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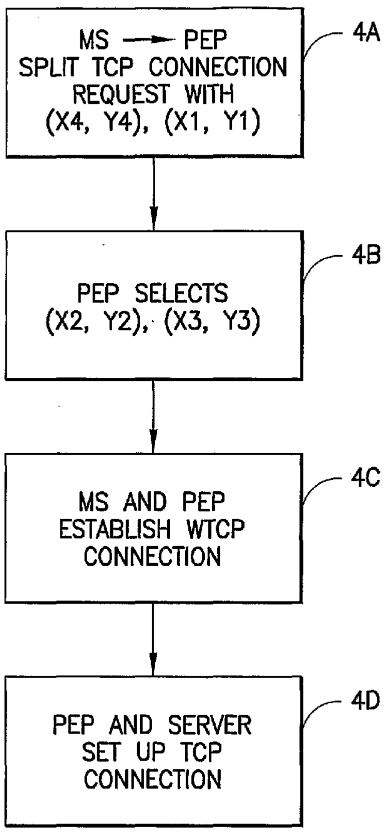
(54) Title: METHOD AND APPARATUS PROVIDING A PROTOCOL TO ENABLE A WIRELESS TCP SESSION USING A SPLIT TCP CONNECTION



(57) Abstract: Disclosed are a method and a system that operates in accordance with the method to set up a TCP session between a MS and an end point destination via a wireless network and the Internet. The method includes sending a split TCP connection request from the MS to a PEP located in the network, where the split TCP request includes information for identifying a network address of the MS and a network address of the end point destination. The method further includes, in response to receiving the split TCP connection request from the MS, establishing a split TCP connection that includes a wireless TCP (WTCP) connection between the MS and the PEP, and a TCP connection at least part way between the PEP and the end point destination. In one embodiment the end point destination is an application server that is coupled to the Internet, and the TCP connection is established between the PEP and the application server. In another embodiment the end point destination is a second MS that is coupled to a second PEP in a second wireless network, and the TCP connection is established at least as far as the second PEP, and then as a WTCP connection from the second PEP to the second MS.

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METHOD AND APPARATUS PROVIDING A PROTOCOL TO ENABLE A WIRELESS TCP SESSION USING A SPLIT TCP CONNECTION

TECHNICAL FIELD:

This invention relates generally to mobile Internet devices, procedures and protocols, and more specifically relates to the set up of wireless Transport Control Protocol (TCP) sessions.

BACKGROUND:

There currently exists the concept of a TCP connection that is set up over a wireless link, such as in a cellular network. Wireless TCP (WTCP) is a TCP protocol that is optimized for use in wireless environments. Wireless links are prone to long latencies and high error rates. These factors can make the conventional TCP perform poorly in the wireless link environment, as the end-to-end TCP dynamics is usually not fast enough to track the variations in the wireless link quality and thus the wireless link, which usually is the bottleneck in the end-to-end path, is not optimally used. In an attempt to overcome these problems the Internet Engineering Task Force (IETF, http://ietf.org/html.charters/pilc-charter.html), as well as the Open Mobile Alliance (OMA, http://www.openmobilealliance.org/tech/affiliates/wap/wap-225-tcp-20010331-a.pdf) have recommended a number of enhancements to conventional TCP to make it more efficient over wireless links.

One proposed enhancement recommends splitting the end-to-end TCP connection at certain intermediate network entities. For example, and referring to Fig. 1, if a mobile station (MS) 1 is to set up a TCP connection with application web server 2 in the wired Internet 4, it is recommended that one TCP connection be set up over a wireless access network 5 between the MS 1 and an intermediate network entity, sometimes referred to as a performance enhancing proxy (PEP) 3, while another TCP connection is set up between the PEP 3 and the web server 2. This enables the connection between the MS 1 and the intermediate network entity (the PEP 3) to run a version of TCP that is optimized for wireless links (also referred to as wireless profiled TCP), while the other connection runs the conventional (wireline) TCP. The intermediate network entity or PEP 3 can reside on a WAP proxy or on a gateway between the wireless access network 5 and the Internet 4.

As may be appreciated, an appropriate signaling mechanism is required to set up a split TCP connection in a cellular communications network, such as in the CDMA network architecture or in the GPRS/UMTS network architecture. Further, in the case of a mobile-to-mobile session, the PEPs 3 at each of two ends may need to communicate so that an appropriate split TCP connection can be set up.

However, while it is known in the prior art (e.g., IETF's Performance Implication of Link Characteristics (PILC) working group and the WAP 2.0 protocol) to recommend the use of the split TCP connection for performance enhancement, no mechanisms are available or have been proposed, to the knowledge of the inventors, to actually set up such split TCP connections in a cellular environment. Note in this regard that if the PEP 3 is to reside on *a priori* known network elements, such as on a WAP Proxy, then no specific mechanism is needed other than to have address of the WAP Proxy configured in the mobile station or other type of terminal. However, if the PEP 3 is to be hosted on a network element such as the GGSN/PDSN, these elements are not *a priori* known to the mobile station, as the specific GGSN/PDSN that the terminal connects to depends on the location of the mobile station.

SUMMARY OF THE PREFERRED EMBODIMENTS

The foregoing and other problems are overcome, and other advantages are realized, in accordance with the presently preferred embodiments of these teachings.

This invention provides a mechanism to set up a split TCP connection in a cellular network, and involves identifying the PEP and informing the PEP about the required connection parameters, such as the IP address and TCP port number of the remote end of the connection. The PEP, in response, sends certain parameters to the MS so that a split TCP connection can be set up.

Disclosed herein is a method, and a system that operates in accordance with the method, to set up a TCP session between a mobile terminal (MT) or mobile station (MS) and an end point destination via a wireless network and the Internet. The method includes sending a split TCP request from the MS to a PEP located in the wireless network, where the split TCP request includes information for identifying a network address of the MS and a network address of the end point destination. The method further includes, in response to receiving the split TCP request from the MS, establishing a split TCP connection that includes a wireless TCP (WTCP) connection between the MS and the PEP, and a TCP connection at least part way between the PEP and the end point destination. In one embodiment the end point destination is an application server that is coupled to the Internet, and the TCP connection is established between the PEP and the application server. In another embodiment the end point destination is a second MS that is coupled to a second PEP in a second wireless network, and the TCP connection is established at least as far as the second PEP, and then as a WTCP connection from the second PEP to the second MS.

In another embodiment the MS_A and the MS_B are served by the same PEP using two different WTCP connections.

In one exemplary embodiment the wireless network is a CDMA network, and the PEP is embodied in or is co-located with a Packet Data Support Node (PDSN) in the CDMA network. In another exemplary embodiment the wireless network is a General Packet Radio Service (GPRS) or Universal Mobile Telecommunications System (UMTS) network, and the PEP is embodied in or is co-located with a Gateway GPRS Support Node (GGSN) in the GPRS or UMTS network.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of these teachings are made more evident in the following Detailed Description of the Preferred Embodiments, when read in conjunction with the attached Drawing Figures, wherein:

Fig. 1 is a diagram that illustrates a split TCP connection as proposed in the prior art;

Fig. 2 shows an embodiment where a PEP is located with a PDSN in a CDMA cellular architecture, and is useful in describing a MS-web server WTCP embodiment;

Fig. 3A shows an embodiment where a PEP is located with a GGSN in a GPRS/UMTS cellular architecture, and is also useful in describing the MS-web server WTCP embodiment;

Fig. 3B shows an embodiment where a first PEP is located with a first GGSN in a first GPRS/UMTS cellular architecture and where a second PEP is located with a second GGSN in a second GPRS/UMTS cellular architecture, and is useful in describing a MS-MS WTCP embodiment;

Fig. 3C shows an embodiment where a single PEP is located with the GGSN in the GPRS/UMTS cellular architecture, and is useful in describing a MS-MS WTCP embodiment;

Fig. 4 is a logic flow diagram that illustrates a method for accommodating the MS-web server embodiment of Fig. 3A;

Fig. 5 is a logic flow diagram that illustrates a method for accommodating the MS-MS multi-PEP embodiment of Fig. 3B; and

Fig. 6 is a logic flow diagram that illustrates a method for accommodating the MS-MS single PEP embodiment of Fig. 3C.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Described herein are several embodiments of split TCP connections for the case of the MS-server connection and for the case of the MS-MS connection. The case of the MS-

MS connection is based on, and extends, the solution for the MS-server connection case. The general messaging and message flow is described in the context of embodiments for CDMA and GPRS/UMTS architectures. For the case of the MS-server connection the term "server" in a generic fashion, and as used herein implies that this end point of the connection is a node that does not require wireless TCP (WTCP) service.

In embodiments of this invention the end point of the connection may not be the web server 2 that is connected to the conventional wired Internet 4, but it may be another MS, thereby requiring a MS-to-MS connection to be established as described below in relation to Fig. 3B. Of course, the second MS may be functioning as a web server, just not one that is connected the wired Internet.

Case (i): MS-web server connection

Assume that the MS 1 wishes to initiate a wireless TCP connection with the web server 2. The following conventions can be used in the description of this case:

x1,y1 : IP address and port number at the MS 1
x2,y2 : IP address and port number at the PEP 3 that the MS 1 communicates with
x3,y3 : IP address and port number at PEP 3 that the server 2 communicates with
x4,y4 : IP address and port number at the server 2 that the PEP 3 communicates with

Referring also to Fig. 4, this embodiment of the invention performs the following procedure:

4A. The MS 1 sends a message to the PEP 3 specifying the need for split TCP connection. This split TCP connection request message includes, or is sent in conjunction with, information that is descriptive of (x4,y4) and (x1,y1). Note that the (x1,y1) information may be implicit in the split TCP connection request message as it is the address and port of the origin of the message (i.e., the address and port of the MS 1).

4B. The PEP 3 selects (x2,y2) and (x3,y3) to be used in the split TCP connection. This may be accomplished by a table lookup procedure.

4C. The MS 1 and the PEP 3 establish a WTCP connection between (x1,y1) and (x2,y2). For this purpose the PEP 3 may first send a message to the MS 1 informing the MS of (x2,y2), and the MS 1 may then initiate the TCP connection setup (for example, by the use of a conventional SYN, SYN ACK and ACK transaction). In an alternate embodiment, the PEP 3 may initiate the TCP connection setup with the MS 1.

4D. The PEP 3 and the server 2 set up a TCP connection between (x3,y3) and (x4,y4) (for example, by using the conventional SYN, SYN ACK and ACK handshake used to establish TCP connections).

Embodiment for CDMA2000 architecture:

Referring to Fig. 2, the PEP 3 may reside on or be co-located with a Packet Data Support Node (PDSN) 6 in the CDMA network architecture defined by 3GPP2. The PEP 3 may be implemented as a software module that is executed by a data processor of the PDSN 6, or by another data processor in the CDMA network architecture. The PEP/PDSN 6 is reached from the wireless link 5 via a radio network (RN) element 7 and an A10/A11 interface 8.

For accessing the Internet 4 over the CDMA network, the MS 1 first establishes a conventional Point-to-Point Protocol (PPP) connection with the PDSN 6. If using simple IP, the MS 1 obtains its IP address during the PPP connection establishment. For mobile IP, the PDSN 6 and the MS 1 perform agent advertisement/solicitation signaling for the IP address assignment. The established PPP connection can then be used to carry out Step 4A from the MS 1 to the PDSN 6. A Resv message defined in 3GPP2 Specification X.P0011.*, Wireless IP Network Standard, February 2003, can be used in a modified form to encode the request to establish the split TCP connection and to convey the reverse link (x4,y4) information. The (x2,y2) information in Step 4C can be conveyed from the PDSN 6 to the MS 1 in a ResvConf message, also defined in 3GPP2 Specification X.P0011.*, Wireless IP Network Standard, February 2003, which functions basically as an acknowledgment to the Resv message.

Embodiment for GPRS/UMTS architecture:

Further by example, and referring to Fig. 3A, the PEP 3 can reside (in a General Packet Radio System or GPRS embodiment) on or be co-located with a Gateway GPRS Support Node (GGSN) 13 in the GPRS, or in an Universal Mobile Telecommunications System (UMTS) network architecture, as defined by 3GPP. The PEP 3 may be implemented as a software module that is executed by a data processor of the GGSN 13, or by another data processor in the GPRS/UMTS network architecture. In this embodiment the PEP/GGSN 13 is reached from the wireless link 5 via a base station system (BSS) 9 that is connected to a conventional mobile switching center (MSC) 10 and to a serving gateway support node (SGSN) 11 that in turn connects to an Internet Protocol (IP) core network 12 and thence to the GGSN 13.

When accessing the Internet 4 over the GPRS network, the MS 1 first establishes a primary Packet Data Protocol (PDP) context with the GGSN 13. The MS 1 obtains its IP address during the PDP context establishment procedure, as defined in 3GPP Technical Specification TS 23.060, General Packet Radio Service (GPRS); Service description; Stage 2 (Release 1999), Version 3.10.0, January 2002. While setting up the PDP context, the MS 1 also specifies the desired service from the GPRS/UMTS access network. This can be accomplished by the use of an access point name (APN) field in a PDP Activate message. As in Step 4A for setting up the split TCP connection, the MS 1 may initiate the PDP context (primary or secondary) with the GGSN 13 by providing an APN value that is predetermined to be indicative of the request for WTCP service. The MS 1 preferably also includes the (x4,y4) information along with this message. The (x2,y2) information in Step 4C can be conveyed from the GGSN 13 to the MS 1 in an acknowledgment to the PDP Activate message, as described in 3GPP Technical Specification TS 23.060, General Packet Radio Service (GPRS); Service description; Stage 2 (Release 1999), Version 3.10.0, January 2002.

Case (ii): MS-MS connection

The foregoing discussion of Figs. 2, 3A and 4 considered the case in which the MS 1 establishes a WTCP connection with the server 2. What is now described is the case, shown for convenience and not by way of limitation in a GPRS architecture system in Fig. 3B, in which a MS 1, say MS_A, establishes a WTCP connection with another MS 1, say MS_B. The following naming convention is used during the description of this case:

x1,y1 : IP address and port number at MS_A
x2,y2 : IP address and port number at PEP (PEP_A) that MS_A communicates with
x3,y3: IP address and port number at PEP_A that the PEP for MS_B (PEP_B) communicates with
x4,y4 : IP address and port number at PEP_B that PEP_A communicates with
x5,y5 : IP address and port number at PEP_B that MS_B communicates with
x6,y6 : IP address and port number at MS_B

In this embodiment it may be assumed that both MS_A and MS_B desire to have a WTCP connection. The associated PEPs 3 are PEP_A and PEP_B, respectively. Referring also to Fig. 5, this embodiment of the invention performs the following procedure:

5A. The MS_A sends a message to PEP_A specifying a request for a split TCP connection to be set up, along with information about MS_B (at least (x6,y6)) and also the IP address and port number at MS_A (x1,y1). The (x1,y1) information may be implicit in the message, as it is the address and port of the origin of the message.

5B. The PEP_A selects (x2,y2) and (x3,y3) to be used in the split TCP connection, such as through a table look up procedure.

5C. The MS_A and PEP_A establish a WTCP connection between (x1,y1) and (x2,y2).

For this purpose the PEP_A may first send a message to the MS_A informing MS_A of (x2,y2), and MS_A may then initiates a WTCP connection setup. In an alternate embodiment, PEP_A initiates the WTCP connection setup.

5D. PEP_A begins the process of establishing a TCP connection with MS_B. Once MS_B receives a TCP SYN message from PEP_A, it begins the procedure of establishing a WTCP connection with PEP_B.

5E. MS_B sends a message to PEP_B conveying its WTCP set up request, along with the appropriate end-point information, (x3,y3) and (x6,y6). The (x6,y6) information may be implicit in the message, as it is the address and port of the origin of the message.

5F. The PEP_B selects (x4,y4) and (x5,y5) to be used in the split TCP connection, such as through a table look up procedure. The MS_B and PEP_B establish a WTCP connection between (x6,y6) and (x5,y5). For this purpose the PEP_B may first send a message to the MS_B informing MS_B of (x5,y5), and MS_B may then initiates a WTCP connection setup. In an alternate embodiment, PEP_B initiates the WTCP connection setup.

5G. PEP_B, from (x4,y4), also sends a TCP-SYN ACK to PEP_A, at address (x3,y3), and encapsulates MS_B's information (x6,y6) in this TCP-SYN ACK packet. When PEP_A sees the encapsulated TCP-SYN ACK packet, it understands that it is a special case where PEP_B is acting as a proxy for MS_B for this particular TCP-SYN request.

5H. PEP_A initiates a TCP connection with PEP_B with end-points (x3,y3) and (x4,y4), respectively, using a conventional TCP SYN, SYN ACK and ACK handshake.

As can be appreciated, after performing steps 5A-5H there are WTCP connections established between MS_A and PEP_A, and between MS_B and PEP_B, while there is a conventional TCP connection established between PEP_A and PEP_B.

The process by which the MSs A and B acquire IP addresses in the CDMA2000 and

GPRS/UMTS architectures, in this case, is similar to what is described in the previous case.

The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the best method and apparatus presently contemplated by the inventors for carrying out the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. As but some examples, the use of other similar or equivalent system architectures, message types and signalling protocols may be attempted by those skilled in the art.

Furthermore, it is possible that MS_A and MS_B may be served from a single PEP 3, such as when they are two mobile stations connected to the same network operator. Reference in this regard can be made to Fig. 3C for showing the exemplary GPRS embodiment (note that the CDMA embodiment of Fig. 2 can be employed as well, where MS_A and MS_B are both served from the same PEP 3/PDSN 6). In the embodiment of Fig. 3C it is assumed that both MS_A and MS_B desire to have a WTCP connection. Also in this embodiment it is assumed that (x3,y3), the IP address and port number at PEP_A that PEP_B communicates with, and (x4,y4), the IP address and port number at PEP_B that PEP_A communicates with, are not used. Further, it is assumed that (x5, y5), the IP address and port number at PEP_B that MS_B communicates with, is modified so as to represent the IP address and port number at PEP 3 that MS_B communicates with. Alternatively, parameters (x7,y7) could be defined for this purpose, it being realized that the embodiments of Figs. 3B and 3C could very well both be used together (depending on where MS_B happens to be located). Referring to Fig. 6, this embodiment of the invention performs the following procedure:

6A. The MS_A sends a message to PEP 3 specifying a request for a split TCP connection to be set up, along with information about MS_B (at least (x6,y6)) and also the IP address and port number at MS_A (x1,y1). The (x1,y1) information may be implicit in the message, as it is the address and port of the origin of the message.

6B. The PEP 3 selects (x2,y2) and modified (x5,y5), shown as $(x5, y5)_M$ in Fig. 6, or (x7, y7), to be used in the split TCP connection, such as through a table look up procedure.

6C. The MS_A and PEP 3 establish a WTCP connection between (x1,y1) and (x2,y2). For this purpose the PEP 3 may first send a message to the MS_A informing MS_A of (x2,y2), and MS_A may then initiate a WTCP connection setup. In an alternate embodiment the PEP 3 initiates the TCP connection setup.

6D. PEP 3 begins the process of establishing a TCP connection with MS_B. Once MS_B receives a TCP SYN message from PEP_A, it begins the procedure of establishing a WTCP connection with PEP 3.

6E. The MS_B and PEP 3 establish a WTCP connection between (x6,y6) and the modified (x5,y5). For this purpose the PEP 3 may first send a message to the MS_B informing MS_B of (x5,y5), and MS_B may then initiate a new TCP connection setup. In an alternate embodiment the PEP 3 initiates the TCP connection setup.

As can be appreciated, after performing steps 6A-5E there are two WTCP connections established, one between MS_A and PEP 3 and one between MS_B and PEP 3. In operation, the PEP 3 operates to copy from port-to-port

As a further exemplary and non-limiting modification to the foregoing teachings the MS 1 need not send (x4, y4), in the embodiment of Fig. 4, or (x6, y6), in the embodiment of Figs. 5 and 6, but may instead send a URL (such as http://www.someserver.com or http://www.somemobile.someoperator.com), and the corresponding address information can be provided using a conventional domain name server (DNS) procedure. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

Furthermore, some of the features of the present invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles of the present invention, and not in limitation thereof.

CLAIMS

What is claimed is:

1. A method to set up a Transport Control Protocol (TCP) connection between a mobile station (MS) and an end point destination via a wireless network and the Internet, comprising:

sending a split TCP connection request from the MS to a performance enhancing proxy (PEP) located in the network, the split TCP connection request comprising information for identifying a network address of the MS and a network address of the end point destination; and

in response to receiving the split TCP connection request from the MS, establishing a split TCP connection comprised of a wireless TCP (WTCP) connection between the MS and the PEP, and a TCP connection at least part way between the PEP and the end point destination.

2. A method as in claim 1, where the end point destination comprises an application server that is coupled to the Internet, and where the TCP connection is established between the PEP and the application server.

3. A method as in claim 1, where the end point destination comprises a second MS that is coupled to a second PEP in a second wireless network, and where the TCP connection is established at least as far as the second PEP, and then as a WTCP connection between the second PEP and the second MS.

4. A method as in claim 1, where the wireless network comprises a CDMA network, and where the PEP is embodied in or co-located with a Packet Data Support Node (PDSN) in the CDMA network.

5. A method as in claim 4, where sending the split TCP connection request from the MS

to the PEP uses a Point-to-Point Protocol (PPP) connection.

6. A method as in claim 4, and where establishing the split TCP connection includes sending a network address of the PEP to the MS for use by the MS in initiating a WTCP connection set up procedure.

7. A method as in claim 6, where sending the split TCP connection request from the MS to the PEP uses a Resv message during a Point-to-Point Protocol (PPP) connection, and where the network address of the PEP is sent to the MS in a ResvConf message.

8. A method as in claim 1, where the wireless network comprises a General Packet Radio Service (GPRS) or Universal Mobile Telecommunications System (UMTS) network, and where the PEP is embodied in or co-located with a Gateway GPRS Support Node (GGSN) in the GPRS or UMTS network.

9. A method as in claim 8, where sending the split TCP connection request from the MS to the PEP occurs during a Packet Data Protocol (PDP) context establishment procedure.

10. A method as in claim 8, where establishing the split TCP connection includes sending a network address of the PEP to the MS for use by the MS in initiating a TCP connection set up procedure.

11. A method as in claim 10, where sending the split TCP request from the MS to the PEP occurs during a Packet Data Protocol (PDP) context establishment procedure using an Access Point Name (APN) in a PDP Activate message to specify the split TCP request, and where the network address of the PEP is sent to the MS in an acknowledgment to the PDP Activate message.

12. A computer program comprised of computer executable instructions for operating at least one computer to set up a Transport Control Protocol (TCP) connection between a mobile station (MS) and an application server via a wireless network and the Internet, comprising:

first computer executable instructions in said MS for sending a split TCP connection request from the MS to a performance enhancing proxy (PEP) located in the network; and

second computer executable instructions in said PEP that are responsive to receiving the split TCP connection request from the MS to establish a split TCP connection comprised of a wireless TCP (WTCP) connection between the MS and the PEP, and a TCP connection between the PEP and the application server.

13. A computer program as in claim 12, where

x1,y1 represents an IP address and port number at the MS; x2,y2 represents an IP address and port number at the PEP; x3,y3 represents an IP address and port number at the PEP that the application server 2 communicates with; and x4,y4 represents an IP address and port number at the server, and where execution of the first and second computer instructions causes

the MS to send a split TCP connection request message to the PEP that comprises information that is descriptive of (x4,y4) and (x1,y1);

the PEP to select (x2,y2) and (x3,y3) to be used in the split TCP connection;

the MS and the PEP to establish a WTCP connection between (x1,y1) and (x2,y2); and

the PEP and the application server to set up a TCP connection between (x3,y3) and (x4,y4).

14. A computer program as in claim 13, where for the MS and the PEP to establish the WTCP connection the PEP sends a message to the MS informing the MS of (x2,y2), and in response the MS initiates the TCP connection setup.

15. A computer program as in claim 14, where the MS initiates the WTCP connection

setup by the use of a SYN, SYN ACK and ACK transaction.

16. A computer program as in claim 12, where for the MS and the PEP to establish the WTCP connection the PEP initiates the WTCP connection setup with the MS.

17. A computer program as in claim 16, where the PEP initiates the WTCP connection setup by the use of a SYN, SYN ACK and ACK transaction.

18. A computer program as in claim 13, where (x1, y1) is sent implicitly from the MS to the PEP in the split TCP connection request message.

19. A computer program comprised of computer executable instructions for operating at least one computer to set up a Transport Control Protocol (TCP) session between a first mobile station (MS_A) and a second MS (MS_B) via a wireless network and the Internet, comprising:

first computer executable instructions in MS_A and in MS_B, said first computer instructions for sending a split TCP connection request from MS_A to a first performance enhancing proxy (PEP_A) located in the wireless network; and

second computer executable instructions in PEP_A and in PEP_B, said second computer instructions responsive to receiving the split TCP request from MS_A to establish a split TCP connection comprised of a first wireless TCP (WTCP) connection between MS_A and PEP_A, a TCP connection between PEP_A and a second PEP (PEP_B), and a second WTCP connection between PEP_B and MS_B.

20. A computer program as in claim 19, where

x1,y1 represents an IP address and port number at MS_A; x2,y2 represents an IP address and port number PEP_A that MS_A communicates with; x3,y3 represents an IP address and port number at PEP_A that PEP_B communicates with; x4,y4 represents an IP address and port number at PEP_B that PEP_A communicates with; x5,y5 represents an

IP address and port number at PEP_B that MS_B communicates with; and x6,y6 represents an IP address and port number at MS_B, and where execution of the first and second computer instructions causes

MS_A to send a split TCP connection request message to PEP_A that comprises information that is descriptive of (x6,y6) and (x1,y1);

PEP_A to select (x2,y2) and (x3,y3) to be used in the split TCP connection;

MS_A and PEP_A establish a WTCP connection between (x1,y1) and (x2,y2);

PEP_A to initiate the establishment of a TCP connection with MS_B by sending a message to MS_B;

MS_B to send a WTCP connection request to PEP_B that comprises information that is descriptive of (x3,y3) and (x6,y6);

PEP_B to initiate a WTCP connection with MS_B with end-points (x5,y5) and (x6,y6);

PEP_B, from address (x4,y4), to send a TCP-SYN ACK packet to PEP_A, at address (x3,y3), that encapsulates at least (x6,y6); and

PEP_A to interpret the encapsulated TCP-SYN ACK packet as a case where PEP_B is acting as a proxy for MS_B, and to initiate a TCP connection with PEP_B with end-points (x3,y3) and (x4,y4).

21. A computer program as in claim 19, where the MS_B is responsive to receiving a TCP SYN message from PEP_A to initiate establishing a WTCP connection with PEP_B by sending the WTCP connection request to PEP_B.

22. A computer program as in claim 20, where for MS_A and PEP_A to establish the WTCP connection PEP_A sends a message to MS_A informing MS_A of (x2,y2), and in

response the MS_A initiates the TCP connection setup.

23. A computer program as in claim 22, where MS_A initiates the TCP connection setup by the use of a SYN, SYN ACK and ACK transaction.

24. A computer program as in claim 19, where for MS_A and PEP_A to establish the WTCP connection PEP_A initiates the TCP connection setup with MS_A.

25. A computer program as in claim 24, where PEP_A initiates the TCP connection setup by the use of a SYN, SYN ACK and ACK transaction.

26. A computer program as in claim 20, where (x1, y1) is sent implicitly from MS_A to PEP_A in the split TCP connection request message.

27. A computer program as in claim 20, where (x6, y6) is sent implicitly from MS_B to PEP_B in the WTCP connection request.

28. A computer program comprised of computer executable instructions for operating at least one computer to set up a Transport Control Protocol (TCP) session between a first mobile station (MS_A) and a second MS (MS_B) via a wireless network, comprising:

first computer executable instructions in at least MS_A, said first computer instructions for sending a split TCP connection request from MS_A to a performance enhancing proxy (PEP) located in the wireless network; and

second computer executable instructions in the PEP that are responsive to receiving the split TCP request from MS_A to establish a first wireless TCP (WTCP) connection between MS_A and the PEP, and a second WTCP connection between the PEP and MS_B.

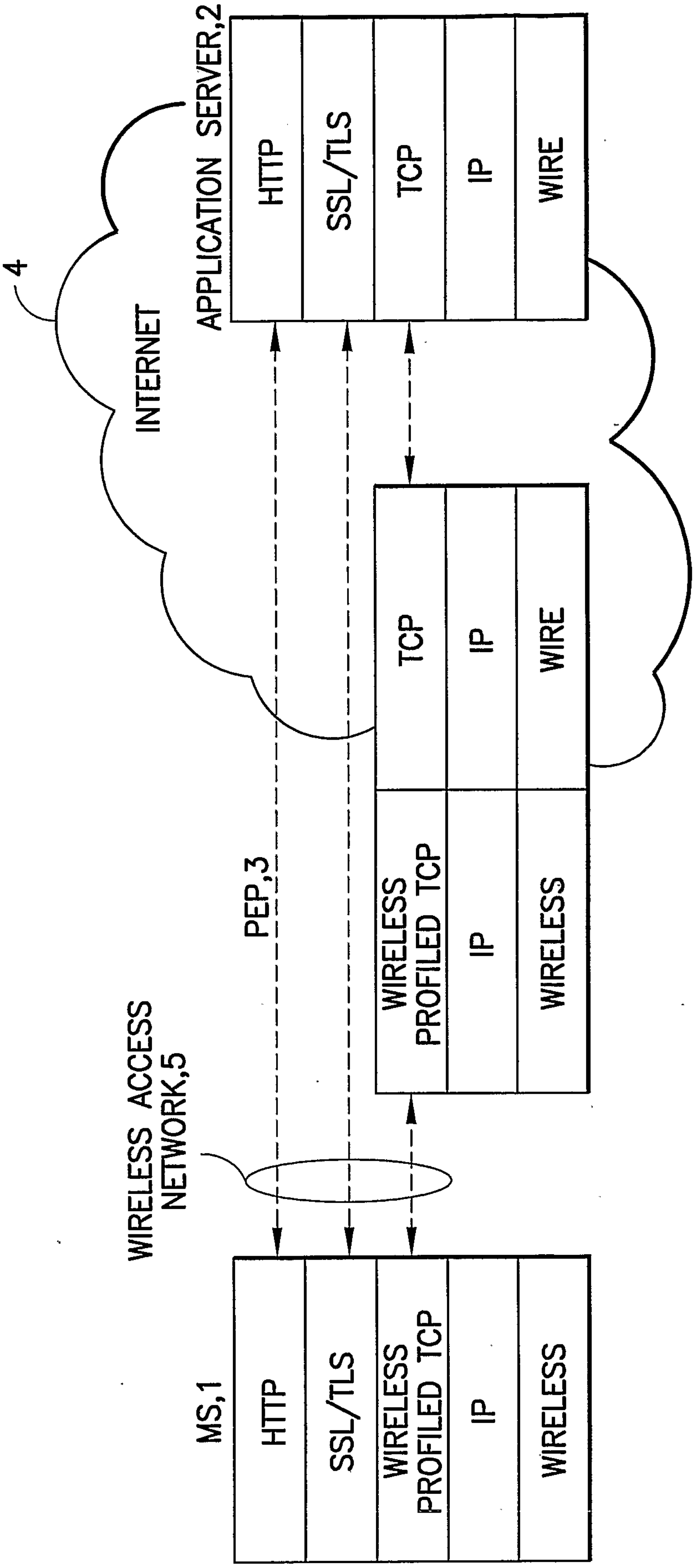
29. A mobile terminal comprising a data processor bidirectionally coupled to an interface to a wireless communications network, said data processor operable to initiate set up of a

Transport Control Protocol (TCP) connection between the mobile terminal and an end point destination via the wireless communications network and the Internet, said data processor sending a split TCP connection request to a performance enhancing proxy (PEP) located in the wireless communications network, the split TCP connection request comprising information for identifying a network address of the mobile terminal and a network address of the end point destination; and in response to the PEP receiving the split TCP connection request and establishing a split TCP connection comprised of a wireless TCP (WTCP) connection between the mobile terminal and the PEP, and a TCP connection at least part way between the PEP and the end point destination, said data processor conducting a TCP session with the end point destination.

30. A mobile terminal as in claim 29, where the end point destination comprises an application server that is coupled to the Internet, and where the TCP connection is established between the PEP and the application server.

31. A mobile terminal as in claim 29, where the end point destination comprises a second mobile terminal that is coupled to a second PEP in a second wireless communications network, and where the TCP connection is established at least as far as the second PEP, and then as a WTCP connection between the second PEP and the second mobile terminal.

32. A mobile terminal as in claim 29, where the wireless communications network comprises a cellular network.



SPLIT TCP CONNECTION

FIG.1

PRIOR ART

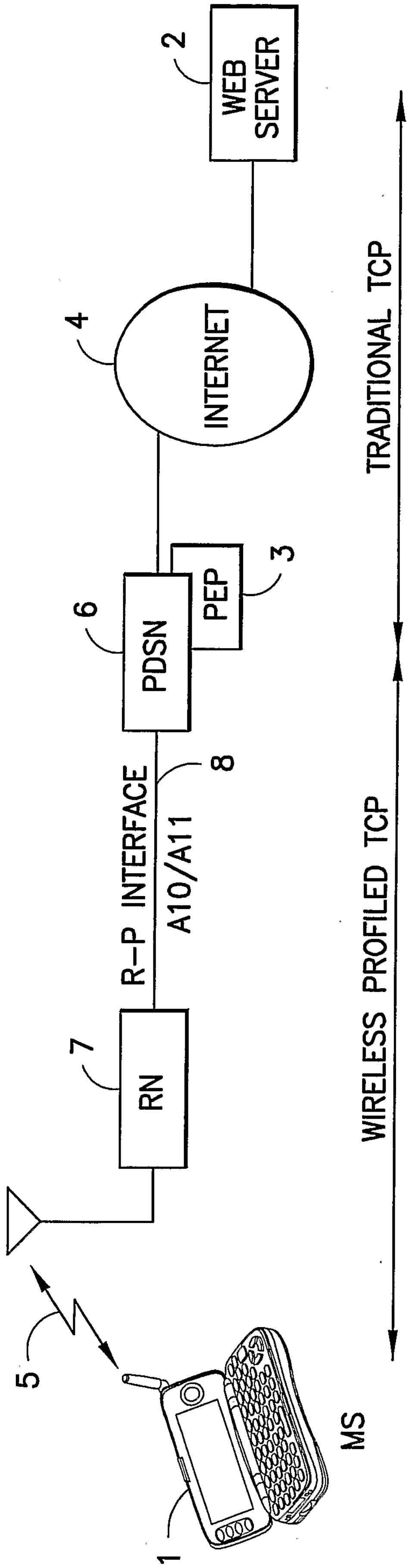

WEB SERVER
2
INTERNET
4
PDSN
6
PEP
3
R-P INTERFACE
A10/A11
8
RN
7
5
1
MS
TRADITIONAL TCP
WIRELESS PROFILED TCP

FIG.2

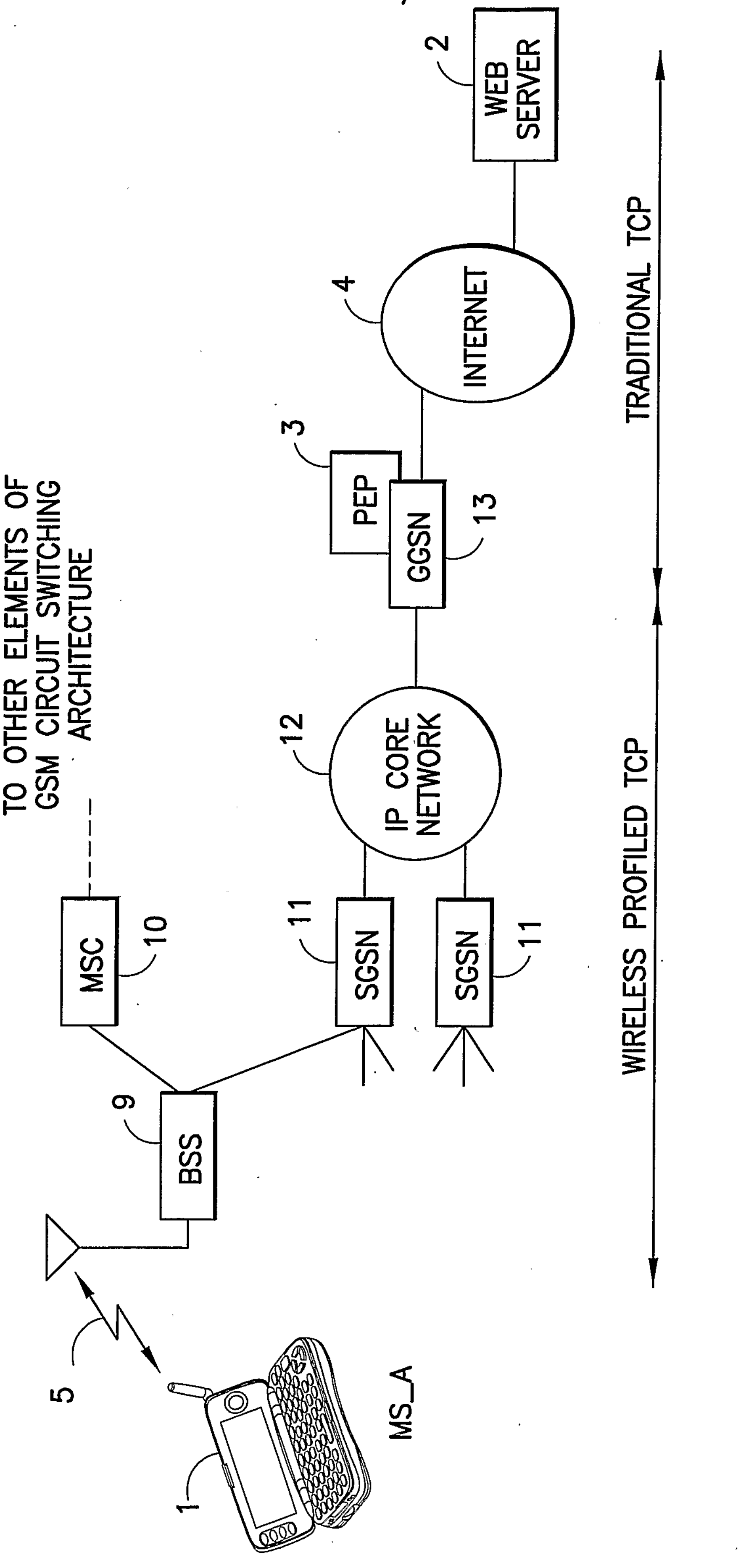

TO OTHER ELEMENTS OF GSM CIRCUIT SWITCHING ARCHITECTURE
MSC
10
BSS
9
SGSN
11
SGSN
11
IP CORE NETWORK
12
GGSN
13
PEP
3
INTERNET
4
WEB SERVER
2
5
1
MS_A
WIRELESS PROFILED TCP
TRADITIONAL TCP

FIG.3A

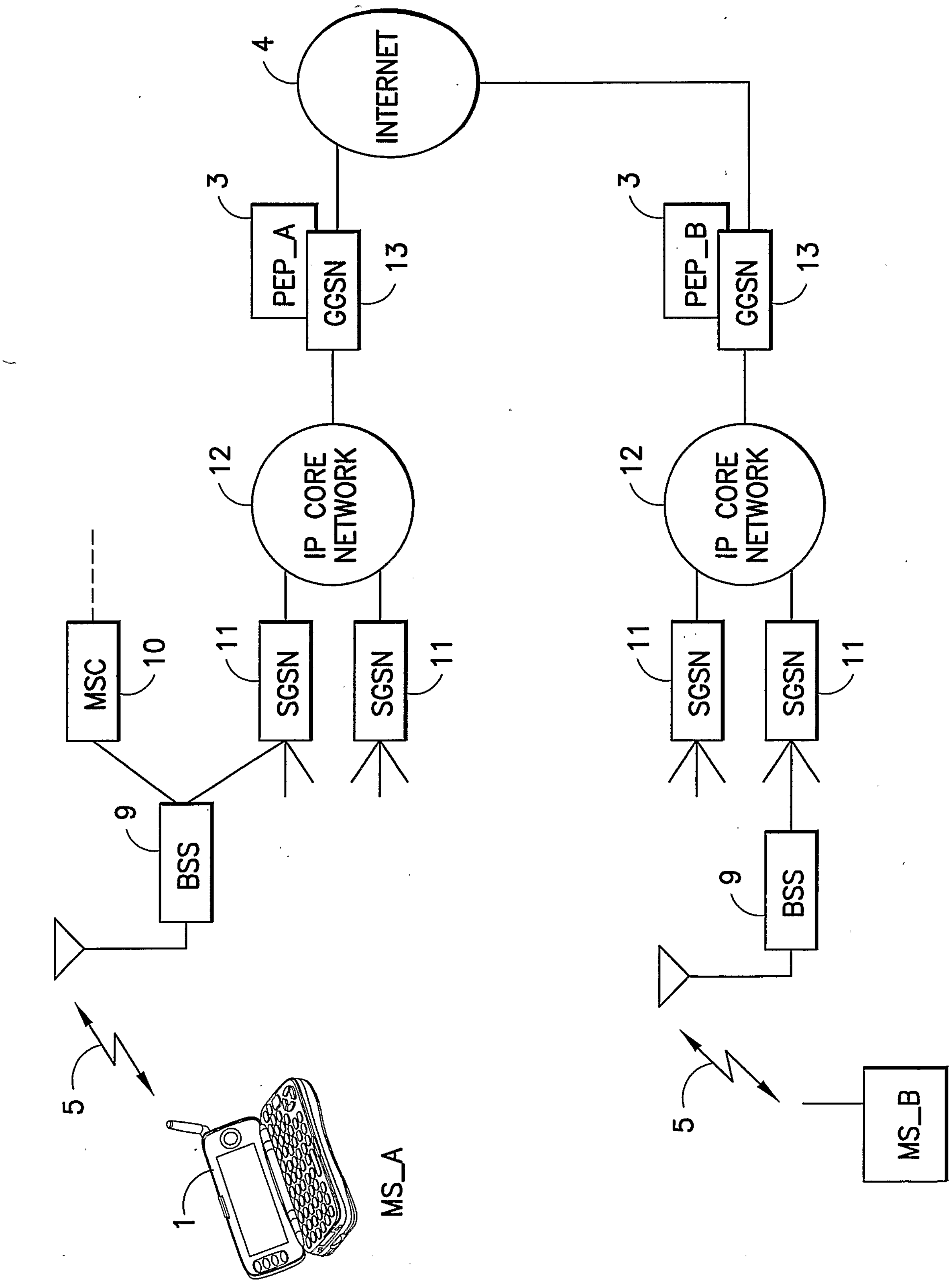

INTERNET
4
PEP_A
GGSN
3
13
PEP_B
GGSN
3
13
IP CORE NETWORK
12
IP CORE NETWORK
12
MSC
10
SGSN
11
SGSN
11
SGSN
11
SGSN
11
BSS
9
BSS
9
5
5
1
MS_A
MS_B

FIG.3B

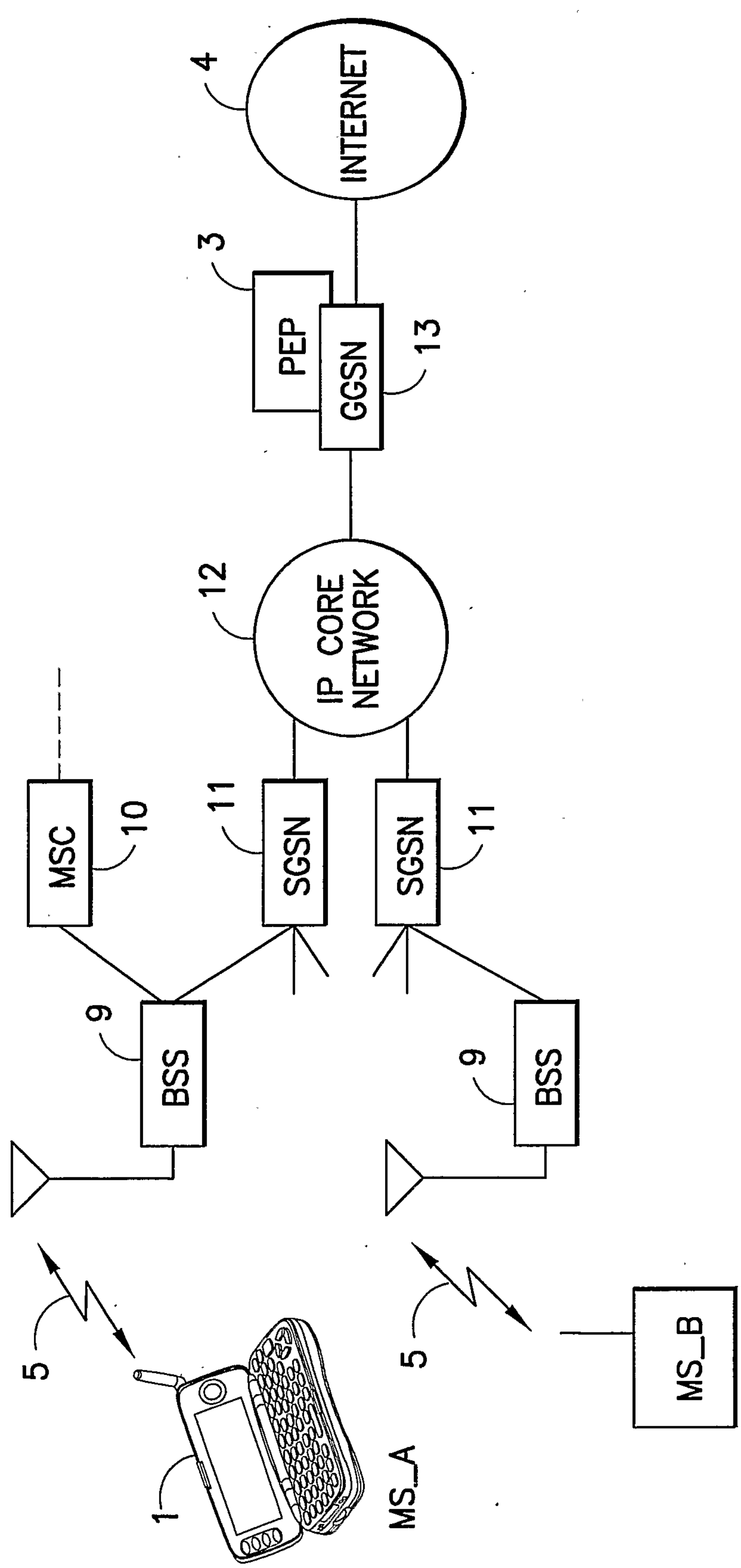

4
INTERNET
3
PEP
GGSN
13
12
IP CORE
NETWORK
MSC
10
SGSN
11
SGSN
11
9
BSS
9
BSS
5
5
MS_B
1
MS_A

FIG.3C

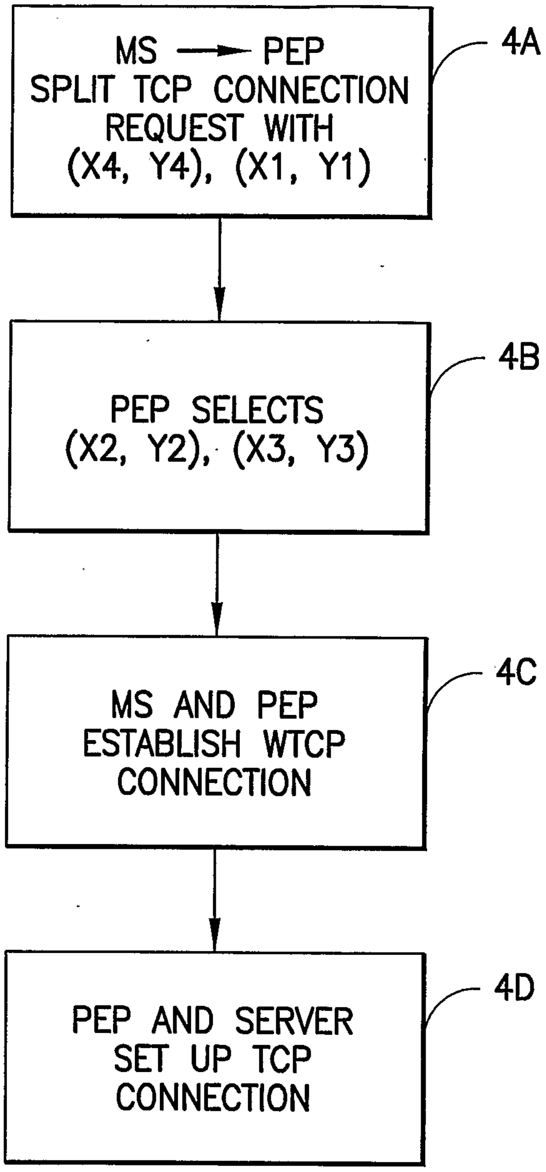

MS → PEP
SPLIT TCP CONNECTION
REQUEST WITH
(X4, Y4), (X1, Y1)
4A
PEP SELECTS
(X2, Y2), (X3, Y3)
4B
MS AND PEP
ESTABLISH WTCP
CONNECTION
4C
PEP AND SERVER
SET UP TCP
CONNECTION
4D

FIG.4

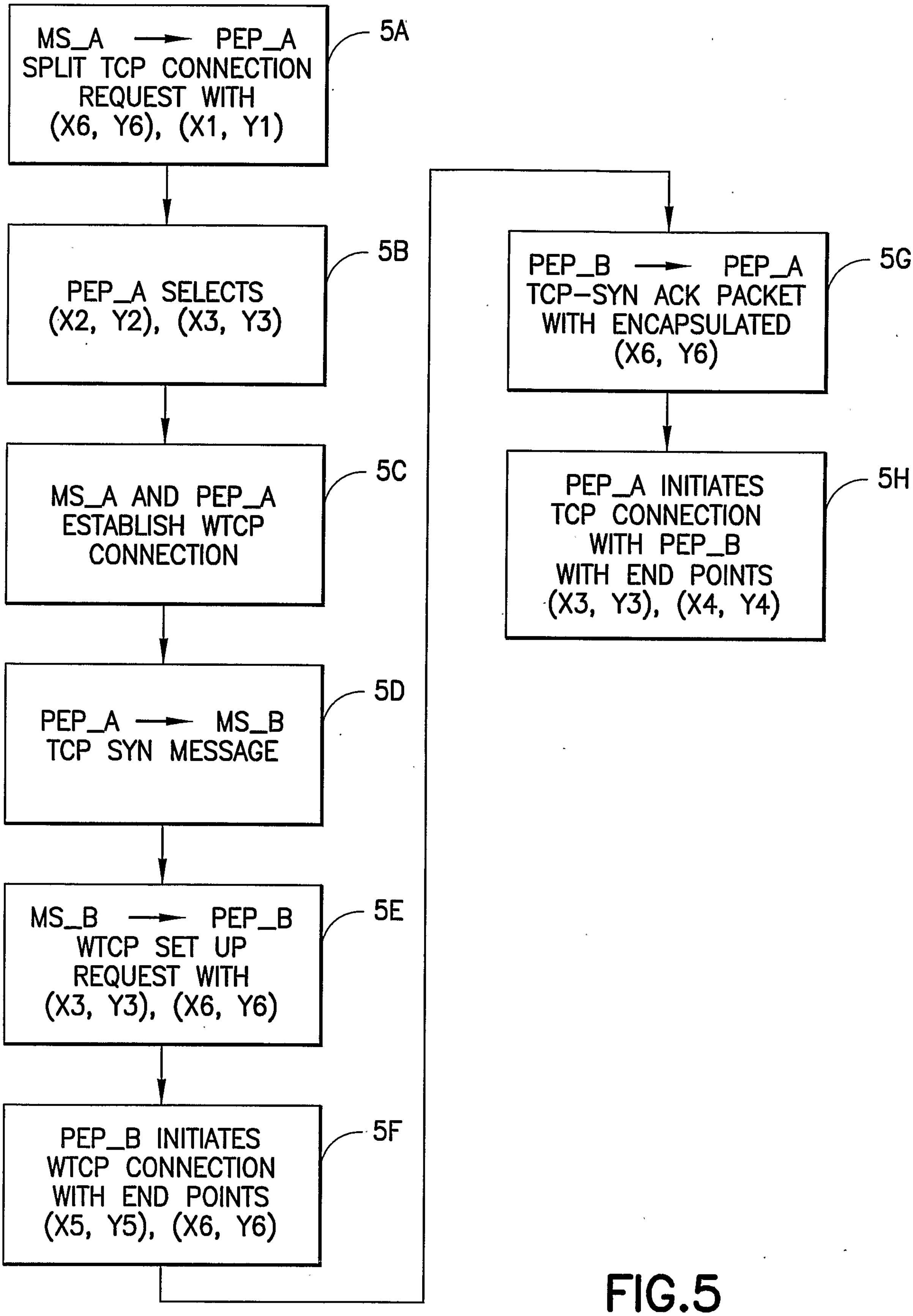

MS_A → PEP_A SPLIT TCP CONNECTION REQUEST WITH (X6, Y6), (X1, Y1)
5A
PEP_A SELECTS (X2, Y2), (X3, Y3)
5B
MS_A AND PEP_A ESTABLISH WTCP CONNECTION
5C
PEP_A → MS_B TCP SYN MESSAGE
5D
MS_B → PEP_B WTCP SET UP REQUEST WITH (X3, Y3), (X6, Y6)
5E
PEP_B INITIATES WTCP CONNECTION WITH END POINTS (X5, Y5), (X6, Y6)
5F
PEP_B → PEP_A TCP-SYN ACK PACKET WITH ENCAPSULATED (X6, Y6)
5G
PEP_A INITIATES TCP CONNECTION WITH PEP_B WITH END POINTS (X3, Y3), (X4, Y4)
5H

FIG.5

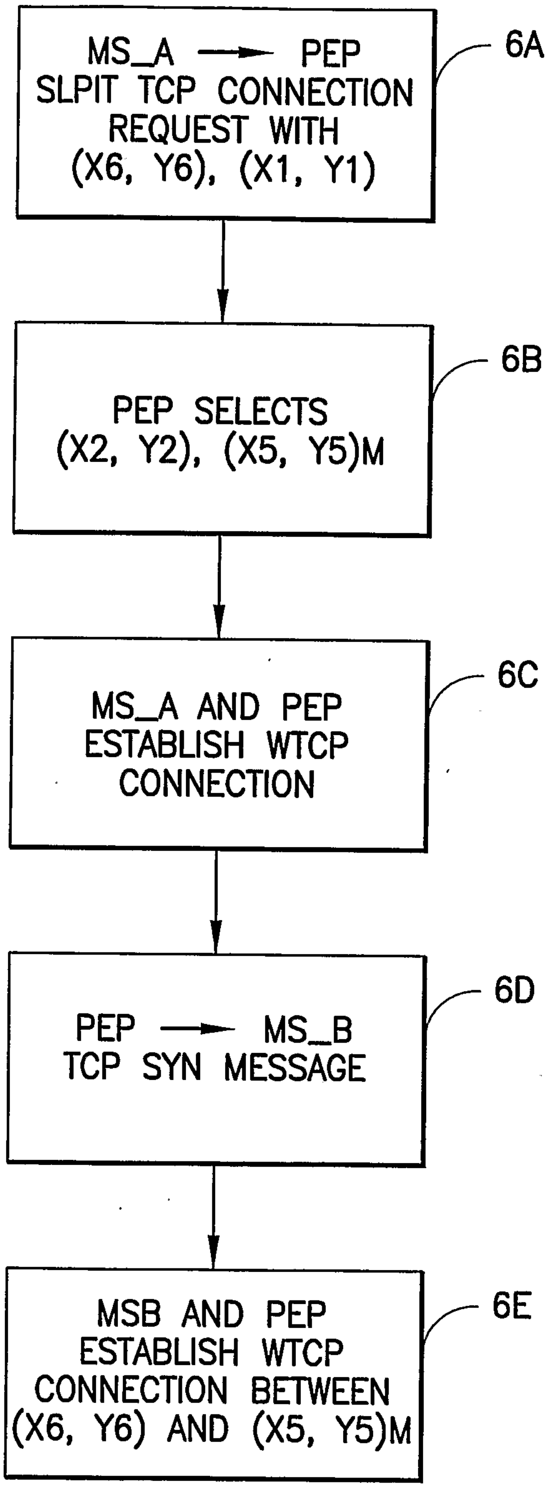

MS_A → PEP
SLPIT TCP CONNECTION
REQUEST WITH
(X6, Y6), (X1, Y1)
6A
PEP SELECTS
(X2, Y2), (X5, Y5)M
6B
MS_A AND PEP
ESTABLISH WTCP
CONNECTION
6C
PEP → MS_B
TCP SYN MESSAGE
6D
MSB AND PEP
ESTABLISH WTCP
CONNECTION BETWEEN
(X6, Y6) AND (X5, Y5)M
6E

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 2005/000448

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 29/06, H04L 29/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1206071 A2 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 15 May 2002 (15.05.2002), abstract, [7-11] --	1-32
A	US 20030131079 A1 (JASON NEALE ET AL), 10 July 2003 (10.07.2003), [42-49] --	1-32
A	US 5941988 A (PRAVIN BHAGWAT ET AL), 24 August 1999 (24.08.1999), column 2, line 20 - column 3, line 5, abstract --	1-32
A	EP 1278348 A1 (ALCATEL), 22 January 2003 (22.01.2003), [18] --	1-32

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 2005	09-06-2005

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Anders Edlund/MN Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 2005/000448

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 03090417 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 30 October 2003 (30.10.2003), page 2, line 2 - line 21	1-32

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30/04/2005

International application No.
PCT/IB 2005/000448

EP	1206071	A2	15/05/2002	JP	2002208944	A	26/07/2002
				US	20020058480	A	16/05/2002
US	20030131079	A1	10/07/2003	CA	2473863	A	22/05/2003
				EP	1446931	A	18/08/2004
				US	20030123394	A	03/07/2003
				US	20030123481	A	03/07/2003
				WO	03043285	A	22/05/2003
				WO	03043288	A	22/05/2003
				WO	03043289	A	22/05/2003
US	5941988	A	24/08/1999	KR	255501	B	01/05/2000
EP	1278348	A1	22/01/2003	NONE			
WO	03090417	A1	30/10/2003	AU	2002309186	A	00/00/0000
				EP	1497955	A	19/01/2005