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(54) **Title:** METHOD AND SYSTEM FOR ROAMING OF A USER EQUIPMENT IN A VISITED PUBLIC LAND MOBILE NETWORK

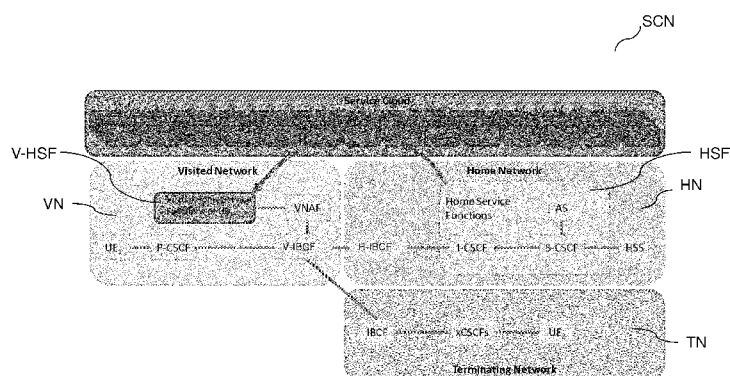


Fig. 2

(57) **Abstract:** The present invention relates to a method for roaming of a user equipment in a visited mobile communication network, comprising the steps of a) Registering the user equipment to the visited network other than a home network of the user equipment b) Forwarding signaling for home service functions of the user equipment from the visited network to the home network c) Executing home service functions in the home network d) Returning results of the executed home service functions to the user equipment in the visited network e) At least part of the home service functions of the home network are virtualized, f) The virtualized home service functions are transferred to the visited network for the respective user equipment by using a service cloud network connected to the home network and the visited network, and g) The virtualized home service functions are executed in the service cloud network and/or in the visited network. The present invention relates also to a system for roaming of a user equipment in a visited public land mobile communication network.



METHOD AND SYSTEM FOR ROAMING OF A USER EQUIPMENT IN A VISITED PUBLIC LAND MOBILE NETWORK

5 The present invention relates to a method for roaming of a user equipment in a visited mobile communication network, comprising the steps of

- a) Registering the user equipment to a visited network other than a home network of the user equipment
- b) Forwarding signaling for home service functions of the user equipment from
10 the visited network to the home network
- c) Executing home service functions in the home network
- d) Returning results of the executed home service functions to the user equipment in the visited network.

15 The invention relates also to a system for roaming of a user equipment in a visited mobile communication network, preferably for performing with a method according to one of the claims 1-9, comprising a user equipment, a home network of the user equipment, wherein the home network further comprises at least one entity is configured to be operable to provide home service functions and/or virtualized
20 home service functions, a H-border entity configured to be operable to provide interconnection to the visited network, the visited network of the user equipment, wherein the user equipment is configured to be operable to register at the visited network, and wherein the visited network further comprises a V-border entity for providing interconnection to the home network for the user equipment.

25 Conventional IP multimedia subsystems provide services to which a user of a user equipment may subscribe. All of the services are executed in the home network of the subscriber respectively user. If the user or subscriber travels for example abroad, the user equipment registers with a visited network for international
30 roaming so that the user equipment may use local network infrastructure of the visited network. When the user equipment is registered with the visited network the services to which a user has subscribed are executed in the home network.

- 2 -

Such a conventional IP multimedia subsystem (IMS) roaming is shown in Fig. 1. The user equipment UE₁ is registered with a visited network VN. The user equipment UE₁ contacts an interconnection border control function V-IBCF, a visited call state control function V-CSCF, a transit routing function TRF, transit
5 functions or the like, with respect to different architectures based on 3GPP TR 23.850. This local anchor entity is anchoring the signal path in the visited network for the user equipment after the signaling returned from the home network. In the home network service control is executed for home service functions to which the user equipment UE₁ has subscribed.

10 In case of roaming, i.e. a subscriber travelling abroad according to conventional IMS roaming, for example all call signaling will be forwarded to the home network of the subscriber for service control. However, one of the most likely cases is that the subscriber will call other subscribers in the visited network, for example
15 colleagues or even other roaming subscribers travelling with the subscriber together. While IMS media routing for data sessions will be short cut, i.e. will be routed directly via the visited network to the internet IMS signaling suffers delay from long distances and/or multiple networks involved. Call set up time and service quality in case of the long physical paths for the signaling provides a lesser quality
20 of service for the user of the user equipment in the visited network.

It is therefore an objective of the present invention to provide a method and a system for roaming of a user equipment in a visited mobile communication network which provide a higher quality of service and/or quality of experience for a
25 user of a user equipment.

It is a further objective of the present invention to provide reduced call setup times, while enhancing service quality.

30 It is an even further objective of the present invention to provide a method and a system for roaming of a user equipment in a visited mobile communication network which are more flexible when performing home service functions.

- 3 -

It is an even further objective of the present invention to provide a method and a system for roaming of a user equipment in a visited public land mobile network which reduces the latency when executing home service functions.

- 5 According to the invention the aforementioned objectives are accomplished by a method of claim 1 and a system of claim 10.

According to claim 1 the method for roaming of a user equipment in a visited mobile communication network, comprising the steps of

- 10 a) Registering the user equipment to the visited network other than a home network of the user equipment
b) Forwarding signaling for home service functions of the user equipment from the visited network to the home network
c) Executing home service functions in the home network
15 d) Returning results of the executed home service functions to the user equipment in the visited network.

According to claim 1 the method is characterized by

- 20 e) at least part of the home service functions of the home network are virtualized, that
f) the virtualized home service functions are transferred to the visited network for the respective user equipment by using a service cloud network connected to the home network and the visited network, and that
g) the virtualized home service functions are executed in the service cloud
25 network and/or in the visited network.

- According to the invention the system for roaming of a user equipment in a visited public land mobile network, preferably for performing with a method according to one of the claims 1-9, comprising a user equipment, a home network of the user
30 equipment, wherein the home network further comprises at least one entity is configured to be operable to provide home service functions and/or virtualized home service functions, a H-border entity configured to be operable to provide interconnection to the visited network, the visited network of the user equipment, wherein the user equipment is configured to be operable to register at the visited

- 4 -

network, and wherein the visited network further comprises a V-border entity for providing interconnection to the home network for the user equipment.

5 According to claim 10 the system is characterized by a visited network anchor function entity in the visited network connected to the V-border entity, a service cloud network connected to the home network and the visited network, and an execution entity, preferably the visited network anchor function entity, located in the service cloud network and/or in the visited network, wherein the service cloud network is configured to be operable to convey virtualized home service functions
10 from the home network to the execution entity, and wherein the execution entity is configured to be operable to execute the virtualized home service functions for the user equipment when registered in the visited network.

15 According to the invention it has first been recognized that by virtualizing at least part of the home service functions and transferring them for execution into the cloud service network and/or the visited network the physical signaling path is significantly reduced.

20 According to the invention it has further been first recognized that call set up times and service quality is significantly increased.

25 According to the invention it has further been first recognized that a more local routing is enabled in case both communicating parties, i.e. user equipment are registered in the same visited network.

According to the invention it has even been further first recognized that the home network is not involved for originating sessions which are terminated in a network other than the home network.

30 The term "virtualizing" in connection with home service functions is to be understood in particular in the description, preferably in the claims, that the home service function is provided in such a way that the home service function may be executed on different entities other than the dedicated entity in the home network. For example input/output functions or ports as well as transfer functions for

- 5 -

transferring the results of an execution of the home service functions have to be provided for virtualization of the home service functions.

5 Further features, advantages and preferred embodiments are described in the following subclaims.

10 According to a preferred embodiment service execution filtering of home service functions in the visited network is performed to reroute is to an execution entity in the service cloud network and/or in the visited network. This enables a flexible definition which of the home service functions are moved and which of the home service functions are still routed into the home network. This may be performed by service execution filtering according to a roaming session filter. Settings for the service execution filtering, in particular the roaming session filter may be provided by the subscriber call state control function S-CSCF in the home network for an entity in the visited network.

20 According to a further preferred embodiment the home service functions are evaluated prior to virtualizing. If the home service functions are evaluated prior to virtualizing, only those home service functions are virtualized which are to be moved to the visited network and/or to the service cloud network. For example home service functions in form of voice and/or video sessions are virtualized in case of both user equipment involved are located in the visited network.

25 According to a further preferred embodiment the cloud service network is accessed via an interface from the visited network and the home network. Accessing the service cloud network via an interface allows virtualized home service functions to be transferred more easily from the home network to the visited network and vice versa. A corresponding entity in the home network may then for example perform steps e) and f): The entity in the home network for example instantiates a new virtualized home service function in the visited network.

- 6 -

According to a further preferred embodiment a service control function for the virtualized home service functions is transferred from the home network to the visited network after performing step a). For example when the service control function is transferred from the home network after registering the user equipment to a visited network an interconnection border control function in the visited network is instructed with roaming session filter settings so that the virtualized home service functions are executed locally in the visited network. This enables a fast and reliable execution of virtualized home service functions in the service cloud network and/or the visited network.

According to a further preferred embodiment a transfer of the service control function for the virtualized home service functions from the home network to the visited network is triggered according to a pre-given parameter and/or according to user behavior. This allows to implement operator business models or subscriber behavior, for example pre-paid subscribers that do not use their user equipment frequently for outgoing and/or terminating sessions when roaming might not need to have their services moved.

According to a further preferred embodiment the service control function is removed from the visited network by transmitting a de-registering request from the visited network to the home network and removing the service control function from the visited network by the home network. This enables a simple and reliable way to move the execution of home service functions from the service cloud network and/or the visited network back to the home network. Also a timeout of a home subscriber server or of the service cloud network could lead to a removal of the service control in the visited network. Service control functions are then moved back to the visited network when for example a service cloud network timeout is happening earlier than a timeout in the home subscriber service in the home network.

According to a further preferred embodiment the service control function is removed in the visited network upon registering of the user equipment in the home network. This allows for example in case the user equipment runs out of battery or loses connectivity and moves back to the home network without any de-

- 7 -

registration, the removal of the service control from the visited network enabling to free resources in the service cloud network and/or in the visited network.

According to a further preferred embodiment a change of the home service function of the user equipment in the home network is synchronized with the virtual home service function in the visited network, preferably by the service cloud network. This enables for example that after a change in service settings of the service control in the visited network to synchronize the settings with an application server providing home service functions in the home network.

There are several ways how to design and further develop the teaching of the present invention in an advantageous way. To this end it is to be referred to the patent claims subordinate to patent claim 1 on the one hand and to the following explanation of preferred embodiments of the invention by way of example, illustrated by the figure on the other hand. In connection with the explanation of the preferred embodiments of the invention by the aid of the figure, generally preferred embodiments and further developments of the teaching will be explained. In the drawings

Fig. 1 shows a conventional method for roaming of a user equipment;

Fig. 2 shows a method according to a first embodiment of the present invention;

Fig. 3 shows a signaling between the visited network, the home network and the service cloud network according to a second embodiment of the present invention;

Fig. 4 shows a signaling between the visited network and the home network of a method according to a third embodiment of the present invention;

- 8 -

- Fig. 5 shows a signaling between the visited network, the home network and the service cloud network of a method according to a fourth embodiment of the present invention;
- 5 Fig. 6 shows a signaling between the visited network, the home network and the service cloud network of a method according to a fifth embodiment of the present invention;
- 10 Fig. 7 shows a signaling between the visited network, the home network and the service cloud network of a method according to a sixth embodiment of the present invention;
- 15 Fig. 8 shows a signaling between the visited network, the home network and the service cloud network of a method according to a seventh embodiment of the present invention;
- 20 Fig. 9 shows a signaling between the visited network, the home network and the terminating network of a method according to an eighth embodiment of the present invention;
- Fig. 10 shows a signaling between the visited network, the home network and the originating network of a method according to a ninth embodiment of the present invention;
- 25 Fig. 11 shows a signaling between the visited network, the home network and the originating network of a method according to a tenth embodiment of the present invention.
- 30 Fig. 1 shows a conventional method for roaming of a user equipment.

In Fig. 1 a user equipment UE₁ is roaming in a visited network VN. The user equipment UE₁ is assigned to a home network HN providing home service functions of an IP multimedia subsystem IMS. The user equipment UE₁ uses a

- 9 -

“local breakout”, i.e. uses a proxy call session control function P-CSCF and a data breakout gateway, according to Fig. 1 a visited interconnection border control function V-IBCF. Further, in the visited network VN a visited network anchor function VNAF is connected to the visited interconnection border control function V-IBCF. The visited network anchor function VNAF could be co-located with the interconnection border control function V-IBCF, or a visited call state control function V-CSCF, a transit routing function TRF, transit functions or the like which are described as alternatives of 3GPP TR 23.850 standard.

The visited interconnection border control function in the visited network, denoted with reference sign V-IBCF, is connected to a corresponding interconnection border control function in the home network HN, denoted with reference sign H-IBCF. In the home network HN the home interconnection border control function H-IBCF is connected to an interrogation call state control function I-CSCF which is further connected to a serving call state control function S-CSCF and an application server AS. The interrogation-CSCF, the server-CSCF and the application server AS provide home service functions HSF.

The server-CSCF is further connected to a home subscriber server HSS providing user profile server functions. When the user equipment UE₁ tries to establish a connection to a second user equipment UE₂, which is located in a further terminating network TN the visited interconnection border control function V-IBCF contacts the corresponding terminating interconnection border control function T-IBCF in the terminating network TN. The terminating interconnection border control function T-IBCF is connected to corresponding call state control functions x-CSCF in the terminating network TN which are further connected to the second user equipment UE₂.

Fig. 1 shows a conventional 3GPP roaming architecture according to TR 23.850 for voice-over-IP multimedia subsystem. The visited interconnection border control function V-IBCF is acting as anchor entity anchoring the signal path in the visited network VN after the signaling returned from the home network HN which executed service control for the home service functions HSF. This visited network

- 10 -

anchor function VNAF is connected to the visited interconnection border control function V-IBCF.

Fig. 2 shows a method according to a first embodiment of the present invention.

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In Fig. 2 an IP multimedia subsystem roaming architecture with a service cloud is shown. Home service functions HSF for the first user equipment UE₁ are moved into the visited network VN when the first user equipment UE₁ registers with the IP multimedia subsystem IMS. For moving the home service function HSF the home service functions HSF are virtualized to virtualized home service function V-HSF and transferred via a service cloud network SCN to the visited network VN. In the visited network VN the virtualized or virtual home service function V-HSF of the first user equipment UE₁ are collocated with the visited network anchor function VNAF which is then also executing service control for the virtual home service function V-HSF. The service cloud network SCN is able to run instances of the virtualized home service functions V-HSF for each subscriber, i.e. user equipment and is connected to both the home network HN and the visited network VN.

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Home service functions HSF which are evaluated with respect to beneficial effects for the user are virtualized and moved to the visited network VN. Services of the home service functions experiencing a change in their service settings are also synchronized via the service cloud network SCN to ensure consistency of corresponding entries and functions in the different networks HN, VN. The visited network anchor function VNAF is connected to the service cloud network SCN and has access to the virtual home service functions V-HSF of the subscriber for the first user equipment UE₁. The virtual home service functions V-HSF can be executed by an entity in the service cloud network SCN or a dedicated entity or directly in the visited network anchor function VNAF. In Fig. 2 the virtual home service functions V-HSF are – as mentioned above – collocated with the visited network anchor function VNAF which is then also executing service control for the virtual home service functions V-HSF.

If the service control for the home service functions HSF is moved from the home network HN to the visited network VN for a particular user equipment, i.e. in Fig. 2

- 11 -

the first user equipment UE₁, the visited interconnection border control function V-IBCF is instructed with so-called roaming session filter settings RSF-S which are sent from the server call state control function S-CSCF to be used by the visited network anchor function VNAF for further session handling to execute the home service functions locally, i.e. in the visited network VN. The roaming session filter settings RSF-S are moved to the visited network VN preferably at the time of the IMS registration of the first user equipment UE₁. Depending on the roaming session filter settings RSFS sent from the server call state control function S-CSCF, the interconnection border control function in the visited network VN, i.e. the V-IBCF, routes for particular services also to the home network HN for service execution as in the conventional IMS roaming. The roaming session filter RSF provides filter criteria on which the interconnection border control function IBCF routes traffic to the visited network anchor function VNAF or back to the home network HN and relates to initial filter criteria iFC of the subscriber.

The movement of the service control to the visited network is for example beneficial for services like:

- Customized ringback tone: signaling + media path optimization
- Customized alerting tone: signaling + media path optimization
- IPTV: signaling path optimization, potentially media path optimization.
Allows to discover visited network IPTV services in conjunction with home network IPTV services (as they have been transferred)
- PUCI: signaling + media path optimization (media in case of using a voice mail test)
- Conferencing service in case of participants in roaming network: signaling + media path optimization (media path only in case of server based conferencing service)
- Voice/Video sessions in case of both parties located in the roaming network: signaling path optimization
- Voice/Video Mailbox (synchronized): signaling + media path optimization
- Call Forwarding (synchronized): signaling path optimization.

The following Figures 3-11 only show the visited network anchor function VNAF and not the virtualized home service functions V-HSF for simplification reasons. All

- 12 -

following subsequent appearances of the visited network anchor function VNAF include that the visited network anchor function VNAF involves the virtual home service functions V-HSF which may be hosted by the visited network anchor function VNAF itself or in the service cloud network SCN or somewhere else on a dedicated entity.

Fig. 3 shows a signaling between the visited network, the home network and the service cloud network according to a second embodiment of the present invention.

In detail Fig. 3 shows the IP multimedia subsystem registration of a user equipment including in the movement of the service control to the visited network VN.

In Fig. 3 the steps 1 to 19 as well as the steps 23 – 25 and 27 – 28 follow the conventional procedure according 3GPP TS 23.228, clause 5.2.2.3 in version 11.1.0 as well as according to 3GPP TS 24.299, clause 5 in the version V11.0.0..

The steps 1 to 19 show in general a registration in the IP multimedia subsystem after a successful challenge-response of security parameters according to 3GPP TS 24.299, clause 5 in the version V11.0.0..

In step 20 the home network HN has decided to move home service function HSF of the roaming subscriber of the first user equipment UE₁ to the visited network VN, the server call state control function S-CSCF and the application server AS contact the service cloud SCN and sent all subscription and service related information, for example subscription profile, invoked service types, initial filter criterias (iFC), service settings, etc. to the service cloud SCN. Not all home service functions need to be virtualized and moved to the service cloud SCN based on the decision of the home network HN. For example in the home subscriber server HSS, the server-call state control function S-CSCF or in the application server AS, some home service functions HSF may remain in the home network HN. Which home service functions HSF are moved to the visited network VN and which are home routed are described in the roaming session filter RSF which are sent to the visited interconnection border control function V-IBCF. The information including

- 13 -

the visited network anchor function VNAF and the roaming session filter RSF is included in 200 OK messages from the server-call state control function S-CSCF in step 23 to the interrogation call state control function I-CSCF as well as in the 200 OK message from the interrogation call state control function I-CSCF to the home interconnection border control function H-IBCF as well as from the 200 OK message form the home interconnection border control function H-IBCF to the visited interconnection border control function V-IBCF.

In step 21 the service cloud network SCN, i.e. a respective entity in the service cloud network SCN instantiates a new virtual home service function V-HSF in the visited network VN according to the received information from the server call state control function S-CSCF and application servers AS and discovers the visited network anchor function VNAF for a virtual home service function V-HSF-visited network anchor function VNAF binding. In step 26 the visited interconnection border control function V-IBCF receives – as mentioned above – the 200 OK messages including the roaming session filter RSF which is implemented at the visited interconnection border control function V-IBCF to include the visited network anchor function VNAF for further local service handling for the first user equipment UE₁, i.e. for executing virtualized home service function V-HSF and also instructs the visited interconnection border control function V-IBCF for which home service functions the visited network anchor function VNAF shall be included. In case of multiple visited network anchor function VNAF in the visited network VN the visited network anchor function VNAF has to announce itself to the service cloud network SCN in order to assist the service cloud network SCN for the virtual home service function V-HSF-visited network anchor function VNAF binding.

Fig. 4 shows a signaling between the visited network and the home network of a method according to a third embodiment of the present invention.

In Fig. 4 no service cloud network SCN is used for the virtual home service function transfer from the home network HN to the visited network VN. In this case an interconnection interface between the home network HN and the visited network VN is provided. Further a special function in the home network HN needs

- 14 -

to perform step 21 of Fig. 3 which was executed by an entity in the service cloud network SCN in Fig.3. This interconnection interface then used to move the service control from the home network AN to the visited network VN (step 21 in Fig. 4). The step 22 to 27 corresponds to the steps 23 to 28 in Fig. 3.

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The entities in the home network HN for example for performing the interrogation call state control function I-CSCF may comprise a database of all visited network anchor function addresses for service control decision so that in steps 22 to 27 the correct visited network anchor function VNAF is included. The server call state control function S-CSCF and the application server AS contact the visited network anchor function VNAF in the visited network VN directly in step 20 and send all subscription and service related information, for example subscription profile, invoked service types, initial filter criterias iFCs, service settings, etc. to the visited network anchor function VNAF. Movement of the service control at the time of the registration of a user equipment is preferred in order to minimize setup times for later service request. It is also possible that other conditions may trigger the movement of the service control, for example the first service request from the user equipment UE in the visited network VN, first terminating session, or once a certain number of requests are exceeded, etc.. These triggers may be based on operator business models and/or on the subscriber behavior, for example pre-paid subscribers that do not use the user equipment frequently for outgoing and/or terminating sessions when roaming might not need to have their services moved from the home network HN to the visited network VN.

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Fig. 5 shows a method according to a fourth embodiment of the present invention.

In detail Fig. 5 shows a removal of a previously allocated visited network anchor function VNAF. The steps 1 to 10 as well as 14 and 15 correspond to the conventional standard procedure shown in TS 23.228.

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If the user equipment is returning to its home network HN or to another visited network VN the old visited network anchor function VNAF which is not up-to-date anymore needs to be removed. This may then preferably at the time of

- 15 -

deregistration of the user equipment, i.e. once the home network HN receives a deregistration request, a service control removal is initiated in the same way as the service control is moved to the visited network anchor function VNAF, for example at the time of registration. When an acknowledgement message of the
5 deregistration request is sent, the call state control function S-CSCF may either add an indication for the visited interconnection border control function V-IBCF in the visited network VN that the roaming session filter RSF corresponding to the old visited network anchor function VNAF for the user equipment is removed or the visited interconnection border control function V-IBCF may remove the roaming
10 session filter RSF itself provided that the visited interconnection border control function V-IBCF has sufficient logic.

In case the user equipment UE₁ runs out of battery or loses the connectivity to the interrogation call state control function I-CSCF or further entities, i.e. it moves
15 back to register at the home network HN without any deregistration in the visited network VN, then the removal of the service control is preferably performed at the time of registration at the home network HN in order to free resources in the service cloud network SCN and/or the visited network VN.

The steps 1. to 10. in Fig. 5 correspond to the respective steps for a removal of a previously allocated visited network anchor function VNAF according to TS 23.228. The 11 step is performed in the home network HN: Once the home network decided to remove the service control, for example upon receiving a deregistration request the server call state control function S-CSCF and the
20 application server AS contact the service cloud network SCN to discover in step 12 the old visited network anchor function VNAF by the service cloud network SCN. The service cloud network SCN then initiates removal of the service control in the 13 step from the visited network VN.

Fig. 6 shows a signaling between the visited network, the home network and the service cloud network of a method according to a fifth embodiment of the present invention.
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- 16 -

Fig. 6 shows a removal of an allocated visited network anchor function VNAF triggered in the service cloud network SCN. In a first step 1 the service cloud network SCN triggers the removal of the service control from the old visited network anchor function VNAF and informs the home network HN about the removal. In a second step 2 the home network either reinstalls the initial filter criterias iFC in the server call state control function S-CSCF for service handling or triggers an IP multimedia system deregistration. Further the service cloud network SCN then removes the service control from the old visited network anchor function VNAF in the visited network VN in a third step 3. The old visited network anchor function VNAF in the visited network VN then removes in a fourth step 4 itself as well as the roaming session filter from the visited interconnection border control function V-IBCF. The visited interconnection border control function V-IBCF then issues an 200 ok message in a fifth step 5 confirming the removal to the visited network anchor function VNAF.

A removal of the service control in the visited network VN may be due to a timeout in the home subscriber server HSS or in the service cloud network SCN. If for example the service cloud network SCN has a timeout and this timeout is happening earlier than the timeout in the home subscriber server HSS, a next service request from the user equipment will trigger the movement of the service control back to the visited network VN according to Fig. 6.

Fig. 7 shows a signaling between the visited network, the home network and the service cloud network of a method according to a sixth embodiment of the present invention.

In Fig. 7 a synchronization of service settings via an application server AS in the home network HN is shown. If the user equipment UE₁ changes the service settings via a user terminal interface in the application server AS (first step 1 in Fig. 7) then these settings need to be updated with the corresponding visited network anchor function VNAF in the visited network VN: In a second step 2 the application server AS in the home network HN synchronizes service settings with the service cloud network SCN. The service cloud network SCN synchronizes the service settings in a third step 3 and sends a corresponding message to

- 17 -

synchronize service settings with the visited network anchor function VNAF in the visited network VN in a forth step 4.

It is also possible that the user equipment UE₁ addresses directly the visited network anchor functions VNAF in the visited network VN which then updates the application server AS in the home network HN via the service cloud network SCN which is shown in Fig. 8.

Fig. 8 shows a signaling between the visited network, the home network and the service cloud network of a method according to a seventh embodiment of the present invention.

In Fig. 8 a synchronization of service settings via the visited network anchor function is shown.

In Fig. 8 the user equipment UE₁ in the visited network VN addresses the visited network anchor function VNAF in the visited network VN and updates its service settings with the visited network anchor function VNAF in a first step 1. The visited network anchor function VNAF then synchronizes in a second step 2 the service settings with the service cloud network SCN which performs in a third step 3 the synchronization of the service settings and sending in a fourth step corresponding service settings information to the application server AS in the home network HN so that the service settings are then synchronized with those of the user equipment UE₁.

Fig. 9 shows a signaling between the visited network, the home network and the terminating network of a method according to an eighth embodiment of the present invention.

In Fig. 9 an IP multimedia subsystem session setup with service control in the visited network VN is shown with corresponding flow. At the time of the registration of the user equipment UE₁ the visited interconnection border control function V-IBCF already received instructions based on received roaming session filters RSF to route incoming service requests from user equipment UE₁ to the visited network

- 18 -

anchor function VNAF. When the INVITE request from the user equipment UE₁ reaches (steps 1 and 2) the visited interconnection border control function V-IBCF, in a step 3 the visited interconnection border control function V-IBCF detects that local service handling, i.e. local execution of home services functions HSF, has to be performed instead routing the corresponding service for execution to the home network HN. The visited interconnection border control function V-IBCF forwards the request to the visited network anchor function VNAF in a fourth step 4. In a fifth step 5 the visited network anchor function VNAF performs service control with the virtual home service function V-HSF which could be hosted by the visited network anchor function VNAF itself or in the service cloud network SCN or somewhere else. After performing the service control in the fifth step 5 the visited network anchor function V-NAF forwards the INVITE request back to the visited interconnection border control function V-IBCF in a sixth step 6. The visited interconnection border control function V-IBCF then directly contacts a terminating interconnection border control function T-IBCF in a terminating network hosting a second user equipment UE₂ to which the first user equipment UE₁ requests an establishment of a session (seventh step 7). The terminating interconnection border control function T-IBCF is directly contacted via the visited interconnection border control function V-IBCF without routing via the home network HN and routes the INVITE to the remote and i.e. the second user equipment UE₂ (steps 8 and 9). Then corresponding 200 ok messages are transmitted from the second user equipment UE₂ to the first user equipment UE₁ according to steps 10 to 16 which are standard procedure steps according to TS 23.228.

Fig. 10 shows a signaling between the visited network, the home network and the originating network of a method according to a ninth embodiment of the present invention.

In Fig. 10 an IP multimedia subsystem session termination with service control in the visited network VN is shown. Fig. 10 shows a session termination flow including the service control and the visited network VN. The steps 1 to 7, 9 to 11, 16 to 18 as well 21 to 28 are conventional steps according to IMS roaming call flow according to TS 23.228.

- 19 -

In step 8 the server call state control function S-CSCF detects if the service control has been moved to the visited network VN. In Fig. 8 the S-CSCF recognizes that the first user equipment UE₁ or services shall be executed in the visited network VN. Thus, it will not trigger terminating initial filter criterias iFCs. Once the INVITE message reaches the visited interconnection border control function V-IBCF from the second user equipment UE₂, via the originating interconnection border control function O-IBCF the visiting interconnection border control function V-IBCF, after third step 3 detects that local service handling, i.e. executing home service functions HSF will be executed locally instead of being routed to the home network HN. The visited interconnection border control function V-IBCF forwards then the INVITE request in a thirteen step 13 to the visited network anchor function VNAF which performs in a fourteen step 14 service control with a virtual home service function V-HSF. The virtual home service functions V-HSF could be hosted by the visited network anchor function VNAF itself or in the service cloud network SCN or somewhere else on a dedicated entity. After performing the service control the visited network anchor function VNAF forwards the INVITE request back to the visited interconnection border control function V-IBCF in a fifteen step 15. After the session, for example a call, is terminated normally via the proxy call state control function P-CSCF 200 ok messages are exchanged between the visited interconnection border control function V-IBCF and the visited network anchor function VNAF in steps 19 and 20. These are 200 ok messages from the user equipment UE₁ which are provided to the visited network anchor function VNAF and the virtual home service functions V-HSF.

Fig. 11 shows a signaling between the visited network, the home network and the originating network of a method according to a tenth embodiment of the present invention.

In Fig. 11 a further embodiment of an IP multimedia subsystem session termination with service control in the visited network VN is shown. In Fig. 11 the originating interconnection border control function O-IBCF of the originating network ON detects in a third step 3 if the service control has been transferred to the visited network VN. This may be the case in a scenario where the originating network ON is the visited network VN. This means that the interconnection border

- 20 -

control function IBCF of a network know which interconnection border control function IBCF is responsible for the visited network anchor function VNAF. Alternatively it is also possible that all interconnection border control functions IBCF get informed of the roaming session filter RSF. Therefore the originating
5 interconnection border control function O-IBCF directly contacts the visited network anchor function VNAF in the visited network VN and thus step 5 of Fig. 10 may be omitted. This reduces the signaling overhead of about 25% when assumed that 10 messages being saved and assumed a processing and transmission delay of 15 milliseconds per message/hop 0,5 seconds are saved for
10 a call setup. The coordination of the different interconnection border control function IBCF of mobile communication networks may be handled by conventional methods or mechanisms.

In summary the present invention provides a method for moving home network IP
15 multimedia subsystem services to a visited network in a roaming case. The present invention further provides a logic of deciding what services to move with service control according to certain conditions. The present invention further provides logic in the interconnection border control functions IBCFs to detect roaming subscriber and to invoke local services based on roaming session filters.
20 Further the present invention provides a method to remove service control after user equipment left the visited network. The present invention enables a synchronization of services after service settings which were changed in the visited network. The present invention optimizes signal parts for IMS roaming by transferring service logic to the visited network. The present invention utilizes a
25 service cloud network to create an instance of the service logic for the roaming subscriber.

The present invention provides the following advantages:

- 30 1. Optimization of signaling paths and if applicable also media path optimization.
2. Home network is still in control of which home service function are transferred.
3. Enabling execution of services, i.e home service function in the visited network.

- 21 -

4. Home network is in control which of the home service functions are to be transferred.
5. Reduction of signaling and latency in case of execution of home service function in the visited network close to the access of the subscriber in the same way as it would be executed in the home network.
6. Enabling local routing in case that both communicating parties are located in the same visited network.
7. The home network is not involved for originated sessions which are terminated in the network different to the home network.

The present invention even further provides or enables:

- for Home S-CSCF + AS
 - Capability to transfer service state and iFC, Application type and a state to the Service Cloud.
 - Capability to manage iFCs according to the movement of service control to the visited network.
 - Creation of RSFs according to the iFC handling and instruct the visited network IBCF for service dependent involvement of the VNAF.
 - Capability to synchronize service settings with the VHSF through the Service Cloud.
- for Visited Network (V-IBCF)
 - Capability to discover the VNAF
 - Capability to interpret and enforce the RSFs from the S-CSCF.
 - Capability to detect whether the remote end is in the same visited network to optimize the communication
- for Visited Network Anchor Function (VNAF)
 - Capability to interact with the Service Cloud to include the VHSF for local service execution.

And with respect to the cloud service network the present invention provides

- 22 -

- Capability to create an instance of the V-HSF in the visited network
- Capability to synchronize the V-HSF in the visited network with the service setting changes in the home network.
- Capability to link the VNAF in the visited network with the V-HSF.

5

Even further the present invention provides faster session setup times in case of IMS roaming which is beneficial for international operators allowing them to minimize international traffic via their own networks. Thus a more efficient use of network resources of the different operators is provided.

10

Many modifications and other embodiments of the invention set forth herein will come to mind the one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing description and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

15

Claims

- 5 1. Method for roaming of a user equipment (UE₁) in a visited mobile communication network (VN), comprising the steps of
- a) Registering the user equipment (UE₁) to the visited network (VN) other than a home network (HN) of the user equipment (UE₁),
- 10 b) Forwarding signaling for home service functions (HSF) of the user equipment (UE₁) from the visited network (VN) to the home network (HN),
- c) Executing home service functions (HSF) in the home network (HN),
- d) Returning results of the executed home service functions (HSF) to the user equipment (UE₁) in the visited network (VN),
- 15 Characterized in that
- e) At least part of the home service functions (HSF) of the home network (HN) are virtualized, that
- f) the virtualized home service functions (V-HSF) are transferred to the visited network (VN) for the respective user equipment (UE₁) by using a
- 20 service cloud network (SCN) connected to the home network (HN) and the visited network (VN), and that
- g) the virtualized home service functions (V-HSF) are executed in the service cloud network (SCN) and/or in the visited network (VN).
- 25 2. The method according to claim 1, characterized in that service execution filtering of home service functions in the visited network is performed to reroute it to an execution entity in the service cloud network and/or in the visited network.
- 30 3. The method according to one of the claims 1-2, characterized in that the home service functions (HSF) are evaluated prior to virtualizing.

- 24 -

4. The method according to one of the claims 1-3, characterized in that the service cloud network (SCN) is accessed via an interface from the visited network (VN) and the home network (HN).

5 5. The method according to one of the claims 1-4, characterized in that after performing step a) a service control function (SCF) for the virtualized home service functions (V-HSF) is transferred from the home network (VN) to the visited network (VN).

10 6. The method according to one of the claims 1-5, characterized in that a transfer of the service control function (SCF) for the virtualized home service functions (V-HSF) from the home network (HN) to the visited network (VN) is triggered according to a pregiven parameter and/or according to user behavior.

15 7. The method according to one of the claims 1-6, characterized in that the service control function (SCF) is removed from the visited network (VN) by transmitting a deregistering request from the visited network (VN) to the home network (HN) and removing the service control function (SCF) from the visited network (VN) by the home network (HN).

20 8. The method according to one of the claims 1-7, characterized in that the service control function (SCF) is removed in the visited network (VN) upon registering of the user equipment (UE1) in the home network (HN).

25 9. The method according to one of the claims 1-8, characterized in that changes of the home service functions of the user equipment in the home network are synchronized with the virtual home service functions in the visited network, preferably by the service cloud network.

30 10.A system for roaming of a user equipment (UE₁) in a visited mobile communication network (VN), preferably for performing with a method according to one of the claims 1-9, comprising

- 25 -

a user equipment (UE₁),
a home network (HN) of the user equipment (UE₁), wherein the home network (HN) further comprises

at least one entity (I-C SCF, S-CSCF, AS) is configured to be operable to provide home service functions (HSF) and/or virtualized home service functions (V-HSF),

an H-border entity (H-BCF) configured to be operable to provide interconnection to the visited network (VN),

the visited network (VN) of the user equipment (UE₁), wherein the user equipment (UE₁) is configured to be operable to register at the visited network (VN), and wherein the visited network (VN) further comprises

an V-border entity (V-IBCF) for providing interconnection to the home network (HN) for the user equipment (UE₁),

characterized by

a visited network anchor function entity (VNAF) in the visited network (VN) connected to the V-border entity (V-IBCF), a service cloud network (SCN) connected to the home network (HN) and the visited network (VN), and

an execution entity, preferably the visited network anchor function entity (VNAF), located in the service cloud network (SCN) and/or in the visited network (VN), wherein

the service cloud network (SCN) is configured to be operable to convey virtualized home service functions (V-HSF) from the home network (HN) to the execution entity, and

wherein the execution entity is configured to be operable to execute the virtualized home service functions (V-HSF) for the user equipment (UE₁) when registered in the visited network (VN).

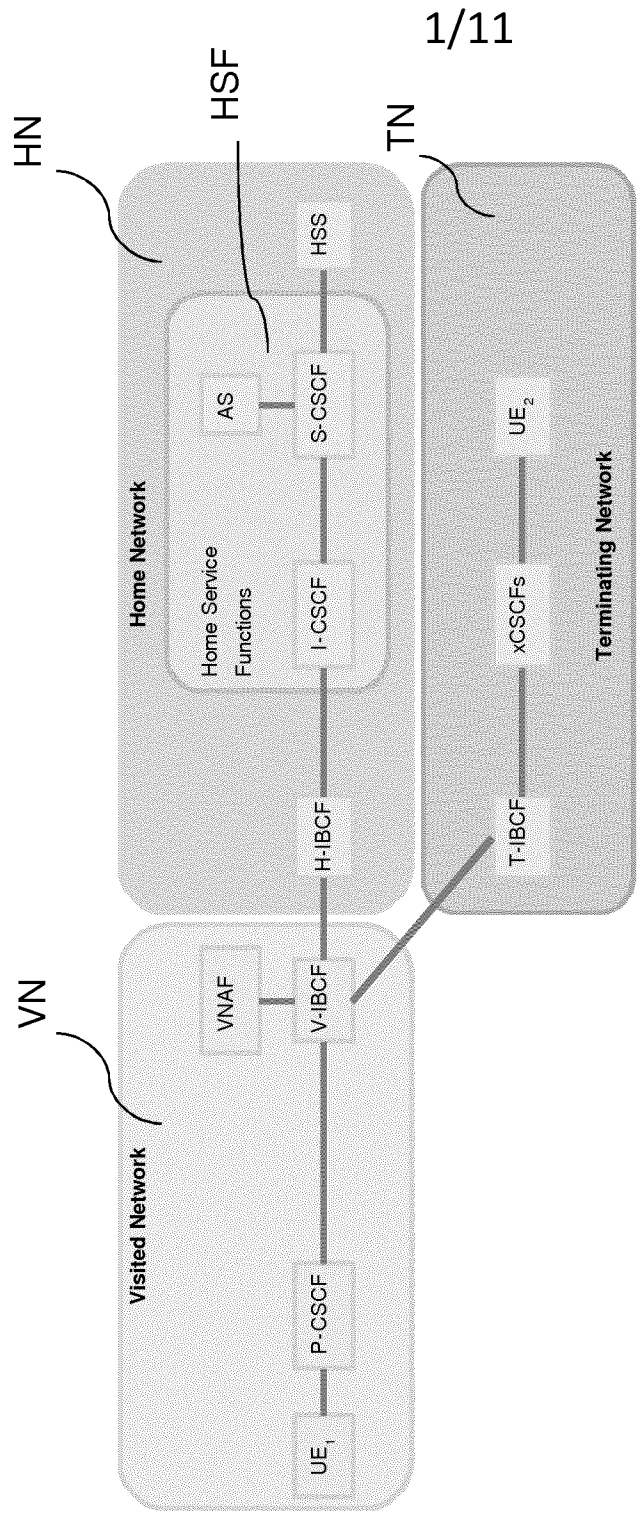


Fig. 1

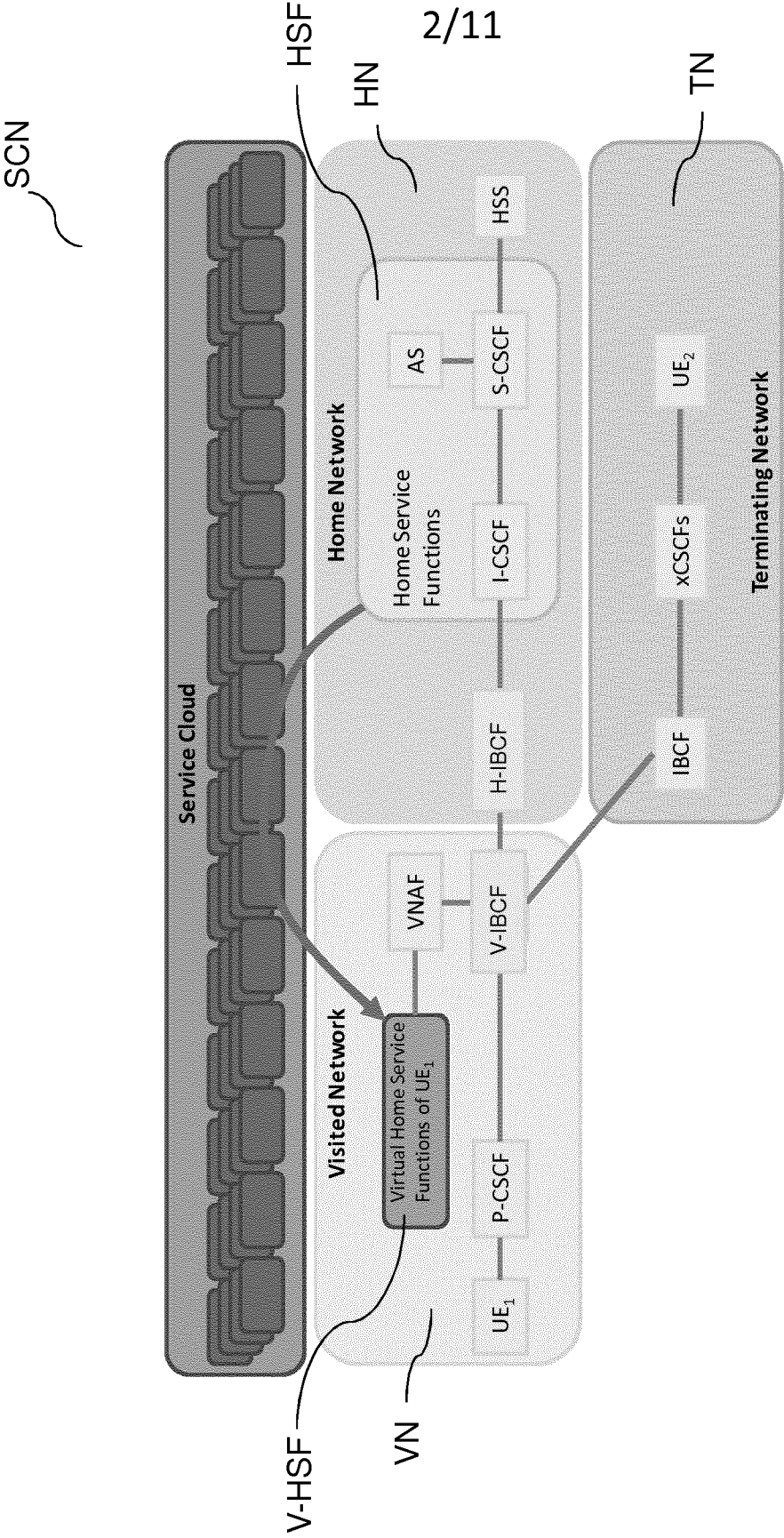


Fig. 2

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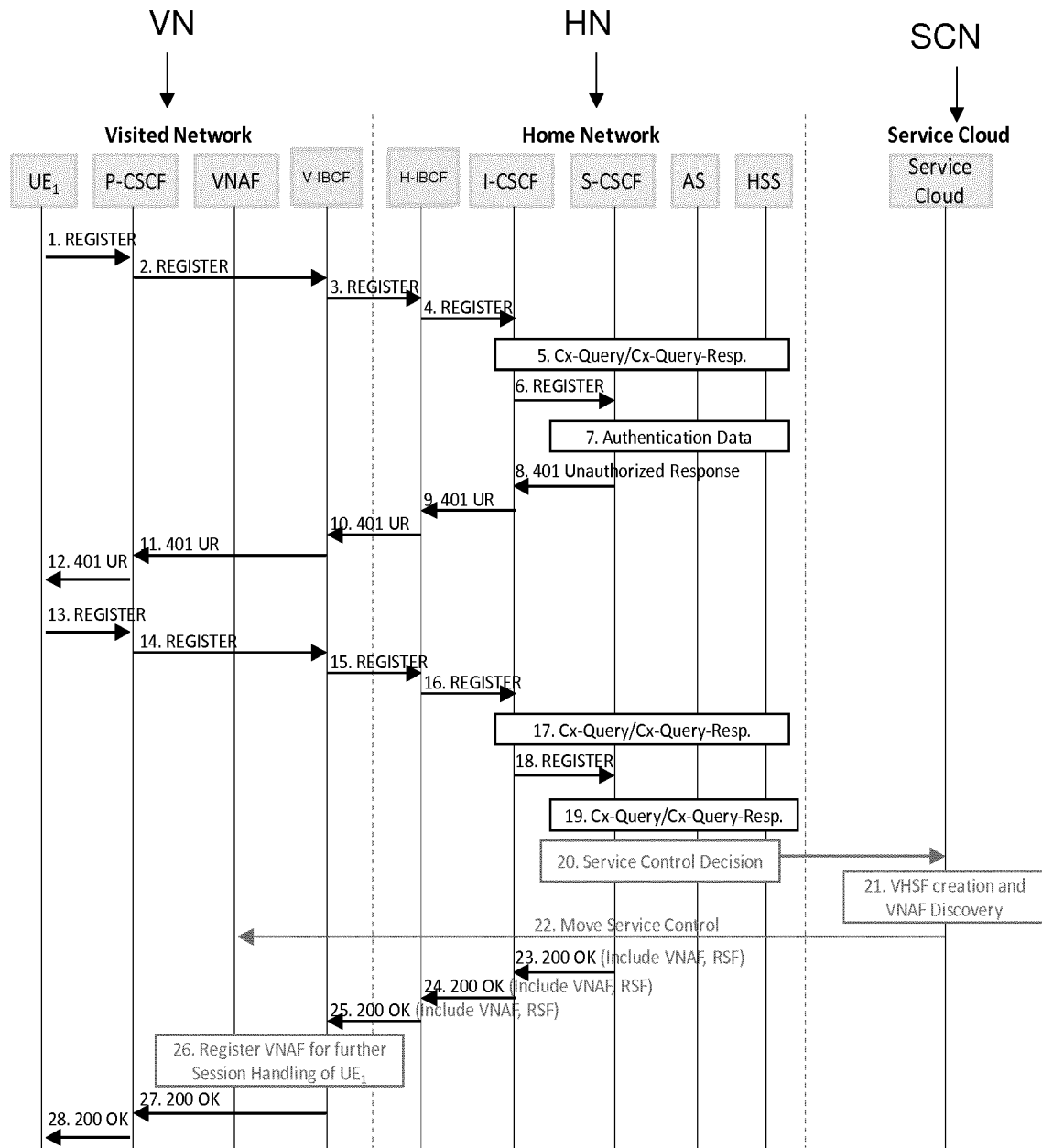


Fig. 3

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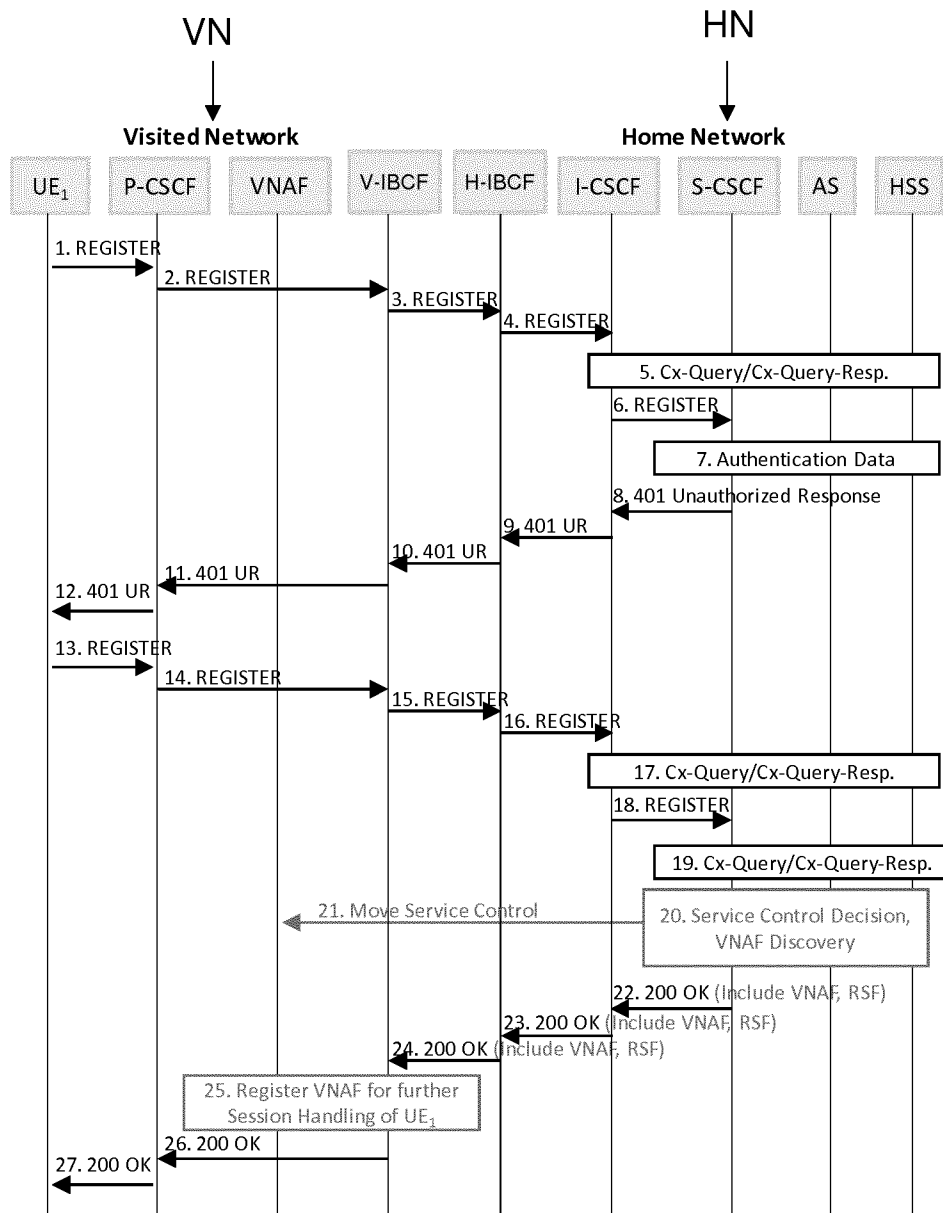


Fig. 4

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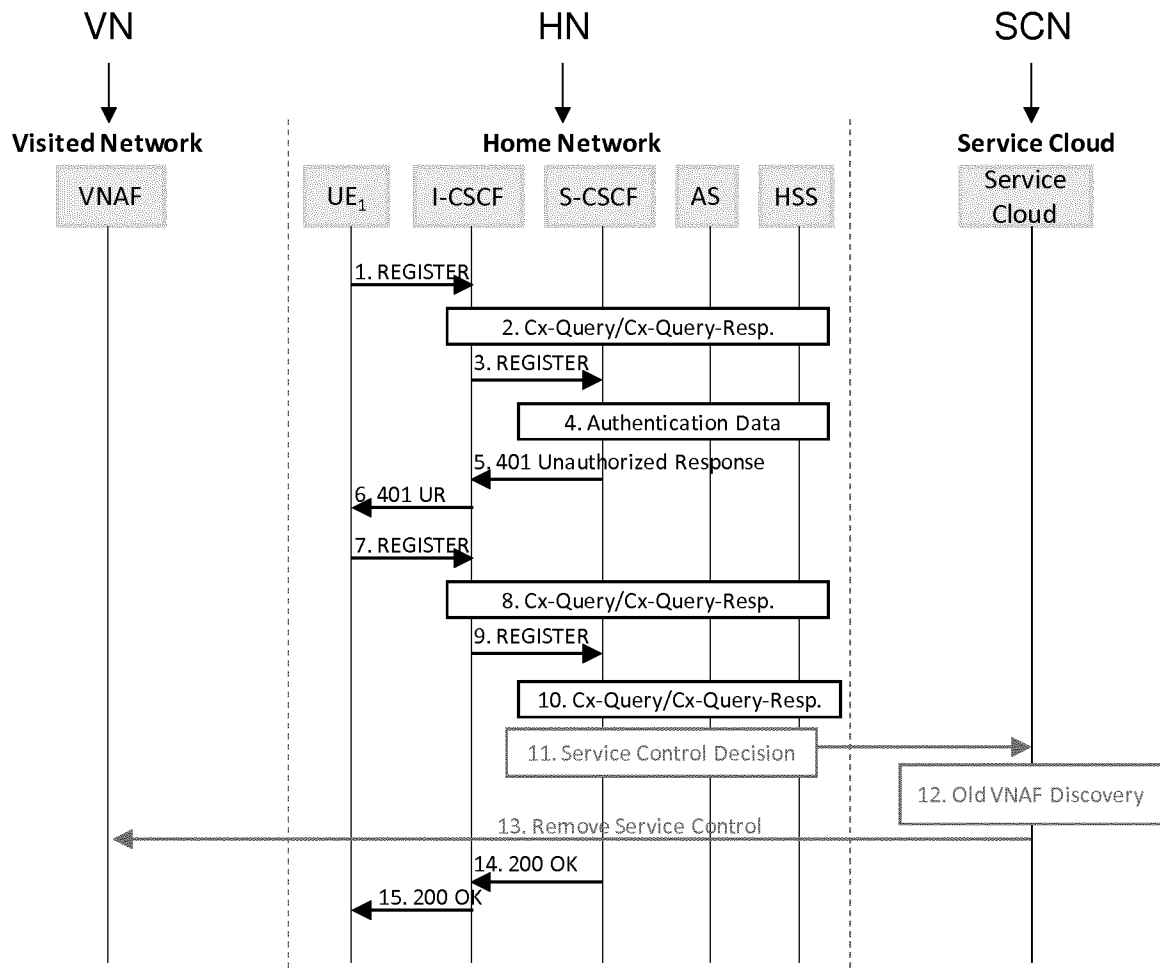


Fig. 5

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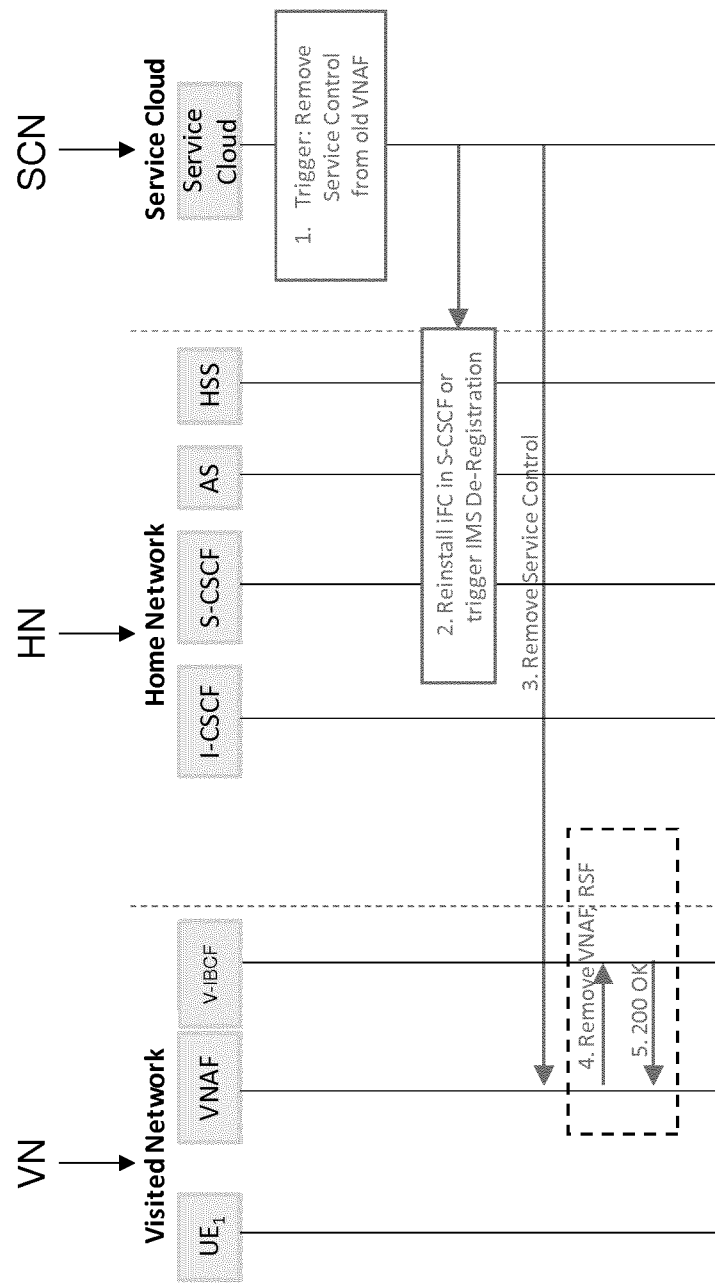


Fig. 6

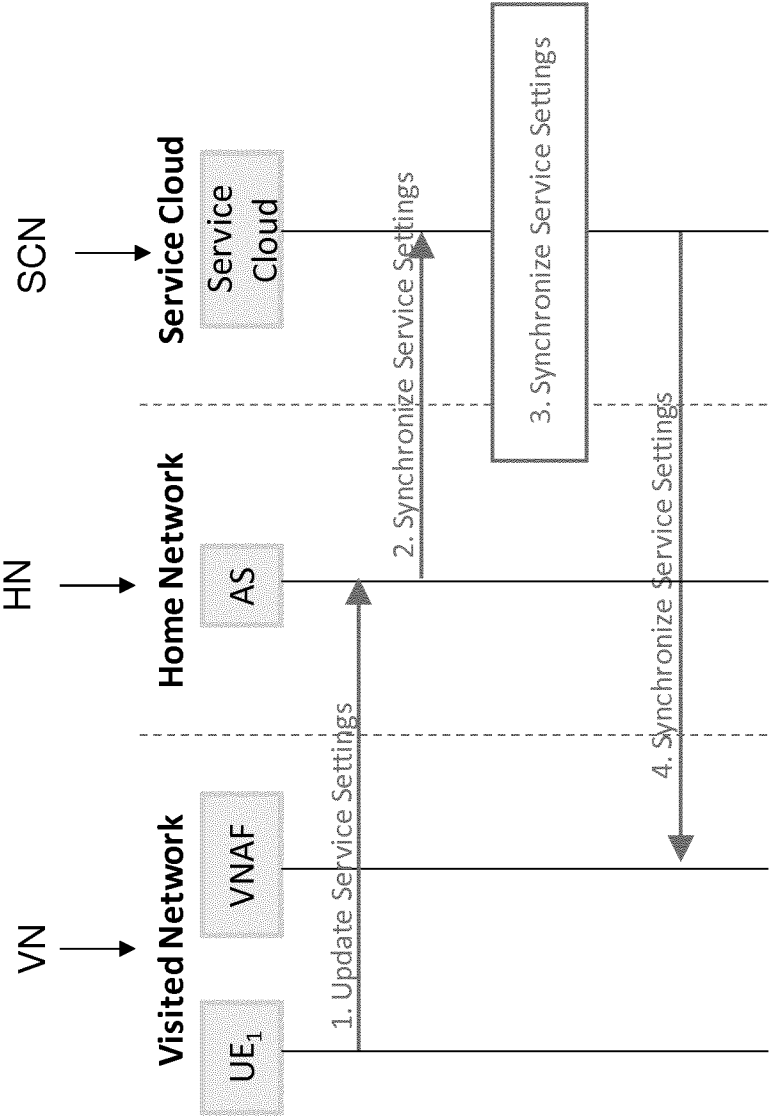


Fig. 7

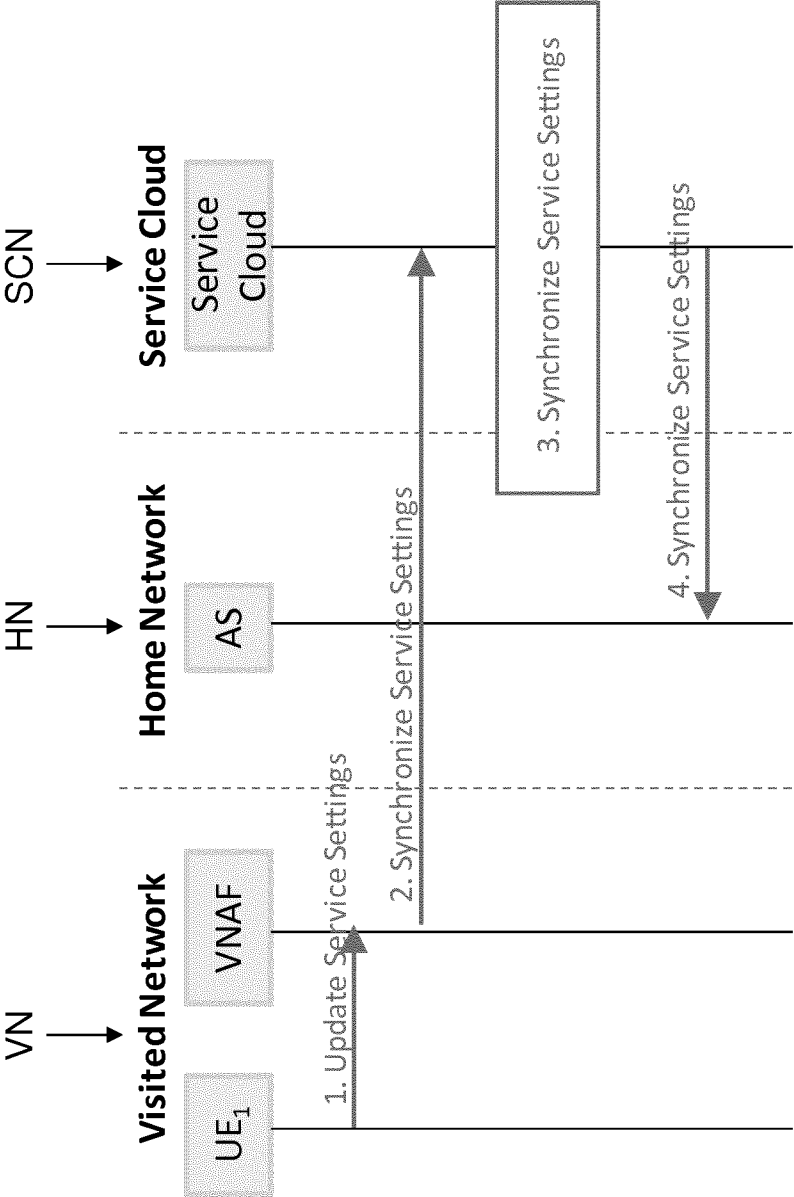


Fig. 8

9/11

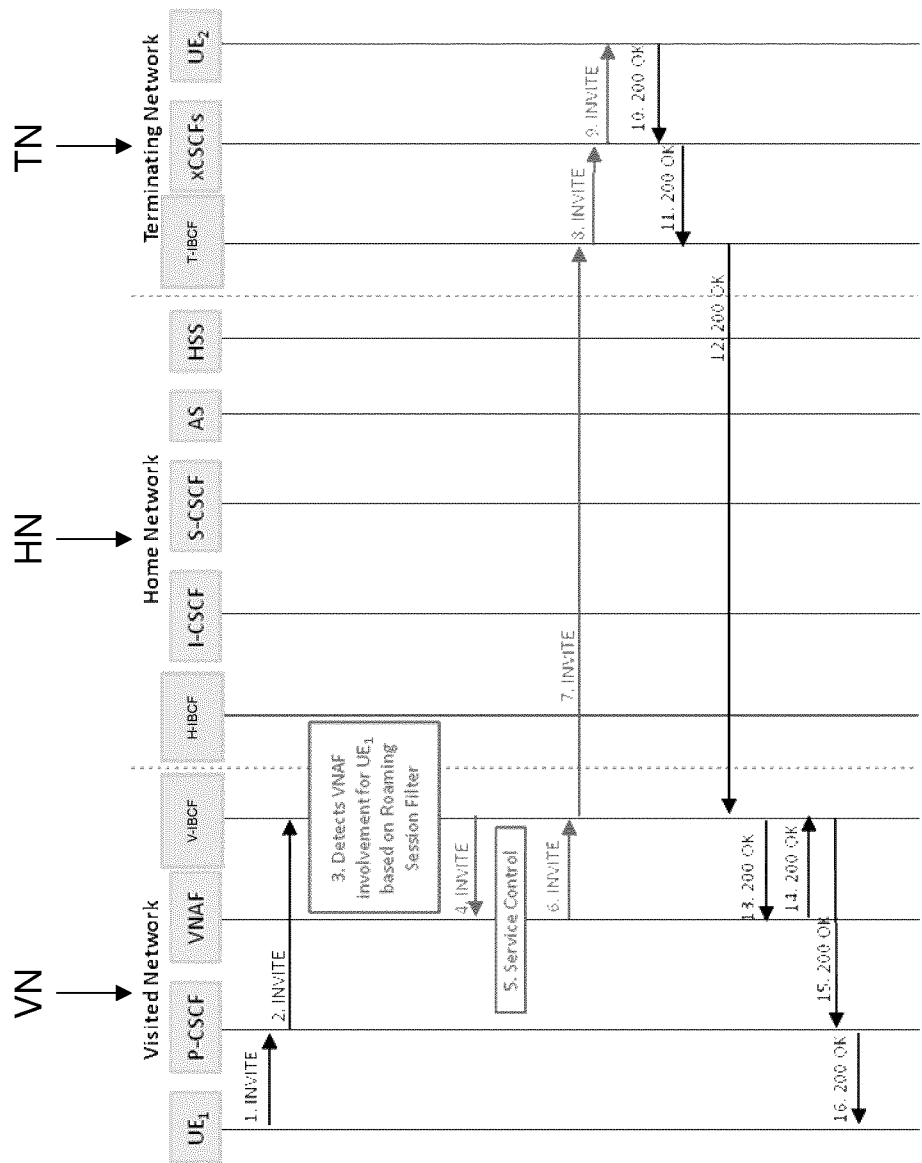


Fig. 9

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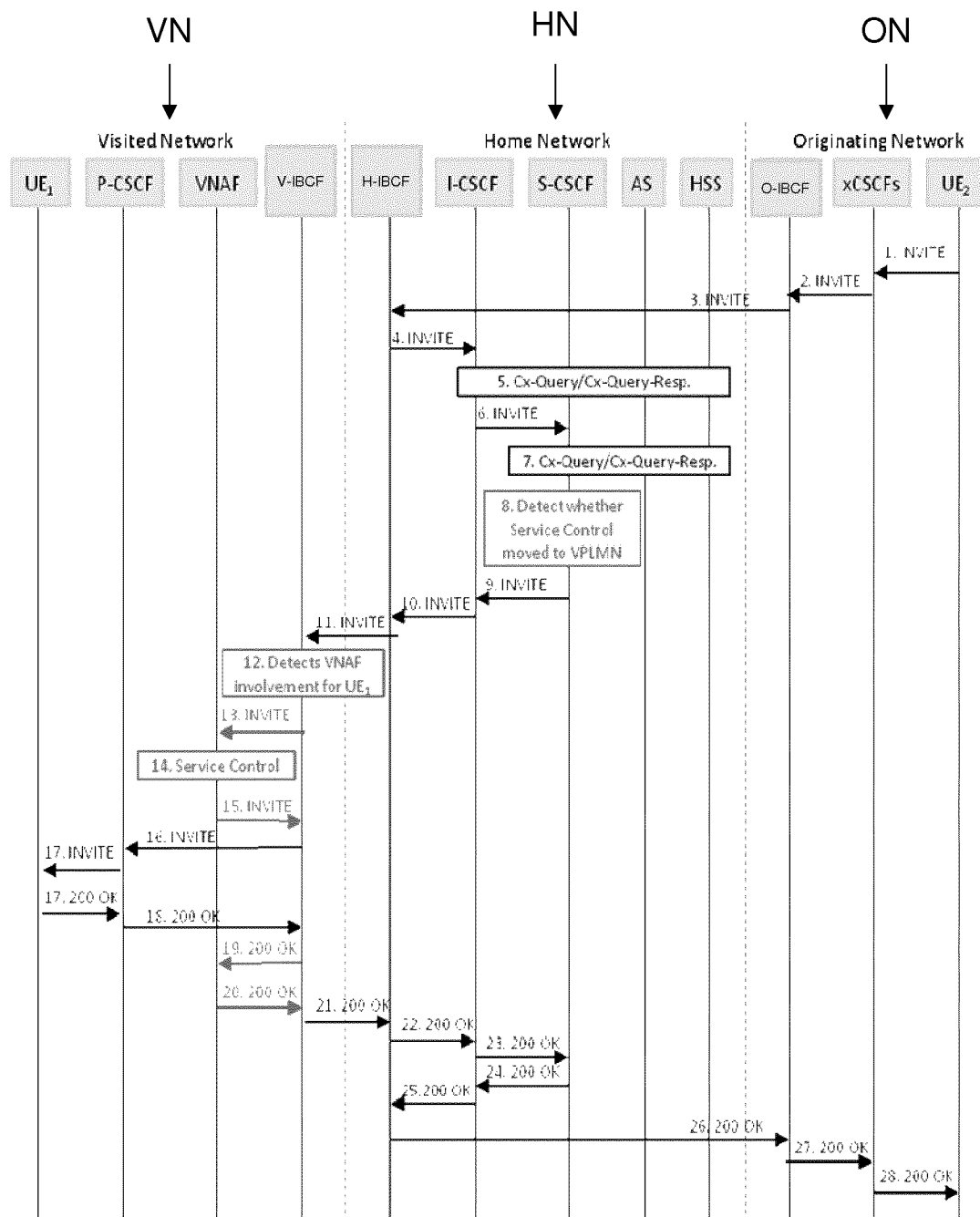


Fig. 10

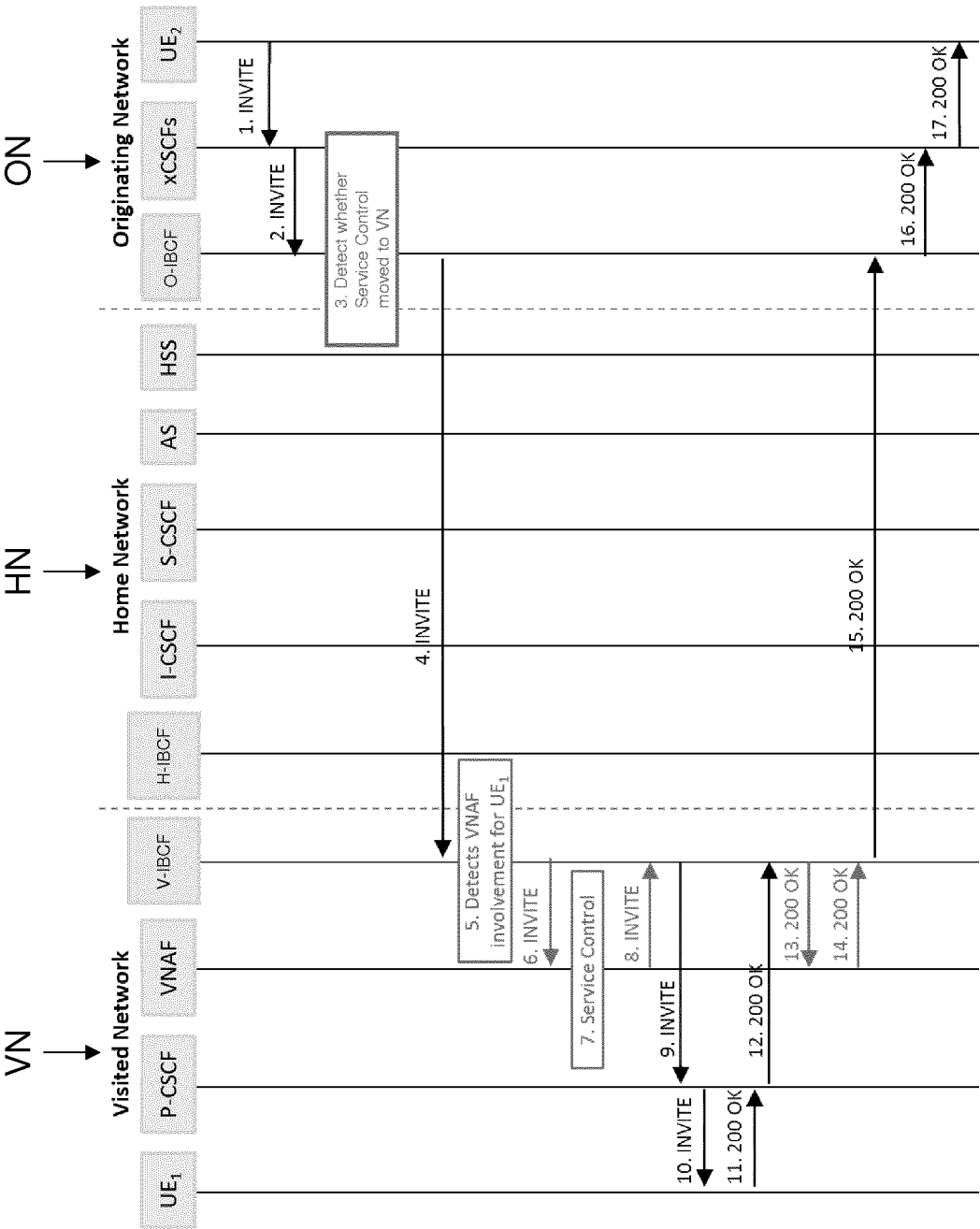


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/066197

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W60/00 H04L29/06 H04W36/00
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)
H04W 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	WO 02/32178 A1 (NOKIA CORP [FI]; PHAN ANH SON [HU]) 18 April 2002 (2002-04-18) abstract page 3, line 14 - line 26 page 4, line 10 - line 30 page 5, line 28 - page 6, line 8 page 10, line 34 - page 11, line 27 page 12, line 24 - page 19, line 9 figures 1,2A,2B ----- -/--	1-10



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

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"&" document member of the same patent family

Date of the actual completion of the international search

8 November 2012

Date of mailing of the international search report

16/11/2012

Name and mailing address of the ISA/

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Matt, Stefan

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2012/066197

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LUCENT TECHNOLOGIES*: "Service Control Architecture", 3GPP DRAFT; S2-001301 SRVC-CTRL-ARCH, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Bristol, UK; 20000911, 11 September 2000 (2000-09-11), XP050344879, [retrieved on 2000-09-11] Summary figures 1,4,5 1.2 Home and Visited Control 2.3 Visited s CSCF and Visited AS 2.4 Visited S-CSCF and Home/3rd Party AS 3.2 NNI -----	1-10
X	ERICSSON: "Registration procedures", 3GPP DRAFT; S2-001465, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Bristol, UK; 20000911, 11 September 2000 (2000-09-11), XP050344988, [retrieved on 2000-09-11]	1-5
A	1 Introduction 5.3.2.4 Registration Information Flow A: Start of registration 5.3.2.6 Registration Information Flow C: Continuation of Registration - S-CSCF in visited network pages 1,3 -----	6-9
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Roaming Architecture for Voice over IMS with Local Breakout (Release 11)", 3GPP STANDARD; 3GPP TR 23.850, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. SA WG2, no. V1.0.0, 14 September 2011 (2011-09-14), pages 1-37, XP050553769, [retrieved on 2011-09-14] the whole document -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/066197

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