Ambient Networks – A Framework for Multi-Access Control in Heterogeneous Networks

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Abstract— In the Ambient Networks project research is ongoing in order to define a new control space for future internetworking. This internetworking will be characterized by a high degree of network heterogeneity as well as nomadicity and mobility of both users as well as networks. The so called Ambient Control Space (ACS), provides functionality to support how to manage these traits of future internetworking. This paper provides a short presentation on the architecture of Ambient Networks and the ACS, and then focus on how connectivity is handled from a multi-access and mobility perspective through the support of the ACS.

***Index Terms*— Ambient, Future Networking, Multi-access, Network Control**

I. Introduction

Ambient Networks is a large-scale collaborative project within the European Union 6th Framework Program that investigates future communication systems beyond today's fixed and 3rd generation mobile networks. It is part of the Wireless World Initiative [3]. The project aims at the establishment of a new networking technology called *Ambient Networking*, to ease cooperation between future heterogeneous mobile and wireless networks, as to facilitate simple to use services & applications for the end user, regardless of the networks in use.

II. Motivation and Background to Ambient Networking

This chapter will introduce important drivers and the key concepts of ambient networking, such as composition.

III. Architecture Overview

The Ambient Network architecture builds on three constituents. The Ambient Control Space Framework, the Control Space Functional Elements and the three AN reference points interfacing towards ACS external functions inside the same Ambient Network and towards ACS functions in other Ambient Networks (see Figure 1). These three elements represent the scope of the Ambient Networks project.

The Ambient Network control space consists of a number of Functional Entities that cooperate to implement the overall control functionality. The Functional Entities embed into the Control Space Framework, which ensures the basic operation by providing elementary functionality such as the connectivity between the individual Functional Entities.

The Ambient Service Interface (ASI) implements the communication towards services and applications, Communication between the control space and the basic connectivity is combined into the Ambient Resource Interface (ARI). Finally, the Ambient Network Interface (ANI) is used for the communication of Functional Entities across network boundaries.

A. Ambient Control Space Architecture

The key features of the ACS architecture are its distributed nature and modularity. Although a small number of control functions must be present in any ACS to make a network "ambient" (i.e. establish a "minimum ACS"), additional control functions can be added to or removed from the control space during regular operation of the network.

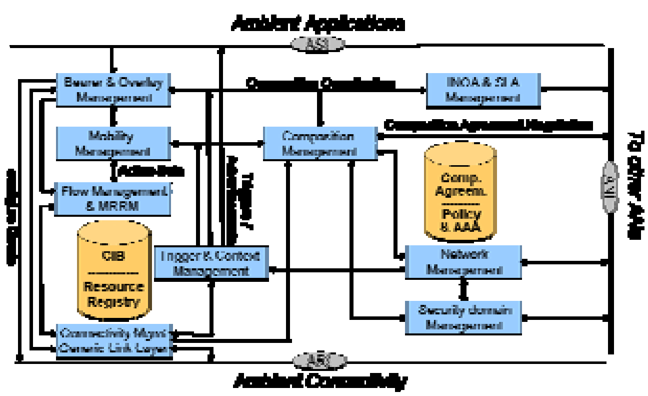

Figure 1: Illustration of the high-level ACS structure.

The control space structure depicted in Figure 1 exhibits two parts representing the two main areas of functionality the ACS provides. The "right" part deals with network and security domain management, policies and composition. The "left" part sets up, maintains and moves user plane connectivity.

The ACS is designed to cooperate with any type of technology present in the underlying (ambient) connectivity. Thus, it operates on abstract connectivity entities provided by a *flow abstraction*. Similarly, the ACS offers *bearer abstractions* through the ASI to allow the design of applications that are independent of any underlying mobility, service quality or media delivery mechanisms.

The part of the ACS that supports and manages user plane connectivity, and which is in the focus of this paper, embraces the following Functional Entities:

- The **Bearer and Overlay Management** functions offer end-to-end bearer services to applications through the ASI.
- The **Flow (and Multi-Radio Resource) Management** functions configure and establish flows both in the wired as well as in the wireless part of the network
- The **Connectivity Management (and Generic Link Layer)** functions detect new links and initiate the establishment of connectivity between ANs utilizing them.
- The **Mobility Management** functions ensure that bearers remain independent and unaware of connectivity changes or movement events that occur in the underlying connectivity which consists of flows that are bound to locators (the current point of attachment to a network).
- The **Triggering and Context Management** functions coordinate the storage, access control, dissemination and aggregation of context information (e.g. triggers, user preferences or network status)

IV. Multi-Access and Mobility Support

The requirements for a bearer are passed to the Flow (and Multi-Radio Resource) Management. MRRM is the subclass of flow management that is responsible for handover decisions for the radio access parts [1]. For a bearer a number of different access flows can be available as depicted in Figure 2. The Connectivity Management (and Generic Link Layer) functions detect new links and initiate the establishment of connectivity between ANs utilizing them. Once new connectivity is detected, the secure attachment procedure is initiated [4]. The Generic Link Layer (GLL) is a subclass of connectivity management, which is responsible for managing access links, and monitors the access links by receiving measurements from the connectivity layer via the Ambient Resource Interface (ARI).

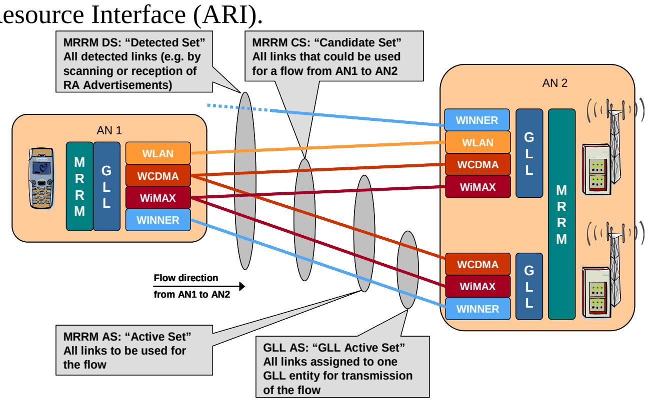

Figure 2: Ambient Networks support for Multi-Radio Access.

Measurements received via ARI include link quality, achievable data rates, cell load and transmission resource costs. GLL filters local measurements according to thresholds negotiated with MRRM and translates them into a generic and access-independent format. Whenever pre-defined events occur, these are reported to MRRM for access selection. Flow configuration and setup requests are received from flow and multi-radio resource management and the links are then configured accordingly via the ARI.

The Active Set of access links is reported from MRRM to **Mobility Management.** The bearers are bound to higher-level objects in the naming framework which have non-changing identifiers, such as application points of attachment or cryptographic node IDs. The key role of mobility management is to maintain, in both the host end system and in the network, the mapping between the current locator and the identifier, thus enabling communication to take place regardless of the current Network Point of Attachment. The Mobility Management FE bases its handover decisions on triggers, context information and policies.

Trigger management consists of functions such as: collecting and identifying events from various sources, filtering and classifying those events, calculating triggering event correlations and making the triggers available for any other function in the ACS, such as handover decision [3]. The triggering functions are likely to be distributed in the system. For example, the collection and filtering of link layer specific triggers may be located in the different GLL entities, while more filtering may be performed in MRRM.

As some triggers may be received independently of each other, different types of movements might be detected simultaneously, e.g. the mobile entity may move between access technologies and address spaces at the same time. This leads to the assumption, that the mobility events can be seen to take place in multiple orthogonal dimensions, e.g. physical location, address space, and security domain. From the received triggers it is possible to determine what should be moved, where and how. Suitable mechanisms can then be dynamically selected to execute the mobility event.

V. Conclusions (Full Paper Outlook)

In the final paper, we will present the architecture in more detail, and provide an extensive sample scenario, in which we show how GLL abstracts radio information. We further explain the interactions of GLL, MRRM, and Mobility Management, to demonstrate how access selection is performed, and describes mechanisms for how handover can be performed between different (radio) technologies.

References

[1] G. P. Koudouridis, R. Agüero, E. Alexandri, M. Berg, A. Bria, J. Gebert, L. Jorguseski, H. R. Karimi, I. Karla, P. Karlsson, J. Lundsjö, P. Magnusson, F. Meago, M. Prytz, J. Sachs, "Feasibility Studies and Architecture for Multi-Radio Access in Ambient Networks", Proc. 15th Wirless World Research Forum (WWRF) Meeting, 8-9 December 2005, Paris, France.

[2] Ambient Networks, Deliverable D1-5, "Ambient Network Framework Architecture", December 2005

[3] Ville Typpö, Osvaldo Gonsa, Teemu Rinta-aho, Bruno Tharon, and Servane Bonjour, Triggering Multi-dimensional Mobility in Ambient Networks, in Proceedings of IST'05 Conference, June 2005

[4] J. Arkko, P. Eronen, P. Nikander, and V. Torvinen, "Secure and Efficient Network Access", Extended abstract presented in the DIMACS workshop, November 2004.

[5] A. Karmouch, R. Giaffreda, A. Jonsson, A. Galis, M. Smirnov, R. Glitho and A. Karlsson, “Context Management Architecture for Ambient Networks”, WWRF#12, November 2004