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# Interfering Issue in High Density WIFI Hotspot Area and its Way out

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**Abstract:** With the wide spread of WiFi hotspot in the area flooded by a lot of populations, i.e., Mall, city squares and railway stations, many WiFi hotspots are deployed by the shop stores and telecommunication providers. However, the concentrated excessive WiFi hotspot would lead to the interfering among the hotspots in the areas and the network speed is slowed down. Here, the network performance in the high density WiFi hotspot areas is analyzed and the relative techniques about interfering cancellation are presented in details. Finally, the possible solutions about WiFi hotspot management as the effective approaches are also proposed in the review.

**Key words:** WiFi hotspots, network interfering, wireless local networks, interfering cancellation

## INTRODUCTION

Based on the IEEE 802.11a/b/g/n standards as technical specifications, various WiFi devices work at the ISM frequency ranges, which could be deployed into small wireless local interworks in small areas. Furthermore, with the development of the WiFi techniques, the low price economic WiFi could be deployed in popular human lives with high wireless access speeds. Thus, the telecommunications companies in most countries had deployed a lot WiFi hotspots to serve the incremental wireless access requirements with various portable devices, i.e., smart phones, iPADs, notebook computers and so on. At the same time, the WiFi devices works as wireless access devices in human houses as the substitutes of human families for the twisted-pairs that disturb human lives with their cables. Thus, the wireless access in family environments becomes also one part of human ordinary lives. However, in the areas with high density population, i.e., railway stations, great Mall, public squares, large numbers of WiFi devices in local limit areas would lead to the jams of various WiFi access devices. So, this issue should be paid more attention to figure one way out. In this study, the relative techniques to the wireless signal interfering are discussed and the final possible technique scheme is proposed to conduct further research is displayed.

## NETWORK PERFORMANCE OF HIGH DENSITY WIFI HOTSPOTS IN LIMITED AREAS

In the areas with high density WiFi hotspots, various WiFi hotspots are competing to use the limited wireless frequency resources without any wireless channel administration. As various WiFi hotspots are working the closed or same channel resources, the co-channel interfering (Li *et al*., 2007) and near channel interfering (Tan *et al*., 2010) would be caused by these competing devices. According to the current WiFi technique specification, i.e., 802.11 a/b/g/n standards, these co-channel interfering would lead to the issues in two aspects in the Media Access Control (MAC) layer of the 802.11 standards, i.e., network jams and flooding handshake messages from the base stations that reduced the transport efficiencies (Li *et al*., 2007). Meanwhile, the near channel interfering would lead to the decrease of signal noise ratio that received by various WiFi receiving devices, which further deduced the whole network performances.

According to the WiFi performance test results in the 2010 Guangzhou Asia Sport Games fields (Li and Wen, 2010), the WiFi hotpot signal is with enough intensity in the airport, Mall and large public areas, but the wireless access speed was too low to play the online video application and only the web surfing could be conducted. This fact test results could reflect the current

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puzzle dom of the high density WiFi hotpots in limited areas. Here, the factors about co-channel and near channel interfering are the main effecting factors to the network performances (Fields, 2009; Angrisani *et al*., 2008), which could bring the 50% reduction of network throughput to the various WiFi hotspots. So, in order to conduct the online video applications with high Quality of Service (QoS) requirements, some technique schemes should be conducted to cancel or reduce the possible implicit channel interfering in the high density WiFi hotpots areas.

## CURRENT RESEARCH RESULTS ABOUT CHANNELS CANCELLATION

As the common issues that should be considered in various wireless access systems, the interfering cancellation technical methods had been proposed to reduce the possible co-channel and near-channel interfering. The technical schemes to reduce the interfering among various WiFi hotpots, congestion control protocols, wireless resource allocations, are used to cancel the possible interfering from WiFi hotspots and lots of terminals. So, the following several aspects about interfering cancellation techniques could be outlined as the content shown:

- Interfering cancellation techniques in physical transport layers
- Congestion control techniques
- Link adaptive technique of wireless resources
- WiFi hotpots managements
- Various QoS guarantee techniques

These techniques are expected to get rid of the performance reduction that caused by various channel interfering in the fact WiFi deployments and the network transportation of various business data streams for special custom application cases with QoS guarantee techniques. Thus, the possible network congestion could be reduced in the high density WiFi hotspots. In the following content, the several aspects about above interfering techniques would be reviewed with the followed possible proposed scheme by the authors of this review.

**Interfering cancellation techniques in WiFi:** In the theories of wireless network technique standards, many 802.11 networks could work in the non-overlaid channels in local areas without any interfering to each other. However, with limited channel resources, too many WiFi devices are deployed into the same limited local areas, the cases that many devices work in the overlaid channels could not be avoided, which would lead to the co-channel interfering and the competing channels (Li *et al*., 2007; Fuxjager *et al*., 2007). Finally, the wireless networks are jammed. Furthermore, too many WiFi devices work in the crowed areas, would also lead to the near-channel interfering, which would cause two vital affect to the whole network performances (Fuxjager *et al*., 2007), i.e., the data frame would be destroyed with the increased cross-channel interfering and the network congestion caused by frequent carries detections in the MAC layers.

Tan *et al*. (2010) presented the effects of adjacent channel interfering on the network performances by a lot of experiment on the WiFi hotpots. The adjacent channel interfering could be reduced by changing the path loss and the channel intervals and the requirement minimal transmit power could be obtained between nodes to cancel the possible adjacent channel interfering. Thus, the transmit power could be reduced by 37-45 dB between the two adjacent network nodes, which would not cause the adjacent channel interfering. At the same time, based on the work status of adjacent channels, the network Access Points (AP) would allocate the channels and their parameters to the connected nodes and this would also further reduce the possible adjacent channel interfering (Kim *et al*., 2010).

In fact, when the current WiFi network is overlaid by another WiFi hotspot, the base station in the overplayed area would be disturbed by some implicit terminals which could lead to the loss of justice for the channel access of other possible terminals. In this case, when the base station sensed the existence of overlaid WiFi hotspot, it could cut off in time to other channels without any distributions from these implicit terminals in the overlaid areas. Thus, the distribution from the implicit terminals could be avoided. However, how to sense the existence of overlaid WiFi hotspots is one special issue with many difficulties (Tandai *et al*., 2006):

- The nodes in current networks could receive the data from other nodes and in the case that the current network with large throughput while other network with high frame rate, the current network nodes could not detect the network identification of other network data frames
- If the radius of the current network is smaller than that of the overlaid areas, the data from other network nodes would disturb the transportation of current networks

Therefore, the reference (Lee *et al*., 2007a) and (Tandai *et al*., 2006) used the results of carrier detections

and the errors of data frames as the measure of the degree that the network nodes were disturbed by the interfering from those implicit terminals.

In order to describe the toleration to the network distribution from other WiFi hotspots, the reference (MacDonald and Ucci, 2007) proposed the concept of distribution temperature, which could measure the toleration degree to the wireless interfering from those devices with special protocols and modulation modes. Furthermore, the research results reported in the reference (Tan *et al*., 2011) for the interfering of other WiFi hotspots to current WiFi networks indicated that the interfering is vital to the throughput of data link layers and is linear to the transmission power of other WiFi hotspots in the overlaid areas. Aiming at the commutative interfering of many WiFi hotspots in the overlaid limited areas, the reference (Abusubaih *et al*., 2009) could cancel the interfering among the overlaid WiFi hotspot areas by the way of the cooperation and resource allocation among the co-existed WiFi hotspots in one limited area. When the user terminal realized the decline of QoS with high intensity interfering, the base station under the same overlaid area with interfering from other base stations would negotiate about the channel access schemes and the channel access become to the time slot from CSMA/CA methods. Thus, the interfering issues could be avoided among the overlaid base stations of many WiFi hotspots in one local limited area. At the same time, the justice among these overlaid WiFi hotspots could also be preserved effectively. However, the transmission power control method was used to avoid the interfering to each other in the high density WiFi hotspot area in the reference (Mhatre *et al*., 2007; Yang *et al*., 2004).

**Congestion control technology:** With the increase of network access devices, the wireless channel resources become very few and this would lead to the case that many network devices compete for the shared channel resources. Thus, the data request in the network could not be satisfied and the network congestion appears. In the case with network congestion, the throughput of wireless terminals is reduced and the transportation time is prolonged. Furthermore, both the delay of point to point in the network and the loss packet are increased and the data transportation with high real-time requirement could not be loaded in the networks in the limited area with high density WiFi hotspots (Dong *et al*., 2003; Lee and Lim, 2010).

Aiming at the dynamic network in the 802.11 WLAN, the reference (Yoo and Kim, 2011) could use several metrics, i.e., the channel idle time, the data line length at the network interfaces, the re-transmission ratio and so on, as the congestion metrics about the network congestion degree. Here, the congestion time remaining (CORE) is proposed as a simple congestion metric with good efficiency, which indicates the possible congestion time between the measure IP location and the MAC layer. However, the network competence intension is used as the metric that indicates the current congestion status. According to the network competence intension status, the appropriate network width and transmission rate would be selected in the reference reported results (Lee *et al*., 2007b). At the same time, one network congestion control scheme under the point-to-point MAC layer was described in the reference (Shi *et al*., 2009), whose basic idea is that the data transmission rate at the MAC layer could be controlled by the congestion control window. This method could increase the channel utilization and the link justice of several WiFi hotspots in the overlaid area and the feed-back mechanism, load balance and channel layout are introduced in the overlaid areas with high density WiFi hotspots (Lawabni and Tewfik, 2004; Zhou *et al*., 2004), so that the network resources could be shared fairly by various WiFi access devices and the loaded data transmission could be realized reliably in time.

**Wireless resource management technology:** In order to improve the whole WLAN performance in the case of network congestion, the data sending requirement in the network could be satisfied by appropriate wireless resource management and allocation and the data throughput of the whole network is improved obviously. For the random access MAC protocols of 802.11 networks, one adaptive wireless resource management scheme is given by the reference (Wang *et al*., 2006), which could adapt the minimal competing windows according to the network data transmission. The GPS MAC protocol layer use one feed-back system control model to design one adaptive P and PI controller and the data transmission request with QoS guarantee could be satisfied. However, the reference (Wang and Cuthbert, 2007) proposed one smart wireless resource management system and the wireless access point could decide its overlaid areas according to its data transmission request. What's more, one wireless resource management based agents is also described in the reference (Wang *et al*., 2004) and the agent could conduct the cooperation between one WLAN access point and its adjacent WiFi hotspots to adapt dynamically their network parameters with minimal interfering to each other.

As known by everyone, the bandwidth parameter in MAC layer has direct relationship to the network rate and could be adapted according to the wireless resource

requirement in the physical layer. Consequently, one framework to describe the network performance and resource utilization is given in the reference (Davis and Raimondi, 2005), which adopts the bandwidth parameters in MAC layers. Furthermore, the relation between the bandwidth parameters in MAC layers and the competing process about wireless resources in the WLAN terminals, is charactered in the way of graphic forms. In the case of network adjacent channel interfering, one route protocol based bandwidth request limits is proposed in the reference (Liu and Liao, 2009) for the MAC layer protocols based competition in the 802.11 WLAN networks. The distributive thresholds at every network node would trigger the relative bandwidth estimation algorithm (Liu and Liao, 2009) to evaluate the possible required channel bandwidth for the data requests. Thus, the adaptive bandwidth allocation based QoS requirement could be implemented in the high density WiFi hotspot areas.

At the same time, the cooperation about wireless resource allocation between the access point and the terminal devices is proposed in the reference (Fukuda *et al*., 2007) and every access point can provide it connected device information and the relative wireless resource utilization status to the terminal devices. These terminal device further select approximate access point according to the received access point information and its access point signal intensity. And, every access point would broadcast the connected terminal device number in special designed time intervals to report its wireless link utilization. In current deployed WLAN systems, every terminal device could automatically join the access point with maximal received signal intensity. However, this would lead to the influx of a large number of terminal devices to one access point and the link impartiality would be reduced. Hence, the inter-channel interfering could be reduced by approximate channel allocation and wireless cooperation technology. Thus, based the cooperation between the access point and the terminals, the justice and validity of the shared wireless link resources could be preserved in the WLAN with high density hotspots (Yoo and Kim, 2008; Bouam and Othman, 2004).

**QoS guarantee in WiFi overlaid areas:** In current 802.11 networks, only two access functions (Bouam and Othman, 2004) are designed in the MAC protocol, i.e., (1) DCF but without any type priority access business; (2) PDF function could support the business with time requirement but without any time sensitivity to transmission time. Now, according to the 802.11e standards, the wireless network in the future would provide the QoS support guarantee and could provide different QoS guarantee to different data business (Tartarelli and Nunzi, 2006). But, no products of 802.11e appear in current wireless 802.11 WLAN hotspots. The function about PCF, new EDCF and HCF is still in the way to the world and one simple QoS management protocol is designed in the report indicated in the reference (Portoles *et al*., 2004). The protocol could easily implemented in current DCF access devices. For the WiFi hotspots in human family, the delay and packet loss rate are used as the measure of QoS and one wireless resource management algorithm with QoS guarantee in the house environments is also proposed in literature (Oottamakorn and Bushmitch, 2004). It could provide relative and absolute QoS guarantee for special data transmission requirement.

With consideration about the difference of the actual subscribed service, the scheme conducted in the literature (Sharony and Sen, 2004) could provide the 802.11e specified QoS guarantee to different service on the base of the WiFi hotspot management server. Furthermore, it could also provide the corresponding QoS support according to the user subscribed service types. For the QoS requirement of the subscribed users, one time-variant DDR allocation scheme according to the report (Abusubaih and Wolisz, 2008) is given with consideration about the time variant intervals of RF transmission signal and it could preserve custom bandwidth for custom subscribed users while the remain bandwidth resource would be allocated to the non-custom users. Under the case of bad signal strength, it could detect and identify the marginal MUs that would cost a lot network resources and reduce the bandwidth of the selected non-custom users so that the subscribed user bandwidth could be preserved with special QoS guarantee. Thus, good network congestion control could be implemented in the high density WiFi hotspots.

**WiFi hotspot management technology:** Currently, the research about the WiFi hotspot management technology focused on the theories to implement the function similar to the roam in GSM cellular networks. For the current network bandwidth allocation scheme, every network access point is limited to the specified bandwidth resources and could adaptively select the usable bandwidth according to its endured interfering from other WiFi hotspots. Therefore, one new bandwidth allocation algorithm for the network access point is described in the literature (Tamura and Ito, 2005) and each network access point could use the bandwidth resources allocated adaptively by the central controlled network nodes. When the user in the network access point is disturbed by other

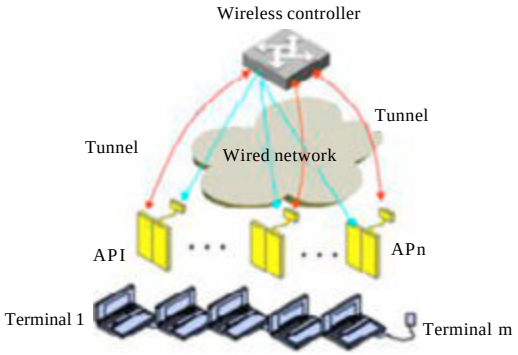


Fig. 1: Thin AP management framework based cable networks

access points, it could only use the allocated bandwidth resources of its affiliated access points. Without interfering from other access point, its affiliated access point would allocate more bandwidth to it. In order to provide the real-time service with high priority, the multiple mode terminals in the mobile wireless communication systems implemented the hotspot management protocols based the SIP protocols in the literature (Lu *et al*., 2009; Demestichas *et al*., 2007), which could cooperate between the SIP agents and the 802.1x authentication servers. Thus, the usage status of physical channels and its decoders could be dynamically managed by the proposed schemes.

With the increase of deployed WLAN hotspots in limited areas, the terminal could find more and more WiFi hotspots in its sensing range. How to administer these WiFi access points so that the maximal network throughput could be reached for the terminal devices, is the vital issue in the high density WiFi hotspot area. A network management scheme centered on the users, is proposed in the literature (Zhu *et al*., 2011) and it could obtain the optimal network transmission rate in the case of current network conditions, the user sensed network status and its access priority.

In the enterprise with a large number of deployed access points, these deployed access points would lead to large cost of software update and transmission power configurations. In the year about 2002, new WLAN trend appear in the enterprise deployments (Calhoun *et al*., 2008), i.e., thin AP (FIT AP) as displayed by Fig. 1. Many access points are management by one wireless controller and some tunnel protocols between AP and AC are used to exchange messages. Furthermore, the wireless access packets are disposed by the AP and AC, respectively. However, as a whole, the classical AP implemented all the wireless access functions and it is called as FAT AP.

Obviously, the thin AP frame is controlled by the thin AC and it has a whole view of all the WLAN access points. It is the base for the terminal to roam among many wireless AP with relative resource managements.

Whereas, the thin AP management frame based cables, is only fit for the management of many wireless AP with common protocols in one enterprise. Whats'more, it must rely on the cable network of AP and could adapt the case that the exchange messages among many APs in the high density WiFi hotspot area. So, its application is limited in fact.

## DISCUSSION

Up to now, more attention are paid to the interfering cancellation, congestion control, resource management, QoS guarantee and WiFi hotspot management technologies and deep discussion and design are also described in many literatures. As we know, the solutions to those issues in factual applications are valuable to the improved network performance. However, these researches could find the effective solution in the high density WiFi hotspot areas. The main issues are listed as followings:

- Various WiFi hotspots are deployed by individuals or independent entries and could not exchange themselves network parameters in the status of non-administrant and non-managements
- Large interfering signal among various WiFi hotspots, which lead to the network performance degrade for these WiFi hotspots and the special service with QoS guarantee could be burdened
- Many WiFi hotspots compete the shared channel resources and this lead to the network congestion and the rapid degrade of network performance.

At the same time, the current focus of researchers from the World, are paid on the WiFi hotspots deployed by one mobile service provider and the roaming function and service similar to that in mobile cellular communication systems are implemented. Therefore, how to manage the large number of WiFi hotspots in limited areas with high density population, i.e., Mall, Airports, Railway station, Bus stations and conference centers, is one issue faced by the local administrator. This is very vital to provide supervised video transmission, emergent compere in these public areas with special real-time communication service with special QoS guarantee.

## CONCLUSION

Aiming at the network interfering issues in high density WiFi hotspots area with a larger number of populations, the causes about interfering is analyzed in this review. Then, the research results in recent years are reviewed and discussed. Finally, the research special direction is proposed to the issued in the high density WiFi hotspot areas and could be referred by the interested research from abroad.

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