

Title: Connecting system, inverse multiplexer, data communication network, method and computer program

The invention relates to a telecommunication network connecting a first subnetwork and a second subnetwork, preferably via a number of local loop telephone lines, a connecting device for use in such a telecommunication network, a method for transmitting data between a first subnetwork and a second subnetwork and a computer program.

PCT Patent Application WO 02/41660 describes how inverse multiplexing can be used to distribute data communication between a computer system and the Internet over a plurality of telephone lines, so that a combined bandwidth is obtained which is higher than the bandwidth over a single telephone line. For the connection of computer systems in houses with networks located outside the houses, such as the Internet, a wide range of possible connections with networks is known, such as dial-up lines, ISDN lines and ADSL lines and cable television connections. Such networks will be referred to as telecommunication networks in the sense that the network connects nodes remote from each other, in different buildings, with each other, without this being limited to the telephone network.

In this application, the following italicized terms are understood to mean at least the following, respectively. A *network* is formed by two or more nodes which are at least indirectly connected with each other. A *(network) node* is at least understood to mean: any device, such as for instance a computer, switching device, or other device, present in a data communication network and connected with one or more other nodes by means of a connection. A(n) *(network) end node* is a network node located at the end of a network, such as for instance a client computer in a client-server network or a telephone in a telephone network. In general, an

end node generates data, while other nodes only transmit data. A *connection* is understood to mean a physical connection between at least two network nodes which is suitable for the transmission of data-representing signals between the network nodes. A connection may be any suitable medium such
5 as for instance a cable or a wireless radio connection. A connection between nodes in two different (sub)networks is referred to as an *inter(sub)network connection*, while an *intra(sub)network connection* is understood to mean a connection between nodes in the same (sub)network.

A *multiplexer* is at least understood to mean: a device or apparatus
10 which can combine at least two separate flows of data signals into one single flow of multiplex data signals. In this application, this symbol is used for a multiplexer: mux. A *demultiplexer* is a device which can recover the original flows of data signals from a flow of multiplex data signals. This symbol is used for a demultiplexer: demux. An *inverse multiplexer* is a device or
15 apparatus which can split one single flow of data signals into at least two separate flows of inverse multiplex data signals. This symbol is used for an inverse multiplexer: mux⁻¹. An *inverse demultiplexer* is a device or apparatus which can combine flows of inverse multiplex data signals into the original, single flow of data signals. This symbol is used for an inverse
20 demultiplexer: demux⁻¹.

It is noted that both (de)multiplexers and inverse (de)multiplexers may have been arranged to simultaneously operate on two or more incoming flows. It is also noted that both (de)multiplexers and inverse (de)multiplexers are generally known per se in the field of data
25 communication, for instance from Alex C. Snoeren, 'Adaptive Inverse Multiplexing for Wide-Area Wireless Networks', in *Proceedings of IEEE GlobeCom*, Rio de Janeiro, December, 1999. Luiz Magalhaes and Robin Kravets, 'End-to-End Inverse Multiplexing for Mobile Hosts', in *Proceedings of the 19th Brazilian Symposium on Computer Networks*, Florianopolis,

Brazil, 2001 and K. Sklower et al, 'The PPP Multilink Protocol', *IETF RFC* 1990, August, 1996.

Data communication networks with subnetworks connected via a connecting system are generally known. For instance, for the connection of
5 computer systems in houses with networks located outside the houses, such as the Internet, there is a wide range of possible data communication networks.

Known are, for instance, networks where there is one single connection per house, with which one single end node, such as a personal
10 computer present in the house, is connected with a dial-up server. The connection may, for instance, comprise a POTS (plain old telephone system) or an ISDN (integrated services digital network) line and modems and other network equipment suitable for this. In this case, the end node forms the
only node in a first subnetwork in the house, while the dial-up server forms
15 a node in a second subnetwork located outside the house, which connects the first and second network. However, such a configuration is inefficient because the available capacity of the connection between the subnetworks is not utilized or not completely utilized for most of the time.

It is also known, when there are multiple end nodes in a house, to
20 connect these with a network located outside the house. It is, for instance, known to provide an internal network in a house which comprises multiple end nodes, for instance personal computers, and a node connecting the internal network with the network located outside it, for instance a home router. This internal network then forms a first subnetwork completely
25 located inside the house. The connecting node can then be connected with another subnetwork outside the house, for instance the Internet or the like, by means of a suitable data connection. In that case, by statistical multiplexing, the available capacity of the connection between the subnetworks can be utilized more optimally than when only one end node is
30 present in the first subnetwork, because, with statistical multiplexing, the

peaks and troughs in the data flows generated by the different end nodes can average each other out.

However, in particular in networks with computer systems in houses of consumers, but also in other networks, there is a need for an increase of the throughput of data both from and to the end nodes. The throughput to
5 the end nodes is also referred to as "download speed", while the throughput from the end nodes is also referred to as upload speed". For increasing a throughput, different solutions are known, such as for instance replacing a narrowband connection by a broadband connection for each individual
10 house. For instance, an asymmetric digital subscriber line (ADSL) or a data connection via the television cable of the house with a network located outside the house can be installed to replace a POTS or ISDN line. With these known broadband connections, a download speed can be obtained which is usually between 0.5 and 2 Mbps and an upload speed between 0.1
15 and 0.5 Mbps.

However, these known solutions for increasing the throughput have the drawback that, although the throughput is sufficient by current standards, there will be a need for a further increase of the throughput in the (near) future. However, increase of this throughput requires great and
20 expensive adjustments to the existing infrastructure, such as for instance the installation of glass fiber cables into the house.

The inverse multiplexing and/or demultiplexing described in PCT Patent Application WO 02/41660 meets this need for increase of the bandwidth. However, the proposed solution has the drawback that each
25 connection can only be used by the end nodes in one individual house. As a result, the bandwidth is utilized inefficiently in time because, for a great part of the time, the maximum available data capacity is not completely used by the end node, for instance because the users of the end nodes are absent for a great part of the time or utilize only a part of the available
30 capacity.

Summary of the invention

It is the general object of the invention to provide an improved
5 connecting system for connecting a first subnetwork and a second
subnetwork in a data communication network. In particular, it is the object
of the invention to provide a connecting system by means of which the
throughput between subnetworks can be utilized more efficiently and can
simply be increased.

10 To this end, the invention provides a network according to claims 1
and 2. In such a network, the throughput between subnetworks in a data
communication network can be utilized more efficiently. The data
transmitted from or to a node, such as a personal computer or a bundling of
personal computers, are distributed over the multiple intersubnetwork
15 connections such as local loop telephone lines by inverse multiplexing. For
this purpose, different nodes share the multiple intersubnetwork
connections. Each of the nodes is capable of receiving and/or transmitting
original data which are transmitted over the shared plurality of
intersubnetwork connections in an inverse-multiplexed manner. Thus, a
20 plurality of inverse multiplex/demultiplex subsystems is provided, each for a
respective node, while the different inverse multiplex/demultiplex
subsystems share the multiple intersubnetwork connections with each
other. On the side of the nodes, each inverse multiplex/demultiplex
subsystem comprises, for each node, an inverse multiplexer and/or
25 demultiplexer coupled to the node.

Preferably, for this, at each node, use is made of a separate
connecting device which is, on the one side, locally coupled to the node and a
intersubnetwork connection and, on the other side, remotely coupled to one
or more other(s) of such connecting devices. Such connecting devices are, for
30 instance, placed in different housings, each with a, for instance, regular

connection with a local computer and a, for instance, wireless transmission connection to corresponding connecting devices in neighboring housings. Here, the local connecting device provides the inverse multiplexing and/or demultiplexing of original data from or for the local node. One part of the
5 inverse multiplex signals is communicated via the local intersubnetwork connection and another part is communicated via the other connecting devices over other intersubnetwork connections. At least in this sense, the connections between the connecting devices form a subnetwork, without the term "subnetwork" implying whether it is possible or not to interchange
10 other messages outside of the intersubnetwork connections, for instance from computer to computer via the connecting device.

By using different inverse multiplexers and/or demultiplexers for different nodes, compared to the use of one central multiplexer for these nodes, less bandwidth is necessary for the combination of traffic from the
15 nodes to the inverse (de)multiplexers and from there to the different intersubnetwork connections.

The data transmitted from a node in the first subnetwork to the second subnetwork, by the inverse multiplexer over the intersubnetwork connections at least indirectly connected thereto, can be transmitted as
20 inverse multiplex data. The inverse multiplex data can be converted into the original data again on the second subnetwork side. An end node in the first subnetwork can thus use multiple intersubnetwork connections for transmitting data. The combined throughput of the intersubnetwork connections thus forms the total, maximum available throughput for that
25 end node.

Further, the throughput can simply be increased by connecting one or more extra intersubnetwork connections with the inverse multiplexer. In addition to providing the added intersubnetwork connection(s), this requires no further infrastructural adjustments such as for instance changing the
30 type of connection. Then, the data flows can simply be distributed over the

already existing and the added intersubnetwork connections via the at least one inverse multiplexer.

When, in the first subnetwork, multiple nodes are connected with the connecting system, which each generate a data flow with a varying size, the fluctuations in the separate data flows of the nodes can mutually compensate each other. Due to this, the data flows of inverse multiplex signals obtained from the separate data flows can have a uniform size. The maximum throughput of the intersubnetwork connections is utilized more efficiently due to the uniform size. Further, then, proportionally less reserve capacity for accommodating for peaks needs to be present.

Specific examples of embodiments of the invention are set forth in the claims. Further details and aspects of the invention will be discussed in the following by way of example with reference to the Figures shown in the drawing, in which:

Fig. 1 diagrammatically shows an example of a data communication network according to the invention.

Fig. 2 diagrammatically shows a block diagram of an example of an inverse multiplexer suitable for use in the example of Fig. 1.

Fig. 3 diagrammatically shows a block diagram of an example of an inverse demultiplexer suitable for use in the example of Fig. 1.

Fig. 4 diagrammatically shows a block diagram of an example of a connecting system according to the invention.

Fig. 5 diagrammatically shows a block diagram of an example of subnetwork and a connecting system connected thereto for in a data communication network according to the invention.

Fig. 6 shows a graph which illustrates statistical multiplexing.

The example shown in Fig. 1 comprises a first subnetwork 1 and a second subnetwork 2. The second subnetwork may, for instance, be a high-speed Internet and the first subnetwork may, for instance, comprise one or more further networks in houses or networks between houses.

The first subnetwork 1 and the second subnetwork 2 are connected with each other via a connecting system comprising intersubnetwork connections 30,31. Both on a first subnetwork side where they are connected with the first subnetwork 1 and on a second subnetwork side where they are
5 connected with the second subnetwork 2, the intersubnetwork connections 30,31 are connected with a routing unit 10,11;20.

The first subnetwork 1 comprises network nodes 10-15. The network nodes 10-15 comprise network end nodes 12-15 connected with routing units 10 and 11, respectively, via intrasubnetwork connections 33-38. The
10 nodes 10-15 may each be located in separate buildings, for instance houses. It is also possible that two or more nodes are in the same building. Here, the nodes 10-15 may have a physically separate design or form an integrated whole. For instance, a general-purpose computer may simultaneously be used as a client computer, for instance for sending e-mail, and operate as a
15 router. From a functional point of view, the general-purpose computer then comprises two nodes, that is, an end node (client computer) and a connecting node directly connected therewith (the router), but is physically one integral whole (that is, the general purpose computer). It is also possible, for instance, to have a general-purpose computer function as a server for other
20 computers connected with the general-purpose computer and simultaneously as a router for data transmitted from or to these other computers.

The second subnetwork 2 comprises three nodes 20-22, of which a routing unit 20 is connected via the intersubnetwork connections 30, 31
25 with the first subnetwork 1. The routing unit 20 is connected via respective intrasubnetwork connections 39,40 with the end nodes 22,21. In the first subnetwork 1 in Fig. 1, a first routing unit 10 is directly connected with the network nodes 12,13 in a first subnetwork 1, via intrasubnetwork connections 33,35. A second routing unit 11 is directly connected with end
30 nodes 13-15 via respective intrasubnetwork connections 36-38. The end

nodes 12 and 13 are also directly connected with each other by means of an intrasubnetwork connection 34. The two routing units 10,11 are directly connected with each other via an intrasubnetwork connection 32.

It is noted that the nodes 12,13 connected with the first routing unit 10 and the first routing unit 10 can together be considered a first subsubnetwork in the first subnetwork 1. The nodes 13-15 connected with the second routing unit 11 and the second routing unit can be considered a second subsubnetwork in the first subnetwork 1.

A network according to the invention may also have a different topology than that shown in Fig. 1. For instance, the subnetworks 1,2 may have a ring topology or differ otherwise. In particular, the subnetworks 1,2 may contain more or fewer nodes, comprise more or fewer subsubnetworks, be connected with further subnetworks or differ otherwise from the example shown in Fig. 1. Further, the first and second subnetwork 1,2 may be connected with each other by means of more or fewer than the number of intersubnetwork connections shown in Fig. 1 and/or each contain more or fewer routing units than shown in Fig. 1.

The routing units 10,11 in the first subnetwork 1 each comprise an inverse multiplexer (mux⁻¹), which may, for instance, be designed like the example shown in Fig. 3, which is described in more detail below. However, the inverse multiplexer may also have a different design. The routing unit 20 in the second subnetwork 2 comprises an inverse demultiplexer, which may, for instance, be designed like the example shown in Fig. 3 or otherwise.

The inverse multiplexer in the first routing unit 10 is arranged to receive data signals transmitted from those end nodes 12,13 to the second subnetwork 2. In the example shown, the inverse multiplexer in the first routing unit 10 is arranged to receive a data flow of original data signals from the end node 12 via the intrasubnetwork connection 33 and a data flow of original data signals from the end node 13 via the intrasubnetwork

connection 35 and to distribute the incoming data flows over the intersubnetwork connections 30,31 by means of inverse multiplexing.

The second routing unit 11 in the first subnetwork 1 is also provided with an inverse multiplexer which distributes the incoming data flows from end nodes 13-15 in a similar manner over the intersubnetwork connections 30,31. The data flows to the second subnetwork from the end nodes 12,13 and 13-15, respectively, in the first subnetwork 1 are distributed over the two intersubnetwork connections 30,31 by the inverse multiplexers in the routing units 10,11.

The inverse multiplexers process the received, original data signals in the incoming data flows into inverse multiplex data signals. The inverse multiplex data are transmitted by the inverse multiplexer to the intersubnetwork connection 30,31 connected with the respective routing unit 10,11 and to one or more of the other routing units in the first subnetwork 1.

The inverse multiplexer in the routing unit 20 in the second subnetwork 2 may, for instance, be designed like the inverse multiplexer 200 in Fig. 3. However, the inverse multiplexer may also have a different design. The inverse demultiplexer is arranged to receive data flows of inverse multiplex data transmitted by the inverse multiplexers over the intersubnetwork connections 30,31. The inverse multiplexer in the routing unit 20 recovers the original data signals from inverse multiplex data and transmits the recovered original data signals on, for instance to nodes 21,22.

By the inverse (de)multiplexers in the example shown in Fig. 1, the nodes in the second subnetwork 2 receive the original data coming from the (end) nodes in the first subnetwork 1, while all nodes 10-15 in the first subnetwork 1 can use the data throughput of multiple intersubnetwork connections 30,31 present. For each of the nodes 10-15 in the first subnetwork 1, the maximum throughput is thus the added throughput of the intersubnetwork connections 30,31. The maximum throughput can

simply be increased by adding intersubnetwork connections and providing suitable inverse (de)multiplexers.

In the example of Fig. 1, the inverse multiplexers in the two routing units 10,11 transmit inverse multiplex data to the other routing unit in the first subnetwork 1 via the intrasubnetwork connection 32 directly
5 connecting the routing units 10,11 with each other. However, the inverse multiplex data may also be transmitted via an indirect connection. For instance, in the example of Fig. 1, by the inverse multiplexer, inverse multiplex data can be transmitted from the first routing unit 10 to the
10 second routing unit 11 in the first subnetwork 1 via the intrasubnetwork connections 35,36 and the node 13.

For transmitting the inverse multiplex data signals to the second subnetwork 2, the inverse multiplex data signals contain destination data indicating that the inverse multiplex data are to be transmitted to the
15 second subnetwork 2. The routing units 10,11 then transmit the inverse multiplex data received from the other routing unit over the intersubnetwork connections 30,31. Thus, by the inverse multiplexers, the incoming data flows from the end nodes 12-15 are distributed over two or more of the intersubnetwork connections 30,31 present as outgoing flows of
20 inverse multiplex data. However, the inverse multiplex data may also be directed to the second subnetwork in a different manner. For instance, the inverse multiplexer may transmit the inverse multiplex data to the intersubnetwork connections via one or more separate data channels connecting the inverse multiplexers with the other intersubnetwork
25 connections 30,31 and over which no other types of data are transmitted.

The inverse multiplexer may be designed such that it distributes the inverse multiplex data over the intersubnetwork connections 30,31 according to a predetermined distribution criterion. The inverse multiplexer can then distribute the data with or without mutual tuning to the other
30 inverse multiplexers in the first subnetwork 1. For instance, each inverse

multiplexer can split, without tuning, the incoming data flow of each end node 12-15 into two or more flows of inverse multiplex data of the same size and transmit these to each of the intersubnetwork connections 30,31. When the intersubnetwork connections 30,31 have a throughput which is of
5 substantially the same size, the intersubnetwork connections 30,31 are equally loaded.

Further, by statistical multiplexing, without further complex control devices, a uniform load of the intersubnetwork connections can be realized because peaks and troughs in the data flows transmitted from each of the
10 routing units 10,11 to the respective intersubnetwork connection 30,31 can average each other out in time and are relatively less strong.

As illustrated in Fig. 6, for instance the data flows S_1 from one inverse multiplexer may have a peak p_1 with a size of 100%, as indicated by arrow B, of the average size of the data flow, as indicated by arrow A, at
15 time t_1 and the data flows S_2 from a different inverse multiplexer may be equally great on average in time, but have a peak p_2 of 100% of the average size at time t_2 . Then, the relative peak heights of the peaks p_{t_1} at t_1 and p_{t_2} at t_2 in the flow S_t of the added inverse multiplex data is lower (50% of the average size of the added flows, as indicated by arrows C and D) than in the
20 separate flows of inverse multiplex data. Further, by buffering in, for instance, the routing unit, peaks can be spread in time, so that the (relative) peak height is likewise reduced.

However, the distribution criterion may also have a different design. For instance, the inverse multiplexers may be arranged to split the
25 incoming original data into two or more different flows of inverse multiplex data whose sizes are proportional to the throughput of the intersubnetwork connection through which the respective flow is transmitted, for instance when the intersubnetwork connections 30,31 have different throughputs.

However, other distribution criteria are also possible, for instance
30 based on the number of nodes connected with an intersubnetwork

connection, the number of intersubnetwork connections connected at least indirectly with an inverse multiplexer or the like.

Fig. 2 diagrammatically shows an example of an inverse multiplexer 100 suitable for use in a network or a routing unit according to the invention. The example shown of an inverse multiplexer 100 comprises data inputs 101 for receiving incoming data flows. A multiplexer element 110 is connected with data inputs 101. The data inputs 101 may, for instance, be (indirectly) connected with end nodes. The multiplexer element 110 multiplexes the incoming data flows to a single flow of multiplex data. In this example, the multiplex element 110 can be omitted if only one node is connected with the inverse multiplexer 100.

By the multiplex element 110, the flow of multiplex data is added to an inverse multiplex element 120 connected with the multiplex element 110. The inverse multiplex element 120 splits the single flow of multiplex data into multiple flows of inverse multiplex data, by subjecting the multiplex data to an inverse multiplex process known per se, which results in inverse multiplex data. The flow of inverse multiplex data is presented by the inverse multiplexer to the inverse multiplex data outputs 102. In the example of Fig. 1, the inverse multiplex data outputs may, for instance, be connected with the intersubnetwork connection 30,31 and/or the intrasubnetwork connection 32 between the routing units 10,11.

After receipt in the second subnetwork 2, the different flows of inverse multiplex data can be converted into the flows of original data again, for instance by the example of an inverse demultiplexer 200 shown in Fig. 3. The example shown in Fig. 3 comprises two inverse multiplex data inputs 201 for receiving incoming flows of inverse multiplex data. An inverse-demultiplexed element 220 is connected with the inverse multiplex data inputs 201. The inverse multiplex element 220 combines the incoming inverse multiplex data into one outgoing data flow by inverse demultiplexing the incoming inverse multiplex data. In the case that the

inverse multiplex data are generated with the inverse multiplexer 100 of Fig. 2, this results in the multiplex data. The outgoing data flow is supplied by the inverse demultiplexer 220 to a demultiplexer 210 connected with the inverse multiplexer 220. The demultiplexer 210 recovers the flows of
5 original data from the incoming flow of multiplex data. The recovered original data are then supplied by the demultiplexer 210 to data outputs 202, which may, for instance in Fig. 1, be connected with nodes 21,22.

Fig. 4 diagrammatically shows a block diagram of an example of a
10 connecting system according to the invention. The connecting system comprises routing units 10a-10c, on a first subnetwork side 1', which are connected with routing units 20a-20c on a second subnetwork side 2' by means of intersubnetwork connections 301-303.

The routing units 10a-10c and 20a-20c, respectively, are provided
15 with transmission equipment, not shown and known per se, to receive incoming data and to transmit them via an output suitable for the destination of the data. The lines in Fig. 4 represent physical connections, whereas the arrows represent communication between different entities, while use may then be made of the transmission equipment (not shown) in
20 the routing units and the physical connections present.

The routing units 10a-10c are each connected with each other by means of intrasubnetwork connections 130,131. The routing units 10a-10c are also connected with further nodes 1-n₁, 1-n₂ and 1-n₃, respectively, in the first subnetwork 1 by means of intrasubnetwork connections 310,311,
25 312,313, and 314,315, respectively. The routing units 20a-20c are each mutually connected by means of intrasubnetwork connections 230,231. The routing units 20a-20c are further connected with nodes 1-p₁, 1-p₂ and 1-p₃, respectively, in the second subnetwork 2 by means of intrasubnetwork connections 320,321, 322,323 and 324,325, respectively.

The routing units 10a-10c on the first subnetwork side 1' each comprise a local (de)multiplexer, loc (de)mux 111, which is connected with the intrasubnetwork connections 310,311, 312,313 and 314,415, respectively. The loc (de)mux 111 is connected with an inverse (de)multiplexer 121 (demux⁻¹). The inverse (de)multiplexer 121 in each of the routing units 10a-10c can present a flow of inverse multiplex data to a system (de)multiplexer, sys (de)mux 112 in the respective routing unit, as indicated by the arrows 143, 144 and 146, respectively. The inverse (de)multiplexer 121 can also transmit flows of inverse multiplex data to system (de)multiplexers 112 in the other routing units, as indicated by the double arrows 140,145, 141,142 and 147,148, respectively. The system (de)multiplexers 112 are communicatively connected with the intersubnetwork connections 301, 302 and 303, respectively.

As indicated by the arrows in Fig. 4, the routing units 10a-10c; 20a-20c can process data flows both in an upward direction, from the first subnetwork side 1' to the second subnetwork side 2', and in a downward direction, opposite to the upward direction, from the second subnetwork side 2' to the first subnetwork side 1'.

Here, the (inverse) (de)multiplexers 111, 112, 121 on the first subnetwork side 1' function as (inverse) multiplexers for data transmitted from the first subnetwork side 1' to the second subnetwork side 2', while they function as (inverse) demultiplexers for data flowing from the second subnetwork side 2' to the first subnetwork side 1'. Conversely, the (inverse) (de)multiplexers 211, 212, 221 on the second subnetwork side 2' function as (inverse) demultiplexers for data transmitted from the first subnetwork side 1' to the second subnetwork side 2', while they function as (inverse) multiplexers for data flowing from the second subnetwork side 2' to the first subnetwork side 1'.

In use, data destined for the second subnetwork side 2' coming from the nodes 1-n₁, 1-n₂ or 1-n₃ connected with the respective routing

unit 10a-10c are supplied to the respective loc (de)mux 111. The loc (de)mux 111 multiplexes these data flows to a flow of multiplex data and presents these to the inverse (de)multiplexer 121. Each of the local (de)multiplexers 111 thus receives only data from the nodes 1-n₁, 1-n₂ and 5 1-n₃, respectively, which are connected to the respective routing unit 10a-10c. The inverse (de)multiplexer 121 inverse-multiplexes the multiplex data in two or more flows of inverse multiplex data. Those flows are each presented to a different system (de)multiplexer 112 by the inverse multiplexer 121. The system (de)multiplexers 121 thus receive flows of 10 inverse multiplex data from the different routing units 10a-10c. The system (de)multiplexers 121 combine the incoming inverse multiplex data flows to one single flow of data which is transmitted over the intersubnetwork connections 301 connected with the respective (de)multiplexer to the second subnetwork 2.

15 The flow of data transmitted to the second subnetwork 2 is, on the second subnetwork side 2', for each of the intersubnetwork connections 301-303, received by a system (de)multiplexer 212 in each of the routing units 20a-20c. In use, each of these system (de)multiplexers 212 carries out an operation which is substantially opposite to the method of the 20 system (de)multiplexers 112 on the first subnetwork side 1'. The system (de)multiplexers 112 thus recover the flows of inverse multiplex data which have been transmitted from the inverse demultiplexers 121 on the first subnetwork side 1', by demultiplexing the incoming data into two or more flows of demultiplexed data. The flows of recovered inverse multiplex data 25 are then presented by the system (de)multiplexers 212 to both an inverse (de)multiplexer 221 in the respective routing unit 20a-20c, as indicated by the arrows 244, 246 and 243, respectively, and to the inverse (de)multiplexers 221 in the other routing units 20a-20c, as indicated by the arrows 240-242, 245, 247 and 248, respectively, which may, for instance, be

carried out by transmitting these flows over the intrasubnetwork connections 230, 231 to the respective inverse (de)multiplexers.

The inverse (de)multiplexers 221 combine the different incoming flows of recovered inverse demultiplex data to a flow of inverse demultiplexed data by a method which is substantially the inverse of the method carried out by the inverse (de)multiplexers 121 in the first subnetwork. The inverse (de)multiplexers 221 in routing units 20a-20c on the second subnetwork side 2' thus recover the multiplex data transmitted from the local (de)multiplexers 111.

The recovered multiplex data are presented by the inverse (de)multiplexers 221 to local (de)multiplexers 211, which recover the original flows of data from the recovered multiplex data. The local (de)multiplexers 211 present the recovered original data to an intrasubnetwork connection 320-325 which matches the data and transmits the data over this to nodes 1-p₁, 1-p₂ and 1-p₃, respectively, in the second subnetwork 2.

For data transmitted from the second subnetwork 2 to the first subnetwork 1, the routing units 20a-20c on the second subnetwork side 2' operate in a similar manner to the routing units 10a-10c on the first subnetwork side 1' processing data transmitted from the first subnetwork 1 to the second subnetwork 2. The routing units 10a-10c on the first subnetwork side 1' operate in a similar manner to the routing units 20a-20c on the second subnetwork side 2'.

It is noted that, in the example of Fig. 4, the system (de)multiplexers can be omitted if there is only one routing unit in the respective subnetwork, such as for instance shown in Fig. 5 in the second subnetwork. Also, the local (de)multiplexer can be omitted if the respective routing unit is connected with only one intrasubnetwork connection.

The example diagrammatically shown in Fig. 5 comprises a first subnetwork 1 with end nodes E1-E3, for instance computers in different

houses. Each of the end nodes E1-E3 is connected with a local inverse (de)multiplexer 100. The local inverse (de)multiplexers 100 each have an inverse multiplexer input with which they are connected with the respective end node and two or more inverse multiplexer outputs. The inverse
5 multiplexer outputs are each connected with a system (de)multiplexer, in the present example designed as a routing element R1-R3 having the functionality of a system (de)multiplexer, as is described in more detail hereinbelow. Each of the local inverse (de)multiplexers 100 is connected with a separate routing element R1-R3. Each of the routing elements R1-R3
10 is connected both with the other routing elements and with an intersubnetwork connection 301-303.

The end nodes E1-E3 can each transmit data to a local inverse (de)multiplexer 100 connected with the end node E1-E3. The local inverse (de)multiplexers 100 can each split this flow of data into two or more flows
15 of inverse multiplex data. Via the inverse multiplexer outputs, the flows of inverse multiplex data can be presented to inputs of the routing elements R1-R3. The routing elements R1-R3 transmit a part of the incoming flows of inverse multiplex data to an intersubnetwork output connected with the intersubnetwork connection 301-303. Another part of the flows of inverse
20 multiplex data is transmitted to the other routing elements R1-R3.

Thus, each routing element R1-R3 receives not only inverse multiplex data from the local inverse (de)multiplexer 100 directly connected therewith, but also flows of inverse multiplex data coming from the other routing elements R1-R3. The flows of inverse multiplex data coming from
25 the other routing elements R1-R3 are guided to the intersubnetwork output by the respective routing element R1-R3 and mixed with the flow of inverse multiplex data coming from the local inverse (de)multiplexer directly connected with the respective routing element. The routing elements R1-R3 thus function as system (de)multiplexers. The data flow coming from an end
30 node is thus distributed over two or more intersubnetwork

connections 301-303, in this example all intersubnetwork connections present.

It is also possible that instead of the end nodes E1-E3, one or more subsubnetworks are connected with the inverse multiplexer. For instance, network servers may be provided at the location of the end nodes E1-E3, which network servers are then connected with further nodes in the respective subsubnetwork. The subsubnetworks may, for instance, be Internet networks in different houses, and the network server may be the Internet server of an Internet provider. These subsubnetworks can then be connected by means of the connecting system with a network in a different city, so that the throughput speed between the networks in the different cities can be increased. In addition, the intersubnetwork connection can then have a wireless design, for instance by means of a radio link, or the intersubnetwork connection may comprise existing lines, such as a rented line, thereby avoiding the necessity for installing, for instance, glass connections between cities.

The intersubnetwork connections 301-303 on the second subnetwork side 2' are all three connected with the same routing unit 20. The routing unit 20 comprises an inverse (de)multiplexer 222 and a local (de)multiplexer 211. The flows of inverse multiplex data from all three intersubnetwork connections 301-303 shown coming from the first subnetwork 1 are inverse-demultiplexed by the inverse (de)multiplexer 222 into a flow of data which is presented to the local (de)multiplexer 211. The local (de)multiplexer 211 demultiplexes this flow into multiple flows of data which are presented to suitable intrasubnetwork connections 320-321 in the second subnetwork 2'.

Existing subnetworks can simply be modified to the example shown in Fig. 5. For instance, an existing configuration in which there are one or more end nodes, that is, personal computers in the house which are connected via an ADSL (or cable) modem or router with a network located

outside the house (the Internet), can be modified to the example shown in Fig. 5. For instance the computer or the router can then be suitably provided with a computer program or hardware providing inverse multiplex functionality, and the routers in different houses can be wirelessly
5 connected with each other in a manner known per se. For instance, the routers can be connected by means of a Wireless local area network (WLAN) device known per se or meshed wireless network connections, such as for instance the systems available under the brand names of: Mesh networks, Rooftop networks and Hiperlan.

10 The intersubnetwork connection may also be wireless and comprise, for instance, a radio connection, thereby avoiding the necessity for installing special connections with high throughput capacity, for instance glass connections.

 In the example shown in Fig. 5, the ratio of the number of end nodes
15 to the number of intersubnetwork connections is 1:1, so that the average capacity available per end node is at least equal to that of one intersubnetwork connection. However, it is also possible to provide for a different ratio, for instance, multiple end nodes per intersubnetwork connection may be provided. It is also possible to provide a proportion of
20 multiple intersubnetwork connections per end node so that the average available capacity per end node is increased.

 The invention is not limited to the above-described examples. After reading the above, variants will be obvious to a skilled person. It is, for instance, obvious to design the invention as a computer program comprising
25 computer code for carrying out one or more steps of a method according to the invention when it is loaded in a programmable device, such as for instance a computer, a telephone exchange, a router or the like. Such a computer program may be provided on a physical (data) carrier, such as a magnetic storage medium, an optical data carrier, a medium for signal
30 transmission or other medium.

It is also obvious to design one or more elements in a device, although logically separate, in a physically integrated manner. For instance, in the example of Fig. 5, the inverse (de)multiplexers may be located in a same physical device as the end nodes, but, in this example, the inverse
5 (de)multiplexers may also be designed in a same physical device as the routing elements. Also, for instance, in the example shown in Fig. 4, different inputs or outputs may be designed as one physical connecting point where different data flows are inputted or outputted.

Preferably, for the intersubnetwork connections, use is made of "local
10 loop" telephone lines, with, for instance, normal, DSL or ADSL transmission. The term local loop is known to a skilled person and refers to the last, individual connections from the telephone network to the terminals with individual subscribers.

In the above-described, the first and the second subnetwork can
15 essentially be interchanged, so that what has been described about inverse multiplexing in the first subnetwork and inverse demultiplexing in the second subnetwork also applies to inverse demultiplexing in the first subnetwork and inverse multiplexing in the second subnetwork. However, the subnetworks do not need to be symmetrical. For instance, in the case of
20 communication over local loop lines, between terminals of different subscribers and an exchange, preferably, in the exchange, a common inverse multiplexer and/or demultiplexer is used for the different nodes. This common inverse multiplexer and/or demultiplexer then transmits respective recovered original data from different nodes on to different destinations, or
25 performs inverse multiplexing on messages for the different nodes in order to transmit the resulting inverse multiplex signals so as to be distributed over different local loop connections. One embodiment provides only inverse multiplexing on the side of the exchange and only inverse demultiplexing on the side of the subscriber terminals. This is sufficient in many applications
30 where much more data are transmitted to the nodes than from the nodes. In

that case, the original data can be transmitted over a single local loop connection from the nodes to the exchange without inverse multiplexing.

In another embodiment, a plurality of inverse multiplexers or demultiplexers are provided on the side of the exchange, for instance one for
5 each node. In this case, multiplex data from different nodes received via multiple intersubnetwork connections are guided to a selected demultiplexer, or original data coming from the subnetwork for different nodes are multiplexed by different inverse multiplexers and transmitted via multiple intersubnetwork connections.

10 The word "comprising" does not exclude the presence of one or more other elements than mentioned. The word "a" does not exclude more than one being used.

CLAIMS

1. A telecommunication network, comprising
 - a first subnetwork;
 - a plurality of nodes in the first subnetwork;
 - a plurality of intersubnetwork connections for connection of the first
 - 5 subnetwork to a second subnetwork, each intersubnetwork connection with a first subnetwork side and second subnetwork side;
 - a plurality of inverse multiplexers, each with an input which is connected with a respective node, which inverse multiplexers are arranged for receiving an original data signal transmitted from the node to the second
 - 10 subnetwork and inverse multiplexing the original data signal to a plurality of inverse multiplex data signal for transmitting the original data signal via the plurality of intersubnetwork connections in an inverse-multiplexed manner;
 - a plurality of system multiplexers, each connected with outputs of a
 - 15 plurality of the inverse multiplexers and at least one of the intersubnetwork connections, wherein each system multiplexer is connected with a different intersubnetwork connection, and the system multiplexers are arranged for transmitting the inverse multiplex data signals to the second subnetwork, wherein the inverse multiplex data signals are each transmitted over a
 - 20 different intersubnetwork connection; wherein each of the system multiplexers is arranged to receive and transmit inverse multiplex data signals from each of the inverse multiplexers.
2. A telecommunication network, comprising
 - a first subnetwork;
 - 25 - a plurality of nodes in the first subnetwork;

- a plurality of intersubnetwork connections for connection of the first subnetwork with a second subnetwork, each intersubnetwork connection with a first subnetwork side and second subnetwork side;
 - a plurality of inverse demultiplexers, each with an input which is
5 connected with a respective node, which inverse demultiplexers are arranged for receiving a plurality of inverse multiplex data signals, recovering an original signal transmitted from the second subnetwork from the inverse multiplex data signals and presenting the recovered signal to the respective node of the inverse demultiplexer;
 - 10 - a plurality of system demultiplexers, each connected with inputs of a plurality of the inverse demultiplexers and at least one of the intersubnetwork connections, wherein each system demultiplexer is connected with a different intersubnetwork connection, and the system demultiplexers are arranged for receiving the inverse multiplex data signals
15 from the second subnetwork, wherein the inverse multiplex data signals are each received over a different intersubnetwork connection; wherein each of the system demultiplexers has connections to transmit inverse multiplex data signals to each of the inverse demultiplexers.
3. A telecommunication network according to claim 1 or 2, wherein the
20 intersubnetwork connections comprise different local loop telephone connections.
4. A telecommunication network according to claim 3, wherein at least two nodes on the first subnetwork side are located in different buildings.
5. A telecommunication network according to any one of the preceding
25 claims, with routing units which each comprise a combination of one of the inverse multiplexers and one of the system multiplexers and/or a combination of one of the inverse demultiplexers and one of the system demultiplexers, wherein each routing unit, for interchanging the inverse multiplex data signals with the nodes, is, without intervention of one of the

other routing units, connected with a respective node, and via at least one of the routing units with the other nodes than the respective node.

6. A telecommunication network according to claim 5, wherein at least one of the routing units is connected via a regular connection with its
5 respective node, and is connected via a wireless transmission connection for communication with at least one of the other routing units for interchanging the inverse multiplex data signals with the other nodes than the respective node.

7. A telecommunication network according to one or more of the
10 preceding claims, wherein at least one of the at least two intersubnetwork connections is a broadband connection, such as an ADSL connection.

8. A telecommunication network according to claim 7, wherein at least one of the broadband connections has a data throughput speed between 0.5 and 2.0 Mbps in the direction from the second subnetwork to the first
15 subnetwork.

9. A telecommunication network according to one or more of the preceding claims, wherein the number of intersubnetwork connections is smaller than the number of nodes connectable with the connecting system in the first subnetwork.

20 10. A telecommunication network according to one or more of the preceding claims, wherein the number of intersubnetwork connections is equal to the number of end nodes in the first subnetwork connectable with the second subnetwork via the intersubnetwork connections.

11. A telecommunication network according to any one of the preceding
25 claims, wherein at least one of the inverse multiplexers is arranged for distributing the inverse multiplex data signals over the intersubnetwork connections connected with the inverse multiplexer according to a predetermined distribution criterion.

12. A telecommunication network according to claim 11, wherein the
30 inverse multiplexer is arranged for transmitting an amount of inverse

multiplex data signals over each of the intersubnetwork connections in proportion with the bandwidth of the respective intersubnetwork connection.

13. A telecommunication network according to claim 11 or 12, wherein
5 the inverse multiplexer is arranged for transmitting an amount of inverse multiplex data signals over each of the intersubnetwork connections in proportion with the number of intersubnetwork connections.

14. A telecommunication network according to any one of the preceding claims, wherein the second subnetwork comprises a shared inverse
10 demultiplexer and/or inverse multiplexer for inverse demultiplexing and/or multiplexing original data from and/or for the combined nodes.

15. A telecommunication network according to any one of claims 1-13, wherein the second subnetwork comprise a plurality of inverse demultiplexers and/or inverse multiplexers, each for inverse multiplexing
15 and/or multiplexing of original data from and/or for a respective node from the first subnetwork.

16. A connecting device for supporting the interchange of data signals between nodes and a subnetwork, which connecting device is provided with

- a terminal for a connection with a first node;
- 20 - a terminal for an intersubnetwork connection to the subnetwork;
- an inverse multiplexer and/or inverse demultiplexer, for inverse multiplexing and/or demultiplexing a local original message during communication with the subnetwork, wherein the inverse multiplexer and/or inverse demultiplexer converts the local message in a plurality of
25 multiplex data signals and/or recovers the local message from a plurality of multiplex data signals, respectively;
- a multiplexer element, coupled between the inverse multiplexer and the terminal for the intersubnetwork connections, and further provided with a connection for communication with a multiplexer element of at least one
30 other connecting device, wherein the multiplexer element is arranged to

- (a) communicate a first of the multiplex data signals for the local original message with the subnetwork via the intersubnetwork connection; and
- (b) communicate a second of the multiplex data signals for the local original message with the subnetwork via the multiplexer element at the at least one other connecting device; and
- (c) routing multiplex data signals from a non-local original message for further nodes between the intersubnetwork connection and the multiplexer element of the at least one other connecting device.
- 10 17. A connecting device according to claim 16, wherein the intersubnetwork connection is a local loop telephone connection.
18. A connecting device according to claim 16, wherein the connection for communication with the multiplexer element of the at least one other connecting device is a wireless transmission connection.
- 15 19. A connecting device according to claim 16, wherein the intersubnetwork connection is a broadband connection, such as an ADSL or cable connection.
20. A connecting device according to any one of claims 16-19, wherein the inverse multiplexer is arranged for distributing the inverse multiplex data signals over the intersubnetwork connection and the multiplexer element of the at least one other connecting device, according to a predetermined distribution criterion.
21. A method for transmitting data in a telecommunication network between a first subnetwork and a second subnetwork, comprising:
- 25 - inverse multiplexing of original data to inverse multiplex data signals;
- communicating the inverse multiplex data signals between the first subnetwork and second subnetwork over at least two intersubnetwork connections, wherein at least two of the inverse multiplex data signals are
- 30 each transmitted over a different intersubnetwork connection; and wherein

- multiple systems of inverse multiplex data signals, each system for original data from or to a respective node, are transmitted over the same said at least two intersubnetwork connections in a distributed manner in the first subnetwork.

5 22. A method according to claim 21, wherein the intersubnetwork connections are local loop telephone lines.

23. A computer program, comprising a program code for carrying out steps of a method according to claim 22 when the program code is loaded into a programmable device.