The present invention provides a device referred to as a packet and circuit router and a method for transparently interfacing circuit and packet networks. The packet and circuit routing device (410) includes an external circuit network port (510), an external packet network port (530), an enterprise circuit switched network (130) and an enterprise network port (540). In addition, the packet and circuit router device (410) includes a gateway device (535) for converting packet data to circuit data and vice versa as well as a processor (537) for controlling configuration and operation of the packet and circuit router device (410). According to one embodiment, the present invention is applied to interface an enterprise containing a circuit network such as a PBX system (135) and a packet network such as an LAN system (170) to an external circuit network (110) (e.g., PSTN) and an external packet network (120) such as that provided by a NSP. A control program orchestrates operation of the packet and circuit routing device and determines routing of calls to and from the external and enterprise networks. Conversion between circuit and packet switched data is provided by a gateway device (535) located on the packet and circuit routing device (410).
A DEVICE AND METHOD FOR INTERFACING CIRCUIT AND PACKET NETWORKS

FIELD OF THE INVENTION

The present invention relates to the area of telecommunications networks. In particular, the present invention pertains to interfacing circuit and packet networks.

BACKGROUND INFORMATION

Circuits are the primary method used to transport voice-band information in the public switched telephone network ("PSTN"). In circuit switching, a dedicated channel (or circuit) end-to-end is established for the duration of the transmission. Multiple digital circuits may be combined together for transmission using time division multiplexing ("TDM") or by using other circuit multiplexing techniques. For example, the PSTN links together wire segments to create a single unbroken line for each telephone call. Conventional voice-band circuits are designed to transmit information in the 300 Hz to 3.4 kHz spectrum.

Packet telephony is a technique for transporting "voice-band" information over packet data networks. With packet switching, messages are divided into packets and each packet is sent individually. The packets may take different routes and may arrive at the destination out of order. Once all the packets forming a message arrive at the destination, they are recompiled into the original message. For example, the Internet is based on a packet-switching protocol, TCP/IP ("Transmission Control Protocol/Internet Protocol").

However, interfacing packet networks with circuit networks is often problematic because circuit networks are typically legacy systems with proprietary interfaces and protocols. For example, interfacing packet telephony with a PBX ("Private Branch eXchange") system, which is a circuit network, is often problematic because legacy PBX equipment deployed in most enterprises uses proprietary interfaces.

The problem of interfacing packet telephony with a PBX is compounded for the network service provider ("NSP") that desires to deploy packet telephony to enterprise customers. NSP's may be providers of physical access lines or they may rent physical access lines from the local telephone company. In either case, the NSP is responsible for defining and providing packet telephony service. Installing and configuring packet telephony to interface with the wide range of legacy PBX equipment deployed at enterprise locations presents a significant challenge for the NSP.
FIG. 1, which is prior art, is a block diagram of a network architecture including an enterprise, the PSTN and an external packet network in which packet and circuit services have not been integrated. PBX 135 provides all of the circuit telephony routing for enterprise 130. PBX 135 is coupled to PSTN 110 via trunk line 160b, which utilizes an industry standard PSTN interface such as T1, E1 or ISDN-PRI ("Integrated Services Digital Network – Primary Rate Interface"). Enterprise telephone sets 140a-140c are coupled to PBX 135 via extension circuits 115a-115c respectively. Extension circuits 115a-115c may use standard circuit telephone protocols such as BRI ("Basic Rate Interface") or POTS ("Plain Old Telephone Service"), but often use interfaces that are proprietary to the PBX 135 manufacturer. Multiple PBX’s may be coupled together in enterprise 130 using tie-line circuits (not shown), which often use proprietary interfaces.

Border router 125 couples enterprise packet network (LAN 170) and external packet network 120 (e.g., Internet). In particular, internal packet network (e.g., LAN 170) is coupled to external packet network 120 (e.g., Internet) via network side interface 180, border router 125, 100-base-T connection 160a and LAN interface 190. LAN 170 provides communication between PC’s 175a-175 on enterprise 130, for example, using the Ethernet protocol. LAN interface 190 provides connection to border router 125 and may utilize a variety of protocols including 100-base-T. Typically external packet network 120 is provided by an NSP, which prescribes the protocol used at network side interface 180. For example, network side interface 180 may include frame relay over T1, or ATM ("Asynchronous Transfer Mode") over xDSL ("Digital Subscriber Line"). Typically the NSP supplies or recommends border router device 125 to simplify provisioning of their packet service to enterprise 130.

For illustrative purposes only, it is assumed that external packet network 120 utilizes the Internet protocol ("IP") for packet routing. However, the present invention is compatible with any type of packet routing protocol. Each node in an IP network is assigned a unique IP address. Thus, routing of data packets in IP networks is accomplished by creating a packet header for each packet transmitted through the network that contains the IP address of a destination node. Typically, an enterprise 130 will be assigned a range of IP addresses that are known globally in the IP network. For example, an enterprise 130 may be assigned IP addresses in the range 198.4.191.0 through 198.4.191.255. This range of 256 unique IP addresses is commonly known as a "class C" Internet domain. All packets having an IP
address in this range are routed through the IP network (e.g., 120) to a border router 125 of an enterprise 130 that owns the domain. Border router 125 then forwards the packets to the enterprise node that owns the individual IP address.

Typically enterprise 120 also contains a firewall (not shown) to prevent unauthorized access to the enterprise LAN 170. Firewalls are security devices that prevent unauthorized access to an enterprise LAN by rejecting unsolicited packets. The packet network between the border router 125 and the firewall (not shown) is commonly referred to as the DMZ ("De-Militarized Zone") because this area of the enterprise network is not protected by firewall security.

FIG. 2, which is prior art, is a block diagram that depicts a method for adding packet telephony to an enterprise telephone network. Gateway device 210 provides an interface between circuit network PBX 135 and external packet network 120 and provides the critical function of converting packet information to circuit information and vice versa. In particular, PBX 135 is coupled to external packet network 120 via multi-channel circuit 220, gateway 210, packet connection 230, border router 125, network side interface 180 and T1 line 160c. Multi-channel circuit 220 may, for example, be a spare PBX trunk connection, a PBX tie-line or a number of spare extension lines. Tie-lines and extension lines may use proprietary PBX interfaces. Packet connection 230 may use an industry standard interface such as 100-base-T. Interfaces between PBX 135 and circuit connection 220 and between PBX and extension circuits 115a-115c typically use proprietary interfaces of the PBX manufacturer. However, typically interfaces to packet network 120, i.e., network side interface 180, interface to packet connection 230 and interface to 100-base-T connection 160a employ industry standards.

Because each enterprise 130 utilizes a unique protocol, in general, interfacing gateway device 210 to PBX 135 is problematic and will require significant on-site provisioning. In particular, PBX 135 must have a spare multi-channel circuit 220 available and this circuit must be compatible with gateway 210. Furthermore, using the configuration depicted in FIG. 2, regardless of the interface used, PBX 135 must be reprogrammed to route calls to and from gateway 210. PBX 135 must support flexible routing to and from gateway 210 via circuit 220. This may involve complex reprogramming of PBX 135 at great expense and effort. If PBX 135 programming is not carried out optimally, PBX performance will be degraded.

For example, in the configuration depicted in FIG. 2, PBX 135 performs all call
routing between PSTN 110, telephones 140a-140c and gateway 210. For standard circuit operation, PBX 135 routes calls between PSTN 110 and telephones 140a-140c. For packet telephony calls, PBX 135 routes calls to and from gateway 210 via circuit 220. In order to perform this routing function, PBX 135 must be programmed to route calls arriving over PSTN 110 via trunk line 160b to gateway 210 via circuit connection 220, calls arriving from gateway 210 over circuit connection 220 to PSTN 110 via trunk line 160b, calls from telephones 140a-140c via extension circuits 115a-115c to circuit connection 220 and calls from gateway 210 via circuit connection 220 to telephones 140a-140c via extension circuits 115a-115c.

FIG. 3, which is prior art, is a block diagram that depicts an alternative method for adding packet telephony to an enterprise telephone network. According to this alternative approach, a new type of PBX 310 that contains an integrated gateway 210 is added to the network. Although this approach solves the problem of interfacing PBX 135 to gateway 210 (i.e., they are combined into one unit), it creates significant additional complexity for the NSP. In particular, the approach depicted in FIG. 3 requires the NSP or the enterprise to purchase a new PBX 310, increasing cost. Installing a new PBX system introduces novel and different features that will affect the entire enterprise 130. Furthermore, either the NSP or enterprise 130 must provision and configure the new PBX 310. Existing telephone sets may be incompatible with the new PBX 310 and therefore may need to be replaced, increasing costs. In addition, the NSP may become responsible for some PBX operations in addition to basic packet network service.

Thus, in general, the NSP is confronted with significant problems in deploying packet telephony to an enterprise 130 that uses a legacy PBX 135. These problems are representative, in general, of the difficulties inherent in interfacing packet networks and legacy circuit networks. There is a need for a standard mechanism to add and interface packet services to work in conjunction with circuit networks.

**SUMMARY OF THE INVENTION**

The present invention provides a device referred to as a packet and circuit router and a method for transparently interfacing circuit and packet networks. The packet and circuit routing device includes an external circuit network port, an external packet network port, an
enterprise circuit switched network and an enterprise packet network port. In addition, the packet and circuit router device includes a gateway device for converting packet data to circuit data and vice versa as well as a processor for controlling configuration and operation of the packet and circuit router device. According to one embodiment, the present invention is applied to interface an enterprise containing a circuit network such as a PBX system and a packet network such as a LAN system to an external circuit network (e.g., PSTN) and an external packet network such as that provided by a NSP. A control program orchestrates operation of the packet and circuit routing device and determines routing of calls to and from the external and enterprise networks. Conversion between circuit and packet switched data is provided by a gateway device located on the packet and circuit routing device.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1, which is prior art, is a block diagram of a network architecture including an enterprise, the PSTN and an external packet network in which packet and circuit services have not been integrated.

FIG. 2, which is prior art, is a block diagram that depicts a method for adding packet telephony to an enterprise telephone network.

FIG. 3, which is prior art, is a block diagram that depicts an alternate method for adding packet telephony to an enterprise telephone network.

FIG. 4 is a block diagram that depicts a network architecture for adding packet telephony to an enterprise by integrating a packet and circuit router device according to one embodiment of the present invention.

FIG. 5a is a detailed block diagram of a packet and circuit router device according to one embodiment of the present invention.

FIG. 5b is a detailed block diagram of a packet and circuit router device according to an alternative embodiment of the present invention.
FIG. 6a depicts an exemplary configuration of a packet and circuit router device for routing a conventional circuit switched call according to one embodiment of the present invention.

FIG. 6b depicts an exemplary configuration of a packet and circuit router device for routing a call between a packet terminal on an enterprise LAN and a PBX telephone.

FIG. 6c depicts an exemplary configuration of a packet and circuit router device for routing a call between a PBX telephone and an external packet network according to one embodiment of the present invention.

FIG. 6d depicts and exemplary configuration of a packet and circuit router device for conducting packet telephony from outside an enterprise according to one embodiment of the present invention.

FIG. 7a depicts an exemplary configuration of a packet and circuit router device for data routing between an enterprise LAN and an external packet network according to one embodiment of the present invention.

FIG. 7b depicts an exemplary configuration of a packet and circuit router device allowing analog modems to transmit packets over the PSTN according to one embodiment of the present invention.

FIG. 8a depicts a data structure for storing a call routing rule according to one embodiment of the present invention.

FIG. 8b depicts an exemplary call routing rule file that stores a set of call routing rules according to one embodiment of the present invention.

FIG. 9 is a flowchart depicting a set of steps for routing calls on a packet and circuit
router device according to one embodiment of the present invention.

DETAILED DESCRIPTION

The present invention pertains to a device referred to as a packet and circuit router for transparently interfacing circuit switched and packet networks. According to one embodiment the present invention is applied to interface an enterprise including an internal circuit network such as a PBX system and an internal packet network such as a LAN system to an external circuit network (e.g., PSTN) and an external packet network such as the Internet. However, the embodiments discussed herein are merely illustrative. The present invention may be applied to interface any type of packet networks and circuit networks.

FIG. 4 is a block diagram that depicts a network architecture for adding packet telephony to an enterprise by integrating a packet and circuit router device according to one embodiment of the present invention. Packet and circuit router device 410 provides circuit and packet routing functionality for enterprise 130 using PBX 135. Packet and circuit router 410 manages the routing between a packet network (e.g., external packet network 120) and a circuit network (e.g., PSTN 110) at the edge of enterprise 130. In particular, packet and circuit router 110 provides a circuit and packet interface at the edge of enterprise 130. As described in detail below packet and circuit router 410 does not interfere with conventional circuit and packet routing between enterprise 130 and service providers (e.g., PSTN 110 and external packet network 120) or existing enterprise security processes. In addition, as described in detail below, packet and circuit router 410 provides enterprise security for VoP ("Voice over Packet") and RAS ("Remote Access Services") calls. In order to provide this functionality, packet and circuit router 410 monitors signaling information on all circuit calls, routes selected circuit calls onto the appropriate packet network and monitors packet routing data to route valid packet calls onto the appropriate circuit network.

Packet and circuit router 410 is coupled to PSTN 110 via access trunk 430 using a standard PSTN interface. Packet and circuit router device 410 is coupled to external packet network 120 via access line 420 using an access interface (not shown) defined by an NSP. Packet and circuit router device 410 is coupled to PBX 135 via trunk line 440, that is transparent to PBX 135 (i.e., to PBX 135, trunk line 440 is indistinguishable from PSTN trunk-line 160b shown in FIGS. 1-3). Packet and circuit router device 410 is coupled to LAN
170 via 100-base-T connection 160a, which uses an industry standard interface such as T1. Packet and circuit router 410 transparently routes circuit information between PSTN 110 and PBX 135 so that PBX 135 operates as if directly connected to PSTN 110 and therefore does not require any reconfiguration. Packet and circuit router 410 also transparently routes data packets between external packet network 120 and enterprise LAN 170. Furthermore, packet and circuit router device 410 transparently routes packet telephony calls via a gateway function to PSTN 110 and PBX 135 so that no reconfiguration is required at PBX 135.

FIG. 5a is a detailed block diagram of a packet and circuit router according to one embodiment of the present invention. Packet and circuit router device 410 includes PSTN port 510, external packet network port 530, PBX port 520 and LAN port 540. Note that PSTN port 510, LAN port 540 and PBX port 520 are merely illustrative. In general, packet and circuit router 410 is designed to interface between any type of packet networks and circuit switched networks.

External packet network port 530 and LAN port 540 are coupled to VoP/RAS gateway 535. LAN port 540 provides an optional interface to provide a direct and secure path from enterprise LAN 170 to VoP/RAS gateway 530. In particular, external packet network port 530 and LAN port 540 are only capable of accessing VoP/RAS gateway 531. Thus, packets cannot be transmitted between external packet network port 530 and LAN port 540 directly.

Border router 125 is coupled to external packet network port 530 and DMZ network 546. According to one embodiment, external packet network 120 utilizes a unique IP address for communicating VoP and RAS packets with enterprise 130. In particular, external packet network port 530 is assigned a unique IP address in the enterprise domain so that only packets intended for packet and circuit router 410 are routed to packet and circuit router 410. All other packets are transmitted to firewall 547 via DMZ network 546 where they are either accepted by firewall 547 or rejected. For example, external packet network port 530 and LAN port 540 might be assigned the IP addresses 198.4.191.10 and 198.4.191.11 respectively. Thus, according to this example, external packet network port 530 will only accept packets with an IP address of 198.4.191.10 in the header field. All other packets arriving from external packet network 120 are either accepted by firewall 547 or rejected.
VoP/RAS gateway 535 converts packet data to circuit data and circuit data to packet data. According to one embodiment, the VoP and RAS functions of the gateway may be integrated into one device. According to an alternative embodiment, these functions may be implemented as separate devices. The function and architecture of VoP/RAS gateway 535 is well known in the art. In particular, VoP/RAS gateway 535 includes DSP ("Digital Signal Processor") 532 and packet processor 537 blocks, which may be implemented as discrete integrated circuits. DSP 532 performs coding and decoding of data in various formats. For example, according to one embodiment, DSP implements various various speech codecs such as ITU "International Telecommunication Union" G. 723 and G. 729 as well as protocols for pulse code modulation of voice frequencies such as G. 711. In addition, DSP may implement various protocols for facsimile ("FAX") transmission over the PSTN and IP networks, e.g., T.30 and T. 38. In order to provide RAS functionality, DSP may implement protocols for modem access such as V. 90 for data or V. 17 with T. 30 or T. 38 for FAX transmission over the PSTN or IP networks. VoP/RAS gateway 535 includes at least one port for connection to external devices. Furthermore, if VoP and RAS functions are implemented as separated devices, each of these separate devices will typically include at least one port for connection to external devices.

Circuit switch 515, which is of the non-blocking variety, is coupled between PSTN port 510, VoP/RAS gateway 535 and PBX port 520. The functionality of circuit switch 515 is known in the art. Essentially it is a switching device that can be configured to route circuit switched calls from any input port (not shown) to any output port (not shown). Thus, for example, circuit switch 515 may route an outgoing call arriving from PBX port 520 to VoP/RAS gateway 535 where it will be converted to a packet switched call. Or, circuit switch 515 may route an incoming IP telephony call arriving from external network port 530 which has been converted to circuit switched format via VoP/RAS gateway 535 to PBX port 520.

Packet and circuit router 410 also includes control block 525, which orchestrates the operation of circuit and packet router 410. According to one embodiment, control block 525 is a microprocessor. Control block 525 may also be an ASIC ("Application Specific Integrated Circuit") that is specifically designed to perform control and routing on packet and circuit router 410. Control block 525 performs functions for routing calls between circuit
switched network (i.e., PSTN 110 and PBX 135) and VoP/RAS gateway 535. In particular, control device 525 transmits signals to circuit switch 515 for establishing and breaking down circuit connections based upon an analysis of the particular nature of a call.

FIG. 5b is a detailed block diagram of a packet and circuit router according to an alternative embodiment of the present invention. The embodiment depicted in FIG. 5b provides a higher degree of integration by bundling border router 125 into packet and circuit router 410. If packet and circuit router 410 were configured according to the embodiment depicted in FIG. 5b, external packet network port 530 would carry both packet telephony traffic bound for VoP/RAS gateway 535 and DMZ traffic bound for firewall 547. DMZ port 545 is coupled to firewall 547. In order to maintain security, LAN port 540 is restricted to communicate only with VoP/RAS gateway 535 by directly connecting LAN port 540 to VoP/RAS gateway 535.

Router 539 performs routing functions for packet data. According to one embodiment, a unique IP address is assigned to VoP/RAS gateway 535 for all external packet network traffic and LAN port 540 functions as shown in FIG. 5a. In this way, the network topology and security remain identical to that described in FIG. 5a. According to one embodiment, routing functions performed by router 539 may be implemented in software using a stack architecture and executed on a processor on packet and circuit router 410. In an alternative embodiment, router 539 may be implemented as a dedicated hardware device such as an ASIC.

FIGS. 6a-6d depict exemplary routing configurations of a packet and circuit router 410 according to one embodiment of the present invention. Of course since packet and circuit router device 410 handles multiple calls simultaneously, each configuration shown in figures 6a-6d may be established simultaneously for different calls.

FIG. 6a depicts an exemplary configuration of a packet and circuit routing device for routing a conventional circuit switched call according to one embodiment of the present invention. As depicted in FIG. 6a, packet and circuit router 410 routes conventional circuit calls directly between PSTN 110 and PBX 135. In this case, control block 525 causes circuit switch 515 to establish a direct circuit connection between PSTN port 510 and PBX port 520 on packet and circuit router device 410. Thus, circuit data flows from PSTN 110 through access trunk 430 to PSTN port 510 on packet and circuit router device 410 through circuit
switch 515 to PBX port 520 on packet and circuit router device 410 through trunk line 440 to PBX 135 to access lines 115a-115c and finally to telephone sets 140a-140c. Circuit data from telephone sets 140a-140c also flows over an identical reverse path to PSTN 110.

FIGS. 6b-6d depict three possibilities for routing of packet telephony calls according to one embodiment of the present invention. FIG. 6b depicts an exemplary configuration of a packet and circuit routing device for routing a call between a packet terminal on an enterprise LAN and a PBX telephone. In this case, control device 525 on packet and circuit router 410 causes circuit switch 515 to establish a circuit connection between PBX port 520 and VoP/RAS gateway 535. Thus, circuit data flows from PBX telephones 140a-140c over respective access lines 115a-115c to PBX 135 over trunk line 440 to PBX port 520 on packet and circuit router 410 to circuit switch 515. At circuit switch 515 the data is routed to VoP/RAS gateway 535 where it is converted to packet data and encoded in an appropriate format for transmission (e.g., G. 723). The resulting packet data is routed to LAN port 540 (since at this point it contains an IP address for a packet terminal on LAN 170) over 100-base-T connection 160a to LAN interface 190 and over LAN 170 possibly to a PC such as 175a-175b. Data from a packet terminal (e.g., 175a-175b) will flow over an identical reverse path but of course, packet data arriving at gateway 535 will be decoded and converted to circuit data.

FIG. 6c depicts an exemplary configuration of a packet and circuit routing device for routing a call between a PBX telephone and a packet network according to one embodiment of the present invention. In this case, control block 525 causes circuit switch 525 to create a circuit connection between PBX port 520 and VoP/RAS gateway 535. Circuit data flows from a telephone set (e.g., 140a) through access line (e.g., 115a) to PBX 135 and over trunk line 440 to PBX port 520 on packet and circuit router device 410. At packet and circuit router 410 the circuit data is routed via circuit switch 515 to VoP/RAS gateway 535 where it is converted into packet format and encoded using an appropriate protocol (e.g., G. 723). The packet data is transmitted from VoP/RAS gateway 535 where it is routed to external packet network port 530 (since at this point the packet data contains an IP address for a destination on the external packet network 120) and to external packet network 120 where it is transmitted to a node on the external packet network 120 having the appropriate IP address.

Packet data flows from a node on external packet network 120 to a PBX telephone set
(e.g., 140a) in the identical reverse path. Of course, in this case, packet data arriving at external packet network port 530 is routed to VoP/RAS gateway 535 because it contains the IP address mapped to PBX 135. At VoP/RAS gateway 535, the packet data is decoded and converted to circuit data for transmission to PBX telephone (e.g., 140a).

FIG. 6d depicts exemplary configuration of a packet and circuit router device for conducting packet telephony from outside of an enterprise according to one embodiment of the present invention. In this case, control block 525 causes circuit switch 515 to create a circuit connection between PSTN port 510 and VoP/RAS gateway 535. Circuit data arriving from PSTN 110 (e.g., from a telephone set connected to PSTN 110) arrives over access trunk 430 at PSTN port 510 on packet and circuit router device 410. The circuit data is transmitted to circuit switch 515 where it is routed to VoP/RAS gateway 535. At VoP/RAS gateway 535 the circuit data is converted to packet data and encoded for transmission over external packet network 120 in an appropriate format. The packetized data is then transmitted to external packet network port 530 (since the packet data contain an IP address for a destination on external packet network 120). The packet data is then transmitted from external packet network port 530 to external packet network 120 via access line 420 where it is routed to the destination node containing the appropriate IP address.

Packet data arriving from external packet network 120 is transmitted over an identical reverse path. However, packet data arriving from external packet network 120 at external packet network port 530 is routed to VoP/RAS gateway 535 because it contains an IP address associated with a PSTN destination. The data is decoded at VoP/RAS gateway 535 and converted to circuit format for transmission over PSTN 110 via circuit switch 515, PSTN port 510 and access trunk 430.

FIGS. 7a-7b depict various data routing configurations for a packet and circuit router device according to one embodiment of the present invention. FIG. 7a depicts an exemplary configuration of a packet and circuit routing device for data routing between an enterprise LAN and a packet network according to one embodiment of the present invention. In this case, packet data is transparently routed directly through packet and circuit router device 410. Packet data from packet network 120 is transmitted to packet network port 530 on packet and circuit router 410. The data packets are routed to DMZ port 545 based upon the IP addresses of the packets. From DMZ port 545, the data packets are transmitted over 100-base-T.
connection 160a to LAN interface 190 where they are transmitted to a particular device on LAN 170 (e.g., PC devices 175a-175b). Packets traveling in the reverse direction assume an identical reverse path.

FIG. 7b depicts an exemplary configuration of a packet and circuit routing device allowing analog modems to transmit packets over the PSTN according to one embodiment of the present invention. In particular, the configuration shown in FIG. 7b depicts a scheme for remote access services to LAN 170 from a PSTN node such as a computer connected to PSTN 110 via an analog modem device (not shown).

Control block 525 runs one or more processes to perform routing functions for calls arriving at packet and circuit router 410. According to one embodiment, when a call is received at packet and circuit router 410, information regarding the call is ascertained and analyzed by control block 525 to determine a routing treatment for the call. Control block 525 then performs the routing, for example, by configuring circuit switch 515 to route the call to a particular destination.

According to one embodiment, packet and circuit router 410 performs call routing using a set of call routing rules ("CRRs") based upon a called telephone number and a call type parameter. However, the routing decision process described herein is merely illustrative and the present invention is compatible with a myriad of possibilities for performing routing decision.

FIG. 8a depicts a data structure for storing a CRR according to one embodiment of the present invention. Each CRR record 802 includes rule number field 805, source port field 810, call type field 815, phone number code ("PNC") field 820, login field 825 and destination port field 830.

Rule number field 805 stores a unique identifier for the CRR. Source port field 810 stores the port on which a call arrives at circuit and packet router 410. For example, according to one embodiment, source port field 810 stores an identifier pertaining to either the PSTN port 510, the packet network port 530, the enterprise PBX port 520 or the enterprise LAN port 540.

Call type field 815 stores an identifier that describes the nature of the underlying communication. According to one embodiment, call type field 815 stores an identifier that pertains to either a voice communication or a data communication. For example, voice calls
may either be PSTN, PBX or VoP calls. Data calls may be, for example, ISDN data calls or RAS packet calls.

PNC field 820 stores a phone number identifier of either a called party or a calling party. Calls are typically routed based on the called telephone number and thus, PNC field usually stores a called telephone numbers or a range of called telephone numbers.

Login field 825 stores a binary value determining whether authorization is required in order to process the call. For example, according to one embodiment, login field 825 stores a single bit that indicates whether an authorization step is required in order to complete the call.

Destination port field 830 stores the destination port of the call. This information is used directly to perform call routing. According to one embodiment, the destination port may be either the PSTN port 510, packet network port 530, enterprise PBX port 135, enterprise LAN port 540, VoP port or the RAS port on VoP/RAS gateway 535.

FIG. 8b is an exemplary CRR file that stores a set of CRR rules according to one embodiment of the present invention. In particular, FIG. 8b depicts a CRR file that stores CRRs 801(1)-801(9). It is assumed for this example that an enterprise desires to use VoP service for calls to France, Germany and New York City.

Rule 1 (record 802(1)) allows remote users to dial into the VoP/RAS gateway 535 and place a phone call onto the PSTN network 110. According to rule 1, all voice calls placed from the PSTN 110 to destination telephone number “609-860-2901” are routed to the VoP port on VoP/RAS gateway 535. This feature may be used to reduce phone charges associated with telecommuters. Rule 2 (record 802(2)) allows remote users to dial into the enterprise LAN 170. According to rule 2, all voice calls placed from the PSTN 110 to destination number “609-860-2902” are routed to the RAS port on VoP/RAS gateway 535. Rules 3, 4 and 5 (records 802(3), 802(4) and 802(5) respectively) route all PBX calls to France, Germany or New York City over the external packet network 120. Thus, according to rules 3-5, all voice calls placed from PBX 135 to the telephone numbers “011 33”, “011 49” or “1 212” are routed to the packet network port 530 provided by the NSP. Rule 6 (record 802(6)) routes incoming VoP calls from the packet network 120 to the PBX 135 at the enterprise 130. Rule 7 (record 802(7)) routes all other incoming VoP calls from the external packet network 120 to the PSTN 110. This feature allows the reduction of phone charges associated with telecommuters. Rule 8 (record 802(8)) routes all VoP calls from the LAN
170 onto the PSTN 110. This feature enables VoP telephones used on the enterprise LAN to place PSTN phone calls. Rule 9 (record 802(9)) allows LAN users to use the RAS gateway to dial-up remote modems over the PSTN 110.

FIG. 9 is a flowchart depicting call routing functions performed on a packet and circuit router according to one embodiment of the present invention. In step 910, a call is received at packet and circuit router 410. In step 915, the source port of the call is determined to establish a source port parameter.

In step 917, the source port is monitored to determine a phone number information (“PNI”) parameter. According to one embodiment, the PNI parameter includes information regarding the called party number and may also include the calling party number. VoP calls contain a called telephone number embedded into the VoP packets and circuit call contain the called phone number in signaling information. For calls originating from the PSTN or PBX ports (510, 520), the PNI parameter, which includes the destination phone number, is determined by monitoring signaling information that is available from the PSTN or PBX ports (510, 520). For example, when the PBX 135 originates a call to the PSTN 110, it sends "off hook" and "called phone number" signals to the central office. This signaling information is carried on the "D" channel for ISDN circuits or in the "A/B" bits if T1 trunks are used. For inbound phone calls from the PSTN 110 to the PBX 135, the destination phone number may not always be available if T1 circuits are used. Thus, according to an alternative embodiment, each line must be assigned a unique phone number and the destination phone number is determined to be the number associated with the line that is "ringing".

Also, in step 917, for packet telephony calls originating from the packet network 120 or LAN 170, circuit and packet router 410 must also determine if the call is destined for the VoP or RAS gateway by determining a call type parameter. According to one embodiment, a call type parameter is embedded into packet information when the call is originated. After the call is assigned to the VoP or RAS gateway 535, packet and circuit router 410 uses the called phone number to determine how to route, authorize and process the call.

In step 920, the CRR file is searched using the PNI, call type and source port parameters to find a matching CRR. If a CRR match occurs, then the call is routed as defined by the matching CRR. According to one embodiment, CRR rules are processed first to last. The number of CRR rules is arbitrary and the first rule that matches a call is used to process
the call.

If no matching CRR is found (‘no’ branch of step 920), the routing process fails (step 970). If a matching CRR is found (‘yes’ branch of step 920), the process checks to determine whether the call is a circuit call (step 925). This may be determined by checking whether the source port is either the external circuit switched port or the enterprise PBX port. If the call is a circuit call (‘yes’ branch of step 925), an optional authorization step is performed (step 927) based upon login field 825 of the CRR. Authorization is typically performed by requiring an external user to provide a login name and password in order to be provided service. Authorization may be effected only with respect to particular services. For example, a packet telephony call may not require authorization if it is an incoming call destined for the PBX. However, authorization would typically be required when external callers attempt to place a toll call.

If the authorization fails (‘no’ branch of step 927), the routing procedure ends (step 970). Otherwise (‘yes’ branch of step 927), the circuit switch is configured to route the call to the destination port contained in the matching CRR (step 930) and routing is successful (step 960).

If the call is a packet call (‘no’ branch of step 925), an optional authorization step is performed in step 947. If the authorization is successful (‘yes’ branch of step 947), the circuit switch is configured to route the packet call to the destination port determined in the matching CRR (step 950) and routing is successful (step 960). Otherwise (‘no’ branch of step 947), the procedure fails (step 970).

The following pseudo-code describes in greater detail the call routing procedure depicted in FIG. 9. Note that the pseudo code and CRR rules and definition provided herein are merely illustrative and not intended to limit the scope of the claims appended hereto.

25 There exist many design options to perform authorization and call routing decisions that are not provided herein. Error handling and call termination procedures are also not included in order to maintain clarity and readability. The options and procedures that are omitted herein are well understood by those skilled in the art.

Notation:

30 • CRRs are the Call Routing Rules as depicted in FIGS. 8a-8b
• CRR[n].X is the contents of section ‘X’ of CRR rule number ‘n’. where X may be one of
the following: SRC, TYPE, PNC, LOGIN, DEST

- N = the total number of CRR rules
- srcPort is the port that is originating the call, and is one of the following: PSTN, NSP, PBX, or LAN.
- srcPNI is the phone number information that the circuit and packet router 410 acquires by monitoring srcPort. srcPNI always includes the "called party number", and may also include the "calling party number".
- srcType is the type of call (voice or data) found by monitoring circuit signaling or packet type information. If srcType information is not available then this is assumed to be "voice".

1. START_CALL: // srcPort is already known
   1.1. if( srcPort == PSTN)
       1.1.1. Select a free circuit from the PBX port
       1.1.2. Switch the srcPort circuit through to this PBX circuit
       1.1.3. Get srcType and srcPNI information by monitoring PSTN port signaling
   1.2. if( srcPort == PBX)
       1.2.1. Select a free circuit from the PSTN port
       1.2.2. Switch the srcPort circuit through to this PSTN circuit
       1.2.3. Get srcType and srcPNI information by monitoring PBX port signaling
   1.3. if( srcPort == NSP)
       1.3.1. Get the srcType and srcPNI information from the call request packets
   1.4. if( srcPort == LAN)
       1.4.1. Get the srcType and srcPNI information from the call request packets
   1.5. for( n = 1 to N)
       1.5.1. if( srcPort == CRR[n].SRC)
           1.5.1.1. if( srcType == CRR[n].TYPE)
               1.5.1.1.1. if( srcPNI matches the CRR[n].PNC)
                   1.5.1.1.1.1. if( srcPort == PSTN or PBX)
                   1.5.1.1.1.2. goto AUTHORIZE_CIRCUIT
           1.5.1.1.2. if( srcPort == NSP or LAN)
1.5.1.1.2.1. goto AUTHORIZE_PACKET
1.6. return to main program    // this is a call between the PSTN and PBX

2. AUTHORIZE_CIRCUIT:
   2.1. if( srcPort == PSTN)
       2.1.1. Hangup and free the previously connected PBX circuit
   2.2. if( srcPort == PBX)
       2.2.1. Hangup and free the previously connected PSTN circuit
   2.3. if( CRR[n].LOGIN == yes)
       2.3.1. if( CRR[n].DEST != RAS)
           2.3.1.1. Voice prompt the calling party to enter their account number and password on their dial-pad, and perform authorization. This is prior art.
   2.3.2. if( login is ok)
       2.3.2.1. goto ROUTE_CIRCUIT
   2.4. hangup and free the srcPort circuit
2.5. return to main program    // login failed

3. AUTHORIZE_PACKET:
   3.1. if( CRR[n].LOGIN == yes)
       3.1.1. Request login name and password from calling party via packet transactions, and perform authorization. This is prior art.
   3.1.2. if( login is ok)
       3.1.2.1. goto ROUTE_PACKET
   3.2. reject call request packets    // login failed
   3.3. return to the main program

4. ROUTE_CIRCUIT:
   4.1. if( CRR[n].dest == RAS)
       4.1.1. Select a free circuit from the RAS gateway, and switch connect the srcPort circuit to this RAS circuit
       4.1.2. The RAS gateway will now establish a modem connection with the calling party, perform a RAS login procedure, and connect the caller with the LAN.
       4.1.3. return to main program // RAS connection established

   20
   25
   30
4.2. if (CRR[n].dest == VoP)
   4.2.1. Select a free circuit from the VoP gateway, and switch connect the srcPort circuit to this VoP circuit
   4.2.2. The VoP gateway will voice prompt the caller to enter the destination phone number. This is commonly referred to as "2-stage" dialing since the calling party dials the VoP gateway first, and then enters the destination phone number. 2-state VoP gateways are prior art.
   4.2.3. return to main program // VoP connection established

4.3. if (CRR[n].DEST == PSTN)
   4.3.1. Select a free circuit from the PSTN port, and place a circuit call to the PSTN network using the called party number from srcPNI information
   4.3.2. Switch connect the srcPort circuit to this PSTN circuit
   4.3.3. Return to main program // circuit to PSTN route established

4.4. if (CRR[n].DEST == PBX)
   4.4.1. Select a free circuit from the PBX port, and place a circuit call to the PBX using the called party number from srcPNI information
   4.4.2. Switch connect the srcPort circuit to this PBX circuit
   4.4.3. Return to main program // circuit to PBX route established

4.5. if (CRR[n].DEST == NSP)
   4.5.1. Select a free circuit on the VoP Gateway
   4.5.2. Switch srcPort circuit to this VoP circuit
   4.5.3. The VoP gateway places a packet call into the NSP network using the called party number from srcPNI information, and bridges the circuit call onto the packet network. This is prior art.
   4.5.4. return to main program // circuit to NSP route established

4.6. if (CRR[n].DEST == LAN)
   4.6.1. Select a free circuit on the VoP Gateway
   4.6.2. Switch srcPort circuit to this VoP circuit
   4.6.3. The VoP gateway places a packet call into the LAN network using the called party number from srcPNI information, and bridges the circuit call onto the packet network. This is prior art.
4.6.4. Return to main program // circuit to LAN route established

5. ROUTE_PACKET:

5.1. if( CRR[n].DEST == RAS)

5.1.1. Route the call request packets to the RAS gateway

5.1.2. Select a free circuit on the RAS gateway

5.1.3. Select a free circuit from the PSTN port

5.1.4. Switch connect the RAS circuit to the PSTN circuit

5.1.5. Use the destination phone number in srcPNI to originate a call into the PSTN network, and establish a modem connection. This is prior art for known as "dialing out" of a RAS gateway.

5.1.6. Return to main program

5.2. if( CRR[n].DEST == PSTN or VoP)

5.2.1. Route call request packets to the VoP gateway

5.2.2. Select a free circuit on the VoP gateway

5.2.3. Select a free circuit from the PSTN port

5.2.4. Switch connect the VoP circuit to the PSTN circuit

5.2.5. Use the destination phone number in srcPNI to originate a circuit call through the PSTN network, and establish a voice connection. This is prior art known as "hopping off" of a VoP gateway or network.

5.2.6. Return to main program

5.3. if( CRR[n].DEST == PBX)

5.3.1. Route call request packets to the VoP gateway

5.3.2. Select a free circuit on the VoP gateway

5.3.3. Select a free circuit from the PBX port

5.3.4. Switch connect the VoP circuit to the PBX circuit

5.3.5. Use the destination phone number in srcPNI to originate a circuit call to the PBX, and establish a voice connection. This is prior art known as "hopping off" of a VoP gateway or network.

5.3.6. Return to main program

5.4. if( CRR[n].DEST == NSP or LAN)

5.4.1. Reject this call request packets since packet forwarding between packet
networks is not supported.

5.4.2. Return to main program
What Is Claimed Is:

1. A device for interfacing at least one packet network and at least one circuit switched network comprising:

   an external circuit network port;

   an external packet network port;

   an enterprise circuit network port;

   an enterprise packet network port;

   a gateway device for converting packet data to circuit data and for converting circuit data into packet data, wherein the gateway device includes at least one port;

   a circuit switch;

   a processor, wherein the processor is adapted to:

   determine a source port for a call;

   determine a destination port for the call;

   configure the circuit switch to route the call to the destination port.

2. The device according to claim 1, wherein the processor is further adapted to monitor the source port to determine at least one of a call type parameter and a called number parameter.
3. The device according to claim 2, wherein the processor is further adapted to determine the destination port based upon at least one of the call type parameter and the called number parameter.

4. The device according to claim 3, wherein the gateway device further includes a voice over packet ("VoP") gateway and a remote access services ("RAS") gateway, wherein the RAS gateway includes at least one RAS port and the VoP gateway includes at least one VoP port.

5. The device according to claim 4, wherein:

   if the source port is one of the external circuit network port and the enterprise circuit port and the destination port is the RAS port, the processor configures the circuit switch to route the call to one of the at least one RAS ports;

   if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is the VoP port, the processor configures the circuit switch to route the call to one of the at least one VoP ports;

   if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is the external circuit network port, the processor configures the circuit switch to route the call to the external circuit network port;

   if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is an enterprise circuit network port, the processor configures the circuit switch to route the call to the enterprise circuit network port;

   if the source port is one of the external circuit network port and the enterprise circuit port and the destination port is an external packet network port, the processor configures the circuit switch to route the call to the external packet network port:
if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is an enterprise packet network port, the processor configures the circuit switch to route the call to the enterprise packet network port.

6. The device according to claim 4, wherein:

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is one of the at least one RAS ports, the processor configures the circuit switch to route the call to one of the at least one RAS ports;

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is one of the external circuit network port and one of the at least one VoP ports, the processor configures the circuit switch to route the call to one of the at least one VoP ports;

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is the enterprise circuit network port, the processor configures the circuit switch to route the call to the enterprise circuit network port.

7. The device according to claim 6, wherein:

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is one of the enterprise packet network port and the external packet network port, the processor rejects the call.

8. The device according to claim 1, wherein the enterprise circuit network port is a private branch exchange ("PBX") port.
9. The device according to claim 1, wherein the enterprise packet network port is a local area network ("LAN") port.

10. The device according to claim 1, wherein the external circuit network port is a public switched telephone network ("PSTN") port.

11. The device according to claim 1, wherein the external packet network port is an Internet port.

12. The device according to claim 1, wherein the gateway device includes the capability of encoding and decoding packet data for packet telephony.

13. The device according to claim 1, wherein the processor is further adapted to perform an authentication step.

14. A method for interfacing an external circuit switched network, an external packet network, an enterprise circuit switched network and an enterprise packet network, comprising the steps of:

   receiving a call from one of the external circuit network, the external packet network, the enterprise circuit network and the enterprise packet network;

   determining a source port for the call;

   monitoring the source port to detect at least one routing parameter;

   determining a destination port for the call using the at least one routing parameter, wherein the destination port is coupled to one of the external circuit network, the external packet network, the enterprise circuit network, the enterprise packet network and a gateway device;
routing the call to the destination port.

15. The method according to claim 14, wherein the at least one routing parameter includes at least one of a called type parameter and a called number parameter.

16. The method according to claim 14, further including the step of performing authorization of a user to complete the call.

17. The method according to claim 14, wherein the step of determining a destination port for the call further includes the steps of:

if the source port is one of an external circuit network port and an enterprise circuit network port and the destination port is a RAS port, setting the destination port to be the RAS port;

if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is a VoP port, setting the destination port to be the VoP port;

if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is the external circuit network port, setting the destination port to be the external circuit network port;

if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is an enterprise packet network port, setting the destination port the enterprise packet network port;

if the source port is one of the external circuit network port and the enterprise circuit
network port and the destination port is the external packet network port, setting the destination port to be the external packet network port;

if the source port is one of the external circuit network port and the enterprise circuit network port and the destination port is the enterprise packet network port, setting the destination port to be the enterprise packet network port.

18. The method according to claim 14, wherein the step of determining a destination port for the call further includes the steps of:

if the source port is one of an external packet network port and an enterprise packet network port and the destination port is a RAS port, setting the destination port to be one the RAS port;

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is one of an external circuit network port and a VoP port, setting the destination port to be to the VoP port.

if the source port is one of the external packet network port and the enterprise packet network port and the destination port is an enterprise circuit network port. setting the destination port to be the enterprise circuit network port.

19. A method for adding packet telephony to an existing enterprise circuit telephony network comprising the steps of:

terminating an existing PSTN trunk circuit at a routing device;

coupling the routing device to the existing enterprise circuit telephony network;
coupling the routing device to an external packet network.

20. The method according to claim 19, wherein the step of coupling the routing device to the existing circuit telephony network further includes the step of coupling the routing device to an enterprise PBX via an existing PSTN trunk circuit used by the PBX.

21. The method according to claim 19, wherein the step of terminating an existing PSTN trunk circuit at a routing device further includes the step of coupling the routing device to a pre-existing PSTN trunk circuit.

22. The method according to claim 19, further including the step of coupling the routing device to one of an enterprise packet network and a LAN.

23. The method according to claim 19, wherein the routing device includes:

   at least two circuit network interface ports;

   a circuit switch;

   a gateway device

   at least one packet network interface port.

24. The method according to claim 23, wherein the gateway device further includes a voice over packet ("VoP") gateway and a remote access services ("RAS") gateway, wherein the RAS gateway includes at least one port and the VoP gateway includes at least one port.
FIG. 1 (Prior Art)
<table>
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<tr>
<th>Rule#</th>
<th>Call Type</th>
<th>Source Port</th>
<th>Login?</th>
<th>Destination Port - 830</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>PSTN</td>
<td>609 860 2901</td>
<td>YES</td>
<td>VoIP</td>
</tr>
<tr>
<td>2</td>
<td>PSTN</td>
<td>609 860 2902</td>
<td>YES</td>
<td>RAS</td>
</tr>
<tr>
<td>3</td>
<td>PBX</td>
<td>011.33</td>
<td>NO</td>
<td>NSP</td>
</tr>
<tr>
<td>4</td>
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<td>1212</td>
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<tr>
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<td></td>
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<td>NO</td>
</tr>
<tr>
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<td></td>
<td></td>
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<tr>
<td>0</td>
<td>PSTN</td>
<td></td>
<td></td>
<td>NO</td>
</tr>
</tbody>
</table>

FIG. 8A

FIG. 8B

SUBSTITUTE SHEET (RULE 26)
Call Initiated 910

Determine Source Port 915

Monitor Source Port to Determine PNI and Call Type - 917

CRR found? 920

no

routing failed 970

yes

Circuit Call 925

Authorization Successful? 947

no

Routing Failed 970

yes

Authorization Successful? 947

no

Configure Circuit Switch to Route Packet Call to Destination Port 950

Routing Successful 960

yes

Configure Circuit Switch to Route Circuit Call to Destination Port 930

FIG. 9
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : H04L 12/56
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)

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tbody>
<tr>
<td>X</td>
<td>US 5,892,764 A (RIEMANN ET AL) 06 APRIL 1999, col. 5, line 30 to col. 12, line 8.</td>
<td>1-3, 8-13, 14-16 and 19-23</td>
</tr>
</tbody>
</table>

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
  "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
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  "V" 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
  "X" document member of the same patent family

Date of the actual completion of the international search
30 AUGUST 2000

Date of mailing of the international search report
14 SEP 2000

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
DUONG, FRANK
Telephone No. (703) 308-5428

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