



Third Programming Assignment¹

COMPUTER NETWORKS

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In this assignment you will **design** and **implement** some protocols for wireless mobility (over Ethernet networks).

1 Introduction

As was said in the class, one of the methods which could be used for Host Mobility is the Mobile IP protocol. In more depth, the goal of Host Mobility is to let end-users to change their location while keeping its connections to outside world established (without interruption). But routing in networks like the Internet is based on IP address and so for keeping connections alive while changing end-user physical place, it is required to keep end-user IP address constant (at least from eye site of the outside world). But IP address is also related to the location and the network which user is connected through it. Thus it's not possible to keep IP address constant, but it's possible to design a mechanism to show the same/old IP address of the end-user to out side world. Indeed Mobile IP is such a protocol.

You should implement this mechanism in this assignment. Indeed Mobile IP has complexities for increasing performance, establishing security, etc. which are not required to be implemented. So it's better to **design** and **implement** required protocols in the simplest form. Usually this mechanism will be used for wireless communications, but for simplicity in working with layer 2 packets, you should design and implement the mechanism for an Ethernet-based network (instead of Wifi, etc.) and the movement of nodes for testing your program will be simulated; just like that all communications are in a wireless environment with one difference that layer 2 headers are Ethernet ones.

¹Thanks to Sadegh Dorri, Shayan Pooya, Behnam Momeni, Hassan Eslami and Amir Sheikha

2 Environment

The Basis of your work in the mechanism will be in 2nd, 3rd and 4th layers. In this assignment the Partov² system will be used for executing your programs. For this purpose it's required to implement your programs using the Client Framework (CF) of Partov. For more information you could check the CF User Manual document.

3 Topology

The initial topology which will be given to each student is like the illustration 1. Of course your program should not be dependent to any special topology and should not assume any special assumption about the topology.

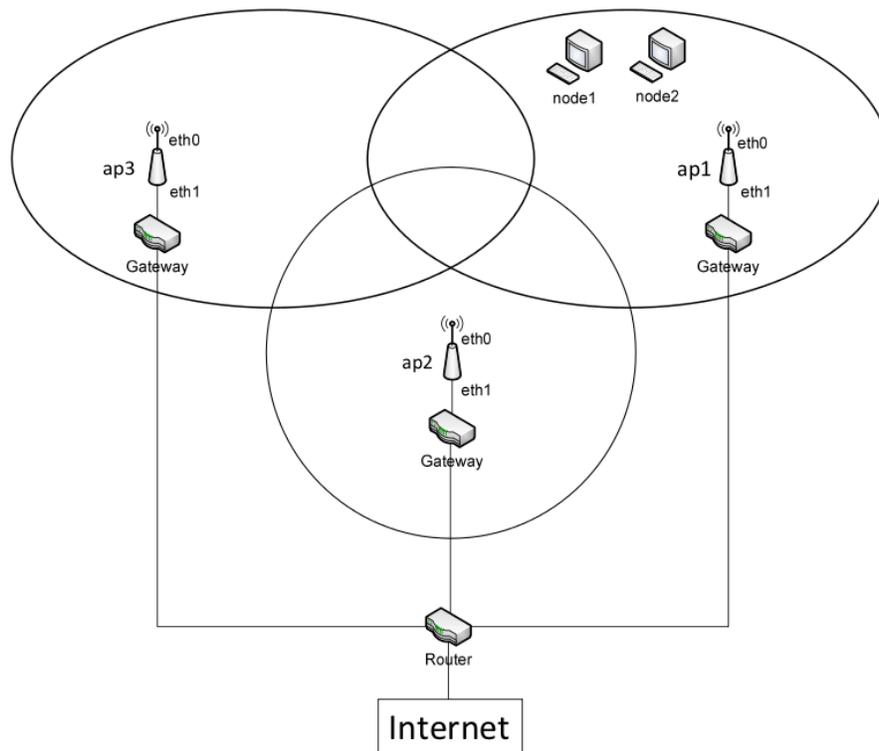


Illustration 1: A typical topology

Each topology contains some Nodes (end-users) and some Access Points (APs). Each AP has a coverage area which could receive packets sent by all Nodes within the coverage area through its eth0 interface. Of course it's possible that some APs' coverage area intersect which then packets sent by Nodes within the intersection area will reach all of those APs. Also all packets sent by an AP through its eth0 interface could reach all nodes who are in the coverage area. In addition, each AP is connected

2 Portable And Reliable Tool fOr Virtualization (Partov)

to Gateway (and so to the Internet) through its eth1 interface. And each Node will send/receive packets through its eth0 interface.

4 Expectations

You should implement two programs. One for Nodes and one for APs. So you must copy sm.cpp file to create two programs. Also you should change the Makefile as required to compile all of your files correctly. The Makefile changes must be so that

make node

command creates an executable file, namely node.out, (which is the Nodes program) and also

make ap

command creates an executable file, namely ap.out (which is the APs program). Indeed node.out and ap.out are like cf.out in the previous assignment which must be run using suitable arguments so they could be placed and executed on appropriate devices in the virtual topology. Some scripts for correct running these programs in addition to the Client Framework are given to you. In what follows more details about these two programs will be presented.

5 Programs

5.1 Nodes' program

One Node is just like an end-user which in beginning (when connecting to the network) has no IP address. It could even be out of all APs' coverage areas. So it must get IP address with some mechanism. This mechanism could be like DHCP. It's both possible that a Node could request for its IP address from an AP or the AP could periodically announce IP addresses for Nodes. BTW, you are free to design your own protocol for this purpose, but:

- For simplicity assume that the Node initially enters to coverage area of just one AP and not intersection of multiple APs and it won't leave the AP's coverage area before it gets IP address. Also it requires the IP acquiring mechanism does not take longer than 10 seconds³,
- Of course this protocol (like DHCP) should be implemented in layer 3 and over Ethernet,
- Since this protocol is executed among Nodes and APs and the used communication technology is wireless, packets may get corrupted or lost. Thus

³ All time constants which are noted in this document must be defined by #define in beginning of your program so they could be changed easily.

mechanisms like “checksum”⁴ (for detecting corrupted packets) and “timeout” and “acknowledgement” (for detecting lost packets) should be used.

- Assume that the IP which Node gets from AP for the first time (of course if you implemented the mechanism correctly) is a public IP address in the Internet and so it's must be possible to “ping” the Node from your own machine.

In order to be able to “ping” Nodes, the Node program must reply the “ICMP Echo Request” packets by “ICMP Echo Reply” packets. So in addition to the IP acquiring mechanism, you should implement this part for Node too. Testing your program during the face-to-face delivery includes “ping”ing Nodes too. For more information you could check following references:

- http://en.wikipedia.org/wiki/Internet_Control_Message_Protocol
- <http://tools.ietf.org/html/rfc792>

5.2 APs' program

This part is the real heart of Mobile IP mechanism and as was said initially it's not required the original complex mechanism. Each AP has three main duties:

1. Registering and checking existence of a Node in its own network:
 - If a Node without any IP address, entered coverage area of an AP, the IP assigning mechanism should be executed (layer 3 protocol),
 - An AP must know which Nodes are in its network (layer 3 protocol),
 - When a Node entered coverage area of an AP while that AP is a “foreign agent” for that Node, AP should announce entering of the Node to its network to the “home agent” of that Node. So there must be a protocol for this purpose between APs. But since this information is critical to the system, logically a reliable mechanism should be used for transferring its related messages. In other words you should use Acknowledgement and Timeout mechanisms (layer 4 protocol over IP).
2. Forwarding outside packets to Nodes. If AP was “home agent” of a Node and receives a packet from outside for that Node, then it should send the packets directly to Node if the Node was in the AP's coverage area otherwise it should send the packet using an “IP tunnel” to the AP which is the “foreign agent” of Node so “foreign agent” AP sends the original packet (by extracting it from the IP tunnel) to the Node directly.
3. Forwarding packets of Nodes to outside network (through the Gateway).

4 Calculate a 2-bytes checksum

In the “custom information” of AP programs, following information are provided respectively in separate line:

- MAC address of Gateway's interface which is connected the eth1 interface of AP node,
- IP addresses which AP could assign to Nodes. Assume that count of IP addresses is more than count of Nodes.

6 Important Notes

First the real IP addresses are those who are started by 213.233 and assume that Nodes will initially enter coverage area of an AP which has public IP address for assigning to Nodes (it will be home agent of the Node). So if the IP allocation mechanism be implemented correctly, and also the ICMP Echo Reply sending be implemented correctly too, it must be possible to ping Nodes. Of course your implementation must not be dependent to IP address values in anyway. For example you could NOT say that “if an IP address starts with 213.233 then do that task”.

Second you could get IP and MAC address value of each interface though methods of the Interface class. Of course for the Node there is no IP address initially. Also take care that the IP addresses that APs use for communicating with each others, are IP addresses of their eth1 interface.

Third the APs' program does not need to consider ARP packets. Those packets which are sent between Gateway and APs, will be handled by the Partov system itself and their inspection is implemented. Indeed your AP's program won't get such packets at all. Additionally since you are implementing programs of both sides of the communication (between a Node and an AP), producing or non-producing of such packets depends on your designed protocol.

Forth the topology which you will test your program with it, is like illustration 1 which in it, name of Nodes are node1 and node2 and names of APs are ap1, ap2, and ap3. In this topology the timing of Nodes movement is shown in tables 1 and 2.

In this way, if you implemented your programs correctly, it must be possible to ping Nodes for one minute duration. Of course it's possible for some packets in this duration to be lost. Take care that ping operation will be done using public IP addresses and even Nodes are moving in the network, but this IP must be seen constant from the viewpoint of the outside adversary (who is pinging). So ping reply packets should be sent using the public IP address as its source IP address too.

| Time passed from start of node1 (seconds) | Coverage areas which node1 is there |
|--|--|
| 0 – 5 | - |
| 5 – 15 | ap1 coverage area |
| 15 – 20 | ap1 and ap2 coverage areas |
| 20 – 30 | ap2 coverage area |
| 30 – 35 | ap2 and ap3 coverage areas |
| 35 – 45 | ap3 coverage area |
| 45 – 50 | ap1 and ap3 coverage areas |
| 50 – 60 | ap1 coverage area |

Table 1: The node1 Node movement schedule

| Time passed from start of node2 (seconds) | Coverage areas which node2 is there |
|--|--|
| 0 – 5 | - |
| 5 – 15 | ap1 coverage area |
| 15 – 20 | ap1 and ap3 coverage areas |
| 20 – 30 | ap3 coverage area |
| 30 – 35 | ap2 and ap3 coverage areas |
| 35 – 45 | ap1 and ap2 and ap3 coverage area |
| 45 – 50 | ap1 and ap2 coverage areas |
| 50 – 60 | ap1 coverage area |

Table 2: The node2 Node movement schedule

7 Important recommendation

As was noted, the original Mobile IP mechanism has complexities which are not required to be implemented. Try to design a simple protocol (as you can) to make your implementation simple. If the designed protocols were not simple, this assignment will become very hard for you. So spend enough time for a good design and ask about any ambiguities in the course mailing list.

8 Assistant resources

The Mobile IP protocol concepts are described in course slides. For more detailed information about it you could check:

- <http://www.acm.org/crossroads/xrds7-2/mobileip.html>
- <http://www.tml.tkk.fi/Opinnot/Tik-111.550/1999/Esitelmat/MobileIP/Mobip.html>

Also you could refer to RFC 3344⁵ (but not required).

9 And at last

You must prepare a document (2 till 3 pages) describing all designed protocols. You should only describe protocol's header and fields and specify the purpose of each field (what is it's meaning and why use are going to use it). Make this design document PDF with name protocol-80123456 (which 80123456 should be replaced with your own Student ID).

When you finished this assignment, first *make clean* the code and then rename your working folder to pa3-80123456 (which 80123456 should be replaced with your own Student ID) including all of source code files and the design document, zip it, and email it to kharrazi@ce.sharif.edu and CC to dorri@ce.sharif.edu with same subject (pa3-80123456) value.

⁵ <http://tools.ietf.org/html/rfc3344>