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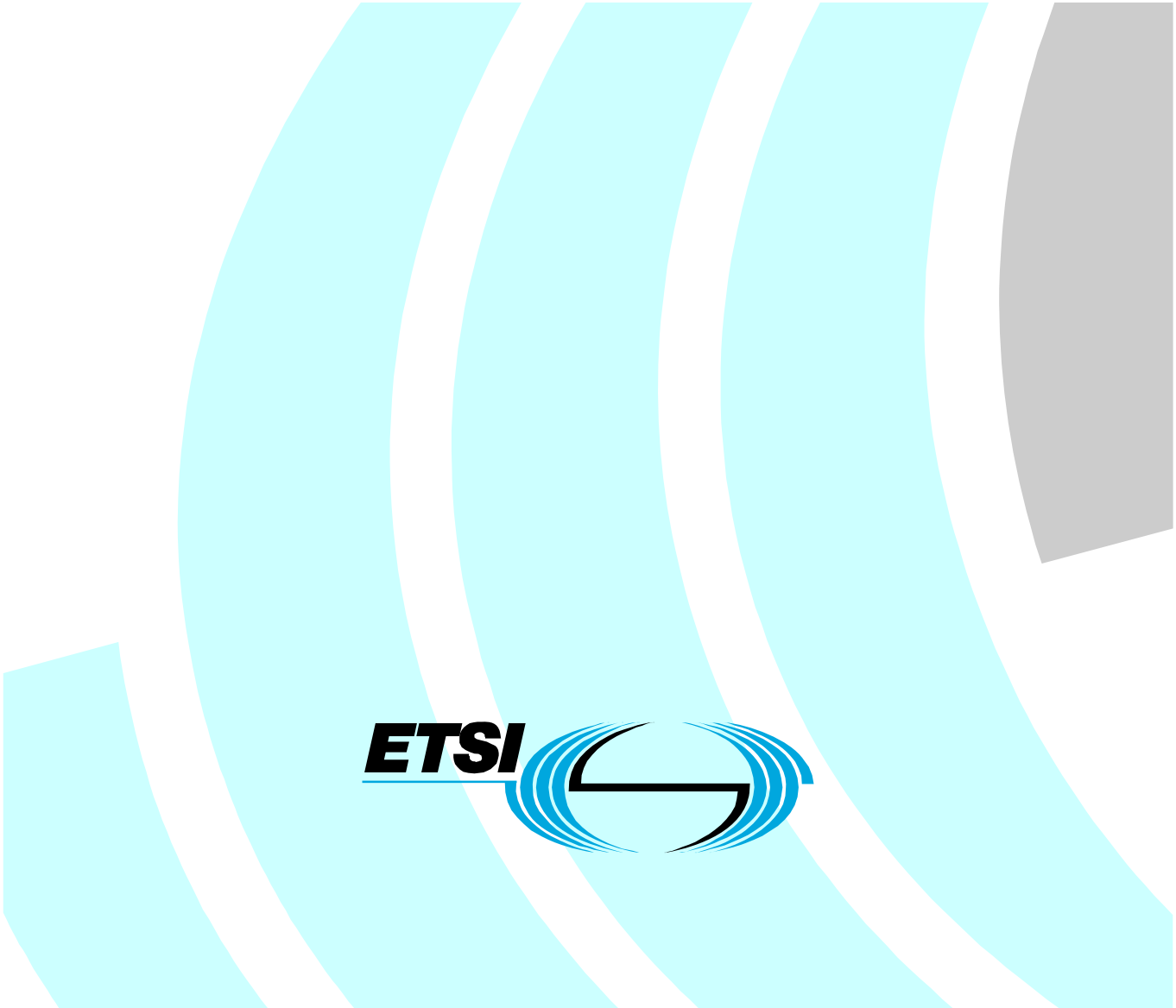
Technical Report

Reconfigurable Radio Systems (RRS); Use Cases and Scenarios for Software Defined Radio (SDR) Reference Architecture for Mobile Device



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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

1 Scope

The present document collects the Use Cases which have been identified for Reconfigurable Radio Systems building on SDR Mobile Devices following the SDR Architecture specifications in [i.1]. These Use Cases will identify actors and information flows, and will form the basis of future work, including system requirements, at TC RRS for Software Defined Radio (SDR) systems and Cognitive Radio (CR) systems.

The architecture of this system or its functional implementation is out of scope of the Use Cases document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references only, the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 102 680: "Reconfigurable Radio Systems (RRS); SDR Reference Architecture for Mobile Device".

[i.2] ETSI TS 125 304: "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) procedures in idle mode and procedures for cell reselection in connected mode (3GPP TS 25.304 Release 9)".

[i.3] IEEE 802.11: "Draft Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements; Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE P802.11-REVma/D89.0, Publication Year: 2010 , Page(s): 1 - 1230".

[i.4] IEEE 802.15.4: "Draft Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (WPANs) IEEE P802.15.4REVi/D04, September, 2010, Publication Year: 2011 , Page(s): 1 - 334".

[i.5] IEEE 802.16m: "Draft Amendment Standard for Local and Metropolitan Area Networks; Part 16: Air Interface for Broadband Wireless Access Systems - Advanced Air Interface, IEEE P802.16m/D8, August 2010, Publication Year: 2010 , Page(s): 1 - 1053".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

camping on a cell: having completed the cell selection/reselection process and having chosen a cell

NOTE 1: In the framework of 3GPP, this term is defined in TS 125 304 [i.2] as follows: UE has completed the cell selection/reselection process and has chosen a cell. The UE monitors system information and (in most cases) paging information".

NOTE2: In addition to the context defined in 3GPP, the term "Camping" is here also used in the context of any type of association to any other wireless system, such as WiFi, etc.

context information: cross-technology context information

NOTE 1: The availability and selected inherent operational parameters of heterogeneous Radio Access Technologies (RATs) is an example.

NOTE 2: The term does not address 3GPP specific context information which is assumed not to be available for the SDR Reference Architecture inherent decision making.

Mobile Network Operator (MNO): potential user for a specific use case

Network management system: network Management of one or more Reconfigurable Radio Systems

Reconfigurable Radio System (RRS): radio system using reconfigurable radio technology

system use case: use case describing the system functionality level and specifying the function or the service that the system provides for the user

NOTE: A system use case will describe *what* the actor achieves interacting with the system. For this reason it is recommended that a system use case specification begin with a verb (e.g. *create* voucher, *select* payments, *exclude* payment, *cancel* voucher). Generally, the actor could be a human user or another system interacting with the system being defined.

use case: description of a system from a user's perspective

NOTE 1: Use cases treat a system as a black box, and the interactions with the system, including system responses, are perceived as from outside the system. Use cases typically avoid technical jargon, preferring instead the language of the end user or domain expert.

NOTE 2: Use cases should not be confused with the features/requirements of the system under consideration. A use case may be related to one or more features/requirements, a feature/requirement may be related to one or more use cases.

NOTE 3: A brief use case consists of a few sentences summarizing the use case.

user: it represents the User of the Mobile Network

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3rd Generation Partnership Project
CE	*Conformité Européenne* (French for "European conformity")
CPC	Cognitive Pilot Channel
CR	Cognitive Radio
CRS	Cognitive Radio System
DoC	Declaration of Conformity

GSM	Global System for Mobile Communications
HSxPA	High Speed Packet Access
IF	Interface
IMT	International Mobile Telecommunications
IMT-A	International Mobile Telecommunications-Advanced
LAN	Local Area Network
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MD	Mobile Device
RAT	Radio Access Technology
RF	Radio Frequency
RRS	Reconfigurable Radio Systems
SDR	Software Defined Radio
TR	Technical Report
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
WiMAX	Worldwide Interoperability for Microwave Access

4 Reconfigurable Radio Systems operating in licensed spectrums

4.1 General description and reference to past work

TR 102 680 [i.1] details an SDR Architecture for Mobile Device, highlighting in particular a set of 5 requirement groups:

- General architectural requirements.
- Capability requirements.
- Operational requirements.
- Interface requirements.
- Other requirements.

Based on these requirement groups, an SDR Architecture has been defined as it is presented in detail by [i.1] and briefly summarized in clause 4.2. The refined understanding of the final architecture proposal and the corresponding inherent capabilities that were developed during the creation of [i.1] lead to the decision to create the present document for giving a detailed overview on related use cases and scenarios.

4.2 Example of a typical Reconfigurable Radio Systems capabilities

The following capabilities of Reconfigurable Radio Systems have been derived in [i.1] for a Mobile Device:

a) **Multiradio configuration capability:** SDR equipment in mobile device is expected to install, load and activate a radio application while running a set of radio systems already.

b) **Multiradio operation capability:** SDR equipment in mobile device is expected to execute a number of radio systems simultaneously by taking into account temporal coexistence rules designed for their common operation.

c) **Multiradio resource sharing capability:** SDR equipment in mobile device is expected to execute a number of radio systems simultaneously by sharing computation, memory, communications and RF circuitry resources available on the radio computer platform by using appropriate resource allocation, binding and scheduling mechanisms.

Building on these requirements, the following components are introduced in [i.1], also illustrated by:

1) **Configuration Manager:** (de)installation and (un)loading of radio applications into radio computer as well as management of and access to the radio parameters of those radio applications.

2) **Radio Connection Manager:** (de)activation of radio applications according to user requests and overall management of user data flows, which can also be switched from one radio application to another.

3) **Flow Controller:** sending and receiving of user data packets and controlling the flow.

4) **Multiradio Controller:** scheduling the requests on spectrum resources issued by concurrently executing radio applications in order to detect in advance the interoperability problems between them.

5) **Resource Manager:** management of radio computer resources in order to share them among simultaneously active radio applications, while guaranteeing their real-time requirements.

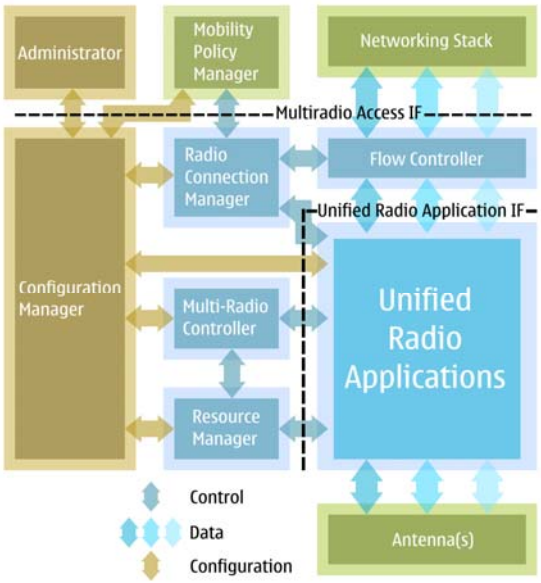

Figure 1: Functional Architecture of SDR Equipment

Furthermore, [i.1] identifies four candidate interfaces for standardization:

a) **Multiradio Interface** as the uniform interface for network protocol stacks and other user domain entities to access services of the radio computer.

b) **Unified Radio Application Interface** at the boundary between the common radio computer platform and the specific radio applications.

c) **Radio Programming Interface** including software development-time concepts and run-time interfaces between radio software entities and radio computer platform.

d) **Interface to the Reconfigurable RF Transceiver** to support multiple radio applications, even concurrently.

Among these interfaces, the **Multiradio Interface** has most potential for standardization. It is expected to enable an easier integration of radio platforms into handsets that benefits both chipset vendors and device manufacturers; moreover, it offers significant functionality on top of SDR. Common methods of accessing the SDR services ease the definition and deployment of cognitive radio, providing capability to implement the functionality independently on both sides of the interface.

The deployment of the **Multiradio Interface** is expected to proceed in phases with platform capability advancing, starting from legacy radio access technologies, gradually moving towards a full SDR:

1) Radio applications use pre-defined fixed resources. Radio applications come from a single source, and a list of concurrently supported radios is provided. Additional CR functionality is introduced by means of parameter management of individual radio applications.

2) Radio applications have fixed resource requirements. Instead of fixed resources, a worst-case resource consumption budget is attached to each radio. The SDR platform does admission check and resource allocation for concurrently running radios, enabling higher resource utilization at the cost of less determinism.

3) Radio applications have dynamic resource requirements. In addition to phase 2 capabilities, the resource demand of radios varies based on their type of activity (for instance power-save vs. active data link). Admission control and resource allocation is done whenever a radio changes its behavior classification.

4) Radio applications come from third-party vendors. This stage mostly affects the security requirements on the platform, as well as the tools to create radios.

5 Use Cases

5.1 Overview

In the sequel, the following key refined Scenarios and Use Cases are proposed for the SDR Reference Architecture for Mobile Device which was derived in [i.1]:

- Use Case "Terminal-Centric Configuration in a Heterogeneous Radio Context":
  - A detailed scenario description is given in clause 5.2.3.
- Use Case "Network driven Terminal Configuration in a Heterogeneous Radio Context":
  - A detailed scenario description is given in clause 5.3.3.
- Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices":
  - A detailed scenario description is given in clause 5.4.3.
- Use Case "Provision of a new cognitive feature (e.g. cross-technology spectrum measurement)":
  - A detailed scenario description is given in clause 5.5.3.

5.2 Use Case "Terminal-Centric Configuration in a Heterogeneous Radio Context"

5.2.1 General Use Case Description

A Mobile Device is able to detect a heterogeneous wireless framework, typically consisting of Cellular systems (such as 3GPP GSM, UMTS, LTE, etc.), Wireless LAN (based on IEEE 802.11 [i.3] a/b/g/n/ac/ad/etc.), Wireless Personal Area Networks (based on IEEE 802.15.4 [i.4]), etc. Based on its reconfiguration capabilities, the Mobile Device is camping on a single RAT or a set of multiple RATs simultaneously, depending on the context (e.g. Context Information) in order to optimize the operational conditions (e.g. optimization of power consumption).

Note that this Use Case addresses only RAT selection between distinct systems which are not designed in an integrated framework. In particular, various cellular systems such as GSM, UMTS, HSxPA, LTE, LTE-Advanced, etc. are designed within an integrated framework with centralized resource management in the network. This use case does not suggest to move corresponding resource management functions into the terminal.

5.2.2 Stakeholders

End users: mobile devices accessing internet and other similar mobile data services.

A single or multiple Network operators: operate(s) and maintain(s) the required infrastructure; may operate other networks in other frequency bands. May provide Context Information to Mobile Device for supporting the Mobile Device centric selection of RATs.

External entities: e.g. 3rd party context provider, may operate for example a 3rd party Cognitive Pilot Channel.

5.2.3 Scenario Case Description

As illustrated below, the considered Mobile device selects the RAT (or multiple simultaneous RATs) to connect to according to the context in order to optimize the operational conditions. Note that RAT selection in the Mobile Device is limited to the selection of systems that are not designed in an integrated framework. I.e., the selection of the most **suitable cellular BS and cell type (Macro-Cell, Pico-Cell, etc.) is handled as defined by 3GPP (typically by network** centric resource management).

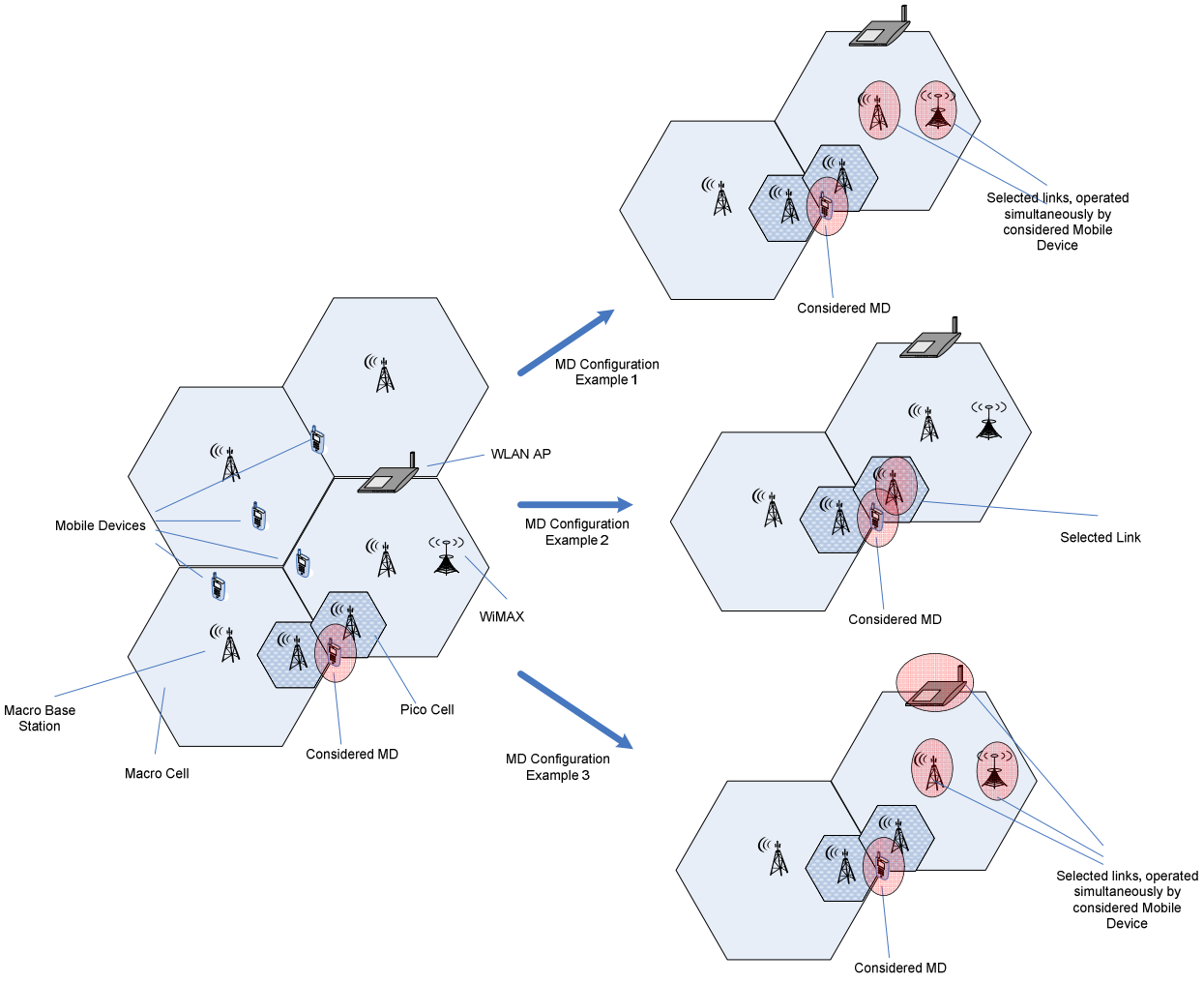

Figure 2: Scenario Illustration for Use Case "Terminal-Centric Configuration in a Heterogeneous Radio Context"

5.2.4 Information Flow

The inherent data-flow concerns mainly the following:

- Context Information related data flow.
- Configuration Selection related data flow.

The Context Information related data flow is required in order to enable the Mobile Devices to obtain knowledge about the existing wireless radio framework. The concerned Context Information needs to enable the Mobile device to select among systems which are not designed in an integrated framework, i.e. internal operational parameters of a cellular system are not required. A multitude of possibilities exists in order to achieve this task, including:

- Context Information acquisition by a Cognitive Pilot Channel - the Mobile Device receive a Cognitive Pilot Channel giving indications on the available wireless framework. Depending on the operator of the Cognitive Pilot Channel (Network Operator, 3rd party Cognitive Pilot Channel provider, etc.) and subscription type.
- Context Information acquisition by inter-Mobile-Device communication - Mobile Devices directly exchange distributed spectrum measurement results; etc.

Configuration Selection related data flow:

- The Mobile Device performs a selection of the most suitable RAT(s). A subsequent data-flow is required in order to initiate the link establishment and negotiation and the start of the data exchange.

The corresponding information flow is illustrated in the Figure 3.

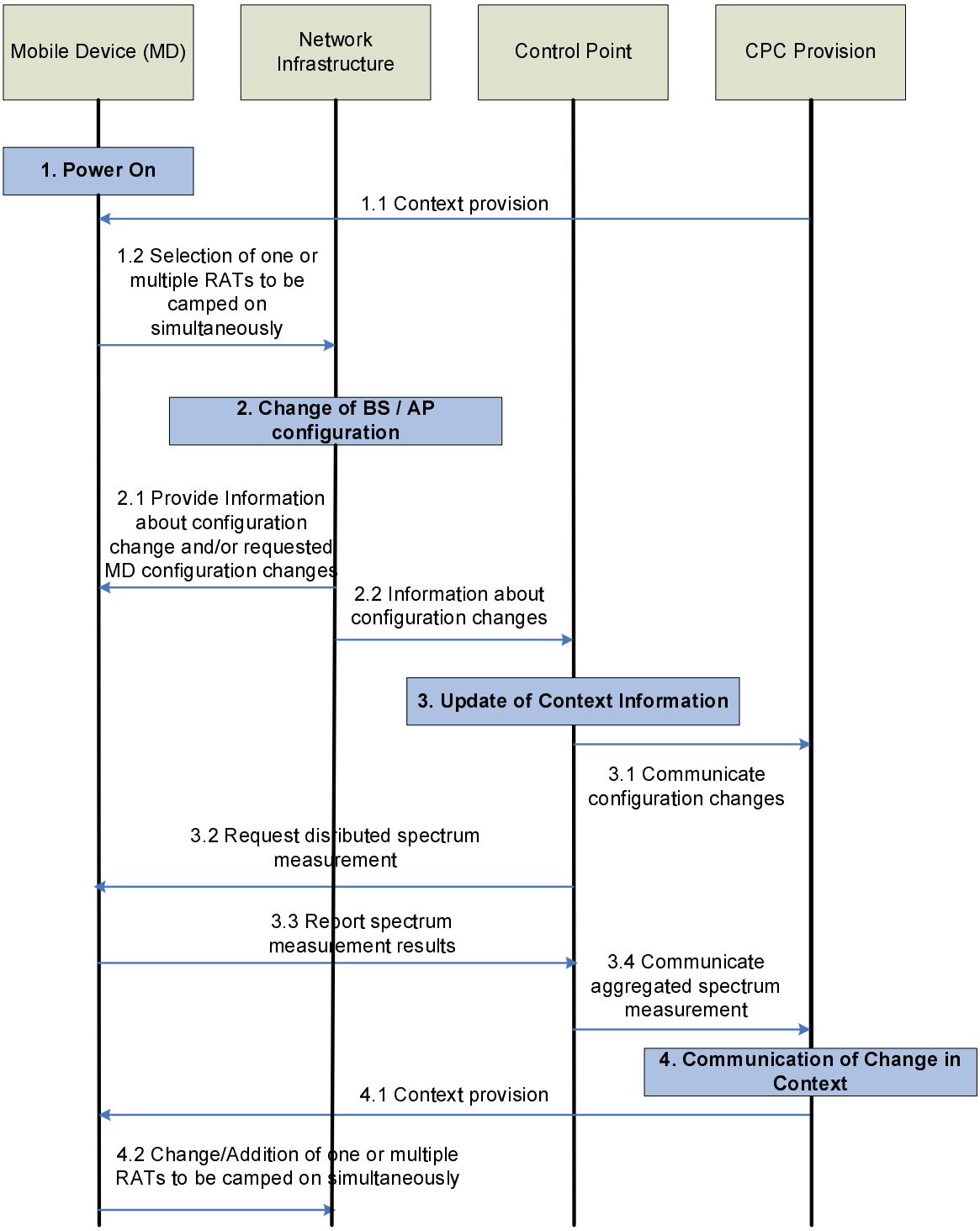

Figure 3: Information Flow Illustration for Use Case "Terminal-Centric Configuration in a Heterogeneous Radio Context"

Note that in Figure 3, it is suggested to separate the operation of context knowledge gathering (Control Point, including functionalities such as information requesting, gathering, merging and distributing) and the actual distribution of the aggregated knowledge (CPC provision). Optionally, those two functions can be merged into a single entity. In addition, Control Point and CPC provision functionalities can be managed by the Network Operator or an external entity. The description reported above has to be intended as general as possible without any reference to who is managing such functionalities.

With the term distributed spectrum measurement is intended to request to different mobile to perform measurements on different part of the spectrum each. The aggregated result is then communicated to the interested entities.

5.2.5 Potential system requirements

System requirements, on both the Network and Mobile Device side, are indicated below for:

i) the initialization phase of the Mobile Device; and

ii) the ongoing operational phase of the Mobile device.

Table 1: Potential System Requirements for Use Case "Terminal-Centric Configuration in a Heterogeneous Radio Context"

	Functions in the Mobile Device	Functions in the Network
Initialization Phase (switch-on) of Mobile Device	Detection of available systems in the heterogeneous radio framework; Reception of Context Information using at least one of the available systems. Selection of suitable RAT(s) to camp on possibly simultaneously (for systems which are not designed in an integrated framework).	Provision of Context Information supporting Mobile Device centric RAT selection for systems which are not designed in an integrated framework.
Ongoing Operational Phase of Mobile Device	Change, Addition or Removal of a RAT to camp on, depending on the operating conditions (e.g. power consumption optimization) for systems which are not designed in an integrated framework. Change, Addition or Removal of a RAT to camp on, depending on the context (e.g. mobility of the User,) for systems which are not designed in an integrated framework. Determination of heterogeneous radio framework through distributed spectrum measurement and CPC. Obtained information can be sent to the network or other Mobile Devices.	Provision of updated Context Information if change occurs.

5.3 Use Case "Network driven Terminal Configuration in a Heterogeneous Radio Context"

5.3.1 General Use Case Description

A Mobile Device is operated in a heterogeneous wireless framework, typically consisting of Cellular systems (such as 3GPP GSM, UMTS, LTE, etc.), Wireless LAN (based on IEEE 802.11 [i.3] a/b/g/n/ac/ad/etc.), Wireless Personal Area Networks (based on IEEE 802.15.4 [i.4]), etc. The Network is assumed to have knowledge of the heterogeneous radio context and of the configuration capabilities of the Mobile Device. The Network decides the single link or a set of multiple, simultaneously operated links to be maintained by the Mobile Device. Finally, the Mobile Device is configured correspondingly.

5.3.2 Stakeholders

End users: Mobile Devices accessing internet and other similar mobile data services.

A single or multiple Network operators: operate(s) and maintain(s) the required infrastructure; may operate other networks in other frequency bands. Decides which configuration needs to be selected in the Mobile Devices.

5.3.3 Scenario Case Description

As illustrated in Figure 4, the considered Mobile device selects the link configuration which leads to the optimum operational conditions as outlined above.

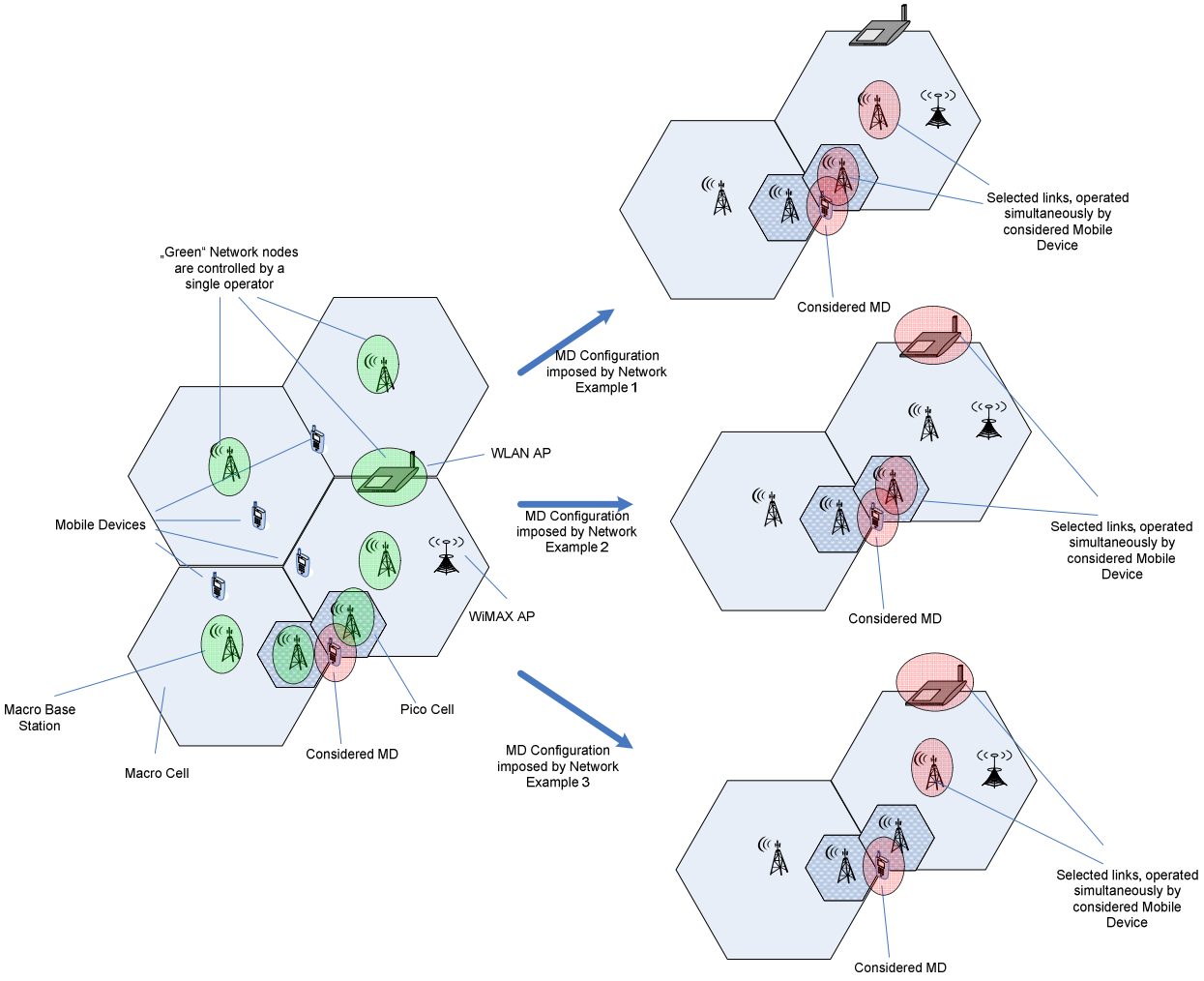

Figure 4: Scenario Illustration for Use Case "Network driven Terminal Configuration in a Heterogeneous Radio Context"

5.3.4 Information Flow

The inherent data-flow concerns mainly the following:

- Context Information related data flow.
- Configuration Selection related data flow.

The Context Information related data flow is required in order to enable the Network to complement its knowledge about the existing wireless radio framework. Typically, spectrum measurements tasks are giving to the various Mobile Devices and they report the corresponding results to the Network.

Configuration Selection related data flow: Once the network has decided on the configuration to be chosen by a given Mobile Device, the corresponding selection decisions are communicated to the concerned device.

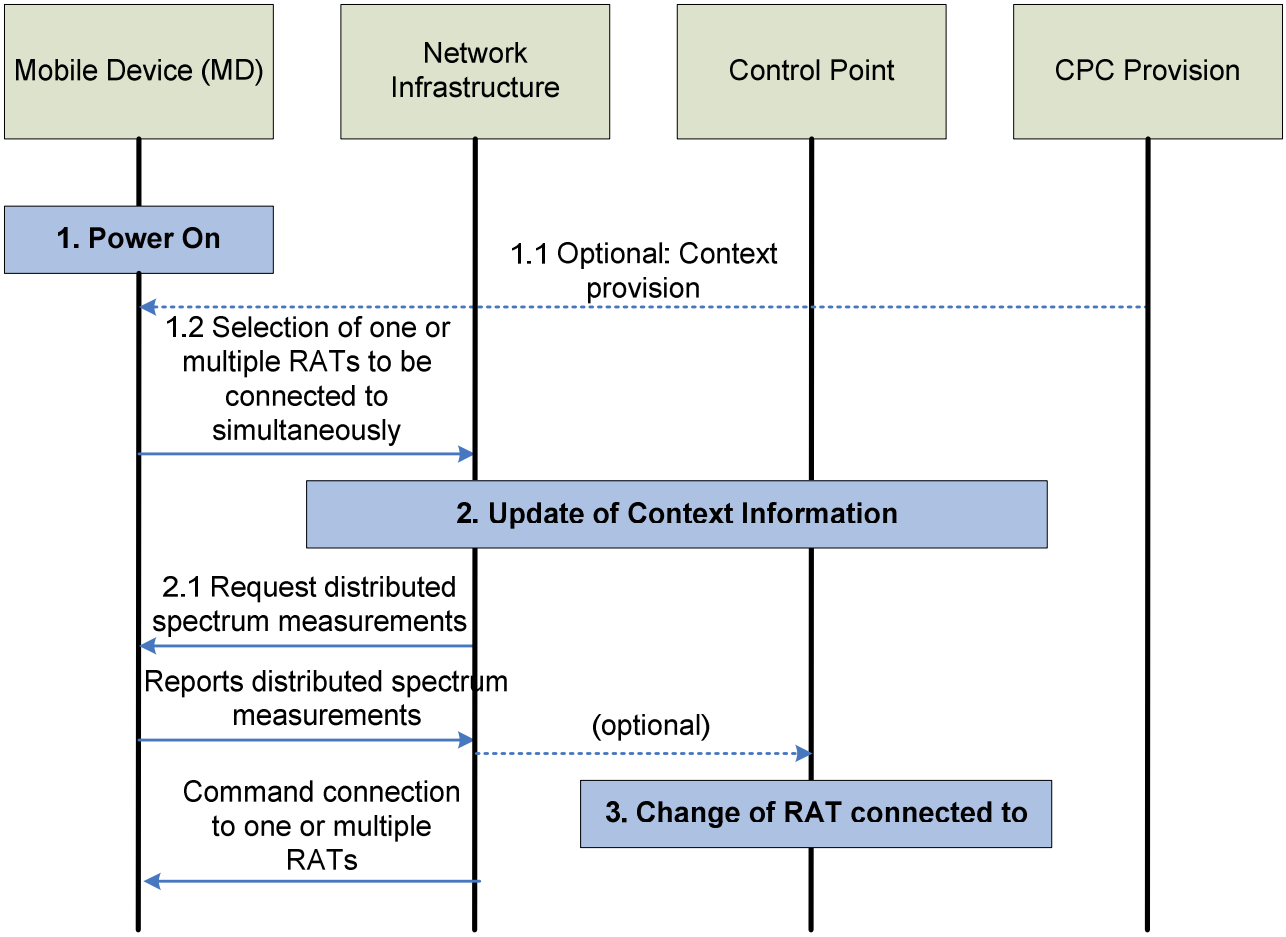

Figure 5: Information Flow Illustration for Use Case "Network driven Terminal Configuration in a Heterogeneous Radio Context"

Note that Figure 5 includes the CPC Provision and Control Point entities only optionally. If desired, those can be omitted.

5.3.5 Potential system requirements

System requirements, on both the Network and Mobile Device side, are indicated below for:

i) the initialization phase of the Mobile Device; and

ii) the ongoing operational phase of the Mobile device.

Table 2: Potential System Requirements for Use Case "Network driven Terminal Configuration in a Heterogeneous Radio Context"

	Functions in the Mobile Device	Functions in the Network
Initialization Phase (switch-on) of Mobile Device	Detection of context information in the heterogeneous radio framework and provision of information to the Network. Operation of suitable links, possibly simultaneously following the decisions in the Network.	Selection of suitable links for a given Mobile Device, possibly simultaneously operated links. Communication of the decision to the concerned Mobile Device.
Ongoing Operational Phase of Mobile Device	Change, Addition or Removal of a radio link depending on Network Decisions. Determination of heterogeneous radio framework through spectrum measurements and provision of the related results to the network.	If required, updated selection of suitable links for a given Mobile Device, possibly simultaneously operated links. Communication of the decision to the concerned Mobile Device.

5.4 Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices"

5.4.1 General Use Case Description

A Mobile Device is operated in a heterogeneous wireless framework, typically consisting of Cellular systems (such as 3GPP GSM, UMTS, LTE, etc.), Wireless LAN (based on IEEE 802.11 [i.3] a/b/g/n/ac/ad/etc.), Wireless Personal Area Networks (based on IEEE 802.15.4 [i.4]), etc. Novel systems are constantly under definition and deployment. For example, in the framework of IMT-Advanced, new systems will be introduced with promising candidates being, among others, 3GPP LTE-Advanced, WiMAX Next Generation (based on IEEE 802.16m [i.5]), WiFi evolution towards 1 Gbps with operation below 6 GHz (IEEE 802.11 [i.3] ac) and at 60 GHz (IEEE 802.l1 [i.3] ad), etc. It is possible that a Mobile Device is introduced to the market and the corresponding owner wishes to add new features, in particular the support for new standards, to the device. The addressed post-sale provision of new features is expected to be considered for Declaration of Conformity (DoC) and CE Marking issues and/or other regulatory items.

5.4.2 Stakeholders

End users: mobile devices accessing internet and other similar mobile data services.

A single or multiple Network operators: operate(s) and maintain(s) the required infrastructure; may operate other networks in other frequency bands.

External entities: e.g. the manufacturer of the Mobile Device is contacted by the End user for the installation of new features.

5.4.3 Scenario Case Description

As illustrated in Figure 6, the considered Mobile device detects the presence of a radio standard which it is unable to operate. The Mobile Device contacts the manufacturer of the Device and requests an update of Software in order to enable the device to operate the new standard.

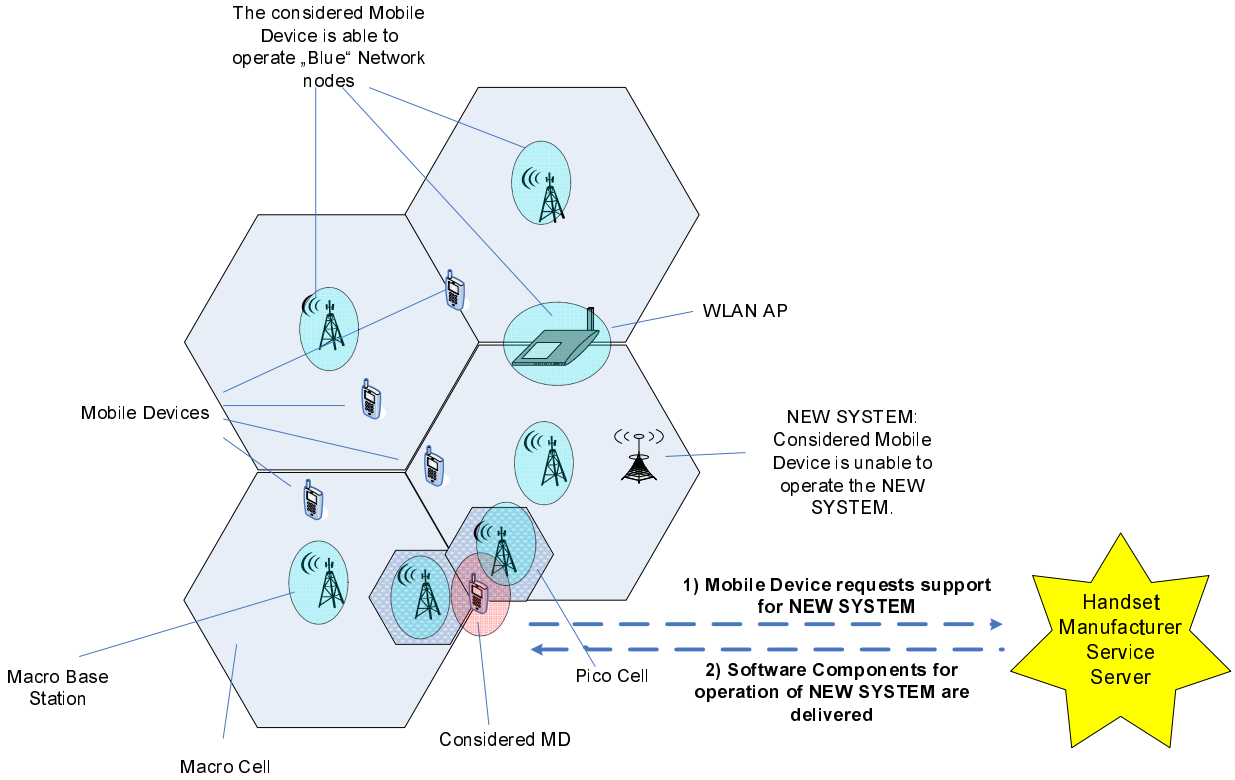

Figure 6: Scenario Illustration for Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices"

5.4.4 Information Flow

The inherent data-flow concerns mainly the following:

- Mobile Device requesting support for a new standard.
- Delivery of Software Components to Mobile Device, enabling support of the new standard.

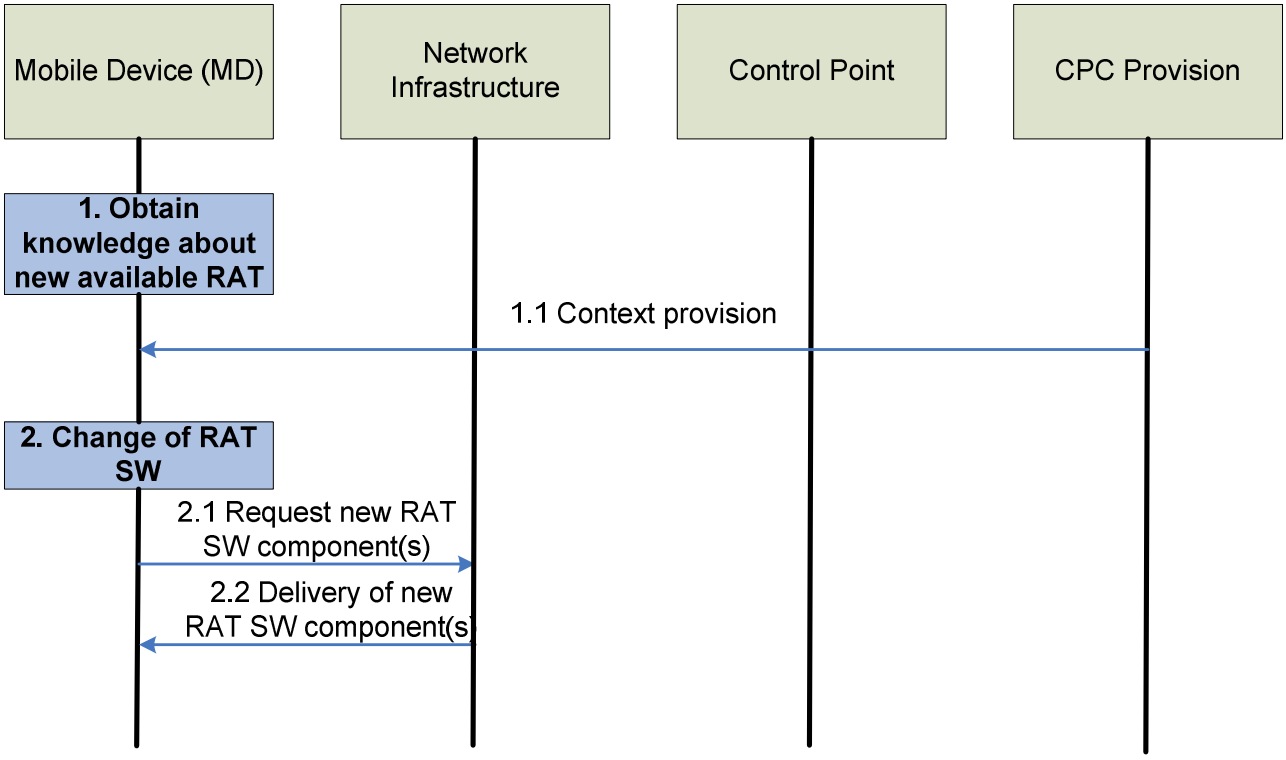

Figure 7: Information Flow Illustration for Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices"

In general, the request of a new RAT software component(s) can be triggered by the Network Operator as well as the mobile device or based on user preferences.

5.4.5 Potential system requirements

System requirements, on both the Network and Mobile Device side, are indicated below for:

i) the initialization phase of the Mobile Device; and

ii) ongoing operational phase of the Mobile device.

Table 3: Potential System Requirements for Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices"

	Functions in the Mobile Device	Functions in the Network
Initialization Phase (switch-on) of Mobile Device	Capability of installing Software Components for support of novel standards.	Delivery of Software Components for support of novel standards.
Ongoing Operational Phase of Mobile Device	Capability of installing Software Components for support of novel standards.	Delivery of Software Components for support of novel standards.

5.5 Use Case "Provision of a new cognitive feature (e.g. cross-technology spectrum measurement)"

5.5.1 General Use Case Description

A Mobile Device is operated in a heterogeneous wireless framework, typically consisting of Cellular systems (such as 3GPP GSM, UMTS, LTE, etc.), Wireless LAN (based on IEEE 802.11 [i.3] a/b/g/n/ac/ad/etc.), Wireless Personal Area Networks (based on IEEE 802.15.4 [i.4]), etc. Novel systems are constantly under definition and deployment. In order to acquire knowledge about the radio context, Mobile Devices need to adapt their spectrum measurements correspondingly. In contrast to the upper Use Case "Addition of new features, such as support for novel radio systems, to Mobile Devices", the only the provision of new post-sale features is considered which are not expected to lead to issues for Declaration of Conformity (DoC) and CE Marking and/or other regulatory items.

5.5.2 Stakeholders

End users: mobile devices accessing internet and other similar mobile data services.

A single or multiple Network operators: operate(s) and maintain(s) the required infrastructure; may operate other networks in other frequency bands.

External entities: e.g. a potential provider of context information which requests spectrum measurements information from Mobile Devices.

5.5.3 Scenario Case Description

As illustrated in Figure 8, the considered Mobile device is requested to provide spectrum measurement information related to the presence and parameterization of a radio standard which it is unable to operate. The Mobile Device contacts the manufacturer of the Device and requests an update of Software in order to enable the device to operate the required spectrum measurement mechanisms.

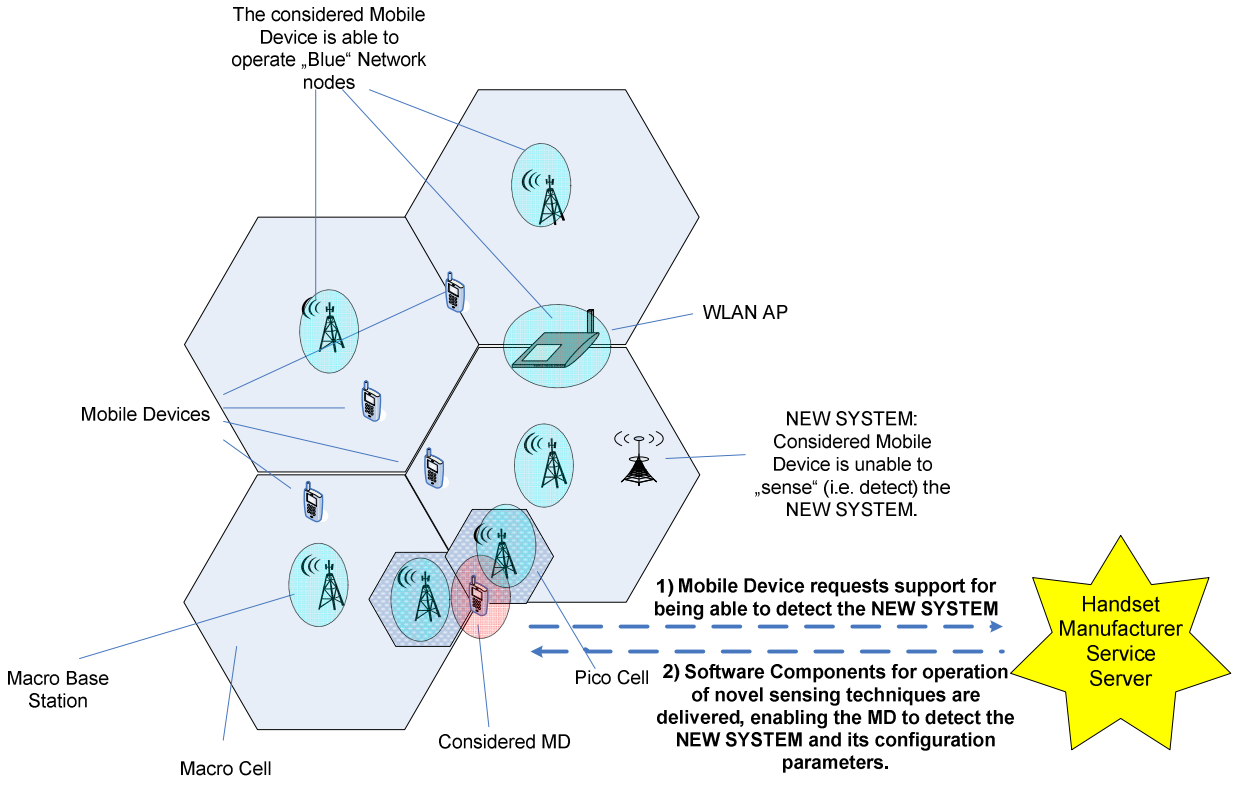

Figure 8: Scenario Illustration for Use Case "Provision of a new cognitive feature (e.g. cross-technology spectrum measurement)"

5.5.4 Information Flow

The inherent data-flow concerns mainly the following:

- A Network Operator or other entity (the MD itself, a third party context information provider, etc.) requests spectrum measurement information from a MD.
- Mobile Device requesting support for being able to provide spectrum measurement information related to a new standard.
- Delivery of Software Components to Mobile Device, enabling spectrum measurement support of the new standard.

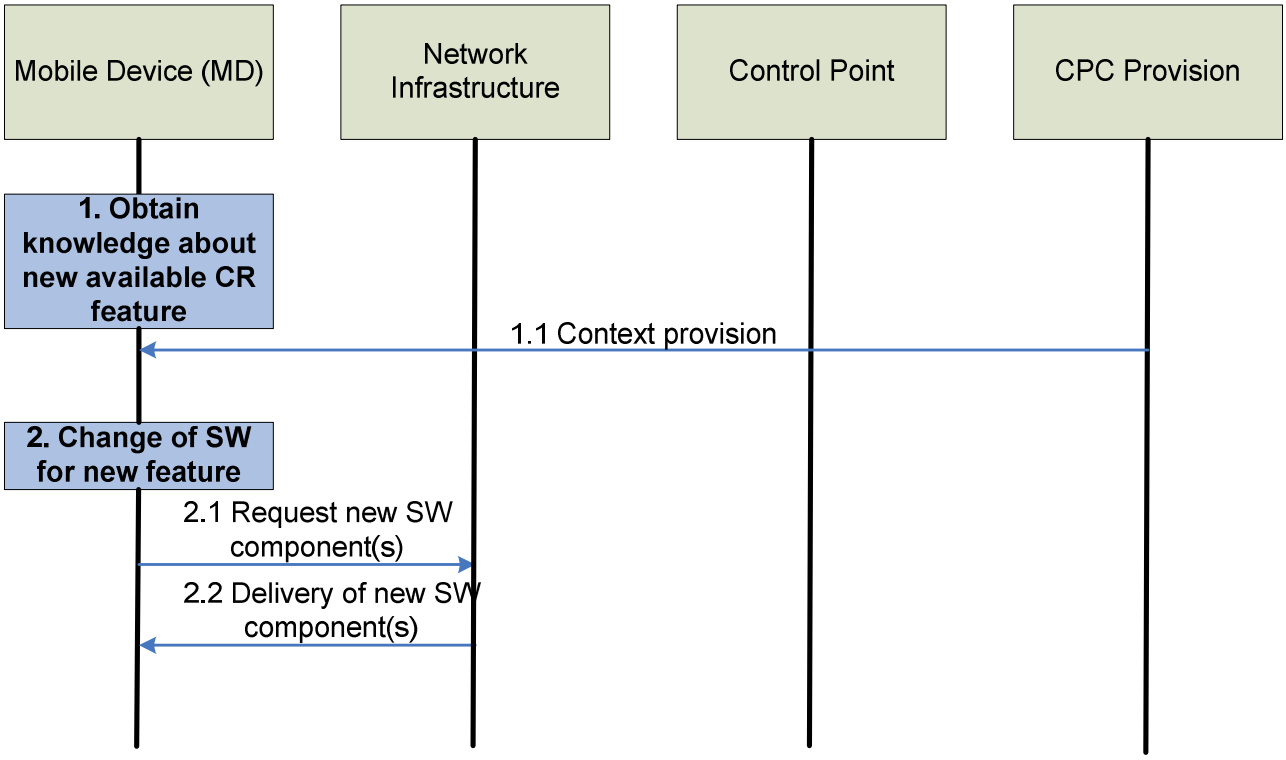

Figure 9: Information Flow Illustration for Use Case "Provision of a new cognitive feature (e.g. cross-technology spectrum measurement)"

In general, the request of a new software component(s) can be triggered by the Network Operator as well as the mobile device.

5.5.5 Potential system requirements

System requirements, on both the Network and Mobile Device side, are indicated below for:

i) the initialization phase of the Mobile Device; and

ii) ongoing operational phase of the Mobile device.

Table 4: Potential System Requirements for Use Case "Provision of a new cognitive feature (e.g. cross-technology spectrum measurement)"

	Functions in the Mobile Device	Functions in the Network
Initialization Phase (switch-on) of Mobile Device	Capability of installing Software Components for support of novel standards.	Delivery of Software Components for support of novel standards.
Ongoing Operational Phase of Mobile Device	Capability of installing Software Components for support of novel standards.	Delivery of Software Components for support of novel spectrum measurement mechanisms.

Annex A (informative): Bibliography

- ETSI TR 102 802: "Reconfigurable Radio Systems (RRS); Cognitive Radio System Concept".

History

Document history		
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