



- (51) International Patent Classification:
H04L 12/24 (2006.01)
- (21) International Application Number:
PCT/EP2017/055931
- (22) International Filing Date:
14 March 2017 (14.03.2017)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/307,825 14 March 2016 (14.03.2016) US
- (71) Applicant: NOKIA SOLUTIONS AND NETWORKS
OY [FI/FI]; Karaportti 3, 02610 ESPOO (FI).
- (72) Inventors: BODOG, Gyula; Telkes utca 41, 1046 Bud-
apest (HU). ANDRIANOV, Anatoly; 908 Casey Court #2,
Schaumburg, Illinois 60173 (US).
- (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, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, 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.

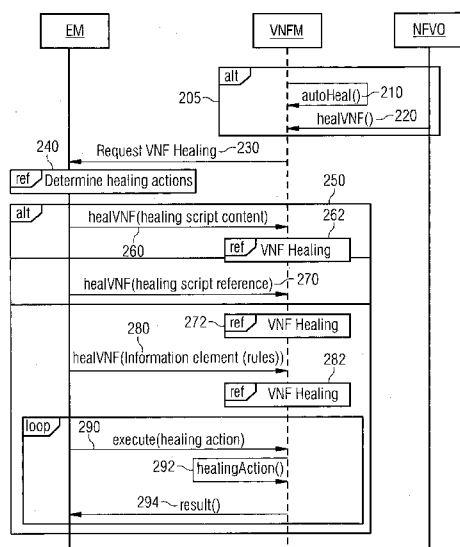
- (84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: END-TO-END VIRTUALIZED NETWORK FUNCTION HEALING

FIG 2



(57) Abstract: Various communication systems may benefit from repair mechanisms. For example, wireless communication systems that include a virtualized network function may benefit from end-to-end virtualized network function healing. A method can include receiving, at an element manager, a request to heal a virtualized network function. The method can also include initiating, by the element manager, a healing action responsive to the request.

DESCRIPTION

TITLE

End-to-End Virtualized Network Function Healing

CROSS-REFERENCE TO RELATED APPLICATION:

[0001] This application is related to and claims the benefit and priority of U.S. Provisional Patent Application No. 62/307825, filed March 14, 2016, the entirety of which is hereby incorporated herein by reference.

BACKGROUND:

Field:

[0002] Various communication systems may benefit from repair mechanisms. For example, wireless communication systems that include a virtualized network function may benefit from end-to-end virtualized network function healing.

Description of the Related Art:

[0003] Figure 1 shows an architectural framework that has been defined. For example, the illustrated framework has been defined in European Telecommunication Standards Institute (ETSI) network function virtualization (NFV). In this architectural framework, a virtualized network function manager (VNFM) can be responsible for the virtualized network function (VNF) management, while a network function virtualization orchestrator (NFVO) can be responsible for network service management.

[0004] One of the tasks of VNF management is VNF healing. VNF healing can be determined by automated rules in the VNFM or can be requested by the NFVO.

[0005] VNF healing is a complex process that may span across multiple layers. For example for a fault occurring at the network function virtualization infrastructure (NFVI), such as an underlying hardware fault, the healing actions may include a series of steps. For example, the healing actions may include certain remediation at the virtualized resources, such as reallocation of virtualized network or virtualized compute resources. This remediation at the virtualized resources may be followed by remediation at the virtual machine, for example restart or even re-instantiation of a virtual machine. The remediation at the virtual machine may be followed by remediation at the VNF, such as redeployment of a VNF software (s/w) image. The remediation at the VNF can be followed by remediation at the application level, for example re-start or re-configuration or even re-install of the VNF application. Certain remediation at the service level may be needed as well. For example, these remediation

actions may include virtualization domain changes in the network forwarding path/forwarding graph, application domain changes in neighboring nodes, or the like.

[0006] In ETSI NFV there may be a desire to have automated healing in the NFVI and below, controlled by virtualized infrastructure manager (VIM), and VNF healing controlled by the VNFM. Since the VNFM may be application agnostic and may not have access to information about the application domain, the VNFM may not perform healing actions in the application and therefore may not guarantee an end-to-end healing. Even in the virtualization domain, VNFM does not have the knowledge of VNF software architecture and may not be able to perform healing of complex VNFs composed of multiple VNFCs of different types.

[0007] Thus, the VNFM conventionally may not perform any healing actions outside of the virtualization domain. Moreover, conventionally the VNFM lacks detailed knowledge of VNF software architecture and application details needed to perform healing of complex VNFs within virtualization domain.

[0008] Conventional VNF healing has been partially defined in ETSI NFV GSs IFA010, IFA007 and IFA008, which are hereby incorporated herein by reference. The methods defined by IFA GSs do not go beyond invocation of a healing procedure on VNFM either internally, namely auto-healing, or externally by NFVO or EM. The details of such healing procedures are currently undefined. It is assumed that the vendor that is the VNF provider may provide a healing script as part of the VNF package. Thus, the responsibility of the VNFM with regard to VNF healing may be just to execute such script. Accordingly, the conventional approach may provide only one possible action for all kinds of potential problems. A typical healing action performed by the above-mentioned script may be a VNF(C) "restart", which can be a reboot of a virtual machine, or a VNF(C) "re-instantiation", which can be deletion and instantiation of VNF(C) on the same set of virtualized resources.

SUMMARY:

[0009] According to a first embodiment, a method can include determining, at an element manager, a need to heal a virtualized network function. The method can also include initiating, by the element manager, a healing action responsive to the request, wherein the healing action is selected from a set of healing actions based on the request.

[0010] In a variant, the determining the need can include receiving a request to heal the virtualized network function.

[0011] In a variant, the method can also include determining the healing action to take in response to the request.

[0012] In a variant, the method can include sending a message to a virtualized network

function manager to trigger the healing action.

[0013] In a variant, the message can include healing script content.

[0014] In a variant, the message can include a healing script reference.

[0015] In a variant, the message can include at least one rule for healing.

[0016] In a variant, the message can indicate a healing action to be performed.

[0017] In a variant, the method can further include receiving a response from the virtualized network function manager indicating that the healing action has been taken.

[0018] In variant, the response can include an indication of the result of the healing action.

[0019] In a variant, the request can be sent from a virtualized network function manager.

[0020] According to a second embodiment, a method can include determining, by a virtualized network function manager, that virtualized network function healing is needed. The method can also include sending, by the virtualized network function manager, a request for virtualized network function healing to an element manager.

[0021] In a variant, the method can further include performing self-triggered healing by the virtualized network function manager.

[0022] In a variant, the method can further include performing healing by the virtualized network function manager triggered by a network function virtualization orchestrator.

[0023] In a variant, the request can be configured to trigger the element manager to determine a healing action to be performed.

[0024] In a variant, the method can further include receiving a message from the element manager in response to the request.

[0025] In a variant, the message can include healing script content.

[0026] In a variant, the message can include a healing script reference.

[0027] In a variant, the message can include at least one rule for healing.

[0028] In a variant, the message can indicate a healing action to be performed.

[0029] In a variant, the method can further include performing a healing action based on the message.

[0030] In a variant, the method can further include sending, by the virtualized network function manager, a response to the element manager indicating that the healing action has been taken.

[0031] According to third and fourth embodiments, an apparatus can include means for performing the method according to the first and second embodiments respectively, in any of their variants.

[0032] According to fifth and sixth embodiments, an apparatus can include at least one

processor and at least one memory and computer program code. The at least one memory and the computer program code can be configured to, with the at least one processor, cause the apparatus at least to perform the method according to the first and second embodiments respectively, in any of their variants.

[0033] According to seventh and eighth embodiments, a computer program product may encode instructions for performing a process including the method according to the first and second embodiments respectively, in any of their variants.

[0034] According to ninth and tenth embodiments, a non-transitory computer readable medium may encode instructions that, when executed in hardware, perform a process including the method according to the first and second embodiments respectively, in any of their variants.

[0035] According to tenth and eleventh embodiments, a system may include at least one apparatus according to the third or fifth embodiments in communication with at least one apparatus according to the fourth or sixth embodiments, respectively in any of their variants.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0036] For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

[0037] Figure 1 shows an architectural framework that has been defined.

[0038] Figure 2 illustrates various embodiments that may be used alone or in combination with one another.

[0039] Figure 3 illustrates a method according to certain embodiments.

[0040] Figure 4 illustrates a system according to certain embodiments.

DETAILED DESCRIPTION:

[0041] Certain embodiments may provide a healing procedure as an end-to-end process, which may allow the procedure to actually heal the problem. Certain embodiments may also make the healing procedure flexible and allow the procedure to adapt to a particular failure case where a minimal set of targeted/focused actions is sufficient. This may contrast with a procedure that involves just one extreme action such as entire virtualized network function (VNF) re-instantiation.

[0042] Certain embodiments may allow interaction of a virtualized network function manager (VNFM) with an element manager (EM). An EM may have full application knowledge including the software (s/w) architecture, roles of individual virtualized network

function components (VNFCs), state of the application, load conditions, scope and extent of negative impact, and so on. The EM may also have the ability to perform application level remediation at a network element (NE) level, such as by initiating an active/standby switch procedure. Alternatively, in or in addition, the EM may inform the NM that the NM is to perform service level remediation, such as redirecting traffic to unaffected NEs, reconfiguring neighboring nodes, or the like.

[0043] VNF healing can be a complex task and may require complex decision making process when a VNF healing is executed. IFA008, mentioned above, currently provides a "HealVNF" request that a VNF or EM can request from the VNFM. The currently available attributes of the operation indicate only Vnfc instances and the cause, nothing more.

[0044] VNF and EM have wider knowledge of the VNF itself and can tell exactly what to heal and how to heal. Certain embodiments of the present invention may adapt a HealVNF request or any similar message to provide greater insight as may be possible at the VNF and/or EM.

[0045] In a Generic VNFM case these healing procedure may be realized as so called healing scripts. But the current specification does not allow to differentiate what scripts to run and when. By contrast, certain embodiments allow a trigger condition or a method in which EM or VNF can tell to the VNFM the exact healing script execution. Thus, there can be different scripts for handling different situations.

[0046] Figure 2 illustrates various embodiments that may be used alone or in combination with one another. In a first embodiment, 205, the VNF healing procedure can be initiated at the VNFM. This can be, according to a first option 210, by an auto-healing functionality on the VNFM, or according to a second option 220, by the request from NFVO.

[0047] In either case, or in other cases, a healing request can be sent at 230 by the VNFM to the EM. This request can be received at the EM. At 240, the EM can determine the correct healing actions based on the EM's view of the VNF, including the EM's view of virtualization resources and application(s). As mentioned below, the EM may make this determination based on the request or may make this determination without receiving any explicit request. The EM can then take the appropriate action at 250, which includes several alternative options that can be used individually or in combination with one another.

[0048] When the EM determines the appropriate healing actions, the EM may communicate with NM/OSS to initiate, for example, service level redundancy. The communication may result in a reconfiguration in the neighboring network elements, may require atomic actions towards the VNFM such as restart a particular VNFC instance, change the VNFC configuration or change in the VL or re-apply SW IMG of a particular VNFC instance. These

actions can be described in healing scripts or in so called healing rules. As shown at 260, the EM can send the healing scripts or the healing rules in the healVNF operation to the VNFM. Then, at 262, the VNFM can perform VNF healing.

[0049] It is also possible that the healing scripts are predefined and are part of the VNF package. In this case the EM can just send, at 270, a reference to the correct healing script in the healVNF operation. Then, at 272, the VNFM can perform VNF healing.

[0050] Another possibility is that EM creates a set of rules and these rules are sent, at 280, to the VNFM from the EM in the healVNF operation as a complex Information Element. Then, at 282, the VNFM can perform VNF healing.

[0051] A further possibility is an interactive execution of the healing process where, at 290, EM invokes remote execution of individual healing actions at the VNFM. The EM can also invoke execution of individual healing actions locally, or at the NM/OSS. At 292, the VNFM can perform the healing action and report back at 294. The EM can analyze the results and decide whether the healing of a VNF is complete or requires additional actions. The process continues until the healing is complete.

[0052] Thus, in certain embodiments an operation can be provided between VNFM and EM to trigger the healing actions from VNFM to the EM, such as the request sent at 230 in Figure 2. The EM can then send healing scripts or a reference to the healing script in the Heal VNF operation as one of several options for handling healing in various embodiments.

[0053] Figure 3 illustrates a method according to certain embodiments. As shown in Figure 3, a method can include, at 310, receiving, at an element manager, a request to heal a virtualized network function. The request can be sent from a virtualized network function manager. Receiving the request can be one way that the element manager can determine that there is a need to heal a virtualized network function. As mentioned above, in reference to item 240 of Figure 2, this determination can also be made other ways, however, such as the element manager itself detecting the need, without an explicit request from another device.

[0054] The method can also include, at 315, determining the healing action to take in response to the request. This determination can involve selecting a particular healing action from a set of possible healing actions. The selection can be made based on the nature of the request, the kind of information contained in the request, any problems identifiable from the request or from other data available to the element manager, or from the timing of the request. Other bases for making the determination or selection are also permitted.

[0055] The method can further include, at 320, initiating, by the element manager, a healing action responsive to the request. As will be mentioned below, this initiation can involve preparing and sending a message. The message can be customized to address the particular healing action determined at 315.

[0056] The method can further include, at 330, sending a message to a virtualized network function manager to trigger the healing action. This may be the way in which the element manager initiates the healing action. Alternatively, or in addition, the element manager itself may perform a healing action itself.

[0057] The message can include one or more of the following: healing script content, at least one healing script reference, or at least one rule for healing. Moreover, the message can indicate a healing action to be performed.

[0058] The method can further include, at 340, receiving a response from the virtualized network function manager indicating that the healing action has been taken. The response can include an indication of the result of the healing action. For example, the response can indicate that a particular healing action has been started, triggered, or successfully completed.

[0059] The above features from 310 to 340 may be performed by an element manager. A virtualized network function manager can perform additional features.

[0060] For example, the method can also include, at 350, determining, by a virtualized network function manager, that virtualized network function healing is needed. This determination can be the result of a variety of possible inputs or processes. For example, the determination can be the result of receiving a message indicative of such a need, or the result of a diagnostic process or group of processes that indicate the need.

[0061] For example, the method can further include, at 352, performing self-triggered healing by the virtualized network function manager. The method can additionally or alternatively include, at 354, performing healing by the virtualized network function manager triggered by a network function virtualization orchestrator.

[0062] The method can further include, at 360, sending, by the virtualized network function manager, a request for virtualized network function healing to an element manager. This can be the same request that is received by the element manager at 310. The request can be configured to trigger the element manager to determine a healing action to be performed, such as to trigger the determination made at 315.

[0063] The method can further include, at 370, receiving a message from the element manager in response to the request. This may be the message sent at 330, as discussed above. As also discussed above, the message can include one or more of the following:

healing script content, at least one healing script reference; or at least one rule for healing.

The message can indicate a healing action to be performed. For example, the message can indicate a particular action or a class of actions. The message may indicate the action directly by identifying the action or indirectly by indicating a desired outcome.

[0064] The method can further include, at 380, performing a healing action based on the message, such as the specific healing action identified in the message or a related healing action. The action taken can be any of the actions described above, for example, with reference to section 250 of Figure 2.

[0065] The method can additionally include, at 390, sending, by the virtualized network function manager, a response to the element manager indicating that the healing action has been taken. This can be the same response received at 340.

[0066] In certain embodiments, a heal VNF operation can be performed. This heal VNF operation, which can also be referred to as a HealVNF operation, can enable either a VNF instance or an EM to request a VNFM to perform a healing procedure. Thus, a HealVNF request, which can be referred to as a HealVNFRequest, can be sent from VNF to a VNFM or from an EM to a VNFM. Other network elements and functions can likewise send a request for a heal VNF operation using this or a similar message.

[0067] In response to such a request, the VNFM can send a heal VNF response message, which can be referred to as a HealVNFResponse. The HealVNFResponse or other response can be sent from a VNFM to a VNF, EM, or other network element or function.

[0068] The information element sent when invoking the operation can include one or more of the following information elements or the indications associated with such information elements: vnfInstanceId, vnfcInstanceId, cause, and/or healScript. Each of vnfInstanceId and vnfcInstanceId can be information elements that include one or more identifier. Thus, vnfInstanceId can identify the instance requiring a healing action, and similarly vnfcInstanceId can identify a list of VNFC instances requiring a healing action. The cause information element can indicate the reason why a healing procedure is required. Finally, the healScript information element can provide a link to a script that is to be executed as part of the healing action or can provide a set of rules for one or more healing procedure. In certain embodiments, a HealVNFRequest message or HealVNFResponse message can include all of any of the identified information elements, in any combination. For example, the message can include the healScript information element, containing a script or a link or other reference to a script, in combination with one or more of the other described information elements.

[0069] As a result of the healing operation, the producer, such as VNFM, can indicate to the consumer, such as VNF or EM, whether or not the procedure invocation was successful. The producer can also indicate other related information, such as the specific procedures invoked or attempted in the process.

[0070] The VNFM can notify to subscribed functional blocks about the start and end of the healing procedure using the VNF Lifecycle Change Notification interface, or any other desired interface.

[0071] Figure 4 illustrates a system according to certain embodiments of the invention. It should be understood that each block of the flowchart of Figure 3 may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry. In one embodiment, a system may include several devices, such as, for example, VNFM 410 and EM 420. The system may include more than one EM 420 and more than one VNFM 410, although only one of each is shown for the purposes of illustration.

[0072] A VNFM 410 and EM 420 may each include at least one processor or control unit or module, respectively indicated as 414 and 424. At least one memory may be provided in each device, and indicated as 415 and 425, respectively. The memory may include computer program instructions or computer code contained therein, for example for carrying out the embodiments described above. One or more transceiver 416 and 426 may be provided, and each device may also include an antenna, respectively illustrated as 417 and 427. Although only one antenna each is shown, many antennas and multiple antenna elements may be provided to each of the devices. Other configurations of these devices, for example, may be provided. For example, VNFM 410 and EM 420 may be configured for wired communication, instead of wireless communication, and in such a case antennas 417 and 427 may illustrate any form of communication hardware, without being limited to merely an antenna.

[0073] Transceivers 416 and 426 may each, independently, be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that may be configured both for transmission and reception. The operations and functionalities may be performed in different entities, such as nodes, hosts or servers, in a flexible manner. In other words, division of labor may vary case by case. One or more functionalities may also be implemented as a virtual application that is provided as software that can run on a server.

[0074] Processors 414 and 424 may be embodied by any computational or data processing device, such as a central processing unit (CPU), digital signal processor (DSP), application specific integrated circuit (ASIC), programmable logic devices (PLDs),

field programmable gate arrays (FPGAs), digitally enhanced circuits, or comparable device or a combination thereof. The processors may be implemented as a single controller, or a plurality of controllers or processors. Additionally, the processors may be implemented as a pool of processors in a local configuration, in a cloud configuration, or in a combination thereof.

[0075] For firmware or software, the implementation may include modules or units of at least one chip set (e.g., procedures, functions, and so on). Memories 415 and 425 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate therefrom. Furthermore, the computer program instructions may be stored in the memory and which may be processed by the processors can be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language. The memory or data storage entity is typically internal but may also be external or a combination thereof, such as in the case when additional memory capacity is obtained from a service provider. The memory may be fixed or removable.

[0076] The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as VNFM 410 and/or EM 420, to perform any of the processes described above (see, for example, Figures 2 and 3). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions or one or more computer program (such as added or updated software routine, applet or macro) that, when executed in hardware, may perform a process such as one of the processes described herein. Computer programs may be coded by a programming language, which may be a high-level programming language, such as objective-C, C, C++, C#, Java, etc., or a low-level programming language, such as a machine language, or assembler. Alternatively, certain embodiments of the invention may be performed entirely in hardware.

[0077] Furthermore, although Figure 4 illustrates a system including a VNFM 410 and a EM 420, embodiments of the invention may be applicable to other configurations, and configurations involving additional elements, as illustrated and discussed herein. For example, an NFVO may be included and the NFVO may be similarly constructed with at least one memory including computer program code, at least one processor, and communications hardware.

[0078] In network functions virtualization (NFV), the architecture may involve virtualizing

network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function (VNF) may comprise one or more virtual machines running computer program codes using standard or general type servers instead of customized hardware. Cloud computing or data storage may also be utilized.

[0079] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention.

[0080] List of Abbreviations

[0081] VNF – Virtualized Network Function

[0082] EM – Element Manager

[0083] NFVO – Network Function Virtualization Orchestrator

[0084] SW – Software

[0085] IMG – Image

[0086] VNFC – Virtualized Network Function Component

[0087]

WE CLAIM:

1. A method, comprising:
determining, at an element manager, a need to heal a virtualized network function;
and
initiating, by the element manager, a healing action responsive to the request,
wherein the healing action is selected from a set of healing actions based on the request.
2. The method of claim 1, wherein the determining the need comprises receiving a request to heal the virtualized network function.
3. The method of claim 1, further comprising:
determining the healing action to take in response to the request.
4. The method of claim 1, further comprising:
sending a message to a virtualized network function manager to trigger the healing action.
5. The method of claim 4, wherein the message comprises healing script content.
6. The method of claim 4, wherein the message comprises a healing script reference.
7. The method of claim 4, wherein the message comprises at least one rule for healing.
8. The method of claim 4, wherein the message comprises a healing action to be performed.
9. The method of claim 1, further comprising:
receiving a response from the virtualized network function manager indicating that the healing action has been taken.
10. The method of claim 9, wherein the response comprises an indication of the result of the healing action.
11. The method of claim 1, wherein the request is sent from a virtualized network

function manager.

12. A method, comprising:

determining, by a virtualized network function manager, that virtualized network function healing is needed; and

sending, by the virtualized network function manager, a request for virtualized network function healing to an element manager.

13. The method of claim 12, further comprising:

performing self-triggered healing by the virtualized network function manager.

14. The method of claim 12, further comprising:

performing healing by the virtualized network function manager triggered by a network function virtualization orchestrator.

15. The method of claim 12, wherein the request is configured to trigger the element

manager to determine a healing action to be performed.

16. The method of claim 12, further comprising:

receiving a message from the element manager in response to the request.

17. The method of claim 16, wherein the message comprises healing script content.

18. The method of claim 16, wherein the message comprises a healing script

reference.

19. The method of claim 16, wherein the message comprises at least one rule for

healing.

20. The method of claim 16, wherein the message indicates a healing action to be

performed.

21. The method of claim 16, further comprising:

performing a healing action based on the message.

22. The method of claim 21, further comprising:

sending, by the virtualized network function manager, a response to the element manager indicating that the healing action has been taken.

23. An apparatus, comprising:

means for determining, at an element manager, a need to heal a virtualized network function; and

means for initiating, by the element manager, a healing action responsive to the request, wherein the healing action is selected from a set of healing actions based on the request.

24. The apparatus of claim 23, wherein the determining the need comprises receiving a request to heal the virtualized network function.

25. The apparatus of claim 23, further comprising:

means for determining the healing action to take in response to the request.

26. The apparatus of claim 23, further comprising:

means for sending a message to a virtualized network function manager to trigger the healing action.

27. The apparatus of claim 26, wherein the message comprises healing script content.

28. The apparatus of claim 26, wherein the message comprises a healing script reference.

29. The apparatus of claim 26, wherein the message comprises at least one rule for healing.

30. The apparatus of claim 26, wherein the message comprises a healing action to be performed.

31. The apparatus of claim 23, further comprising:

means for receiving a response from the virtualized network function manager

indicating that the healing action has been taken.

32. The apparatus of claim 31, wherein the response comprises an indication of the result of the healing action.

33. The apparatus of claim 24, wherein the request is sent from a virtualized network function manager.

34. An apparatus, comprising:

means for determining, by a virtualized network function manager, that virtualized network function healing is needed; and

means for sending, by the virtualized network function manager, a request for virtualized network function healing to an element manager.

35. The apparatus of claim 34, further comprising:

means for performing self-triggered healing by the virtualized network function manager.

36. The apparatus of claim 34, further comprising:

means for performing healing by the virtualized network function manager triggered by a network function virtualization orchestrator.

37. The apparatus of claim 34, wherein the request is configured to trigger the element manager to determine a healing action to be performed.

38. The apparatus of claim 34, further comprising:

means for receiving a message from the element manager in response to the request.

39. The apparatus of claim 38, wherein the message comprises healing script content.

40. The apparatus of claim 38, wherein the message comprises a healing script reference.

41. The apparatus of claim 38, wherein the message comprises at least one rule for

healing.

42. The apparatus of claim 38, wherein the message indicates a healing action to be performed.

43. The apparatus of claim 38, further comprising:
means for performing a healing action based on the message.

44. The apparatus of claim 43, further comprising:
means for sending, by the virtualized network function manager, a response to the element manager indicating that the healing action has been taken.

45. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code,
wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to
determine, at an element manager, a need to heal a virtualized network function; and
initiate, by the element manager, a healing action responsive to the request, wherein the healing action is selected from a set of healing actions based on the request.

46. The apparatus of claim 45, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to determine the need by receiving a request to heal the virtualized network function.

47. The apparatus of claim 45, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to determine the healing action to take in response to the request.

48. The apparatus of claim 45, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to send a message to a virtualized network function manager to trigger the healing action.

49. The apparatus of claim 48, wherein the message comprises healing script content.

50. The apparatus of claim 48, wherein the message comprises a healing script reference.

51. The apparatus of claim 48, wherein the message comprises at least one rule for healing.

52. The apparatus of claim 48, wherein the message comprises a healing action to be performed.

53. The apparatus of claim 45, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to receive a response from the virtualized network function manager indicating that the healing action has been taken.

54. The apparatus of claim 53, wherein the response comprises an indication of the result of the healing action.

55. The apparatus of claim 45, wherein the request is sent from a virtualized network function manager.

56. An apparatus, comprising:
at least one processor; and
at least one memory including computer program code,
wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to
determining, by a virtualized network function manager, that virtualized network function healing is needed; and
sending, by the virtualized network function manager, a request for virtualized network function healing to an element manager.

57. The apparatus of claim 56, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform self-triggered healing by the virtualized network function manager.

58. The apparatus of claim 56, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform healing by the virtualized network function manager triggered by a network function virtualization orchestrator.

59. The apparatus of claim 56, wherein the request is configured to trigger the element manager to determine a healing action to be performed.

60. The apparatus of claim 56, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to receive a message from the element manager in response to the request.

61. The apparatus of claim 60, wherein the message comprises healing script content.

62. The apparatus of claim 60, wherein the message comprises a healing script reference.

63. The apparatus of claim 60, wherein the message comprises at least one rule for healing.

64. The apparatus of claim 60, wherein the message indicates a healing action to be performed.

65. The apparatus of claim 60, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform a healing action based on the message.

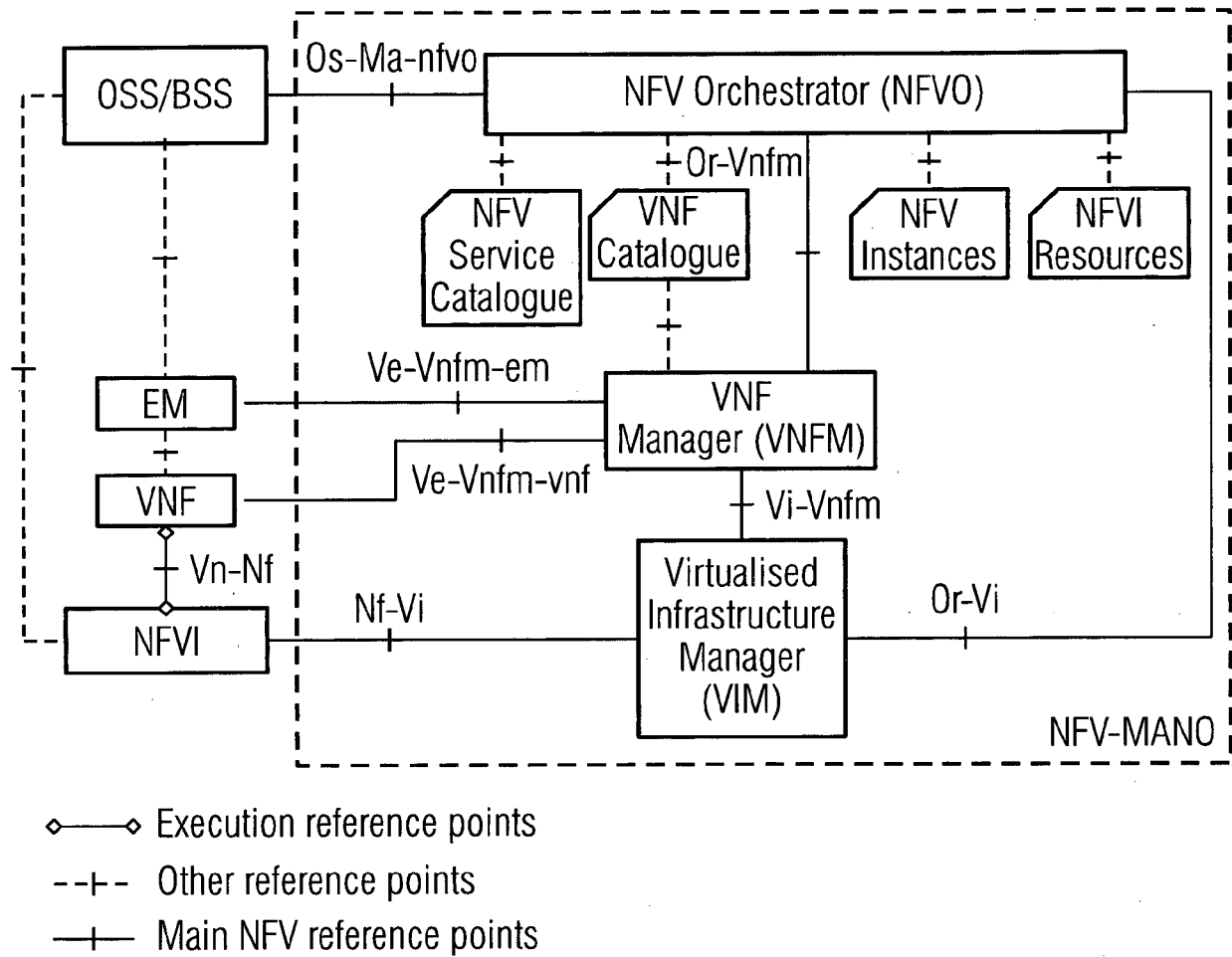
66. The apparatus of claim 65, wherein the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to send, by the virtualized network function manager, a response to the element manager indicating that the healing action has been taken.

67. A computer program product encoding instructions for performing a process, the process comprising the method according to any of claims 1-23.

68. A non-transitory computer readable medium encoded with instructions that, when executed in hardware, perform a process, the process comprising the method according to any of claims 1-23.

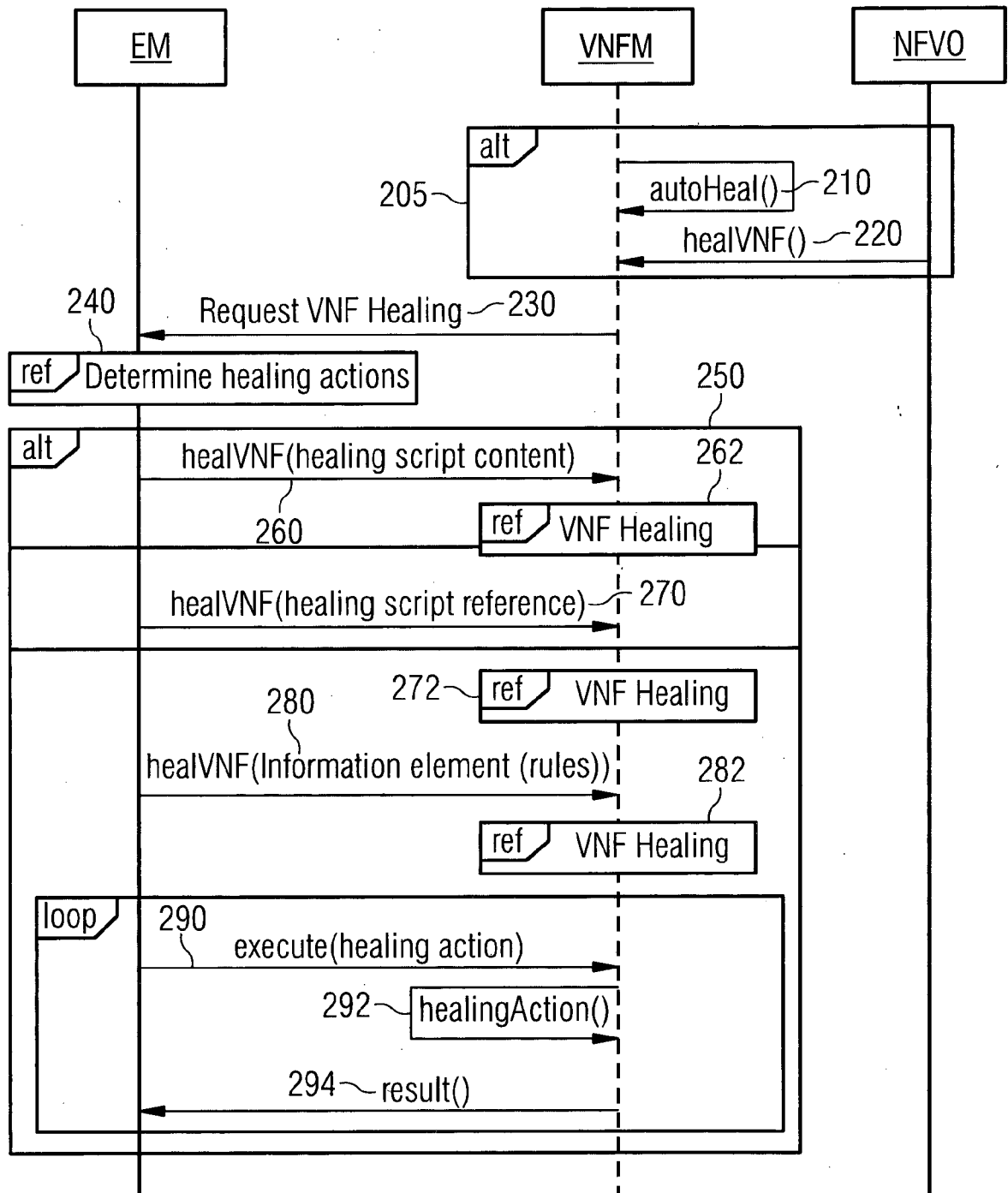
1/4

FIG 1



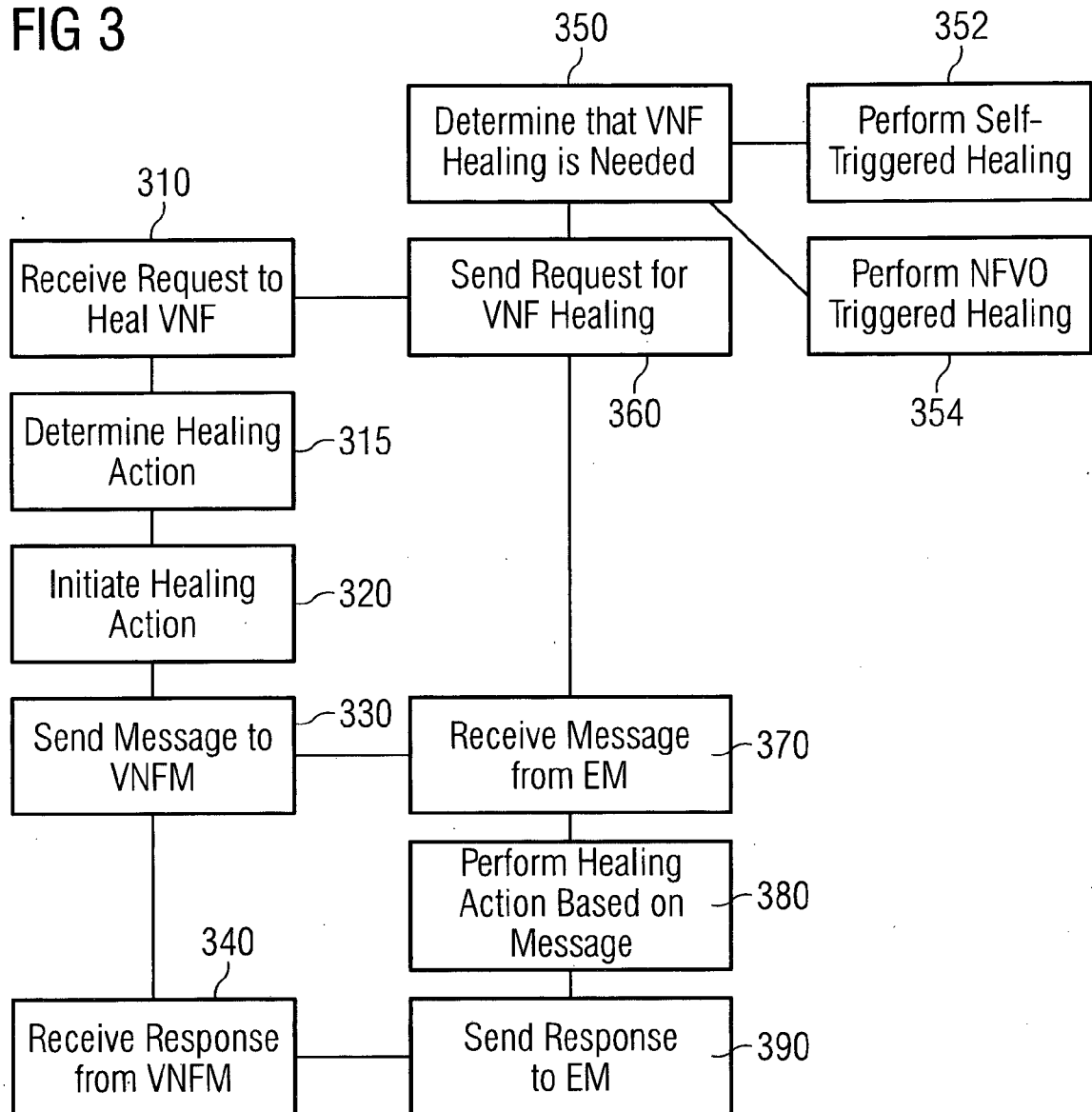
2/4

FIG 2



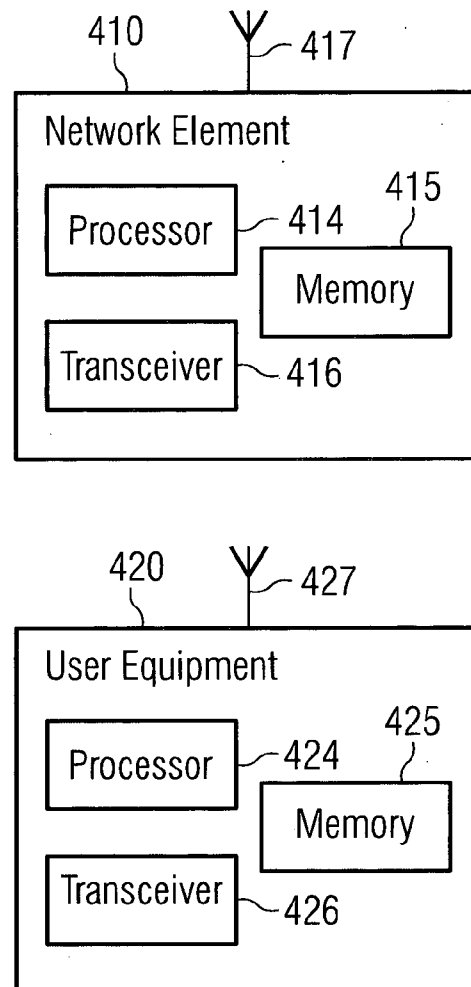
3/4

FIG 3



4/4

FIG 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/055931A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/24
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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	3GPP TR 32.842 V1.0.0 (2015-03):: "3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Study on network management of virtualized networks (Release 13)", 31 March 2015 (2015-03-31), pages 1-48, XP055349679, Retrieved from the Internet: URL:https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=2248 [retrieved on 2017-02-27] page 10, section "5.1 Use cases for Fault management" page 21, section "5.5 Use cases for Core Network Lifecycle Management" page 30, section "7 Potential solutions" -/--	1-68



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 application or patent 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

18 April 2017

Date of mailing of the international search report

26/04/2017

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

Koch, György

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/055931

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	figures 7.1-1 - 7.3.3-2 -----	
X	WO 2016/022698 A1 (INTEL IP CORP [US]) 11 February 2016 (2016-02-11) page 3, line 5 - page 6, line 30 page 10, line 1 - page 10, line 32 figures 1, 3	1-68

A	WO 2015/042937 A1 (HUAWEI TECHNOLOGIES CO LTD) 2 April 2015 (2015-04-02) the whole document	1-68
A,P	& EP 3 024 174 A1 (HUAWEI TECH CO LTD [CN]) 25 May 2016 (2016-05-25) page 10, paragraph 73 - page 15, paragraph 134 figures 1-5 -----	1-68

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/055931

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016022698 A1	11-02-2016	CN 106537842 A	22-03-2017
		KR 20170021304 A	27-02-2017
		WO 2016022698 A1	11-02-2016

WO 2015042937 A1	02-04-2015	CN 104685830 A	03-06-2015
		EP 3024174 A1	25-05-2016
		JP 2016533655 A	27-10-2016
		KR 20160060741 A	30-05-2016
		US 2016224409 A1	04-08-2016
		WO 2015042937 A1	02-04-2015
