Self-adaptable IP Connectivity Control in Carrier Grade Mobile Operator Networks

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Abstract. The current trend in operator networks is towards the deployment of high capacity radio technologies such as LTE accommodating a high number of devices and their data traffic. However, the current network architecture was designed for a lower level of communication in which scalability was achieved through uniform operator control. Connectivity for each mobile device was handled in the same manner, no matter of its characteristics, network location or resources required resulting in a high overhead in supporting a large part of the subscribers. This paper introduces a new self-adaptation concept realized as a subscriber oriented management layer enabling the customization of the control procedures and resources reserved to the individual communication requirements for each device. The concept is exemplified for access network selection and core network path adaptation use cases, adapted for the 3GPP Evolved Packet Core architecture and evaluated through a testbed realization based on the Fraunhofer FOKUS OpenEPC toolkit.

Keywords: Self-adaptation, mobility management, Evolved Packet Core.

1 Introduction

During the last two decades, the telecommunication technologies have reached a high level of acceptance mainly due to the development of the Internet which allowed previously unimaginable levels of information exchange and due to the mobile communications which empowered users with continuous reachability. Following this trend, the mobile communication industry is currently passing into a novel massive broadband communication age through the harmonization of previously voice centered services with the Internet technologies [1]. Four factors are of significance for this evolution.

First, novel radio technologies became available and are currently rolled out by carrier grade network operators such as LTE. They come to supplement the already deployed technologies like HSPA, UMTS, CDMA and WiFi. Although heterogeneous as capacity, delay, packet loss and operational costs, the access networks altogether are offering remote wireless communication with a high level of throughput, thus being able to accommodate large levels of communication [2].

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Secondly, the users accustomed with both Internet and mobile communication technologies are gradually adopting, as commodity, devices such as smartphones, tablets and laptops. The adoption of the heterogeneous devices corroborated with the data traffic increase enlarges the current communication subscriber based while at the same time requires an extended support from the core networks [3].

Following, due to the opportunity of delivering services anywhere and anytime and to a large set of users, novel services and applications are foreseen especially targeting mobile subscribers. Added to this, the current applications used over fixed lines access networks are adapted to the mobile networks, offering a large variety of services to the mobile subscribers [3].

Finally, due to the massive deployment of access networks offering remote communication at reduced costs, other industries such as energy, automotive and security are considering the usage of operator infrastructures for a new type of mobile communication for which the human interaction is limited, generically named Machine-2-Machine (M2M). For this, it is estimated an increase with one order of magnitude of the connected devices and a high diversification of their capabilities [4].

However, in order to be fully accepted, the massive broadband mobile communication core network infrastructure is expected to reach similar quality and reduced operational costs as the evolution to Next Generation Networks (NGN) brought to the fixed lines communication. As the wireless networks are natively cellular, the devices located at a specific moment of time at a specific location compete for the same resources, thus requiring resource mediation. Also, in order to be able to maintain the reachability of the mobile devices, the network has to be able to offer mobility support considering how the location changes for each device. These two technical limitations of the mobile technology apart from the deployment ones, such as renting of antenna sites, make the mobile technology more expensive to use and requires separate architecture design.

In fact, there is a stringent requirement for more scalable features in the core network as to be able to reduce the operational costs through the adaptation of the resources available for each subscribed device as close as possible to the resources required without deterring the communication from the perspective of the end users.

This paper proposes a novel approach for the adaptation of the communication characteristics for each mobile device. A management layer function is introduced in the core network having as main role to provide customized parameters independently for each of the subscribers according to their network profile information, current mobility pattern through the physical environment and the resources required for the communication as well as based on the network conditions e.g. available access networks at the device location or available core network entities which can support the device communication. The proposed solution enables the usage of no more resources than required for each subscriber.

The information structures and communication procedures are exemplified for the cases of customized data path selection in the access and core network as additions of the 3GPP Evolved Packet Core (EPC) ([5], [6], [7], [8]), representing the standard architecture for the future mobile communication encompassing the connectivity support for LTE and the other heterogeneous fixed and wireless access network. The practical realization of different parts of the described concept is presented as extensions of the OpenEPC toolkit and using the afferent testbed realization ([9]).

The remainder of the paper is organized as follows: Section 2 provides the background of the proposed framework, while Section 3 describes the concept, followed by the algorithm in Section 4 and the 3GPP Exemplification in Section 5. Section 6 provides an overview of the testbed and of the evaluation scenarios while in Section 7 the conclusions are provided.

2 Background

In order to be able to offer more capacity in term of connected devices and available resources, currently the network operators are deploying multiple radio technologies such as LTE, HSPA, EDGE, WiFi etc. in the same locations, highly overlapping and enabling complimentary connectivity service with different characteristics specific to the heterogeneous wireless technologies. These heterogeneous access networks are supported in a convergent manner by the functionality in the core network, including transparent mobility inside or between multiple access networks. Additionally, the network deployment sustains the allocation of resources for each subscriber based on the subscription profile and on the available resources as well as mechanisms for device authentication, data traffic accounting and charging.

With the increase in number of devices and in their data traffic supported by the radio technologies, a novel level of efficient handling of IP connectivity is reached: the network has to scale as control and as user data transport in order to enable the communication for all the mobile users. This may be reached only through the distribution of the same functionality in multiple locations through the wireless system resulting in parallel handling of the devices in different network locations geographically distributed, as depicted in Figure 1.

The radio network high overlap and the core network distribution require new algorithms for flexible selection of the access and core network control and user data plane entities. The selection ensures the optimal usage, the flexibility, the reliability and the easiness of maintenance of the carrier grade operator core network.

Currently, there are two mechanisms deployed for access network and core network path selection depending on the degree of integration of the core network functionality: one mechanism for the integrated access networks such as GPRS, HSPA and LTE ([5], [7]) and one for access networks which are separately controlled such as WiFi or WiMAX ([6]). For brevity, the second case is not further considered in this paper. However the same principles of the here proposed solution also apply.

In case of operator managed networks, the selection process which precedes a handover procedure is made by the control entities of the specific access networks i.e. the eNodeB or the Mobility Management Entity (MME) for LTE access, the Serving GPRS Support Node (SGSN) for the GPRS/EDGE and UMTS/HSPA accesses. When a handover has to be executed in order to maintain the service continuity, a target cell is selected by either the source cell for LTE or by the target control entity MME or SGSN. The target cell is selected based on the signal strength at the location of the

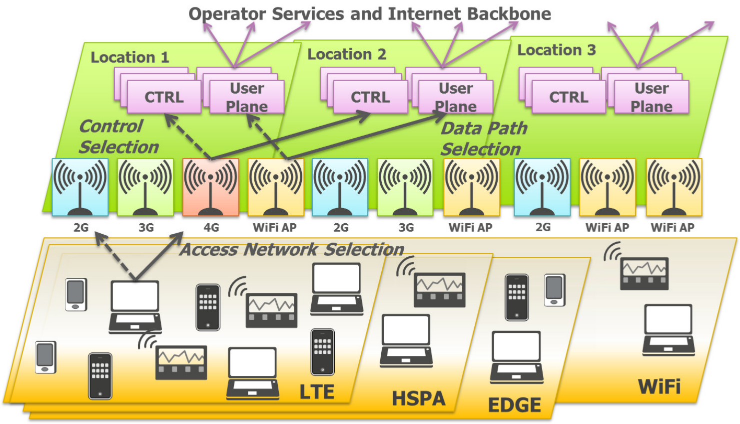

Fig. 1. High Level Operator Network Architecture

mobile device independent of its resources consumed or of the direction of its mobility through the wireless environment. Additionally, a handover to an access network of another radio technology is not possible when the service continuity over the same radio technology can be ensured from the perspective of the radio signal strength. Therefore, a device which is connected to an LTE access network will not be handed over to a HSPA access network even when the LTE is congested.

Coming to mitigate this issue the Self-Organizing Networks (SON) tries to introduce a more dynamic selection of the access network from a management perspective introducing weight-based load balancing between the distinct radio networks. This type of solution enables to steer the devices to the different accesses depending on the momentary load and on their network positioning ([10]).

A similar solution is also introduced for the selection of the core network control and user plane entities. A weighted round-robin algorithm is executed in the entity which makes the selection based on the proportions received through a DNS query. The round robin algorithm ensures that the balancing can be executed with limited errors without requiring actual monitoring of the entities.

However, the devices which are foreseen to be deployed in the future carrier grade network infrastructures have highly different capabilities. The capabilities include not only the different radio device interfaces which enable the wireless connectivity, but also the processing and storage capabilities, apart from the distinct mobility patterns through the physical environment and data path resources required such as guaranteed QoS characteristics. Due to this differentiation of devices on two dimensions: resources consumption and mobility pattern through the physical environment, the SON and the weighted-DNS solutions are not able to provide in the majority of cases the most suitable solution. For example, a device which is highly mobile would require a specific Packet Data Network Gateway (PDN GW) to be selected which reduces the number of reselections required independent of the load balancing algorithm.

3 SelfFit Concept

This article proposes a new management concept oriented towards individual connected devices in which the access network and the core path initial and subsequent selection procedures are executed depending on the specific parameters of the mobile device. The parameters include the momentary available information such as the current entities which are in use and the resources require enabling immediate service continuity and parameters acquired as knowledge related to the mobile device such as the mobility or the resource consumption pattern. The concept is depicted in Figure 2.

In the core network of the operator a novel SelfFit subscriber oriented management function is added to the already existing functionality. It contains three functional entities. First, a Subscription Profile Repository (SPR) enables the framework to access subscription profile information. It represents an extension with the customized information of the already deployed core network Subscription Information entities. Additionally, it may subscribe and receive notifications to subscription information modification events which then will require a new set of parameters to be selected for the selection decisions.

The Access Selection Management Function (ASMF) enables individual access selection parameters for each of the subscribers. When a handover is required and a cell of the same technology or another access network technology has to be selected, the selecting entity in the core network queries the ASMF on the specific target cell information. As the cell is selected on a per-subscriber basis, this query replaces the weighted-DNS query, thus not being required anymore to execute the round-robin algorithm. Based on the ASMF response, the target cell is selected. The following handover preparation and handover execution procedures require no modification. They are executed as specified in the current standards.

The Core Network Management Function (CNMF) enables the independent selection for each subscriber of the control and of the data path entities serving a specific node. The operations are triggered by either a handover of the mobile device to another access network, by the modification of the resources required from the network or by the modification of the configuration of the network through management means e.g. a control or data path entity is introduced or removed from the

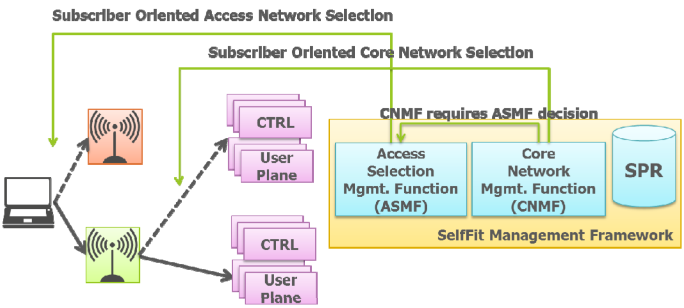

Fig. 2. Concept Architecture

network for energy efficiency reasons. Especially for the data path, a shorter data path stretch in average considering all the mobility of the device enables a lower average end-to-end delay and fewer resources consumed from the network in forwarding the data to the device. The CNMF makes such a decision either by receiving an administrative trigger or because of a request on behalf of a connected device received from the core network. The response of the decision enables the core network to select the appropriate data path for each of the devices through the core network.

In some specific cases, the core network path requires an access reselection decision. For example, a data path gateway cannot be reached unless the device is connected to a specific access network. In this case the decision of the CNMF is transmitted as trigger for the access network selection.

In order to reach the appropriate decision, in essence both the ASMF and the CNMF are executing the same algorithm in combining the subscriber related with network management information. However, the proportions in which the different parameters influence the final decision are highly distinct as the service continuity remains the main issue of the access networks, while in the core network traffic steering from a large number of subscribers between different geographically separated sites is also sustained and desirable in some situations.

In order to respond to the selection or reselection query, the ASMF and the CNMF use network management information such as a coverage map including all the access networks available at a specific location. Additionally, it uses the location information of the mobile device as well as information on which is the source cell or network entity. It is recommended that the same access technology will be used in case of a handover as not to require device driver reconfiguration. In order to make a subscriber oriented decision, the ASMF and CNMF request from the SPR information on the current resources required by the mobile device.

In addition to this, as to make an accurate decision which enables the mobile device to communicate without requiring an additional reselection procedure for a longer duration of time, the ASMF and CNMF receive from the SPR general information on the communication parameters for the mobile device. This information may include the resource consumption pattern i.e. resources consumed in specific time intervals etc. It is assumed that an access selection with a high capacity will be selected for a device which requires a high level of resources. A similar assumption is made also for the core network entities.

4 Algorithm Description

The selection algorithm is based on the computation of a selection utility for all the possible choices based on the following formula:

$$U_{x,MS}=L_x*MP_{MS}*RP_{MS} \quad (1)$$

where X is one of the possible choices to be selected for mobile station MS, U_x is the computed utility, L_x is the proportion of the capacity, MP_{MS} and RP_{MS} represent the probability that MS moves respectively uses resources in the area best covered by X.

Fig. 3. Simplified Network Model

In order to grasp the concept presented in the previous section and its implications on the selection procedure, a simple network model was realized as depicted in Figure 3. A network system containing a single access network, separated into four distinct areas was considered. Each of the areas is served by a local PDN GW. It is assumed that any PDN GW can support the mobile device in any of the areas, however the local one is considered better due to the shortest data path stretch for the signaling and the data traffic i.e. similar to local break-out scenarios.

The selection scenario presumes that a Mobile Station (MS) is establishing an initial data path for the communication, procedure in which the most appropriate PDN GW has to be selected. The steps of the algorithm as well as the probabilities and the coefficient are exemplified in Figure 4.

The weight representing the capacity proportions of the PDN GWs assumed presumes that PDN GW 1 is able to receive 30% of the system data traffic, PDN GW 3 50% while PDN GW2 and PDN GW4 10% each.

It is assumed that the MS is active for a day and that its mobility pattern is presuming that the user is located in Area 1 and in Area 2 in the same measure while not passing through the Area 3 and Area 4. The assumptions on the accurate prediction of the mobility pattern are based on the results presented in [11] where human mobility predictability was extensively analyzed. We assume in the model a potential predictability of 75% which is highly conservative compared to the results from [12] where a potential predictability of 93% was obtained. Thus the probability that the MS will move out of the mobility pattern is considered of 25% and split equally between Area 3 and Area 4.

Additionally we assume the depicted data traffic pattern which correlated with the mobility pattern information assumes that 20% of the data traffic will be executed while the device is in Area 1 and 80% while it is located in Area 2. The same potential predictability of 75% is assumed also for the data traffic. Similarly to the mobility pattern, the probability that the data traffic will be exchanged in the Area 3 and Area 4 is considered of 25% and split equally. The algorithm here presented assumes that all the data traffic receives the same QoS classification and thus is handled in the same manner in the core network.

When the reselection trigger is received (Step 1), the subscription profile including the subscription and the data traffic pattern are retrieved from the SPR (Step 2). Then the candidate PDN GWs are retrieved including their weighted parameters. For each of the PDN GWs a coefficient is generated based on these probabilities. This coefficient will evolve through the execution of the steps of the algorithm into a final one representing the opportunity of selecting one of the gateways. In case of the current deployed algorithm, due to the deliberately and arbitrary selected proportions in which PDN GW3 can handle 50% of the data traffic, for the given MS there is ½ chance that the PDN GW3 will be selected and that the data path for none of the data traffic is optimal.

Based on the assumed mobility pattern, a set of probabilities are generated. The previously designed coefficient is multiplied with these probabilities resulting in a new coefficient representing the probability that the device is located in the specific network area combined with the capacity proportion of the specific PDN GWs. The resulting coefficient makes the PDN GW1 as the best selection as it can hold a larger proportion of the overall system data traffic. As it was assumed that the MS is roaming in the Area 1 for 50% of the time this result is acceptable, especially in the case when the data traffic pattern of the MS is uniform.

However, the mobile devices communication over the network is highly non-uniform. We assume in this paper a distribution of the data traffic in time as depicted in Figure 3. This information correlated with the area location information, as derived from the mobility pattern results in a new set of probabilities in which of the areas the data traffic will be exchanged. A large simplification was considered here through the

Algorithm	Assumed Parameters	PDN GW1	PDN GW2	PDN GW3	PDN GW4
1. Trigger of reselection decision					
2. Retrieve Subscriber Structure					
3. Possible Candidates Match	30% PDN GW1 10% PDN GW2 50% PDN GW3 10% PDN GW4	30	10	50	10
4. Mobility Pattern Fit	50% Area 1 50% Area 2 75% Trust	P=50%*75% 11.25	P=50%*75% 3.75	P=25%/2 6.25	P=25%/2 1.25
5. Resource Pattern Fit	20% Area 1 80% Area 2 75% Trust	P=20%*75% 1.6875	P=80%*75% 2.25	P=25%/2 0.78	P=25%/2 0.15625
6. Make Policy Decision			PDN GW2		

Fig. 4. Example Algorithm Coefficient Computation

consideration of a mobility pattern in which the MS is moving between Area 1 and Area 2 at specific moments in time. As it is assumed that a large proportion of the data traffic will be executed in Area 2 (80%), the resulting coefficient from the multiplication of the previous one with the obtained probabilities is giving a large proportion selection to PDN GW2 followed by PDN GW1 representing the areas in which the MS is connected.

However, if the proportions of the data traffic would have been selected in a different proportion between the Area 1 and Area 2 (40%-60%), the PDN GW1 would have gained a larger final coefficient. Therefore, even though for the specific MS, PDN GW2 would have been the best selection as the most of the data traffic is exchanged in the specific area, PDN GW1 would have been selected as considered better by the system due to the handling of a larger proportion of the overall data traffic.

The algorithm here presented represents a first tentative in introducing subscriber oriented wireless system components selection. It is assumed that the proposed method requires further probability adjustments depending on the deployments. Additionally, parts of the information may not be gathered in a specific operator networks, therefore simplifications as number of steps have to be also considered.

In case of an access network selection, it may not be any more assumed that all the base stations are visible at all the locations or that all can in a specific measure support the data traffic of the subscriber. In this case, the algorithm should become stricter in its probabilities as local parameters specific to the area where the device is can be better determined. Additional, to the selection of a next cell in order to ensure the service continuity, the algorithm offers a simplified solution to the access network selection enabling the balancing of subscribers between the different radio networks controlled by the same operator.

5 EPC Exemplifications

The 3GPP Evolved Packet Core (EPC) was selected as the exemplification core network architecture due to its capability to enable connectivity for LTE and for the other heterogeneous access networks including all-IP connectivity features such as authentication and authorization, mobility support, resource reservations and charging.

A minimal architecture for LTE access is depicted in Figure 5. The connection to the other access networks is not depicted for brevity. The LTE base stations (eNodeBs) are handling the radio connectivity for the User Equipment (UE). A Mobility Management Entity (MME) controls the connectivity to the LTE access network including the data path components selection and the intra-LTE handovers. For its decisions, the MME is able to retrieve subscription profile information from a Home Subscriber Server (HSS). The data traffic is anchored in a Serving GW (S-GW) for the 3GPP accesses and in the Packet Data Network GW (PDN GW) for the complete system. In the example, a single MME is deployed with multiple eNodeBs and co-located S-GW + PDN GW.

The EPC can be extended with the SelfFit framework functionality in all the selection processes including the selection of the MME, S-GW and PDN GW in case

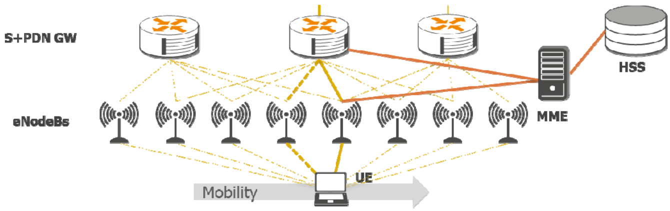

Fig. 5. Simplified EPC Architecture

of an initial attachment and of the target eNodeB, MME and S-GW in case of an intra-LTE handover.

For the attachment procedure, as a single MME is included in the system and as the S-GW is co-located with the PDN GW, the single selection required is the one for the PDN GW. The data flow of the procedure is depicted in Figure 6. When the Attachment Request is received by the eNodeB from the UE, it is forwarded to the MME (Step 1). Based on this request authentication and location procedures are executed including the subscription profile retrieval from the HSS (Step 2).

In order to establish a data path, the MME has to select an appropriate PDN GW. For this, it queries the SelfFit framework (Step 3). As to bring a minimal modification of the system, the MME is querying the SelfFit framework with a Diameter communication interface, similar to the interface between the MME and the HSS used for the retrieval of the subscription profile. Based on this one of the SelfFit a framework deployment alternative includes its integration as a front-end to the HSS.

The SelfFit framework retrieves the weighted PDN GWs identities from the DNS server as in the current network solution (Step 4). The lists of PDN GWs as well as the weights are used as parameters in making a selection decision along with the mobility and data traffic pattern which may be stored locally or retrieved from the HSS. The decision is made based on the previously described algorithm (Step 5).

The response in the form of a single PDN GW or of multiple weighted PDN GW identities are send back by the SelfFit to the MME (Step 6). In case of multiple PDN

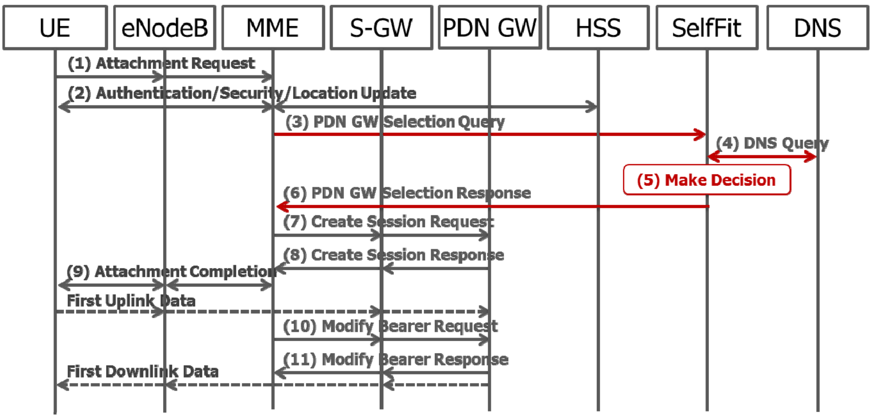

Fig. 6. Simplified LTE Attachment Procedure

GWs, the MME executes the weighted round robin algorithm and selects one of the PDN GW. Then, the MME controls the establishment of a data path to the selected PDN GW through a session establishment procedure (Step 7 and Step 8).

The rest of the LTE attachment procedure is executed including the notification on attachment complete to the UE over the radio link (Step 9) and the modification of the session to include the IP address allocated to the UE by the core network (Step 10 and Step 11).

Through this procedure, the PDN GW which will be maintained for the full attachment duration of the UE to the core network considering the mobility of the device through the wireless environment and the resources consumed as predicted based on previous knowledge of the operator network. Through this means, the appropriate PDN GW is selected not only based on the current location or on the network capacity, but also on the subscription profile information. For the intra-LTE handover, an S1-based procedure was chosen in which the decision to which target cell to execute the handover is taken by the MME. Similarly with the previous case, as the example system proposed has a single MME and that the S-GW are co-located with the PDN GW, there is no need for an MME or S-GW selection procedure. It is assumed that the UE is connected through a Source eNodeB to the EPC core and exchanging data with correspondent nodes through a previously selected PDN GW. The data flow is depicted in Figure 7.

Due to modifications in the physical communication with the UE, a handover is requested by the Source eNodeB (Step 1). It is assumed in this scenario that the source eNodeB is not aware of the eNodeBs in its vicinity and can not execute direct X2 procedures. This is also the case when the eNodeB is at the border of an LTE deployment and the handover has to be executed to other 3GPP access networks such as HSPA or GPRS.

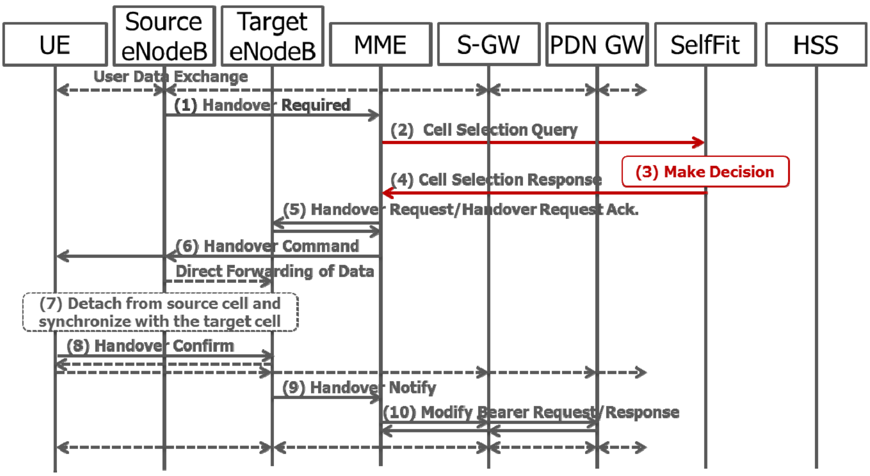

Fig. 7. Simplified LTE S1-based Handover Procedure

When receiving the request, the MME makes a "Cell Selection Query" to the SelfFit framework, including the identity of the UE, its momentary location and the handover requirement (Step 2). The SelfFit function makes a handover decision following the algorithm previously described adapted for cell selection (Step 3). The selected cell along with the specific handover parameters are forwarded to the MME (Step 4).

The rest of the procedure follows the standard operations for S1-based handovers. The MME transmits a Handover Request which is acknowledged to the Target eNodeB (Step 5) and a Handover Command to the Source eNodeB (Step 6), command which is forwarded to the UE. An indirection tunnel is established between the Source and the Target eNodeB enabling zero-packet loss handovers even for downlink data. The UE detaches from the source eNodeB and attaches to the Target eNodeB (Step 7) and then transmits a handover Confirmation (Step 8) which is transformed into a Handover Notification send from the Target eNodeB to the MME (Step 9) which at its turn issues a request for the modification of the communication to the new path in the S-GW and PDN GW (Step 10).

Through this procedure, the Target eNodeB cell is selected based on the subscriber's requirements for sustaining the future communication. This is especially important in the case when the communication may be established through multiple eNodeBs at the same location for example in case the macro-network is augmented with femto-cells of the same network provider and in the case a network provider is deploying multiple cells in different frequency bands.

The same procedure is to be used in case of handovers from LTE to other 3GPP access networks. However, in this case the selection decision is first transmitted to the SGSN which makes a new selection decision which is the most appropriate 2G or 3G cell to be used.

With several extensions which are not considered in this article, the procedure can be adapted for handovers to other non-3GPP accesses. However, the handover command including the target network cannot be transmitted directly over the LTE wireless link, thus requiring another communication mechanism.

The handover duration is time critical and as the respective subscriber oriented decisions may affect also other handover parameters such as the LTE Radio Time-To-Trigger (TTT) parameter which defines the duration in which the UE is maintaining the connectivity to the Source eNodeB in order to avoid rollbacks and other exception cases. In order to reduce the duration of the newly introduced procedure steps, it is expected that the MME will executed this steps immediately when the UE is attached to the Source eNodeB and will cache the information until requested as part of the state information maintained on the UE. Further investigations on the specific procedure have to be considered especially for the case when the selection is made by the Source eNodeB.

6 OpenEPC Testbed

For evaluating the opportunity of the previous proposed SelfFit concept as well as for enabling demonstrations and proof-of concept of novel R&D features related to the core networks and to the delivery of applications in the future mobile wireless environments, Fraunhofer FOKUS developed the OpenEPC toolkit as depicted in Figure 8 ([9]).

OpenEPC Rel. 3 enables the docking of off-the-shelf base stations for a large set of access networks such as LTE, HSPA, EDGE and WiFi and enabling the realization of complete operator testbeds including the radio and the core network features while using commercial available smartphones and modems.

Currently, OpenEPC features all the 3GPP standard components including the procedures for the attachment and the detachment for the various radio technologies and transparent mobility management between the access networks. It also enables convergent resource reservations and charging based on the requirements from the applications and on the device subscription profile.

Regarding the concept here presented, OpenEPC was deployed with two distinct PDN GWs which may be selected while attaching to the different base stations of the same or of different access technologies with different priorities. Through this testbed the initial attachment scenario was implemented and demonstrated.

The SelfFit framework was implemented as a separate component using a proprietary interface of the OpenEPC which enables fast development of a simple communication protocol between two distinct entities. The SelfFit was capable of making a simple decision on which PDN GW to select. Currently, no information on the mobility or data traffic pattern was included as this presumes further network modeling. It was observed that for the PDN GW selection a delay less than 50ms was introduced on the network side which in a real operator environment will be compensated by the parallel execution of the attachment procedures over the radio link.

From the perspective of the OpenEPC practical implementation, the duration and the computation required for the PDN GW selection is acceptable, due to the single execution of the procedure per attachment. However, the delay is considered too large for the eNodeB selection, thus a different mechanism for the transmission of the selection parameters should be considered, such as the caching here proposed.

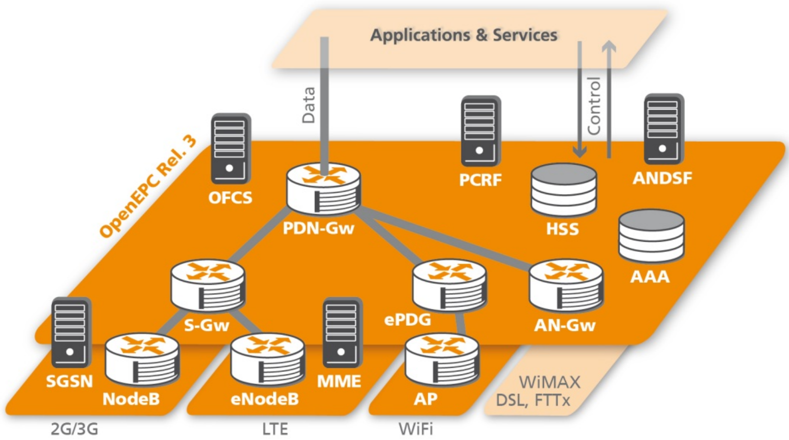

Fig. 8. OpenEPC Rel. 3 Testbed Architecture

7 Conclusions and Further Work

In this article we have described a novel concept for the customized selection of network entities by using a subscriber oriented management framework which makes decisions considering the specific characteristics of the communication of the mobile device based on the subscription profile, momentary network topology and status and based on predictions of the mobility and data traffic patterns.

The presented concept addresses carrier grade operators enabling connectivity to large number of devices using highly overlapping heterogeneous access networks and geographically distributed core networks. For this environment, the concept presented reduces the number of required reselections by customizing the selection process for each mobile device independently.

The practical implementation of the LTE attachment procedure using the Fraunhofer FOKUS OpenEPC proves the feasibility of the presented concept for selecting core network entities. A further optimization of the proposed signaling has to be considered for the cell selection as the potential duration may be too large.

Further work will include the optimization related to the cell selection in LTE environments as well as the integration with the X2 intra-eNodeB interface and with other SON related functionality. Also a special attention with be given to the integration of OpenEPC with off-the-shelf LTE eNodeBs enabling the evaluation of the procedures through friendly trials.

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