Xcast6 Treemap Islands - Revisiting Multicast Model

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ABSTRACT

Due to the complexity and poor scalability, IP Multicast has not been used on the Internet. Recently, Xcast6 - a complementary protocol of IP Multicast has been proposed. However, the key limitation of Xcast6 is that it only supports small multicast sessions. To overcome this, we propose Xcast6 Treemap islands (X6Ti) - a hybrid model of Overlay Multicast and Xcast6. In summary, X6Ti has many advantages: support large multicast groups, simple and easy to deploy on the Internet, no router configuration, no restriction on the number of groups, no multicast routing protocol and no group management protocol. Based on simulation, we compare X6Ti with IP Multicast and NICE protocols to show the benefits of our new model.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Network communications*

Keywords

Xcast6 Treemap islands, IP Multicast, Overlay Network

1. INTRODUCTION

As mentioned in [3], IP Multicast encounters a major obstacle in the routing table size in routers when supporting multiple groups at the same time. For this reason, Xcast6 protocol - RFC 5058 [3] has been proposed. Because of its simplicity, Xcast6 has been successfully tested in real networks (e.g. Xcast Communication from a Flying Airplane in Japan [7]). Recently, Xcast6 Treemap (X6T) [5] has been proposed which works well even without Xcast-aware router on the network. However, there are two disadvantages hindering the deployment of Xcast6 (and X6T): first, the lack of IPv6 world-wide deployment and second, only small multicast sessions can be supported. In this paper, we develop Xcast6 Treemap islands (X6Ti) - a hierarchical architecture Overlay Multicast with the core is X6T. In other words, X6Ti allows interchange (without any configurations) between Overlay Multicast mode (end-hosts duplicate and forward data) and X6T mode (Xcast-aware routers duplicate and forward data like IP Multicast). The example in the next section explains how X6Ti works in the two modes.

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2. XCAST6 TREEMAP ISLANDS

2.1 Xcast6 Treemap in an island

We keep the format of the X6Ti packet same as X6T [5] but change the forwarding algorithm in X6Ti end-hosts [1]. In summary, each X6Ti packet header includes a list of destination IP addresses, a list of bitmap (bitmap = 1 is to mark the end-hosts which have not received the packet yet) and a treemap (which encodes an overlay tree of end-hosts). It is clear that the packet header contains all necessary information about the multicast group and also the overlay tree, hence the routers do not need to store any additional multicast information. This explains why X6Ti has no restriction on the number of multicast groups. Moreover, following IPv6 standard, X6Ti packets can be handled by both Xcast-aware and normal IPv6 routers on the network. When receiving an X6Ti packet, Xcast router uses its unicast routing table to look up all IP addresses in the list of destinations, then duplicates, changes the bitmap and forwards the packet to appropriate network interfaces (Fig. 1). Therefore, there is no need to develop a new multicast routing protocol. On the other hand, X6Ti packet also set the first unsent IP address in the list of destinations as its destination like a unicast packet. Thus, normal routers can route an X6Ti packet like a normal unicast packet. In addition, when an end-host receives an X6Ti packet, based on the bitmap and the treemap, it knows which end-hosts have not received the packet yet and then forwards the packet as the overlay tree. As shown in Fig. 1, in parts of the network which has Xcast routers (X1 and X4), the overlay tree is not used and packets are duplicated by routers, otherwise, data are multicasted by X6Ti end-hosts based on the treemap.

2.2 Xcast6 Treemap islands

Assuming the MTU is 1500 bytes, then the payload length of an X6Ti packet is equal to $(1348 - 16N)$ (N is the number of IP addresses in the packet header) [1]. In the current implementation [1], at most 64 IPv6 addresses can be embedded in each packet header and it is also the maximum number of members in each island (an overlay tree with one branch from the root as shown in Fig. 2). With hierarchical design (2-tiers), many islands are connected using special hosts (X6Ti sub-roots) to form a larger Overlay Network. In fact, this model can be extended to n-tiers in which X6Ti clients can work as X6Ti sub-roots to connect islands. There are several criteria to select an X6Ti sub-root such as outgoing bandwidth, stability of end-host, etc. (more details

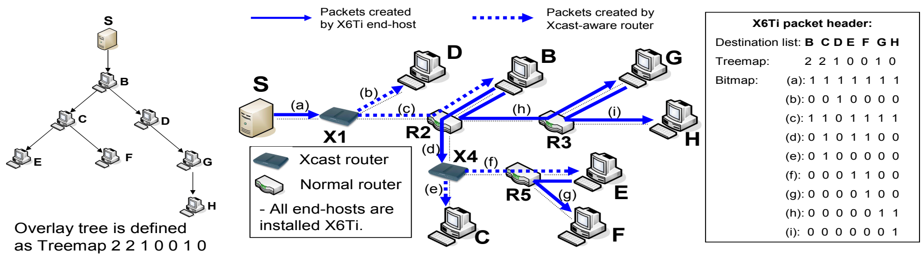

Figure 1: Source S sends data to a group of recipients

can be found in [1]). Note that, in the traditional Overlay Multicast, only end-hosts duplicate and forward data, thus there is still much traffic redundancy on the network. For X6Ti, it works like the traditional Overlay Multicast when there is no Xcast router, otherwise Xcast routers automatically duplicate and forward data like IP Multicast.

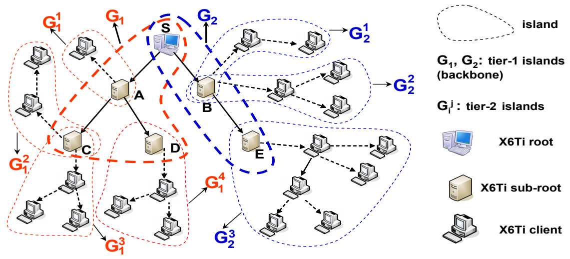

Figure 2: 2-tiers X6Ti model

3. SIMULATION AND DISCUSSION

In this section, we compare X6Ti with NICE [2] and IP Multicast. We use the network topology of France [6] with 25 routers in the backbone. There is a single source and 24 X6Ti sub-roots, each of them connect to a backbone router. Each sub-root manages several tier-2 islands in which X6Ti clients connect to the nearest sub-root. We increase the number of members in each island uniformly so that the total number of hosts in the multicast session is from 200 to 2600. For each test, we select at random 0% (X6Ti-0), 30% (X6Ti-30), 70% (X6Ti-70) and 100% (X6Ti-100) of the routers to be Xcast-aware routers. We collect end-to-end delay (total amount of time a packet is transmitted from the source to a receiver) and link stress (the number of duplicate packets that a physical link has to carry).

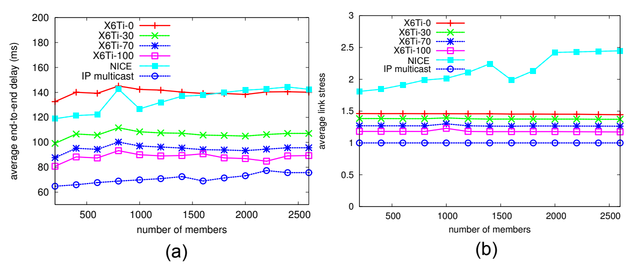

Figure 3: (a) End-to-end delay and (b) Link stress

IP Multicast transmit traffic optimally with low end-to-end delay and no traffic redundancy (link stress = 1) (Fig. 3). X6Ti works as pure Overlay Multicast when there is no Xcast-aware router (X6Ti-0 has less link stress than NICE since we choose a good overlay tree as described previously). And obviously, performance of X6Ti is improving when more Xcast-aware routers are deployed on the network.

Table 1: A comparison table

	IP multicast	Overlay Multicast	X6Ti
Efficiency in bw/delay	High	Low-Medium	Medium
Ease of deployment	Low	High	High
Fast route adaptation	High	Low	Medium

Table 1 shows some properties in comparision between IP multicast, Overlay Multicast and X6Ti. X6Ti is easy to deploy and no need any router configurations. In addition, with the world-wide IPv6 deployment [4], X6Ti can be deployed at end-hosts first and works like Overlay Multicast. Then, the network operators will deploy Xcast-aware routers when they see it is useful. In fact, X6Ti is even better than Overlay Multicast in term of "Fast route adaptation". When the overlay tree is changed (e.g. hosts join/leave), the X6Ti root or sub-root simply modifies the treemap, there is no need for other hosts to update or store new overlay tree in local like Overlay Multicast. More details and more features on the comparisons can be found in [1].

4. CONCLUSION

We believe that the X6Ti model overcomes most shortcomings of IP Multicast, Overlay Multicast and Xcast6. In summary, X6Ti solves the problem of difficulty in deployment and state scalability at routers (IP Multicast); multicast group size (Xcast6); traffic redundancy and instability when hosts join/leave (Overlay Multicast). For future work, real applications using X6Ti should be deployed on the Internet to test the feasibility of the protocol.

5. ACKNOWLEDGMENTS

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