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Internetworking of WLAN and UMTS Networks

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Abstract: Wireless Internet technology will be the next milestone for modern telecommunication technology. In order to provide Internet connectivity over a wide area it is necessary to utilize the advanced features of modern cellular systems known as 3G wireless Cellular such as UMTS and their future evolution. One problem towards such utilization is the current technological shortcomings of cellular systems that limit the data rate. One way to bypass this limitation is to use Wireless LAN in cooperation with cellular network such as GPRS/UMTS networks, an increasing number of wireless telecommunication providers are now offering both voice and data services to their users. These services and the emerging multimedia services demand higher data rates to achieve a better quality of service (QOS). So the high tier wireless systems such as UMTS provide users high mobility but less bandwidth. On the other hand wireless systems such as wireless LAN offer higher bandwidth with less mobility. To support seamless roaming between heterogeneous wireless networks is one of the key issues in the future mobile communication systems. So the 3G will dominate the future wireless Internet access, UMTS and hotspot wireless LAN. These technologies will be complement each other to provide ubiquitous high-speed wireless Internet connectivity to mobile users. In such environment it will be required to support inter technology Handoff of mobile terminals without causing disruptions to their ongoing Internet Session. Though there is a handoff technique between wireless LAN and UMTS Networks, this proposal aims to give a smooth seamless handoff between Wirelesses LAN and UMTS network by rectifying the drawbacks (like delay in latency and Packet loss) which is present in the already existing techniques.

Key words: WLAN, UMTS, AP, GGSN, handoff, hotspot

INTRODUCTION

The study mainly focuses on the improvement of network performance by reducing the handoff delay and packet loss, when the mobile user moves from WLAN boundary to UMTS networks. It uses Network Simulator 2 for showing the demonstration of Handoff between WLAN to UMTS network. Although many techniques are available for Handoff between these two networks, this proposed study minimizes the expected number of handoff and minimizes the packet loss and Handoff delay.

Universal mobile telecommunications system: A new mobile system for worldwide use is now being developed to enhance and supersede current systems. The Universal Mobile Telecommunications System (UMTS) will be an enhanced digital communications system that will provide universal communications to anyone, regardless of their whereabouts (Fig. 1). UMTS will allow for wireless Internet access, video-conferencing and other bandwidth intensive applications. Benefits from this new system of wireless communications are expected to be:

- Support to existing mobile services and fixed telecommunications services up to 2 Mb/s;
- Support to unique mobile services such as navigation, vehicle location and road traffic information services, which will become increasingly important in world market;
- The ability to enable the use of the system terminal from multiple environments - in the home, the office and in the public environments -in both rural areas and city centers;
- Provision of a range of mobile terminals - from a low cost pocket telephone to sophisticated terminals to provide advanced video and data services.

Wireless local area network: Compared with a wired infrastructure, wireless LAN (WLAN) has unique advantages, such as broadband bandwidth capability and low deployment cost. Thanks to the technology provided by IEEE 802.11, the WLAN market is experiencing explosive growth in hot spots such as hotels, hospitals and campuses, to mention just a few. With WLAN being deployed in an unlimited way as access points, wireless users can access real-time and Internet services virtually

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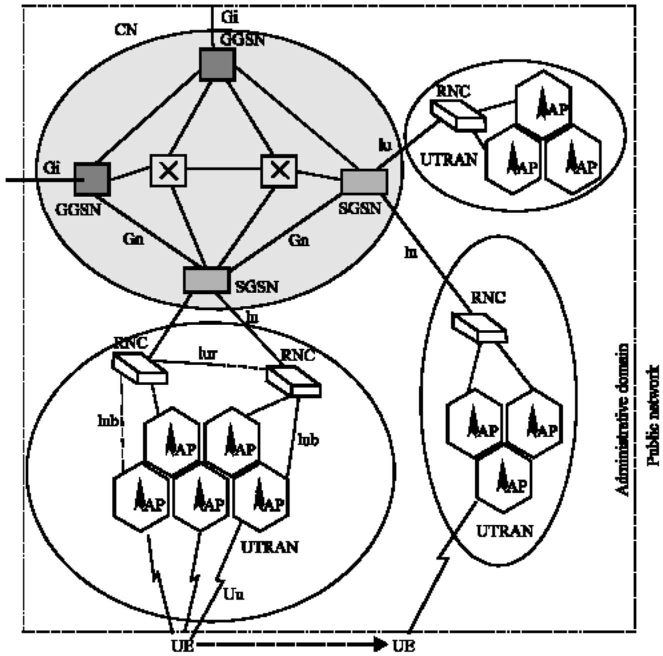

Fig. 1: UMTS network components

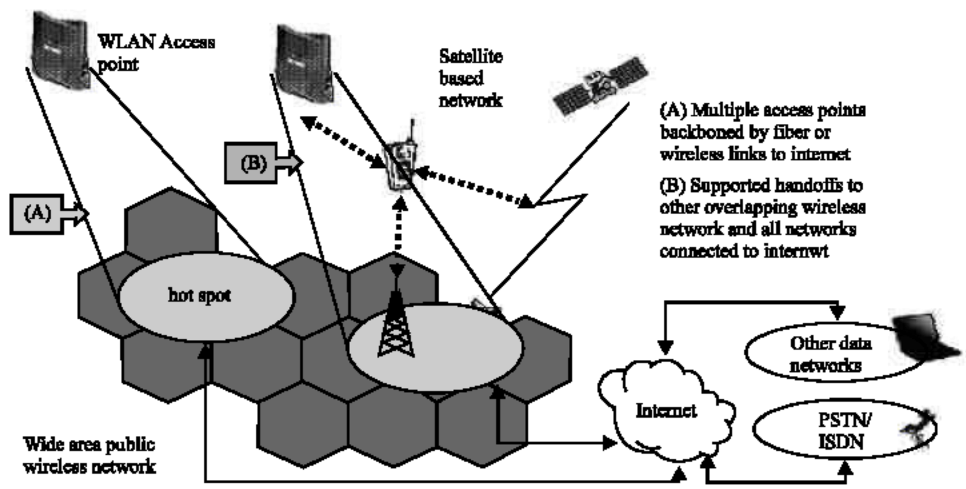

Fig. 2: WAN architecture

anytime, anywhere, while enjoying the flexibility of mobility and guaranteed connectivity. IEEE 802.11 is designed for best effort services only. The lack of a built-in mechanism for support of real-time services makes it very difficult to provide quality of service (QOS) guarantees for throughput-sensitive and delay-sensitive multimedia applications. Therefore, modification of existing 802.11 standards is necessary. Although IEEE 802.11e is being proposed as the upcoming standard for the enhancement of service differentiation, QOS guarantee in 802.11 is still a very challenging problem and needs further study primarily for high speed best-effort data service only. For integrating UMTS with WLAN there is more than one point of integration in the UMTS network that may define a workable solution. The applicability of integration architecture management and inter-system handover procedures (Fig. 2).

Integration of UMTS and WLAN: The 3G cellular networks, e.g., UMTS are designed to provide voice and data services to mobile users. The sustainable per user data rate is hundreds of kbps limited by the total cell

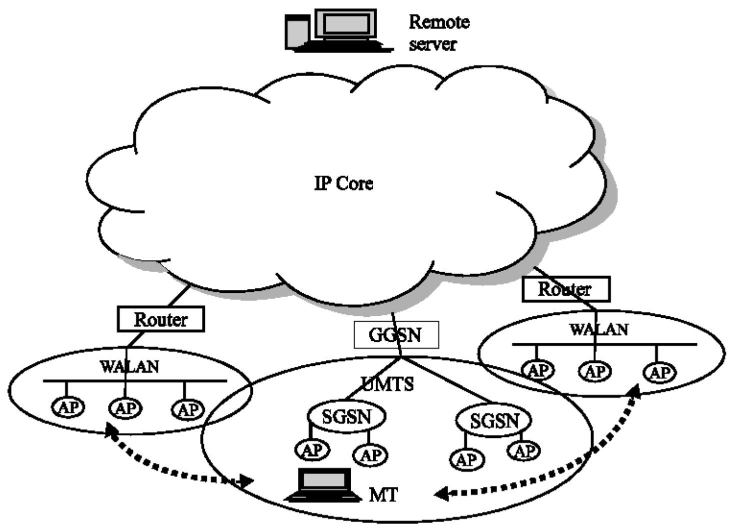

Fig. 3: The integration architecture of UMTS and WLAN

capacity of up to 2-3 Mbps. Multimedia users are known to exhibit asymmetric bandwidth usage behavior, where the download bandwidth is usually two to three order of magnitude higher than the upload bandwidth. Furthermore, the high-speed usage is clustered in certain areas. For example, in internet cafés, office buildings and apartment buildings etc. These clusters of high-speed usages are called hot spots fortunately these areas are scattered within a wireless operator's domain. The operators would like to deploy low cost high-speed solution to cover the hot spots that is either an extension of UMTS or inter-workable with UMTS. So that they can use, they can maximally utilize the already deployed infrastructure. Wireless LANs, e.g., 802.11, offers a viable and attractive choice as being high-speed (up to 54 Mbps) and low-cost (hundreds of dollars an AP) for this space.. This is especially attractive because WLAN is currently used primarily for high speed best-effort data service only. Integrating UMTS with WLAN, there is more than one point of integration in the UMTS network that may define a workable solution (Fig. 3). The applicability of integration architecture management and inter-system handover procedures (Li *et al*., 2004; Tsao and Lin, 2002).

RELATED WORK

Several strategies for the internetworking of 3G (UMTS) and WLAN have been studied. They are classified as Protocol based approach, Gateway approach and Emulator based approach. The Protocol based approach support internetworking between heterogeneous networks by reusing or slightly modifying protocols. The Gateway based approach needs new equipment which can serve as a gateway to connect 3G networks and WLAN. A gateway called IOTA, which incorporate all the functionalities of 3G networks and WLAN. Both are regrouped in to what is termed as loosely coupled approach. In the Emulator based approach, WLAN are connected to a 3G core networks, in order to act as access networks. This approach is called the tightly coupled approach. Here both signals and data always pass through the 3G core networks. Several issues such as AAA problem, seamless connectivity maintenance and (QOS) Guarantee, which need to be considered when integrating 3G networks such as UMTS and WLAN. However this means the approximate location and signal strength of the mobile Host need to be cached in nearby router or base station. Additional signaling may be required in order to enable such a system to operate correctly (Nam *et al*., 2004; Tan *et al*., 2004).

PROPOSED SOLUTIONS

The proposed solution has taken in to consideration of the loose coupling integration i.e., (Independent architecture) and basic scheme of seamless handoff has been implemented along with optimized seamless handoff scheme. The proactive, reactive, spurious trigger problems have been rectified using the optimized seamless Handoff scheme. Interface selection problem is the most important issue and here the author has proposed a simple algorithm based on the signal strength. Stations have to detect the lack of radio connectivity based on weak received signal reported by the physical layer or failed frame transmission. It also assumes that there is a better Access Point (AP) in range as soon as the received signal gets weak. This paper focuses on radio signal fading or the station being out of range.

Smart detection: We propose to reserve a bit, that we call the border bit, in the beacons transmitted by the WLAN APs. The border bit is set to 1 for those APs from which it is physically possible to exit the hot spot coverage. The WLAN APs near the front and parking doors of the hotel (whose coverage is indicated in dark gray color), will have the border bit set to 1 in their beacons. Then, the mobile terminals can use the method which has been implemented here, to generate robust inter technology handoff triggers (Parikh and Chaskar, 2002; Velayos and Karlsson, 2002).

Methodology adopted: Here the method adopted is terminal initiated handoff (Chen and Lin, 2005). The mobile terminal decides to initiate the inter technology Handoff from WLAN to UMTS networks, when its crosses the WLAN boundary. So it send a request to UMTS networks via Access router(AR).AR in turn sends a request to GGSN. In addition the mobile terminal establishes a Bearer Context to the GGSN via the AR. Bearer Context contains the following information

- QOS requirements of mobile terminal
- Mobile station Identity Number
- TFT(Traffic Flow Template) to enable establishment of packet filter in GGSN

In turn GGSN responds to the message and send the Acknowledgement to the mobile terminal via AR. It contains the challenge for authentication and authorization purpose. Then the mobile terminal responds by sending a Registration request to the GGSN via AR. Using this request GGSN determines the home AAA domain of the Mobile terminal and query the Home AAA with description of access service requested by the mobile terminal. After the authentication and service authorization the home AAA sends a Success indication to the GGSN, authenticating the mobile terminal access. It also sends a ticket to the GGSN in clear text and encrypted form.

Now the mobile terminal waits to hear from the UMTS networks over the cellular interface. While it is waiting the UMTS networks perform a bearer setup and perform a registration procedure with the mobile terminal's HA. After the registration reply from the HA, GGSN forwards it to the Mobile Terminal, upon one of the established access bearer. This Home AAA can generate a session key and forward it in clear text as well as in encrypted form to the GGSN. The GGSN stores the clear text key and forward the encrypted key to the mobile terminal. The Mobile terminal can then use the key to authenticate or encrypt future message transaction with the GGSN.

SIMULATION RESULTS AND DISCUSSIONS

In order to evaluate the system a Mobile Node(MN) was taken and which is in the boundary of WLAN shown in the Fig. 4. Initially Mobile Node gets details from HA and sends the details to AR, in turn AR Sends details to GGSN as shown in the Fig. 5. When it moves towards UMTS boundary as in Fig. 6 GGSN sends details to AR, in turn AR sends details to MN. So MN begins handoff between WLAN to UMTS networks. As in Fig. 7 MN again gets back to its original position and gets detail from HA and send details to AR.

As this study focused on reduce handoff delay using Latency, Figure 8 clearly shows an improvement in the handoff latency and Fig. 9 shows a reduced packet drop ratio. The percentage of packet received and delivery ratio is plotted in Fig. 10 and 11. In summary results show a clear indication of the improvement of handoff delay and packet loss using the Smart detection algorithm. The experimental study was done using NS2 simulator and some simulator examples are indicated below:

set *ns* [new Simulator]: generates an NS simulator object instance and assigns it to variable *ns* (italics is used for variables and values in this section). What this line does is the following: Initialize the packet format (ignore this for now)

Fig. 4: MN is in WLAN boundary

Fig. 5: MN is still in WLAN boundary, but sends signals to AR

Fig. 6: MN moves towards UMTS boundary and MH begins Handoff

- Create a scheduler (default is calendar scheduler)

- $ns color fid color: is to set color of the packets for a flow specified by the flow id (fid). This member function of Simulator object is for the NAM display and has no effect on the actual simulation.
- $ns namtrace-all file-descriptor: This member function tells the simulator to record simulation traces in NAM input format. It also gives the file name that the trace will be written to later by the command *$ns* flush-trace. Similarly, the member function trace-all is for recording the simulation trace in a general format.

Fig. 7: MN again gets back to its original boundary

- proc finish { }: Is called after this simulation is over by the command *$ns* at 5.0 *"finish"*. In this function, post-simulation processes are specified.
- set n0 [$ns node]: The member function node creates a node. A node in NS is compound object made of address and port classifiers (described in a later section). Users can create a node by separately creating an address and a port classifier objects and connecting them together. However, this member function of Simulator object makes the job easier.
- $ns duplex-link node1 node2 bandwidth delay queue-type: Creates two simplex links of specified bandwidth and delay and connects the two specified nodes. In NS, the output queue of a node is implemented as a part of a link; therefore users should specify the queue-type when creating links. In the above simulation script, Drop Tail queue is used. If the reader wants to use a RED queue, simply replace the word Drop Tail with RED. The NS implementation of a link is shown in a later section. Like a node, a link is a compound object and users can create its sub-objects and connect them and the nodes find out how to do this.
- $ns queue-limit node1 node2 number: This line sets the queue limit of the two simplex links that connect node1 and node2 to the number specified Simulator objects are available and what they are.
- $ns duplex-link-op node1 node2...: The next couple of lines are used for the NAM display. To see the effects of these lines, users can comment these lines out and try the simulation.

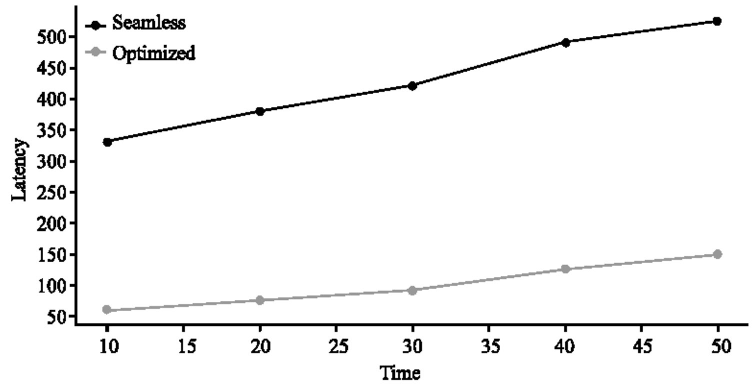

Fig. 8: Speed vs latency

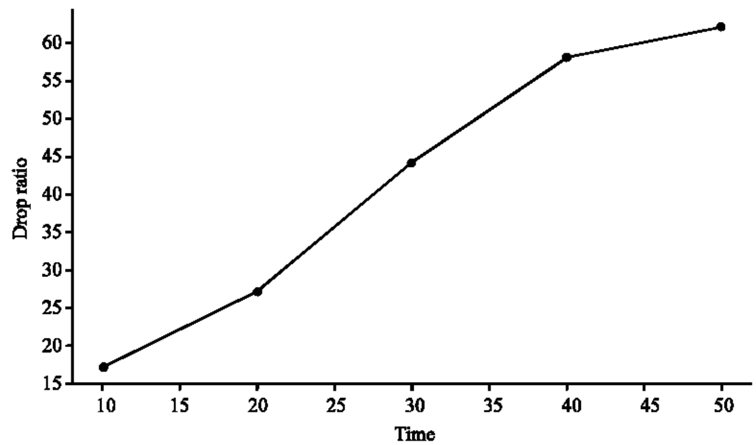

Fig. 9: Packet drop ratio

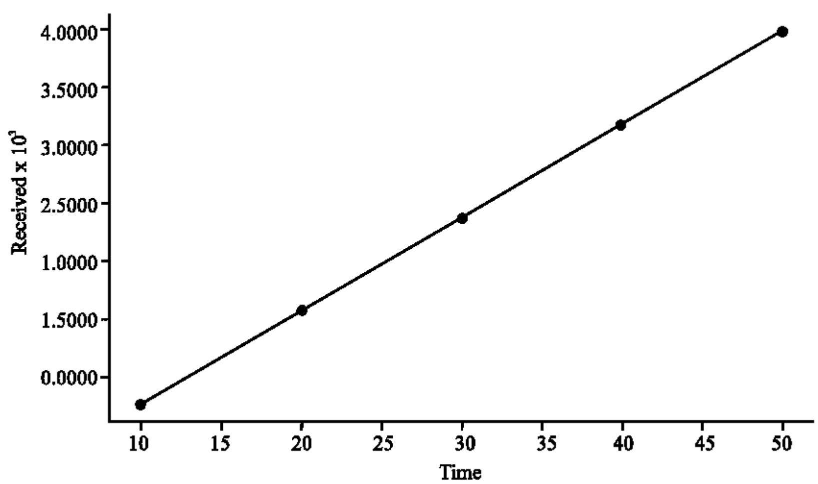

Fig. 10: Packet received

- set tcp [new Agent/TCP]: This line shows how to create a TCP agent. But in general, users can create any agent or traffic sources in this way. Agents and traffic sources are in fact basic objects (not compound objects), mostly implemented in C++ and linked to OTcl. Therefore, there are no specific Simulator object member functions that create these object instances. To create agents or traffic sources, a user should know the class names these objects (Agent/TCP, Agent/TCPSink, Application/FTP and so on). This information can be found in the NS documentation or partly in this documentation.

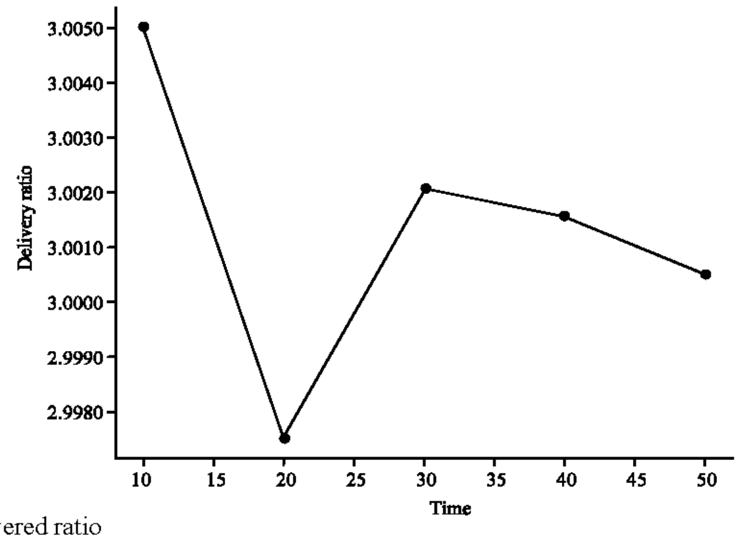

Fig. 11: Packet delivered ratio

- $ns attach-agent node agent: The attach-agent member function attaches an agent object created to a node object. Actually, what this function does is call the attach member function of specified node, which attaches the given agent to itself. Therefore, a user can do the same thing by, for example, $n0 attach $tcp. Similarly, each agent object has a member function attach-agent that attaches a traffic source object to itself.
- $ns connect agent1 agent2: After two agents that will communicate with each other are created, the next thing is to establish a logical network connection between them. This line establishes a network connection by setting the destination address to each others' network and port address pair.
- $ns at time "string": This member function of a Simulator object makes the scheduler (scheduler_ is the variable that points the scheduler object created by [new Scheduler] command at the beginning of the script) to schedule the execution of the specified string at given simulation time. For example, $ns at 0.1 "$cbr start" will make the scheduler call a start member function of the CBR traffic source object, which starts the CBR to transmit data. In NS, usually a traffic source does not transmit actual data, but it notifies the underlying agent that it has some amount of data to transmit and the agent, just knowing how much of the data to transfer, creates packets and sends them.

After all network configurations, scheduling and post-simulation procedure specifications are done, the only thing left is to run the simulation. This is done by $ns run.

CONCLUSIONS

This study presented the integration of optimized handoff techniques between WLAN hotspots into UMTS networks, using Loosely coupled method. Simulation results showed in relation to the mobile node velocity and the handoff delay in the moving –in and the moving –out vertical handoff scenarios. Here the number of continuous beacon signals whose signal strength from the WLAN falls below the predefined threshold values was used. This study completely dealt with a mobile node moving from WLAN to UMTS network not vice versa.

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