GPS-IP based Fast-handoff for Mobiles

(Extended Abstract)

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Abstract:
Reducing transient data loss during a mobile's frequent subnet handoff depends upon several factors such as layer 2 handoff detection, faster IP address discovery, registration and media re-direction. This paper investigates GPS coordinate based faster IP address discovery method suitable for high-speed vehicular users. This extended abstract presents a new methodology associated with GPS-IP discovery approach that has been implemented in the testbed. It discusses several issues involved with this process such as layer 2 detection, IP address assignment, and duplicate address detection.

1. Introduction

There are several components at different communication layers that contribute to the overall delay of multimedia stream delivery during a mobile's handoff. As the mobile moves from one cell to another it is subjected to delays at various layers. In the beginning it experiences a layer 2 handoff denoted as Δ1, where the mobile decides to connect to a different access point after listening to the new beacon. However some technologies such as CDMA provide soft-handoff techniques. If the base stations in the adjacent cells belong to the same subnet; the delay due to L2 handoff will take into account the beacon interval from an Access Point. Although beacon interval delay is a configurable parameter, a typical parameter set for good performance is 100ms. After a layer 2 handoff is complete and the mobile connects to the adjacent Access Point it needs to determine that it is in a different subnet. This is achieved by listening to the ICMP router advertisement, FA (Foreign Agent) advertisement or any other server advertisement. During this process the client also configures itself with a new IP address or FA (Foreign Agent) COA (Care-of-Address). This process can be described as IP address discovery phase and is mostly denoted as Δ2 . Besides static IP address provisioning and Auto-IP configuration using IETF zero-conf approach, existing IP address discovery process can be either stateful and stateless. A stateful IP address assignment involves a server interaction where the server keeps a state of all the IP addresses assigned. Example of a stateful server can be a DHCP server/relay agent, PPP server or MIP server using FA COA. A stateless IP address configuration is mostly used in IPv6 scenario where an IP address is determined by using subnet prefix being advertised by the router and the link local prefix. After a client is reconfigured either with a new IP address or FA COA, based on the type of mobility management, it will send either SIP Re-invite, MIP register or MIP update so that the media will get redirected to the mobile's new location. Thus delay incurred between the IP address discovery (client's reconfiguration) and the arrival of new media is denoted as Δ3. This factor will evidently depend upon the number of signaling messages traversed between MH, CH and Home Agent, distance between the mobile and the correspondent host. Figure 1 shows details of a handoff latency associated at each step.

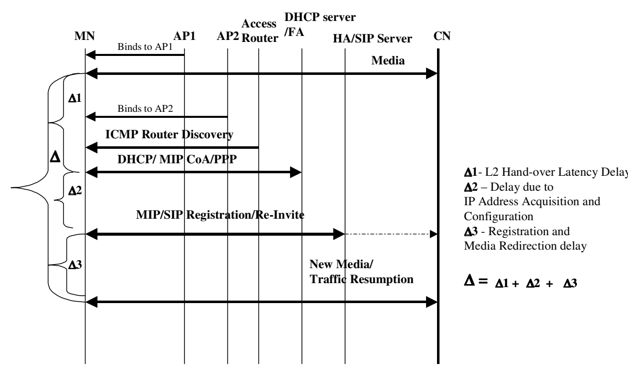

Figure 1: Handover Latency Analysis

2. Related Work

There have been some previous work to reduce these components that contribute to the handoff delay [2], [3],[4],[5]. Geocast [1] on the other hand explains several mechanisms by which IP address space can be augmented with the geographic address space using GPS coordinates. It proposes three different ways of achieving geographically-routed messages such as 1) geographically-aware router solution, 2) a multicast solution and 3) an extended Domain Name Service (DNS) solution. Ergen et al. [6] provides a methodology whereby one can leverage the information of the mobile and base station positions, obtained via the GPS and improve the performance of adhoc routing. It helps adaptively to determine the appropriate base station capacity to be reserved strictly for handoffs, to inform mobiles about the prospective future location. Geopriv working group within IETF defines ways of obtaining coordinates of the IP address by providing GPS coordinates as the DHCP option. Specific mechanism described here provides a new approach of reducing the delay associated with IP address acquisition due to frequent hand-off between heterogeneous (802.11, CDMA 1XRTT) networks.

3. Motivation for GPS-IP Handoff

The following sections describe a scenario where GPS coordinates can be used to obtain IP address in a faster way thus providing further reduction in Δ2. Figure 2 shows an example illustrating the motivation for fast-handoff.

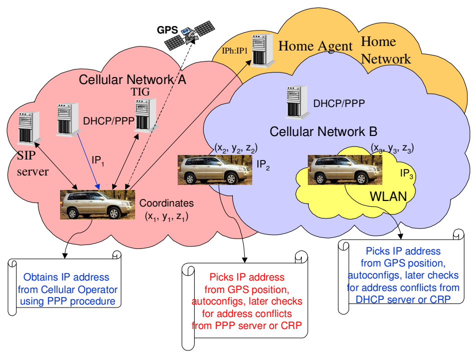

Figure 2: GPS-IP fast-handoff scenario

It shows that a mobile client that has obtained an IP address IP1 from the cellular network A using different means such as DHCP or PPP and it has a GPS coordinate (x1,y1,z1). At this point it registers with the SIP (Session Initiation Protocol) server for location management and/or updates the home agent with its IP address IP1. As the client moves away, the mobile may experience two different kinds of movement scenario. It may move to a new cellular network B or may make a move to a new 802.11b network. Depending upon the types of network it moves the mobile connects to a DHCP server or PPP server to obtain an IP address or may do stateless auto-configuration. In the process it may experience a delay because of the associated protocol exchange between the client and the server. Key motivation behind this approach here is to assign a globally routable IP address almost instantly based on the GPS coordinate. After the GPS-IP address has been assigned it is an interesting design decision to implement as to if the mobile will continue with the IP address it has obtained via GPS-IP procedure or it will go through another cycle of obtaining an IP address using PPP or DHCP. During the first transition as shown in figure 2, the mobile has made a move to a cellular network, thus IP2 actually belongs to a broadcast domain controlled by the NAS server in cellular network B. In this scenario, during the transition the client obtains the GPS coordinate {x2,y2,z2). Thus combination of GPS coordinate, a unique ID such as vehicle ID and MAC address on the mobile will translate to a unique IP address. This IP address can be obtained from the GPS-IP table ahead of time available from a local server. IP address acquisition does not involve any signaling transaction it will take a little processing time to assign the IP address (IP2). As the IP2 is globally routable IP address, the mobile can continue to communicate with the CH with a very little interruption in service. At this point it is a design decision as to if it should proceed with another PPP transaction or continue with the same address (IP2). As part of the second transition the mobile makes a move into a LAN environment moving away from the cellular network B. During the transition to LAN when its GPS coordinate is {x3,y3,z3), it assigns a new IP address IP3, using the similar procedure as above. This time IP3 is in the same broadcast domain as the LAN and is considered to be unique that is verified by using Conflict Resolution Protocol defined later.

4. Conflict Resolution Protocol

It is important to make sure that the mobile has obtained the unique address within a subnet. There are many approaches based on ARP that provide duplicate address detection mechanism but add few seconds of delay as a result. Reference [9] provides an analysis of IP address acquisition delay due to DHCP. In order to augment GPS-IP based fast-handoff we provide here a duplicate address detection mechanism using ARP cache, SNMP and localized scope-based multicast address. It has been verified that DHCP server and the respective router keep the ARP cache entries of the mobiles in the respective subnets. It is also possible that a local server can use SNMP monitoring agents such as HP Open-view or SNMP-walk to extract the ARP cache information from the routers for its respective clients within the subnets. Thus the server has an instantaneous ARP cache information of all the mobiles in the subnet at any particular point of time. Any GPS-IP equipped mobile client, during the boot-strap process will point to a localized multicast address within its specific zone. As it points to a specific multicast address (M1) within the specific zone's scope, it can get a listing of all the addresses (instantaneous mapping) currently being used in this zone. As the mobile moves from one subnet to another within its zone it will still have the same information available ahead of time. Thus a mobile client does not need to an ARP check once it moves to a subnet as often performed in DHCP.

Figure 3 provides an example of how an IP address is assigned using GPS-IP based fast-handoff technique as the mobile moves between subnets.

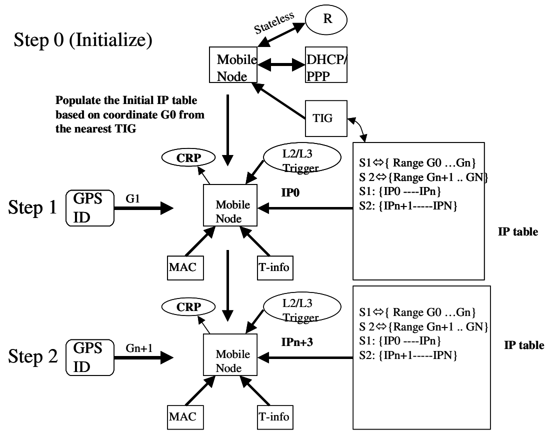

Figure 3: A sample GPS-IP handoff process

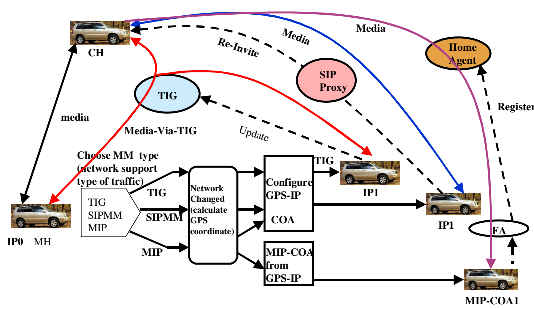

Figure 4: GPS-IP enabled Mobility Management

Figure 4 shows a scenario where GPS-IP based address acquisition has been integrated with different kinds of mobility management such as SIP based [7], Mobile-IP [8] based and transaction (TIG) based.

5. Implementation

We have used both WAN and LAN roaming for GPS-IP implementation. Initially when the client comes up it uses DHCP/PPP process to obtain an IP address. During the initial stage it downloads GPS-IP database specific to that zone. This database will contain the list of all the IP addresses that can be assigned and are globally routable within that zone. This will also provide the information of GPS address range and the subset of IP addresses that can be assigned from that range. As the mobile moves from one subnet to another within its zone it still has the same information available ahead of time.

We have implemented GPS-IP fast-handoff scenario using Linux 2.4.7-10 kernel, Orinoco Access Points, GARMIN GPS 72 receivers spanning over three zones. Freeware version of GPSMAN has been customized to provide online coordinates of the mobile as it moves along. Localized Multicast and SNMP agent in Cisco router have been integrated to implement the Conflict Resolution Protocol (CRP). Experiments while transitioning from WLAN to wide area network such as PPP revealed some of the issues such as inability of PPP link to support broadcast ARP and ingress filtering on the network access server. Alternate mechanisms were developed to take care of these issues. IPTABLES based NAT approach was applied to change the source address to avoid the ingress filtering problem. Figure 5 shows a snapshot of the implementation using SIP mobility and GPS-IP fast handoff.

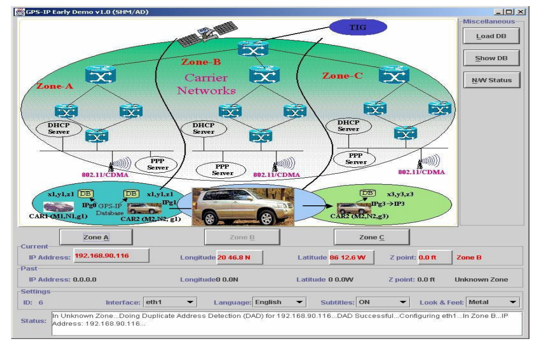

Figure 5: A sample snapshot of implementation

6. Acknowledgement

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7. References

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