(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 November 2011 (24.11.2011)

PCT

(10) International Publication Number
WO 2011/145119 A1

(51) International Patent Classification:
G06F 9/54 (2006.01)

(21) International Application Number:
PCT/IN2011/000352

(22) International Filing Date:
19 May 2011 (19.05.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1166/DEL/2010 19 May 2010 (19.05.2010) IN

(71) Applicant *(for all designated States except US)*: **HUGHES SYSTIQUE INDIA PRIVATE LIMITED** [IN/IN]; 1, Shivji Marg, Westend Greens, N.H.-8, New DelhI 110 038 (IN).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **KUMAR, Anil** [IN/IN]; C/o. Hughes Systique India Private Limited, 1, Shivji Marg, Westend Greens, N.H.-8, New Delhi 110038 (IN). **BHATNAGAR, Shilpa Mahna** [IN/IN]; c/o. Hughes Systique India Private Limited, 1, Shivji Marg, Westend Greens, N.H.-8, New Delhi 110038 (IN).

(74) Agents: **WILSON, Neeti** et al.; Anand And Anand Advocates, B-41, Nizamuddin East, New Delhi 110 013 (IN).

(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).

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: METHOD AND SYSTEM FOR EFFICIENT INTER- PROCESS COMMUNICATION IN A HIGH AVAILABILITY SYSTEM

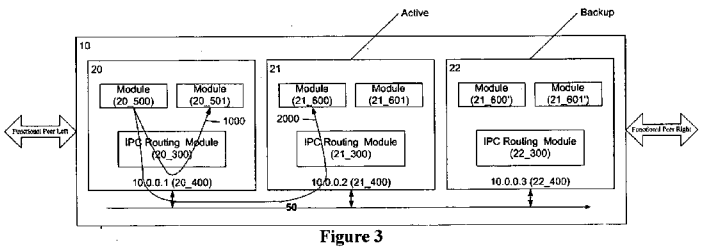


Figure 3

(57) Abstract: A system, method and associated data structures for providing inter process communication where IPC endpoints may get relocated during the operation of the system. A device in accordance with the principles of the present invention comprises IPC filter rule management process, IPC filter rule lookup process, IPC filter rule table and plurality of IPC endpoints and a network interface for connectivity, wherein IPC filter rule management process creates, deletes and updates the entries in IPC filter rule table, and wherein IPC filter rule lookup process finds the matched rule and takes the forwarding actions. A system in accordance with the principles of present invention for providing inter process communication where IPC endpoints may get relocated during the operation of the system comprises a plurality of preferred devices which in an embodiment may be connected with plurality of functional peers through plurality of network interfaces.

WO 2011/145119 A1

METHOD AND SYSTEM FOR EFFICIENT INTER-PROCESS COMMUNICATION IN A HIGH AVAILABILITY SYSTEM

FIELD OF THE DISCLOSURE

The present disclosure relates to inter process communication methods in software. More specifically, the present disclosure pertains to a method and associated system and data structure for efficient inter process communication in an environment where the IPC address associated with the destination entity may change at any time.

BACKGROUND OF THE DISCLOSURE

In conventional communication systems shown in Figure 1, a node 10 is required to interface with many neighbors. These are collectively shown in Figure 1 as "Functional Peer Left" and "Functional Peer Right". There are strict availability and scalability requirements for the said node on all interfaces. In order to meet availability requirements, the system is implemented using redundant software components, redundant hardware elements and one or more of several possible high availability schemes. Scalability requirements are met through modular design. Software components are mapped to hardware elements which provide an execution environment for these software components. High availability schemes are realized using appropriate check pointing, data replication and failure detection schemes. On failure of a working hardware element or software component, a standby (hot) software component starts functioning in place of the failed software component. It also includes switching of hardware elements.

Figure 2 shows a communication system 10 comprising plurality of hardware elements 20 through 2x. Software functional components associated with the processing of the interworking with functional peer left comprising plurality of modules 20_500 through 20_5xx and with functional peer right comprising plurality of modules 21_600 through 21_6xx. Functionality of these components is defined by the relevant specification in terms of protocol data units (PDU) or messages received from the functional peer and actions to be taken by the node 10. Such an action is performed by the plurality of software functional components 20_500 through 20_5xx and 21_600 through 21_6xxx and may or may not produce PDU on the same interface or on other interface. To realize this processing, the software functional components 20_500 through 20_5xx and 21_600

through 21_6xx are required to communicate among each other. This type of communication is referred to as inter process communication (IPC). Software function components that communicate with each other using IPC are called IPC end points. This is realized using a network 50 internal to the node. Every hardware element is connected to network 50 through network interface 20_400 through 2x_400 and assigned layer 3 addresses 10.0.0.1 through 10.0.0.x+1. The IPC endpoints may be located on the same hardware element or on different hardware elements. IPC endpoints 20_300 through 2x_300 are responsible for delivering the IPC messages to the destination IPC endpoints. There are also several different timing or design specific considerations for inter process communication.

There are many standard platforms such as cPCI, ATCA, microTCA etc. available off the shelf which can be used to realize node 10. These standard platforms can accommodate one or more hardware elements (such as hardware boards) to realize plurality of hardware element 20 through 2x. These hardware elements have a CPU, memory, the required communication interface, other hardware accelerators and a host operating system such as Linux. A communication interface on the hardware element is assigned one or more IP addresses and used for local-to-remote communication. A loopback interface is also provided for local communication.

IPC routing module maps the destination IPC endpoint to IP address and IPC message is sent through TCP/IP and routed using a kernel IP routing table to the destination IPC endpoint. To communicate with a desired IPC endpoint, the source IPC endpoint is required to select the correct IP address associated with the hardware element where the desired destination IPC endpoint is located. In other words, an IP address is associated with an IPC endpoint. Figure 3 shows IPC message exchange 1000 from 20_500 to 20_501 located on same hardware element 20. IPC endpoint 20_300 maps 20_501 to the IP address 20_400 and message is routed using IP routing table. IPC endpoint 20_300 receives the message and sends it to 20_501. Figure 3 also show IPC message exchange 2000 from 20_500 to 21_600 located on hardware elements 20 and 21 respectively. IPC endpoint 20_300 maps 21_600 to the IP address 21_400 and message is routed using IP routing table. IPC endpoint 21_300 receives the message and sends it to 21_600. Hardware element 22 is hot standby to hardware element 21.

The association of an IP address with an IPC endpoint is not fixed and may change because of failure. Figure 4 shows that on failure of hardware element 21, hardware element 22 becomes active and 21_600 is now associated with different IP address (22_400). This means IPC endpoint 20_300 should send messages for IPC exchange to IP address 22_400.

PDUs from left functional peer and right functional peer are processed in a user data context which may be established through control PDUs exchange or statically configured. There will be many user data contexts exist in the system, one each for every PDUs flow. A scalable system would implement plurality of software functional elements and plurality of hardware elements for handling many user data contexts. Due to this user data context associated with a flow will have many instances. Software functional components are required to communicate with each others to process PDUs associated with user data context. This means a software functional component together with user data context participates in inter process communication and are being referred to as IPC endpoints.

The IPC endpoints may get relocated because of exceeded capacity, failure or change in the Functional peer and will require change in the selected layer 3 address and destination IPC end point by source IPC endpoint for IPC messaging. IPC message exchange between two IPC endpoints is called as IPC message flow.

It can be seen that there is a need for a method and data structures for providing efficient inter process communication where IPC endpoints may be relocated during operation of the system.

SUMMARY OF THE INVENTION

To overcome the limitations described above, and to overcome other limitations that will become apparent upon reading the understanding of the state of art, the present invention discloses a system, method and associated data structures for providing inter process communication where IPC endpoints may get relocated during the operation of the system.

An embodiment of the present invention solves the above described problems by assigning a filter rule to IPC message flow, storing said rule in IPC filter rule table, identifying a match rule when an IPC message is send and forwarding IPC message according forwarding action of the matched rule. It further comprises updating the affected filter rules when IPC destination is relocated.

A device in accordance with the principles of the present invention includes IPC filter rule management process, IPC filter rule lookup process and IPC filter rule table, wherein IPC filter rule management process creates and updates the entries in IPC filter rule table, and wherein IPC filter rule lookup process finds the matched rule and takes the forwarding actions.

A system in accordance with the principles of present invention for providing inter process communication where IPC endpoints may get relocated during the operation of the system comprises a plurality of preferred devices which in an embodiment may be connected with plurality of functional peers through plurality of network interfaces.

An implementation according to a preferred embodiment of the present invention can use system events such as addition, deletion, failure and mobility of IPC endpoint; system scalability and/or combination thereof for IPC filter rule management process to update the IPC filter rule table.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

Figure 1 shows a typical data communication system

Figures 2 through 4 show the conventional method of IPC message forwarding

Figure 5 shows a device and associated data structure according to a preferred embodiment

Figure 6 is a flow chart describing an exemplary IPC filter lookup according to a preferred embodiment

Figure 7 is an exemplary system demonstrating IPC message flow forwarding according to a preferred embodiment

Figure 8 is an exemplary system demonstrating relocation of IPC endpoints

DESCRIPTION OF THE DISCLOSURE

In the following description of the embodiments, reference is made to the accompanying drawings that form a part hereof, and which is shown by way of illustration of the specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized without departing from the scope of the present invention.

The present invention provide method, system and associated data structures for providing inter process communication (IPC) where IPC endpoints may get relocated during the operation of the system.

As used herein, the term "filter rule" collectively refers to filter mask, filter value and forwarding action. As used herein, term "filter mask" collectively refers to fields of IPC message such as source and destination IPC endpoint identifiers, IPC message flow identifier and any other fields in IPC message. As used herein, the term "filter value" refers to the values of the fields selected by filter mask for the said rule. As used herein, filter mask and filter value of a filter rule uniquely associates a filter rule with an IPC message flow through and vice a versa. As used herein "forwarding action" refers to the address and outgoing interface to be used for forwarding IPC message. As used herein, the term "matched rule" or "selected rule" refers to a rule which is when a filter mask of the said rule is applied on an IPC message, resultant fields' values are equal or identical to the filter value of the said rule.

An embodiment of the present invention solves the above described problems by assigning a filter rule to IPC message flows, storing said rules in IPC filter rule table, identifying a match rule when an IPC message is send and forwarding IPC message according to forwarding action of the matched rule. It further comprises updating the affected filter rules when IPC endpoint is relocated.

A device in accordance with the principles of the present invention as shown in Figure 5 includes IPC filter rule management process (20_700), IPC filter rule lookup process (20_800), IPC filter rule table (20_900) and plurality of IPC endpoints 20_500 through 20_5xx and a network interface (20_400) for connectivity, wherein IPC filter rule management process creates, deletes and updates the entries in IPC filter rule table, and wherein IPC filter rule lookup process finds the matched rule and takes the forwarding actions.

We use an IPC Filter Rule Table 20_900 to store the Filter rules for efficient lookup. In the following discussion 'IPC Filter Rule Table' and 'Table' are used interchangeably. This table comprises:

1. *Filter Mask*: defines the fields of IPC message to be used from the IPC message for matching the entry in the table. An implementation according to a preferred embodiment may use source and destination IPC endpoint identifiers, IPC message flow identifier and any other fields in IPC message Source Identifier. Source and destination IPC endpoint identifiers may be mapped to the network address in the packet or any identifiers assigned to the IPC end points. IPC message flow identifier is an identifier assigned to uniquely identify an IPC message exchange between two IPC endpoints. IPC flow identifier may also be a protocol field defined by communication protocol.

2. *Filter Value*: defines the value(s) for the corresponding fields of an IPC message selected by Filter Mask. A value can be wild card, which is a match for all possible values of the corresponding field.

3. *Forwarding Action - Address*: provides the IP address or IPC endpoint identifier to be used for forwarding the IPC message.

4. *Forwarding Action - Interface*: Network interface to be used for forwarding the IPC message. "lo" is a special interface. If IPC message is forwarded through this interface then it is delivered to a IPC endpoint exists locally on the same hardware element. This forwarding mechanism is operating system dependent and can be for example, socket, POSIX queue, shared memory.

An implementation according to preferred embodiment of the present invention can use system events such as addition, deletion, failure and mobility of IPC endpoint; system scalability and/or combination thereof for IPC filter rule management process to update the IPC filter rule table. IPC filter rule management process may be required to split an existing filter rule into two or more filter rules or merge many existing filter rules into one filter rule at the time of adding, updating or deleting a filter rule. Existing filter rule in the table is required to be splitted when there would be two or more filter rules with identical filter mask and filter value but different forwarding actions. A filter rule is splitted into multiple filter rules by adding one more fields to the filter mask. Two or more existing filter rules in the table are required to be merged into one entry when their forwarding actions are identical. Filter rules are merged by removing the one or more fields from the filter masks for which filter values are not identical.

Figure 6 is a flow chart 800 of filter rules lookup performed by IPC Filter Rule Lookup process (20_800). Process begins by receiving an IPC message on either incoming or outgoing interface (100) on any of the interface of the system. All filter rules from beginning to end are checked (200, 410) if "values of the fields in the IPC message selected by filter rule's filter mask" are identical to "filter values" (320). If such a filter rule is found (420) then IPC message is forwarded to the filter rule's forwarding address (420). If end of the table is reached then message is dropped (310).

Figure 7 shows an exemplary system 10 according to a preferred embodiment of the present invention comprising plurality of preferred devices 20 through 2y and which in an

embodiment may be connected with plurality of external functional peers 50 and 55 through plurality of network interfaces 500 through 50m. IPC endpoints of IPC message flow 1000 are located on the same device 20. IPC endpoints of IPC message flow 2000 are located on different devices 20 and 21. A function peer 50 communicates with system 10, IPC endpoint 20_500. A protocol field (e.g. GRE Key 123450) in the message exchange is used as IPC message flow identifier. System 10 is connected with function peer 55 through network interface 500. IPC endpoint 21_501 of System 10 communicating with function peer 55 is also shown. A protocol field (e.g. GRE Key 56789) in the message exchange is used as IPC message flow identifier. System 10 is connected with function peer 55 through network interface 50m. Corresponding IPC Filter rule table is also shown in Figure 7. IPC Filter rule table 20_901 is used by IPC Filter rule lookup process 20_800 and IPC Filter rule table 21_901 is used by IPC Filter rule lookup process 21_800.

Figure 8 demonstrates the relocation of IPC end point according to the preferred embodiment of the present invention. IPC message flow 2000 is relocated from 21 to 22. IPC filter rule tables after the relocation are also show in the figure 8. Subsequent IPC messages of 2000 will be forwarded to 22 by IPC Filter Rule Lookup process 20_800. IPC Filter Rule Lookup process 22_800 will forward these IPC messages to 22_500.

The foregoing description of the exemplary embodiment of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not with this detailed description, but rather by the claims appended hereto.

We claim:

1. A device for providing inter process communication where IPC end points may get relocated during the operation of the device comprising:
    a. one or more network interfaces
    b. an IPC filter rule management entity to create, update and delete IPC filter rules as IPC message flows are created, relocated or deleted
    c. an IPC filter rule table to store IPC filter rules
    d. an IPC filter rule lookup entity to associate an IPC filter rule in the IPC filter rule table, forwarding an IPC message in accordance with the forwarding actions of the IPC filter rule
    e. one or more IPC end points

2. A device as claimed in claim 1, wherein the filter rule comprises a filer mask, a filter value and a forwarding action comprising a forwarding address and an interface

3. A device as claimed in claim 2, wherein the filter mask comprises any combination of standardized or non-standardized fields of the IPC message that uniquely identify an IPC message flow

4. A device as claimed in claim 2 or 3, wherein the filter value comprises values of the fields selected by the filter mask to identify all IPC messages of an IPC message flow.

5. A device as claimed in claim 4, wherein the field value comprises of a scalar value, a range or a wild card

6. A device as claimed in claim 1, wherein the IPC filter rule table is implemented as a hash table, a ordered table or an unordered table

7. A device as claimed in claim 2, wherein the forwarding address can be an Internet Protocol address or any other form of address assigned to identify a IPC endpoint

8. A device as claimed in claim 1, wherein the IPC message is forwarded to the address through the interface provided in the forwarding action of the associated filter rule.

9. A device as claimed in claim 1, wherein the IPC message is dropped when the forwarding address is not specified in the associated rule.

10. A device as claimed in claim 1, wherein the IPC message is forwarded to the IPC endpoint using an implementation specific manner to the forwarding action address in the associated filter rule when the forwarding action interface is configured as "lo".

11. A system for providing inter process communication where the IPC end points may get relocated during the operation of the system, comprising one or more interconnected devices as claimed in claim 1.

12. A system as claimed in claim 11, comprising one or more interfacing units for communicating with peer nodes.

13. A system as claimed in claim 11, wherein the IPC endpoints of an IPC message flow are located within the system.

14. A system as claimed in claim 11, wherein atleast one of the IPC endpoints of an IPC message flow is located outside the system.

15. A system as claimed in claim 11, wherein one or more system events comprising addition, deletion, failure and mobility of an IPC endpoint and system scalability are used by the IPC filter rule management entity to update the IPC filter rule table.

16. A method for inter-process communication between a source and destination IPC endpoints, comprising the steps of:

    a. adding, deleting, and updating one or more IPC filter rules;

    b. waiting for and receiving one or more incoming or outgoing IPC message;

    c. determining the rule associated with the IPC message; and

    d. forwarding the IPC message according to the forwarding action of the IPC filter rule.

17. A method as claimed in claim 16, wherein the outgoing IPC messages are received on the device comprising the source IPC endpoint of the IPC message.

18. A method as claimed in claim 16, wherein the incoming IPC messages are received on the device comprising the destination IPC endpoint of the IPC message.

19. A method as claimed in claim 16, wherein determining the rule associated with IPC message comprises the steps of:

    a. comparing the value of the IPC message fields selected by the filter mask of the IPC filter rule with the filter value of the rule

    b. determining the applicability of the IPC filter rule based on the comparison.

20. A method as claimed in claim 16 or 19, comprising analyzing all the IPC filter rules in the table from beginning to end till an applicable IPC filter rule is found.

21. A method as claimed in claim 16, 17 or 20, wherein the IPC message is silently dropped when no applicable IPC filter rule can be found.

22. A method as claimed in claim16, 19 and 20, wherein an exception is generated and the IPC message is silently dropped when no applicable IPC filter rule can be

found.

23. A method as claimed in claim 16, 19 or 20, wherein the IPC message is forwarded using a default forwarding action when no applicable IPC filter rule can be found.

24. A method as claimed in claim 16, 19 or 20, wherein the IPC message is silently dropped when an invalid forwarding action is found in the IPC filter.

25. A method as claimed in claim 16, 19 or 20, wherein an exception is generated and IPC message is silently dropped when an invalid forwarding action is found in the IPC filter.

26. A method as claimed in claim 16, 19 or 20, wherein the IPC message is forwarded using a default forwarding action when an invalid forwarding action is found in the IPC filter.

27. A method as claimed in claim 24, 25 or 26, wherein the forwarding action is considered invalid if the forwarding address is not reachable through the interface, the forwarding address is not configured or the interface is not valid.

28. A method as claimed in claim 16, wherein the IPC message is forwarded to the IPC endpoint using an implementation specific manner to the forwarding action address in the associated filter rule when the forwarding action interface is configured as "lo".

29. A method as claimed in claim 19, wherein the scalar value of a field in the IPC filter rule is considered to be equal to the corresponding filed value in IPC message when the two values are equal.

30. A method as claimed in claim 19, wherein the range value of a field in the IPC filter rule is considered to be equal to the corresponding field value in IPC message when the range comprises the field value.

31. A method as claimed in claim 19, wherein a wild card value in a field in the IPC filter rule is always considered to be equal to the corresponding field value in the IPC message.

32. A method as claimed in 19, wherein the IPC filter rule is applicable when the values of all the fields of the IPC message match with the corresponding IPC filter values of the IPC filter rule.

33. A method as claimed in claim 16, wherein adding a new IPC filter rule comprises the steps of:

a. constructing a new IPC filter rule by assigning a filter mask, filter value and forwarding action corresponding to an IPC message flow;

b. resolving conflicts of the new IPC filter rule with the existing IPC filter rules that have identical filter mask and filter values but different forwarding action;

c. inserting the new IPC filter rule in the table; and

d. merging two or more rules in the table that have identical forwarding action and filter mask.

34. A method as claimed in claim 16, where deleting an IPC filter rule comprises the steps of:

a. removing the rule from the table; and

b. merging two or more remaining rules in the table that have identical forwarding action and filter mask.

35. A method as claimed in claim 16, wherein updating an IPC filter rule comprises the steps of:

a. removing the IPC filter rule from the table; and

b. adding the updated rule as claimed in claim 33;

36. A method as claimed in claim 33 or 34, wherein merging two or more IPC filter rules comprises the steps of:

    a. constructing a new rule comprising fields which have identical values;

    b. removing the IPC filter rules to be merged from the table

    c. adding a new rule to the table.

37. A method as claimed in claim 33, wherein resolving conflict between two IPC filter rules comprise adding one more IPC message fields that have different values in the IPC message flows corresponding to conflicting rules to filter mask of the conflicting rules.

SHEET 1/ 5

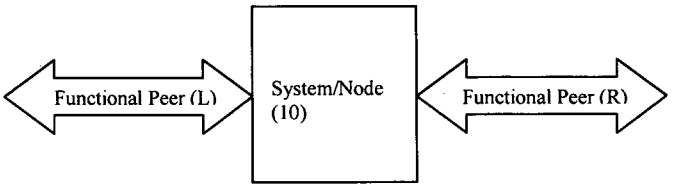


Figure 1

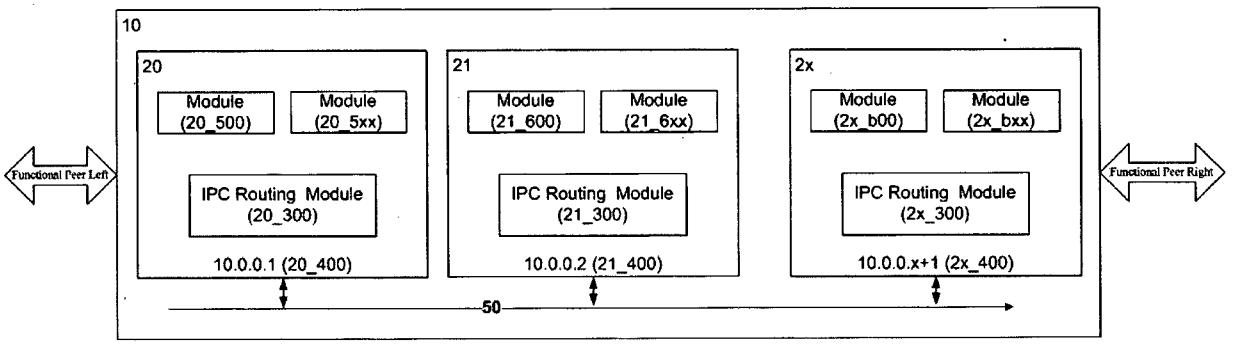


Figure 2

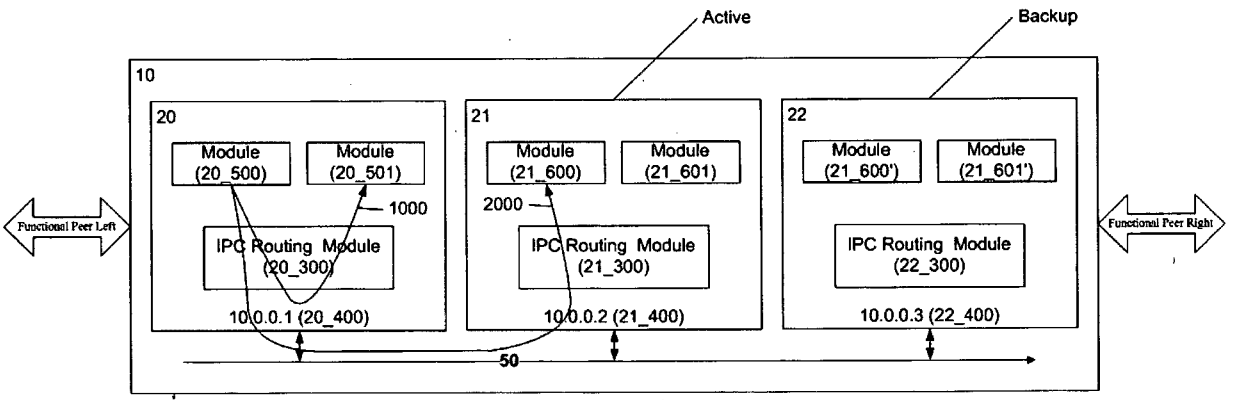


Figure 3

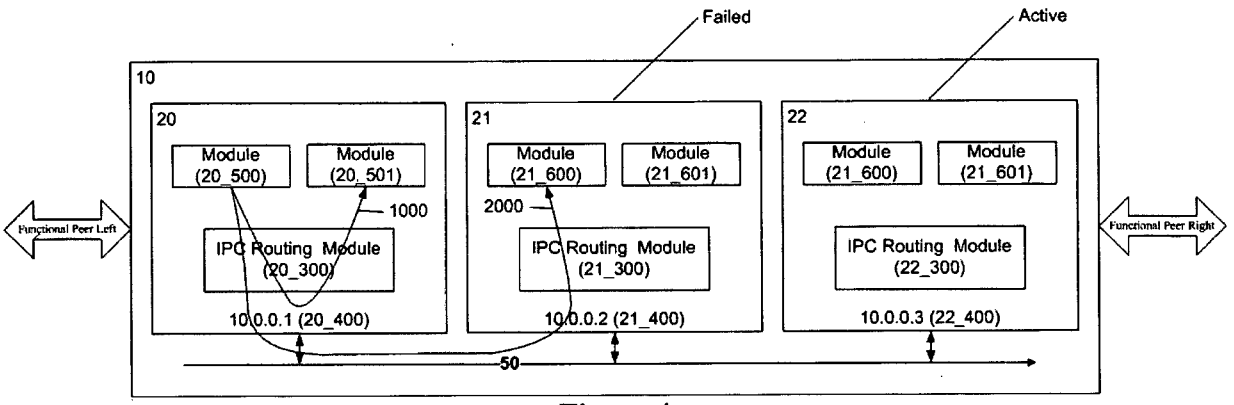


Figure 4

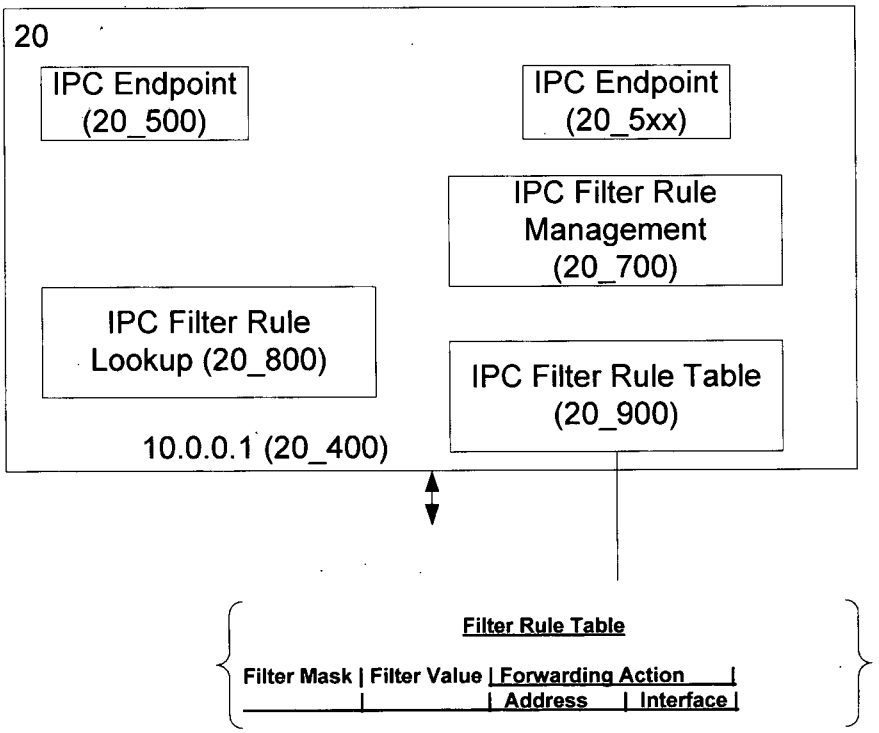


Figure 5

SHEET 3/ 5

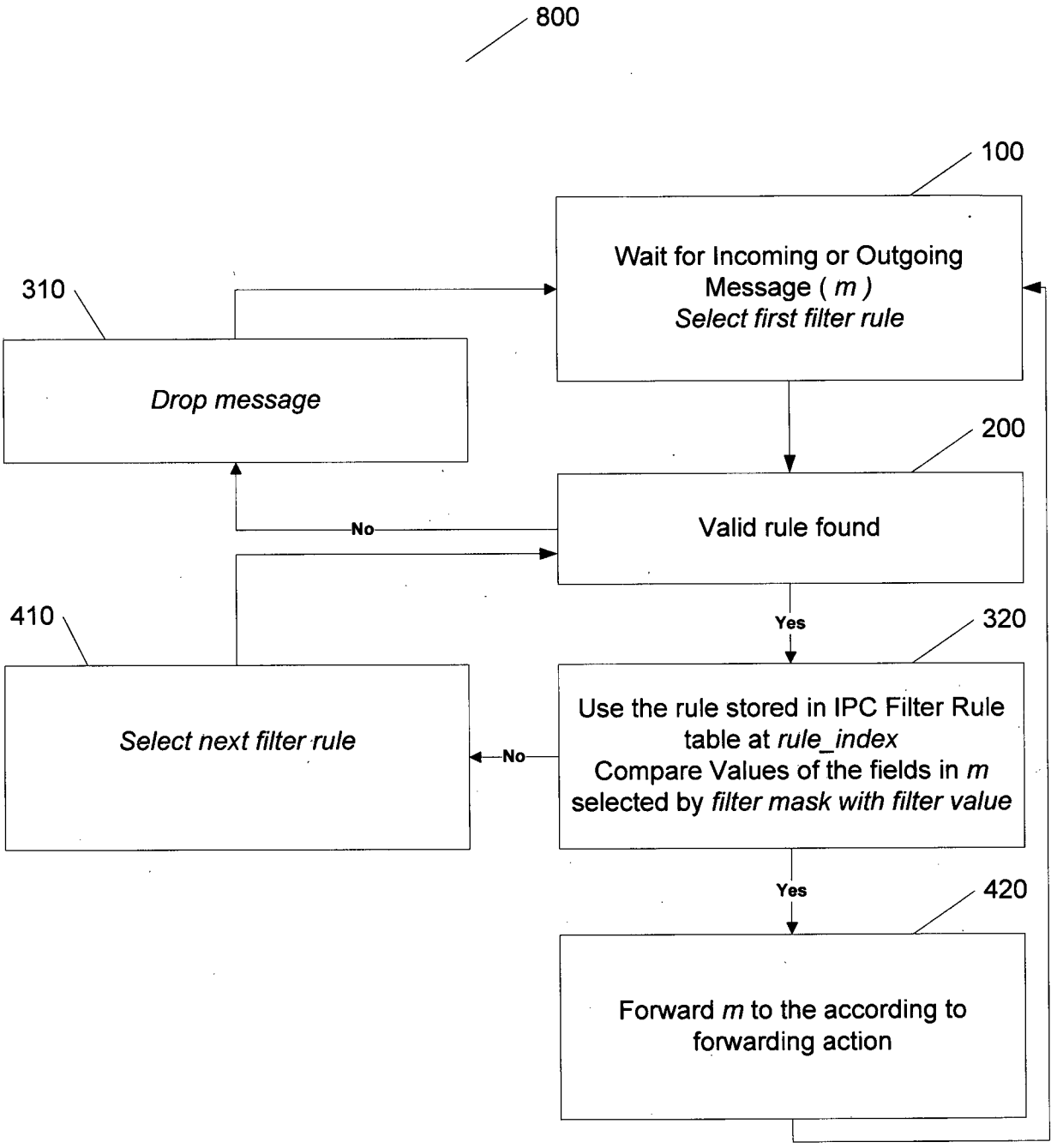


Figure 6

SHEET 4/ 5

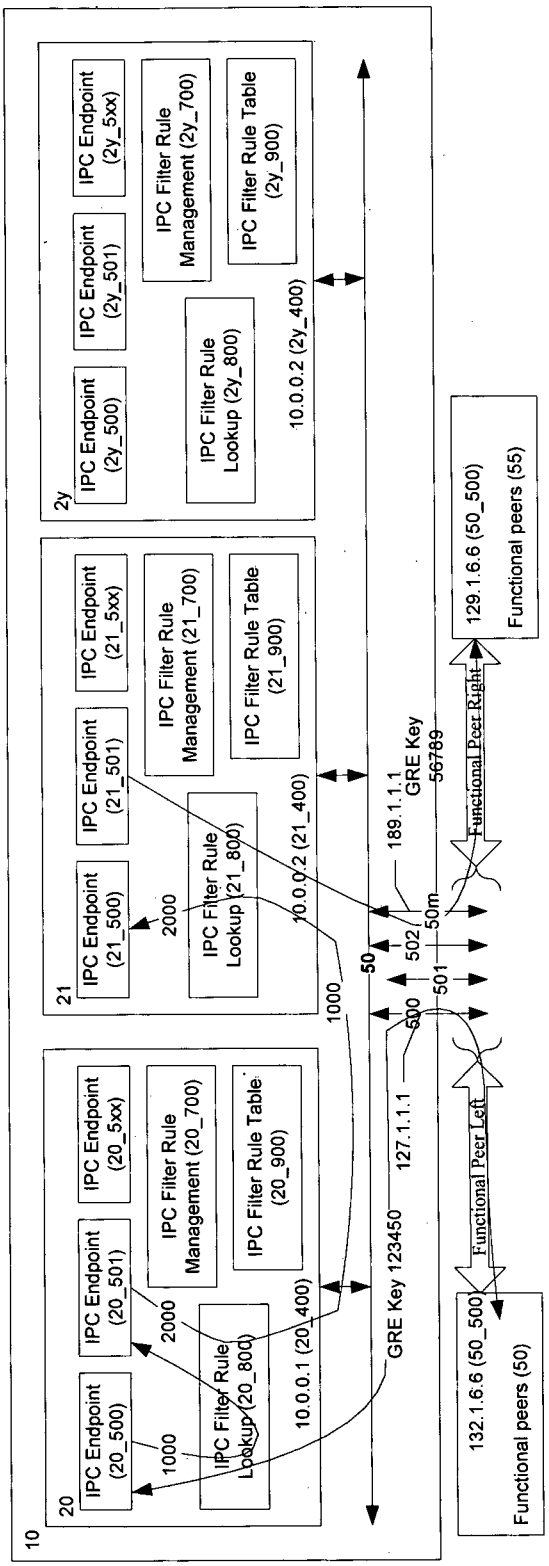


Figure 7

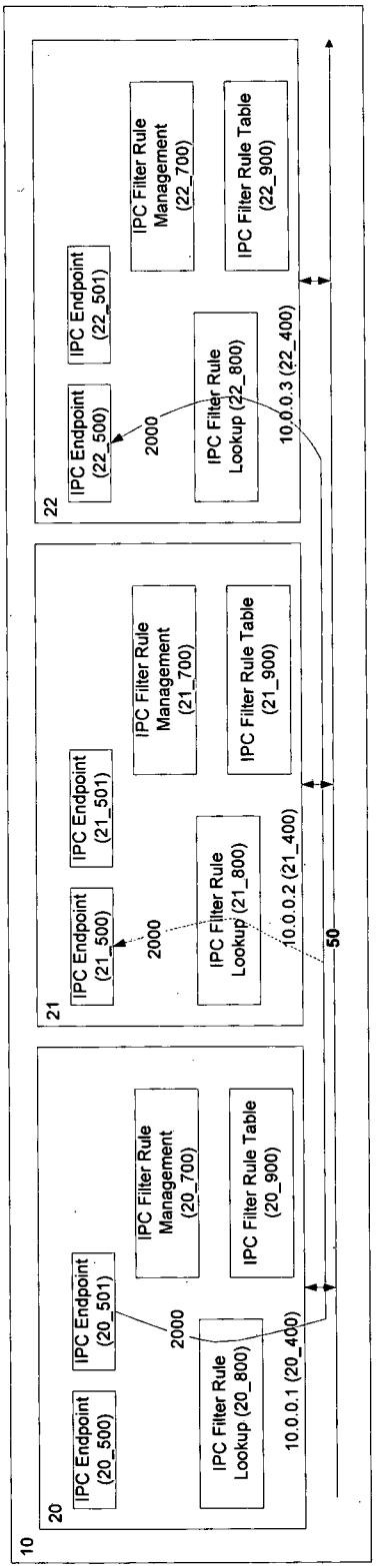
Filter Rule Table (20_901)

Rule No.	Filter Mask	Filter Value	Forwarding Action	
			Address	Interface
1	Source Identifier	20_500	20_501	lo
	Destination Identifier	20_501		
	IPC Flow Identifier	1000		
2	Source Identifier	20_501	10.0.0.2	20_400
	Destination Identifier	21_500		
	IPC Flow Identifier	2000		
3	Source Identifier	132.1.6.6	20_501	lo
	Destination Identifier	172.1.1.1		
	IPC Flow Identifier/ GRE Key	123450		

Filter Rule Table (21_901)

Rule No.	Filter Mask	Filter Value	Forwarding Action	
			Address	Interface
1	Source Identifier	20_501	21_500	lo
	Destination Identifier	21_500		
	IPC Flow Identifier	2000		
2	Source Identifier	*	129.1.6.6	21_500
	Destination Identifier	129.1.6.6		
	IPC Flow Identifier/ GRE K	56789		

SHEET 5/ 5



Filter Rule Table (20_901)

Rule No.	Filter Mask	Filter Value	Forwarding Action	
			Address	Interface
1	Source Identifier	20_501	10.0.0.3	20_400
	Destination Identifier	21_500		
	IPC Flow Identifier	2000		

Filter Rule Table (21_901)

Rule No.	Filter Mask	Filter Value	Forwarding Action	
			Address	Interface

Filter Rule Table (22_901)

Rule No.	Filter Mask	Filter Value	Forwarding Action	
			Address	Interface
1	Source Identifier	20_501	22_500	lo
	Destination Identifier	21_500		
	IPC Flow Identifier	2000		

Figure 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2011/000352

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F9/54
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)
G06F

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)
EPO-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 6 047 323 A (KRAUSE MICHAEL R [US]) 4 April 2000 (2000-04-04) abstract column 1, line 55 - column 6, line 67; figures 1-16 column 7, line 64 - column 77, line 9; claims 1-47 -----	1-37
X	WO 95/31780 A1 (APPLE COMPUTER [US]) 23 November 1995 (1995-11-23) abstract page 2, line 15 - page 5, line 10 page 7, line 1 - page 52, line 8 Appendix Afigures 1-21 claims 1-27 ----- -/--	1-37

[X] Further documents are listed in the continuation of Box C.

[X] 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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2011	07/10/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wierzejewski, Piotr

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2011/000352

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/082737 A1 (DANKLE THEODORE B [US] ET AL) 1 April 2010 (2010-04-01) abstract paragraph [0014] - paragraph [0065]; claims 1-20; figures 1-12 -----	1-37

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IN2011/000352

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