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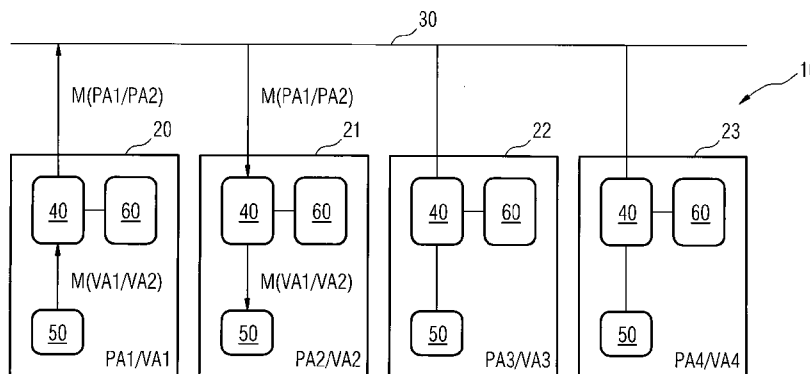
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(54) Title: A METHOD OF RUNNING A SUBSTATION OF AN ELECTRIC POWER SUPPLY SYSTEM

FIG 3



(57) Abstract: The invention inter alia relates to a substation device (20, 21, 22, 23, 26) for a substation (10) of an electric power supply system, wherein said substation device is configured to use device-dependent physical addresses (PA1-PA6) for communication with other substation devices of said substation, and wherein said substation device comprises a processing module for processing the data content of messages. According to an embodiment of the invention, said substation device further comprises an address translating module (40) for translating said device-dependent physical addresses into device-independent virtual addresses (VA1-VA5) and vice versa. Said processing module (50) is preferably connected to said address translating module and configured to process messages based on said virtual addresses.

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Description

A METHOD OF RUNNING A SUBSTATION OF AN ELECTRIC
POWER SUPPLY SYSTEM

5 The invention relates to substation devices for substations of electric power supply systems. Such substation devices may comprise protection and/or control equipment for measuring, switching, protecting and/or controlling electrical components or branches of the electric power supply system.

10

Prior art substation devices comprise processing modules for processing data content of messages, and are configured to use device-specific physical addresses for communication with other substation devices.

15

Prior art substation devices require costly and error prone engineering processes. Each substation device needs to be configured separately using vendor supplied tools. Included in the parameter set of each device are device-specific physical addresses such as MAC addresses (MAC: Media-Access-Control-addresses) of other substation devices. These addresses are used for communication such as for sending GOOSE messages according to IEC61850 standard (GOOSE: General Object Oriented System Environment).

25

Since physical addresses are device specific and often not alterable, replacement of a single substation device requires also reconfiguration of all other substation devices connected to the one being replaced. For instance, if a substation device needs to be replaced, other substation devices that were configured to send messages to the old MAC address of the replaced substation device need to be identified and reconfigured.

30

The object of the present invention is to provide a substation device which requires less reconfiguration effort in case of a device replacement.

5 According to the invention, this object is achieved by a substation device comprising the features of claim 1.

According to the invention the substation device comprises an address translating module for translating device-dependent
10 physical addresses into device-independent virtual addresses and vice versa.

The essential advantage of the present invention consists of the decoupling of external communication from internal data
15 content processing. The data content processing can be carried out based on virtual addresses, only. As such, if an old substation device is replaced by a new substation device, the processing modules of the remaining substation devices need not be updated as they can continue their processing algo-
20 rithms based on the old virtual addresses. Only the address translating module needs to be modified by updating the assignment between the virtual address, which remains unchanged, and the new physical address. This update, however, can easily be carried out. For instance, if the translating
25 module uses a routing table comprising virtual and physical address pairs, each of which correlating a physical address and a corresponding virtual address, the update merely requires an exchange of a single address pair. Obviously, the remaining routing table may stay unchanged. In other words,
30 an update just requires the exchange of a single physical address with a single entry in a routing table. Preferably each substation device updates itself after receiving an update message comprising a new address pair for its routing table.

Preferably, the address translating module is configured to modify incoming messages, which are no update messages, by replacing all physical addresses comprised therein with the corresponding virtual addresses. The address translating module preferably forwards the modified messages to the processing module.

Furthermore, the address translating module preferably modifies outgoing messages, which are provided by the processing module and which are no update messages, by replacing all virtual addresses comprised therein with corresponding physical addresses. Then, the address translating module may transmit the modified messages to the recipient(s).

According to a further preferred embodiment, the address translating module has access to a routing table which comprises virtual and physical address pairs. Each address pair correlates a physical address and a corresponding virtual address.

The routing table may be stored in a central memory located in one of the substation devices. In this case, all other substation devices should also have access to the central memory.

Alternatively, each substation device comprises its own memory for storing the routing table.

In the latter case, the translating module is preferably configured to update its routing table upon receiving an update message comprising an address pair having the physical address of a new device and the virtual address of an old device, which has been replaced by the new device. Such an up-

date message is preferably generated by the new device after initialization.

The physical addresses are preferably Media-Access-Control-
5 addresses. A MAC address is a unique identifier assigned to most network adapters or network interface cards by the manufacturer, and used in the Media Access Control protocol sublayer. MAC addresses are also known as Ethernet Hardware addresses (EHA), hardware addresses, or adapter addresses.

10

The invention also relates to a substation of an electric power supply system. According to a preferred embodiment, each of the substation devices comprises a device-dependent physical address for communication over a communication network. Further, each of the substation devices is assigned a
15 device-independent virtual address in addition to the device-dependent physical address. An address translating module in each of the substation devices translates physical addresses into virtual addresses and vice versa. A processing module in each of the substation devices internally processes the contents of messages based on the virtual addresses. The substation devices are connected with each other via the communication network which forwards messages based on the physical
20 addresses.

25

The invention further relates to a method of running a substation of a power supply system. Preferably substation devices exchange messages via a communication network, wherein the messages indicate the physical address of the respective
30 sender and/or the physical address of the respective recipient(s). Upon receiving a message each substation device replaces physical addresses contained in the message with corresponding virtual addresses, and internally processes the message based on the virtual addresses.

The substation devices may also process outgoing messages based on virtual addresses, only, and replace all virtual addresses with corresponding physical addresses before transmitting the messages via the communication network.

The substation devices may use a routing table comprising pairs of physical addresses and corresponding virtual addresses, and may replace physical addresses with corresponding virtual addresses and vice versa virtual addresses with corresponding physical addresses referring to entries in the routing table.

Upon replacing an old substation device with a new substation device, the new device preferably publishes an address pair comprising its physical address and the virtual address of the old device. The other substation devices will receive this new address pair and can automatically update their routing table in order to send and receive further messages based on the new address pair.

In order that the manner in which the above-recited and other advantages of the invention are obtained will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are therefore not to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail by the use of the accompanying drawings in which

Figure 1 shows an exemplary embodiment of an inventive substation;

5 Figure 2 shows an exemplary embodiment of a routing table for the substation shown in Figure 1;

10 Figures 3 and 4 show in exemplary fashion a transmission of messages between substation devices of the substation shown in Figure 1;

15 Figure 5 shows in exemplary fashion the replacement of a substation device of the substation shown in Figure 1 and the subsequent automatic reconfiguration;

20 Figure 6 shows an exemplary embodiment of an updated routing table for the substation shown in Figure 1; and

Figure 7 shows an exemplary embodiment of a substation device with reference to the OSI model.

25 The preferred embodiments of the present invention will be best understood by reference to the drawings, wherein like parts are designated by like reference signs throughout.

30 It will be readily understood that the message modification steps of the present invention, as generally described and illustrated in the figures herein, could vary in a wide range of different message modification steps. Thus, the following more detailed description of the exemplary embodiments of the present invention, as represented in Figures 1 - 7 is not in-

tended to limit the scope of the invention, as claimed, but is merely representative of presently preferred embodiments of the invention.

5 Figure 1 shows an exemplary embodiment of a substation 10 of an electric power supply system. The substation 10 comprises a plurality of substation devices 20, 21, 22, and 23 which are connected by a communication network 30. The substation devices may be field devices for switching, protecting and/or
10 controlling the electric power supply system.

Each substation device is assigned a device-dependent physical address for communication over the communication network 30. The device-dependent physical addresses of substation de-
15 vices 20-23 are designated by reference signs PA1-PA4, respectively.

Each substation device is further assigned a device-independent virtual address in addition to the device-
20 dependent physical address. The device-independent virtual addresses of substation devices 20-23 are designated by reference signs VA1-VA4, respectively.

Each substation device comprises an address translating module 40 for translating physical addresses into virtual ad-
25 dresses and vice versa, and a processing module 50 for internally processing the data content of messages.

The internal processing carried out by the processing module
30 50 is based on the virtual addresses VA1-VA4 of the substation devices 20-23. However, the communication over the communication network 30 is managed based on the device-dependent physical addresses PA1-PA4.

Each address translating module 40 has access to an internal routing table 60 which comprises virtual and physical address pairs, each address pair correlating one of the physical addresses PA1-PA4 to the corresponding virtual address VA1-VA4.

5

An exemplary embodiment of a routing table 60 is shown in Figure 2. Each row in routing table 60 comprises an address pair comprising a physical address and the corresponding virtual address.

10

Figure 3 shows in an exemplary fashion the transmission of a message M(PA1, PA2) from substation device 20 to substation device 21. The message M(PA1, PA2) indicates the physical address PA1 of the sending substation device 20 and the physical address PA2 of the receiving substation device 21.

15

Upon receiving the message M(PA1, PA2) the address translating module 40 of substation device 21 replaces the physical addresses PA1 and PA2 contained in the received message M(PA1, PA2) with corresponding virtual addresses VA1 and VA2, and generates a modified message M(VA1, VA2). The exchange of addresses is carried out using the routing table 60 shown in Figure 2. Then, the modified message M(VA1, VA2) is forwarded to the processing module 50 of substation device 21 and processed therein.

20

25

Figure 4 shows in an exemplary fashion the transmission of a reply message from substation device 21 to substation device 20. First, the processing module 50 of substation device 21 analyzes the received message M(VA1, VA2), processes data and generates an outgoing message based on virtual addresses VA1 and VA2 which are assigned to the substation devices 20 and 21. The generated outgoing message is designated by reference sign M(VA2, VA1) in Figure 4. Thus, the message M(VA2, VA1)

30

indicates the virtual address VA2 of the sending substation device 21 and the virtual address VA1 of the receiving substation device 20.

5 The processing module 50 of substation device 21 forwards the outgoing message M(VA2, VA1) to the address translating module 40 of substation device 21. The address translating module 40 modifies the outgoing message M(VA2, VA1) by replacing the virtual addresses VA1 and VA2 with corresponding physical
10 addresses PA1 and PA2. Thus, the address translating module 40 generates a modified outgoing message M(PA2, PA1) which comprises physical addresses, only. Then, the address translating module 40 transmits the modified message M(PA2, PA1) to the recipient, i.e. substation device 20.

15

Figure 5 shows in an exemplary fashion the substation 10 of Figure 1 after replacing the substation device 20 by a new substation device 26. The new substation device 26 comprises a physical address PA6 which differs from the physical address PA1 of old substation device 20.
20

Upon replacing the substation devices, the new substation device 26 - automatically or triggered by personal - publishes an address pair (PA6, VA1) comprising its own physical address PA6 and the virtual address VA1 of the old substation
25 device 20.

The other substation devices 21-23 receive the address pair (PA6, VA1), and update their routing tables 60'. This allows
30 for further communication with new substation device 26 based on physical address PA6. Internal processing of data may be based on virtual address VA1 which was formerly assigned to substation device 20 and which is now assigned to new substation device 26. An exemplary embodiment of an updated routing

table 60' is shown in Figure 6. Again, each row in the routing table 60' comprises an address pair comprising a physical address and the corresponding virtual address.

5 Figure 7 shows in an exemplary fashion that the address translating module 40 and the processing module 50 may be comprised by an address translating layer 40' and a processing layer 50', respectively. Both layers 40' and 50' preferably belong to OSI layer 7 (application layer) according to
10 OSI reference model (OSI: Open System Interconnection Reference Model). The address translating layer 40' has preferably direct access to OSI layer 2 (data link layer) in order to allow for the exchange of physical and virtual addresses contained in messages.

15

Reference Numerals

	10	substation
	20-23	substation device
5	26	new substation device
	30	communication network
	40	address translating module
	40'	address translating layer
	50	processing module
10	50'	processing layer
	60	internal routing table
	60'	updated internal routing table
	M	message
15	PA1-PA6	device-dependent physical address
	VA1-VA6	device-independent virtual address

Claims

1. Substation device (20, 21, 22, 23, 26) for a substation (10) of an electric power supply system,
- 5 - wherein said substation device is configured to use device-dependent physical addresses (PA1-PA6) for communication with other substation devices of said substation, and
- wherein said substation device comprises a processing module for processing the data content of messages,
- 10 characterized in that
- said substation device further comprises an address translating module (40) for translating said device-dependent physical addresses into device-independent virtual addresses (VA1-VA5) and vice versa,
- 15 - wherein said processing module (50) is connected to said address translating module and configured to process messages based on said virtual addresses.
2. Substation device according to claim 1,
- 20 characterized in that
- said address translating module is configured to modify an incoming message (M(PA1, PA2)) by replacing physical addresses comprised therein with corresponding virtual addresses, and
- 25 - wherein said address translating module is further configured to forward the modified message (M(VA1, VA2)) to said processing module.
3. Substation device according to any of the preceding
- 30 claims,
- characterized in that
- said address translating module is configured to modify an outgoing message (M(VA2, VA1)), which is provided by the

processing module, by replacing virtual addresses comprised therein with corresponding physical addresses, and
- said address translating module is further configured to transmit said modified message (M(PA2, PA1)) to the recipient or the recipients.

4. Substation device according to any of the preceding claims,
characterized in that
10 said address translating module has access to a routing table (60) comprising virtual and physical address pairs, each address pair correlating a physical address and a corresponding virtual address.

15 5. Substation device according to claim 4,
characterized in that
said routing table is stored in a memory of the substation device.

20 6. Substation device according to claim 5,
characterized in that
said address translating module is configured to update its routing table upon receiving an update message comprising an address pair having the physical address of a new device and
25 the virtual address of an old device, which has been replaced by said new device.

7. Substation device according to any of the preceding claims,
30 characterized in that
said physical addresses are Media-Access-Control-addresses.

8. Substation (10) of an electric power supply system, the substation comprising at least two substation devices (20, 21, 22, 23, 26) according to any of the preceding claims, characterized in that

- 5 - each of said substation devices comprises a device-dependent physical address (P1-PA6) for communication over a communication network (30),
- each of said substation devices is assigned a device-independent virtual address (VA1-VA5) in addition to the
10 device-dependent physical address,
- each of said substation devices comprises an address translating module (40) for translating physical addresses into virtual addresses and vice versa, and
- each of said substation devices comprises a processing
15 module (50) for internally processing the data content of messages based on virtual addresses,
- wherein the substation devices are connected to said communication network which forwards messages based on physical addresses.

20

9. Method of running a substation (20, 21, 22, 23, 26) of an electric power supply system, characterized in that

- 25 - substation devices exchange messages via a communication network (30), the messages indicating the physical address of the respective sender and/or the physical address of the respective recipient,
- wherein upon receiving a message each substation device replaces the physical addresses contained in the received
30 message with corresponding virtual addresses, and internally processes the received message based on the virtual addresses.

10. Method according to claim 9,

characterized in that

- each substation device internally processes outgoing messages based on virtual addresses, and replaces all virtual addresses with corresponding physical addresses before
5 transmitting the messages via the communication network.

11. Method according to claim 9 or 10,

characterized in that

- 10 the substation devices replace physical addresses with corresponding virtual addresses and vice versa virtual addresses with corresponding physical addresses based on entries in a routing table which comprises pairs of physical addresses and corresponding virtual addresses.

15 12. Method according to any of the preceding claims 9-11,

characterized in that

- when replacing an old substation device with a new substation device, the new substation device publishes an address pair (PA6, VA1) comprising its own physical address
20 and the virtual address of the old device,
- wherein the other substation devices, which receive the address pair, update their routing table in order to send and receive further messages based on the updated routing table comprising the new address pair.

25

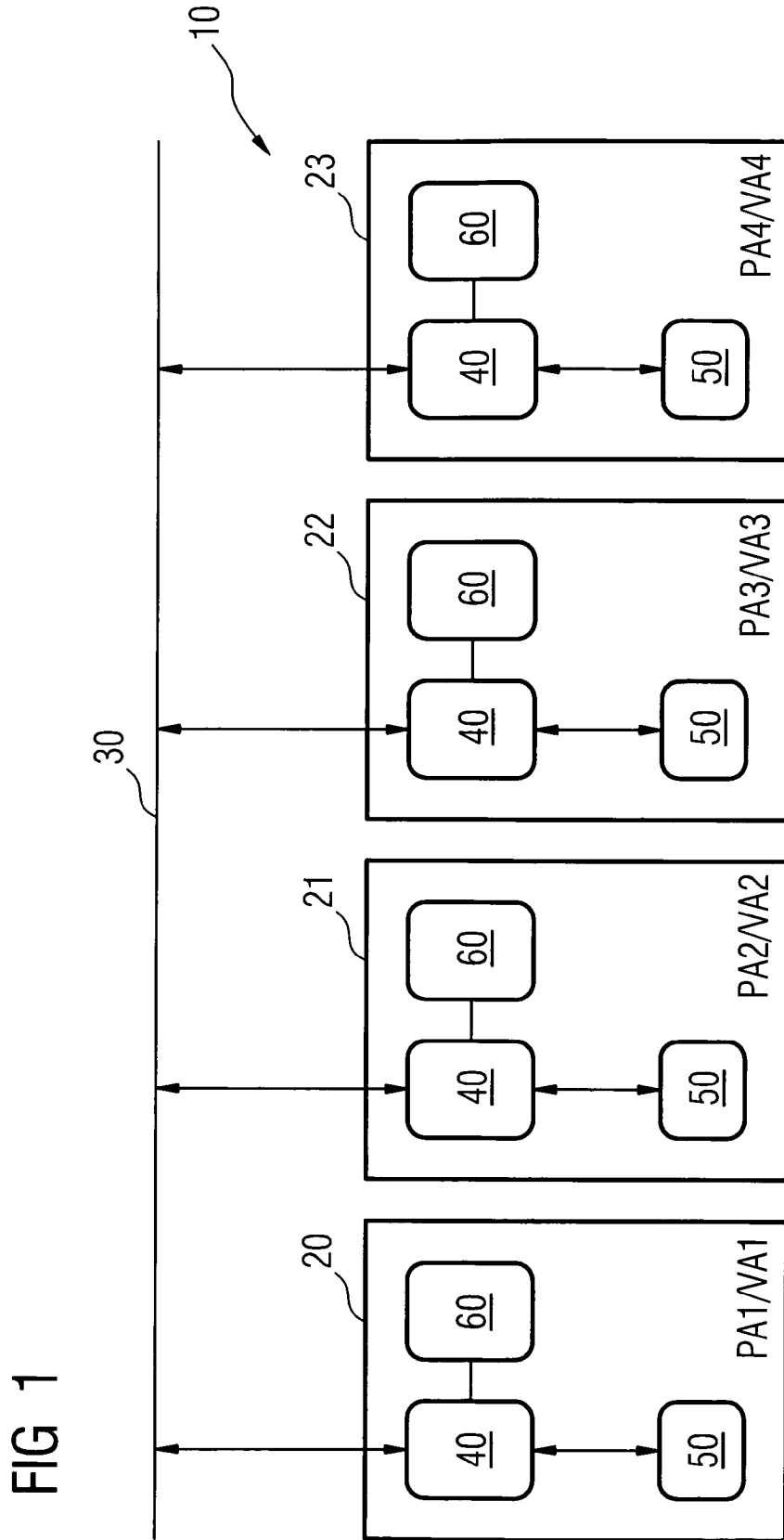
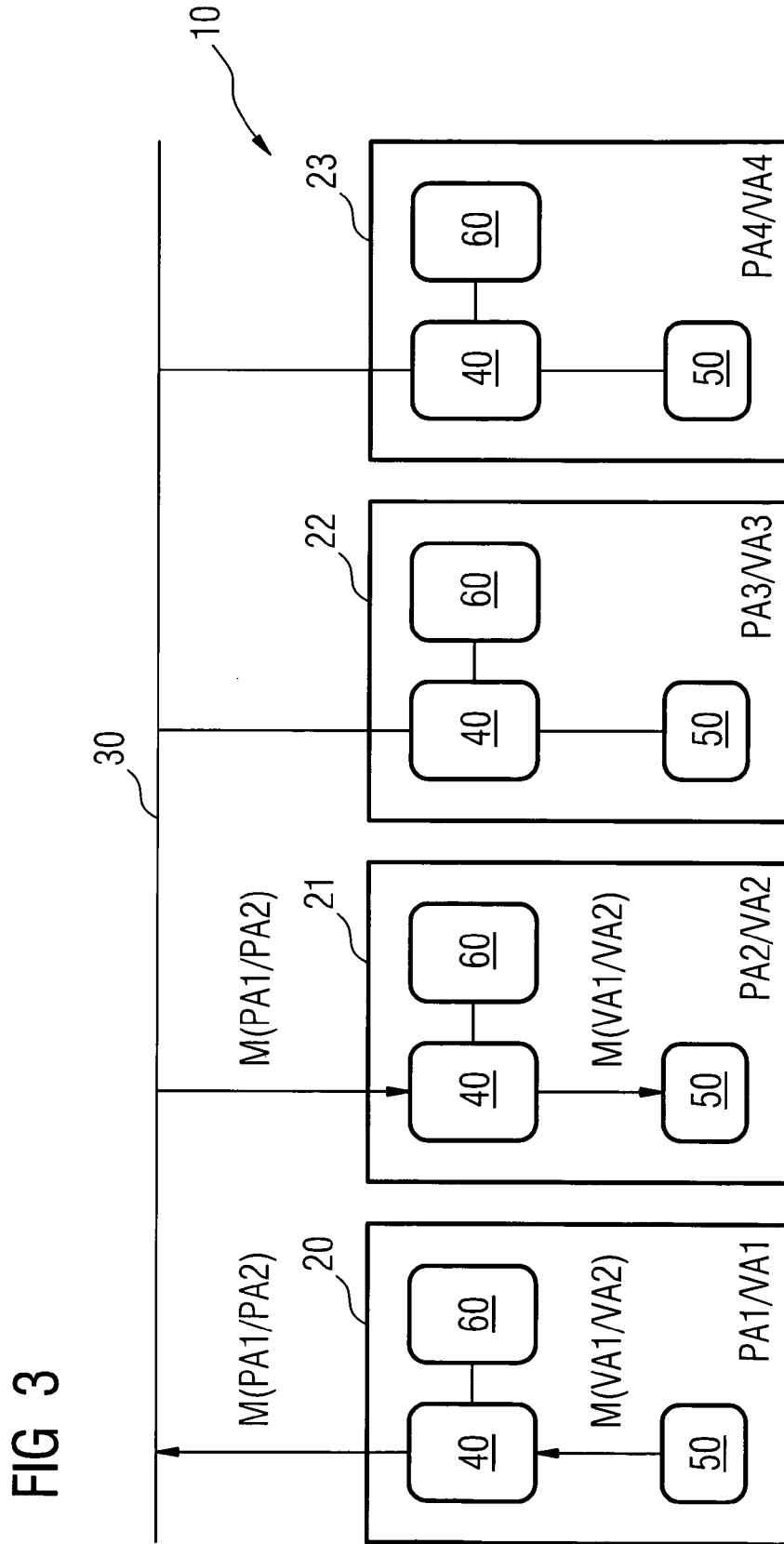


FIG 1

FIG 2

PA1	VA1
PA2	VA2
PA3	VA3
PA4	VA4

60



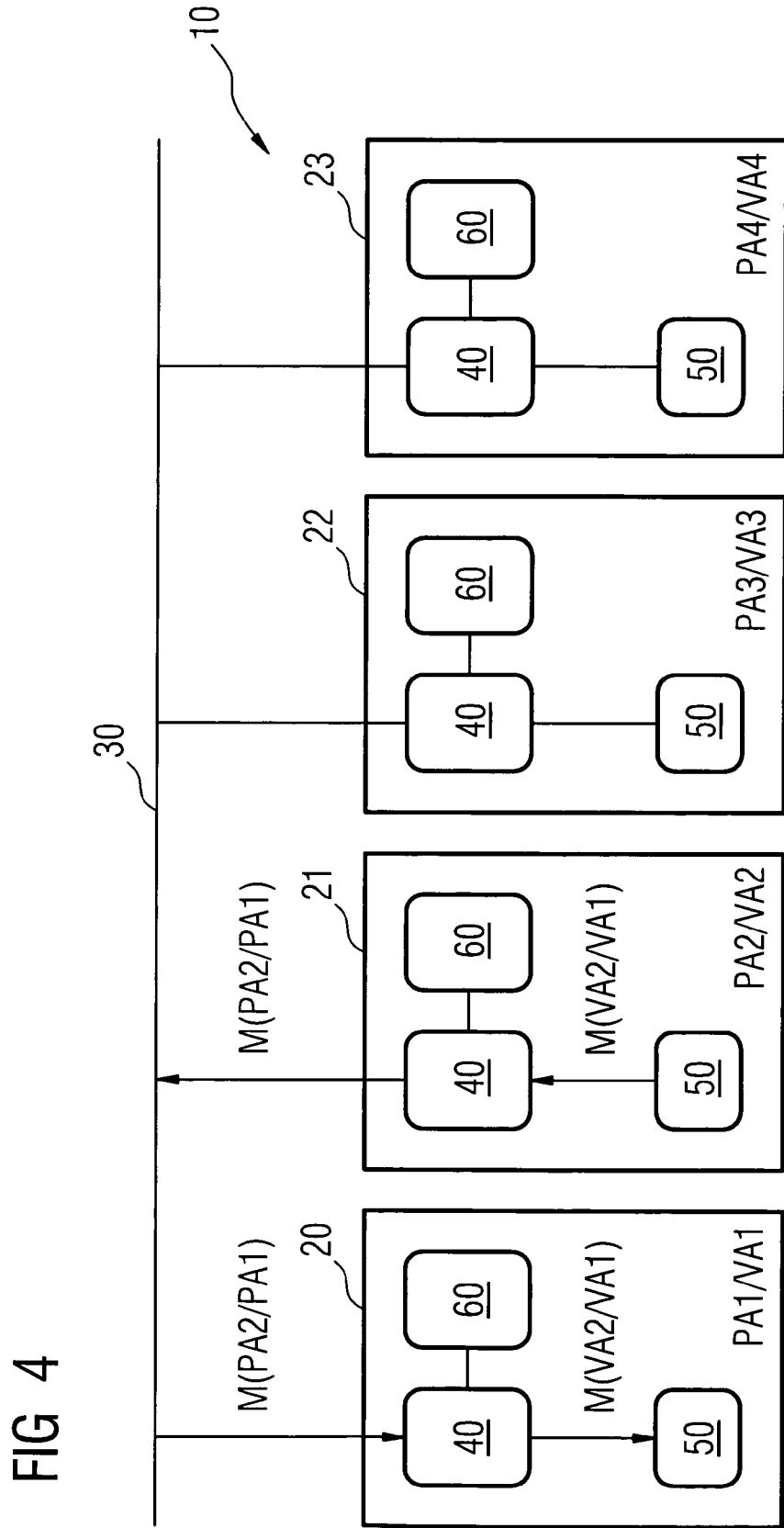


FIG 4

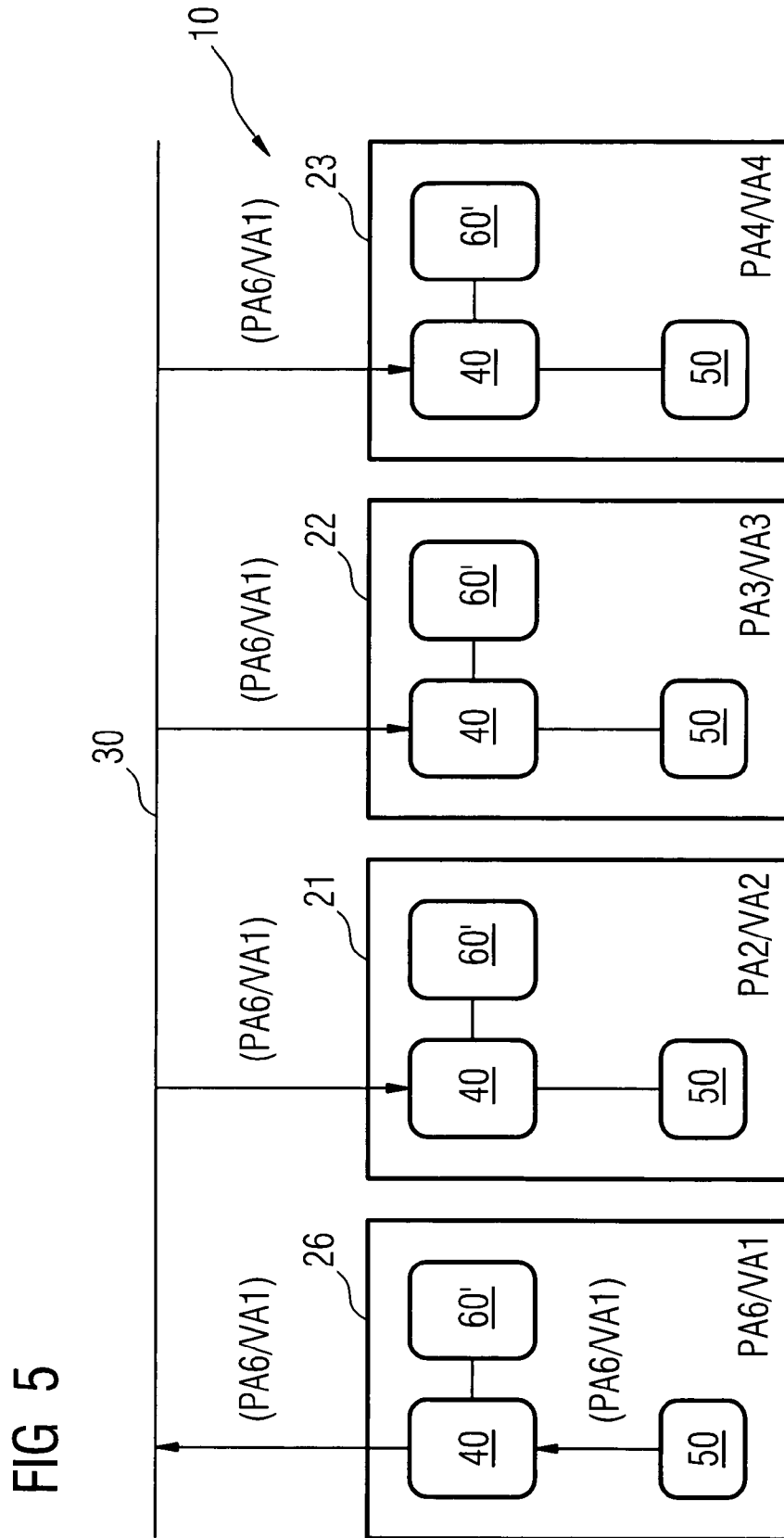


FIG 6

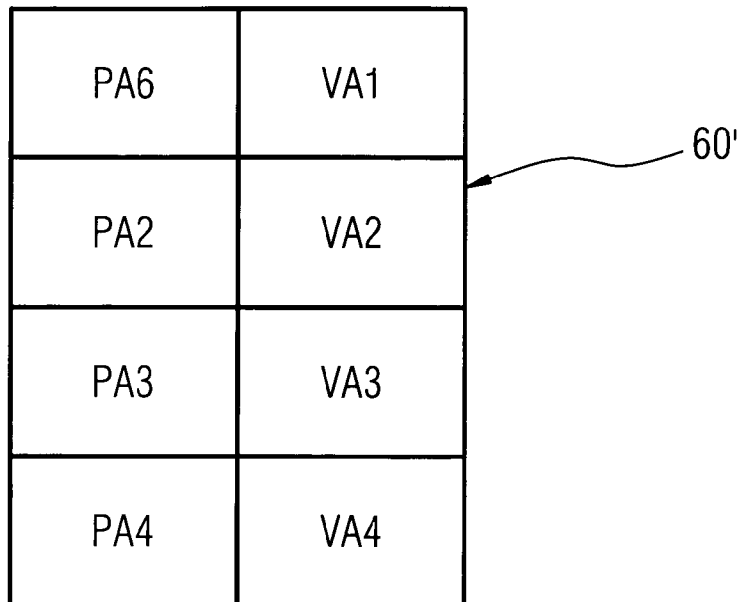
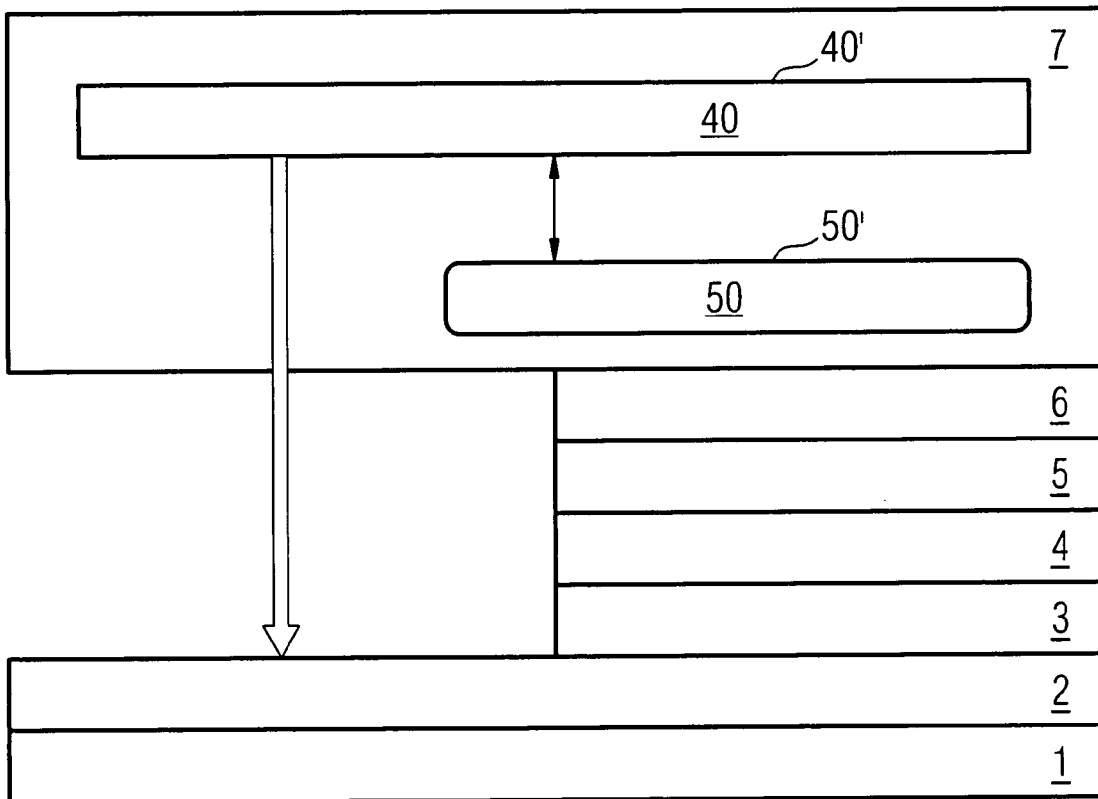


FIG 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/006691

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L29/12
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)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2007/288653 A1 (SARGOR CHANDRAMOULI [US] ET AL) 13 December 2007 (2007-12-13) paragraphs [0020] - [0029]; figure 4a -----	1-12
A	US 2008/313362 A1 (TAKAMOTO YOSHIFUMI [JP]) 18 December 2008 (2008-12-18) abstract paragraphs [0067] - [0070] -----	1-12
A	US 2008/205425 A1 (VUPPULA STEVENS B [US] ET AL) 28 August 2008 (2008-08-28) abstract paragraphs [0004], [0005] -----	1-12

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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