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(54) Title: SELECTION OF PACKET SWITCH ROUTER ROUTING METHOD AND BEARER TYPE WITHIN A SYSTEM INTRANET

(57) Abstract: Packet switch routing nodes (54), each supporting a plurality of routing methods, are interconnected (36) through the use of a plurality of different types of bearers to form a system intranet communications network. Responsive to intranet performance data input (100) and the operation of an expert system (58), the packet switch routers are configured (104, 106) to implement a certain routing method and interface to a certain bearer type or combination of bearer types in order to tailor portions of the system intranet to handle certain types of traffic.

SELECTION OF PACKET SWITCH ROUTER ROUTING METHOD AND BEARER TYPE WITHIN A SYSTEM INTRANET

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to the management of communications networks and, in particular, to the selection for packet switch router use within a system intranet of a traffic tailored routing method and bearer type.

Description of Related Art

Historically, communications networks have been designed as tightly coupled systems wherein one traffic type, one cell switch routing method, and one switch interconnecting bearer type are linked together to define and provide communications service through the network. For example, a communications network being designed to primarily handle voice traffic may utilize a completely different selection of routing method and bearer type than a network being designed to primarily handle data (computer) traffic. Also, where only one bearer type is available within the network, the routing method selected for use on that bearer type is typically chosen to complement the carried traffic type on that specific bearer.

Recent developments in communications network design concern the use of generic packet switch routers that support the use of plural routing methods and that are interconnected by plural bearer types that are available for use. These networks, through proper selection of routing method and choice of a bearer or combination of bearers, are capable of efficiently and effectively supporting the communication of many different types of traffic. It is the selection of routing method and bearer type(s), however, that presents quite a challenge to the network operator. In fact, this selection may be made even more difficult in situations where plural traffic types need to be supported, and thus configuration of the network involves choosing plural routing methods and plural bearer types in a proper proportion to each other to best carry the desired traffic, and thus tailor the network to traffic needs. Proper selection becomes even more problematic if variations in not only traffic density but also traffic type occur over time. There is accordingly a need for a system and method for automatically selecting the best apportionment of routing methods and bearer types (i.e., tailored to the carried traffic) for use in such a communications network.

SUMMARY OF THE INVENTION

Packet switch routing nodes are interconnected to form a system intranet communications network. These interconnections between the packet switch routers are made through the use of a plurality of different types of bearers. Furthermore, each packet switch router supports the use of a plurality of routing methods over the available bearer types. A system intranet transport controller monitors intranet performance indicators relating to handling the carried traffic and characterizes the current state of system intranet health. Based on this evaluation of system intranet health, the system intranet transport controller selects the particular type(s) of bearer(s) to be interface supported at each packet switch router, and also selects the particular routing method(s) to be utilized by each packet switch router, to best match traffic needs.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is a block diagram of a client/server environment wireless communications network in accordance with the present invention; and

FIGURE 2 is a flow diagram of the routing method/bearer traffic tailored selection process of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 1 wherein there is shown a block diagram of a client/server environment wireless communications network in accordance with the present invention, and also to FIGURE 2 wherein there is shown a flow diagram of the routing method/bearer traffic tailored selection process of the present invention. In providing wireless communications services, the clients 10 comprise a plurality of base stations 12 that support subscriber communications over an air interface 14 with a plurality of mobile stations 16. The server 18 comprises a mobile switching center 20 having functionalities for network signaling and control 22, gateway operations 24 for interfacing the network to the Internet or an intranet, and service provision 26 for supporting subscriber access to services such as, for example, voice mail, intelligent networking (IN), and the like.

Interconnecting the clients 10 to the server 18 is a core network 30 comprised of a plurality of edge routers 32 supporting connections to the base stations 12 and the mobile switching center 20, and a plurality of packet switch routers 34 that are

interconnected 36 in at least an almost fully-meshed network configuration to provide a system intranet 38. Some of the packet switch routers 34 within the intranet support connections to the edge routers 32. The interconnection 36 between packet switch routers within the system intranet 38 on a physical layer (OSI layer 1) is made through interfaces 40 to a selected one or ones of an available plurality of bearer types. In the context of the present invention, "bearer" or "bearer type" refers to a means by which packet based communications in a bidirectional symmetric, bidirectional asymmetric or unidirectional fashion are established using a channel connection (either virtual or material). For example, a first portion (perhaps all) of pairs of packet switch routers 34 within the system intranet may be interconnected through their interfaces 40 using a first bearer type such as a T1/T3 link, while a second portion (some the same as the first portion) of pairs of packet switch routers may be interconnected through their interfaces using a second bearer type such as a fiber optic link. It will, of course, be understood that the first and second types of bearers may be any suitable packet switch router interconnecting bearer types (other examples include: unshielded twisted pair, SONET and the like). Each packet switch router 34 is further capable of implementing one or more different routing methods (at OSI layer 3) such as: open shortest path first (OSPF), border gateway protocol (BGP), private network-to-network interface (PNNI), interior gateway routing protocol (IGRP), routing info protocol (RIP), and the like (including their variants), for use in routing packets over the selected available bearers.

The network further includes a system intranet transport controller 50 (perhaps implemented in the form of an expert system) that operates to select routing method(s) and bearer(s) based on (and to accommodate) not only traffic needs within the system intranet but also network operator preferences. To this end, the transport controller 50 includes a performance control functionality 52 that constantly monitors network (and perhaps more particularly system intranet) performance indicators such as throughput, utilization, end-to-end delay, packet delay variation, insertion delay, label space usage, and the like, that are indicative of traffic need. These indicators are, generally speaking, derived by the functionality 52 from performance related data supplied thereto by the packet switch routers 34 in the normal course of their operation (step 100). From the derived performance indicators, the functionality 52 then characterizes the current (and predicted future) state of system intranet health (step 102), perhaps through the use of an evaluator algorithm. The generated characterization of system intranet health may take the form of an overall system intranet performance index. As an example, the index may be derived as follows:

The edge routers of the network periodically send, for example, an update of their label space usage (in terms of percent), insertion delay (in terms of seconds) and cumulative throughput (in terms of bits per second) on a per label switched path basis. Typically, this information is provided through the use of "heartbeat" messages (background signaling). The performance control functionality takes a sample of these indicators on a periodic basis (such as once every thirty seconds) and applies the following exemplary algorithm to determine the index:

$$Index = \left(\log\left(\frac{a}{TP} x \frac{b}{ID} x \frac{1}{LSU} \right) x10 \right)$$

wherein: a = 155,000,000; a constant selected based on the type of connection (in this case an OC-3 connection) to scale the measured throughput;
b = 0.01; a constant selected to scale the measured insertion delay;
TP = throughput in bits per second;
ID = insertion delay in seconds; and
LSU = label space usage in percent.

Given this exemplary index equation, with a throughput of 100 Mbps, an insertion delay of 50 msec and label space usage of 80%, the measured and calculated performance index for the system would be -20 (rounded off from -24) on a scale of -20 to +20 (worst to best). On the other hand, a throughput of 1 Mbps, an insertion delay of 1 msec and label space usage of 90% would yield a performance index of +12.

It will, of course, be recognized that other evaluation algorithms (as selected by the system operator) may alternatively be used to process the performance indicators and derive the overall system intranet performance index.

Generally speaking, the process implemented by the performance control functionality 52 first collects from the packet switch routers certain sampled statistics concerning, for example, throughput, end-to-end delay and utilization. Next, these sampled statistics are processed through a parser and then the evaluator algorithm to identify whether the system intranet is operating well. Lastly, a conclusion is reached based on that operating condition identification of an index (or other suitable measure) reflecting the operating status of the physical network. This index is generated on a regular basis, and is then processed (as will be described in more detail below) to correct, over the long-term, the physical set up (i.e., routing method and bearer type) of the system intranet to be more closely tailored to traffic needs.

The transport controller 50 further includes a control signal routing functionality 54 that operates to choose for the system intranet, and more particularly

for each of the individual packet switch routers 34, the particular one or ones of the supported plurality of routing methods to be used (step 104). This selection is made by the functionality 54 based on an evaluation of the characterization of system intranet health (e.g., the derived overall system intranet performance index) and network operator routing method preferences. For example, given an index of +12 (as determined above), an operator preference for RIP and the availability of IGRP and RIP, an exemplary rule system could give priority to the operator's RIP preference since the index of +12 is favorable. Conversely, given an index of -20 (as determined above), an operator preference for RIP and the availability of IGRP and RIP, that exemplary rule system would yield IGRP since its impact on routing updates is less than the impact caused by RIP.

Responsive to a selection made by the functionality 54, the system intranet transport controller 50 issues the requisite control signals and messages to the packet switch routers 34, and the routers respond by making the appropriate selection.

The system intranet transport controller 50 still further includes a content transport functionality 56 that operates to choose, for each packet switch router 34, the best bearer or combination of bearers, selected from the plurality of interface 40 supported bearers, for use in physically interconnecting each pair of packet switch routers for communication (step 106). This selection is made by the functionality 56 based on an evaluation of the characterization of system intranet health (e.g., the derived overall system intranet performance index as set forth above), the selected routing method and network operator bearer preferences in accordance with certain configuration rules. For example, the bearers UTP, SONET, T1 and fiber may be available with the routing protocols of IGRP, OSPF and RIP. Given that, and an index of 0, a current routing preference set to RIP and a current bearer set to T1, the configuration rules would dictate a change because RIP/T1 performance is unstable (as indicated by the index at 0). Most likely this is due to many routing updates performed in RIP and the quiescent bit rate of T1 that forces retransmissions of those routing updates. The configuration rules in this instance may select OSPF for the routing protocol and a fiber bearer for the long term in order to regain stability.

Responsive to a selection made by the functionality 56, the system intranet transport controller 50 issues the requisite control signals and messages to the packet switch routers 34, and the routers respond by enabling the appropriate OSI layer 1 interfaces 40 to establish interconnections within the system intranet using the specified bearer or combination of bearers.

Although the system intranet transport controller 50 is illustrated as a discrete node within the network, it will, of course, be understood that such need not be the

case. In fact, a preferred embodiment of the present invention implements the system intranet transport controller 50 as a software/hardware module that resides in various different physical nodes within the network (or system intranet). For example, the transport controller may reside in both types of the edge and packet switched routers.

An expert system implemented by the system intranet transport controller 50 (or more particularly the included functionalities 52, 54 and 56) to make the routing method/bearer selection relies on artificial intelligence in order to emulate the kind of intelligent behavior shown by experts. Expert systems contain a knowledge base and an inference engine. The knowledge base contains the specific domain knowledge (or facts), and the inference engine controls the reasoning process and user interface. In the context of the present invention, the expert system implements the actions of steps 104 and 106 wherein the routing methods and bearers are selected and then configured at certain ones of the packet switch routers 34. Configuration of such an expert system to make optimization decisions is well within the capabilities of one skilled in the arts of artificial intelligence and expert system design. Thus, it is seen that given certain data relating to the knowledge base, the inference engine is capable of selecting both routing method and bearer type for the network in order to provide an optimized configuration for current traffic needs.

Although preferred embodiments of the method and apparatus of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A system intranet, comprising:

a plurality of packet switch routers interconnected in at least a partially meshed configuration within a core network using a plurality of available bearer types, each packet switch router further supporting a plurality of routing methods; and

a system intranet transport controller operable to monitor traffic state within the system intranet and select based on monitored traffic needs a certain one of the plurality of routing methods for routing packet traffic and a certain bearer type for use in carrying packet traffic between each interconnected pair of packet switch routers.

2. The system intranet as in claim 1 wherein the system intranet transport controller comprises:

a performance control functionality that processes traffic related system intranet network performance indicators concerning traffic state to characterize system intranet health.

3. The system intranet as in claim 2 wherein the system intranet transport controller further comprises:

a control signal routing functionality that selects for the packet switch routers of the system intranet the certain one of the routing methods based on the determined characterization of system intranet health.

4. The system intranet as in claim 2 wherein the system intranet transport controller further comprises:

a content transport functionality that selects the certain one of the bearer types for each interconnecting pair of cell switched routers based on the determined characterization of system intranet health and the selected routing method.

5. The system intranet as in claim 4 wherein each packet switch router includes an interface for each supported one of the plurality of bearer types, and the content transport functionality of the system intranet transport controller further orders the packet switch routers to enable the appropriate interface based on the selection of the certain supported one of the bearer types.

6. A system intranet, comprising:

a plurality of packet switch routers interconnected in at least a partially meshed configuration within a core network using a plurality of available bearer types, each packet switch router supporting a plurality of routing methods; and

a system intranet transport controller operable to monitor traffic state within the system intranet and select based on monitored traffic needs a certain one of the plurality of routing methods for routing packet traffic and a certain combination of bearer types for use in carrying packet traffic between interconnected pairs of packet switch routers.

7. The system intranet as in claim 6 wherein the system intranet transport controller comprises:

a performance control functionality that processes traffic related system intranet network performance indicators concerning traffic state to characterize system intranet health.

8. The system intranet as in claim 7 wherein the system intranet transport controller further comprises:

a control signal routing functionality that selects for the packet switch routers of the system intranet the certain one of the routing methods based on the determined characterization of system intranet health.

9. The system intranet as in claim 7 wherein the system intranet transport controller further comprises:

a content transport functionality that selects the certain combination of bearer types for interconnecting the cell switched routers based on the determined characterization of system intranet health and the selected routing method.

10. The system intranet as in claim 9 wherein each packet switch router includes an interface that supports connection to the plurality of bearer types, and the content transport functionality of the system intranet transport controller further orders the packet switch routers to enable the interface based on the selection to connect with the selected combination of bearer types.

11. The system intranet as in claim 9 wherein the content transport functionality of the system intranet transport controller further selects an apportionment between the selected combination of bearer types for interconnecting the cell switched routers.

12. A method for making routing method and bearer type selections for a system intranet comprised of a plurality of packet switch routers interconnected in at least a partially meshed configuration using a plurality of bearer types, each packet switch router supporting a plurality of routing methods, comprising the steps of:

monitoring traffic state within the system intranet in order to characterize system intranet health;

selecting for the packet switch routers of the system intranet a certain one of the routing methods based on the determined characterization of system intranet health; and

selecting a certain bearer type or combination of bearer types for interconnecting pairs of cell switched routers based on the determined characterization of system intranet health and the selected routing method.

13. The method as in claim 11 wherein the step of monitoring comprises the step of processing traffic related system intranet network performance indicators concerning traffic state to characterize system intranet health.

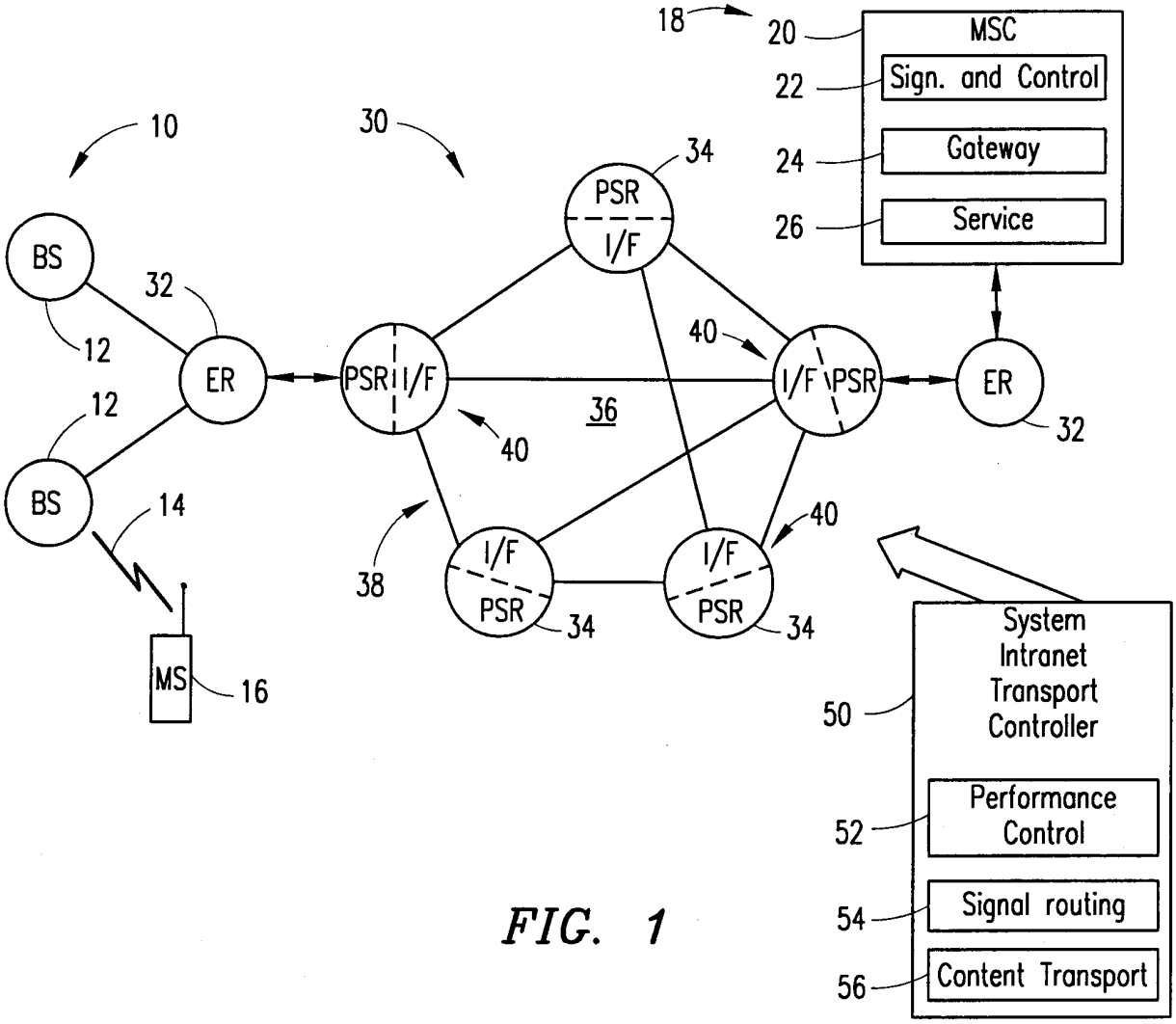
18
20
MSC
22
Sign. and Control
24
Gateway
26
Service
10
30
34
PSR
I/F
BS
32
12
ER
PSR
I/F
40
I/F
PSR
ER
36
32
12
40
BS
14
38
I/F
PSR
34
I/F
PSR
34
40
MS
16
System
Intranet
Transport
Controller
50
Performance
Control
52
Signal routing
54
Content Transport
56

FIG. 1

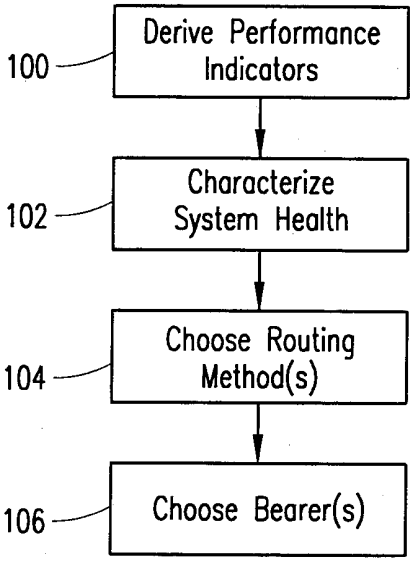
100
Derive Performance Indicators
102
Characterize System Health
104
Choose Routing Method(s)
106
Choose Bearer(s)

FIG. 2