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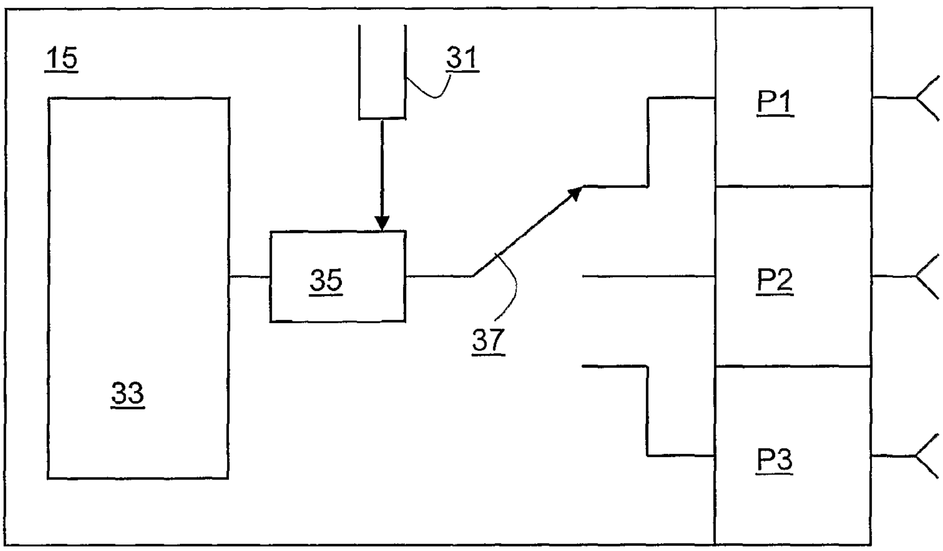
(54) **Title:** METHOD AND APPARATUS FOR ROUTING PACKETS



(57) **Abstract:** Packets may be routed in a heterogeneous communications network as follows: for a set of packets comprising at least one packet to be transmitted from a sending node, said sending node being able to handle communication according to at least two access technologies, - selecting in a selection unit in the sending node an access technology for use when transmitting the set of packets, - selecting a receiving node in the network to which to transmit the set of packets among nodes in the network that are able to handle said selected access technology - transmitting the set of packets to the selected receiving node using the selected access technology. Alternatively, a set of packets may be transmitted to one or more nodes using at least two different access technologies. Depending on the transmission quality, one node may be selected to forward the set of packets.

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METHOD AND APPARATUS FOR ROUTING PACKETS

Technical Field

The present invention relates to a method and an apparatus for routing packets between a source and a destination in a communications network having multiple access technologies.

Background

In every communications network one of the major problems to be solved is how to route the information in the best possible way between the source and the destination. Routing protocols may generally be classified into two different categories, namely centralised and distributed routing protocols. In centralised routing some central node determines the path to follow from source to destination, whereas in distributed routing all nodes in the network participate in the routing decision and each node is able to calculate a "good" path to follow from itself in the direction of the destination. Most currently used routing protocols are developed for wired networks, in which the shortest path is selected, and then used over some period in time. A typical metric for the shortest path may aim to minimize delay.

Routing in wireless networks has traditionally been based on adaptations of the methods developed for wired networks. This means that in the general case a path is selected and all packets transmitted between a source and a destination follow the same path, unless something major happens that changes the structure of the network. That is, in practice, single path routing is commonly used in wireless networks.

Wireless networks are, for several reasons, generally more dynamic than wired networks. The experienced interference levels at different receivers will vary depending on whether anything is being transmitted on a particular link at a given time and with what power. Moreover, propagation conditions are exposed to time variations depending on the user location and obstacles in the environment, i.e. movement of nodes as well as obstacles affects the channel. Similarly, the channel may vary in the frequency domain due to time dispersive propagation. Short term fading may also arise, due to large number of randomly scattered (and possibly direct) signals superimposed at the receiver antenna.

Since the channel fluctuates, not only does the desired received carrier fluctuate, but also the experienced interference will fluctuate. This is due to channel variations, but also to what appear as random and unpredictable traffic variations. The quality for a link is dependent both on the desired signal as well as the interference, and typically both vary.

Trying to follow the rapid changes in the network when routing packets is often infeasible since it may lead to extensive control signalling. One other option is to calculate the routing decisions on the basis of averages.

Thus, one problem of single path routing in wireless networks is that local and instantaneous propagation and queue conditions that can provide additional guidance in the forwarding decision are often not fully exploited. For example one node in a predetermined path may experience a temporary and high path loss due to fast fading, which is not reflected in the routing choice.

What has been described above is true for most routing methods, but some routing methods are opportunistic in the sense that they make use of variations in the network to select a transmission path that is particularly advantageous at a given moment. For example, multiuser diversity, as described in WO 2004/091155, can be used in opportunistic routing by transmitting at any given time to the user that at this particular time has a better connection than the others. Subsequently, the user forwards any data according to the same transmission principle, and the data heads towards the destination. By always transmitting on the paths that are momentarily good the network is utilized in the best possible way. Since the received signal quality will generally vary over time, all users will in the long run receive data.

In recent years nodes and terminals have emerged that can use two or more different radio access technologies, so called multi access or multi-radio access, each radio access technology being characterized by certain strengths and weaknesses for different conditions. One such combination that is often found is Wireless Local Area Network (WLAN) and Wideband Code Division Multiple Access (WCDMA). Typically different radio access technologies make use of separate frequency bands, meaning that multi access capable nodes and terminals can get access to multiple independent spectrum resources. In existing multi access terminals and nodes the source chooses which radio access technology to use at a given time, the decision being based on one or several factors such as current channel conditions, interference levels in the corresponding frequency bands, and/or more general properties such as typical quality of service level offered, or simply by availability of the respective radio access technologies at the current location.

A network in which only one single access technology is used is referred to as a homogeneous network, whereas a network allowing multiple access technologies is often referred to as a heterogeneous network. Traditionally, routing in homogenous networks has been the object of many studies, while the interest in wireless routing for heterogeneous networks has been significantly smaller. In particular, routing in heterogeneous networks has not addressed radio aspects yet. Moreover, existing routing schemes for heterogeneous networks are not responsive to the rate of changes experienced in a radio environment.

Object of the Invention

Thus, it is an object of the invention to enable routing in heterogeneous wireless networks that better utilizes the possibilities offered by such a network.

Summary of the Invention

The present invention achieves this object by means of a method for routing packets between a source and a destination in a heterogeneous communications network comprising the steps of

for a set of packets, comprising at least one packet, to be transmitted from a sending node, said sending node being able to handle communication according to at least two access technologies:

- selecting in a selection unit in the sending node an access technology for use when transmitting the set of packets;
- selecting a receiving node in the network to which to transmit the packets among nodes in the network that are able to handle said selected access technology; and
- transmitting the set of packets to the selected receiving node using the selected access technology

The object is also achieved by a sending node for use in a heterogeneous communications network in which packets are routed between a source and a destination, said sending node being able to forward packets to at least two receiving nodes in the network and said node comprising protocol means for handling communication according to at least two access technologies, said node comprising:

- protocol selection means for selecting an access technology for use when transmitting a set of packets comprising at least one packet,
- node selecting means for selecting a receiving node in the network to which to transmit the packets among nodes in the network that are able to handle said selected access technology
- transmission means for transmitting the set of packets to the selected receiving node using the selected access technology.

The solution according to the invention provides greater bandwidth, better channel resource utilization and a greater overall transmission rate in the network, by allowing the selection at any time of both next hop node and access technology to be used. It also provides diversity in that the technology that has a good channel, and/or little load at any given time, can be selected for transmission.

Some nodes in the network may provide for several different access technologies, others only one.

Preferably, the protocol selection means is arranged to select the access technology in dependence of the channel quality for the access technology. This is preferably accomplished such that the coherence time of the channel is long enough that the channel quality can be considered to be constant until the time when the quality is used for scheduling. This could be defined as that the channel dependent scheduling to be operating on “instantaneous” channel quality.

The node selecting means is preferably arranged to select the receiving node in dependence of the channel quality of the connection to said receiving node, and or in dependence of the cost from the sending node to the destination and the cost from the receiving node to the destination.

The node and access technologies can also be selected in dependence of the type of service, or the type of data that is to be transmitted.

In a preferred embodiment, the inventive sending node further comprises probe means for transmitting a probe to at least one receiving node using at least one access technology, and evaluation means for evaluating the channel quality on the basis of the response from the receiving node. Alternatively, the channel quality for a particular link may be determined by statistical data collected during communication and stored in a database in the sending node. The channel quality can be determined in different ways for different links from the same sending node.

The sending node preferably comprises packet-selecting means for selecting a set of packets to send from packets stored in the buffers. This is particularly useful if the sending node comprises more than one packet flow (henceforth the words packet flow and buffer will be used interchangeably), but may also be used to select a set of packets within one packet flow. The packet selecting means may be arranged to select the set of packets in dependence on the instantaneous quality of the link on which said set of packets is to be sent.

The sending node may further comprise rate mode selection means for selecting the transmission rate for the set of packets. This enables adaptation to instantaneous network capacity as well as to the preferences of a particular user.

The sending node may also comprise property selection means for selecting at least one other link property, such as transmit power, for the transmission.

The idea of multi-user diversity is applied in a multi-access context, resulting in that the perceived instantaneous optimum access technology is chosen at each instance. Hence, one can avoid blocked or overloaded access technologies smoothly in an opportunistic manner. One can more specifically utilize fluctuations due to unpredictable interference and fading to select the best access technology at each instance. A simple example of the benefit of opportunistic selection of access technology is now given. Assume that the probability of an access technology's availability is P, and N access technologies exist, then the probability that any access technology is available, increases to $P(\text{At least one RAT available}) = 1-(1-P(\text{RAT available}))^N$.

To illustrate the benefit when multiple access technologies are available, assume that one has two access technologies and the probability for success at each access technologies is 0.9, then the total success probability adds up to 0.99.

Moreover, the invention proposes an efficient and appealing solution to multi-access technology routing. In particular the increased degrees of opportunistic freedoms offered by the availability of more than one access technology increases the performance, e.g. with respect to throughput, latency and energy/power consumption, over prior art routing schemes.
A hierarchy of opportunistic selection levels offer low complexity.
In addition, in scheduling packets with differentiated QoS requirements (such as delay, throughput, residual packet error rate etc.) to be sent, it is possible to exploit the different characteristics of the different radio access technologies. This may also include taking the usage cost (in e.g. dollars or other currency) of different access technologies into account.

Brief Description of the Drawings

The present invention will be described in more detail in the following, with reference to the appended drawings, in which:
Figure 1 illustrates schematically an embodiment of a node according to the invention.
Figure 2 shows an example of how a packet can be routed in a heterogeneous network according to the invention.
Figure 3 is a simplified view of a node according to the invention.
Figure 4 is a more detailed view of a node according to the invention.
Figure 5 illustrates the transmission according to the invention.
Figures 6a and 6b are flow charts of the operation of the selection function performed in a node according to the invention.
Figures 7a and 7b are flow charts of the operation of each access technology in a node according to the invention.

Detailed Description of Embodiments

Figure 1 illustrates an embodiment of a node according to the invention. The node is able to handle three different access technologies P1, P2 and P3 Note that each access technology may also be composed of a set of protocols. Each access technology is schematically illustrated in Figure 1 by a protocol stack comprising two layers, L1 and L2. Above the protocol stacks a forwarding layer comprising an algorithm according to the invention is placed, and above the forwarding layer, possibly other protocol layers are placed, which are not important from the point of view of the invention and will not be discussed here. Between the protocol stacks P1, P2, P3 and the forwarding layer a convergence layer is preferably found. The convergence layer comprises one part for each of the access technologies and is used to provide data to the forwarding layer regarding the available access technologies. The convergence layer may also be seen as an internal and entirely integrated part of the forwarding layer, ensuring smooth Service Access Point (SAP) interfacing to the different access technologies.

According to the invention the forwarding layer receives a signal, or decides itself, that it should try to transmit one or more information packets residing in the node. The forwarding layer sends out an interrogation message to the convergence layer for each of the access technologies. The interrogation message enquires each (or a subset of the available) access technology to test the communication quality to all, or some, relay nodes in the vicinity of the node.

Based on the responses received from all interrogated multi-access technologies, the forwarding layer uses this information, as well as routing cost information, to determine which access technology to use and which relay node to send to. In addition, one or more other parameters may be selected, such as the flow from which a packet should be transmitted, and physical layer transmit parameters, such as rate mode, power, and antenna parameters. Note that when a relay station is close to the destination node, then the selected relay station may also coincide with the destination node. The selected packet is subsequently sent to the selected relay station, using the selected access technology with parameters as selected.

The parameters requested by the forwarding layer may be obtained in different ways for different access technologies. If a homogenous opportunistic forwarding method, such as Multiuser Diversity Forwarding (MDF) is used as one of the access technologies, a physical probing signal is issued to determine the instantaneous communication quality to the respective relay stations. For another access technology it may not be feasible to use a physical probing signal. Instead, information on channel quality may be stored in a database during communication and used to provide statistical data when the forwarding layer requests such information. In the example shown in Figure 1, such databases are used for the second and third access technologies, P2 and P3.

As shown in Figure 1, a convergence layer facilitates the interface between the access technologies and the forwarding layer. The database is preferably found in or in connection to the convergence layer. Each convergence layer enables interrogation and responses to and from the access technology layer below, or simply contains a database holding data for the access technology it interfaces to. This database contains information about communication quality to various nodes, that is, information similar to that which can be obtained by physical probing in a homogenous opportunistic forwarding method.

Figure 2 shows an example of how a packet can be routed in a heterogeneous network according to the invention. A source 11, a receiver 13, and four nodes 15, 17, 19, 21 are shown. The source 11, the receiver 13, and each of the nodes 15 and 19 comprise three different access protocol stacks P1, P2, P3 and are able to communicate using all these three technologies. Node 17 comprises two different protocol stacks P1 and P2, and node 21 comprises protocol stacks P1 and P3.

To optimize the routing through the network, according to the invention, each node determines both the best access technology to use for the next hop, and which node to send to. From the source 11, access technology P1 is selected to transmit to the first node 15. The first node 15 determines that the third access technology should be used for the next hop, which should lead to the node 21. From this node 21, access technology P1 is used again, to transmit to the receiver. As can be seen, for each hop, the node to transmit to is selected in dependence of the selected access technology.

When a node is to transmit a packet through the network, according to the invention, the following process is used:

The forwarding layer of the node requests quality information from all access technologies that are available in the node. Quality information is returned to the forwarding layer. As discussed above, such quality information is either the result of probing or (statistical) data found in a database.

Each node also has information about the cost, C_{own}, involved in transmitting from the node to the destination, as well as the neighbour's costs in transmitting from the neighbour to the destination. The skilled person is familiar with ways of determining the cost from a source to a destination. For example, a standard shortest path protocol, such as the Bellman-Ford algorithm may be adopted to generate the costs for each destination of interest.

An algorithm for the forwarding of packets according to the invention can be represented by an objective function f with a predetermined metric being optimized over the multiple available access technologies (here we consider the optimization towards one destination, but in practise multiple destinations generally exists). This optimization is performed in the forwarding layer and optimizes the selection of transmission path and technology, preferably taking into account the instantaneous channel quality and the cost of transmission, according to

$$\underset{\substack{\forall r\in R\\ \forall a\in A}}{opt}\{f(Q_{ra},C_{own},C_r)\} \qquad (1)$$

where C_r is the cost for the next node for transmitting to the destination

R is the set of all relay stations, or nodes and

A is the set of all available access technologies

Q is a measure of the quality based on, for example, the rate, the bit error rate and the delay. Note that the quality typically differs for different access technologies between own and considered relay node.

Typically, the equation will be

$$\underset{\substack{\forall r\in R\\ \forall a\in A}}{opt}\{f(Q_{ra},C_{own}-C_r)\} \qquad (2)$$

where C_{own}-C_r (the cost progress) indicates the length of the step taken in the direction of the destination. If C_{own}-C_r is negative, this means that the packet will be travelling away from the destination, which is undesirable. A long step will be desirable, but for many metrics this will also generally lead to low quality in the link. Therefore, the length of the step should be balanced against the quality loss.

The result of the optimization is given by

$$\left\{\tilde{r},\tilde{a}\right\}=\arg\underset{\substack{\forall r\in R\\ \forall a\in A}}{opt}\{f(Q_{ra},C_{own},C_r)\}, \qquad (3)$$

which means that the result of the optimization will be the selection of a relay station $\tilde{r}$ to send to and an access technology $\tilde{a}$ to be used. Note that the access technology and the relay station are jointly selected in the optimization procedure above.

In addition to the above, the flow from which to select a packet, and the rate may also be adaptively (and jointly) selected to optimize the performance even more. The rate is adapted e.g. through selecting suitable modulation and coding.

Figure 3 is a simplified view of a node 15 according to the invention comprising functions for selecting a node to send to and an access technology. The node 15 shown in Figure 3 is able to use three different access technologies, P1, P2, P3. The packets to be transmitted are found in one or more buffers 31, where each of the buffers holds one packet flow. For simplicity only one buffer is shown. A selection unit 33 requests information regarding the communication quality to each of the neighbouring nodes using each of the access technologies P1, P2, P3. The quality data is obtained as discussed above and returned to the selection unit 33 that operates according to one of the formulas above to select the optimal access technology and relay station to send to. The connections for the quality data are not shown in Figure 3. An addressing unit 35 receives the packet to be sent from the buffer 31 and selection information from the selection unit 33. A switch 37 directs the packet through one of the access technology stacks P1, P2, P3 according to the selection information. In Figure 3, the packet will be sent using access technology P1.

While the access technology, relay node address, rate and flow are selected jointly in the optimization procedure, the actual transmission of a packet may follow a given sequence. For instance, first the packet is taken out from the queue, then the rate is selected, the node address is determined and finally, the packet is forwarded to the selected access protocol stack.

Figure 4 is a more detailed view of a node according to the invention. As in Figure 3, the node can handle three different access technologies, P1, P2, P3. Three different flows of data packets are handled, represented by three buffers 31. A buffer switch 41 selects the buffer from which a packet should be sent at any given time.

A selection unit 33 receives cost information for each possible link from a number of databases 43, each corresponding to one of the access technologies. The selection unit 33 also receives channel quality information on connections 45, usually in response to requests transmitted from the selection unit.

As in Figure 4, an addressing unit 35 is used to address the packet to be sent and a switch 37, arranged to receive the packet from the addressing unit 35 is used to direct the packet to the selected access technology P1, P2, P3. Between the selection unit and the addressing unit a rate selector 47 is arranged.

The selection unit 33 also receives information from the buffers 31 regarding the presence of packets in the buffers 31, and their queuing time. Based on this information, the selection unit 33 selects the access technology P1, P2, or P3, the node to send to, the rate and finally the packet to be sent. Control signals regarding these selections are sent to the switch 37 for selecting the access technology, to the addressing unit 35, the rate selector 47 and the buffer switch 41, respectively, in order to control the transmission of the packet according to what has been determined by the selection unit. The control signals from the selection unit 33 are indicated in Figure 4 by dashed lines.

A switch 48 on the input to the node is used to direct incoming packets into the appropriate buffer 31. An Automatic Repeat Request (ARQ) unit 49 is usually arranged to monitor whether transmitted packets are received as intended. The ARQ unit 49 receives acknowledgments from the nodes to which packets are sent and when a packet has been acknowledged, it can be deleted from the transmission buffer 31.

An illustration of the transmission according to the invention is provided in Figure 5. In the example illustrated in Figure 5 as well as the previous examples, three different access technologies P1, P2, P3 are assumed to be present in the same node. Each access technology is represented by a plane. To the left in Figure 5, the interrogation is illustrated using arrows. As discussed above, for each available access protocol channel quality information for different nodes is requested. This request is represented by downward pointing arrows 51 in Figure 5. The interrogation responses are represented by upward pointing arrows 53 to the unit transmitting the request. Thereafter, one destination of data is selected and data is transmitted to this recipient, which is referred to as the destination. The transmission of data is represented by a downward pointing arrow 55. Preferably, the receipt of data is acknowledged in an ACK signal represented by an upward pointing arrow 57. Note that for some access technologies, the interrogation message (which is sent from the forwarding layer to the underlying access technologies), may have two different result depending on the considered access technology. Either the databases in the access technology is interrogated, or if the access technology allows, a probe signal is sent out to test the availability of one or more nodes and the associated communication quality. The probed nodes answer with a probe response.

As discussed above, the resulting interrogation responses may be responses to probing signals, or consist of statistical data from a database.

Figures 6a and 6b illustrate functions performed in the transmitters forwarding layer to select an access technology to use for a subsequent transmission. The communication is initiated from the selection unit 33 in Figure 3 or corresponding unit in Figure 4. The elliptic shapes at the beginning and the end of each flow in Figures 6a, 6b, 7a, and 7b indicate that the selection unit is in the idle state. At first, as shown in Figure 6a the selection unit is in the idle state. In step S1 a transmission trigger is received and in step S2 interrogation messages are sent out to determine the quality of connections on different access technologies that can be used by the node. The selection unit then returns to the idle state. The transmission trigger may occur in several different ways. For instance, a trigger may occur simply by that a packet is received in a queue, or alternatively that a medium access scheduler decides to send a packet residing in a queue.

Figure 6b illustrates the actions taken in the transmitters forwarding layer when the replies to the interrogation messages are received. At first, the selection unit is in the idle state. In step S3 the interrogation message replies are received. In step S4 the replies are stored in the respective database as discussed in connection with Figure 4. Step S5 is a waiting loop until replies have been received from all access technologies. While waiting, the selection unit is in the idle state. When all replies have been received, in step S6 the access technology to be used is selected and in step S7 the forwarding request is sent to the access technology that was selected in step S6. The selection unit then returns to the idle state.

Figure 7a illustrates the operation of each access technology part of the node. First the access technology part is in the idle mode. In step S11 the interrogation message sent out in step S2 is received from the selection unit. In step S12 quality estimation is performed. This is discussed above and may comprise physical probing of each connection, if possible. Alternatively, it may comprise fetching data relating to the quality of each connection from a database. When the quality estimation has been performed, in step S13 an interrogation message reply is transmitted from the access technology part to the selection unit. This is the reply that was received in step S3. The access technology part then returns to idle mode.

In Figure 7b the access technology part that was selected for forwarding the data is first in the idle mode. In step S14 it receives a forwarding request from the selection part. This is the forwarding request sent out in step S7 above. In step S15 the data is sent according to the forwarding request to the selected relay node using parameters that have been selected.

In an alternative embodiment, instead of using the interrogation messages as described in the above, a packet, corresponding to a single flow, can be transmitted (unicasted or multicasted) concurrently over multiple access technologies. Based on the result for each receiving node it can be decided which receiving node should take on the responsibility to further forward the packet towards the destination. For example, the sending node can send a forwarding order to the node that is to forward the packet. Any receiving node that has not received a forwarding order within a certain period of time after receiving the set of packets will then discard the set of packets. This will be less cost-efficient than the embodiments described above, but yields communication robustness, as diversity is inherently offered over the multiple access technologies. More specifically, both flow and rate are predetermined when a data packet is transmitted. Based on this, according to the invention, the access technology and relay node are selected in an opportunistic manner. This can be referred to as selection diversity forwarding, where a node performs a forwarding decision based on multiple responses returned subsequent to the multicasting of data to a number of candidate relays.

Claims

1. A method for routing packets between a source and a destination in a heterogeneous communications network comprising the steps of
for a set of packets comprising at least one packet to be transmitted from a sending node, said sending node being able to handle communication according to at least two access technologies:

- selecting in a selection unit in the sending node an access technology for use when transmitting the set of packets;
- selecting a receiving node in the network to which to transmit the set of packets among nodes in the network that are able to handle said selected access technology; and
- transmitting the set of packets to the selected receiving node using the selected access technology.

2. A method according to claim 1, further comprising the step of selecting the access technology in dependence of a channel quality for the access technology.

3. A method according to claim 2, wherein the channel quality for at least one access technology is an instantaneous channel quality.

4. A method according to any one of the claims 1-3, comprising the step of selecting the receiving node in dependence of the channel quality of the connection to said receiving node.

5. A method according to any one of the claims 1-4, comprising the step of selecting the receiving node in dependence of the cost from the sending node to the destination and the cost from the receiving node to the destination.

6. A method according to any one of the claims 2-5, wherein the channel quality is determined by transmitting a probe to at least one receiving node using at least one

access technology, and evaluating the quality on the basis of the response from the receiving node.

7. A method according to any one of the claims 2-6, wherein the channel quality for a particular link is determined by statistical data collected during communication and stored in a database in the sending node.

8. A method according to any one of the claims 1-7, further comprising the step of selecting a set of packets to send from packets stored in at least one buffer in the sending node.

9. A method according to claim 8, wherein the set of packets is selected in dependence on the instantaneous quality of the link on which said set of packets is to be sent.

10. A method according to any one of the preceding claims, further comprising the step of selecting the transmission rate for the set of packets.

11. A method according to any one of the preceding claims, further comprising the step of selecting at least one link property such as modulation, encoding, or antenna parameters, for the transmission.

12. A method for routing packets between a source and a destination in a heterogeneous communications network comprising the steps of
for a set of packets comprising at least one packet to be transmitted from a sending node, said sending node being able to handle communication according to at least two access technologies,

- transmitting the set of packets to at least two receiving nodes,

- receiving acknowledgements for the successful reception of at least one of the packets that applies to the transmission to the at least two receiving nodes from the at least two receiving nodes,
- selecting in a selection unit in the sending node one of the at least two receiving nodes that is to forward the set of packets to a next receiving node, based on the acknowledgement information indicative of successful reception.

13. A sending node for use in a heterogeneous communications network in which packets are routed between a source (11) and a destination (13), said sending node being able to forward packets to at least two receiving nodes (15, 17, 19, 21) in the network and said node comprising protocol means (P1, P2, P3) for handling communication according to at least two access technologies, said node comprising

- protocol selection means (33) for selecting an access technology for use when transmitting a set of packets comprising at least one packet,
- node selecting means (33) for selecting a receiving node in the network to which to transmit the set of packets among nodes in the network that are able to handle said selected access technology
- transmission means (33, 37) for transmitting the set of packets to the selected receiving node using the selected access technology.

14. A sending node according to claim 13, wherein the protocol selection means (33) is arranged to select the access technology in dependence of the channel quality for the access technology.

15. A sending node according to claim 13 or 14, wherein the node selecting means is arranged to select the receiving node in dependence of the channel quality of the connection to said receiving node.

16. A sending node according to any one of the claims 13-15, wherein the node selecting means is arranged to select the receiving node in dependence of the cost

from the sending node to the destination and the cost from the receiving node to the destination.

17. A sending node according to any one of the claims 13-16, further comprising probe means for transmitting a probe to at least one receiving node using at least one access technology, and evaluation means for evaluating the channel quality on the basis of the response from the receiving node.

18. A sending node according to any one of the claims 13-17, wherein the channel quality for a particular link is determined by statistical data collected during communication and stored in a database in the sending node.

19. A sending node according to any one of the claims 13-18, further comprising packet selecting means (33, 41) for selecting a set of packets to send from packets stored in at least one buffer (31) in the sending node.

20. A sending node according to any one of the claims 13-19, the packet selecting means (33, 41) is arranged to select the set of packets in dependence on the instantaneous quality of the link on which said set of packets is to be sent.

21. A sending node according to any one of the claims 13-20, further comprising rate selection means (33, 47) for selecting the transmission rate for the set of packets.

22. A sending node according to any one of the claims 13-21, further comprising property selection means (33) for selecting at least one link property such as modulation, encoding, or antenna parameters, for the transmission.

23. A sending node for use in a heterogeneous communications network in which packets are routed between a source (11) and a destination (13), said sending node

being able to forward packets to at least two receiving nodes (15, 17, 19, 21) in the network and said node comprising protocol means (P1, P2, P3) for handling communication according to at least two access technologies, said node comprising

- transmission means (33, 37) for transmitting the set of packets to at least two receiving nodes
- receiving means for receiving acknowledgement information from each of the at least two receiving nodes regarding the transmission
- node selection means for selecting one of the at least two receiving nodes from which the set of packets is to be forwarded to a next receiving node, based on the acknowledgement information.

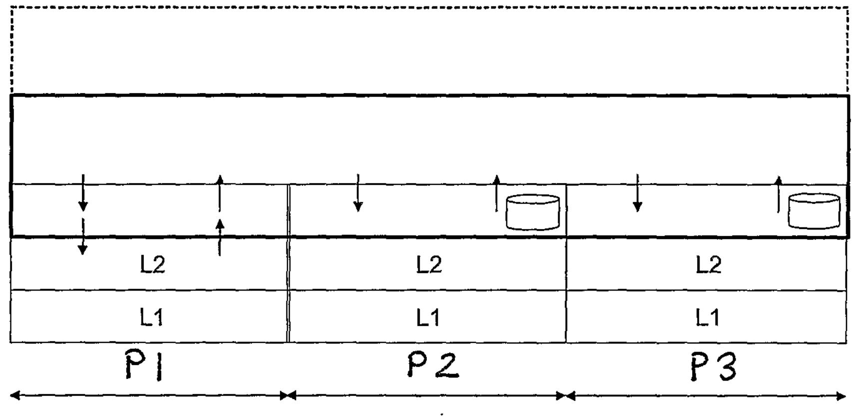


Fig. 1

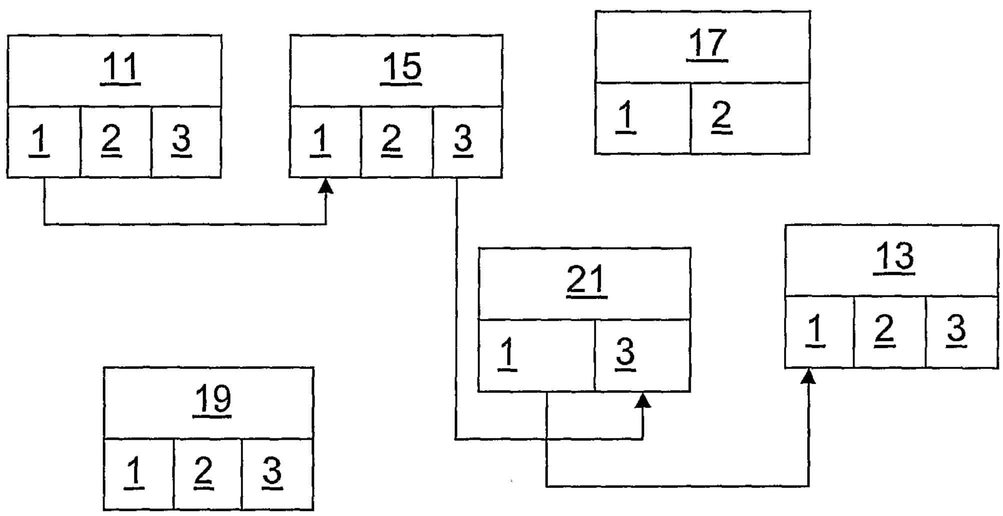


Fig. 2

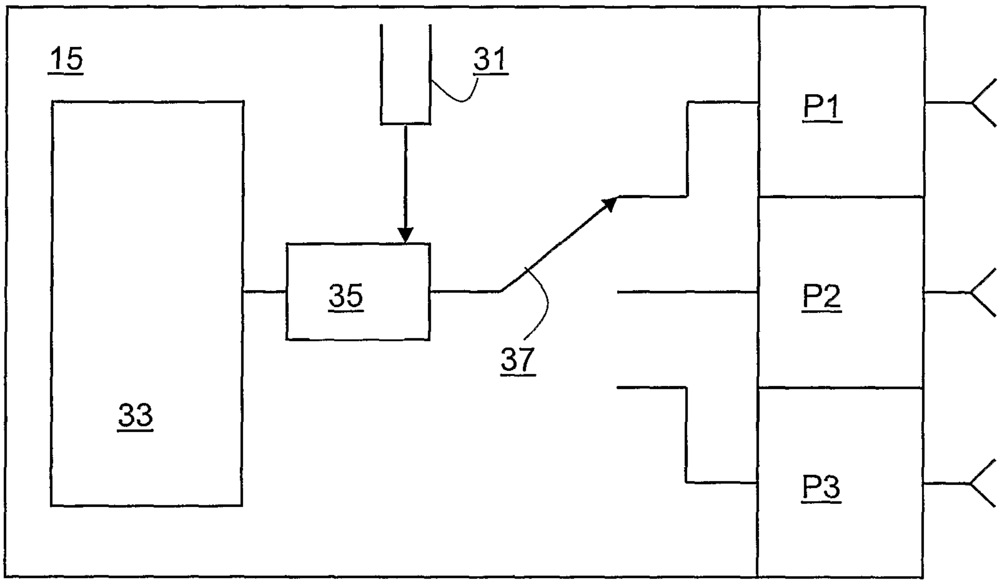


Fig. 3

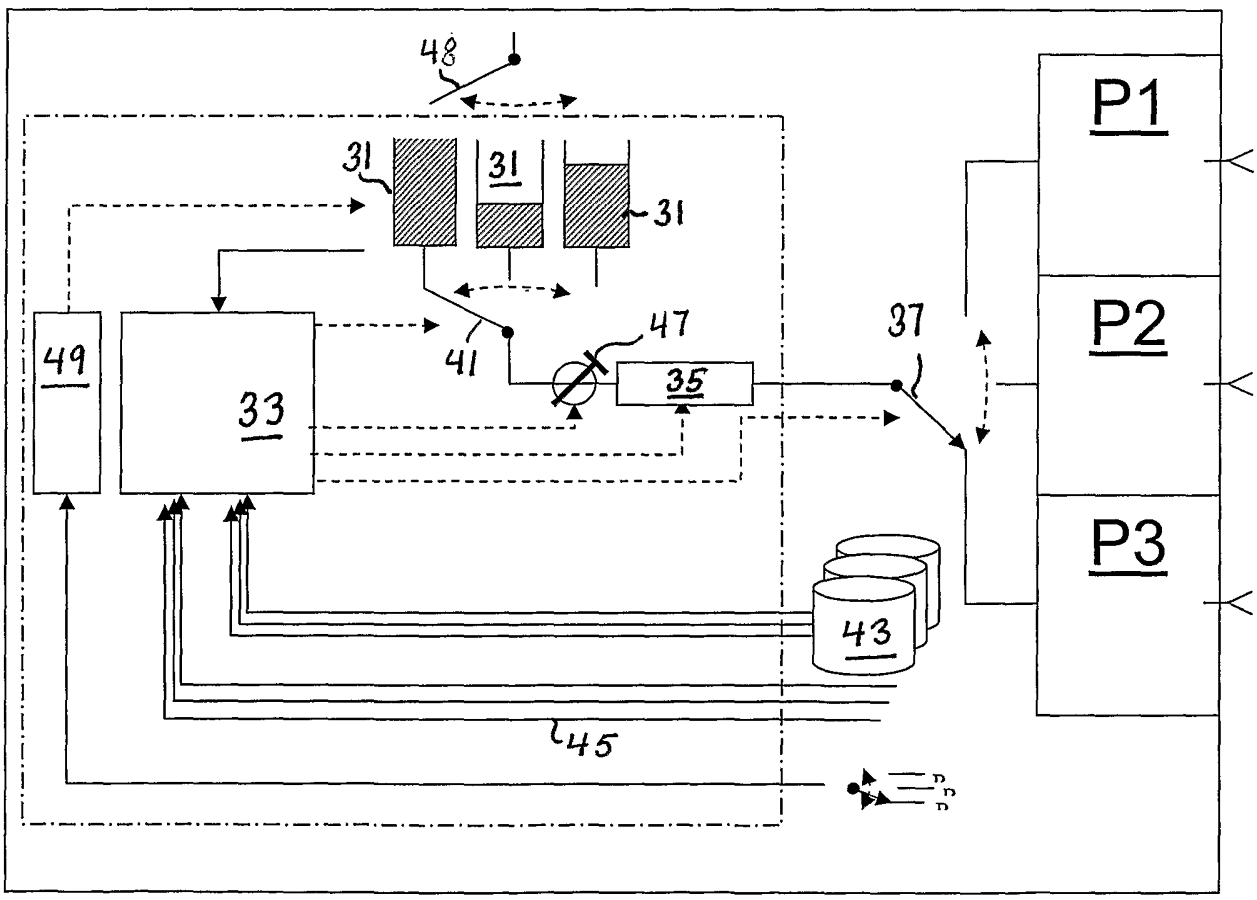


Fig. 4

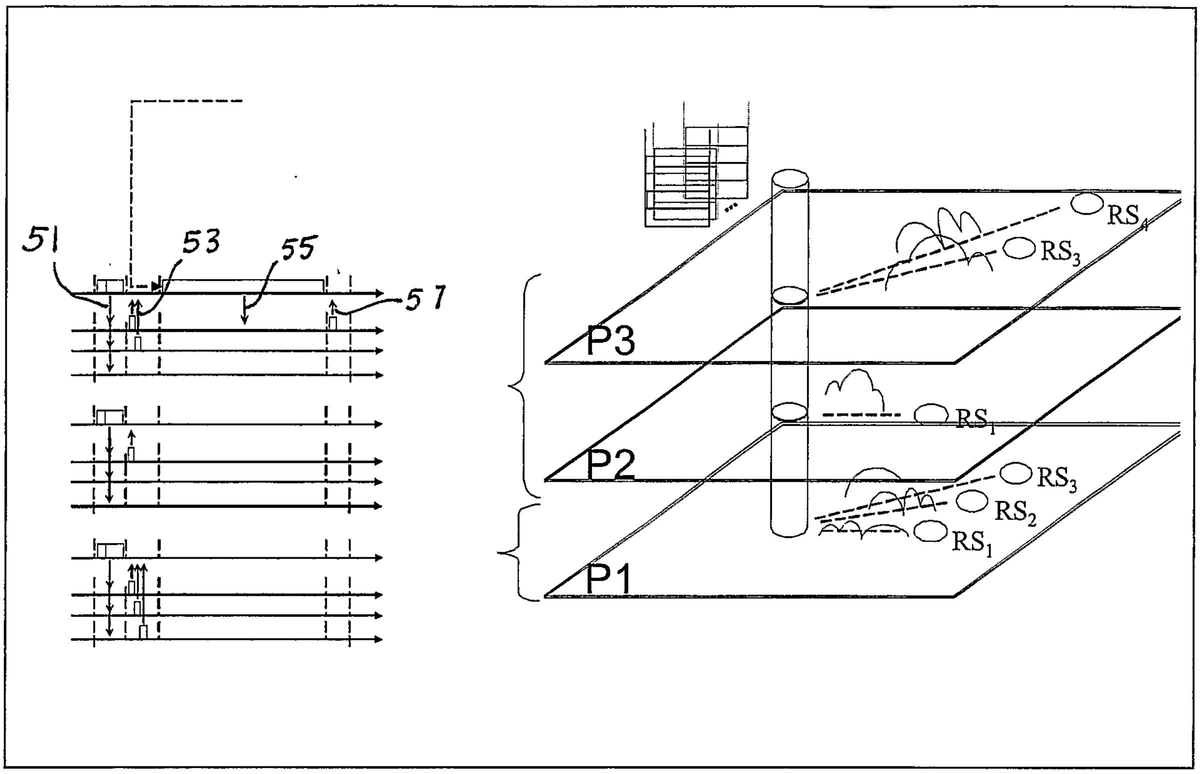


Fig. 5

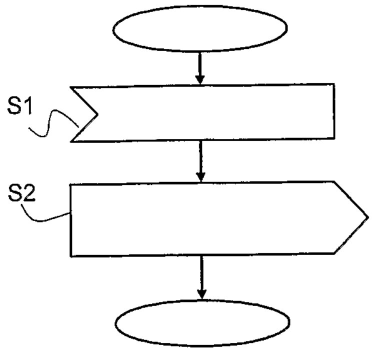


Fig. 6a

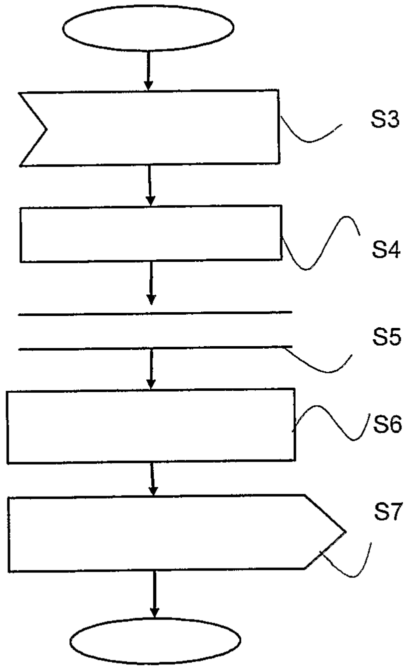
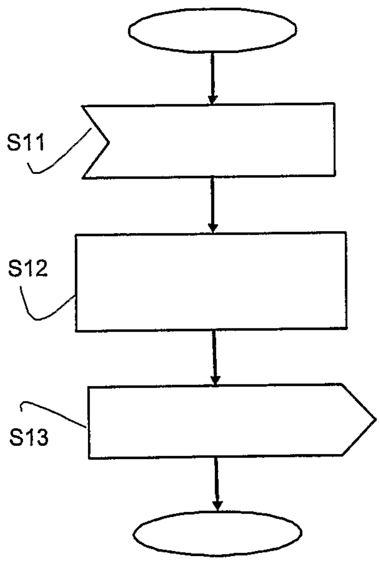


Fig. 6b



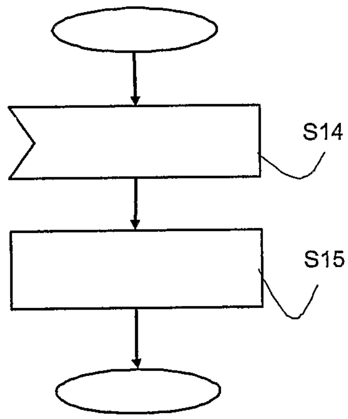


Fig. 7b

Fig. 7a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/001640

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 12/56, H04Q 7/38
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, H04Q

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.
X	US 20030108062 A1 (AGRAWAL, P ET AL), 12 June 2003 (12.06.2003), paragraphs [0003]; [0009]; [0015], figure 1, abstract --	1-23
X	US 20030156543 A1 (SAHINOGLU, Z ET AL), 21 August 2003 (21.08.2003), paragraphs [0002]-[0003]. figure 2, claims 1-4, abstract --	1-23
A	EP 1435708 A2 (ALCATEL), 7 July 2004 (07.07.2004), paragraphs [0014]-[0015], abstract --	1-23

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

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"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
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"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
14 June 2005	16 -06- 2005
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Nabil Sebaa /LR Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1408651 A2 (BROADCOM CORP), 14 April 2004 (14.04.2004), paragraphs [0045]-[0052], claim 1, abstract --	1-23
A	US 20040218605 A1 (GUSTAFSSON, E ET AL), 4 November 2004 (04.11.2004), figure 8, abstract --	1-23
A	WO 0251052 A2 (COMGATES LTD), 27 June 2002 (27.06.2002), page 1, line 4 - line 7, abstract --	1-23
A	EP 1453248 A2 (NTT DOCOMO, INC), 1 Sept 2004 (01.09.2004), figure 1, abstract -- --------	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/04/2005

International application No.
PCT/SE 2004/001640

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				WO	03071750	A	28/08/2003
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EP	1408651	A2	14/04/2004	US	20040133668	A	08/07/2004
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				US	20030141093	A	31/07/2003
EP	1453248	A2	01/09/2004	CN	1525661	A	01/09/2004
				JP	2004320702	A	11/11/2004
				US	20040252696	A	16/12/2004