IP Design for Mobile Networks

Revolutionizing the architecture and implementation of mobile networks

Mark Grayson
Kevin Shatzkamer
Scott Wainner

ciscopress.com

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Kevin Shatzkamer
Scott Wainner

Cisco Press
800 East 96th Street
Indianapolis, IN 46240

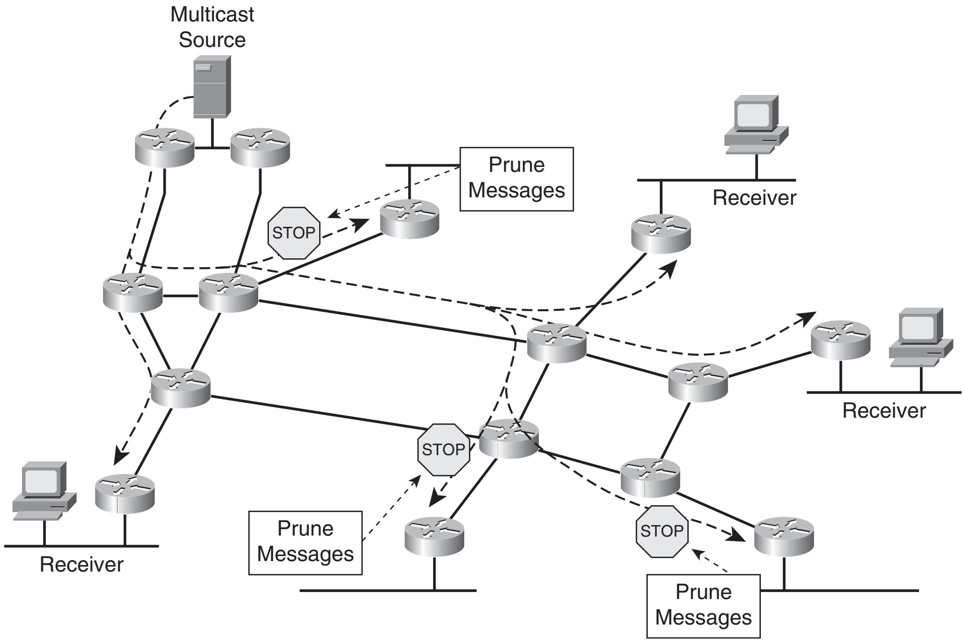

Figure 4-21 *PIM-DM Traffic Distribution*

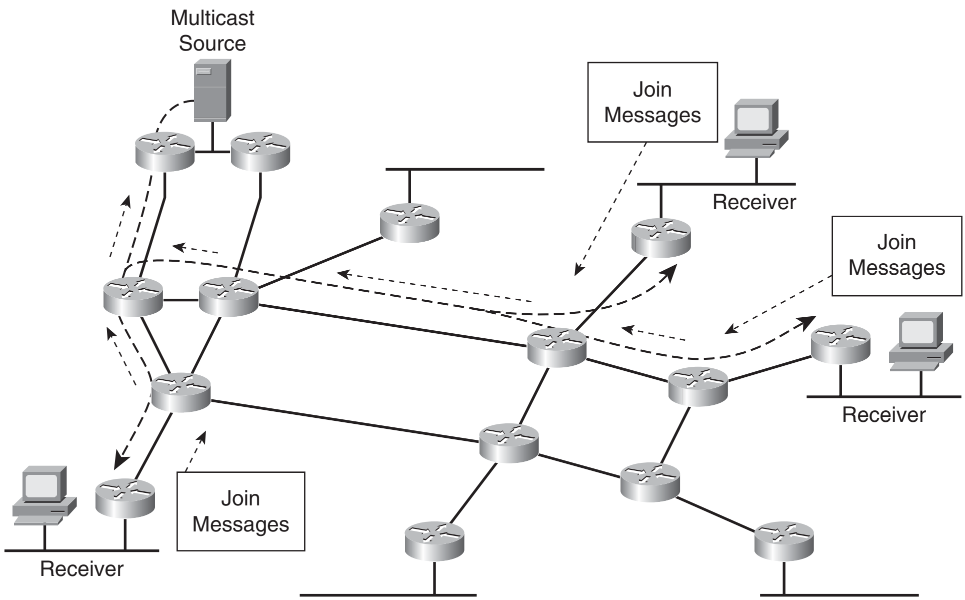

Figure 4-22 *PIM-SM Traffic Distribution*

PIM-SM is complicated by the need to bootstrap the multicast distribution tree. The receivers need a means of discovering the presence of a multicast stream; however, they are not connected to the multicast distribution tree. Several techniques have been created to facilitate this bootstrap process, including the designation of a Rendezvous Point (RP) or a Bootstrap Router (BSR). The potential receivers are made aware of the RP or BSR, which notifies the receivers of multicast groups available. The mobile operator will find that the use of RP and BSR is somewhat counter-productive because the multicast distribution tree may not match the hierarchical topology of the mobile provider network. Figure 4-23 shows how a dynamically selected RP or BSR may not provide the most efficient means of distributing multicast traffic to a set of mobile subscribers.

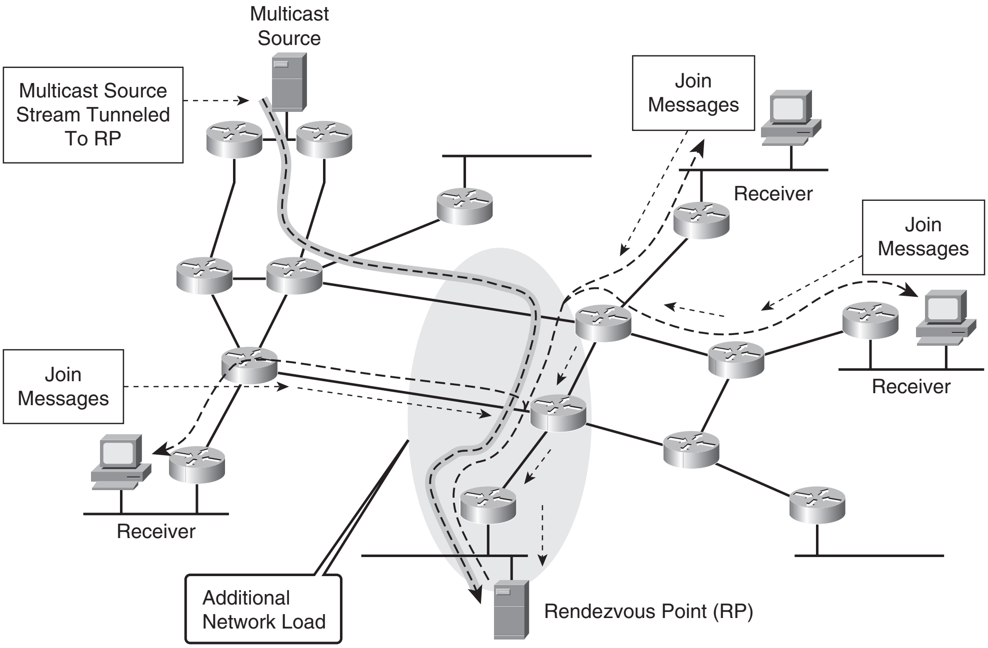

Figure 4-23 *Multicast Distribution via Rendezvous Point*

The PIM Source Specific Mode (PIM-SSM) method was created to mitigate the inefficiencies of PIM-SM. After a receiver knows the source of traffic for a multicast group, the receiver may send a PIM join toward the source bypassing the RP or BSR. Application developers are now building applications that inherently support PIM-SSM. The mobile subscriber can select participation in a service, and the application will automatically join the multicast distribution tree for the duration of the subscriber's participation.

One of the biggest impediments to deployment of multicast on a mobile provider's network is the tunneling architecture used for subscriber aggregation. The absence of a multicast-enabled provider infrastructure requires replication of each subscriber's multicast stream prior to tunneling the traffic to the subscriber. Figure 4-24 shows the legacy mobile provider IP topology and highlights the inefficiency of replicating multicast traffic at the subscriber session manager.

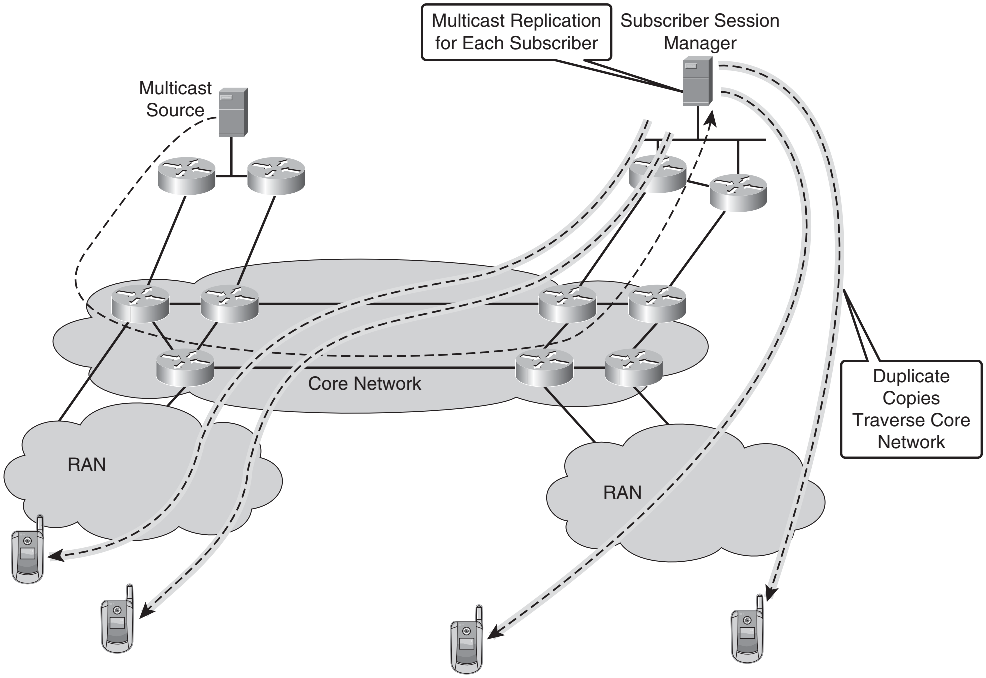

Figure 4-24 *Multicast Distribution on Aggregated Mobile Sessions*

Next-generation mobile IP architectures facilitate more efficient use of multicast where the provider's RAN and WAN execute the replication of multicast traffic. The UMTS architecture leverages the Multimedia Broadcast Multicast Service to replicate traffic at the GGSN, SGSN, and RNC. [7] The multicast-enabled RAN minimizes the number of broadcast/multicast streams that need to be distributed to the periphery of the network. Architecturally, the subscriber session management must be distributed to the periphery of the network in order to manage multicast more efficiently. Figure 4-25 shows the use of distributed subscriber session management where some services are broadcast for all subscribers, whereas others provide two-way multicast services.

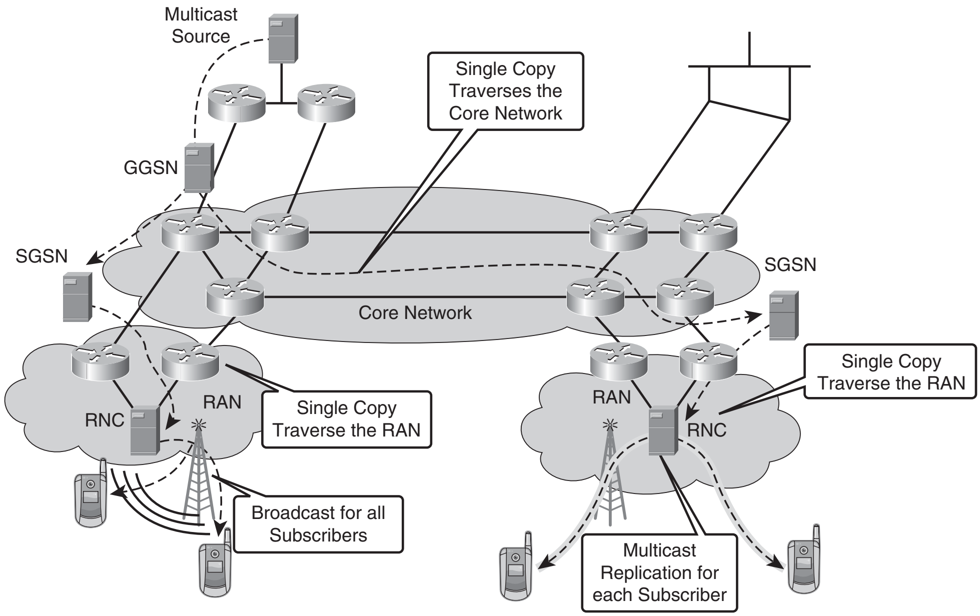

Figure 4-25 *Multicast Distributed Mobile Sessions*

Internet Group Management Protocol

The routing nodes need a method to discover multicast sources and multicast receivers. The Internet Group Management Protocol (IGMP) protocol handles the exchange of group information between the receiver/source and the first routing node participating in the DVMRP or PIM processes. IGMP allows a multicast sender to notify adjacent routers that a multicast application is transmitting multicast traffic to a specific group. The first routing node may then forward the stream on the multicast distribution tree. Likewise, a receiver may notify an adjacent router that access to a multicast stream is required. The router will subsequently join the multicast distribution tree for that group and forward the multicast steam to the local receivers. IGMP uses reports between end-system senders/receivers and the adjacent routers. The reports identify the groups of interest.

IGMP is relevant for the mobile provider in the data center environment. Any multicast applications in the data center will need to make their presence known on the providers' WAN routing infrastructure. The interesting challenge is how to provide multicast services to the mobile subscriber. It is unreasonable for a mobile subscriber to issue an IGMP report requesting to join a multicast group. Architecturally, the multicast stream would have to be replicated on each subscriber's session attachment. Fundamentally, the model of replicating IP multicast on each subscriber session does not scale. The next-generation wireless networks have design broadcast capabilities into the radio access network that operates in parallel to the existing unicast distribution architecture. Figure 4-26 shows the generic architecture used for distribution of multicast traffic to mobile subscribers.

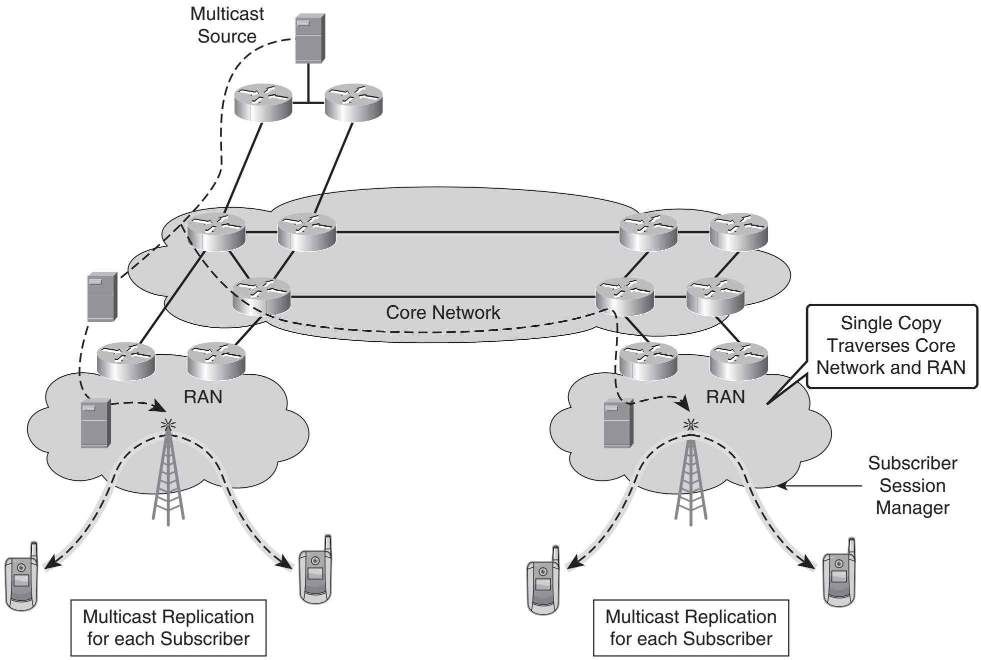

Figure 4-26 *Multicast Wireless Delivery Architecture*

Numerous organizations created variants of this generic architecture, and they primarily focus on where the IP multicast terminates and when the mobile wireless broadcast/multicast begins. Clearly, the goal is to move the IP multicast processes as close to the edge as possible. These wireless edge systems require IGMP functions to join the IP multicast architecture. The edge systems have to convert the IP multicast into a radio multicast architecture that is dependent on the radio systems.

Multicast Listener Discovery

The next generation of IPv6 uses a new method within the IPv6 protocol, as opposed to creating a separate protocol, as IGMP was for IPv4. Multicast Listener Discovery (MLD) is inherently built into the IPv6 protocol stack and performs similar functionality as IGMP in IPv4. The IPv6 protocol has defined several multicast addresses for link-local and interface-local and uses the multicast report and queries to participate in specific multicast groups.

The use of MLD has not become prevalent in the mobile wireless space; however, it too will most likely play a role in the distribution of content via multicast in the data center and on the mobile provider's core network.

Unicast Tunneling of Multicast

Many network elements do not support multicast, in which case the multicast must be tunneled via unicast across those elements. A number of protocols are designed to do just that, some of which are directly applicable to the radio access network.

PIM-Register

The sources of multicast traffic need to transmit the stream to the multicast distribution tree. As mentioned previously, PIM-SM networks use a rendezvous point (RP) to distribute the multicast stream to all potential receivers. To bootstrap the process, the PIM router near the source may use PIM-Register protocols to transmit the multicast stream to the RP encapsulated in a unicast tunnel. The RP can then decapsulate the PIM-Register packet and forward the multicast stream down the multicast distribution tree. Subsequently, the receivers may issue a source-specific multicast join to the source and build a more optimal multicast distribution tree for that specific source.

Multicast Source Discovery Protocol

Multicast Source Discovery Protocol (MSDP) is another important means of transmitting multicast streams between network routing domains. The MSDP protocol connects the RPs from different multicast routing domains and provides a means of forwarding multicast data between them. A multicast stream in one domain can be replicated into the MSDP protocol, which tunnels the multicast stream in a unicast packet. This facilitates linking the multicast domains without having to actually run multicast at the border of the inter-domain routing entities.

The relevance of MSDP for mobile providers will likely between data centers and content providers. The content providers may provide a multicast feed via the Internet; however, subscription services will likely be specifically established between the content sources and the mobile provider as a distributor. MSDP may be the best choice for the mobile provider to obtain multicast streams from various content sources without having to open up their border gateways to multicast.

IP Packet-Switching Protocols

Mobile wireless networks have gradually migrated from a voice-centric infrastructure to a packet-centric infrastructure to accommodate the growth in data services. Although the majority of the data services are based on IP, many of the underlying transport mechanisms continued to use infrastructure based on voice transport. This section looks at the properties of transitioning voice infrastructures to packet infrastructures that are optimized to handle IP traffic.

Connection-Oriented Switching Methods

The dominant service for years in the mobile network has been voice. Voice requires a connection-oriented (CO) switching method for the duration of the call. The initial intro-