AN EFFICIENT ALGORITHM TO IMPROVE HANDOFF IN MOBILITY SUPPORT FOR IPV6 PROTOCOL

Christos Bouras, Yannis Siahos, Paul Spirakis
Computer Technology Institute
Computer Engineer & Informatics Department, University of Patras, Greece
Tel: +30 61 960375, Fax: +30 61 960350, Email: bouras@cti.gr

Abstract: *This paper describes an extension of the mobility support for the IPv6 protocol, which is currently an Internet Draft. We argue that by processing geographical data information a mobile node can efficiently switch between different LANs without disturbance to ongoing data sessions. Furthermore the number of location update messages diminishes as the mobile node transmits them only when switching to a new LAN. This extension requires that each router of the foreign networks the mobile node visits, advertises the GPS coordinates of x points that describe its region. It also requires that the mobile node is capable of receiving GPS signals. Once having collected this information the mobile node can safely figure whether it will continue to be served by the same LAN or it has to switch to a different one because soon it will be out of the old LAN's range. Furthermore using this information the mobile node can also decide to which LAN it is preferable to switch. Lower-layer information, when it is available, such as signal strength or signal quality can be used as auxiliary indications for the switch decision.*

KEYWORDS: Internet, Mobile, IPv6

1 INTRODUCTION

Undoubtedly the future perspectives of networking will demand to support mobile users travelling all over the world. In addition to that the number of portable devices that need access to the Internet is exponentially increasing. Users on the other hand are no longer required to work in their company's offices but they are expected be connected to their company's home network while they may be moving from place to place. At present an extension [3] to IPv4 has been defined to come up with the expectations of the mobile users. But as IPv4 was designed 20 years ago it did not target to support such demanding applications needed by today mobile users. Internet using the next generation IP protocol (IPv6) is evolving to meet with the demands of a global network integrating data, voice and multimedia information. Mobility is natively supported in IPv6 [2]. For example, using the built in auto-configuration methods of IPv6, the mobile node can operate in any location far away from its home subnet without requiring any special support from its each time local router. Furthermore, the security methods that IPv6 utilises solve all the security issues of mobility support in IPv4. A significant improvement in processing has also been introduced by IPv6 with the routing headers option. The use of anycast addresses has also simplified the process of locating the home agent in the mobile node's home network.

Despite the obvious advantages of mobility support in IPv6 it has been shown that the movement detection algorithm does not perform well [1] in an environment where the mobile nodes move fast among small wireless cells. In these cases IP routing introduces delays. These delays are due to the change of the routing services when the mobile node moves into a new network region. The changes generally require an exchange of packets called *"handoff"* and during this period, normal transmissions to the mobile host are disrupted.

According to the Internet Draft for mobility support in IPv6, a mobile node should inform its home agent every time it changes its care-of address. This implies that the mobile node should check periodically its foreign network to detect whether it has moved to a different location (movement detection) or not. Many mechanisms have been proposed in order the mobile node to determine quickly the unreachability status of the current network and switch to a new network with a new default router and a new primary care-of address. These mechanisms are based either on receiving Neighbour Advertisement messages from the default router, or on sending Neighbour Solicitation messages from the mobile node, or on packet exchanging between the default router and the mobile node. Although these mechanisms provide a quite reliable solution to the handoff problem, they have two serious defects. The first one is that the communication between the mobile node and its default router or a correspondent node is necessary to timeout before the mobile node tries to switch to another network. The second problem is that more time is additionally needed for the switching and for the sending of the Binding Update messages to the home agent and the correspondent nodes. These two problems are considered critical for real time applications. It has been shown [6] that although current applications may not be adversely affected by mobile IP handoffs, the problem is likely to become more significant in the future, as more users will become mobile and the frequency of handoffs will increase especially in a pico cell environment.

To overcome these problems many solutions have been proposed. Some of these introduce a structure of foreign agents in a hierarchy [8],[9] so that mobile node advertises the root of the foreign agents structure as its foreign agent to its correspondent nodes outside its temporal network. By this way the change of a foreign agent inside the hierarchy, when changing sub-network for example, does not require the correspondent nodes to be informed. Other solutions are based on the concept of hierarchical mobility management [1] where the cases of the local mobility, of the mobility within an administrative domain and of the global Mobility are separated in order to provide the best solution for each case. There are also multicast based approaches where the base stations to whom the mobile node is connected to, join the same multicast group. Finally, there are proposals that try to solve the problem using the concept of wireless overlay networks [4],[5]. In these cases the local handoffs are efficiently handled with extensions to current Mobile IP protocol.

Most of these proposals succeed to solve the local case of handoff problem. They present efficient solutions to the problem of a mobile host changing base stations while being connected to the same network.

In this study we present a different approach to the problem of movement detection, which is based on processing geographical data by the mobile node in order to decide proactively whether it has to switch to a different network or not. We hope that by implementing our solution the problem of handoff will be confronted. This approach can also apply to mobility support in IPv4 [3] with minimal changes. In our study wireless overlay networks are considered as defined by Stemm M. et al, 1998.

2 OVERVIEW OF THE PROPOSED MECHANISM

The main idea of the proposed mechanism is that each time the mobile node detects a new link, it is informed by the new link's default router about the region that is covered by this network. By this way the mobile node can safely determine if it is going to cross the borders of this area and therefore has to switch to another network. The information of the region that is covered by a network can be provided by extending the normal exchange of packets between the default router of each network and the mobile node. More specifically, the regional information can be provided to the mobile node while being informed about the new network's prefix using the Stateless or Statefull Auto-configuration mechanisms.

A router that supports mobile nodes must advertise apart from its network prefix the GPS values of the region that it covers. The mobile node can combine this information with its GPS value to determine whether it will continue to be connected to the current network or it must try to connect to a new network because it will soon be out of the current network's covered region. The mobile node repeats periodically this check with a frequency relative to its velocity. Mobile node's velocity can easily be estimated by calculating the distance covered in a specific time interval divided by this interval. The only restriction is that the mobile node is equipped with a GPS receiver. This is not far from reality, as nowadays there exist many mobile GPS receivers. With the evolution of technology we expect that in the near future mobile nodes, not only notebooks but mobile phones as well, will be equipped with embedded GPS receivers.

To estimate whether the mobile node needs to change network it makes use of an algorithm, we name it need-to-switch-algorithm, which tracks its movement inside the covered region and checks the direction of the movement in relation to the region covered by the router. Furthermore, the need-to-switch algorithm can choose, in case of indication that the mobile node is going to change network with high probability, the next default router according to the regions covered by each router and the mobile node's direction.

When the Mobile Node decides to switch to another network it can send Binding Update messages to the Correspondent Nodes, the Home Agent and the default router to inform them about its new care-of address. During this transition phase the mobile node can accept packets from both addresses (the old and the new care-of address as the area the mobile node is travelling is covered by both networks) so the packet loss due to the handoff will be minimal and probably close to zero (this depends on the velocity of the mobile node and the convergence of the algorithm).

3 ANALYSIS OF THE NEED-TO-SWITCH-ALGORITHM

Suppose the mobile node of the following figure that travels inside the "Network 1". When the mobile node first connected to network one it received, among other things, the network's prefix and the GPS coordinates of *x* points that belong to the border of the covered area. Using these points the mobile node can identify the area that is covered by Network 1. We name this area "Estimated-Area" of Network 1. The algorithm estimates the distance of the mobile node from each segment of the estimated-area (eg, a1-a2, a2-a3 etc). The mobile node keeps sorted the last "*y*" versions of the distances in memory. By checking upon the relation of the consecutive versions of distances the mobile node can determine its direction. While moving inside the estimated-area, if the distance of a segment becomes less than a predefined threshold "*z*" and the direction of the mobile node is towards this segment, then the mobile node will probably change network.

For example in position 2, the mobile node knows that switching to different base station will not affect its network settings. On the other hand in position 3, the mobile node has found another network (using the default mechanisms of IPv6, eg router solicitation, router advertisement etc) and has also determined that it is going to leave the Network 1 because its distance from a_3-a_4 segment is less than *z*, while its distance from b_7-b_8 is increasing. When the distance from b_7-b_8 becomes greater than *z* the mobile node issues IPv6 binding update messages to inform its home agents and its correspondent nodes about its new network settings.

If the mobile node discovers more than one network in position 3 the need-to-switch algorithm can be used to find the most suitable network to switch. The decision is very simple: The mobile node chooses the network whose area is more suitable according to the mobile node's direction.

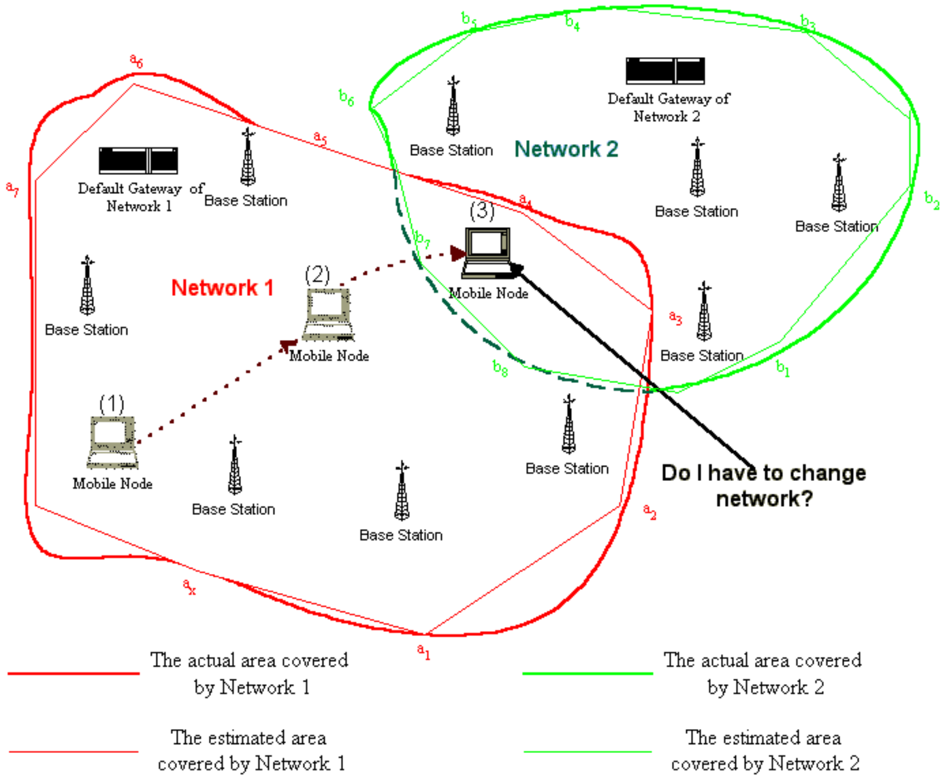

Figure 1 - Graphical representation of the need-to-switch algorithm

We must point out that, as the mobile node has not been yet out of Network's 1 range it can still receive any packets that have its old care-of address as destination address. We expect that by choosing correctly the *z* threshold, with high probability there will be no packet loss. The frequency of the checks that the mobile node does is also very important for the efficiency of our algorithm. That's why we select a frequency that is relative to mobile node's velocity as described in section 2.

A pseudo-code of the need-to-switch algorithm is given below:

x,y are the points that define the segment xy of an estimated covered area
$Distance_{i,j}(x,y)$ is the distance of the mobile node from points x,y in step i of the algorithm for the estimated covered area of network j.

$DirectionTowards_{i,j}(x,y)$ is a flag which is true only if the distance of the mobile node towards x,y is decreasing for the estimated covered area of network j. For initialisation purposes we set the $DirectionTowards_{1,j}(x,y) = True$.

$Velocity_i$ is the velocity of the mobile node at step i

STEP 1
Determine for every x,y of the estimated covered area of the current network k, that $DirectionTowards_{i,k}(x,y) = True$ if $Distance_{i,k}(x,y)$ is less than Threshold z.

If there exist x,y that satisfy the previous condition ($Distance_{i,k}(x,y) < z$) then the mobile node has to switch to another network.

If there exist more than one available networks that cover the area the mobile node travels then the mobile node will switch to the network whose coordinates satisfy the conditions ($Distance_{i,j}(x,y) > z$) and $DirectionTowards_{,i}(x,y) = True$

Else determine for which x,y the $Distance_i(x,y)$ is less than $Distance_{i-1}(x,y)$ and for those x,y set $DirectionTowards_i(x,y) = True$ while for the others x,y set $DirectionTowards_i(x,y) = False$

$Velocity_i$ = the max{$Distance_{i,k}(x,y)$- $Distance_{i-1,k}(x,y)$} / duration of step i for any x,y

If $Velocity_i > Velocity_{i-1}$ then increase the frequency of checks (decrease the duration of steps i) relevant to the increase of the velocity

4 FUTURE WORK

In future we intend to extend the described study in a number of ways. First of all we consider introducing a mechanism to dynamically update the region GPS values that are advertised by the router, so that no problems related with misreported covered areas will appear in case of an antenna failure. Furthermore, administration will be simplified, as this process is much simpler than manually inserting and updating the GPS coordinates for x points.

Secondly, we consider very useful to take advantage of lower layer information such as signal control and signal quality as supplemental indication that the decision of the algorithm (to change or not network or which network is better to connect) is correct. This way the final decision would be a combination of different weights for the result of geographical data processing and for the lower layer indication. The estimation of these weights will be made by conducting specific experiments.

Thirdly, we are planning to use kinetic data structure's theory [7] so that the algorithm that the mobile node uses to check whether it must switch to another network converges faster than the one described before.

5 CONCLUSIONS

In this paper we presented an extension to the mobility support for the IPv6 protocol. This extension introduces the idea of taking advantage of the geographical area covered by a network to achieve better handoff. We believe that our solution in combination with algorithms improving local handoffs provides a reliable solution to the handoff problem that appears in mobile networks. We are going to implement our idea and publish our results in a future presentation.

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