

Multitopology routing method and system

The invention relates, notably, to a method and system that
5 makes it possible to determine optimum routes for transferring
data streams, or information, in a routing system comprising a
number of multitopology-type routers, and making it possible
to distribute the routes in a meshed network to best busy the
resources needed to handle the streams.

10 The invention applies, for example, to networks that use the
Internet protocol IP, the data being transmitted in IP
packets.

The function of an IP router is to relay an IP packet arriving
at one of its interfaces to another interface based on the
15 destination IP address and on a switching table or Forwarding
Information Base (FIB). The switching table is constructed
from information collected by a routing protocol (identity of
the adjacent nodes, state and metrics of the links) and stored
in a routing data table, also called Routing Information Base
20 (RIB).

A multitopology-type router is capable of managing more than
one routing plan on a single physical topology. For each plan,
it maintains a switching table and, when a packet is switched,
it selects the switching table according to indicators read in
25 the packet header. The routing plans can be thought of as
being superimposed in a certain order. A plan is therefore
identified by its level or order number. A plan is
characterized by specific values of the link metrics,
independent of those of the other plans. The result of this is
30 that such a router calculates, based on routing data, as many
switching tables as there are routing plans. In a network made
up of such routers, a packet is relayed on each hop according
to its destination address and the routing plan to which it
belongs, this plan being determined by a characteristic

registered in the packet, for example, in the DSCP (Differentiated Services CodePoint) field of its IP packet header. Alongside the OSPF (Open Shortest Path First) routing protocol, there is thus a multitopology OSPF routing described in a standard recently published by the IETF (RFC 4915). The multitopology routers covered by this patent application can therefore be routers that implement a multitopology OSPF routing and a relay mechanism based on several independent routing tables. In a misuse of language, hereinafter, the term "topology" may signify "routing plan".

The prior art discloses numerous routing and resource management methods. Among these, there are:

- o signaling protocols: RSVP (Resource ReSerVation Protocol), RSVP-TE (Resource Reservation Protocol: Traffic Engineering), CR-LDP (Constraint-Routing Label Distribution Protocol);
- o routing protocols: OSPF (Open Shortest Path First), multitopology OSPF, OSPF-TE (OSPF Traffic Engineering), CSPF (Constrained Shortest Path First), etc.

However, these various methods do not make it possible to obtain a distributed and auto-adaptive routing solution that provides the streams that use the IP protocol with a quality of service QoS and, should there be a lack of resources, that drives an admission control on the streams according to operational importance. The requirements for obtaining such a solution are notably:

- finding the optimum paths for the information streams through a meshed network by taking into account the resources already reserved on each component of this meshed network,
- reserving resources for identifiable streams, by taking into account both the flow objectives to be met and the importance in maintaining these objectives throughout the life of the stream,

- arbitrating the order of passage of the streams in the event of a lack of resources, by rerouting the existing streams of lesser importance to routes less favorable to maintaining the flow objectives, thus freeing up resources in favor of the important streams,
 - reducing, and even prohibiting, the flow of existing streams of low importance, in the event of a general lack of resources, by acting on a signaling intended for the points of entry into the network and for the applications originating the streams;
 - handling the information streams in each component of the meshed network according to the resources reserved by the signaling protocol.
- 15 The invention relates to a method of routing data streams in a meshed system, characterized in that it implements multitopology routers, each provided with an intelligent module, and in that it comprises at least the following steps:
- an accounting of the resource requirements to keep to the quantitative and qualitative flow objectives of the accepted streams, the accounting being organized according to the operational importance of the streams,
 - a propagation from router to router of the expressed requirements using a switched signaling in a topology and a mapping in each router between topology and operational importance in order to allow for the accounting of the accepted needs,
 - said intelligent module uses the accounting of the accepted needs to generate a metric of links for each of the topologies, and in that
 - each multitopology router applies said metric to each of its links for each topology, and sends the values to the other routers,
 - each multitopology router maintains routing data, with,

in particular, the link metrics calculated dynamically by each intelligent module and determines a switching table for each topology,

- 5 ➤ each router can be used to propagate the data streams according to the switching table associated with the topology, a topology that is designated by the packet header fields.

The method can include at least the following steps:

- 10 ○ hierarchically organizing the topologies or routing plans managed by the network of multitopology routers, a topology being defined by independent metrics and giving rise to an optimum route calculation,
- 15 ○ assigning resources to each link, these resources being able to be used immaterially by the data packet streams, independently of the topology to which they belong,
- 20 ○ acting on the metrics of a topology of level $n-1$, based on a local knowledge of the resources busied by the topologies of level n or of a level higher than n ,
- 25 ○ maintaining separate routing data tables for each topology and switching tables that are also separate for each topology,
- updating on each router the routing data tables by using, between the routers, a routing protocol common to all the topologies and metrics specific to each topology.

30 The calculation of the metric can also take into account one of the following characteristics: the bandwidth available for the real time streams, the link transmission delay.

The metric can be modified in levels, the transition from one level to another being protected by hysteresis mechanisms.

A resource management signaling can be used in the method. This signaling can be of RSVP type.

The network is, for example, a communication network supporting the Internet protocol IP and in which a marker indicating the topology in which the packet is routed is arranged in the DSCP field of the data packet header.

5

The invention also relates to a system for routing data streams in the form of packets, characterized in that it comprises a set of nodes, each node comprising a multitopology router, such a router having a software module adapted to execute the steps of the method described previously.

10

The system, for example, consists of an administered meshed network comprising agents located at the edge of the network, the function of said agents being to inject and/or consume the reservation signalings in the routing system.

15

The software module is notably adapted to:

- o manage the routing protocol internal to the system and the resource reservation protocol,
- o determine a metric for a link connecting two nodes,
- 20 o count the resources needed to handle the streams and negotiate modifications in the routes taken by the streams according to the available resources or nodes, and also take into account the priority given to a data stream,
- 25 o determine the switching table for each configured topology.

The software module can be adapted:

- o to maintain routing data tables that are separate for each logical topology and switching tables that are also separate for each logical topology,
- 30 o each routing data table RIB being updated by a common routing protocol collecting metrics specific to each topology,
- o each switching table FIB being the result of a route

calculation based on data from the associated routing data table RIB.

The network supports, for example, the Internet protocol IP
5 and it uses the abovementioned resource reservation protocol RSVP.

Other characteristics and advantages of the present invention will become more apparent from reading the following
10 description with appended figures which represent:

- figure 1: an example of a network in which the invention can be applied,
- figure 2: an example of the implementation of the inventive method, and
- 15 ➤ figure 3: an exemplary data structure for expressing, within an information packet, flow handling performance objectives.

Figure 1 represents an example used to introduce certain
20 concepts used in the present invention:

- 1) a routing domain 1 or administered meshed network,
- 2) agents 1c at the edge of this domain notably having the function of injecting and/or consuming reservation signalings in the routing domain 1 under the control of the domain
25 administration. These agents will notably allow the entry of the streams, format them and will interact with the applications originating the streams.

The administration of the routing domain is an entity that plans an initial "knowledge" which will be pushed to all the
30 components of the domain. It does not have to be directly connected to the elements. This knowledge can be embodied, for example, in remanent configuration files in the components of the domain.

- 3) applications 2 beyond the administrative limits of the

routing domain.

The reference 1 designates a routing domain to which the invention is applied. The domain comprises, in this example, a plurality of routing nodes 1a, transmission links 1b between two nodes 1a, agents 1c arranged at the edge of the domain 1 between the applications generating information streams and routing resources (capacity of the links, capacity of the nodes) of the domain, and adaptive management agents 1d, an agent being arranged at a routing node of the domain.

The reference 2 designates applications that have a need to handle information streams with quality of service (QoS) requirements through routing domains, in particular the domain 1 to which the invention is applied.

The critical information streams with a flow performance objective are referenced 3 and the non-critical information streams 4.

Figure 2 shows elements 10 at the edge of the multitopology routing domain that intercept signalings, such as SIP or H.323 coming from applications, and that generate a reservation signaling, for example of RSVP type, in one of the topologies. The level of the topology is chosen according to the importance in maintaining the performance objectives throughout the life of a session. A session of low operational importance will be maintained by resource requests designating objectives to be reached during a determined percentage of time. The data streams of the session will follow an optimum route in a topology of low importance and the calculation of this route will be reviewed according to metrics that will undergo variations due to the events of the topologies of higher importance. The route of the session may be modified without interrupting the service offered to the applications. This rerouting may introduce a transient deviation in the flow

characteristics, but will maintain connectivity. For example, a spurious noise in a telephone conversation is quite acceptable because of its rarity.

5 Figure 2 represents a nonlimiting exemplary embodiment of the inventive routing method.

The method and the system according to the invention use, notably, multitopology-type routers. These routers comprise, for example, the following elements and functions:

- 10 o the routing data tables RIB and keeping these tables separate for each topology,
- o switching tables (FIB) for each topology, and maintaining them. The routing data tables are updated by a common routing protocol and metrics specific to each
- 15 topology, each FIB is the result of a route calculation specific to the topology that uses the metrics of the topology.

These tables are integrated in multitopology routers and are not represented in the interests of clarity.

20 In this example, the system for implementing the inventive method comprises: a call server 5, linked to a first router 6 or access router, whose function is explained later in the description. The access router communicates with at least one first multitopology router or entry router 7e via a trunk 8ij

25 or section of the communication network. The system comprises a plurality of multitopology routers 7i, interlinked by trunks 8ij. The last router 7s or exit router is linked to the destination 9.

The inventive idea is based notably on the following

30 assumptions:

- dynamically modifying the metrics of an interior gateway protocol IGP (Interior Gateway Protocol) operating according to a multitopology method and producing, for each topology, a switching table used by the module for relaying

the "forwarding engine" data present in the router, according to a method known to those skilled in the art

- supervising the states maintained by the resource reservation protocol RSVP suitable for counting the resources needed to handle the streams, negotiating reductions should there be a lack of resources and taking account of the importance of the streams, an importance that is marked by an identifier in the data packets. This behavior is described, for example, in the document RFC 3181 (accessible via the Internet link www.apps.ietf.org/rfc), and the router will be compatible with this functionality.

From a system point of view, the subject of the invention observes the following principles:

- at the system level, a topology is distinguished by operational importance level, for example a topology corresponding to the command streams, the flow of which is imperative,
- the operational importance may comprise a number of levels. It is possible to define a level for "fast real time" (in the absolute imperative flow sense) information streams, also called "flash",
- a level can be defined for immediate real time (in the imperative flow sense) information streams,
- a level can also be defined for real time urgent (in the critical flow sense) information streams,
- a level can be defined for real time routine (in the normal importance flow sense) information streams,
- a base level can be defined for non-real time information streams (flow that can be delayed).

The number of levels is determined, for example, according to the target application.

The applications that generate the real time streams involve agents 1c (figure 1) situated at the edge of the network that

are responsible for initiating the resource reservation method, within the appropriate topology, according to the operational importance level of the stream.

The resource reservation is propagated through the core of the
5 network (that is, through the routing nodes of the domain and the trunks) and follows, from the source to the destination, on each hop, the path present in the switching table corresponding to the operational importance level for the resource reservation transmission. This method is implemented
10 by each router that is part of the core of the network.

The software or intelligent module associated with each multitopology router periodically determines the proportion of resources busied by the streams accepted for the different operational importance levels, that is, for the different
15 topologies, and calculates a link metric for each of the topologies. The software samples, at a sufficiently high pace, the states to ensure that the time constant of the overall system is good, in relation to the average life of the sessions. The preparation of the metric is based, for example,
20 on the following principles:

preparation of the metric specific to a topology for example takes into account the resources reserved by the streams conveyed on the topologies of strictly higher operational importance,

25 the calculation of the metric can also take into account: the bandwidth available for the real time streams, the link transmission delay,

the metric changes by level. The transition from one level to another is protected by hysteresis mechanisms that contribute
30 to the stability of the metric and therefore the routing decisions therefrom.

The inventive method executes, for example, the following steps:

➤ hierarchically organizing topologies that can be

superimposed within one and the same multitopology router, a topology being defined by independent metrics and giving rise to an optimum route calculation, a superimposition being a use of a single physical topology,

- deducting the resources busied in each topology from the resources assigned to the physical topology,
- acting on the metrics of a topology of level $n-1$, based on the local knowledge of the resources busied by the topologies of level n or of level higher than n ,
- maintaining separate routing data tables for each logical topology and switching tables, also separate, for each logical topology,
- updating the routing data tables RIB using a common routing protocol and metrics specific to each topology.

The control intelligent module can be linked to a resource manager when the links between multitopology routers are multipoint links. A representative example is that of links relayed by satellite in which a set of nodes are all directly interconnected using the satellite relay. A dynamic sharing of the radio resources between all of these nodes is then orchestrated by a radio resource manager which distributes the radio resources that embody the multipoint link as and when required by each of the nodes. The relationship between the control modules and this radio resource manager enables each of the intelligent modules associated with the multitopology routers linked by a multipoint link to know the remaining available capacity of the multipoint link and how the occupancy of this link is distributed by operational importance.

The resource management signaling packets contain, for example, the identification of the flow objectives and the

identification of the importance in maintaining these objectives during the life of a stream. This importance is bijected with a topology (characterized by metrics that are specific to it) over which the data packets must be transmitted. The data packets carry in their header an indication enabling relaying within a topology. This indication is present, for example, in a specific field DSCP of the data packet that is coded as follows, for example:

- "101001" for the rapid real time (flash) topology,
- 10 • "101010" for the immediate real time topology,
- "101011" for the urgent stream real time topology,
- "101100" for the routine real time topology.

Use of IP version 6 offers numerous additional header fields for coding these topology identifiers.

- 15 In a more general case, the topology identifiers can also be deduced by each router from the packet reception conditions (frequency, time slot, etc.).

The streams transmitted over the topologies with real time flow objectives are handled via the low-latency queue and obtain the same level of quality, regardless of the operational importance associated with them.

The exemplary system described in figure 2 operates, for example, in the manner described below. The user terminal notably has the function of managing the signaling protocol and the media streams (stream I represented by a dotted line in figure 2).

The server 5 (agent) is adapted to:

- check the access rights from a directory database and, if necessary, after checking the identity and the authenticity of the user, and validating a level of operational importance of the communication from the initial request from the user and its authorized prerogatives
- transmit the signaling to the server which connects the

caller taking into account the caller's location (arrows II)

- generate the resource reservation on the topology concerned (arrows III)
- 5 ➤ check the behavior of the access router (checking the authorization to send a stream, checking the DSCP marking with the value corresponding to the chosen topology, etc.). If a communication is preempted, then the server asks the router to mark the stream "best effort", until another
- 10 resource reservation request is transmitted successfully.

The access router 7e is responsible, notably, for:

- transmitting the RSVP packets over the appropriate topology to the destination,
- 15 ➤ ensuring the relative relay priority of the user streams according to what is required for this micro-stream,
- marking the packets of a multimedia-type stream, for example, with the correct DSCP, in order to ensure that this stream will be transmitted over the right topology and
- 20 will use the same route as the RSVP generated by the server.

A multitopology router, associated with an intelligent module generating the link metrics, notably has the following functions:

- 25 ➤ keeping the routing database up to date for each topology configured in the system, in particular, the metrics specific to the topology,
- balancing the loads on the topologies through the decisions of the intelligent module which dynamically modifies the link metrics in each router taking into account, for
- 30 example:
 - link characteristics (latency, reliability, etc.),
 - resources reserved by higher operational priorities,
 - transmitting the packets according to the appropriate

switching table in accordance with the DSCP field,

- managing resource reservation on the trunks or sections of the network for the streams from the users,
- managing preemption of the user streams according to standard RFC 3181, for example,
- managing step-by-step relaying according to the DiffServ (differentiated services) principles; the real time multimedia streams are transmitted through the low-latency queue.

10

In the context of an application in a network supporting the IP protocol and using the resource reservation RSVP, the method according to the invention operates, for example, in the manner described hereinbelow.

- 15 The method takes into account the importance in keeping to the stream flow objectives, and it assigns a topology, characterized by metrics that are specific to it, to each level of operational importance, and a value for the DSCP field in the packet header. In this way, the relaying module
- 20 will use, according to the information contained in the DSCP field, a switching table corresponding to the given topology, said table indicating the most effective path for transmitting a data packet in an IP network.

Resource reservation is based, for example, on the standard

25 RSVP signaling or any other signaling having the same characteristics.

The resource reservation level is used by the intelligent module which calculates, for a given topology, the metric of each link according to the reservations made for streams

30 transmitted over the higher level topologies.

After having calculated the metric of the link assigned to a topology, the intelligent software updates the local configuration parameters of the multitopology router and the routing protocol will take account of the new metric values,

will broadcast these values to the other routers, directly for the routers separated by one hop or indirectly for the more distant routers and, if necessary, it updates the switching table.

5

The use of a resource management signaling makes it possible notably to provide a knowledge of the requirement to be handled to the transmission systems in order for them to be able to optimize their transmission service, this optimization possibly being a choice of modulation, of coding, of antenna processing. This touches on the concept of radio resource manager introduced hereinbelow. The transmission system is not necessarily a point-to-point link: it can be a satellite system, an airport system, an IEEE 802.11-type WiFi network, 15 an IEEE 802.16-type WiMax cell. A central decision member dynamically distributes the radio resources between the participants to the multipoint link according to the requirements and environmental conditions - interference, propagation conditions, reception conditions; these systems 20 incorporate "coding", "modulation" and "antenna" portions, these portions can be adapted and it is the radio resource manager that orchestrates this adaptation in order to obtain the optimization of the radio segment for each identified stream, provide an indication, to the agents at the edge and, 25 by ricochet, to the applications, concerning the availability of the stream handling service.

Figure 3 reviews the structure of an IP packet header, notably the presence of a DSCP field, a field coded on the first 6 30 bits of the DS field for broadcasting services in a network implementing Diffserv.

Generally, each information packet is accompanied with markers or identifiers that identify 2 concepts:

- 1) the flow profile to be observed,

2) the importance in maintaining the flow objectives.

These identifiers can either be borne by the packet header as described in the exemplary IP version 4 packet (example in
5 figure 3), or be deduced at each node of the network from the packet reception conditions (radio or optical frequency, time slot, or information transmitted between nodes and correlated with the packet).

10 The method and the system that are the subjects of the invention offer notably the following advantages:

- o finding and adapting an optimum path or route for the data streams through a meshed network taking into account the resources reserved previously and the
15 importance in maintaining the flow objectives of the streams attached to these reserved resources,
- o transmitting the information stream through the meshed network over point-to-point or multipoint sections or trunks in which the resources have been reserved for
20 this identified stream (the reservation signaling gives the identification rules applied to the data packets to be transmitted).
- The routers used for this solution are routers that apply, for example, the principles and protocols published by the
25 IETF and including the RSVP and multitopology OSPF services; the solution offers a higher robustness because of a loose coupling with the control module responsible for calculating the metrics and for the reservation decisions,
- The solution incorporates in the routing domain a new
30 dimension which is the operational importance. Thanks to the overall behavior, the streams that have a high importance level will obtain the most suitable resources for a specific communication.

Claims

- 1 - A method of routing data streams in a meshed system, characterized in that it implements multitopology routers, each provided with an intelligent module, and in that it comprises, for each router, in combination, at least the following steps:
- an accounting of the resource requirements to keep to the quantitative and qualitative flow objectives of the accepted streams, the accounting being organized according to the operational importance of the streams,
 - a propagation from router to router of the expressed requirements using a switched signaling in a topology and a mapping in each router between topology and operational importance in order to allow for the accounting of the accepted needs,
 - said intelligent module uses the accounting of the accepted needs to generate a metric of links for each of the topologies, and in that
 - each multitopology router maintains routing data, with, in particular, the link metrics calculated dynamically by each intelligent module and determines a switching table for each topology,
 - each router can be used to propagate the data streams according to the switching table associated with the topology, a topology that is designated by the packet header fields.
- 2 - The method as claimed in claim 1, characterized in that it includes at least the following steps:
- a) hierarchically organizing the topologies or routing plans, managed by the network of multitopology routers, a topology being defined by independent metrics and giving rise to an optimum route calculation,

- b) assigning resources to each link, these resources being able to be used immaterially by the data packet streams, independently of the topology to which they belong,
 - 5 c) acting on the metrics of a topology of level n-1, based on the local knowledge of the resources busied by the topologies of level n or of a level higher than n,
 - d) maintaining separate routing data for each topology and switching tables that are also separate for each
 - 10 topology,
 - e) updating on each router the routing data by using, between the routers, an all-topology routing protocol and metrics specific to each topology.
- 15 3 - The method as claimed in one of claims 1 or 2, characterized in that the calculation of the metric takes into account at least one of the following parameters: the bandwidth available for the real time streams, the link transmission delay.
- 20 4 - The method as claimed in one of claims 1 to 3, characterized in that the metric is modified in levels, the transition from one level to another being protected by hysteresis mechanisms.
- 25 5 - The method as claimed in one of claims 1 to 4, characterized in that a resource management signaling is used.
- 6 - The method as claimed in claim 5, characterized in that an
- 30 RSVP-type signaling is used.
- 7 - The method as claimed in claim 1, characterized in that the network is a communication network supporting the Internet protocol IP and in that the DSCP data packet field contains a

marker indicating the operational importance of the data.

8 - A system for routing data streams in the form of packets, characterized in that it comprises a set of nodes, each
5 comprising a multitopology router, a router having a software module adapted to execute the steps of the method as claimed in one of claims 1 to 7.

9 - The routing system as claimed in claim 8, characterized in
10 that the software module is adapted:

- o to maintain routing data tables RIB that are separate for each logical topology and switching tables FIB that are also separate for each logical topology,
- o each routing data table being updated by a common
15 routing protocol and metrics specific to each topology.

10 - The system as claimed in claim 8, characterized in that it consists of an administered meshed network, and in that it comprises agents located at the edge of the network, the
20 function of said agents being to inject and/or consume the reservation signalings in the routing system.

11 - The system as claimed in claim 8, characterized in that it supports the Internet protocol IP and in that it uses the
25 resource reservation protocol RSVP.