AN APPROACH TO ENHANCE AGGREGATED SOURCE SPECIFIC MULTICAST SCHEME

AISHA-HASSAN A. HASHIM
International Islamic University Malaysia
P.O. Box 10
50728 Kuala Lumpur
Tel: +60(3)61964516
aisha@iiu.edu.my

WAN HASLINA HASSAN
Sunway University College

MUAZ ZAINAL ARIFIN
AHMAD TAQIYUDDIN AHMAD
WAJDI AL-KHATEEB
FARHAT ANWAR
International Islamic University Malaysia

ABSTRACT

The Aggregated Source Specific Multicast (ASSM) scheme is proposed to overcome the limitations of Source Specific Multicast (SSM). It aims to handle the scalability issue of SSM. The key idea is that multiple groups are forced to share a single delivery tree. However, the ASSM scheme suffers from routers under utilization problem. In our previous work we have proposed an approach to overcome this problem. In this paper our proposed approach was presented and evaluated. It was shown that our proposed scheme results in achieving higher routers utilization.

Key words: IP multicast, multicast tree, group membership, source-specific multicast.

INTRODUCTION

With the advent of new technologies such as Video over Digital Subscriber Line (DSL), distance learning, video conferencing, Streaming Media and others, IP Multicast is becoming a core part of new emerging networks. At the network-layer, IP multicast routing provides efficient communication services for applications that send the same data to multiple recipients, without incurring network overloads. It allows servers to send single copies of data streams which are then replicated and routed to recipients. Hence, at each router, only one copy of an incoming multicast packet is sent per link, rather than sending one copy of the packet per number of receivers accessed via that link (Hashim, Anwar & Al-Irhaym, 2007). The use of IP multicasting is desirable for efficiency. When a host wishes to send a datagram to multiple recipients, the network is entrusted to do packet replication, thereby reducing the resources on the host (as opposed to maintaining multiple point-to-point transmissions). In addition, replication is done only at fork routers, thereby reducing the load on the network as a whole (Deering, 1989). IP multicasting is extremely well suited for group-specific applications such as information distribution, datacasting, video-conferencing, distance learning, and even for resource discovery – network services may be advertised to specific sub-nets which are non-local (unlike in a broadcast environment, where broadcast is limited to the local logical subnet).

The Source-Specific Multicast (SSM) service model is based on applications joining channels rather than groups. A channel is a pair of (S,G) consisting of a Unicast source address S and a multicast group address G.

For each source S and group G the application is to receive data from, it must join the channel (S,G). This means that the application explicitly specifies the sources, and hence it must know the source addresses (Venaas & Tim, 2005).

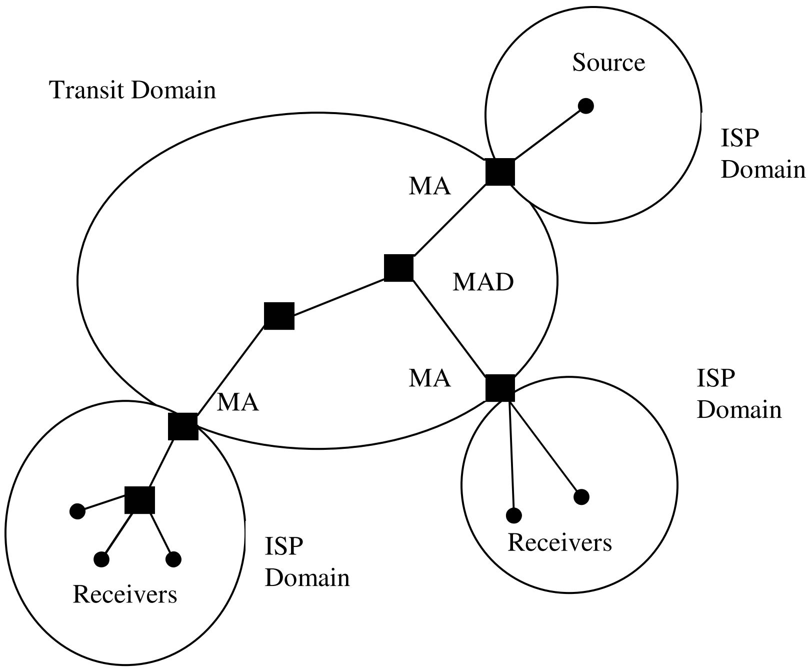
One of the key issues faced in implementing SSM is the state scalability issue. Therefore, the Aggregated Source Specific Multicast (ASSM) protocol was designed to solve this issue. Aggregated multicast is targeted to intra-domain multicast provisioning, and the key idea of it is that, instead of constructing a tree for each individual multicast session in the core network (backbone), multiple multicast sessions are forced to share a single aggregated tree (Jun-Hong, Dario, Jinkyu, Khalid, & Mario, 2002). More information on ASSM will be presented in the subsequent sections.

Aggregated multicast (Jun-Hong *et.al.,*2005) is proposed to improve the state scalability of SSM. The main idea is to force the multicasts group within an intra-domain to share a single delivery tree, instead of following individual tree for each multicast group. Basically, this protocol is targeted where intra-domain multicast is to be implemented. However, there are several things we need to take into consideration. These issues are reduction of multicast state, achievement of transparency to end-users, compatibility with existing multicast technologies, introduction of low overhead and minimization of modifications on core routers.

In Multicast Aggregated Domain (MAD), aggregation is performed at incoming edge routers and is de-aggregated at outgoing edge routers (Jun-Hong, 2003). Moreover, the multicast routing protocol in an Internet Service Provider (ISP) is independent of that in the MAD. To achieve this, the multicast packet will be encapsulated whenever it reaches the incoming edge routers and will be decapsulated in the outgoing edge routers (Fei, Cui, Gerla, & Faloutsos, 2001a). This is due to the fact that we cannot change the multicast channel address in the packet header, which can lead to a problem at the outgoing edge routers to distinguish the multiple multicast channels in order to redistribute packets to ISP networks. Using the IP encapsulation method will introduce some overhead due to processing time and bandwidth waste. However, that is the best solution to achieve ASSM.

The process of encapsulation and decapsulation of packets is done in the edge routers which are known as Multicast Aggregation (MA) Routers. MA routers with incoming traffic are called Source MA routers and MA routers with outgoing traffic are called Destination MA routers. Source MA routers collect multicast packets coming from the ISP networks and distribute them on the right aggregated tree. And the Destination MA routers receive traffic from the MAD and forward them to the ISP networks (Fei, Cui, Gerla, & Faloutsos, 2001b). A generic environment for ASSM is shown in Figure 1.

Figure 1. A Generic Environment for ASSM



The remainder of this paper is organized as follows. The first section presents the related work in the field of IP Multicast, SSM, and ASSM. The second section presents our analysis of ASSM, followed by the third section, where our proposed solution is presented and evaluated. Finally, the last section presents our conclusion.

RELATED WORK

Research into IP multicast has explored a number of diverse issues – from multicast routing, congestion control, multicast scheduling algorithms, to multicast performance analysis. For the purpose of this proposal, the discussion will focus on IP multicasting within the context of SSM and ASSM.

Previous work (Venaas & Tim, 2005; Kevin, Supratik, & Christophe, 2001; Gopi & Sekercioglu, 2003) have focused on how to implement SSM over the currently deployed Any Source Multicast (ASM) service. They also focused on using SSM with IPv6 and the issues that should be ironed out before it is adopted for widespread use. Work in Jun-Hong, Dario, Jinkyu, Khalid and Mario (2005) has developed a protocol (ASSM) to improve the state scalability issue of SSM. However, some overhead and efficiency issues are introduced as a result and we hope to find ways to minimize this. It can be seen that most previous works investigate and deal with the issues that have prevented SSM from being deployed for widespread use. Lastly, our work in Taqiyuddin, Arifin, Hashim, Anwar and Al-Irhayim (2008) presents a comparative study of SSM and ASSM. A summary of this comparison is shown in Table 1.

Table 1. Comparison Between SSM and ASSM

Comparison	**SSM**	**ASSM**
Source	One	One
Relation	One-to-Many	One-to-Many
Multicast routing protocol	PIM-SSM	PIM-SSM
Multicast routing tree	Many	One
Control Messages	M-JOIN, M-LEAVE, M-REPORT	A-JOIN, A-LEAVE, A-ACK and A-MOVE

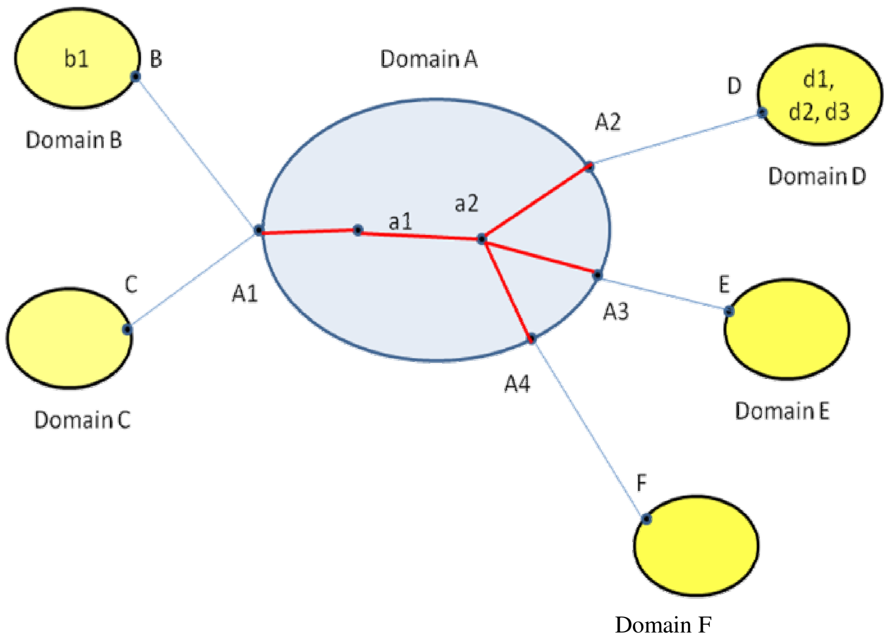
ANALYSIS OF ASSM

While ASSM has its advantages, it has also introduced a bandwidth problem. This problem increases as the number of receiving domains increase. Take, for example, Figure 2. This figure shows that the source originates from domain B, and the receivers are in domain D, which are d1, d2 and d3.

All groups in ASSM share the same single tree. Hence, let us assume we have a group whose members are in Domain D, as illustrated in Figure 2. Using ASSM, data will be transmitted to A2, A3, and A4 even though Domains E and F are not in the same group. When the data arrives at A2, it will be decapsulated and sent to router D where it will forward the packets to the receiver nodes d1, d2, and d3. However, when the data arrives at A3 and A4, it will be dropped because there are no receivers within Domains E and F.

In this case, two packets are considered using the link unnecessarily. For the best case scenario, the minimum packet length is 20 bytes, and therefore only 2 * 20 = 40 bytes of bandwidth are wasted. However assuming a packet length of 150 bytes, then 2 * 150 = 300 bytes of bandwidth are wasted. Now, let us consider that the receiving domains increase from 3 to 10, but with only 1 receiving domain. Again, the best case scenario would be 9 * 20 = 180 bytes of wasted bandwidth, and if the packet length is 150 bytes, then 9 * 150 = 1350 bytes of bandwidth would be wasted.

Figure 2. Tree for Domain A Using the ASSM Service Model



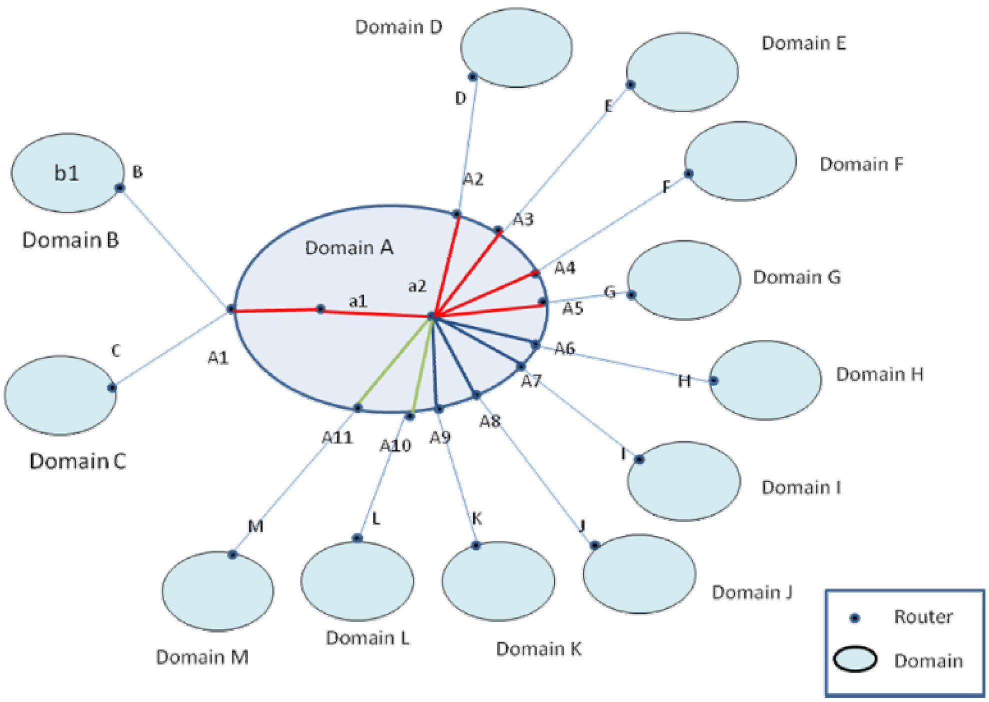
Utilization of routers in ASSM will be very low since all groups share only one aggregated tree. Work in Hommer (2003) has shown that for a multicast router, the maximum number of groups that can be stored without having any packet loss is 4. This varies depending on the router brand, router age and the environment of the network. However, work in Camilo, Silva and Boavida (2004) mentions that there is not much difference in network performance between 1 and 10 trees.

PROPOSED SOLUTIONS

This work was initially proposed by us in Taqiyuddin, Arifin, Hashim, Anwar and Al-Irhayim (2008). Details of this proposal with the evaluation are presented in this paper. Work in Hommer (2003) has shown that for a multicast router, the maximum number of groups that can be stored without having any packet loss is 4. Hence we proposed having four aggregated trees to fully utilize the routers within a MAD instead of having only one. To achieve this we have come up with a few approaches to solve this problem.

For the first part, the first group is the original ASSM aggregated tree. The second group consists of domains 1, 2, , (N/3). The third group will consist of domains (N/3)+1, (N/3)+2, …, 2(N/3) and the last group will consist of 2(N/3),2(N/3)+1, …, N. For example, if N=10 where the domain is D,E,F,G,H,I,J,K,L and M, then the first group will be {D,E,F,G,H,I,J,K,L and M}, the second group will consist of {D,E,F,G}, the third group will consist of {H,I,J,K} and the last group will consist of {L,M}. Figure 3 illustrates this point graphically.

Figure 3. ASSM with 10 Receiving Domains



The first group should connect all the receiving domains. Considering that the source MA router is A1, for the first group, the forwarding tree will be through A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11 routers. For the second tree, the forwarding tree will be A1, A2, A3, A4, and A5 which are in red. The third forwarding tree will be A1, A6, A7, A8, and A9 which are in blue and the last the forwarding tree will be A1, A10, and A11 which are in green.

If a multicast group has members in D, E and H, then the packet will be forwarded using the second and third forwarding tree. If a multicast group has members in K and M, then the data will be forwarded through the fourth forwarding tree.

Now, let us analyze the performance of this proposal assuming that the group has members within domain D only. For the original ASSM, the wasted bandwidth for worst case scenario was 1350 bytes. However, if we use the second forwarding tree, only 3 packets will be dropped at A3, A4 and A5, so the wasted bandwidth is 3 * 150 bytes = 450 bytes. From this, we can calculate the percentage of bandwidth reduced:

$$\% \, bandwidth \, reduced = \frac{1350 - 450}{1350} \times 100 = 66.67\%$$

Let us consider another scenario, where the group members reside within domain D, H, and L. Domain D exists in the second forwarding tree, Domain H exists in the third forwarding tree, and domain L exists in the fourth domain tree. Since the receiving domains exist in all 3 forwarding trees, the original ASSM aggregated tree will be used, and therefore the wasted bandwidth will be the same as the original ASSM.

When data is transmitted from a source to a group, the source MA router will check where the group members reside. If group members reside at any domain within one forwarding tree, then that tree will be chosen to transmit the data. If there are multiple domains with multiple aggregated trees, all the trees will be selected to transmit the data. However, if all three trees are selected, than the first tree will be used to transmit the data. This information is summarized in Table 2.

Table 2. The Division of Domains into 4 Groups

Case	Domain in which the Group Members Reside	Aggregated Tree Chosen
1	(D or E or F or G) and (H or I or J or K) and (L or M)	First
2	(D or E or F or G)	Second
3	(H or I or J or K)	Third
4	(L or M)	Fourth
5	(D or E or F or G) and (H or I or J or K)	Second and Third
6	(D or E or F or G) and (L or M)	Second and Fourth
7	(H or I or J or K) and (L or M)	Third and Fourth

The 4 basic trees are shown in case 1, 2, 3, and 4; whereas, cases 5, 6, and 7 show combinations of the basic cases. We can see that the aggregated tree chosen is based on the domain where the group members reside and by using the table we can give an example of how the trees will be chosen. Supposing there is a group, called $G_{0,}$ whose members are in Domains E, F, and K, we can see from the table that this is case 5 and that the second and third tree should be chosen.

Our second approach is to remove the reserved ASSM aggregated tree and just use the three divided trees. The table is constructed as Table 3.

Table 3. The Division of Domains into 3 Groups

Case	Domain the group members reside	Aggregated Tree
1	(D or E or F or G)	First
2	(H or I or J or K)	Second
3	(L or M)	Third
4	(D or E or F or G) and (H or I or J or K)	First and Second
5	(D or E or F or G) and (L or M)	First and Third
6	(H or I or J or K) and (L or M)	Second and Third
7	(D or E or F or G) and (H or I or J or K) and (L or M)	First, Second, and Third

From this table we can see that the cases are basically the same but the trees are reduced from 4 to 3. From a wasted bandwidth standpoint, both solutions are similar.

Since we discovered that the maximum number of groups that a multicast router can store without affecting its efficiency is 4, we have proposed another solution. We decided to divide the domains evenly into 4 groups. This means that the first group will consist of domains 1, 2, …, (N/4). The second group will consist of domains (N/4)+1, (N/4)+2, …, 2(N/4) and the last group will consist of 2(N/4), 2(N/4)+1, …, N. For example, if N=10 where the domain is D,E,F,G,H,I,J,K,L and M, then the first group will be {D,E,F}, the second group will consist of {G,H,I}, the third group will consist of {J,K,L} and the last group will consist of {M}. From this information, we can construct Table 4.

Table 4. The Division of Domains into 4 Groups

Case	**Domain the group members reside**	**Aggregated Tree Chosen**
1	(D or E or F)	First
2	(G or H or I)	Second
3	(J or K or L)	Third
4	(M)	Fourth
5	(D or E or F) and (G or H or I)	First and Second
6	(D or E or F) and (J or K or L)	First and Third
7	(D or E or F) and (M)	First and Fourth
8	(G or H or I) and (J or K or L)	Second and Third
9	(G or H or I) and (M)	Second and Fourth
10	(J or K or L) and (M)	Third and Fourth
11	(D or E or F) and (G or H or I) and (J or K or L)	First, Second, and Third
12	(D or E or F) and (G or H or I) and (M)	First, Second, and Fourth
13	(G or H or I) and (J or K or L) and (M)	Second, Third, and Fourth
14	(D or E or F) and (G or H or I) and (J or K or L)	First, Second, Third, and Fourth

Therefore, assuming we have the same situation with a packet length of 150 bytes, we use the first forwarding tree where only 2 packets will be dropped. This means that the wasted bandwidth is 2 * 150 bytes = 300 bytes. If we compare this with the previous results of ASSM we can see that:

$$\% \text{ of bandwidth reduced} = [(1350-300)/1350]*100 = 77.78\%$$

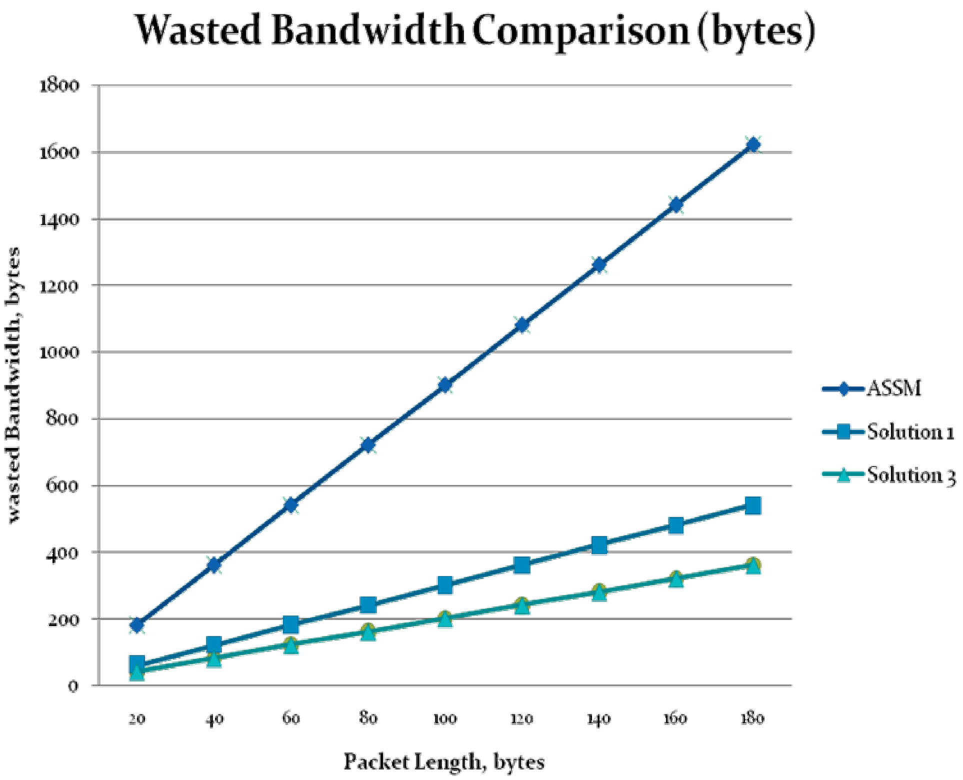
While if we compare this with our first solution, we can see that:

$$\% \text{ of bandwidth reduced} = [(450-300)/450]*100 = 33.33\%$$

From the analysis done, we can construct a graph (Figure 4) to indicate the wasted bandwidth comparison between ASSM, our proposed solution 1, and proposed solution 3.

Proposed solution 2 is not included because it is essentially the same as proposed solution 1 in terms of wasted bandwidth.

Figure 4. A Comparison of Wasted Bandwidth versus Packet Length



From the graph we can see that as the packet length increases, the wasted bandwidth also increases. We can also see that ASSM has a bigger potential to waste bandwidth while proposed solution 3 is the best at not wasting bandwidth.

CONCLUSION

This paper has presented a comparison between ASSM and SSM. The main objective of ASSM is to solve the state scalability problem of SSM. The ASSM protocol is simple, transparent to end-users and compatible with current multicast technologies. The main difference between SSM and ASSM is that in ASSM the multicast groups use only one tree while in SSM multicast groups use multiple trees distribution. In this paper we have also presented the enhancement that we have proposed to increase the router utilization problem associated with ASSM. The evaluation indicates that our approach increases the router utilization when compared to ASSM.

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