

(51) International Patent Classification:
H04L 12/56 (2006.01)(21) International Application Number:
PCT/EP2010/069524(22) International Filing Date:
13 December 2010 (13.12.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09306269.3 18 December 2009 (18.12.2009) EP(71) Applicant (for all designated States except US): **ALCATEL LUCENT** [FR/FR]; 3, avenue Octave Gréard, F-75007 Paris (FR).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **PAPADIMITRIOU, Dimitri** [BE/BE]; Rue du Charme 24, B-1190 Brussels (BE).(74) Agent: **BELL**; Copernicuslaan 50, B-2018 Antwerp (BE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR ROUTING DATA UNITS

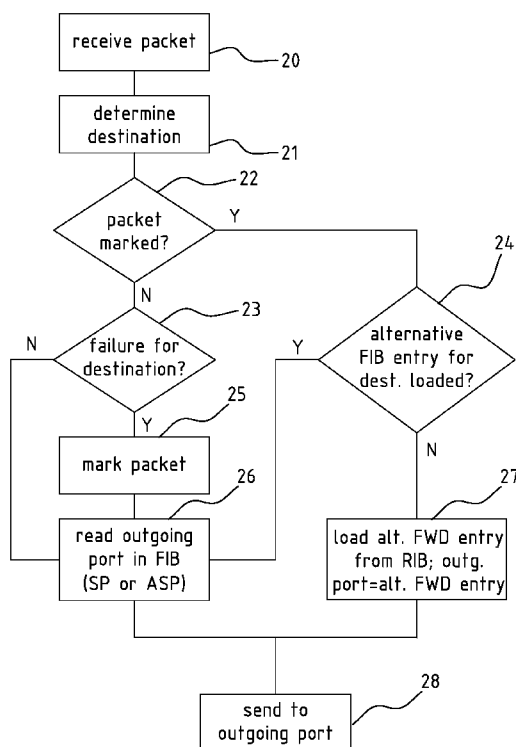


FIG. 2

(57) Abstract: System for routing data units, comprising a routing information base (RIB) storing routing entries; a forwarding information base (FIB) storing forwarding information used to forward data units to a plurality of destinations; a computing function for computing for each destination of said plurality of destinations a normal shortest path and an alternate shortest path using routing information received from adjacent nodes and/or local information; said forwarding information base storing for each of said plurality of destinations normal forwarding information and alternate forwarding information necessary to forward a data unit using the normal shortest path and the alternate shortest path, respectively; a forwarding control means for indicating to at least one following hop of the alternate shortest path that the alternate forwarding information should be used for this data unit.

WO 2011/073140 A1



Published:

— *with international search report (Art. 21(3))*

System and method for routing data unitsTechnical field

The present invention relates to a system and a method for
5 routing data units.

Background

In the prior art so-called "by-passing" solutions exist.
According to this solution a topology change is by-passed by
10 using tunnels not affected by the change. Such methods
typically suffer from computational complexity, tunnel
maintenance and impact on the forwarding plane.

Other solutions use a sequencing of the Forwarding
15 Information Base (FIB) updates, such as timely synchronized
FIB updates or topologically ordered FIB updates upon
occurrence of a failure.

Summary

20 The object of the invention is to provide a method and
system with an improved re-convergence process when a
topology change occurs, e.g. in case of a failure of a link
or node.

25 According to an embodiment of the invention there is
provided a system for routing data units, comprising:
- a routing information base (RIB) storing routing entries
typically composed by a destination, a next-hop interface,
and a metric;
30 - a forwarding information base (FIB) storing forwarding
information used to forward data units to a plurality of
destinations;

- a computing function for computing for each destination of said plurality of destinations a normal shortest path and an alternate shortest path using routing information from adjacent nodes;
- 5 said forwarding information base storing for each of said plurality of destinations normal forwarding information and alternate forwarding information necessary to forward a data unit using the normal shortest path and the alternate shortest path, respectively;
- 10 - a forwarding control means for indicating to at least a following hop of the alternate shortest path that the alternate forwarding information should be used for this data unit.
- 15 By storing at any time not only forwarding information for the shortest path but also for an alternate shortest path, it could be said that precautionary measures are taken before a failure actually occurs. Upon failure, the system can react immediately by using the alternate shortest path.
- 20 Moreover by indicating to a following hop of the alternate shortest path that the alternate forwarding information should be used for the destination loop mitigation is reduced in a simple and effective way.
- 25 According to another embodiment of the invention there is provided a micro-loop mitigation technique triggering the downstream neighbor criteria after a topological change.
- According to yet another embodiment of the invention,
- 30 alternate shortest path pre-computation is coupled with a loop mitigation mechanism. An embodiment of the invention is based on the basic idea consisting in relaxing the loop-free criteria before a topological change occurs, however,

guaranteeing that the alternate shortest path can be rapidly activated at the next hop along the alternate path. The use of alternate shortest paths will ensure that after re-convergence the triggered alternate path remains stable.

5

According to a preferred embodiment of the routing system, the system comprises a routing engine with the RIB and the computing function, wherein the routing entries of the RIB are computed by the computing function based on routing
10 information received from adjacent nodes and/or on local information; and a forwarding engine comprising the FIB and the forwarding control means.

Whenever there is a topological change the routing engine
15 will receive messages in that regard, e.g. messages advertising a new node or withdrawing a node, and the computing function will re-compute the shortest and alternate shortest path. In fact by re-computing the alternate shortest path it is determined a priori which path
20 to use if a certain link fails.

According to a preferred embodiment the forwarding control means comprises a marking means for marking a data unit when the alternate forwarding information should be used. Note
25 that the expression "marking" should be explained in the broad sense referring to any possible indication added to or taken up in the data unit to indicate that the alternate shortest path should be used.

30 According to an alternative embodiment, instead of using marking, the next hop and/or further hops could be informed by the forwarding engine through other means such as the in-band sending of probes. E.g. probe packets could be sent

toward the destination prefixes by the node detecting the failure. Probe packet injection towards the destination prefix affected by the failure is typically used when there is no "traffic" for the corresponding destination. According to an advantageous aspect, to prevent overload along the alternate forwarding path, a small number of probe packets is sent to "activate" the alternate forwarding entry on nodes along the alternate path towards the destination. These probe packets are preferably dropped before crossing the local routing domain boundary so as to prevent leaking into neighboring domains or reaching hosts/terminals. For this purpose, the sending node can for instance set the TTL of these probe packets to the number of hops traversed along the alternate forwarding path to reach routing domain edges.

According to a further developed embodiment the computing means is adapted for computing the alternate shortest path such that it does not include the normal shortest path. In that way it is guaranteed that the alternate shortest path is a loop-free alternate path, as will be further elucidated below when a number of detailed embodiments are discussed.

A further aspect of an embodiment of the system of the invention provides in verification and selecting means for verifying if an incoming data unit to a destination is marked and for selecting the normal or alternate forwarding information accordingly if said destination is a member of said plurality of destinations. In a similar way, when probing is used instead of or in addition to marking, there could be provided means to deal with in-band probe packets and to take the appropriate action, i.e. using the normal or alternate forwarding information.

In certain cases the alternate path may not yet be loaded in the FIB. This may e.g. be due to limited FIB capacity. To address this aspect a further preferred embodiment comprises selection means for selecting an alternate forwarding entry for a destination from the RIB, when a marked data unit is received for said destination and there is no alternate forwarding information stored in the FIB for said destination.

- 10 According to another embodiment of the invention there is provided a method for routing data units, comprising:
storing for each destination of a plurality of destinations:
- pre-computed normal forwarding information to be used normally; and
15 - pre-computed alternate forwarding information to be used in the event of a failure affecting the normal forwarding information;
and
performing the following steps when a data unit has to be
20 sent to a first destination of said plurality of destination:
in the event of a failure affecting the normal forwarding information, indicating to at least one following hop of the alternate shortest path that the alternate forwarding
25 information should be used for this data unit;
- sending the data unit
 using the alternate forwarding information for said first destination, if an indication is received; or
 using the normal forwarding information for said first
30 destination, if no indication is received.

According to a preferred embodiment, the indicating comprises marking the data unit, and the sending of the data

unit uses the alternate forwarding information for said first destination, if the data unit is marked; or the normal forwarding information for said first destination, if the data unit is not marked. Such a marking will then indicate to the next hop (and possibly to further following hops) whereto the data unit is forwarded that the alternate shortest path should be used. This will allow the next hop to use the alternate forwarding information for transmitting the data unit to any further hops of the alternate shortest path. According to an alternative or additional indicating step, in-band probing could be used to indicate to at least one following hop of the alternate shortest path that the alternate forwarding information should be used for this data unit.

According to a further developed embodiment thereof the method further comprises performing the following steps when a data unit for the first destination is received to be forwarded: verifying if the data unit is marked; and forwarding the data unit using the alternate forwarding information, if the data unit is marked. Again similar actions can be taken if in-band probing is used.

According to a preferred embodiment of the method of the invention the method further comprises for each destination of said plurality of destinations, pre-computing for each destination a normal shortest path and an alternate shortest path not comprising said normal shortest path, taking account of topology information derived from routing information received from adjacent nodes; wherein said storing consists in storing the normal forwarding information corresponding with the normal

shortest path and the alternate forwarding information corresponding with said alternate shortest path.

According to a further developed embodiment comprising
5 marking of data units in the event of a failure affecting the shortest path for a destination, the method further comprises:

receiving a marked data unit for a second destination for which no alternate path is stored;

10 loading an alternate forwarding entry for said second destination from a routing information base storing routing information received from adjacent nodes.

Further advantageous features are disclosed in the dependent
15 claims. It is noted that the features of different dependent claims may be combined where judged possible by the person skilled in the art.

The accompanying drawings are used to illustrate presently
20 preferred non-limiting exemplary embodiments of the present invention. The above and other advantages, features and objects of the invention will become more apparent and the invention will be better understood from the following detailed description when read in conjunction with
25 accompanying drawings.

Brief description of the figures

Figure 1A is a node graph of an exemplary topology for illustrating an embodiment of the invention.

30

Figure 1B illustrates schematically the content of the Forwarding Information Base (FIB) for node u of the node

graph of figure 1A, according to an exemplary embodiment of the invention.

Figure 2 is a flowchart for illustrating an embodiment of the method of the invention.

Figure 3 illustrates schematically the architecture of a router system.

10 Description of embodiments

Before explaining in detail the example of figures 1A and 1B, first a number of general terms will be defined in order to better understand the basic ideas behind the invention and the problem solved by embodiments of the invention.

15

Let $G = (V, E, \omega)$ be a weighted undirected graph with positive edge cost ω , where V is the set of vertices ($|V| = m$) and E is the set of edges ($|E| = n$). For $s, t \in V$, let $d(s, t)$ denote the cost of a path from s to t in G , where the cost of a path is the sum of the weights along its edges.

20

For the pair $s, t \in V, s \neq t$, if there exists a vertex u adjacent to s such that $d(u, t) < d(s, u) + d(s, t)$, i.e., u is a loop-free neighbor of s to t , then the path $(v_0(=s), v_1, \dots, v_m(=t))$ is a loop free alternate path where $d(v_i, v_m) < d(v_{i-1}, v_m) + d(v_{i-1}, v_i)$ for all i .

25

For the pair $s, t \in V, s \neq t$, if there exists a vertex u adjacent to s such that $d(u, t) < d(s, t)$, i.e., u is the downstream neighbor of s to t , then the path $(v_0(=s), v_1, \dots, v_m(=t))$ is a distance decreasing downstream path where $d(v_i, v_m) < d(v_{i-1}, v_m)$ for all i . As a particular case, neighbor u of edge s is the downstream SPF neighbor of s for destination t , if u provides the shortest path to t

30

according to a shortest-path first (SPF) routing scheme. The set of downstream paths is a subset of the set of loop-free alternate paths meeting the condition $d(v_i, v_m) < d(v_{i-1}, v_m)$ for all i .

5

Forwarding is a function performed on each node (edge), in which it is independently decided how to map a given destination to an outgoing port so as to forward data units towards the destination. The information necessary to perform this mapping is stored in the Forwarding Information Base (FIB) of each node. Typically, the FIB includes for any destination an entry identifying the outgoing port number to which data units for a given destination should be forwarded. The FIB entries are deduced from information in a Routing Information Base (RIB) populated and maintained by means of routing update messages. Such routing update messages typically allow a node to maintain a coherent full view of the graph at any given instant in time, or in other words, these messages allow a node to have non-local knowledge about the graph topology. When the topology changes, the appropriate routing update messages are exchanged between the nodes, i.e. the nodes react dynamically to topological changes due to e.g. a link/node failure, which leads to a recalculation of the RIB entries.

25

Figure 3 illustrates schematically the architecture of a typical router system 30 comprising a routing engine 31 with a RIB 32 and a routing information processing part 33, and a forwarding engine 35 with a FIB 36. The routing engine 31 processes routing information 34 received from its peers in order to update the RIB 32 and maintain a full view of the topology of the graph. The forwarding engine 35 forwards incoming packets based on the information in the FIB 36. The

30

processing part 33 comprises a computing function for computing, for a number of destinations, both the shortest path and a loop-free alternate shortest path based on the routing information 34. The forwarding information
5 associated with the computed shortest path and the computed alternate shortest path is stored in the FIB 36.

A recognized problem consists in minimizing the re-convergence time upon occurrence of a topological change.

10 Basically this means that each node will need to retrieve a coherent full view of the graph after the topological change so that recomputed RIB entries lead to FIB entries along loop-free paths for the maximum number of destinations, wherein a percentage of the destinations may be identified
15 as being unrecoverable upon failure occurrence. Formally, this means that by finding for any path from s to t , ($s, t \in V$, $s \neq t$) passing through u , a vertex v adjacent to u such that

i) before topological change: $d(v, t) < d(v, u) + d(u, t)$, i.e.
20 the path ($s, \dots, u, v, \dots, t$) is a loop-free alternate path for u to t and
ii) after topological change: $d(v, t) < d(u, t)$ i.e. the path ($s, \dots, u, v, \dots, t$) is a downstream path for u to t ,
it is ensured that after topology change node u can safely
25 switch traffic to neighbor v , its new next-hop for destination t .

Micro-loops may form during the periods when a network is re-converging following any graph topology change resulting
30 into inconsistent FIBs during the transition from the RIB/FIB entries before and after failure. Micro-loops occur when each router in a topological cycle of routers has the next router in the cycle as a next hop for a given prefix. A

basic exemplary scenario is depicted in figure 1A, wherein the arrows indicate the traffic flow from source s to destination t .

- 5 Initially the downstream path from u to t is $2(u, x, t)$ and the downstream path from v to t is (v, u, x, t) or (v, w, u, x, t) . After vertex (u, x) failure, the downstream path from u to t is (u, v, t) or (u, w, v, t) . However, if v has not yet received the corresponding routing update, its downstream path to t
- 10 is still passing via u , either using (v, u, x, t) or (v, w, u, x, t) . In other words, v is not a downstream neighbor of u for t . The result thereof is a temporary micro-loop between u and v for traffic directed to destination t . Here this problem is caused by inconsistent RIB/FIB entries
- 15 between nodes u and v , resulting from the propagation time of the routing update messages from u to v , as well as the different computation times of the RIB entries, and the RIB/FIB update/installation time.
- 20 Micro-loop control strategies fall into two basic classes:
- micro-loop mitigation: reducing but not eliminating the formation of micro-loops.
 - micro-loop avoidance: preventing the formation of micro-loops.
- 25 Knowing that the loop-free neighbor criteria is not verified before the topological change (e.g. when traffic directed to t arrives at v , v forwards this traffic to u , i.e. v is not a loop-free neighbor of u), embodiments of the invention provide a micro-loop mitigation technique triggering the
- 30 downstream neighbor criteria after a topological change (e.g. when traffic from u directed to t arrives at v , v does not forward traffic back to u , i.e. v becomes a downstream neighbor of u).

According to an embodiment of the invention, alternate shortest path pre-computation (i.e. before a topological change occurs) is coupled with a loop mitigation mechanism. An embodiment of the invention is based on the basic idea
5 consisting in relaxing the loop-free criteria before a topological change occurs, however, guaranteeing that the alternate shortest path can be rapidly activated at the next hop along the alternate path. The use of alternate shortest paths will ensure that after re-convergence the triggered
10 alternate path remains stable.

Now an embodiment of the method of the invention performed in a node u will be explained. In a first aspect a loop-free alternate shortest path at node u is calculated for a
15 destination. The outgoing ports corresponding with the shortest path and the alternate shortest path are stored in the FIB of node u. This is illustrated in figure 1B for the example of figure 1A. Note that figure 1B mentions for the different possible destinations t, v, w, x, the shortest
20 path and the alternate shortest path. However, the skilled person will understand that in reality it is not the shortest path itself (or the alternate shortest path itself) which is stored in the FIB. Instead, each FIB entry comprises the outgoing port (towards the next-hop along the
25 path) together with the destination (of the path). The pre-computation of those paths is based on knowledge of the topology by using the information present in the RIB before a topology change.

30 According to a second aspect of this embodiment, upon failure detection of a link (u,x), node u contiguous to link (u,x) will mark packets before sending them to its next hop neighbor v along the alternate shortest path for destination

t. Such a mark will indicate to node v that it should use the alternate shortest path for destination t.

According to a further aspect, node v receiving the marked
5 packet will either use the alternate shortest path from the FIB, if it is already loaded in the FIB, or will load an alternate forwarding entry from the RIB for destination t. In this embodiment it is assumed that a node pre-computes an alternate routing entry per destination address prefix in
10 its RIB. In a case where the corresponding routing entries are not preloaded in the FIB, typically a trigger is provided to load the corresponding entry from the RIB upon traffic drop for a "known" destination, so that buffering can be avoided.

15

Note that the marking is not limited to the next hop along the alternate shortest path. Typically, marking the packets is continued until the loop-free condition is clarified. This means that the next hop along the alternate shortest
20 path can itself trigger its own next hop neighbor to forward traffic along its shortest path towards destination t. Indeed, as long as a loop-free node for destination t is not reached along the alternate shortest path, traffic directed towards t might otherwise still be lost.

25

The skilled person will understand that the marking can be done in many different ways. Purely for illustrative purposes, two examples are given which can be used in IPv4 and IPv6 packet headers. Two possible marking techniques are
30 Packets Scheduling Class (PSC) conserving and non-PSC conserving.

In the PSC conserving case, the Drop Precedence bits are set to a higher value than other packets of the PS Class. For example, packets in Assured Forwarding (AF) PHB group provides forwarding of IP packets in N independent AF classes AF_i , $1 \leq i \leq N$. Within each AF_i class, an IP packet is assigned one of M different levels of drop precedence, $1 \leq j \leq M$. Thus an IP packet that belongs to an AF class i and has drop precedence j is marked with the AF codepoint AF_{ij} , where $1 \leq i \leq N$ and $1 \leq j \leq M$. In the current specifications, four classes ($N=4$) with three levels of drop precedence in each class ($M=3$) are defined with a configuration such that within an AF class, the probability of a node dropping an IP packet decreases with the drop precedence value. In other words AF43 traffic is dropped before AF42 and AF42 before AF41. In such a case a AF44 setting would be perfectly acceptable i.e. 100111 if encoded over 6 bits. Note that such a setting would not require "standardization", as it is allowed for local use per RFC 2474.

In the non-PSC conserving case, a dedicated PS sub-Class is used. This assumes that new sub-classes can be defined. The "lower" AF class is AF_{lx} , thus $AF_{0x}(000xxx)$ could be defined and the corresponding CS0 class ($000xxx$) class defined in RFC 2474 would have to be replaced. Thus, typically, in the non-PSC conserving case there is less flexibility if the newly defined class has to remain compliant with the existing definitions.

Now an embodiment of the method of the invention which can be employed in any node will be explained with reference to figure 2. In a first step 20 a packet is received. Next, the destination is determined, see step 21. Then, in step 22, it

is verified whether the packet has been marked to indicate that an alternate entry in the FIB should be used. If the packet is marked, it is verified in step 24 whether an alternative FIB entry for the destination included in the packet is loaded in the FIB. If the alternative outgoing port is available in the FIB, then this port is read out (step 26), and the message is sent using the alternate outgoing port (step 28). If the alternate FIB entry in step 24 is not loaded in the FIB, then the alternative forwarding entry is loaded from the RIB in step 27. The packet is then forwarded using the alternative forwarding entry from the RIB as the outgoing port. If it is determined in step 22 that the received packet is not marked, it will be verified in step 23 whether a topology change relevant for the destination mentioned in the packet has occurred. If no failure for the destination has occurred, the normal outgoing port is read in step 26, and the packet is forwarded using the normal outgoing port in step 28. If there has been a failure, the packet is marked in step 25, and the alternate outgoing port is read out from the FIB in step 26. The marked packet is then sent using the alternate outgoing port in step 28.

By involving packet marking and data driven triggered FIB updates according to embodiments of the invention, the performance of the routing system and method is improved compared to techniques of the prior art which exclusively assume pre-configuration, control driven RIB/FIB updates.

The system and method of the invention are typically applicable to pure IP environments aiming at decreasing the recovery time by means of a re-routing technique that combines alternate shortest path pre-computation before

topological change with a micro-loop mitigation mechanism after topological change.

While the principles of the invention have been set out
5 above in connection with specific embodiments, it is to be clearly understood that this description is merely made by way of example and not as a limitation of the scope of protection which is determined by the appended claims.

Claims

1. System for routing data units, comprising:

- a routing information base (RIB) storing routing entries;

5 - a forwarding information base (FIB) storing forwarding information used to forward data units to a plurality of destinations;

- a computing function for computing for each destination of said plurality of destinations a normal shortest path and an
10 alternate shortest path using routing information received from adjacent nodes and/or local information;

said forwarding information base storing for each of said plurality of destinations normal forwarding information and alternate forwarding information necessary to forward a data
15 unit using the normal shortest path and the alternate shortest path, respectively;

- a forwarding control means for indicating to at least one following hop of the alternate shortest path that the alternate forwarding information should be used for this
20 data unit.

2. System of claim 1, wherein the forwarding control means comprises a marking means for marking a data unit when the alternate forwarding information should be used.

25

3. System of claim 1, wherein the forwarding control means comprises a in-band probe sending function for sending probe packets to indicate whether the alternate forwarding information should be used.

30

4. System of claim 1, wherein the computing function is adapted for computing the alternate shortest path such that it does not include the normal shortest path.

5. System of claim 1, comprising a routing engine and a forwarding engine,
said routing engine comprising the RIB and the computing function, wherein the routing entries of the RIB are
5 computed by the computing function based on routing information received from adjacent nodes and/or on local information; and
said forwarding engine comprising the FIB and the forwarding control means.

10

6. System of claim 2, further comprising verification and selecting means for verifying if an incoming data unit to a destination is marked and for selecting the normal or alternate forwarding information accordingly if said
15 destination is a member of said plurality of destinations.

7. System of claim 1, further comprising means for selecting an alternate forwarding entry for a destination from the RIB, when a marked data unit is received for said
20 destination and there is no alternate forwarding information stored in the FIB for said destination.

8. Method for routing data units, comprising:
storing for each destination of a plurality of destinations:
25 - pre-computed normal forwarding information to be used normally; and
 - pre-computed alternate forwarding information to be used in the event of a failure affecting the normal forwarding information;
30 and
performing the following steps when a data unit has to be sent to a first destination of said plurality of destination:

- in the event of a failure affecting the normal forwarding information, indicating to at least one following hop of the alternate shortest path that the alternate forwarding information should be used for this data unit;

5 - sending the data unit

using the alternate forwarding information for said first destination, if an indication is received; or

using the normal forwarding information for said first destination, if no indication is received.

10

9. Method of claim 8, wherein the indicating comprises marking the data unit, and wherein the sending of the data unit uses the alternate forwarding information for said first destination, if the data unit is marked; or

15 the normal forwarding information for said first destination, if the data unit is not marked.

10. Method of claim 8, further comprising for each destination of said plurality of destinations:

20 pre-computing for each destination a normal shortest path and an alternate shortest path not comprising said normal shortest path, taking account of topology information derived from routing information received from adjacent nodes;

25 wherein said storing consists in storing the normal forwarding information corresponding with the normal shortest path and the alternate forwarding information corresponding with said alternate shortest path.

30 11. Method of claim 9, comprising performing the following steps when a data unit for the first destination is received to be forwarded:

verifying if the data unit is marked; and

forwarding the data unit using the alternate forwarding information, if the data unit is marked.

12. Method of claim 9, comprising:

- 5 receiving a marked data unit for a second destination for which no alternate path is stored;
loading an alternate forwarding entry for said second destination from a routing information base storing routing information received from adjacent nodes.

10

13. Method of claim 8, wherein the data units are IP packets.

14. Method of claim 9, wherein the marking is based on
15 higher drop precedence using Packet Scheduling Class conserving.

15. Method of claim 9, wherein the marking is based on defining a degraded sub-class per Packet Scheduling Class.

20

1/3

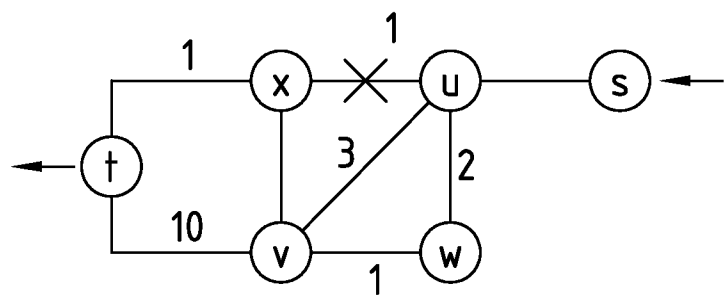
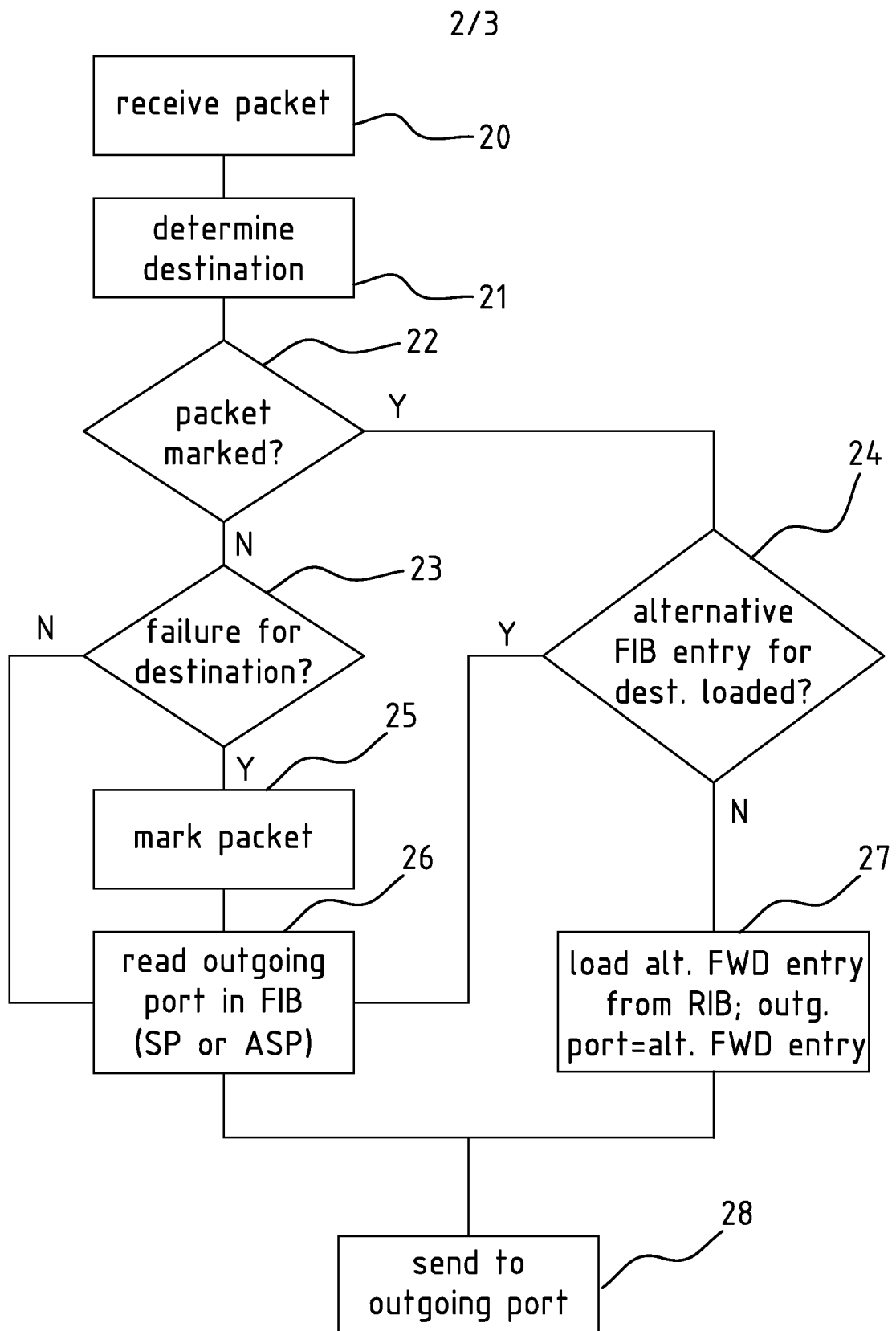


FIG. 1A

NODE u	FIB		
	dest.	SP	ALT SP
	t	ux	uvt or $wwvt$
	v	uv	uwv
		uw	uv
	w	uw	uvw
	x	ux	vtx or $wwtx$

FIG. 1B

FIG. 2

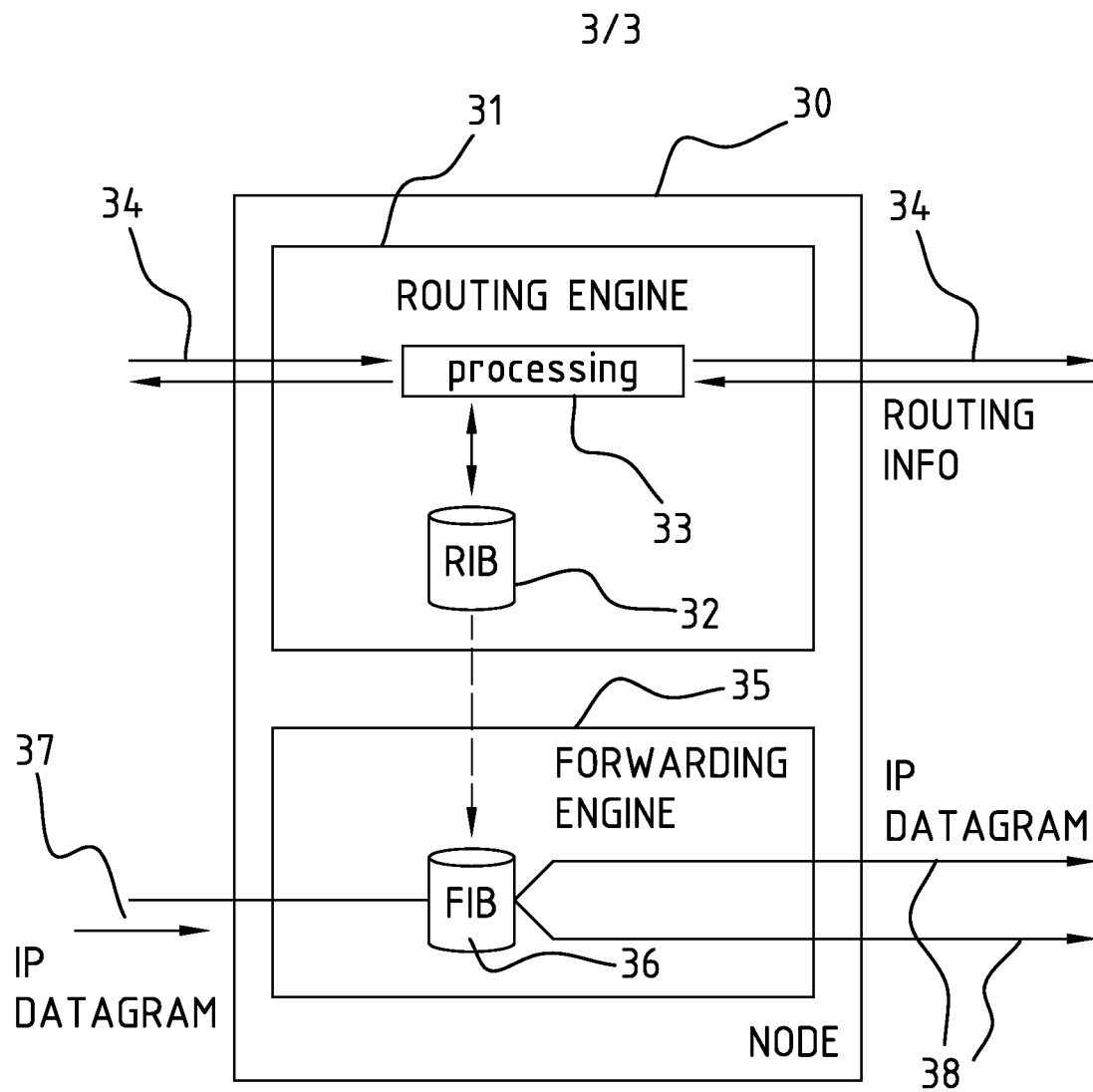


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/069524

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/56
ADD.

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)
H04L

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

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

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/091794 A1 (FILSFILS CLARENCE [BE] ET AL) 26 April 2007 (2007-04-26) paragraphs [0010], [0035], [0049], [0055]; figure 4	1-15
X	YOSHIHIRO T: "A Single Backup-Table Rerouting Scheme for Fast Failure Protection in OSPF", IEICE TRANSACTIONS ON COMMUNICATIONS, COMMUNICATIONS SOCIETY, TOKYO, JP, vol. E91B, no. 9, 1 September 2008 (2008-09-01), pages 2838-2847, XP001516405, ISSN: 0916-8516 the whole document	1-15

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

25 January 2011

Date of mailing of the international search report

01/02/2011

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Schneider, Gernot

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/069524

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ATLAS A ET AL: "Basic Specification for IP Fast-Reroute: Loop-free Alternates; draft-ietf-rtgwg-ipfrr-spec-base-08.txt", IETF STANDARD-WORKING-DRAFT, INTERNET ENGINEERING TASK FORCE, IETF, CH, vol. rtgwg, no. 8, 6 September 2007 (2007-09-06), XP015051641, ISSN: 0000-0004 the whole document -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2010/069524

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007091794	A1	26-04-2007	NONE
