(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 April 2006 (06.04.2006)

PCT

(10) International Publication Number
WO 2006/036463 A2

(51) International Patent Classification:
H04L 12/28 (2006.01)

(21) International Application Number:
PCT/US2005/031530

(22) International Filing Date:
6 September 2005 (06.09.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0420972.2 22 September 2004 (22.09.2004) GB

(71) Applicant *(for all designated States except US)*: **MOTOROLA, INC.** [US/US]; 1303 East Algonquin Road, Schaumburg, Illinois 60196 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **EDWARDS, Mark** [GB/GB]; 40 Wendover Way, Reading Berkshire RG30 4RU (GB). **FRANDSEN, Svend H.,** [DK/DK]; Strandgardsvej 16, DK-DK 4702 Praesto (DK).

(74) Agents: **DAVIS, Valerie M.,** et al.; 1303 East Algonquin Road, Schaumburg, Illinois 60196 (US).

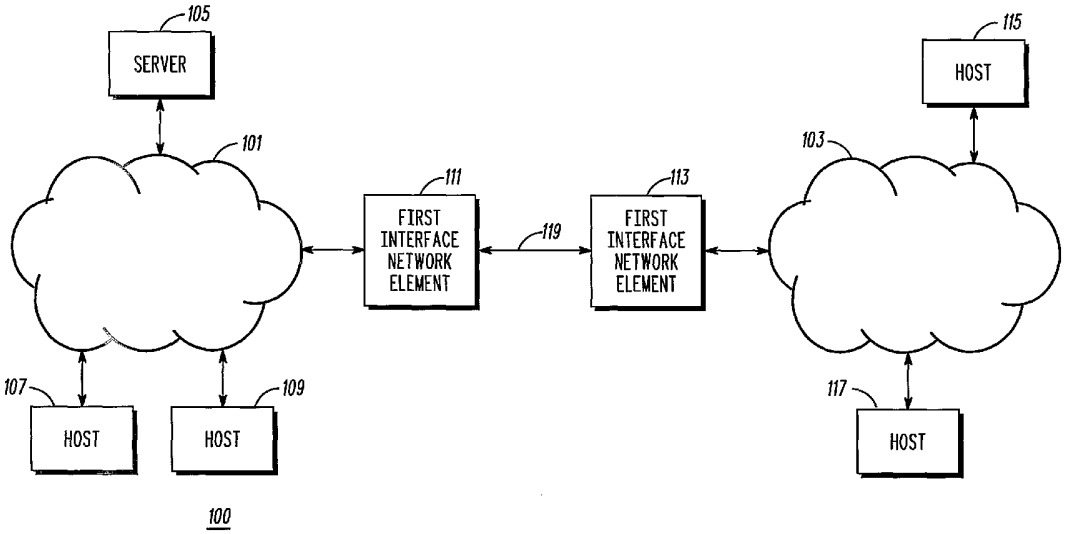
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A COMMUNICATION NETWORK, COMMUNICATION ELEMENTS AND METHODS OF COMMUNICATING DATA PACKETS THEREFOR



(57) Abstract: A communication network that includes a first sub-network (101) and a second sub-network (103) each supporting separate multicast domains. A first interface network element (111) includes a multicast receiver (201) for receiving multicast data packets. A transmit translation processor (203) generates unicast data packets by replacing a multicast address of the multicast data packets by a unicast address. A unicast transmitter (207) forwards the unicast data packets to a second interface network element (113) over a unicast communication link (119). The second interface network element (113) comprises a unicast receiver and a receive translation processor (303) which generates multicast data packets by replacing a unicast address of the unicast data packets by a multicast address. The multicast data packets are then fed to the second sub-network (103).

WO 2006/036463 A2

A COMMUNICATION NETWORK, COMMUNICATION ELEMENTS AND METHODS OF COMMUNICATING DATA PACKETS THEREFOR

Field of the invention

The invention relates to a communication network, communication elements and method of communicating data packets therefor and in particular to communication of multicast data packets.

Background of the Invention

Present day communication systems, both wireless and wire-line, have a requirement to transfer data between communication units. Data, in this context, includes many forms of communication such as speech, multimedia, signalling information, etc. Such data communication needs to be effectively and efficiently routed, in order to optimise use of limited communication resources.

For data to be transferred across data communication networks, a communication unit addressing protocol is required. The communication units are generally allocated addresses that are read by a communication bridge, gateway and/or router, in order to determine how to transfer the data to the addressed unit. The interconnection between networks is generally known as internetworking.

Networks are often divided into sub-networks, with protocols being set up to define a set of rules that allow the orderly exchange of information. Currently,

the most popular protocol used to transfer data in communications systems is the TCP/IP suite of protocols. This suite includes the Transmission Control Protocol (TCP), the User Datagram Protocol (UDP) and the Internet Protocol (IP). IP corresponds to data transfer in the network layer of the well-known OSI model and TCP and UDP correspond to data transfer in the transport layer of the OSI model. Their operation is transparent to the physical and data link layers and can thus be used on any of the standard cabling networks such as Ethernet, FDDI or token ring.

IP multicast capable routers and associated hosts are a relatively new technology in the data transfer marketplace. Several competing multicast protocol standards have been published within the last few years. However, broadcast multimedia services on the Internet have only started to become widely available in the last few years. These services make use of routers within the Internet that are capable of supporting IP multicast protocols. However, multicast capable routers are rarely compatible with each other due primarily to legacy issues, i.e. a number of non-multicast-capable routers exist in networks with many IP hosts that are multicast-capable.

Multicasting is a process where a single source can send data efficiently to multiple receivers. In contrast to broadcast communication, multicasting may effectively address a subset of receivers and thus multicasting to a predefined group may be effectively accomplished. However, implementation of multicasting is typically relatively complex and requires additional multicasting

functionality and signalling. As such it is particularly difficult to implement multicasting in existing networks or between sub-networks where a number of the currently deployed network elements do not comprise multicasting functionality.

In particular, establishing multicast signalling between two different multicast domains provides a number of problems. For example, a host belonging to a first multicast domain may desire to join a multicast group hosted by a server belonging to a different multicast domain. However, conventionally, this requires that physical connection exists between the different domains and that a multicast link and functionality is implemented between the host and the server. This may be implemented by terminating each link of a physical link between the two domains by a multicast router and establishing a single multicast domain comprising both the server and the host.

However, such an implementation requires that the link carries not only multicast application traffic but also multicast signalling required for maintaining the multicast domain. This results in the requirement for communication of substantial amounts of data and is unsuitable for low bandwidth connections. For example, in many situations it is possible that a large proportion of the link traffic is dedicated to just maintaining the multicast states.

Furthermore, the integration of the multicast domains is frequently disadvantageous since this substantially complicates maintenance of the domain and increases the

signalling in the network. Also, the different multicast domains may belong to different operators or independent management centres.

Also, the approach requires that the interconnecting link (plus any other intermediate link) must all provide full multicast functionality and must accordingly use multicast routers which are complex and costly.

Moreover, if the interconnecting link fails then the link routers may converge on an alternative path. However multicast convergence is significantly slower than unicast convergence so such link recovery may take significantly longer resulting in undesirable interruptions to the data communication. The opportunity for a server of the first multicast domain to sell a premium grade high availability multicast service to a host of the second multicast domain may be prevented.

In addition, it is currently very difficult to find a firewall product that is capable of adequately policing a multicast connection. This is because of the complexity needed in the firewall to monitor the multicast states for any of the various types of multicast protocols defined. Accordingly, the conventional approach is not to provide firewall protection for multicast communications. In other words, it is necessary to configure the firewall to recognise the multicast protocol so that the protocol can be effectively ignored by the firewall (i.e. only the bare minimum of checking is performed). However, this results in the serious disadvantage of introducing a security risk, since the firewall is not adequately checking the multicast protocol.

Hence, an improved system for communication of multicast data would be advantageous and in particular a system allowing increased flexibility, reduced cost, reduced complexity, increased security, reduced bandwidth requirement, reduced and/or facilitated multicast maintenance and/or improved performance would be advantageous.

Summary of the Invention

Accordingly, the Invention seeks to preferably mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination.

According to a first aspect of the invention there is provided a communication network comprising: a first network element comprising: means for receiving first multicast data packets, first translation means for generating unicast data packets by replacing a first multicast address of the multicast data packets by a unicast address, and means for forwarding the unicast data packets; and a second network element comprising: means for receiving the unicast data packets, second translation means for generating second multicast data packets by replacing a unicast address of the unicast data packets by a second multicast address, and means for forwarding the second multicast data packets.

The unicast address may be a unicast address which is the same for a plurality of data packets or may e.g. be different for different data packets of the same or

different services. The unicast address of the unicast data packets may e.g. be selected in response to characteristics of a data service associated with the data packets, to information comprised in the data packets or to characteristics of the network environment, including characteristics of a link between the first network element and the second network element. The second multicast address may be the same as the first multicast address or may be different. The first multicast data packets may be in accordance with a first multicast protocol and the second multicast data packets may be in accordance with a second, different multicast protocol.

The invention may enable or facilitate communication of multicast data packets through a unicast link. This may enable or facilitate multicast communication through links or network elements only capable of unicast communication and may thus enable or facilitate multicast communication in or between sub-networks comprising one or more unicast network elements or communication links. In particular, the invention may reduce the multicast signalling required over a communication link and may allow a more efficient use of a limited bandwidth communication link. Furthermore, cost may typically be reduced by allowing lower cost unicast network elements to be used. Also different multicast domains may be kept independent allowing for facilitated management and reduced signalling between different multicast domains. Additionally or alternatively improved recovery may typically be achievable as unicast recovery may be sufficient.

The invention may alternatively or additionally provide additional security and/or facilitate security and/or firewall functions. Specifically, firewall functionality may be applied to a simple unicast communication rather than requiring complex multicast functionality.

According to an optional feature of the invention, the second translation means comprises: memory means for storing associations between unicast data addresses and multicast data addresses; comparison means for matching a unicast data address of a data packet with a matching stored unicast address; and means for replacing the unicast data address of the data packet with a multicast address associated with the matching unicast address.

This feature may provide for an efficient implementation. For example, a look up table providing a direct correspondence between a multicast address and a unicast address may be implemented.

According to an optional feature of the invention, the second network element comprises means for designating a protocol port of the unicast data packets as valid if the protocol port meets a validity criterion and wherein the means for forwarding is operable to forward only data packets for which the protocol port is designated as valid.

Any suitable validity criterion may be used such as for example that the protocol port matches a predefined protocol port value. A plurality of valid protocol ports may for example be manually defined and the protocol port of the first multi cast data packets may be compared to

the valid protocol ports with the unicast data packet only being forwarded to the second network element if a match is found. The feature may improve flexibility and/or selectivity of the forwarding of data packets. For example, only data packets of a specific service may be forwarded.

According to an optional feature of the invention, the first network element is part of a first multicast domain and the second network element is part of a second multicast domain.

The invention may allow two different multicast domains to interact through unicast data packets. This may provide improved performance, reduced complexity of the network and/or management operations and/or enable or facilitate multicast operation between different multicast domains.

The first and second multicast domains may operate in accordance with different multicast protocols. In some embodiments, the invention may provide for a convenient translation and/or interoperation between different multicast protocols.

According to an optional feature of the invention, the second translation means comprises means for extracting the unicast address from a header of the unicast data packets. This provides for a practical and efficient implementation.

According to an optional feature of the invention, the first and second network elements are the same network

element. The first and second network may be implemented in the same unit and may be co-located. A multicast network address translator network element may be provided allowing for address translation between different multicast addresses of for example different multicast domains.

According to an optional feature of the invention, the communication network comprises a cellular communication system coupled to the second network element and operable to receive the second multicast data packets. The invention may provide for an advantageous interface to a cellular communication system wherein multicast communication is possible without requiring multicast domains to extend beyond the cellular communication system.

According to an optional feature of the invention, the cellular communication system comprises a GPRS cellular communication network. The GPRS cellular communication network may be characterized by comprising one or more Serving GPRS Support Nodes (SGSNs) and/or Gateway GPRS Support Nodes (GGSNs). The cellular communication system may for example be a GPRS enhanced Global System for Mobile communication (GSM) cellular communication system or may be a Universal Mobile Telecommunication System (UMTS).

According to an optional feature of the invention, the communication network comprises a user equipment of a cellular communication system, the user equipment comprising the second network element. The second network element may be (part of) a user equipment for a cellular

communication system. The user equipment may for example be a subscriber unit, a mobile station, a communication terminal, a personal digital assistant, a laptop computer, an embedded communication processor or any communication element communicating over the air interface. The implementation of the second network element in the subscriber unit may provide multicast functionality to network elements coupled to or embedded in the user equipment while allowing unicast communication over the air interface.

In some embodiments, the unicast and/or first and/or second multicast data packets are Universal Data Protocol (UDP) data packets. Data packets communicated using UDP may be particularly advantageous as UDP is a relatively simple and stateless protocol where each data packet is communicated independently of other data packets.

In some embodiments, the unicast and/or first and/or second multicast data packets may be Transport Communication Protocol (TCP) data packets.

According to an optional feature of the invention, the unicast and/or first and/or second multicast data packets are Internet Protocol (IP) data packets. The invention may be particularly advantageous in IP based data networks. Hence, the invention is applicable to one of the most widely used data protocols.

According to an optional feature of the invention, the second network element is a router.

According to an optional feature of the invention, the first network element comprises means for determining a protocol port of the first multicast data packets and the means for forwarding of the first network element is operable to forward the unicast data messages in response to the protocol port.

The first network element may forward some data packets but not other data packets depending on the protocol port or may in particular forward data packets to different destinations or using different unicast addresses depending on the protocol port. The feature may provide for increased flexibility in routing of multicast data packets through unicast connections or network elements.

According to a second aspect of the invention, there is provided a network element for a communication network, the network element comprising: means for receiving multicast data packets, translation means for generating unicast data packets by replacing a multicast address of the multicast data packets by a unicast address, and means for forwarding the unicast data packets.

According to a third aspect of the invention, there is provided a network element for a communication network, the network element comprising: means for receiving unicast data packets, translation means for generating multicast data packets by replacing a unicast address of the unicast data packets by a multicast address, and means for forwarding the multicast data packets.

According to a fourth aspect of the invention, there is provided a method of communicating data packets in a

communication network comprising: at a first network element performing the steps of: receiving first multicast data packets, generating unicast data packets by replacing a first multicast address of the multicast data packets by a unicast address, and forwarding the unicast data packets; and at a second network element performing the steps of: receiving the unicast data packets, generating second multicast data packets by replacing a unicast address of the unicast data packets by a second multicast address, and forwarding the second multicast data packets.

According to a fifth aspect of the invention, there is provided a method of communicating data packets in a communication network comprising the steps of: receiving multicast data packets; generating unicast data packets by replacing a multicast address of the multicast data packets by a unicast address; and forwarding the unicast data packets.

According to a sixth aspect of the invention, there is provided method of communicating data packets in a communication network comprising the steps of: receiving unicast data packets; generating multicast data packets by replacing a unicast address of the unicast data packets by a multicast address; and forwarding the multicast data packets.

These and other aspects, features and advantages of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

Brief Description of the Drawings

An embodiment of the invention will be described, by way of example only, with reference to the drawings, in which

FIG. 1 illustrates a communication network in accordance with an embodiment of the invention;

FIG. 2 illustrates a simplified block diagram of a transmit interface network element in accordance with an embodiment of the invention; and

FIG. 3 illustrates a simplified block diagram of a receive interface network element in accordance with an embodiment of the invention.

Detailed Description of a Preferred Embodiment of the Invention

The following description focuses on an embodiment of the invention applicable to a communication network using UDP and IP data packet protocols. However, it will be appreciated that the invention is not limited to this application but may be applied to many other communication networks including for example data communication networks using the TCP data packet protocol.

FIG. 1 illustrates a communication network in accordance with an embodiment of the invention.

The communication network 100 of FIG. 1 comprises a first sub-network 101 and a second sub-network 103. The first sub-network 101 couples a plurality of network elements 105, 107, 109, 111 which may be considered part of the first sub-network 101. Similarly, the second sub-network 103 couples a plurality of network elements 113, 115, 117 which may be considered part of the second sub-network 103.

In the example, the network element 105 may comprise a first server hosting a multicast group comprising the hosts of 107 and 109. Hence, in the example, the first sub-network 101 provides a multicast domain supporting a multicast group which includes applications executing in the network elements 105, 107 and 109.

Similarly, a second multicast domain may exist in the second sub-network 103 supporting for example a multicast group which includes applications executing in the network elements 115 and 117.

Hence, in the example the first sub-network 101 and second sub-network 103 both comprise multicast capable routers and other network elements able to support multicasting. However, in the example, the management and maintenance of the two sub-networks 101, 103 are separate and independent and in particular the management of the multicast domains is separate and independent. For example, the first and second sub-networks 101, 103 may be separate enterprise networks or intranets of different enterprises.

In the embodiment of FIG. 1, the first sub-network 101 and second sub-network 103 are coupled together through a first interface network element 111, a second interface network element 113 and a low bandwidth link 119 connecting these (directly or indirectly). In the example, the first interface network element 111 may be considered part of the first multicast domain and belonging to the first multicast group of the first multicast domain. Similarly, the second interface network element 113 may be considered part of the second multicast domain and belonging to the second multicast group of the second multicast domain.

In conventional data communication networks, an application of a network element of the second sub-network 103 cannot easily join the first multicast group. Accordingly, the server 105 cannot readily provide a multicast service to a host of the second sub-network 103. In order to do so, a single combined multicast domain comprising elements of both the first sub-network 101 and second sub-network 103 is normally generated. This not only requires that it is feasible and practical to manage a single multicast domain across the different sub-networks 101, 103 but also complicates the multicast management and increases the data communication overhead on the low bandwidth link 119 as increased amounts of multicast signalling must be communicated. Furthermore, it requires that the first interface network element 111 and second interface network element 113 are multicast capable network elements such as multicast capable routers. Also should the low bandwidth link 119 fail, the link must be restored through an alternative multicast path using a multicast recovery procedure. This is

typically relatively slow thereby significantly limiting the potential of the server 105 to provide a premium grade high availability multicast service to the network elements of the second interface network element 113.

In accordance with the embodiment of FIG. 1, the first interface network element 111 and second interface network element 113 are coupled together by communication of unicast data packets. Hence, in the example, the low bandwidth link 119 carries unicast data packets and the first interface network element 111 and second interface network element 113 communicate using a unicast communication procedure and protocol.

In particular, the first interface network element 111 is capable of receiving multicast data packets of the first multicast domain from the first sub-network 101 and generating unicast data packets by replacing a first multicast address of the multicast data packets by a unicast address. For example, any multicast data packet received with a multicast address matching the first multicast group is modified by replacing the multicast address with a predefined unicast address. The unicast data packets are then transmitted to the second interface network element 113 via the low bandwidth link 119.

The second interface network element 113 is capable of receiving the unicast data packets and to generate multicast data packets by replacing a unicast address of the unicast data packets by a multicast address. Specifically, the second interface network element 113 may extract the unicast address of the unicast data packets received from the first interface network element

111 and if this address is the predefined unicast address for the first multicast group of the first multicast domain, the second interface network element 113 replaces this address by the multicast address of the second multicast group of the second multicast domain. The generated multicast data packets for the second multicast group are then fed to the second sub-network 103 where they are routed to the network elements 115, 117 belonging to the second group.

Accordingly multicast communication between the first sub-network 101 and the second sub-network 103 is enabled or facilitated using a unicast connection. This may significantly reduce the bandwidth usage of the low bandwidth link 119 as multicast signalling is no longer required. Furthermore, the first interface network element 111 and second interface network element 113 do not need to comprise full multicast functionality and the low bandwidth link 119 need only be capable of supporting unicast communication. Hence, any routers etc comprised in the low bandwidth link 119 need not be multicast capable but may simply be unicast capable. Accordingly, the embodiment may facilitate or enable the introduction of multicast capability into existing communication networks and may alleviate thereby associated legacy problems. The approach may furthermore reduce cost as unicast network elements are typically significantly lower cost than fully multicast capable routers.

Also, should the low bandwidth link 119 fail, a simple unicast recovery process may be used to re-establish the link thereby reducing the interruption caused. The approach also allows for the first and second multicast

domains to remain separate and logically distinct. Hence, a significantly simpler management operation is provided and in some embodiments, multicast communication between sub-networks wherein combined multicast domains is not possible or practical may be enabled.

In some embodiments, the first and/or second interface network elements may comprise a firewall. The firewall may monitor the communications through the low bandwidth link 119 thereby providing protection against intrusions from the other multicast domain. Thus, the two multicast domains may be connected with increased security. The firewalls need only comprise functionality for monitoring unicast traffic and may this be much simpler than multicast firewalls.

FIG. 2 illustrates a simplified block diagram of the first interface network element 111 in accordance with an embodiment of the invention.

In a conventional router, the router receives IP packets and extracts the destination IP address from the received IP packet and then looks for a match between the extracted address and the contents of a locally stored and generated routing table. If a match is found, this indicates the identity of the connection to which the router should forward the IP packet for onward transmission.

Thus, a known multicast capable router typically supports sophisticated routing protocols to help it build a routing table capable of forwarding inbound multicast IP packets to the correct outbound connections and output

ports. The multicast routing table is built up in real time by the router receiving special request commands from multicast capable hosts that wish to register to receive these multicast packets. The underlying assumption is that the router should only forward received multicast packets to multicast capable hosts that have requested them.

The first interface network element 111 of the embodiment of FIG. 1 is further capable of converting multicast data packets into unicast data packets and to forward these to the second interface network element 113 even if no multicast capable network element has requested the multicast data packets.

The concept of forwarding multicast packets onto a route that has not registered multicast group members, and performing this action whilst translating the destination address from a multicast address to a unicast address, is particularly advantageous. Packets arriving at the router, which could only be received and processed by specialised hosts of the first multicast domain can now be received by hosts of the second multicast domain.

In the embodiment of FIG. 2, the first interface network element 111 comprises a multicast receiver 201 which receives multicast data packets from the first sub-network 101. The multicast data packets received are in the specific embodiment IP data packets. The IP multicast data packets are fed to a transmit translation processor 203 which generates unicast data packets by replacing the multicast address of the multicast data packets by a unicast address.

The transmit translation processor 203 is coupled to a transmit look-up table 205 which comprises a list of multicast addresses and associated unicast addresses. In some embodiments, the transmit look-up table 205 comprises only one unicast address for one or more multicast addresses but typically the transmit look-up table 205 comprises a plurality of multicast addresses with one or more unicast addresses for each multicast address. When an IP data packet is received, the transmit translation processor 203 extracts the IP header from the data packet. The IP address field is compared to the multicast addresses stored in the transmit look-up table 205. If a match is found in accordance with any match criterion (such as the stored and extracted multicast addresses being identical), the unicast address stored for that multicast address is retrieved from the transmit look-up table 205.

Subsequently, the transmit translation processor 203 replaces the multicast address of the IP header of the data packet with the retrieved unicast address thereby converting the multicast data packet into a unicast data packet.

The transmit translation processor 203 is coupled to a unicast transmitter 207 which forwards the unicast data packet to the second interface network element 113 over the low bandwidth link 119.

It will be appreciated that the transmit translation processor 203 does not necessarily need to know which IP multicast protocol is in use, since in this embodiment,

it acts entirely on matching the contents of the IP header's destination address with a table of IP multicast addresses.

It will also be appreciated that any suitable algorithm or criterion for associating multicast addresses with unicast addresses may be used without detracting from the invention. For example, the first interface network element 111 may be configured with multiple forwarding unicast addresses, such that the packet can be forwarded to a different host depending on e.g. the multicast packet's source IP address. This may provide additional flexibility and may for example facilitate load sharing amongst the monitoring hosts, which is particularly advantageous when a large volume of multicast packets from a variety of sources are to be forwarded.

FIG. 3 illustrates a simplified block diagram of the second interface network element 113 in accordance with an embodiment of the invention.

The second interface network element 113 comprises a unicast receiver 301 which is coupled to the low bandwidth link 119 and which receives the unicast IP data packets from the first interface network element 111. The unicast receiver 301 is coupled to a receive translation processor 303 which is fed the received unicast data packets.

The receive translation processor 303 is coupled to a receive look-up table 305 which comprises a list of unicast addresses and associated multicast addresses. In some embodiments, the receive look-up table 305 comprises

only one multicast address for one or more unicast addresses but in other embodiments, the receive look-up table 305 comprises a plurality of unicast addresses with one or more multicast addresses for each unicast address.

When an IP data packet is received, the receive translation processor 303 extracts the IP header from the data packet. The IP address field is compared to the unicast addresses stored in the receive look-up table 305. If a match is found in accordance with any match criterion (such as the stored and extracted unicast addresses being identical), the multicast address stored for that unicast address is retrieved from the receive look-up table 305.

Subsequently, the receive translation processor 303 replaces the unicast address of the IP header of the data packet with the retrieved multicast address thereby converting the received unicast data packet into a multicast data packet.

The receive translation processor 303 is coupled to a multicast transmitter 307 which feeds the multicast data packets to the second multicast domain of the second sub-network 103.

Thus, the second interface network element 113 allows multicast communication within a communication sub-network to be generated from unicast data packets. The unicast data packets preferably (but not necessarily) correspond to multicast data packets which have been converted to unicast data packets.

It will be appreciated that although the first and second multicast domains may be kept separate and managed independently in the previously described embodiments, the configuration of the transmit and receive look-up tables may be used to provide suitable associations between groups of the first multicast domain and groups of the second multicast domain.

For example the transmit look-up table may be set up to associate the multicast address of the first multicast group with a specific unicast address. The receive look-up table may be set up to associate the same unicast address with the second multicast group. Thereby, the first and second multicast groups may effectively be joined while allowing the multicast domains to remain distinct.

In some embodiments, a simple and direct coupling of multicast groups of the first sub-network and the second sub-network may be implemented. However, in more complex embodiments, more advanced associations may be implemented. For example, a single multicast group of the first sub-network 101 may be associated with a plurality of multicast groups of the second sub-network 103 and/or a single multicast group of the second sub-network may be associated with a plurality of multicast groups of the first sub-network.

In other embodiments, groups or subgroups may be associated with each other depending on other parameters or characteristics.

For example TCP and UDP data packets identify applications using 16-bit protocol port numbers wherein each protocol port number corresponds to a specific type of service. For example, , file transfer protocol (FTP) servers provide the FTP service on TCP port '21' and Trivial File Transfer Protocol (TFTP) servers provide service on UDP port '69'. TFTP is a simpler form of FTP that uses UDP instead of maintaining the more complex TCP connections.

Hence, in embodiments using e.g. TCP and UDP data packets, the association between multicast groups of the different multicast domains may depend on the type of service supported by the individual data packet. Thus, the first interface network element 111 may specifically select the unicast address in response to the protocol port number of the data packet. Hence, the means for forwarding of the first network element may forward the unicast data messages to different unicast addresses depending on the protocol port.

Alternatively or additionally, the second interface network element 113 may specifically select the multicast address in response to the protocol port number of the data packet.

In some embodiments, the first interface network element 111 may only comprise unicast addresses for some protocol port values but not for other. Hence, the first interface network element 111 may comprise functionality for checking if the protocol port is valid. A valid protocol part may be considered a protocol port having an associated unicast address and an invalid protocol port

may be considered a protocol port not having an associated unicast address. In such embodiments, the first interface network element 111 may only forward data packets having a valid protocol port. This may provide improved performance in many embodiments and may in particular allow for a service selective forwarding of data packets thereby potentially reducing the bandwidth use of the low bandwidth link 119.

In some embodiments, the first interface network element 111 and second interface network element 113 may be functionally integrated with the low bandwidth link 119 effectively being replaced by any suitable communication. For example, the described functionality of the first interface network element 111 and the second interface network element 113 may be implemented in a single network element. Hence, in some such embodiments the interconnecting link may be eliminated and the functionality of both interface elements may be implemented in the same router. This may create a Multicast Network Address Translation (NAT) router which may be convenient in many embodiments and may for example provide some multicast proxy capability, i.e. it will allow hosts in one multicast domain to join a multicast tree hosted by a rendezvous point in a separate multicast domain. Additionally it may also provide some multicast transparency capability; i.e. it will allow a host in one multicast domain to communicate to a host in a separate multicast domain simply through the multicast address translation capability configured in the multicast NAT router.

In some embodiments, the first and second multicast domains may use different multicast protocols and have different multicast states and sequences. In this case, a single network element may provide a means of interworking between the different multicast domains and the network element may specifically function as a multicast converter between the two multicast protocols.

In some embodiments, the second sub-network 103 may advantageously be a cellular communication system. In particular, a GPRS cellular communication network, such as an enhanced GSM cellular communication system or a UMTS cellular communication system, may comprise functionality for supporting multicast communication. Hence, in such an embodiment, multicast services may effectively be coupled from e.g. an external public network, such as the Internet, to a proprietary network such as a GPRS cellular communication network without requiring an integration of these.

In some embodiments, the second interface network element 113 may in particular be implemented in a user equipment of the cellular communication system. For example, the low bandwidth link 119 may correspond to an air interface link of the cellular communication system and the first interface network element 111 may be implemented in the cellular infrastructure (e.g. in the base station). The user equipment may provide an interface to an external network element such as a laptop, which can communicate using a multicast protocol.

Hence, in such an embodiment, the communication application of the external network element may operate

identically and use the same communication protocol independently of whether the network element is coupled directly to e.g. an intranet of an enterprise network through a full multicast router or via the user equipment. Hence, no reconfiguration is required depending on whether the laptop is directly coupled to the network or used remotely through the user equipment.

The invention can be implemented in any suitable form including hardware, software, firmware or any combination of these. However, preferably, the invention is implemented as computer software running on one or more data processors and/or digital signal processors. In particular the functionality of the translation processors may be implemented as software agents in network routers. The elements and components of an embodiment of the invention may be physically, functionally and logically implemented in any suitable way. Indeed the functionality may be implemented in a single unit, in a plurality of units or as part of other functional units. As such, the invention may be implemented in a single unit or may be physically and functionally distributed between different units and processors.

Although the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. In the claims, the term comprising does not exclude the presence of other elements or steps. Furthermore, although individually listed, a plurality of means, elements or

method steps may be implemented by e.g. a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. In addition, singular references do not exclude a plurality. Thus references to "a", "an", "first", "second" etc do not preclude a plurality.

CLAIMS

1. A communication network comprising:

a first network element comprising:

means for receiving first multicast data packets,

first translation means for generating unicast data packets by replacing a first multicast address of the multicast data packets by a unicast address, and

means for forwarding the unicast data packets; and

a second network element comprising:

means for receiving the unicast data packets,

second translation means for generating second multicast data packets by replacing a unicast address of the unicast data packets by a second multicast address, and

means for forwarding the second multicast data packets.

2. A communication network as claimed in claim 1 wherein the second translation means comprises:

memory means for storing associations between unicast data addresses and multicast data addresses;

means for extracting the unicast address from a header of the unicast data packets;

comparison means for matching the extracted unicast data address with a matching stored unicast address; and

means for replacing the extracted unicast data address of the data packet with a multicast address associated with the matching unicast address.

3. A communication network as claimed in claim 2 wherein the second network element comprises means for designating a protocol port of the unicast data packets as valid if the protocol port meets a validity criterion and wherein the means for forwarding is operable to forward only data packets for which the protocol port is designated as valid.

4. A communication network as claimed in claim 1 wherein the first network element is part of a first multicast domain and the second network element is part of a second multicast domain or wherein the first and second network elements are the same network element.

5. A communication network as claimed in claim 1 comprising a GPRS cellular communication system having user equipment and operable to receive the second multicast data packets, the user equipment comprising the second network element.

6. A communication network as claimed in claim 1 wherein the unicast data packets and the multicast data packets are Internet Protocol (IP) data packets.

7. A communication network as claimed in claim 1 wherein the second network element is a router.

8. A communication network as claimed in claim 1 wherein the first network element comprises means for determining a protocol port of the first multicast data packets and wherein the means for forwarding of the first network element is operable to forward the unicast data messages in response to the protocol port.

9. A network element for a communication network, the network element comprising:

means for receiving first multicast data packets,

first translation means for generating first unicast data packets by replacing a first multicast address of the first multicast data packets by a first unicast address,

means for receiving second unicast data packets;

second translation means for generating second multicast data packets by replacing a second unicast address of the second unicast data packets by a second multicast address; and

means for forwarding the first unicast data packets and the second multicast data packets.

10. A method of communicating data packets in a communication network comprising:

at a first network element performing the steps of:

receiving first multicast data packets,

generating unicast data packets by replacing a first multicast address of the multicast data packets by a unicast address, and

forwarding the unicast data packets; and

at a second network element performing the steps of:

receiving the unicast data packets,

generating second multicast data packets by replacing a unicast address of the unicast data packets by a second multicast address, and

forwarding the second multicast data packets.

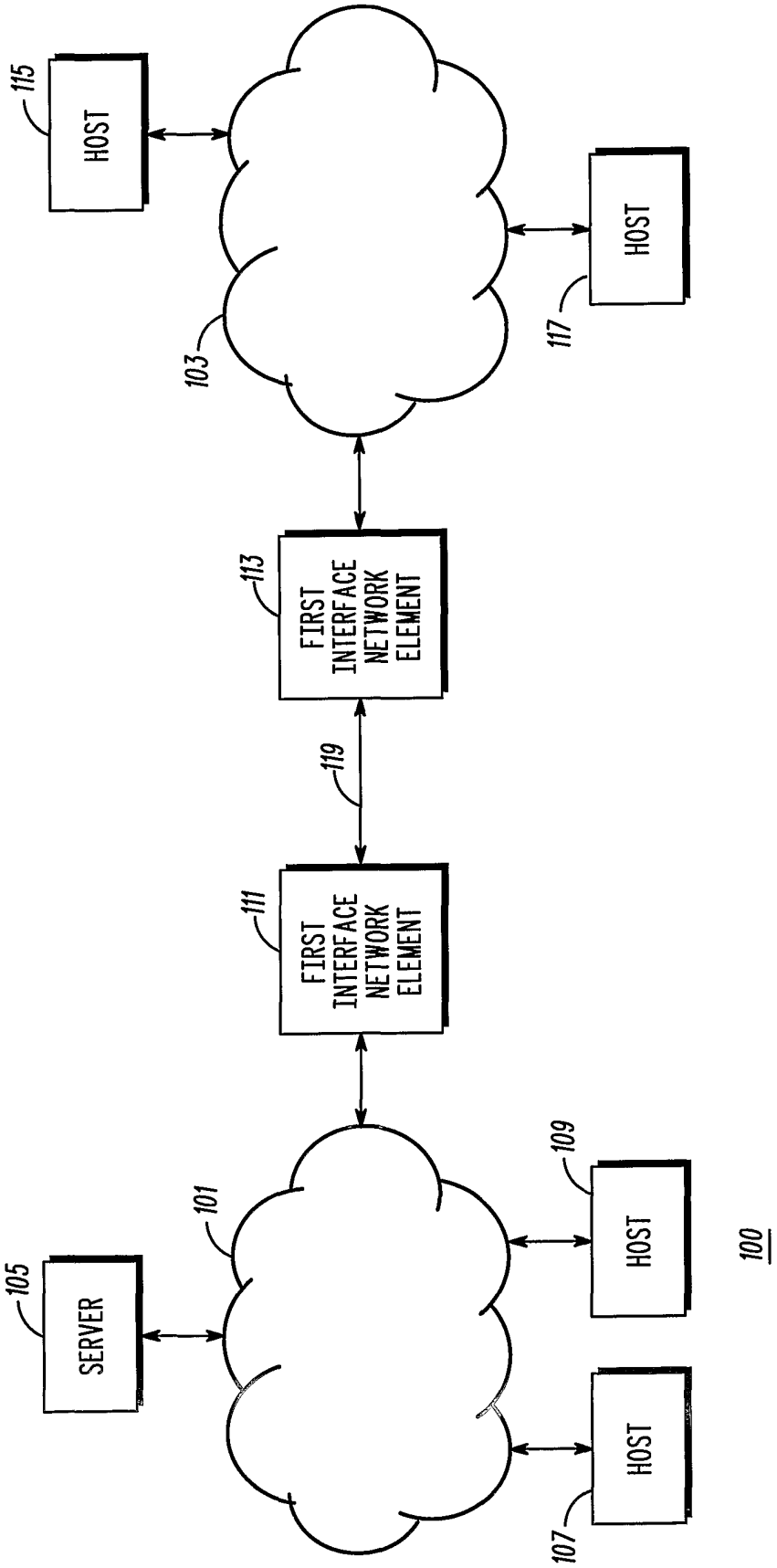

115
HOST
103
117
HOST
113
FIRST INTERFACE NETWORK ELEMENT
119
111
FIRST INTERFACE NETWORK ELEMENT
105
SERVER
101
109
HOST
107
HOST
100

FIG. 1

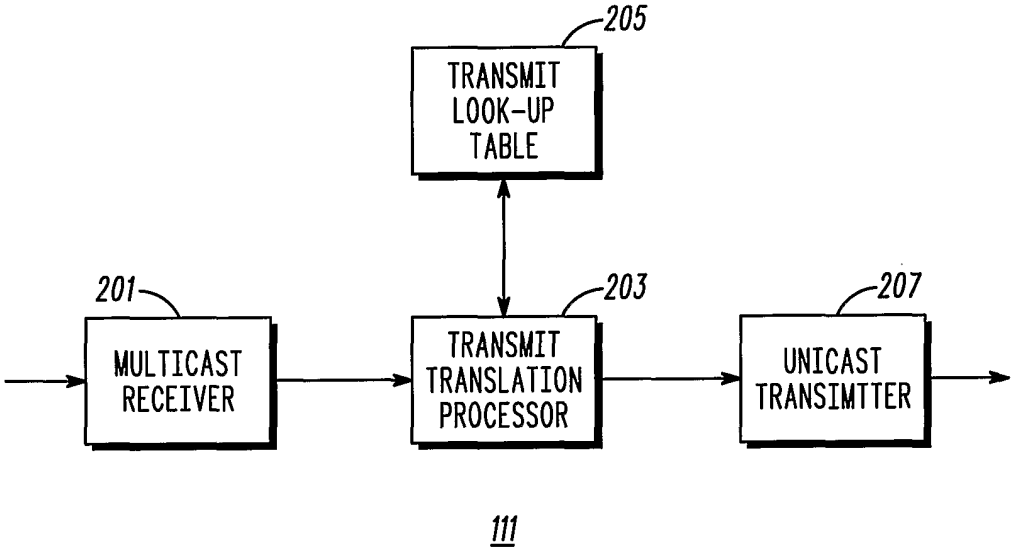

205
TRANSMIT LOOK-UP TABLE
201
MULTICAST RECEIVER
203
TRANSMIT TRANSLATION PROCESSOR
207
UNICAST TRANSIMTTER
111

FIG. 2

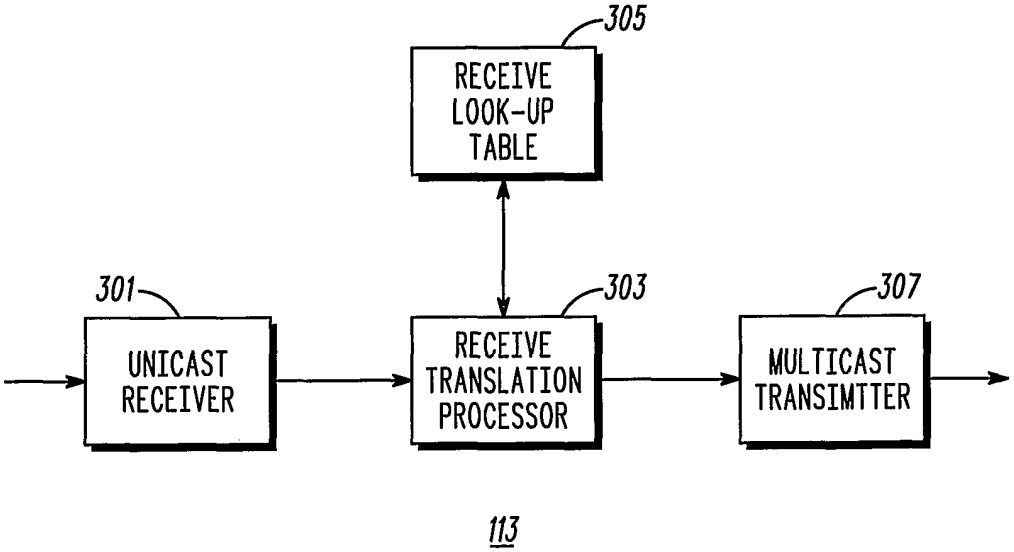

305
RECEIVE LOOK-UP TABLE
301
UNICAST RECEIVER
303
RECEIVE TRANSLATION PROCESSOR
307
MULTICAST TRANSIMTTER
113

FIG. 3