CS-542 Final Project (Fall 2017)

ARP Protocol Design

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Q 1: The ARP protocol uses the the next-hop address and the interface number, found in the routing table, to find the physical address of the next hop. Consider a certain router Ri whose routing table has only three columns: mask, network address, and next-hop address, i.e. the column with the interface numbers has been deleted. (Note that only the column with the info on the interfaces has been removed not the interfaces themselves, i.e. the network configuration has not changed.) Does the ARP protocol still work? If not, how to modify this protocol to make it work? Does your modification affect the network performance?

Answer:

No, the arp protocol won't work because the existing arp protocol uses interface information from the routing table to send the arp request packet to a particular local network .

Since, the interface information has been deleted from the routing table, arp protocol would not be able to decide where to send the arp request packet.

In order to make the arp protocol work, we need to make below modification to the arp protocol.

- Instead of broadcasting arp request packet in a particular local network through the interface obtained from the routing table. Broadcasting should be done to all the local networks which are directly connected to the router.
- Since IP addresses are unique universally, there would exist only one host/router that would reply to the arp request packet. Using the reply packet, arp module will update its cache table and also store the interface number from where it received the reply packet.
- Using this information, ip datagram can now be encapsulated in a frame and transported to the destination.

Eg: Let's consider an example to understand how the modified arp protocol works. As shown in the figure below, host A wants to send a message to host B. When an ip packet arrives at the router 1, the routing table is used to find the next-hop address. Assuming the interface column from the routing table of Router 1 has been removed. The ip packet is then passed to the arp output module to determine the physical address corresponding to the next hop. The output module first checks the cache table(shown below) to see if there exist an entry for the corresponding ip address.

Cache table for Router 1:

Status	Queue	Attempt	Time-Out	Protocol Add	Hardware Add
R	1		900	141.14.0.10	AEAC32457342
F					

Since in our case there is no entry present in the cache table for the target protocol address, the module adds an entry to the table with the state pending and attempt value to 1.

Updated cache table for Router 1:

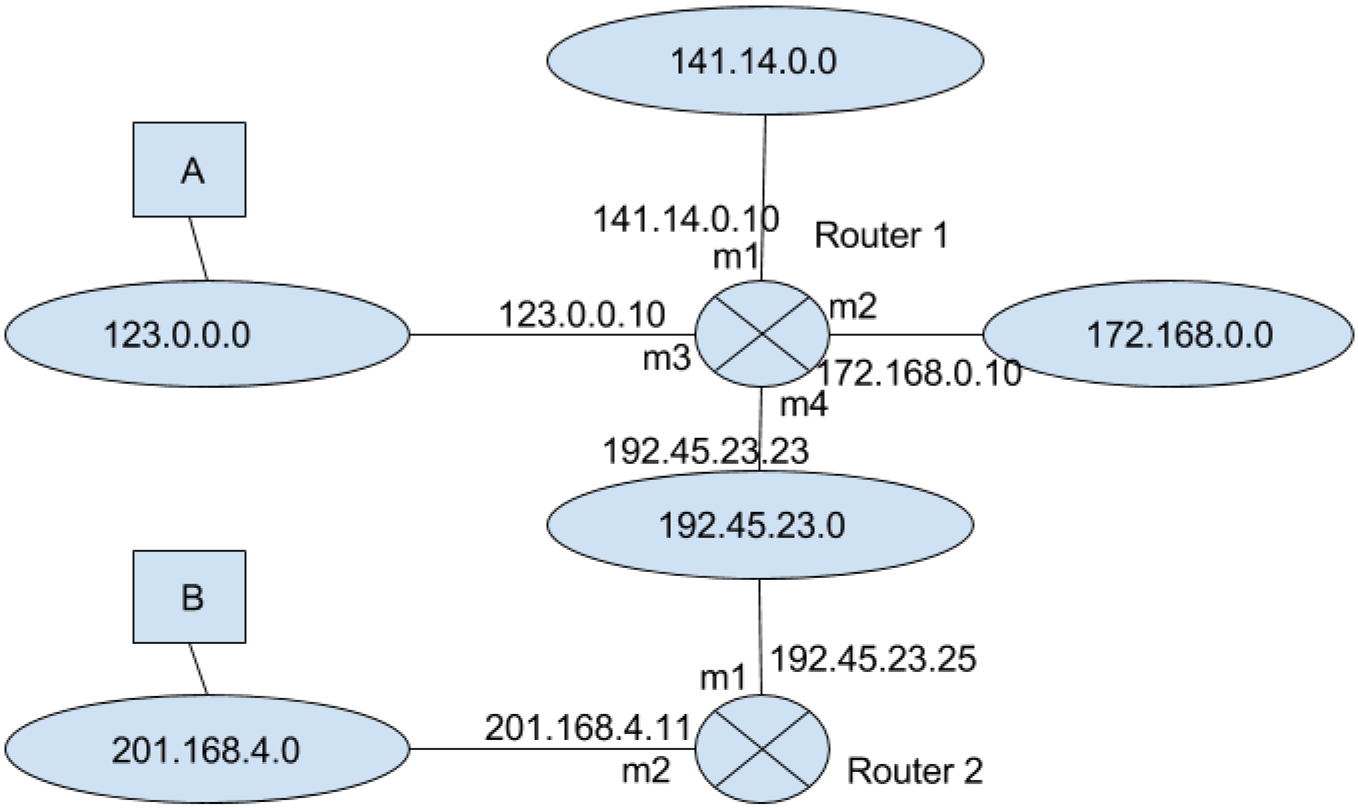
Status	Queue	Attempt	Time-Out	Protocol Add	Hardware Add
R	1		900	141.14.0.10	AEAC32457342
P	2	1		192.45.23.25	

It creates a new queue (2) for this destination and enqueues the packet. It then sends an ARP request to the data link layer for all the directly connected local networks. Since IP addresses are unique universally, one of the host/router replies to the arp request. After few seconds the input module receives an arp reply packet with the target protocol (IP) address 192.45.23.25. The module checks the cache table and finds this address. It changes the state of the entry to resolved and sets a timeout value in secs. The module then adds the target hardware address to the entry. It also create an entry for the interface from which it received the reply in the cache table. Now it accesses the queue and sends all the packets in this queue, one by one to the data link layer. Then the Router 2 transmits the data to the destination network.

Performance:

Updated arp protocol makes the network inefficient by consuming more bandwidth and time in sending the arp request to all the directly connected local networks. If a router interconnects large number of networks, then the network performance would be degraded significantly.

Network configuration:



Q 2. The ARP reply is used to update the ARP cache table. Can the ARP request be also used to update this table? If so, how?

Answer:

Yes, a ARP request can also be used to update the cache table.

- When the host receives an arp request for its mac address. The host creates an entry in the cache table for the source. It only creates an entry if the arp request is for its mac address or else it discards it. The arp module updates its cache with the source ip address to source mac address mapping present in the arp request packet. If the entry is already present in the cache, it is overwritten. If it is not present, it is added. Now that the cache table has both the ip address with its associated mac address it changes the status to 'R' or Resolved in the cache table and set a timeout value for the entry.

Q 3. Two network administrators argue about setting an optimal time-out T for the ARP cache table of a certain router. The first administrator thinks that T=t1 is satisfactory, the other one claims that T=t2 is much better. Propose a set of criteria to evaluate which of them is right. (Maybe both are wrong?) Which of these criteria is the most important from your point of view?

Answer:

Criteria to decide ARP cache timeout:

- Organization network with high amount data transmission from multiple hosts.:
    - In a network where there is a lot of data transmission between hosts then it is better to retain MAC address associated with host IP addresses for a longer period of time, thus the ARP cache table timeout will be larger value. For example Cisco routers have about 4 hours of ARP cache timeout value. If the timeout value is less, the entire network will be flooded with ARP requests and will result in poor performance and delay in data transmission and reception.

- Organization network with low data transmissions with less number of hosts:
    - In a network with low data transmission between hosts, the cache timeout value can be less, as retaining addresses for longer period of time is not efficient as it would result in long cache tables, using up more storage which could restrict any more entries into the table if the cache table gets filled up.

- Network with hosts with low storage capacity:
    - If a host/router has low storage space for its cache table, then the table might get filled up soon and there won't be any more space left for new entries.
    - To solve this problem, it would be a good choice to keep a low timeout value, so that it keep refreshing the cache and accommodate all new entries into the table.

- Hosts for example mobile phones, which have high mobility and interact many different networks:
    - It is important to understand the type of host while deciding the timeout value.

    - A host like mobile phone which have high mobility, may contain entries in the cache which could be unreachable because such devices get connected to many networks. For such devices refreshing the cache by setting a low timeout value could be a good approach.
    - In contrast, it is preferred to increase the timeout value if devices keep the same address and not change often like CCTV cameras.

- Network with many static IP addresses:
    - If a network has many static IP addresses with high data transmission , it will be preferred to keep the addresses in the cache table as long as the network is running. Static IP addresses don't change much so there is no point in updating the cache table.

The first two criteria is the most important from our point of view, because it is very important to understand network requirements of the organization. If the network data traffic flow is less. lower cache table value can be beneficial and vice versa. Thus, according to that the timeout value of cache table can be decided for the network for optimum performance.