Comparison of Multicasting Protocols in Wireless Networks

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Abstract

Providing Multicast over the wireless networks has always been challenging because some of the issues involving multicast such as shielding the movement of the mobile host (MH) from the Main Multicast Delivery Tree, performance issues during hand off, reliability etc. require certain modifications and implementations to suit various applications. In this paper, various protocols have been compared considering the general requirements for Multicast over Wireless networks such as: minimizing re-computation of the multicast delivery tree, reducing packet loss and latency due to hand off, optimal routing and reducing computations at the MH level for reduced power consumption. More emphasis has been given to "MOBICAST" [2] protocol in this paper because of its applicability for the present day scenario and the ease with which it manages multicast data delivery to multiple recipients.

1. Introduction

Multicasting, in general, involves a single source sending messages to multiple destinations using the same IP address, which is called **"Host Group Address".** IPV4 has a special group of addresses called "D" group, entirely dedicated for the Multicast addresses. Hosts intending to send or receive multicast messages have to subscribe to the group dynamically using **"IGMP"**(Internet Group Management Protocol).

Multicasting is necessitated in wireless networks basically for applications, which involve multiple sessions such as:(a) **A database query**, which has to query more than one server at the same time from the distributed database. (b) **A Teleconferencing application**, in which there are more than one receiver for the data at any given time etc. Multicasting is better suited for all such applications particularly in mobile environments because it is **bandwidth efficient** when compared to multiple unicast methods, because multiple unicast **flood the network** apparently with duplicate packets.

1.1 Challenges in implementing Multicasting for Wireless Networks.

Some of the challenges in implementing Multicasting for Wireless Networks can be listed as follows. First of all, the **host mobility** is to be **hidden** from the multicast tree. Second, during hand off, the **packet loss** should be **minima**l and so should the **hand off latency** be. Third, the **dynamic group membership** is to be facilitated accordingly. Fourth, **QoS provisioning** with **Resource Reservation** is to be implemented as well.

In this paper, various **Multicasting Protocols** for wireless networks have been compared, all of which aim at assuaging one or more of the above mentioned challenges.

The rest of my paper is organized as follows. Section 2 comprises of proposals of **IETF Mobile IP** standard for implementing Multicasting in a wireless environment. Section 3 & 4 comprise of descriptions of some of the **protocols based on Mobile IP**. Section 5 comprises of descriptions of a **Reliable Multicast protocol [RMDP].** Section 6 comprises of **summaries and conclusions** along with the **possible future work** in this area.

2. Related Work

2.1 IETF Mobile IP standard approaches.

The two approaches proposed by IETF for multicasting over Mobile IP are:
(a) **Remote Subscription**, (b) **Bi-directional Tunneling.** In Remote Subscription, whenever the Mobile Host (MH) moves in to a new Foreign Network the MH re-subscribes to the desired multicast group. Where as in Bi-directional tunneling method, the MH receives and sends multicast packets through its Home Agent (HA) by means of unicast tunnel.

The advantages of **Remote Subscription** method are: it does not call for special encapsulation, it is simple and offers the shortest path for the multicast data delivery to the MH. On the other hand this method is not suitable for MHs, which are highly mobile because frequent re-subscriptions could lead to lost packets.

The advantages of **Bi-directional Tunneling** lie in the fact that there is no need to re compute the Multicast Tree every time the MH moves in to a new foreign network as all the routing is done through the HA. However the **Bi-directional Tunneling** suffers from **Tunnel convergence problem**. In a way Bi-directional Tunneling offers **multiple unicast** than an exact **Multicast**. Tunnel convergence problem has been dealt with, in one of the protocols that I have described in later sections.

3 Mobile IP based Protocols.

3.1 " Mobile Multicast Protocol "(as MOM) [1]

In this protocol, the authors have proposed a protocol to overcome the **"TUNNEL CONVERGENCE PROBLEM"** in the Bi**-directional Tunneling** method proposed by IETF.

The **Tunnel Convergence Problem** is explained in the following diagram (Fig1).

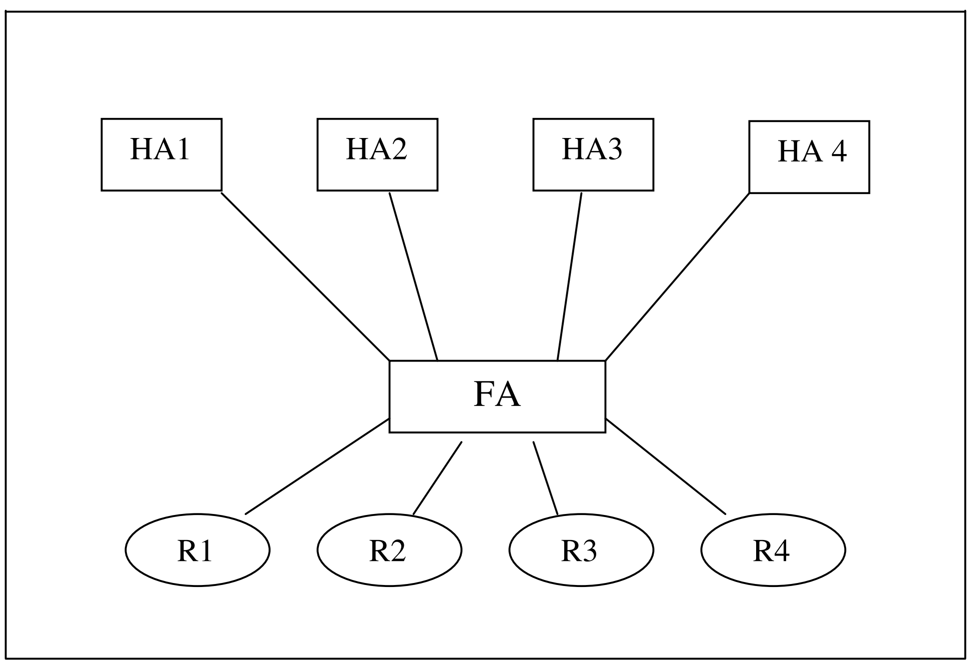

Fig 1
Tunnel Convergence Problem

Here, HA→ Home Agent,

FA → Foreign Agent,

R → Multicast Receiver

As can be seen from the diagram above, when many MHs, belonging to different HAs, move to the same foreign network, each of the HAs establishes a separate tunnel to the FA. If all of the MHs were subscribing to the same multicast group then, all the tunnels would be carrying the same multicast packet, which results in PACKET DUPLICATION and this state is called Tunnel Convergence.

The MOM [1] protocol proposes to over come this problem by deploying **Designated Multicast Service Provider** (DMSP), which is nothing but a particular HA selected among the given set of HAs. But once again this has a limitation that is if the designated MH moves out of this network, the HA, which senses this movement stops forwarding the packets to the old FA. This might lead to loss of packets. So another adaptation proposed in this protocol is to select more than **1 but less than 3 DMSPs** at any given time, so that even if one or two MHs move out of the network, there would not be any packet losses. Once again this leads to Packet duplication.

3.1.a Discussions about the Protocol

There are certain advantages with this protocol namely: Minimal changes are required to IP Multicast and Mobile IP, Provides the ability to support dynamic groups and provide minimal break in service due to the MH movement etc. However the limitations do exist such as: Non-optimal packet routing because the packets have to be routed through the HA and FA. The major drawback is the fact that in spite of using DMSP, the protocol still uses MULTIPLE UNICASTS by the HA for sending the packets to multiple recipients of the group through the FA. It is apt to say that some more work needs to be done in this field to make it a practical protocol for the present day wireless networks.

4. Mobility Architecture of Mobicast Protocol

4.1 <u>“ Mobicast: A multicast scheme for wireless networks ”[2]</u>

This protocol is an interesting work suitable for mobile hosts with small wireless cells, which is extremely relevant for the present state of the art because of the growing need for provisioning of increased bandwidth.

The fig 2 describes the architecture of **Mobicast** in detail.

In the figure 2

R → Router
BS → Base Station
DFA → Domain Foreign Agent

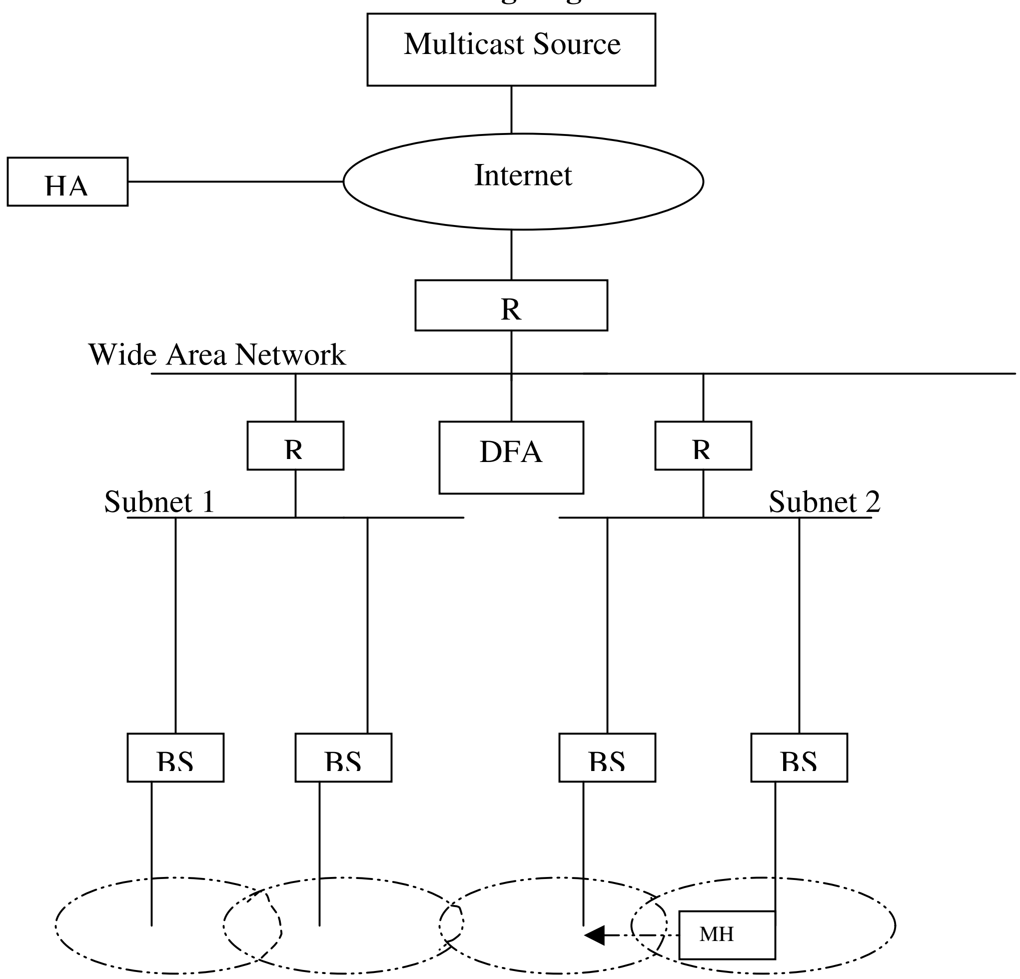

Fig 2
Implementation of DFA in Mobicast

In this paper, the authors propose a hierarchical mobility management approach using a **DOMAIN FOREIGN AGENT (DFA)** as shown in fig 2, for isolating the mobility of the mobile hosts from the main multicast delivery tree. Every foreign domain has a DFA which de-capsulates the multicast packet, sent after encapsulation by the MH, and sends it out on behalf of the MH. The MH subscribes to the multicast group by the serving base station, which relays it to the DFA. The DFA subscribes to the requested multicast group and forwards the requested multicast packets to the MH.

The DFA is responsible for all the foreign MHs inside the WAN. The IP address of the DFA is broadcast periodically, whenever the MH hears a beacon and decides to attach to the wired network, it registers with the DFA to its HA as its care of address. Whenever the MH moves from one Base station to the other inside the same domain, its mobility is shielded from the Main Multicast Delivery Tree. As long as the MH is within the same domain there is no need for re-computation of the main multicast delivery tree.

4.1.a MH as a multicast sender

If the MH is a sender, it encapsulates the multicast packet and unicasts it to the DFA, this is because the MH cannot use the DFA's address as it's care of address as the packet may be discarded during the interface check by a multicast router. After the DFA receives the multicast packet from the MH it decapsulates and sends out the multicast packet on behalf of the MH, with the DFA's address in the source address field of the multicast. Here the authors assume that the higher-level protocols in the application will be able to provide the identification of the original source of the multicast packet.

4.1.b MH as a multicast receiver

The MH sends an IGMP report to the BS to subscribe to a group that the MH wants to join. This subscription is relayed by the serving BS to the registered DFA that is nearest to the MH. The DFA supplies a different multicast address to this BS called Translated Multicast Address. The DFA subscribes to the requested multicast address group and forwards the requested multicast packets to the MHs in its domain. This is done by the BSs, which are members of the multicast group.

4.1.c Handoff Protocol

This approach is based on **Remote Subscription** method of Mobile IP as recommended by IETF. The handoff disruptions are handled by organizing the physically adjacent cells into **Dynamic Macro-cells Virtual** (DVM). Whenever the MH subscribes to a multicast group through the DFA, the serving base station informs the other base stations in its DVM to subscribe to the same multicast group. Only the **currently serving base station forwards multicast data** to the MH. All other base stations buffer the recent packets and in case of handoff will forward the packets to the MH. Since the adjacent base stations would have already subscribed to the multicast group, the hand off latency is greatly reduced.

4.1.d Discussions about the protocol

This major advantages with this protocol can be listed as: First, since it follows Remote Subscription method, some of the problems that exist in bi-directional tunneling approach like tunneling convergence problem, triangular routing are avoided all together. Second, since the MH communicates via DFA, the mobility of the MH is hidden from the Multicast Delivery Tree. Third, the use of multicast as the forwarding mechanism from the DFA to interested MHs in its domain alleviates the DFA from keeping track of the exact location of the MH Fourth, since the neighboring base stations subscribe to the same multicast group prior to the actual movement of the MH, this provides fast hand off and minimizes disruptions to the multicast session.

However there are certain limitations for this protocol like: this protocol assumes the overhead on the network arising due to the buffering of recent multicast packets by the neighboring base stations other than the serving base station to be negligible. In fact this overhead could cause an increase in bandwidth consumption and could lead to increased network traffic. This protocol also necessitates certain modifications in the FA, which is undesirable. This protocol does not address the situation where the MHs are moving in and out of different DFA domains and which would require the re-computation of the main multicast delivery tree.

5 Reliable Multicast Protocols in wireless networks

Reliable Multicast protocols distribute the same data object to a set of receivers, with some kind of guarantee on the delivery process. The present day applications require the reliability of data transmission for example: some applications might require the data packets to be delivered in a certain order, some others might require the data packets to be delivered based on certain timing constraints etc. Here I am presenting one such reliable protocol RMDP based on the paper [6].

5.1 RMDP Protocol (A Reliable Multicast Data Distribution Protocol)[6]

In the paper [6], the authors have come up with a framework based on the use of **Forward Error Correction** (FEC) and **Automatic Retransmission Request** (ARQ), techniques in combination and it is called **Hybrid FEC + ARQ** technique. In pure **FEC**, the redundant data is transmitted (generated by a suitable encoder) which allows the receiver to reconstruct the original message despite some communication errors. Here, the successful completion of the data transfer depends upon the number of received packets than on their identity. In **ARQ,** the receiver requests for a retransmission either implicitly (meaning, using time outs and positive acknowledgements like ACK) or explicitly (meaning, using negative acknowledgements like NACK).

5.1.a Over View of RMDP Protocol

In RMDP, the FEC Encoding is used to make the large groups of receivers to receive and to reduce the amount of feed back from the receivers. And ARQ is used to deal in situations where the default amount of redundancy is not enough to complete reception. In this protocol, if we consider "k" number of packets to be fed to the encoder, the encoder adds redundant data and produces " **n >> k** " number of packets in such a way that any subset of "k" encoded packets allow correct reconstruction of the source data at the receiver. The authors assume that the data object to be transmitted is a file identified by a unique name. The file is split in to packets of s bytes each. Now the ARQ comes in to picture because of the limitation of the " **n >> k** " value.

The implementation comprises of an algorithm in which the sender and the receiver constantly monitor the number of packets sent and received and check with a fixed Default Expansion Factor whether " $\mathbf{C_r = l}$ ", where $\mathbf{C_r}$ is the count of packets received by the receiver and $\mathbf{l}$ is the total file size in packets. If the " $\mathbf{C_r = l}$ ", then the receiver can decode and proceed, otherwise the receiver requests the sender to retransmit. This retransmission is not scheduled periodically as it would cause a feed back storm, but the retransmission is requested randomly within appropriate time intervals $\mathbf{T_R}$ and $T_{C.}$

5.1.b Discussions on the Protocol

This protocol is easy to implement, as it is a software implementation of the FEC. This protocol is also scalable for a multiple receiver and sender scenario, which makes it suitable for Multicast applications. However, some of the drawbacks lie in the fact that software implementation could be expensive. And the authors have assumed that the underlying protocol will account for mobility and hand off scenarios, which happen to be the most critical issues in Multicasting over Wireless Networks.

6. Summaries and Conclusion

In this paper, basically 3 groups of protocols have been compared. One, the protocols proposed by IETF namely Remote Subscription and Bi-directional Tunneling. Two, Multicast Protocols based on Mobile IP, namely, MOM [1] and Mobicast [2]. Three, A reliable protocol for wireless multicasting RMDP [6]. I have summarized the comparisons of these protocols based on their performance with respect to certain parameters as shown in the table below.

Protocol	Optimal Routing	Reduction in Packet loss and Latency during Hand off	Reliability	Changes needed To the MH
Remote Subscription	YES	YES	NO	NO
Bi-directional tunneling	NO	NO	NO	NO
MOM	NO	YES	NO	YES
Mobicast	YES	YES	NO	NO
RMDP	NO	NO	YES	YES

Fig 3

TABLE OF COMPARISON

Mobicast [2] protocol addresses the issues in wireless multicast better than the other protocols because, it considers the wireless network to be made of large number of small cells. In the present day wireless networks, there is the growing need for more number of small cells to provide better bandwidth utilization. Once again this protocol provides efficient approach to handle highly mobile users with least disruptions to the multicast packets.

6.1 Future Work

There is a considerable amount of scope for providing Reliable Multicast with Mobicast and with QoS provisioning. There is also a scope for a combined implementation of Remote Subscription and Bi-directional tunneling technique for obtaining maximum efficiency. Although some work as in paper [3] has envisaged these options, there could be future implementations for reducing the re-computation of main multicast delivery tree.

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