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Dynamic Handoff Decision Based on Current Traffic Level and Neighbor Information in Wireless Data Networks

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***Abstract*—In wireless network, mobile nodes frequently perform layer 2 and layer 3 handoffs. The handoff may occur due to many factors like signal strength, load balancing, number of connections and frequencies engaged…etc. This frequent handoff may disturb the services of real-time applications such as voice over IP. Normally few milliseconds of interrupt will happen during the handoff process. This delay should be minimized for smooth performance. Information exchange between mobile nodes and network monitoring has to be done to achieve seamless layer 2 and layer 3 handoff. Increasing in packet loss rates and heavy traffic will initiate incorrect handoff. We propose a method for avoiding unbeneficial handoffs and to eliminate unwanted traffic.**

***Index Terms*—Handoff, L1, L2, Neighbors Information, Multicasting. Monitoring Network Status, Information Exchange.**

I. Introduction

IEEE 802.11 based WLANs grows rapidly in recent years. The wireless LANs widely used for distributing internet among users in the places like hospitals, university campuses, hotels and airports. One of the limitations of IEEE 802.11 WLANs is the number of orthogonal channels. So the multiple access point (AP) usage within the coverage area of another is required to implement large WANS and configured to operate on the same channel. This creates high interference and high loads, especially when WLANs need to support sudden increase in number of nodes. The interference and high loads creates the problems like low throughput, high losses will results in unreliable network and unbeneficial handoffs.

Handoff is a process of reconfiguring the mobile host, wireless network and backbone wired network to support communication after a user enters a different cell of the wireless network [12]. Normally few milliseconds of interrupt will happen during handoff process. This delay should be minimized for smooth performance. We can classify handoff into two categories, Layer 2 (L2) and Layer 3 (L3) as shown in figure 1.

The mobile node should be inside any one of the AP's coverage area called cells, for getting services. Generally, the cells of same network will be overlapped, so that the mobile can get the service from any place. Based on the signal strength of the AP, the mobile can decide which AP is needed. Also, in heterogeneous networks the cells of different networks may overlay with in another network's cell. This makes vertical handoff possible at any time. The handoff may occur based on factors like signal strength, load balancing, number of connections and frequencies engaged…etc. Normally, the handoff will be triggered, when the mobile node moves far away from the old AP and moving closer to another AP. In this case we have two possibilities:

1) After handoff the mobile need not to change the IP address if the subnet address of new AP and the subnet address of old AP are same (that is both the APs belong to same subnet). This type of handoff is called as L2 handoff.
2) After handoff the mobile need to change the IP address if the new AP and old AP belongs to different subnet. This type of handoff is called as L3 handoff.

L2 handoff process consists of two phases namely, discovery phase and authentication phase. During the discovery phase the mobile node will multicast probe request message. Multiple access points will send probe responds, then the mobile node has to decide which AP is suitable and it will send authentication request message for the selected AP. The new AP will reply for the authentication request and again the mobile node will send the association request to the new AP, finally the new AP will send the association responds. The discovery phase takes more time than authentication phase. The sum of delay caused by both the phases exceeds more than hundred milliseconds which causes considerable amount of interrupt in ongoing services. To perform L3 handoff, first the mobile has to perform the steps of L2 handoff and then it has to perform additional steps to change its IP address. As the L3 handoff steps include the L2 handoff, the handoff delay of L3 is greater than L2.

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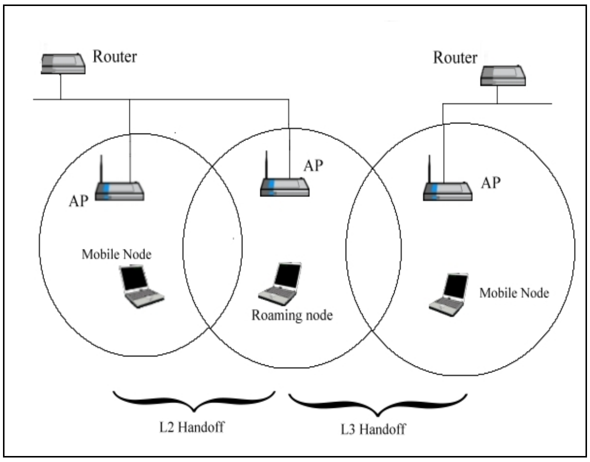

Fig. 1. L2 and L3 handoff environment

In this paper we concentrate on two things, first on information exchange between mobile nodes and second on monitoring of network to perform smooth L2 and L3 handoff for uninterrupted services. We refer mutual information exchange enabled roaming as mutual roaming (MR). The basic idea of the MR is the mobile nodes can collect the information about the nearby APs, subnets and network status from neighbor mobile nodes. Also a mobile node can ask another mobile node (which is in new subnet) to reserve an IP address in a nearby subnet (new subnet) while still it is in old subnet.

This paper is organized as follows. In section II we have presented the related works. Section III introduces the concept of multicast addressing. In section IV we provide the details on monitoring network status. Section V discusses our proposed handoff mechanism for both L2 and L3 handoff. Section VI compares the result. Finally we conclude our proposed mechanism in section VII.

II. Related Works

Last few years, several research papers have been published over the usage and performance of wireless networks. In [1], D.Tang and M.Basker have analyzed the local area wireless networks in the year 2000. In [2], D.Kotz and K.Essien have analyzed the usage of campus wide wireless networks. In [3] D.Tang and M.Basker have analyzed the metropolitan area networks. In [4], M.Balazinska and P.Castro have analyzed the mobility and network usage in a corporate wireless local area network in the year of 2002. The user behavior and network performance of in the public wireless LAN have been analyzed by A.Balachandran, G.M.Voelker. P. Bahl and P.V.Rangan in the year 2002 [5]. In [6], A.Mishra, M.Shin and W.A. Arbaugh have analyzed the IEEE 802.11 MAC Layer handoff process in the year 2003.

Minimizing the L2 probe delay is an implementation issue rather than a protocol issue. According to H. Soliman, C. Castelluccia, K. El-Makri, and L. Bellier [19] along with R. Koodli, et al [20], Link Layer Establishment Delay is between 50ms to few hundred milliseconds. In [21], Ryu1, Y. Lim, S. Ahn, and Y. Mun show the value is at 100ms. According to Y. An, B. H. Yae, K. W. Lee, Y. Z Cho, and W. Y. Jung [22], range is from 100-300ms. In [23], by A.Mishra, et al, the range is from 50-400ms.The L2 delay depends on the physical medium. In [24], different IEEE 802.11 based network has been analyzed and they propose a method to reduce the delay by probe procedure. Also they gave another way to reduce L2 handoff by allowing access routers to send to mobile nodes, few details that might need for quick association with a new access point such as frequency, ESSID and authentication info.

In [25], Van den Witjngaert, states that the movement history of a Mobile Node is kept by Foreign Agents to predict the handoff in advance. This scheme is limited to city streets, where paths are usually straight roads and thus are so predictive and not suitable for the random walk model. In [26], Feng and Reeves, on the other hand, states that a MN can record the previously visited subnets. During the handoff of process these recorded information may used to guess the future target. In case the MN has no records about a specific subnet (that is first time visit), then IPv4 will be used. Both the schemes are history based. These methods may increase burden for the mobile nodes. Since mobile nodes are limited in resources, it is hard to record, calculate and predict during the handoff.

Many others put lot of effects to analyze the performance of L2 and L3 handoff in wireless networks. Analyzing the performance of L2 and L3 handoff is not an easy task. At the time of writing this paper many wireless standards have been approved and few standards are emerging, trying to solve some of the problems a wireless network introduces. All of these standards show difference in infrastructure and in the protocol. S.Shin, A.G.Forte, A.S.Rawat and H.Schlzrinne proposed a method for reducing MAC layer handoff latency in IEEE 802.11 wireless LANs in the year 2004 [7].

All these studies focused on how networks were used and how they perform but not focused in deep why the networks functioned or application performed in a particular way. To address this gap, recent studies have analyzed traces capture from the wireless side of the network using monitors.

III. Multicast Addressing

Using multicast addressing, the one-to-many communication is possible in an IP infrastructure network without knowing about the receivers in prior. In MR, we can utilize the UDP-over-IP multicast packets to exchange information in IPv4. One node can able to communicate with many other nodes using UDP-over-IP packets. These packets will be controlled by TTL field. Initially TTL value can be very small to avoid the flooding of the packets in the congested environment. If the mobile node does not get the required information, then it will increase the TTL value so that the chances of getting information will be increased. Time-to-live (TTL) are used to control the MR multicast packet penetration. In IPv6, the multicast scopes will be used instead of IPv4 multicast.

IV. Network Monitoring Node (NMN)

The network status will be monitored by one or more nodes in a subnet. The network may be busy in some time due to many reasons like sudden increase in number of mobile nodes, unwanted traffic and many other reasons. When a network is inactive for a long time, keep alive packets are used for preventing disconnection. When a client moves and loses connectivity to its AP, it starts gathering information on the APs present in the surrounding area by broadcasting probe messages. These keep alive packet and probe messages will create unwanted traffic in the network. Analysis of such unwanted traffic is important to understand and improve the performance of congested networks. The client overhead increases with the increase in network density. Also the handoff frequency will increase as the network utilization increases.

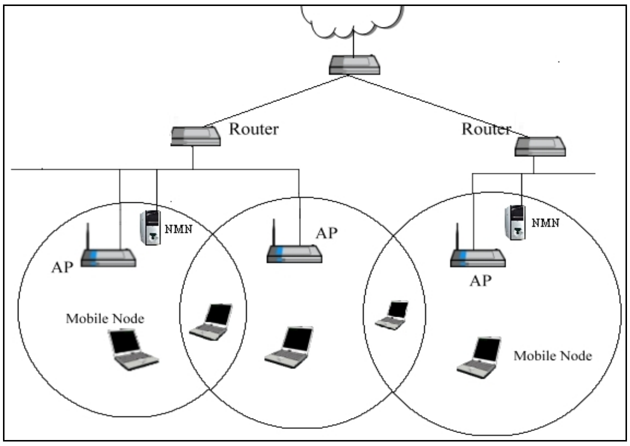

Fig. 2. System Model

The Monitoring of network and traffic will be done, by using any one or more utility like IP Sniffer (Build around packet sniffer), Nagios (The Open Source Network Monitoring Software), MRTG (The Open Source Traffic Monitoring Software), REMSTATS (Network monitoring software), Sysmon (Network monitoring software), Cricket (Router monitoring), MRTG(Traffic monitoring), Ntop (Traffic monitoring) and Kismet (Wireless scanning). The network monitoring tools can be installed in one or more nodes of a subnet. This monitoring node can keep on capturing the frames and it can check whether the network is busy or idle. This network status can be updated to the mobile nodes by multicasting. This multicasting information will be controlled by TTL. The change in network status will be updated to all the mobile nodes only once, it should not repeat unless there is no change in network status. Since, the frequent multicast may create unwanted traffic. The mobile nodes have to maintain this information in its cache.

V. Handoff Decision

In this proposed mechanism, the entire mobile node saves information about the neighbor APs and network status in its cache. The system model is as shown in Figure 2 and the algorithm for the proposed mechanism is as shown in figure 3. Before perform the handoff, the mobile node will decide whether the handoff is needed or not based on the network status information available in the cache. If the network status is good, then it has to check its cache for valid information about the neighbor APs. If the cache contains useful information, then the mobile can select an AP without scanning. If the cache contains no information then it will perform scanning and update its cache. By doing this, we can have two benefits, one is the unbeneficial handoff due to network busy condition will be avoided and second, the scanning time will be saved.

In the cache the APs are ordered according to the signal strength. This signal strength will be calculated during the scanning process and saved in cache before performing handoff. Also the mobile nodes can collect the information about the surrounding APs and network status by sending request to the neighbor nodes via multicasting. The nodes which receive the request can send a responds back. The received reply messages will be collected and validated before updating the cache. Any node can send request and any node can sent a responds. In case the mobile need to perform L3 handoff, the additional information which is required to take decision such as its own IP address, default router's IP address and subnet identifiers will be fetched from the cache. Also the destination AP's information like subnet identifier will be fetched from the cache. By storing the subnet identifiers, a subnet change is detected quickly and L3 handoff is initiated instead of L2, every time the source and destination APs have different subnet identifiers. A sample cache structure is given in table 1.

TABLE I. Sample Mobile node's cache structure

	Current AP	**Neighbor AP1**	**Neighbor AP2**	**Neighbor AP3**
BSSID	MAC A	MAC B	MAC C	MAC D
Signal Strength	90%	70%	63%	54%
Channel	6	114	1	4
Subnet ID	162.41.6.0	162.41.4.0	162.41.4.0	162.41.6.0

```
At Handoff initiation do:
  if the network status is good then
        if information is available select best nearby AP from cache
      else update the cache by scanning
      if the source and destination APs are in same subnet then
           perform L2 handoff
      else if the source and destination APs are in different subnet
           reserve a IP address in the destination subnet in prior
           perform L3 handoff
  else avoid unbeneficial handoff until network status becomes good
```

Fig. 3. Algorithm for proposed mechanism

5.1 Information exchange

If a roaming mobile node needs information about its neighbor APs and subnet, it sends an INFOREQUEST multicast frame with appropriate TTL value. The purpose of TTL is to control the flow. In that frame the current information available in the cache will be attached. The neighbor mobiles will receive the INFOREQUEST frames and each mobile will look for its cache to check, minimum one entry is available in both the cache entry and the information received by INFOREQUEST. If at least one AP is in common then, the mobile nodes send an INFORESPOND multi frame. This INFORESPOND frame will contain information about the APs and subnet which is not known to the roaming mobile node. This INFORESPOND frame will be sent after a random interval of time to ensure, that the other mobiles are not sending the same information. The mobile nodes that have common APs with roaming mobile node may be in the same location of the roaming mobile node and so the required information for the roaming mobile node will be gathered in high probability.

When mobile nodes except the roaming mobile node receives the INFORESPOND multicast frame, it will perform two tasks. First each mobile node will check its own cache and it will ensure that the information provided is correct or not. If the information seems to be wrong then it will try to fix it. Second it will record the information available in the frame to its cache even though it is not requested earlier. By doing this the cache will be filled very soon with useful information. The information in the INFOREQUEST message should be collected for better result.

5.2 *Acquiring IP Address during L3 handoff*

Before performing the handoff, the subnet identifier of the current AP and new AP will be compared. If both the AP has same subnet identifier then the L2 handoff will be performed. In case the subnet identifier of both APs is different, then L3 handoff has to perform. At the time of the L3 handoff the roaming mobile node will communicate to any other mobile node via multicasting. When a roaming mobile node wants to get a new IP address for the new subnet, it sends a unicast IP_REQUEST packet to any one of the active mobile node in the destination subnet.

This IP_REQUEST packet contains the MAC address of the roaming mobile node. This request will be processed by the respective mobile node and it will request an IP address on behalf of the roaming mobile node with the help of DHCP. After getting the new IP address the mobile node can send an IP_RESPOND multicast frame. The roaming mobile node can receive this frame and it can save the new IP address along with default routers IP address. Thus the roaming mobile node can get the IP address for the new subnet before handoff. This will save the time and the handoff latency will be reduced.

5.3 Network Status Information for Reducing Unwanted Traffic

The network status information send by the monitoring node will be saved by all the mobiles in its cache. If the network status is "busy" then the mobile must reduce the frequency of keep-alive packets and probe request. By reducing the frequency of these two packets, the unwanted traffic will be eliminated. The next big advantage of this information is the unbeneficial handoff will be avoided. If the network status is not good then handoff must not be initiated until the network status becomes good. Again, by avoiding the unbeneficial handoff we are eliminating the traffic created by handoff procedure.

VI. Simulation Results

In this section we present the results obtained in our experiments. By the result it is clear that the cache which contains the useful information like signal strength, subnet ID of the neighbor access points and the network status information improves the handoff performance dramatically, since the scanning time is eliminated if the table entry is available. The unbeneficial handoffs are avoided several times, since our algorithm may not encourage the handoff during the bad network status. Proposed mechanism improves both L2 and L3 handoff. The average performance achieved by the proposed mechanism is compared with the legacy handoff in figure 4.

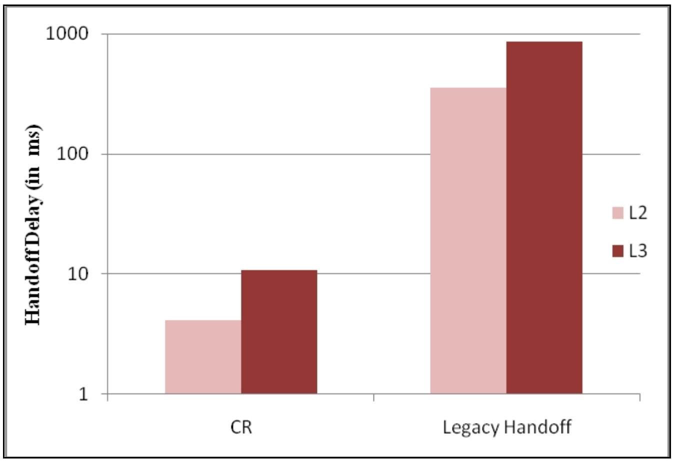

Fig. 4. Comparison between proposed mechanism and legacy handoff.

VII. Conclusion

In this paper we have defined a new mechanism for low latency handoff. This mechanism has many advantages in both L2 an L3 handoff. The real-time applications can make use of this mechanism for having uninterrupted services. The quality of service will be improved in the wireless environment. The Unwanted traffic will be eliminated and the unbeneficial handoff will be avoided.

References

[1] D. Tang and M. Baker, "Analysis of a local-area wireless network," in Proceedings of the ACM MobiCom, Boston, MA, Aug. 2000, pp. 1–10.

[2] D. Kotz and K. Essien, "Analysis of a campus-wide wireless network," in Proceedings of the ACM MobiCom, Atlanta, GA, Sept. 2002, pp. 107–118.

[3] D. Tang and M. Baker, “Analysis of a metropolitan-area wireless network,” Wireless Networking, vol. 8, no. 2/3, pp. 107–120, 2002.

[4] M. Balazinska and P. Castro, “Characterizing Mobility and Network Usage in a Corporate Wireless Local-Area Network,” in Proceedings of MobiSys, San Francisco, CA, May 2003, pp. 303–316.

[5] A. Balachandran, G. M. Voelker, P. Bahl, and P. V. Rangan, “Characterizing user behavior and network performance in a public wireless LAN,” in Proceedings of the ACM SIGMETRICS Conference, Marina Del Rey, CA, June 2002, pp. 195–205.

[6] A. Mishra, M. Shin, andW. Arbaugh, “An empirical analysis of the IEEE 802.11 MAC layer handoff process,” SIGCOMM Comput. Commun. Rev., vol. 33, no. 2, pp. 93–102, 2003.

[7] S. Shin, A. G. Forte, A. S. Rawat, and H. Schulzrinne, “Reducing MAC layer handoff latency in IEEE 802.11 wireless LANs,” in MobiWac ’04: Proceedings of the second international workshop on Mobility management & wireless access protocols. New York, NY, USA: ACM Press, 2004, pp. 19–26.

[8] I. F. Akyildiz, J. Xie, and S. Mohanty, “A survey of mobility management in next-generation all-IP-based wireless systems,” IEEE Wireless Commun., Aug. 2004.

[9] C. Blondia, O. Casals, L. Cerda, N. Wijngaert, and G. Willems, “Performance evaluation of Layer 3 low latency handoff mechanisms,” Mobile Networks and Applications, vol. 9, no. 6, pp. 633-645, Dec. 2004.

[10] A. P. Jardosh, K. N. Ramachandran, K. C. Almeroth, and E. M. Belding-Royer, Understanding Link-Layer Behavior in Highly Congested IEEE 802.11b Wireless Networks,” in Proceedings of EWIND, Philadelphia, PA, Aug. 2005, pp. 11–16.

[11] A. P. Jardosh, K. N. Ramachandran, K. C. Almeroth, and E. M. Belding-Royer, “Understanding congestion in ieee 802.11b wireless networks,” in Proceedings of IMC, Oct. 2005.

[12] Jochen Schiller, “Mobile Communications”, PHI/Pearson Education, Second Edition, 2003.

[13] H. Velayos and G. Karlsson, “Techniques to reduce IEEE 802.11b handoff time,” in Proceedings of ICC, Paris, France, June 2004.

[14] Sangheon Pack, Xuemin (Sherman) Shen, Jon W. Mark, and Jianping Pan, “ Adaptive Route Optimization in Hierarchical Mobile IPv6 Networks”, IEEE transaction on mobile computing, vol 6, no 8, august 2007.

[15] Janusz Gozdecki, Piotr Pacyna, Victor Marques, Rui L. Aguiar, Carlos García, Jose Ignacio Moreno, Christophe Beaujean, Eric Melin, Marco Liebsch, “An IP QoS Architecture for 4G Networks”, In Proceedings of Art-QoS'2003. pp.18~28.

[16] Vasos Vassiliou and Zinon Zinonos, “An analysis of the handover latency components”, Journal of internet engineering, Vol 3, No 1, 2009.

[17] Ramanathan, P., Sivalingam, K.M., Agrawal, P., Kishore, S.: Dynamic Resource Allocation Schemes during Handoff for Mobile Multimedia Wireless Networks. IEEE Journal on Selected Areas in Communications, Vol. 17, No. 7, July 1999.

[18] Saha, S., Jamtgaard, M., Villasenor, J.: Bringing the Wireless Internet to Mobile Devices. IEEE Computer, Vol. 34, No. 6, June 2001.

[19] H. Soliman, C. Castelluccia, K. El-Makri, and L. Bellier, ”Hierarchical Mobile IPv6 Mobility Management (HMIPv6)”, Request for Comment 4140, Internet Engineering Task Force, Aug. 2005.

[20] R. Koodli, et al, “Fast Handovers for Mobile IPv6”, Request for Comment 4068, Internet Engineering Task Force, Jul 2005.

[21] S. Ryu1, Y. Lim, S. Ahn, and Y. Mun, “Enhanced Fast Handover for Mobile IPv6 Based on IEEE 802.11 Network”. ICCSA 2005, LNCS 3480, pp. 398 – 407, 2005.

[22] Y. Y. An, B. H. Yae, K. W. Lee, Y. Z Cho, and W. Y. Jung, “Reduction of Handover Latency Using MIH Services in MIPv6”. Proceedings of the 20th International Conference on Advanced Information Networking and Applications (AINA’06).

[23] A.Mishra, et al, “An Empirical Analysis of the IEEE802.11 MAC Layer Handoff Process”. Proc. of ACM SIGCOMM Computer Communication Review, Vol.33, Issue 2, Apr. 2003.

[24] A. Cabellos-Aparicio, H. Julian-Bertomeu, J. Núñez-Martínez, L. Jakab, R. Serral-Gracia, J. Domingo-Pascual, “Measurement-Based Comparison of IPv4/IPv6 Mobility Protocols on a WLAN Scenario”. Proceedings of the 3rd International Working Conference on Performance Modelling and Evaluation of Heterogeneous Networks. IEE UK, 2005.

[25] Van den Wijngaert, N. and Blondia, C, "A Predictive low latency handover scheme for mobile IP", Proceedings of OPNETWORK, 2002. August.

[26] Feng, F. and Reeves, D, "Explicit Proactive Handoff with Motion Prediction for Mobile JP", IEEE Wireless Communications and Networking Conference, 2004. WCNC. 2004, Volume: 2, pp 855- 860.