and their network deployments above their limits of capabilities (community.arubanetworks.com, 2018). In fact, it is predicted that by the end of 2019, 80% of Internet traffic will be video streaming (aoifes.com, 2018). This has already created a lot of congestions in the network environment as the user density per space area and data transmission rate has increased tremendously. It in turn, erodes on the performance of access points by hampering successful packet delivery, user experience and creating drags and delays in accessing data while on the go. Spectrum of a very large quantity is needed to shore up this ever growing quantity of connected wireless devices. Regrettably, the availability spectrum is always seen to be limited because newer spectrums have not been created and the available ones are depleted and not readily available. If a deep look is taken on the recent chart of spectrum allocation, it will be almost impossible to find an available spectrum that will provide accommodation for the impending surge of mobile wireless data traffic and wireless devices (Kibria *et al*., 2016).

One of the conventional procedures to resolve the challenge of congestion in densely populated wireless environment has been the use of additional wireless access points. Conversely, this will need planning of cell and acquisition of sites thus creating additional increase in complexity and cost of deployment (Lee and Kang, 2000). The use of improved physical-layer technologies can also enhance the efficiency of spectrum use of the limited spectrum available, though; this cannot sufficiently meet up with the current enormous demands in the recent days. This motivated the introduction of Cognitive Radio Scheme in Wireless Access Points. The concept of Cognitive Radio was developed to fight the imminent spectrum unavailability. The users are the ones who are not licensed but locate vacant licensed spectrum dynamically for their use with no resultant interference that could hamper users that are licensed. This will to a large extent, solve the sluggish internet speed in densely populated environments due to struggle for wireless media access, packet drops, jitters, congestions and poor Quality of Service normally experienced in such environments

2.0 Bandwidth

2.1 **Bandwidth issues.** There is a great need to ascertain the number of devices accessing the network and the activities they are engaging themselves with when connected to the network. A wireless access point could have a given bandwidth assigned to it, it is vital to get a clear picture of how many people are accessing the wireless network and what types of activities they are engaging in while connected. Some of these activities may be putting a greater strain on the network thereby robbing other users. For instance, online gaming and streaming of High Definition videos can significantly eat up bandwidth. When devices are using a very big amount of bandwidth, there will be drag in the network for other users. To help solve this, the number of devices eating up the bandwidth is recommended to be removed. When there is the need to stream HD videos or play online game, it is recommended to do so when there are fewer devices running at the same time. This can be set in the router if it utilizes Quality of Service methods.

2.2 Wireless Networking.

Wireless LAN is a local area network which makes use of high frequency radio signals to receive and transmit packets of data over distances of up to some hundreds of feet. Many electronic devices are now capable of receiving Wireless Network. These devices can connect to a network in order to share data and internet through a hotspot. Here, radio waves are means of data transportation over the air, thus creating the possibility of devices to be connected to a network without any cabling or physical connection. Wireless network make use of hotspots to enable devices connect to the backbone. Wireless LANs are the most famous and widely deployed type of wireless networking. Other alternatives include the use of satellite, microwave, cellular, infrared and Bluetooth, and so many others. When compared side by side, wired local area network provides a superior bandwidth, speed, security and reliability than the wireless networks. Wireless LAN network makes available scalability, mobility and more flexibility. Typically, maximum speeds of network are theoretically rated and in effect, these numbers may not actually reflect the real life performance. Generally, the speed of a wireless connection will always be slower than the speed of wired link connection. Wireless routers, Laptops, and other wireless devices can normally connect to one of these wireless standards.

3.1 METHOD.

3.2 Development of algorithm model for the network under consideration.

3.3 Assignment of Spectrum

In this allocation of spectrum, each of the clusters is signified by one vertex. Two vertices are interconnected with an edge when a considerable meddling is created on every one of them. The colour of cluster K is denoted with b_k. The algorithm for spectrum assignment performed by the cluster is as summarized below

```
Initialize
        $\xi_k = \xi$
        select $b_k$ randomly from $\xi_k$
while $b_k$ equals $b_{k'}$, $\exists k' \in \eta_\psi$ do
        $\xi_k = \{b_k\} \cup \xi \setminus \{b_{k'}, \forall K \epsilon \eta_k\}$
        randomly select $b_k$ $from\ \xi_k$
end while
```

In order to demonstrate the progress of this algorithm, an example with $K = 5$ clusters was considered. The Clusters that impede the performance of each other are made to use different spectrum and are connected with an edge. For instance, if device 5 meddles with device 1 and device 3 while they operate on the same spectrum($\eta_s = \{1, 3\}$). The upper most pinnacle on the graph is 4, however in a case where we have just three groups of channels available (B_{max} = 3). The colours are represented by green (g), yellow (y) and red (r): ξ = {g, y,r}. Every one of the clusters reset its choice pallet $\xi_k$with every available colour ($\xi_k = \xi, \forall$k). After the initial iteration, every of the cluster chooses a colour from $\xi_k$homogeneously on a haphazard mode as depicted in left most box. Every one of the cluster k subsequently showcases its colour, b_k and then eavesdrops on its neighbours to know the choice of b_k, $\forall k' \epsilon \eta_k$. All the clusters that did not detect the collision (i.e. 1 and 2) fix their selections. For the following iteration, other clusters (i.e. 3, 4, 5) had their neighbor's colours eliminated from ξ (without any change in their colour) and produced the next set of selectable colours. The colours that are possible can be seen in boxes in white next to every one of the vertexes .On subsequent iteration, all non-coloured clusters make a selection of colour randomly from the collection of probable colours belonging to it. The resultant effect of this colouring can be seen in the centre box. Assuming clusters 3 and 5 chose the same colour {y} again, at the same time as cluster 4 is coloured successfully. The likely options of 3 and 5 remain unchanged as before. For the period of the third iteration, cluster 5 picks {g} at the same time as cluster 3 picks the sole alternative, {y}, as shown in the box at the right hand side . By way of this selection, the graph was coloured such that there will be no two adjacent clusters that are coloured with the same colour. Here, each of the clusters resets its colour pallet ξ_k with the available colour ξ. Colour of the cluster $b_k$is then selected at random from the clusters' colour pallets. Iteration is done, whereby each member of the cluster is observed to determine meddling with other devices. If this is obtainable, a different spectrum will be assigned to prevent interference from clusters that are adjacently placed side by side.

3.4 Performance of Cognitive Access Point Algorithm

The performance of this proposed Cognitive Access Point Algorithm was put side by side to that of conventional cellular Direct Mode (DM: licensed). In this, the base station communicates directly with stations through the licensed frequency bands. To fairly compare them with regards to resources available, base station is assumed to directly communicate with the nodes through the white spaces and also through bands that are licensed. Nonetheless, for this assumption to be factual the transmission power experienced at the nodes and Base Station connections to the White spaces will be low to extent of ensuring that interference does not affect the performance of any of the primary users and that of the secondary users. This operation mode is considered to be "Direct Mode: licensed + White space." In simulations, it is assumed that some degree of white space is available in the radar band (the midpoint of 10 MHz, 3.595 - 3.605 GHz). This matches up to $N = 52$ channels of white-spaces. During the simulations, it was additionally assumed that each of the users have a rate requirement of R = 540 kbps. Having this group of parameters. The average of lowest number of White Space bands (B*) required as the cluster size γ diverges amid two and six. Since the association $B_{max} = {}^{N}\!/_{\gamma} - 1$ determines the number of bands, as the size of the cluster grows or colours reduces. Moreover, the least amount of colours necessary to colour all clusters reduces, due to the fact that clusters are not closely located and thus, the interference graph are light. The best possible K afterwards aligns to the size of the cluster γ where the average B* is nearer to the available number of channels i.e.B_{max}. Through the allocation of channel to every one of the slaves, the number of channels for each cluster, $\beta = 4$. The functions having divergent system parameters and can be warehoused at the base station. Due to the fundamental parameters of the system, the base station could make use of the matching look-up table to decide the optimal size of cluster K.

4.0 Conclusion

When the density of the users grows to 300, the transmission power needed by the CogAp Algorithm goes up to 71% for either of the direct mode methods. As the user density grows to 500, with inadequate licensed band resources, the transmission power demand goes down to 67% when compared with direct mode licensed, "DM: licensed." The figure shows that the number users grow by 20% when comparing CogAp Algorithm and that of both Direct Mode methods. When the cumulative network transmission power is approximated to 75W, Direct Mode: licensed method is capable of supporting up to 400 users, while CogAp Algorithm can take up to 480 users.

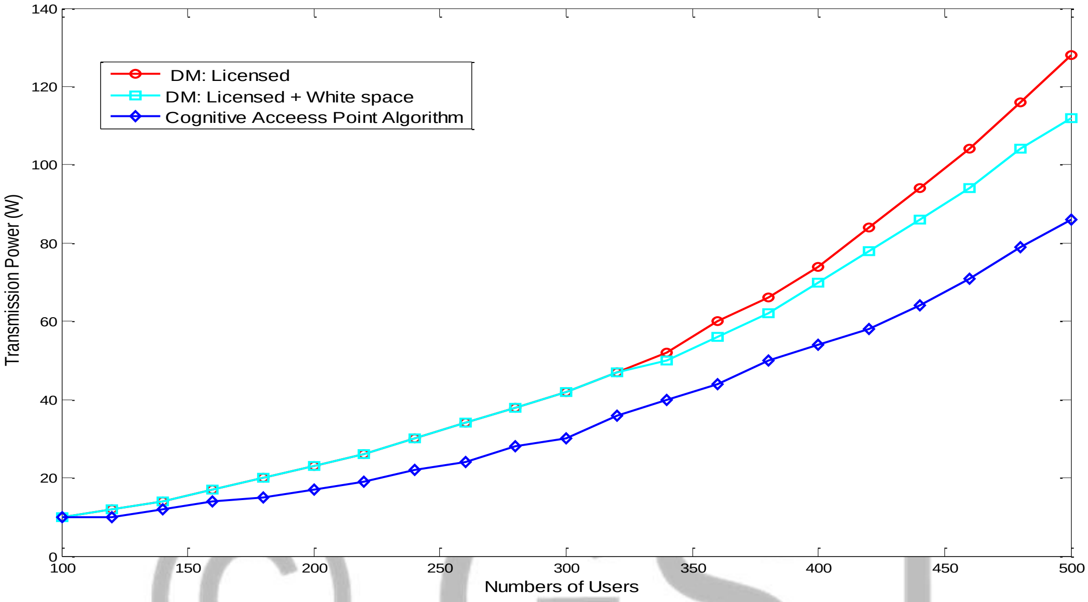

Figure 4.1: Network power when compared against number of users

Similar performance comes up when there is a comparison with Direct Mode methods and can be gotten by keeping the user density constant while the available quantity of the licensed band channels are varied. Fig. 4.1 shows the variance in the required transmission power when licensed-band channel grows from the 500 users to 700 users. If the available spectrum becomes limited, the whole transmission power needed by CogAp Algorithm is merely 67% of Direct Mode licensed and 77% for Direct Mode licensed with White Spaces method. When M grows, the performance of Direct Mode licensed with White Space gets closer to Direct Mode since the White Space channels operating at elevated frequencies when compared with that of licensed channels need to have transmission with bigger power and thus are that effectual. The figure confirms that CogAp Algorithm reduces the network resources to the detriment of the configuration of hotspot–slave overhead.

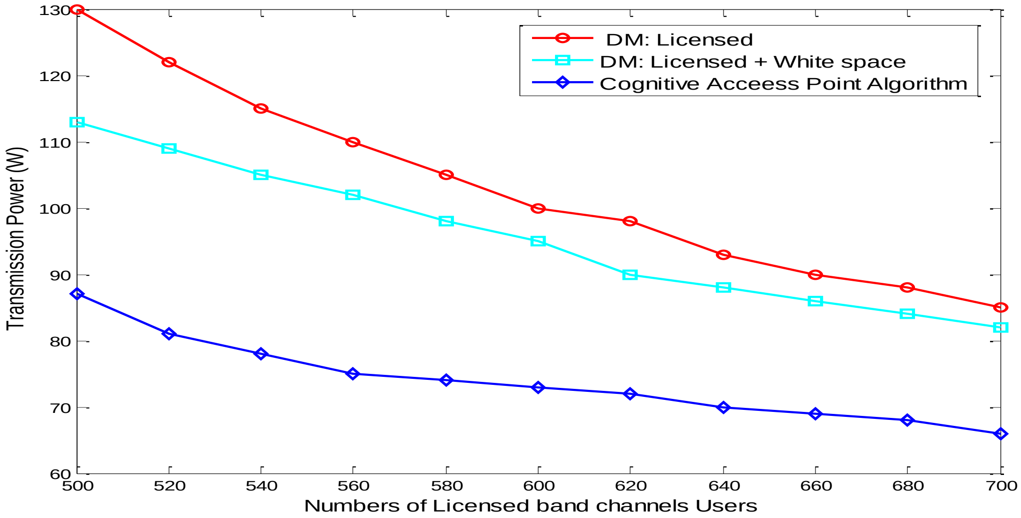

Figure 4.2: Network power when compared against number of licensed band channels

When the rate requirement for each user grows from 0.18 to 1.08 Mbps, the total network transmission power can be seen in fig. 4.22. When the rate requirement of the user grows, the distance threshold grows and therefore, additional white space channels will be needed. The results of the simulation revealed that the average number of white space channels needed by the CogAp Algorithm for each of the rate requirement diverges from N = 26.8 to 116.0. For comparison, the same number of channels is made use of in Direct Mode licensed with white space on all the rate requirements and is pegged at 0.75.

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