Architecture Proposal for the WINNER Radio Access Network and Protocol[1]

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1. Abstract

This paper presents a proposal contributed to the architecture discussion in Work Package 3 of the FP6 IST Project "WINNER" (Wireless World Initiative New Radio). A proposal for a generic description of the Radio Access Network architecture is made. In the second part of the paper, a possible protocol architecture supporting the convergence of the different modes of operation of the WINNER Radio Interface is presented, including the proposal of a Layer-Specific Modes Convergence Protocol, which aims at facilitating seamless cooperation of the different air interface modes.

2. Introduction

The key objective of the WINNER project is to develop a totally new concept in radio access. This is built on the recognition that developing disparate systems for different purposes (cellular, WLAN, short-range access etc.) will no longer be sufficient in the future converged Wireless World. This concept will be realised in the *ubiquitous radio system concept*.
The vision of a ubiquitous radio system concept is one of providing wireless access for a wide range of services and applications across all environments, from short-range to wide-area, with one single adaptive system concept for all envisaged radio environments. It will efficiently adapt to multiple scenarios by using different modes of a common technology basis.
The concept will comprise the optimised combination of the best component technologies, based on an analysis of the most promising technologies and concepts available or proposed within the research community. The initial development of technologies and their combination in the system concept will be further advanced with respect to the project goals towards future system realisation.
To support this system concept, an architecture embracing all those "best component technologies" has to be identified and a suitable protocol architecture has to be defined. A number of proposals for this architectures have been contributed to WINNER Work Package (WP) 3 and remain to be harmonized in the WP internal discussion. This paper presents one of the proposals.

3. The Scenario

- Hot Area scenario:
  Patchy coverage from a wireless mobile broadband system in densely populated areas, e.g. city centers, exhibition halls or airports [1][2].
- For the scenario we assume that the majority users will have low mobility (0-5km/h)
- The traffic types will be "very high multi-media" as well as a lot of email background traffic.
- Short range coverage of public scenarios with wide area networks

4. The Architecture

Figure 1 shows the candidate WINNER architecture proposed by this paper. The following architecture elements have been identified:

- **WINNER Connection Service (CS_W):** The CS_W is the sum of network elements that are required to allow interworking between different Access Elements (AE), e.g. for inter-AE handover. Thereby the AE can also be of different WINNER RI modes. The CS_W is also the interface to the backbone network, most likely the internet.

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Optional (not in the scope of WINNER WP3): The CS_W might also enable the direct interworking with other (non WINNER) AEs (see Figure 2)

- **WINNER Access Element for Mode X (AE_{WX}):** The AE_{WX} as shown as enlargement in Figure 1 comprises always one AP and can be extended by one or several Relay Stations that can be either fixed (FRS) or mobile/movable (MRS). The AE_{WX} is assumed to be WINNER mode X specific. The AP-UT connection can involve several RS.
- **Access Point AP:** The AP is a network element that manages a whole cell. A network node terminating the physical layer, (parts of) the link layer, and possibly also parts of the network layer of the radio interface technology from the network side. Moreover, the AP is the node closest to the core (backbone) network that a UT may be (directly) connected to.
- **Fixed Relay Station FRS:** A fixed relays station (FRS) is a fixed network node with relaying capabilities that is wirelessly connected to an AP, another RS and/or a UT
- **User terminal UT:** A (group of) network element(s) comprising all functionality necessary for an end user to communicate with either another terminal or a network typically but not necessarily mobile. The UT shall be able to communicate with all WINNER RI modes, although some WINNER mode specific might exist.
- *Optional MRS*: The mobile or movable relay station (MRS) is optional in the approach and might be an optional function of the UT. In this case the MRS would also be part of the AE.

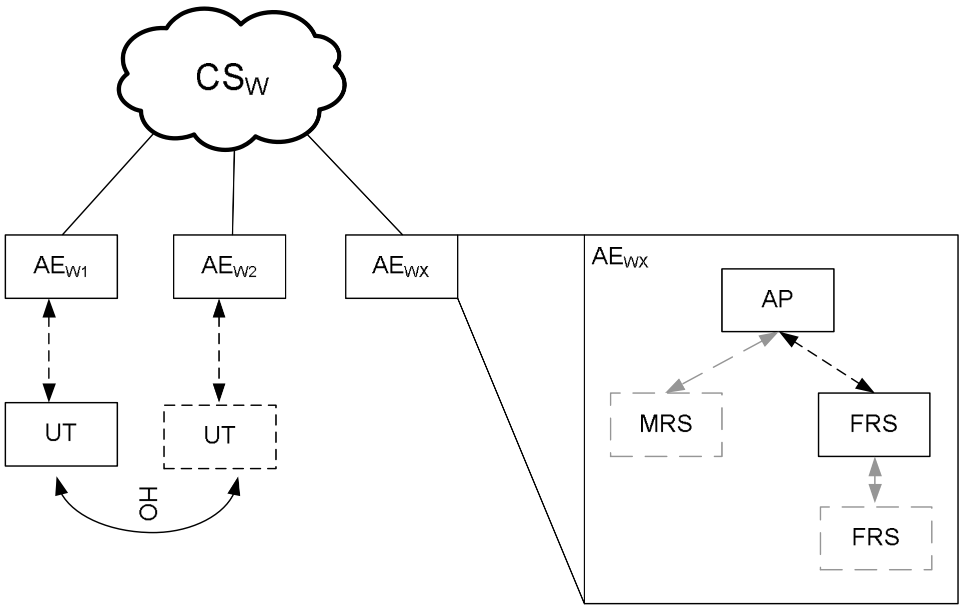

Figure 1: Proposed WINNER Access Network Architecture including relays

4.1 Interworking with WINNER external Access Networks

Figure 2 shows two variants how external AEs can be connected to the WINNER CS. In addition to the WINNER RAT based AEs two other AE, e.g. IEEE 802.11 and UMTS are shown, each connected to a RAT specific CS, CS_1 and CS_2. The two RAT specific CS are interworking by CS_{12} that is providing CS functionalities common for CS_1 and CS_2

The interworking of the new WINNER access network will be performed by the WINNER Connection Service element CS_W.

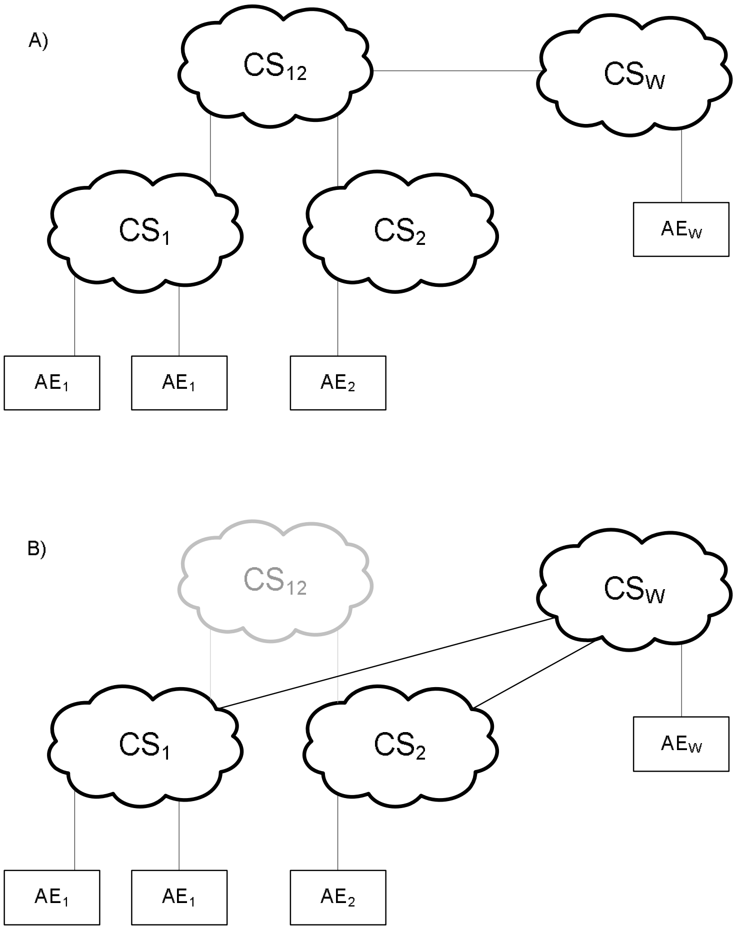

Figure 2: Interworking WINNER with external Access Elements

5. Functionalities

We subdivide the envisaged functionalities into Radio Resource Management (RRM) and Radio Resource Control (RRC).

5.1.1 Radio Resource Management

The RRM comprises all functionalities regarding the management of the pool of radio resources, e.g.

- the (dynamic) assignment of the resources (spectrum allocation)
- connection admission control
- congestion control
- Mobility Management

The RRM functions are located in the AE and fixed part of the access network, which is in charge of the full WINNER Radio Interface (RI). The AE will have to manage the resources within one AE while the fixed part of the access network will do the RRM for the full WINNER spectrum including different AE of the same mode as well as AEs of different modes.
The issue Coordination across APs and FRSs (T3.2#5) might be a function of the fixed part of the access network, if it is centrally controlled or it will be implemented within the elements of the AE in case of a de-central solution.

5.1.2 Radio Resource Control

The RRC comprises all procedures directly related to radio resources once they are assigned, like

- link adaptation
- power control
- measurement support
- congestion control
- support for HO (e.g. measurements, trigger)

RRC functionalities will be implemented in the

5.1.3 Handover (HO):

For the proposed relay based system different kinds of HO can be applied as listed below

- **Intra AE HO**: The intra AE HO will be performed within the AE between the AP and one of the Relays Stations (RS) or between two RSs.
- **Inter AE intra Mode HO** between two AEs of one WINNER mode, most likely between two RS of two AEs
- **Inter AE inter Mode HO** between two AEs of different modes (out of scope of T3.2)

This implies that the HO control is a hierarchically distributed functionality; the number and type of involved nodes depend on the scope of the HO.

6. Possible protocol architecture

6.1 Scope

To support the seamless interworking between different RATs, it is necessary to transfer the status of existing connections between the modes (see Figure 3). The potential applications for this are multi-mode terminals or multi-mode base stations performing inter mode handover.
This requires a partitioning of the functions inside the involved layers into mode-specific and mode-independent functions, as proposed in the GLL concept [5].
However, as already suggested by [3][4], not only the Link Layer Protocols will have to be partitioned in this fashion. The same holds for the whole set of RI-related protocols, such as:

- Mobility Management (MM)
- Radio Resource Management (RRM)
- Radio Resource Control (RRC)
- Error Control (EC)
- Logical Link Control (LLC)
- Medium Access Control (MAC)

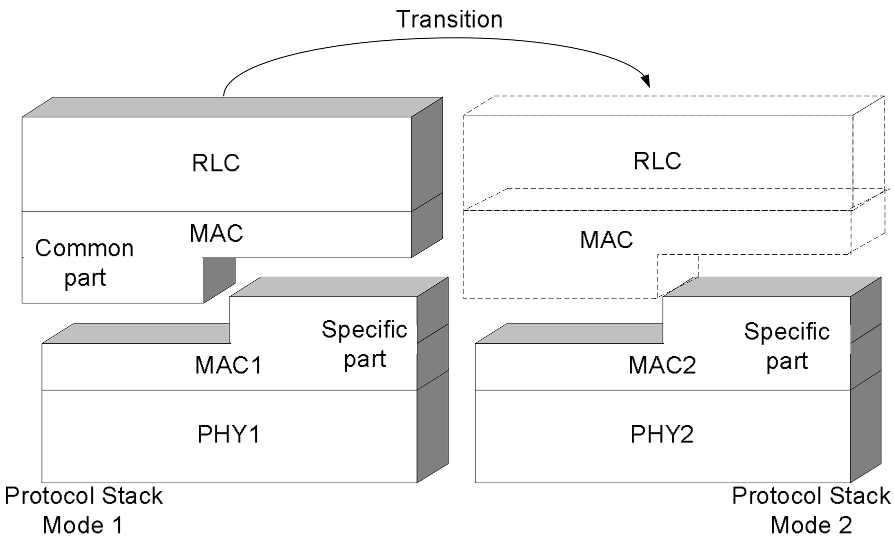

Figure 3: Context transfer (e.g. on the MAC Layer) between different WINNER modes

6.2 Cross-Plane Optimisation

When re-using User-Plane Information and Protocol Data (e.g. the Status of the "Error Control" Protocols) after switching to another RAT, these functions have to be "misused" by the Control-Plane to support a purpose that is the task of higher layers (example: EC as a Layer 2 function provides information to support the Handover, which is a Layer 3 function).

Organising this process efficiently requires a cross-plane (perhaps cross-layer) optimisation, which means that either

- a re-arrangement of functionalities

and

- access to User Plane status data by the control plane

has to be done by means of Control-Plane functions common to the different modes (see Figure 4). Effectively, these common functions would have to rely on a well-defined interface towards the mode-specific functions in their layer.

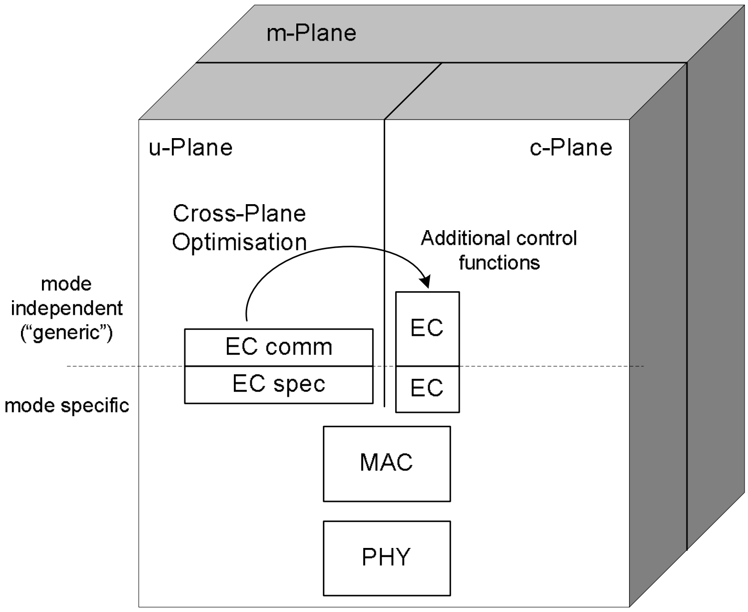

Figure 4: Cross-Plane Optimisation and functional partitioning

6.3 Cross-Stack Mgmt. with the Modes Convergence Protocol (MCP)

Under the assumption that the protocol layers are structured and partitioned in the way described in the last section, they would allow to easily switch between different modes.
The transition between the two modes can be visualized as a "virtual extension" of the Management Plane, to achieve a cross-stack management, as shown in Figure 5.

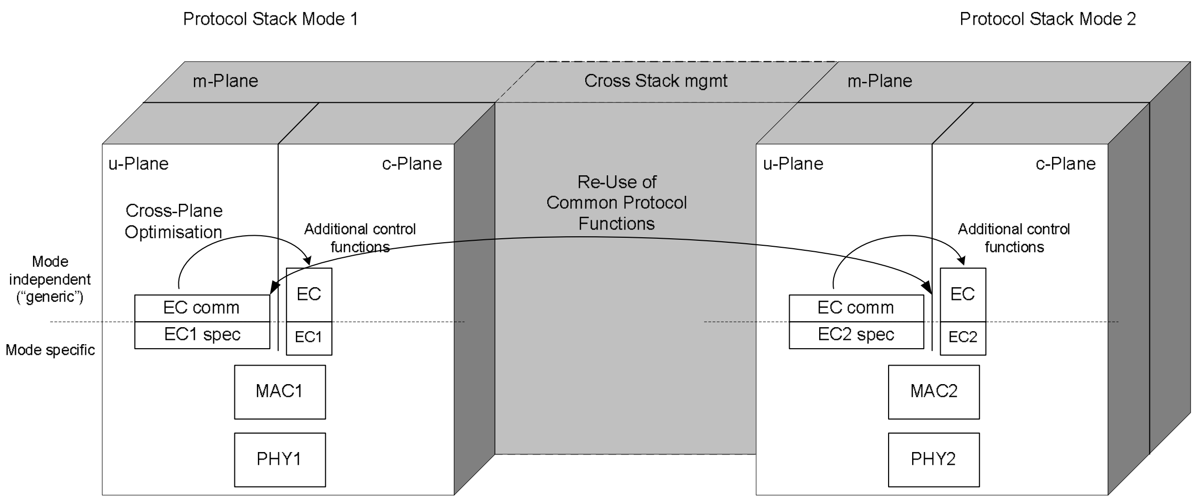

Figure 5: Cross-Stack Management

This extension is achieved by a Layer-Specific Modes Convergence Protocol (LSMCP), which exists for each Layer. The Protocols for the Layers stated in the first section would then be:

- EC-MCP
- LLC-MCP
- RRM-MCP
- RRC-MCP
- MM-MCP
- MAC-MCP
- etc.

Figure 6 shows as an example how the common functions of the EC (part of LLC) protocol achieve horizontal convergence between the specific functions in mode 1 and 2 by means of the LLC-Modes Convergence Protocol (LLC-MCP).
The information flow is as follows:

1. Protocol Status Data is collected by Control-Plane functions common to all modes
2. The Transfer of Protocol Status Information is performed by the LLC-MCP
3. The status information can be re-used in the new mode.

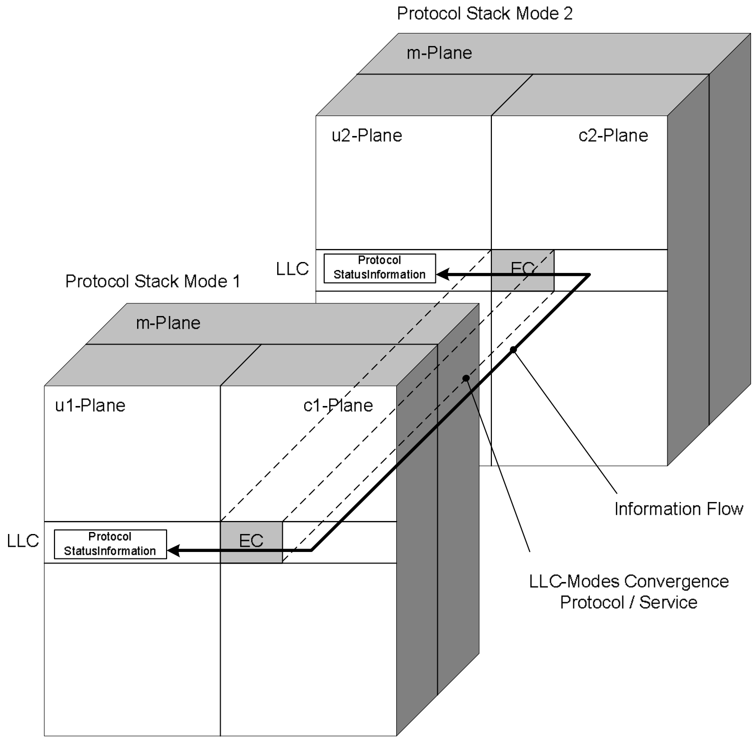

Figure 6: The LLC-Modes Convergence Service and Protocol

6.4 GLL in the context of MCP

The view that is usually taken in standardisation is that "generic" functions are not fully specified and can be enriched by specifying the remaining parts in more detail.
Contrary to that, the GLL (cf. [5]) results from the identification of a common set of Link Layer-functions of different modes, which are then marked with a "G".
As stated before, this identification of common functions also has to be performed in other layers. The Layer-specific Modes Convergence Protocols for these Layers have to rely on the "G"-functions of these layers, i.e. the identified set of common (mode independent) functions.
This makes the GLL an essential prerequisite to implement an LLC-MCP.

7. Conclusions

This paper presents one of the contributions to the WINNER WP3 task of defining the system and protocol architecture for the WINNER RI. We propose an abstract RI architecture and its logical nodes that are capable of reflecting the various scenario-specific modes of the envisaged WINNER RI, paying special attention to relay-based deployment concepts.

In addition to the system architecture, a candidate protocol architecture is discussed that allows seamless interworking between different modes of the WINNER RI. To achieve this goal, a cross-plane optimisation is proposed. It adds a new dimension to the functional partitioning of the different protocol layers into common and specific functions, because it adds and re-arranges functionality across the user/control-plane border.

As a result, so-called cross-stack management becomes possible, a "virtual extension" of the management plane across the protocol stacks of different modes of operation.

For the cross-stack management, a set of Layer-specific Modes Convergence Protocols (MCPs) are proposed for the first time. These MCPs support horizontal convergence of different protocol variants within one protocol layer. The presented proposal will be subject to further study and discussion inside WINNER WP3 to reach a harmonized WINNER approach.

8. References

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9. Acronyms

AN	Access Network
AP	Access Point
CN	Core Network
FI	Fixed Interface
FRS	Fixed Relay Station
GLL	Generic Link Layer
LLC	Logical Link Control
MAC	Medium Access Control
MCP	Modes Convergence Protocol
PHY	Physical Layer
RI	Radio Interface
RRC	Radio Resource Control
RRM	Radio Resource Management
UT	User Terminal
WINNER	Wireless World Initiative New Radio
WP	Work Package