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An overlay network for autonomous information discovery in the post-composition registries of ambient networks ☆

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ABSTRACT

Ambient Networks (ANs) is a new networking concept for beyond 3G. It was developed in the context of the AN project of the European Union Sixth Framework Program. Network composition is a core concept of ANs, envisioned to allow a level of network cooperation, which goes far beyond the static cooperation of today. It allows on-demand, autonomous, scalable, and uniform cooperation between heterogeneous networks. Ambient networks can host several registries (e.g. MIB and SQL database). When ANs compose, the hosted registries need to compose. Registry composition is a sub-process of network composition. Information discovery is a key feature of registry composition. Entities may need access to content hosted by a registry that was in a different network before composition. The interface of such a registry (e.g. SNMP and SQL) may be different from the one used by the interested entity. Our objective is to provide clients the ability to autonomously and seamlessly access the content of registries in the composed network. This paper proposes a solution based on an overlay network. We give background information on ambient networks, network composition, and registry composition. Related work is reviewed. The overlay network and its implementation are described, and its performance is evaluated.

1. Introduction

Ambient Networks (ANs) is a new networking concept for beyond 3G communication networks. It was developed in the context of the AN project, a European Union project funded under the IST Sixth Framework Program (FP6). Its objective is the ubiquitous provisioning of existing and new services over any type of network and access technology. Network composition is a core concept of ANs. It addresses the shortcomings of cooperation in today's wireless networks. Indeed, network cooperation in today's networks (e.g. roaming) has several drawbacks. It relies on offline agreements and manual configuration operations. This makes cooperation time-consuming and sometimes impossible. Furthermore, it can only work between a pre-known set of operators and for a limited and pre-arranged set of services (i.e. those identified in the agreement). Network composition provides a means for dynamic cooperation between heterogeneous networks, including on-line agreement creation and execution. ANs support different degrees of composition to accommodate a wide range of situations. Composition degree is the level of cooperation between the composing networks. It describes how resources are managed and used after composition.

ANs can host several registries. A registry is any authoritative store of information or repository of data. Examples are management information bases (MIBs) and context information bases (CIBs). When ANs compose, the hosted registries need to compose. Registry composition is a sub-process of network composition. Information discovery is a key feature of registry composition. Indeed, entities may need access to a content hosted by a registry that was in a different network before composition.

For instance, network N1 hosts an inventory application that keeps a track of all printers in the network and informs the network manager when their status changes. Let us assume N1 composes with another network, N2, which also hosts printers. N1 and N2 maintain information about their printers in local registries R1 and R2, respectively. The printers in the composed network are the set of printers in both R1 and R2. If the inventory application in N1 is now supposed to inform the network manager about the status of all printers in the composed network, it will need autonomous and seamless access to R2.

The post-composition registries (i.e. registries hosted by a composed network) may be of different types (e.g. centralized, distributed), store heterogeneous types of information (e.g. raw

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data vs. aggregated data), and be accessible via different types of interfaces. These interfaces are either protocols such as peer-to-peer (P2P) discovery protocols (Lua et al., Second Quarter 2005), or programming interfaces such as UDDI APIs (UDDI, 2008). This makes the problem of clients accessing information after composition very challenging. Two types of issues are related to this problem: interface interworking and data interworking. Interface interworking enables dynamic intercommunication between registries with heterogeneous interfaces. Data interworking involves dynamically overcoming data heterogeneity (e.g. format and granularity). This paper focuses on interface interworking.

We propose an overlay network based on a P2P overlay network mechanism (Lua et al., Second Quarter 2005) to solve the interface interworking problem. We selected the concept of P2P overlay networks because it enables scalability, full decentralization, and self-organizing, which suites most ANs (entities can leave and join at any time). An overlay network is created on-the-fly to allow autonomous access to the content of all the post-composition registries. Clients can seamlessly access this content via the pre-composition registries (i.e. registries hosted by the networks before composing). We assume that these registries are still available after composition. The rest of this paper is organized as follows. The following section gives background information on registry composition. Section 3 reviews related work. The proposed overlay network is described in Section 4. Section 5 discusses the implementation and the performance evaluation. Our conclusions are presented in the last section.

2. Registry composition

This section begins with background information on ANs and their composition, followed by an introduction to registry composition as a sub-process of ambient network composition.

2.1. Ambient Networks and their composition

We present the AN architecture, introduce network composition degrees, and discuss the composition procedure.

2.1.1. Ambient Network architecture

The AN architecture is composed of a common network control plane, called the Ambient Control Space (ACS), and a set of well-defined interfaces, as shown in Fig. 1. ACS is the set of the functions of the control layer organized in different functional entities (e.g. QoS FE and composition FE). It can be deployed over various existing and future network types. An AN has three interfaces: an Ambient Network Interface (ANI), an Ambient Service Interface (ASI), and an Ambient Resource Interface (ARI). The ANI enables communication between different ANs, and the ASI allows access to the services offered by the AN. The ARI provides necessary mechanisms to manage the connectivity resources (e.g. routers, switches, and media gateways) and deal with subjacent radio access technologies in a homogeneous manner. An AN may be a network of any type, provided that it has a control space and the necessary interfaces. It may be a single terminal, a Personal Area Network (PAN), or a full-fledged operator network. D18-A.4: Annex F AN System Description (2008) provides a detailed overview of the AN architecture.

2.1.2. Composition degrees

Three degrees of AN composition are possible: network interworking, control sharing, and network integration (Fig. 2). Network interworking is the most common degree of composition. The composing networks remain separate and maintain control over their individual resources (including registries). If no interworking agreement exists between the networks, an agreement is created on-the-fly. With control sharing, composing networks remain separate and share some of their resources. They may exercise joint control over the shared resources. If this is the case, a new AN is created to maintain these resources. In network integration, the composing networks totally merge into a new common composed network. The composed network consists of all the logical and physical resources of the composing networks. For more information on AN composition, the reader is referred to Belqasmi et al. (2008).

2.1.3. Composition steps

Network composition can be triggered by multiple events. One example is when a PAN needs to compose with an access network to provide Internet access or better QoS to its owner. The network composition process comprises five phases (Fig. 3). In the first phase, the networks detect each other, for instance via layer 2 beacons. In the second phase, they exchange information about their capabilities and about the services they can provide. The candidate networks for composition are selected based on this information. In phase 3, the selected networks authenticate each other and establish security and interwork connectivity (e.g. a cryptographic session key is generated and exchanged). In phase 4, they negotiate the composition agreement, which will be executed

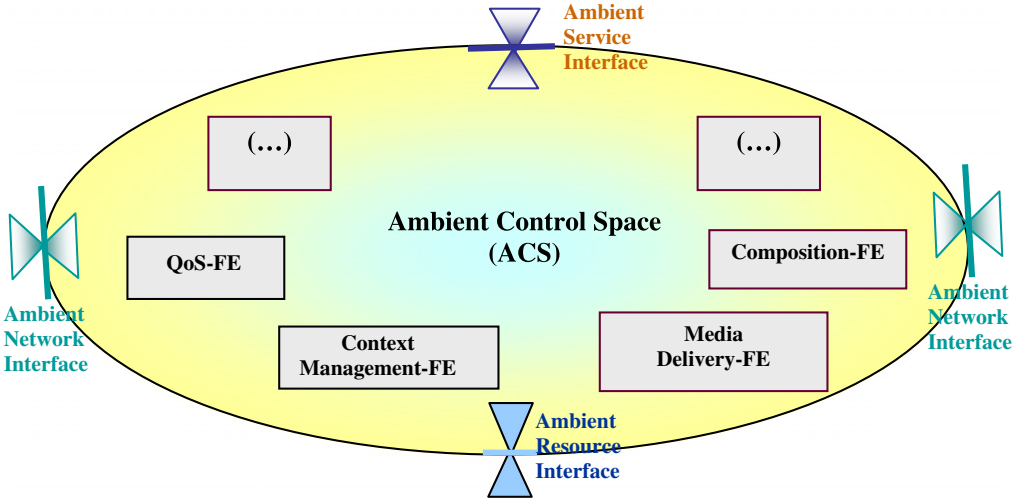

Fig. 1. Ambient network architecture.