Advent and Importance of Handoff under Wireless Communication Evolution

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Abstract

In recent years, wireless local area networks have been developed and deployed in many wireless applications. When the Mobile Node (MN) accesses different access points (APs), handoff latency may cause packet loss and result in serious problems in real-time applications. Also, although, the mobility between access points was initially not a major concern, the inter-AP mobility becomes an essential issue in WLAN towards the paradigm of ubiquitous computing. This project proposes an efficient soft handoff scheme realized by dual handoff. The mobile node maintains two active links to forward and backward access points respectively and the handoffs are never simultaneous to ensure one data link or thoroughfare always exists.

Keywords : *Mobile Communication, Evolution, Cellular Network, Handoff*

1. INTRODUCTION

Communication networks are now days becomes an integral part of human society. These communication networks are broadly classified as wired network and wireless network. Wireless network again broadly divided in two types that are cellular network and wireless local area network. The services provided by these networks are geographically selective. As a result, a wireless communication terminal needs to connect to multiple points of connection and perhaps multiple networks as it moves from one location to another. The method of using different networks with the same terminal for inter-network mobile communications is often referred to as inter-technology, heterogeneous, or non-homogeneous networking. Whether the roaming is intra-network within a single technology or inter-network among different technologies, a wireless mobile terminal moving from one location to another needs to change its point of connection to the wired backbone network. The process of supporting the change from one wireless point of connection to another is referred to as handover or handoff. When a mobile terminal moves away from a wireless point of connection, the signal level degrades and there is a need to switch communications to another wireless point of connection. Handoff is the mechanism by which an ongoing connection between a mobile terminal and the network is maintained.

Every change of wireless point of connection causes a services disruption which affects the quality of service provided to the user. The parameters of the handoff decision algorithm should be selected so that it maximizes the quality of service for the user and minimizes the use of system resources. A number of algorithms are being employed or investigated to optimize the decision making process for handoff. Traditional algorithms employ simple intuitive rules to compare the received signal strength from different points of connection and then decide on when to make the handoff. Degradation of the signal level, however, is a random process, and simple decision mechanisms result in the ping-pong effect whereby several consecutive handoffs degrade the service provided by the network. Consequently, more complex algorithms are needed to decide on the optimal time for handoff. Performance criteria for selecting the optimum handoff decision algorithm are affected by the type of network. The performance criteria for traditional cellular phone networks such as GSM, UMTS and cdma2000, rate adaptive wireless data networks such as WLAN and WPANs, and inter-technology heterogeneous networks are different. In traditional cellular networks we are keen on voice applications and minimizing the number of handoffs and ping-pong effects. In rate adaptive and heterogeneous data networks we are interested in optimizing the delivered average throughput.

Components of cellular network architecture

With the emergence of digital communications, second-generation (2G) mobile systems were introduced in the end of 1980s, supporting both (low bit-rate) data services and conventional voice services.

One well-known system is the Global System for Mobile Communications (GSM) introduced in Europe. GSM technology has been continuously improved to increase spectrum efficiency and offer better services in the market, compared with 1G system.

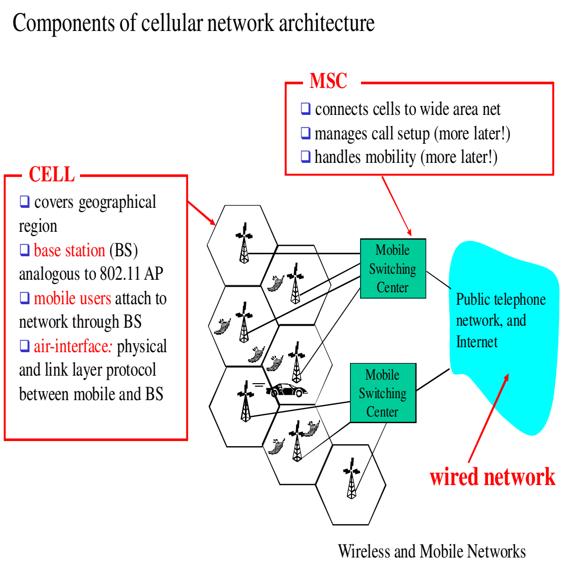

Fig 1: Components of cellular network architecture

New technologies have been developed based on the original GSM system, bringing about some more advanced systems known as 2.5 Generation (2.5G) systems. In 2G systems, the notion of *frequency reuse* was introduced to increase the system capacity. Instead of deploying a powerful base station in large coverage area, the area is divided into multiple smaller cells and a base station deployed in each cell can use smaller transmit power. Thus, two transmissions can employ the same frequency if they are far away enough such that the co-channel interference level is below a desired threshold.

Elements of a wireless network

With the rising demand of mobile communications, third generation (3G) systems were emerged, providing higher data rate to facilitate new multimedia applications such as video telephony and wireless Internet access. There are three primary standards that comprise 3G technology: wideband-code division multiple accesses (W-CDMA), CDMA2000, and time division-code division multiple access (TD-CDMA).
With the development of wireless technology, wireless local area network (WLAN) and mobile communication have been penetrated into all aspects of our life. Roaming is the general topic for mobile nodes (MN). Because of the limitation of sending power and coverage, handoff is necessary and frequent when a MN roaming in WLAN.

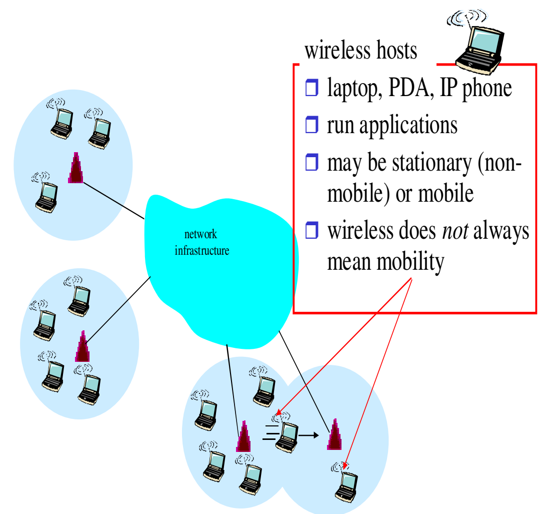

Fig 2: Components of wireless network

There has been a huge development in wireless communication technologies: Mobile and WLAN systems. With the development of wireless technology, wireless local area network (WLAN) and mobile communication have been penetrated into all aspects of our life. Roaming is the general topic for mobile nodes (MN). Because of the limitation of sending power and coverage, handoff is necessary and frequent when a MN roaming in WLAN

2. IMPORTANCE

Handoff

In a cellular telephone network, handoff is the transition for any given user of signal transmission from one base station to a geographically adjacent base station as the user moves around. In an ideal cellular telephone network, each end user's telephone set or modem (the subscriber's hardware) is always within range of a base station. The region covered by each base station is known as its cell. The size and shape of each cell in a network depends on the nature of the terrain in the region, the number of base stations, and the transmit/receive range of each base station. In theory, the cells in a network overlap; for much of the time, a subscriber's hardware is within range of more than one base station. The network must decide, from moment to moment, which base station will handle the signals to and from each and every subscriber's hardware.

Each time a mobile or portable cellular subscriber passes from one cell into another, the network automatically switches coverage responsibility from one base station to another. Each base-station transition, as well as the switching processor sequence itself, is called handoff. In a properly functioning network, handoff occurs smoothly, without gaps in communications and without confusion about which base station should be dealing with the subscriber. Subscribers to a network need not do anything to make handoff take place, nor should they have to think about the process or about which base station is dealing with the signals at any given moment.

Types of Handoff

There are two main classifications for handoffs:

1. Horizontal and Vertical Handoff

Horizontal Handoff: It is a handoff between two network access points that use the same network technology. For example, when a mobile device moves in and out of various 802.11b network domains

Vertical Handoff: Vertical Handoff is a handoff between two network access points using different network connection technologies. For example, when a mobile device moves out an 802.11b network into a GPRS network

2. Hard and Soft Handoff

Handoffs are broadly classified into two categories—hard and soft handoffs. Usually, the hard handoff can be further divided into two different types—intra- and inter-cell handoffs. The soft handoff can also be divided into two different types—multi-way soft handoffs and softer handoffs.

Handoff Criteria:

Several variables have been proposed and used as inputs for handoff criteria, to handoff algorithms.

- Received Signal Strength (RSS).
- Signal-to-Interference Ratio (SIR)
- Distance
- Transmit Power
- Traffic
- Call and Handoff Statistics
- Velocity

In fast motion, mobile nodes access network by roaming among APs. The roaming can be solved at link layer (layer 2) or network layer (layer 3). The movement of MN in different networks belongs to macro-mobility. Mobile IP and its derivatives are proposed to solve the macro-mobility. Cellular IP and HAWAII are solutions for micro-mobility in layer 3. The link layer solutions deal with the features of underlying radio system, such as general packet radio service (GPRS) and WLAN, in which the main task is reducing handoff latency. The handoff on layer2 includes hard-handoff and soft-handoff. The formal is "break-before-make", adopted by IEEE 802.11 and cellular systems, with time division multiple access (TDMA) and frequency division multiple access (FDMA). The latter is "make-before-break", adopted by code division multiple access (CDMA).

Desirable features of Handoff:

Researches on hard-handoff concentrate on reducing handoff latency. The handoff is divided into three phases: scanning, authentication, and re-association. The scanning phase contributes more than 80% of the overall handoff latency, so scanning only selective instead of all channels can observably improve the handoff efficiency. Received signal strength indicator (RSSI) is the crucial factor to trigger handoff.

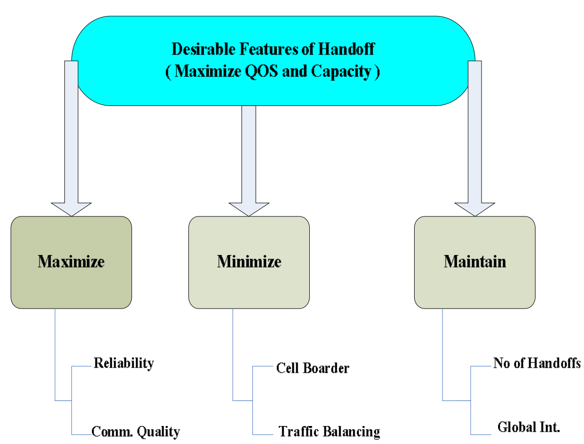

Fig 3: Desirable features of handoff.

Three Phases of Handoff

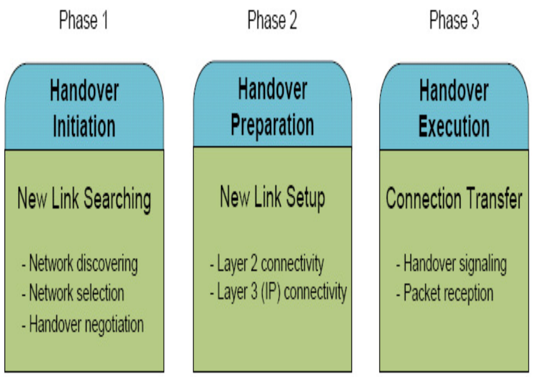

Fig 4: Three Phases of Handoff Process

As to soft-handoff, it is realized in CDMA, which need the support of both base station (BS) and MN. In WLAN, a Dual-MAC maintains both connections with the current and new APs simultaneously using two different medium access control (MAC) addresses. It requires larger coverage of AP. Some protocols are proposed to solve the soft-handoff on higher layer, such as stream control transmission protocol (SCTP), realizing the end-to-end soft-handoff in heterogeneous wireless IP-based networks.

Handoff Algorithms

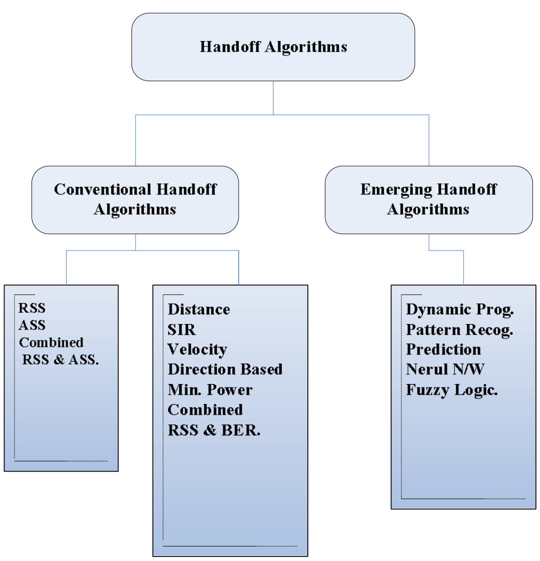

Fig 5: Handoff algorithm criteria

3. SEAMLESS HANDOFF

Dual Soft Handoff

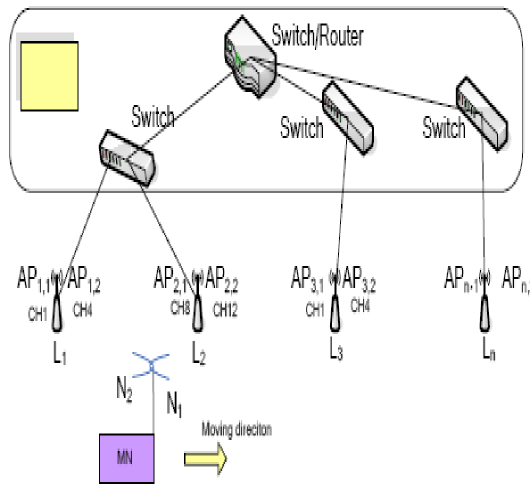

Fig 6: Soft-Dual-Handoff architecture

The Dual-Soft-Handoff scheme discussed in this topic is shown in Fig. 5. Network B is a large network connected by switches and routers. MN is the mobile node which can transfer data with nodes in Network B through APs along the line. Each access point has two APs with directional antennas mounted back-to-back. $AP_{i,j}$ is the AP at point L_i, and j shows its antennas direction:
j=1: It's opposite with MN's moving direction;
j=2: It's the same with MN's moving direction.
MN has two network cards (N_1, N_2) with directional antennas mounted back-to-back.
In topic, we put forward the Dual-Soft-Handoff scheme to support fast seamless roaming in WLAN.

When the MN moves from L_1 to L_2, it can receive signal from $AP_{0,2}$, $AP_{1,2}$, $AP_{2,1}$, and $AP_{3,1}$. The $RSS_{2,1}$ strengthens while $RSS_{1,2}$ lessens continuously. However, after the MN passes L_2, the $RSS_{2,1}$ falls to zero very quickly, and the $RSS_{1,2}$ keeps the link in a period of time. Therefore, N_1's handoff from $AP_{2,1}$ to $AP_{3,1}$ should be completed before arriving L_2. Data transfer is taken on by N_2 through $AP_{1,2}$ at this time.

When the MN arrives L_2, $RSS_{2,2}$ is at its maximum and N_2 can find $AP_{2,2}$. N_2 needs to switch to $AP_{2,2}$ before $RSS_{1,2}$ is under the threshold. The MN has connected with $AP_{3,1}$ by N_1, so data communication is

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held by N_1 and $AP_{3,1}$. Fig. 2 describes the general process of DSH during the MN roaming from L_i to L_{i+1}. It includes two phases.

Phase 1 is the forward handoff, and the new AP (NAP) is in front of the MN. It includes:

1) Data transfer between N_2 and $AP_{i,2}$;
2) N_1 switches from $AP_{i+1,1}$ to $AP_{i+2,1}$.

Phase 2 is the backward handoff, and the NAP is in back of the moving MN. It includes:

1) Data transfer between N_1 and $AP_{i+2,1}$;
2) N_2 switches from $AP_{i,2}$ to $AP_{i+1,2}$.

Here one network card's handoff occurs while the other works normally, so the data link can't be interrupted.

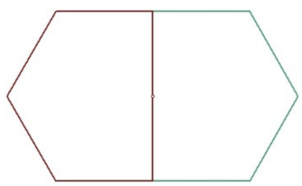

Figure 7 Directional attenuation's coverage

It includes two back-to-back APs. With directional antennas, AP's coverage is similar to a polygon, which is different from the omni-directional antenna.

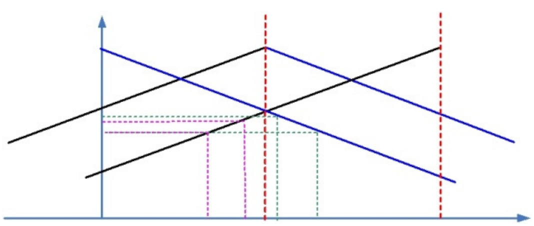

Figure 8 Receiving sig attenuation model of the MN

It describes the change of the signal strength of APs during the MN's moving. In Fig. 4, L_i is the location of AP; $RSS_{i,j}$ is the N_j Received Signal Strength of $AP_{i,j}$; T_i is the time MN passing L_i; t_1 is the time N_1 can switch; t_2 is the earliest time N_1 finishing switch; t_3 is the time N_2 beginning to switch; t_4 is the time N_2 must finish the switch; S_{min} is the threshold of N_1 to be able to probe a AP.

There are different policies to handle the handoff while passing L_2 from L_1:

1) MN finishes the handoff only before the original AP (OAP)'s signal reaches the connection threshold.

2)MN switches immediately when new AP (NAP)'s signal reaches the connection threshold.

If we adopt the former, it has some risk of N_1's handoff not fulfilling accidently. So we choose the latter: N_1 starts its handoff at t_1, just since probing $AP_{3,1}$'s signal; and N_2 also starts handoff at t_3(t_3 = T_2) when receiving signal from $AP_{2,2}$. This policy can ensure both the handoff and the data communication.

Handoff triggering time

Using the immediate handoff policy, it's clear that the backward handoff to be triggered when passing the access point. But the triggering time of forward handoff is worthy researching. Fig.5 illustrates N1 and N2's handoff model.

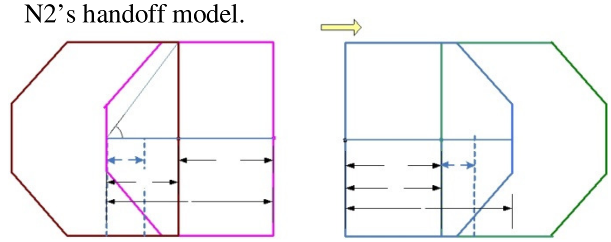

Figure 9. N_1's forward handoff and N_2's backward handoff

In Fig. 5, N_1/N_2 begin to switch at P_1/P_3, and finish switching at P_2/P_4; the distance needed for handoff is d; the distance from the switching point to the OAP is d_{th}; the distance between L_i and L_j is $D_{i,j}$; l is the AP's effective coverage; is the maximum deviation angle of MN's track.

The program describes the major work of Soft-Dual-Handoff. It records moments and positions of handoffs, which are used to make later handoff trigger more accurately.

```
Dual_Handoff (int D_AB )
{ // N2 takes charge of data transfer with AP1,2
i = 1;
while ( dis_current() < D_AB ) { // D_AB=|AB|
if ( distance_fw () >= L_cov - distance_ap( i, i+1) )
if ( probe(i, FW)==true) //find APi,1's signal
if ( trigger_handoff(N1, i, FW) == true) {
Handoff(N1, i, FW ); // N1's forward handoff
data_handover( N1 ); //N1 takes over data transfer
}
if ( distance_bk () >= distance_ap( i, i+1) )
if ( probe( i, BK) == true) // find APi,2's signal
if ( trigger_handoff(N2, i, BK) == true) {
Handoff(N2, i, BK ); // N2's backward handoff
data_handover( N2 ); //N2 takes over data transfer
}i++;}}
```

4. CONCLUSION

With the development of wireless technology, wireless local area network (WLAN) and mobile communication have been penetrated into all aspects of our life. Roaming is the general topic for mobile nodes (MN). Because of the limitation of sending power and coverage, handoff is necessary and frequent when a MN roaming in WLAN. IEEE 802.11 deploys hard handoff. It disconnects with the current access point (AP) at first, and then connects to new AP. There is a handoff interval during which MN can't send or receive any data. There are many studies on how to diminish this interval or how to buffer data and resend them after reconnecting. But the existing interval may be intolerable for real-time applications such as video monitor system, voice over IP (VoIP) and kinds of alarm systems. With this we are trying to introduce a solution for eliminating the interval without data link and providing seamless data transmission during roaming with high speed.

Further analysis in this topics regard will lead us to understand how to achieve a higher data rate through dual soft handoff

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