HANDOFF ARCHITECTURE AND ALGORITHM FOR 4G MOBILE WIRELESS INTEERNET

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ABSTRACT

4G network is a network of emerging various networks such as CDMA2000, Wireless LAN and WCDMA into all IP-based networks that will make it globally available. 4G technology is a very complex technology of integrating different new techniques, and 4G services is for a higher speed wireless internet access. In the near future, wide variety of wireless networks will be merged into the internet and allow users to continue their application with higher degree of mobility. In such environment, wireless mobile internet that are anticipated to deliver service to a mobile terminal "anywhere at anytime", which further requires an efficient handoff. Whereas conventional handoff techniques support single connection terminals that operate within a homogeneous network, 4G wireless systems promise to support terminals with multiple connections carrying different types of traffic, with varying quality of service constraints, which may handoff between different types of networks. In this paper, new handoff techniques are proposed to support wireless mobile internet with quality of service constraints within 4G wireless systems. This proposal will include handoff architecture and algorithm which try to combine cellular network for uplink traffic services and 802.11b Wi-Fi network for downlink traffic service during and after handoff. Unforturelately, the simulation is still going on because of short time, we hope that we can get a good result soon.

KEYWORDS

4G handoff architecture and algorithm uplink and downlink traffic different frequency

1. INTRODUCTION

Futurologist Toffler says "Future always comes too quick, and orders are always wrong". Mobile communication is just an example. Before 3G system has been deployed over the world, the research of 4G has begun for several years. However, it is different from previous situation that people focus on 4G research progress because of the problems of 3G faces.

The birth of 4G originally should aim at the problems that 3G can't overcome during its application, but before 3G is applied to business full-scale, 4G has been paid much more attention. This phenomenon shows that people are not satisfied with 3G from its beginning. For example, 3G is uniform standards all over the world; the voice exchange structure of 3G is still following the circuit exchange of the second generation (2G) but not pure IP structure; the application of multimedia (video frequency) is not satisfactory; data rates is just close to ordinary dial connecting and far slower of xDSL and etc. Therefore, before 3G has been entirely spread and before 3G has been totally applied practically, some of the countries have begun the research of next generation mobile communication (4G).

The requirements of 4G mobile communications can be described as providing various services, the exact specifications for the 4^{th} generation have not yet been specified, but the recent trend is that various interface techniques, such as WLAN, Bluetooth, UMTS, and CDMA2000, are integrated into IP-based networks as an overlay structure. In this structure, the optimum services are provided to mobile hosts. Mobile hosts in this structure can be connected to the network through various access points. Moreover, a seamless handoff should also be supported between different air interface techniques during inter-network movement.

Wireless mobile internet networks will consist of several overlapping tiers: satellite, macro, micro and pico-cellular segments . Each network has its own characteristics such as geographic coverage and data rate supporting. For example, pico cells with data rate in excess of 25Mbit/s will cover a building; micro cells with 2Mbit/s data rate, typically cover the dense urban areas; macro cells with several hundred kbit/s data rate cover wide area; satellite network with data rate 144kbit/s or more covers the continents.

The main important character of the tiered wireless mobile internet networks is that several networks' coverage can be overlapped. The same user can be under the coverage of several kinds of networks at the same time. For example, a mobile terminal in a building can access the wireless LAN in the building and simultaneously it is under the coverage of cellular network and the satellites. To achieve flexibility in communication, it can be anticipated that future terminal will have different radio interfaces for different wireless networks. We call this kind of terminal multi-mode terminal. When the multi-mode terminal is under the coverage of several networks, the control software will select one interface to access Internet depending on specific policies. If the mobile terminal wants to roam between different networks when it is in communication, the handoff mechanisms between the hybrid networks become a critical issue.

The development of mobile devices with built-in wireless access to the Internet will have a major impact on the way we communicate. In particular, two trends are likely to have a major impact on future wireless communication. First, there will be a wide proliferation of various wireless access networks, each having heir own preferred type of service, and second, the developments of software radio technologies which allows a mobile terminal to change the radio access mechanisms on demand.

This paper describes an architecture and algorithm that are able to provide uplink and downlink traffic of services by different wireless access networks. The solution is based on a common core network that interconnects access points of various wireless access points. A mobile host can apply multiple different access networks simultaneously to increase capacity or efficiency. A basic access network, separated from other wireless access networks, is used as a means for wireless system discovery, signaling and paging. Quality of service is of prominent importance due to the heterogeneous environment and the characteristics of the wireless channel.

Actually, 4G networks is a combination of various wireless access networks. To combine different wireless access networks for 4G is to combine different techniques that is including Mobile IP[10][11] and cellular IP integration,[8] mobility management for all-IP networks,[14] End-to-End Multi-path[9] and routing optimization.[12] Based on these new techniques we proposed a novel architecture and algorithm which try to provide uplink and downlink traffic of service over heterogeneous networks with different bandwidth for 4^{th} generation mobile wireless internet during and after handoff.

Since No single wireless network technology simultaneously provides a low latency, high bandwidth, wide area data service to a large number of mobile users. Wireless Overlay Networks – a hierarchical structure of room-size, building-size, and wide area data networks – solve the problem of providing network connectivity to a large number of mobile users in an efficient and scalable way. The two cases in which handoffs occur in our architecture and algorithm are as follows: first, the mobile host serviced in the cellular network movies into the 802.11b region. Second, the mobile host moves from the 802.11b region to cellular network. This paper concerns the first case, the mobile host moves from cellular network into 802.11b region. The second case, the mobile host serviced in the 802.11b region moves into cellular network is out the scope of this paper, because my research focus on uplink and downlink traffic of service is provided by heterogeneous networks with different bandwidth, and it is occurred in first case only.

This paper is structured as follows. In section 2 we discuss the related work in the area of handoff techniques and section 3 introduces the architecture for 4G wireless mobile internet based on IP networks. Following this, in section 4, we present the proposed algorithm and finally section 5 is conclusion and suggestions for future work.

2. RELATED WORK

2.1. mobile IP

Due to roaming, a mobile device may change its network attachment each time it moves to a new link. This might cause a disruption for the internet data packets that have to reach the mobile node. Mobile IP is a protocol, developed by the Mobile IP Internet Engineering Task Force (IETF) working group, that is able to inform the network about this change in network attachment such that the internet data packets will be delivered in a seamless way to the new point of attachment.

The mobile IP protocol allows the mobile node to retain their IP address regardless of their point of attachment to the network. This can be fulfilled by allowing the mobile node to use two IP addresses. The first one, called home address, is static and is mainly used to identify higher layer connections . the second IP address that can be used by a mobile node is the Care-of Address. While the mobile is roaming among different networks, the Care-of Address changes. The reason to this is that the Care-of Address has to identify the mobile's new point of attachment with respect to the network topology.

A mobile node change its point of attachment form an access router to another, this process is called handoff. From above all, there are two operation during handoff, one is to get a Care-of Address, another is to register with home network. These two operation cause handoff latency, since mobile IP describe a global solution that provides host mobility management for a diverse array of applications and devices on the internet. In internet environments, when a mobile node moves and attaches itself to another network, it needs to obtain a new IP address. This changing of the IP address requires all existing IP connections to the mobile node be terminated and then re-connected.

While a mobile node is away from its home network, it updates a special entity, a home agent, with information about its current IP address. The home agent intercepts and packets destined to the mobile node, and tunnels them to the mobile node's current location. Thus, it is necessary for a mobile node to register its location at the home agent. The time taken for this registration process combined with the time taken for a mobile node to configure a new network care-of address in the visiting network, amounts to the overall handoff latency.

The solution was proposed by IETF, they are hierarchical mobile IPv6 and fast handoff for mobile IPv6. Mobile IPv6 increases the efficiency of routing between the mobile node and the corresponding node, since packets are sent directly in both directions. Binding updates are always sent to home agent and to all corresponding nodes the mobile node is communicating with. When wireless nodes are moving frequently between cells the signaling load becomes significant. The idea of hierarchical mobile IPv6 is to localize the management of the handoffs which reduce the amount of signaling. It will also increase the efficiency of mobile IPv6 in terms of handoff speed. So hierarchical mobile IPv6 is well suited to implement access control and handoffs between different access technology.

Hierarchical mobile IPv6 [1] utilize a new node called the mobility anchor point. Mobility anchor point is an entity which assist with mobile IPv6 handoffs. Mobility anchor point are deployed in a treelike structure. Most of the handoffs will not occur at the lowest level and so most of the singalling load is handled near the bottom of the hierarchy. The delay of the handoffs will decrease when they are handled closer the mobile node.

Hierarchical foreign agent scheme introduces minor extensions to the mobile node and the home agent operations. It will not affect to corresponding node operation. Highest mobility anchor point in the hierarchy will receive all the packets on the behalf of mobile node and encapsulates end forward them to the mobile node's care-of address within a local mobility anchor point domain. Mobility anchor point act as a local agent for the mobile node.

Mobile node registers unique virtual care-of address from the highest mobility anchor point to home agent and corresponding nodes outside the hierarchy. This binding doesn't change when mobile node moves inside the hierarchy. So the movement of the mobile node inside the hierarchy remains invisible to the host outside the hierarchy. Also the existence of the hierarchy is invisible to the correspondent host outside the hierarchy. Mobile node has a unique virtual care-of address from every mobility anchor point in the path form the root of the hierarchy to eh lowest mobility anchor point. In addition to the virtual care-of address the mobile node also has a physical care-of address which it uses when communicating with host in the same hierarchy.

Hierarchical structured mobility anchor point can offer seamless mobility to the mobile node when it moves from one mobility anchor point to another while communicating with correspond node. When a mobile node enters a new foreign subnetwork it first acquires a new physical care-of address by means of address autoconfiguration. Physical care-of address must be globally routable, because mobile node use it as the source address of all datagrams that it sends. Mobile node forms its physical care-of address with the network prefix and the EU-64 bitstring. If mobile node tries binding update with a duplicate address, mobility anchor point reply to the mobile node with an error message and request it to try again with a random bitstring as the host address. A similar mechanism can be used for creating the unique virtual care-of address.

When mobile node receives a router advertisement with the mobility information option that contains a new hierarchy, it sends a binding update. That binding update binds its physical care-of address to its lowest virtual care-of address, to the lowest mobility anchor point. After this the lowest mobility anchor point sends surrogate binding update to the next higher mobility anchor point. That binding update forms a binding between the virtual care-of address of the mobile node in the mobility anchor point. This continues until the highest mobility anchor point receives a surrogate binding update. It checks that the mobile node is allowed to use the network and sends a binding acknowledgement to the next lower mobility anchor point. The mobility anchor point also store the security association with the mobile node. These surrogate acknowledgement are sent until the lowest mobility anchor point receives one. Then the lowest mobility anchor point sends acknowledgement to the mobile node.

For fast handoff [2] for mobile IPv6 mechanism which introduces seven additional message types for use between access routers and the mobile node. An access router is the last router between the wired network and the wireless network where the mobile node is situated. These seven messages are: Router Solicitation for Proxy (*RtSolPr*), Proxy Router Advertisement (*PrRtAdv*), Handoff Initiation (*HI*), Handoff Acknowledgement (*HAck*), Fast Binding Acknowledgement (*F-BAck*), Fast Binding Update (*F-BU*) and Fast Neighbor Advertisement (*F-NA*). In addition, the old Access Router (oAR) is defined as the router to which the mobile node is currently attached, and the new Access Router (nAR) as the router to which the mobile node is about to move to. A fast-handoff is initiated on an indication from a wireless link-layer (L2) trigger. The L2 trigger indicates that the mobile node will soon be handed off. Upon receiving an indication, the fast handoff scheme anticipates the mobile node's movement and performs packet forwarding to the nAR(s) accordingly. This is achieved by the mobile node sending a *RtSolPr* message to the oAR indicating that it wishes to perform a fast-handoff to a new attachment point. The *RtSolPr* contains the link-layer address of the new attachment point, which is determined from the nAR's beacon messages. In response, oAR will send the mobile node a *PrRtAdv* message indicating whether the new point of attachment is unknown, known or known but connected through the same access router. Further, it may specify the network prefix that the mobile node should use to form the new care-of address. Based on the response, the mobile node forms a new address described using the stateless address configuration described in [10]. Subsequently, the mobile node sends a *F-BU* to the oAR as the last message before the handoff is executed. The mobile node receives a *F-BAck* either via the oAR or the nAR indicating a successful binding. As the exact handoff instance is unpredictable, the oAR sends a duplicated *F-BAck* to the nAR to ensure the receiving of *F-BAck* by the mobile node. Finally, when the mobile node moves into the nAR's domain, it sends the Fast Neighbor Advertisement (*F-NA*) to initiate the flow of packets at the nAR. In addition to the message exchange with the mobile node, the oAR exchanges information with the nAR to facilitate the forwarding of packets between them and to reduce the latency perceived by the mobile node during the handoff. This is realized by the oAR sending a *HI* message to the nAR. The *HI* message contains mobile node's requesting care-of address and the mobile node's current care-of address used at the oAR. In response, the oAR receives a *HAck* message from the nAR either accepting or rejecting the requested new care-of address. If the new care-of address is accepted by the nAR, the oAR sets up a temporary tunnel to the new care-of address. Otherwise, the oAR tunnels packets destined for the MN to the nAR, which will take care of forwarding packets to the mobile temporarily.

2.2. Multi-path for seamless handoff

In the near future, wireless networks will become one of the major access networks of the Internet, allowing users to continues their application while they are moving. In such environment, stream media application , such as digital audio and video streaming, visual telephone and teleconferencing, will become very popular. For real time application, it is very important to provide seamless handoffs to avoid any disruption in data stream transmission and to avoid drastic quality degradation.

To provide seamless handoffs without any transmission disruption and drastic quality degradation is a challenging problem due to the following two factors: 1) user movement often results in a broken data path and requires the change of point-of-attachment to the network; 2) disparity of available bandwidth in wireless cells may result in congestion during handoffs. User movement in wireless networks often results in the change in its point-of-attachment to the network, and this change does not always guarantee the same amount of bandwidth for the user. Different amount of bandwidth may be available to the user due to different workload in the new cell. This problem is exacerbated as different wireless access techniques, such as WLAN, Bluetooth, CDMA2000, etc., are being deployed to provide ubiquitous connectivity. In such heterogeneous wireless network environment, it is not uncommon for user to face different wireless access network with different link speed and physical capacity when a handoff occurs. This mismatch in available bandwidth may result in congestion if the stream transmission continues without appropriate rate adjustment.

Taking these two factors into consideration , we believe that an ideal handoff scheme for wireless mobile internet should be able to : 1) reduce the packet losses caused by handoffs in order to avoid the drastic quality degradation, 2) maintain the throughput during handoffs in order to avoid stream disruption, 3) carefully probe the available bandwidth in the new wireless cell in order to avoid potential congestion, 4) allow the stream media to gradually adapt its quality to the new available bandwidth.

The existing mobility management techniques can be classified into two categories: network layer mobility management techniques and transport layer mobility management techniques. The common goal of network layer techniques is to reduce packet loss during the handoffs due to the broken data path from the source to the destination. This type of packet loss is referred to as rerouting packet loss; transport layer mobility management techniques are mainly proposed for the reliable data transmission. The common goal of the existing transport layer techniques is to avoid unnecessary timeouts and shrinkage of congestion window during handoffs. Adaptation to different available bandwidth in the new cell depends either on slow start which chokes the stream media application or on TCP backoff mechanism which causes high burst of loss without considering the bandwidth difference.

A new multi-path handoff scheme for stream media, which satisfies all the requirements of ideal handoff scheme mentioned above is proposed in [3][9], it is an infrastructure-based wireless network with cell overlapping areas to allow mobile nodes to connect to multiple neighboring base stations simultaneously, multi-path are maintained while a mobile node transits the overlapping area of two adjacent cells, keeping connections to both cells. To avoid drastic quality degradation and stream disruptions, the proposed scheme reduces packet loss and maintains high throughput during handoffs by transmitting packets on multiple paths.

Meanwhile, high throughput is maintained by exploiting all the available bandwidth on multiple paths. The proposed multi-path handoff scheme avoids congestion and provides smooth stream rate by applying per-path rate control on multiple path.

2.3. 4G All IP network

The 4G mobile system is an all IP-based network and provides the user access to different radio access technologies. In this environment, roaming is seamless and users are always connected to the best network. Researchers and vendors are expressing a growing interest in 4G wireless networks that support global roaming across multiple wireless and mobile networks—for example, from a cellular network to a satellite-based network to a high-bandwidth wireless LAN.

Traditional phone networks (2G cellular networks) such as GSM, used mainly for voice transmission, are essentially circuit-switched. 2.5G networks, such as GPRS, are an extension of 2G networks, in that they use circuit switching for voice and packet switching for data transmission. Circuit switched technology requires that the user be billed by airtime rather than the amount of data transmitted since that bandwidth is reserved for the user. Packet switched technology utilizes bandwidth much more efficiently, allowing each user's packets to compete for available bandwidth, and billing users for the amount of data transmitted. Thus a move towards using packet-switched, and therefore IP networks, is natural.

3G networks were proposed to eliminate many problems faced by 2G and 2.5G networks, like low speeds and incompatible technologies (TDMA/CDMA) in different countries. Expectations for 3G included increased bandwidth: 128 Kbps in a car, and 2 Mbps in fixed applications. In theory, 3G would work over North American as well as European and Asian wireless air interfaces. In reality, the outlook for 3G is neither clear nor certain. Part of the problem is that network providers in Europe and North America currently maintain separate standards' bodies (3GPP for Europe and Asia; 3GPP2 for North America). The standards' bodies mirror differences in air interface technologies. In addition there are financial questions as well that cast a doubt over 3G's desirability. There is a concern that in many countries, 3G will never be deployed. This concern is grounded, in part, in the growing attraction of 4G wireless technologies.

A 4G or 4th generation network is the name given to an IP-based mobile system that provides access through a collection of radio interfaces [4] [5] [6] [7]. A 4G network promises seamless roaming/handover and best connected service, combining multiple radio access interfaces (such as HIPERLAN, WLAN, Bluetooth, GPRS) into a single network that subscribers may use. With this feature, users will have access to different services, increased coverage, the convenience of a single device, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks.

3. THE ARCHITECTURE FOR 4G WIRELESS MOBILE INTERNET BASED ON ALL-IP NETWORKS

Wireless networking is becoming an increasingly important and popular way of providing global information access to users on the move. Current technologies vary widely in terms of bandwidths, latencies, frequencies, and media access methods. Despite this heterogeneity, most existing wireless network technologies can be divided into two categories: those that provide a low-bandwidth service over a wide geographic area and those that provide a high bandwidth service over a narrow geographic area. While it would be desirable to provide a high-bandwidth service to mobile users at all times, this is unlikely. Wireless local area networks only provide limited coverage, and a mobile host equipped only with a wide-area network interface cannot exploit existing high-bandwidth infrastructure, such as in-building wireless local area networks or wired networks. So no single wireless network technology simultaneously provides
a low-latency, high-bandwidth, wide-area data service to a large number of mobile users.

4G wireless mobile internet indicate that local area wireless networks based on IEEE 802.11 standards and cellular wide area wireless networks such as CDMA2000 and UMTS will emerge to offer Internet access to end users. The two technologies offer characteristics that complement each other perfectly. The 802.11 standards allow the realization of economical Wireless LANs that support data rates anywhere from 1 Mbps to 54 Mbps based on the distance to the base station (often called Access Points) . However, 802.11 Access Points can cover areas of only a few thousand square meters, making them suitable for enterprise networks and public hot-spots such as hotels and airports. On the contrary, wireless networks built using the cellular standards, require significant capital investments, support limited peak rates that range from 64 Kbps to nearly 2 Mbps as a maximum, but offer a much wider area of coverage that enables ubiquitous connectivity. The deployment of architectures that allow users to seamlessly switch between these two types of network would present several advantages to both service providers and users.

Our solution is to use a combination of wireless networks to provide the best possible coverage and high date rate over a range of geographic areas. In this paper, an IP-based architecture using mobile IP, as shown in Figure 1, is used. The mobile host has multi-mode card that can access the 802.11b(such as WLAN) and cellular (such as CDMA2000) network, and its hierarchical foreign agents and multi-path structure follows in Figure 2. For conventional handoff techniques, the criteria that select the initial mode in mobile host are the radio link quality, data rate, service type, speed of mobile host, and capacity of cellular network. If its data rate is low and fast moving, then the mobile host can select the CDMA2000 network: and for high data rates, then the WLAN. It also connects the mobile agent (MA) in order to support its mobility management. But for a certain mobile user, we know that the uplink and downlink traffic of service is not balance for accessing internet, normally, we like downlink frequency more wider. So our goal is to use combination of cellular network for uplink traffic of service and 802.11b network for downlink traffic of service to provide an significant application for mobile user to access wireless mobile internet.

The design of a network architecture that efficiently integrates cellular and 802.11 is a challenging task, particularly when the objective is to make the interoperation between the two technologies as seamless and as efficient as possible, both from the end-user's and from the operator's perspectives. Wireless LANs, originally targeted at enterprise and home networks, lack many of the capabilities which are essential in public environments. These capabilities include unified and universally accepted authentication, accounting and billing mechanisms; the integration of mobility mechanisms with QoS and application-level services; the support for heterogeneous network architectures through the implementation of roaming agreements. Conversely, although these characteristics are present by design in cellular networks, their implementation depends on specific wireless access architectures such as CDMA2000 or UMTS, and their extension to other wireless technologies such as 802.11 presents several compatibility issues. Depending on the level of inter-dependence that one is willing to introduce between 802.11 and cellular, the design of integrated multi-technology wireless systems can lead to network architectures that have fundamentally different properties.

In figure 1 structured mobility anchor point (MAP) can offer seamless mobility node when it moves from MAP2 to MAP3 while communicating with corresponding node (CN) , based on integration of 802.11 and cellular wireless data networks, detailed in [8]. In this approach, different mechanisms and protocols can handle authentication, billing and mobility management in the cellular and 802.11portions of the network. However , for seamless operation to be possible and they have to interoperate. In the case of interoperation with cellular, this requires that the 802.11 gateway supports mobile-IP functionalities to handle mobility across networks, as well as Authentication, Authorization and Accounting (AAA) servers to interwork with the cellular home network AAA servers. This would enable the cellular provider to collect the 802.11 accounting records and generate a unified billing statement indicating usage and various price schemes for both networks. At the same time, the use of compatible AAA services on the two networks would allow the 802.11 gateway to dynamically obtain per-user service policies from their home AAA servers, and to enforce and adapt such policies to the 802.11 network. So it is an advantages for this integration approach to allow the independent deployment and traffic engineering of 802.11 and cellular networks, interoperate through roaming agreements with public 802.11 and cellular service providers.

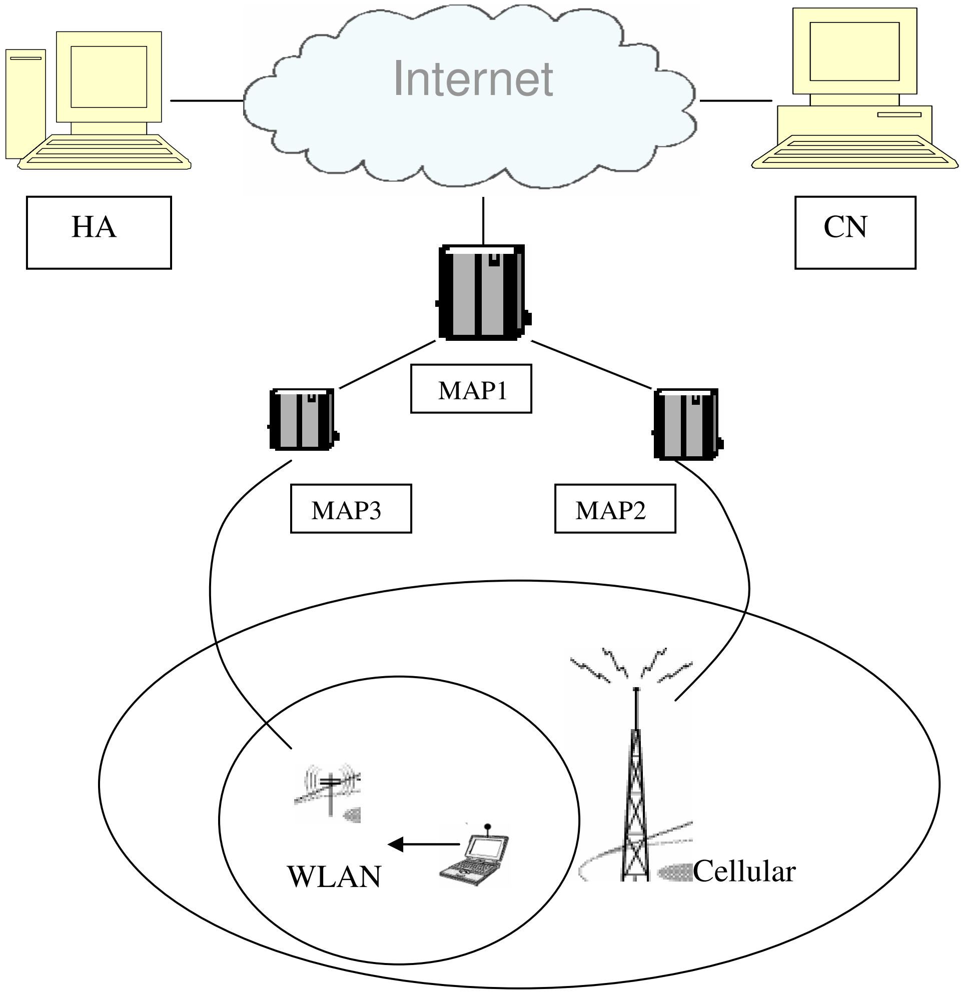

Figure 1. 4G wireless mobile internet architecture based on IP

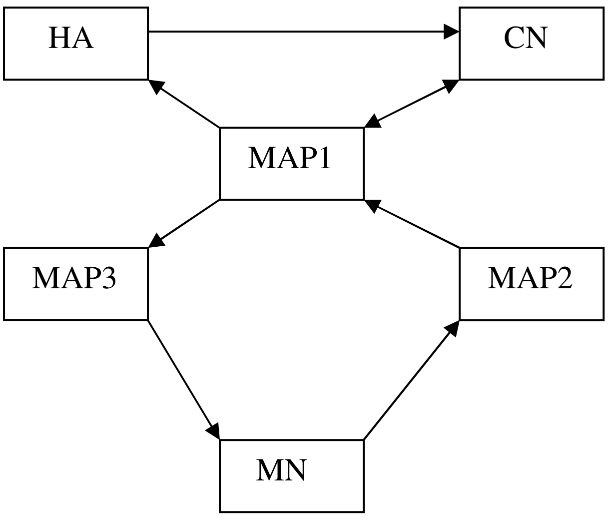

Figure 2. Hierarchical foreign agents and multi-path

Based on this integration approach, in figure 2 hierarchical foreign agents and multi-path show that When a mobile node(MN) enters a new foreign subnetwork it first acquires a new physical care-of address(PCoA) by means of address autoconfiguration, mobile node use it as the source address of all datagrams that it sends.

when mobile node (MN) arrivals in a foreign network, the MN will register the unique virtual care-of address(VCoA) with home agent (HA) and CN. It is also acquires unique VCoA from each level of the hierarchy. So when MN moves to MAP2 it will acquire VCoA2 from MAP2 and VCoA1 from MAP1. when MAP1 receives a packet addressed to VCoA1, which the VCoA of MN located MAP1, it can determine the next VCoA by looking up the binding between VCOA and the next lower VCoA. After this MAP will tunnel the packet to this VCoS. This continues until the datagram reaches the lowest MAP, which tunnels the packet to the mobile node's PCoA. In figure 2 MAP1 tunnels packet to VCoA2. MAP2 decapsulates the packet, encapsulates it and tunnels it to mobile node's PCoA.

When mobile node receives a router advertisement with the mobility information option that contains a new hierarchy, it sends a binding update. That binding update binds its PCoA to its lowest VCoA, to the lowest MAP. After this the lowest MAP sends surrogate binding update to the next higher MAP. That binding update forms a binding between the VCoAs of the mobile node in the MAPs. This continues until the highest MAP receives a surrogate binding update. It checks that the mobile node is allowed to use the network and sends a binding acknowledgement to the next lower MAP. The MAPs also store the security association with the mobile node. These surrogate acknowledgement are sent until the lowest MAP receives one. Then the lowest MAP sends acknowledgement to the mobile node. In figure 2, mobile node sends binding update to the MAP2, which is the lowest MAP. MAP2 sends a surrogate binding update to MAP1. the MAPs create a preliminary entry of the binding into their binding caches. MAP1 is the highest MAP and it processes the authentication header of the original binding update and authenticates the mobile node. After successful authentication it sends a positive binding acknowledgement to MAP2. the acknowledgement propagates downwards in the hierarchy and all the MAPs in the path update the status of the binding for the mobile node in their binding caches. When the mobile node receives the acknowledgement it can start to use the foreign network and sends binding update to its home agent and to all its corresponding nodes.

In figure 1 and figure 2, multiple paths are maintained while mobile node transits the overlapping area of two adjacent cells, keeping connections to both cells. To avoid drastic quality degradation and stream disruptions, in [9], the proposed scheme reduces packet loss and maintains high throughput during handoffs by transmitting packets on multiple paths. Meanwhile, high throughput is maintained by exploiting all the available bandwidth on multiple paths. To allow a source node to be able to maintain multiple paths simultaneously, mobile IP simultaneous binding[10] [11] and route optimization option[12] are used. Simultaneous binding option allows a mobile node to simultaneously register multiple CoAs, and route optimization option allows the sender to be always informed of the CoA registration directly form the receiver.

4. HANDOFF ALGORITHM AND ANALYSIS

when the mobile node serving in the cellular network region enters the 802.11service region, it connects to the 802.11network, such as WLAN. In this case, power saving can be achieved by determining the time of the checking beacon signal in the handoff transition region, and the time to activate the 802.11 card in the mobile node. For example, position information can be used. For seamless handoff service, the handoff point is not a critical factor, because the cellular network covers the 802.11 region with an overlaid network.
In figure 2, the mobile node receives a beacon signal from the access point through activating the 802.11 card, such as WLAN card. If the mobile node receives an agent advertisement message from the MAP3, it sends a handoff ready request message to the MAP2 through the currently serving cellular network. Then the MAP1 transmits in-bound packets to the MPA3. after that, the mobile node checks the received beacon signals continuously to determine whether to handoff or not. If the conditions for the handoff are satisfied, then the handoff procedure is performed. The mobile node requests to keep carry of the channel that is allocated to the cellular network and transmits a reassociation request message to the access point in the

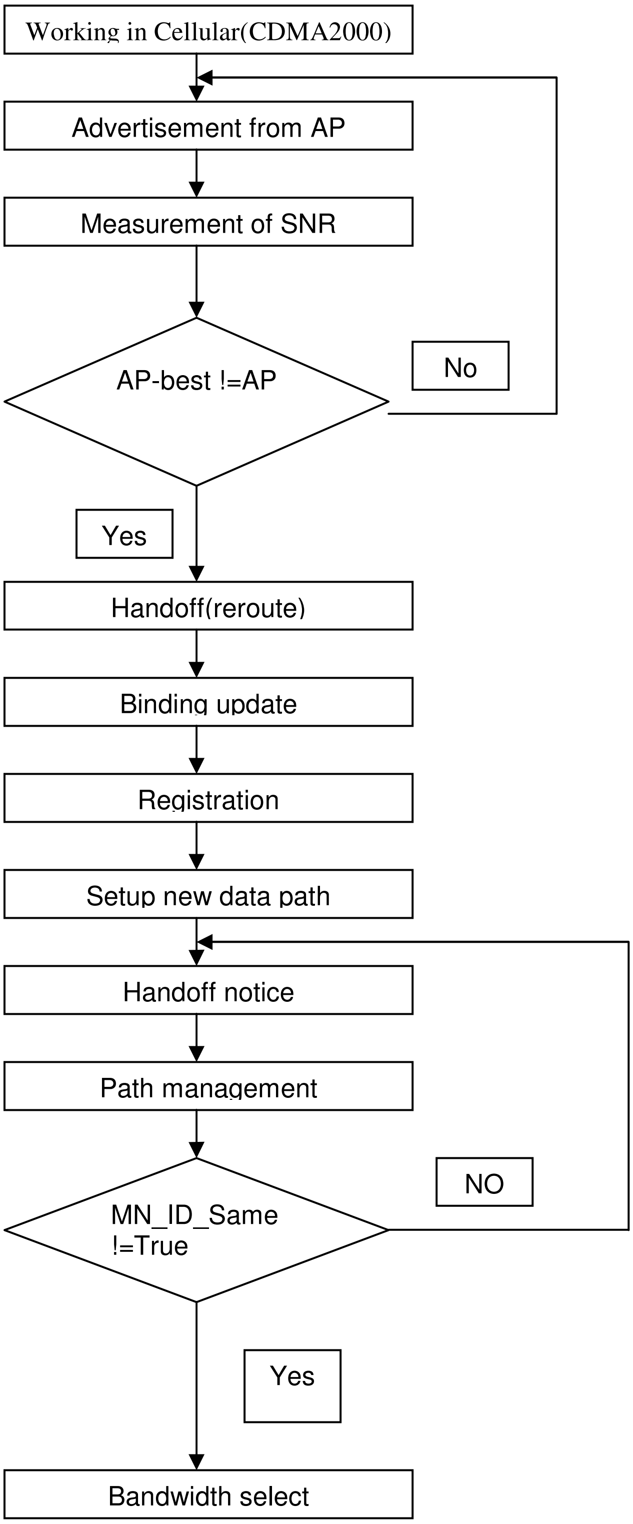

Figure 3. 4G Handoff Algorithm

WLAN. So two connections are used by the mobile node, that is multiple paths. From now on, the mobile node communicates with the both 802.11 network and cellular network.

Since handoff occur between networks whose radio links have different characteristics, this is shown in table 1, we proposed 4G handoff algorithm between the 802.11 (such as WLAN) and cellular (such as CDMA) networks is shown in figure 3.

RA	Coverage	Date Rate	Cost
AP	Limited	2~54Mbps	Low
BSS	Unlimited	9.6~388Kbps	High

Table 1. Specification of AP and BSS

Based on our architecture, we proposed a 4G mobile control handoff algorithm. In our proposal, we hope that the MN request with go through the one connection (MAP2 to MAP1 to CN) and the reply from the other connection (MAP3 to MAP1 to CN). Simply because it is more efficient. In order to implement this, path management is needed to distribute different task by different path based on different bandwidth.

The signal strength measurements are taken by the mobile device, if a candidate 802.11 access point having a better signal strength is detected then the handoff execution process is initiated. A handoff adapter located at the mobile device drives handoff execution, in which this handoff should be soft handoff. To accomplish soft handoff, the mobile device simultaneously receives data from both 802.11 access point and sends data to cellular base station based on multiple connections. In case of our proposed handoff algorithm, when a mobile node enters 802.11 region it firstly get an advertisement from access point and try to measure the signal strength in order to get a best access point for service. After selecting an access point, the mobile node try to acquire a new physical care-of address by means of address autoconfiguration, this physical care-of address is globally routable since mobile node have to use it as the source address of all datagrams that it sends. Mobile node forms its physical care-of address with network prefix and the EU-64 bitstring. If the mobile node tries a binding update with a duplicate address, MAP reply to the mobile node with an error message and request it to try again with a random bit string as the host address. A similar mechanism can be used for creating the unique vertical care-of address. When mobile node receives an advertisement from MAP3 with mobility information option that contains a new hierarchy, it sends a binding update. This binding update binds its physical care-of address to its vertical care-of address 3, to the MAP3. After this the MAP3 sends surrogate binding update to the MAP1, this binding update forms a binding between the vertical care-of addresses of the mobile node in the MAPs. When MAP 1 receives a surrogate binding update, it checks that the mobile node is allowed to use the network and sends a binding acknowledgement to the MAP3. the MAP3 store the security association with the mobile node and sends acknowledgement to the mobile node. The MAPs create a preliminary entry of the binding into their binding caches. Since MAP1 is the highest MAP, it processes the authentication header of the original binding update and authenticates the mobile node. After successful authentication, it sends a positive binding acknowledgement to MAP2. The acknowledgement propagates downwards in the hierarchy and all the MAPs in the path update the status of the binding for the mobile node in their binding caches. When the mobile node receives the acknowledgement it can start to use the 802.11 network and sends binding update to its home agent and its all corresponding nodes. So far, there are two connection established: one is old path which is from mobile node to MAP2 to MAP1 to CN, and the other is from mobile node to MAP3 to MAP1 to CN.

In order to realize this function, a cache is configured in MAP1 which is used for bandwidth option. When a mobile node send a request out, it travels pass from mobile node to MAP2 to MAP1, and then reach to CN. A reply correspond from CN, it come into MAP1. In MAP1, the reply need to reroute. There is a database in the cache of MAP1, which include the mobile node ID. It will go into MAP3, not to MAP2 after compare the mobile node ID if it is the same mobile node. By this way, we realize that the mobile node request go though cellular network, and the reply from 802.11 Wi-Fi network, which more effectively use the available bandwidth, as a result, we get a higher speed data rate.

5. CONCLUSION AND FUTURE WORK

In this paper, we presented a heterogeneous IP-based wireless access network architecture and algorithm that supports uplink and downlink traffic of service with different bandwidth. This IP-based network uses the Internet standard, hierarchical mobile IP to support mobility of mobile nodes. We also illustrated the issues in the integration of cellular networks with 802.11 such as WLAN, and a multi-path handoff scheme, both of them are base of our research. And then we proposed a seamless vertical handoff architecture and effective handoff algorithm for the handoff transition region to simultaneously support sending request from cellular network link and getting reply from WLAN link for one user. It provide two end-to-end mobility supports to utilize disparity of available bandwidths in wireless cells improving system capacity and getting transmission efficiency. For future work, the performance of the proposed architecture and algorithm will be evaluated through simulations. Cost of the proposed scheme will be also carefully evaluated in terms of transmission efficiency.

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