Daidalos: the global architecture and its instantiations

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***Abstract*—Telecom operators are challenged by the increasing user demand for mobility, quality of service and security on one hand, and the constraints imposed by economy and regulatory bodies on the other. Daidalos[1], an EC funded Integrated Project, addresses the vision of a seamlessly integrated heterogeneous network architecture based on an IPv6 infrastructure. The Daidalos architecture addresses conceptual issues of operators, customers and identities, as well as integrated aspects, such as service interfaces, a layered approach and broadcast integration. In this architecture, context issues appear in different formats, and are embedded in several concepts. The architecture is very flexible, and able to be instantiated for different scenarios.**

I. INTRODUCTION

Mobile communication is about to revolutionise our society. People, including children, use or even heavily depend on an entire set of personalised devices and services. In fact, this trend is even more pronounced in youngster, which are tupical earlier adopters of technology. They are biased to experiment and interact with various types of mobile equipment in different environments. Thus, consumer demand and expectations as well as the improved terminal capabilities push the need for ubiquitous mobile high-speed network access – and as youngsters grow old, the market will mature.

In this moving market, competitive pressure, unbundling forced by deregulation and new business models create a fragmented value chain increasingly difficult to be supported by legacy telecom operators. The trends, visible today and acerbated in the future, combined with the variety of technologies and services, lead to complex network and service infrastructures that imposes extreme challenges for these companies.

Companies have been constrained in providing service layers for external usage and naturally analysed how best to exploit these constrains in terms of market penetration. The overall result can be summarised in a fundamental change: telecommunications is becoming a horizontally segmented market, where operators are changing their business approach from the traditional vertical markets. Service provision (which now is becoming a term with a wider scope than simple end-user service provision) is separated from the transport of information and from the access to the same. From a market perspective, this separation fundamentally changes the telecommunications business model. The current business, which is simply information transferral, is not easily horizontalized, but it requires a fundamental analysis of the complexity of the end-user service provision. Several issues are to be taken in consideration on this trend: multi-parties doing business in the telecommunication market and the federation between them, IP as common transport protocol in the telecommunication world, and many types of devices connecting in many different ways to the telecommunication networks. If the future market becomes even more fragmented, this process, albeit potentially increasing the customer base for a telecom operator, will also lead to a much more complex service provision environment.

This paper presents the architectural vision of Daidalos, an EC funded Integrated Project. Daidalos aims to enable the seamless integration of heterogeneous network technologies and to build an open architecture for next-generation networks. Daidalos provides guidance on concepts and project orientation for an open architecture based on a common IPv6 infrastructure. Network operators and service providers will be enabled to provide intelligent access combined with dynamic service provisioning supporting a wide range of voice, data, and multimedia services. Business models and business process interactions are considered from an architectural point of view. The new pervasive network and communication infrastructures will enable every user to benefit from individual and customised communication services. In this pervasive environment, context is a key issue, and is reinterpreted in different modules, in order to achieve the best network behaviour to the user.

II. DAIDALOS ASSUMPTIONS

The Daidalos architecture is based on 4 fundamental assumptions, based on operator-driven visions of next generation telecommunications:

1. **The future telecom operator runs and operates enabling services for a huge number of users and service providers.** In a world where users are empowered (in all aspects of their life), the telecom operator is responsible for providing the necessary communication services. It takes the role of service provider and offers the most crucial services to its customers.
2. **All design will ultimately be made around the user, simplifying his needs.** The user-centric design is particularly important to offer complex technology for the

[1] DAIDALOS - Designing Advanced Interfaces for the Delivery and Administration of Location independent Optimised Personal Services, http://www.ist-daidalos.org/

increasingly technology-agnostic users. The combination of both concepts, operator driven and user centric, create a dichotomy along all development process: the network has to be optimised to fulfil operator requirements, but at the same time, users should be given the chance to freely choose among various operators, services and usage. Lessons learnt from addressing this incongruity will play a fundamental role for a potential clean slate design of the Internet.

3. **Users have the final control of their communication needs.** Users must be free to change between service providers and between technologies, at their own will and risk. This concept, however, implies that the service provisioning environment cannot be considered to be simply a layer on the provider layer. Users receive a service that will be mediated by their devices implying that there is a local service provider, or a middleware functionality, with the sole responsibility to attend to the users explicit or implicit) wishes. This local service provider will reside partially in the user terminal, but can be a commercial service being offered either by a software company (via a middleware loaded by the user) or by a communications company (via a profile).
4. **Services could be produced by multiple providers.** Service providers are not expected to be in specific locations in the network but are expected to have specific business relationships with the operator, identifying the objective contractual relationship expected between them. The fact that several major players will continue to exist in the future (e.g. mobile telephony operator, TV broadcaster), though potentially with different roles, increases the complexity of defining a network architecture.

   Daidalos focuses on feasibility to provide the communications technologies to support all these information transport models, with an unknown number of business parties. In fact, it is to be expected that different types of access, potentially under the ownership of different entities, will be (nearly) always available.

III. ARCHITECTURE

Based on the above assumptions, concepts for the overarching Daidalos architecture as well as specialised inter-operator and pervasive support architecture have been derived.

A. *Goals and architectural assumptions*

The Daidalos architecture definition has a two-fold goal. First, it defines architectural concepts independently of a concrete underlying network infrastructure. Second, it applies and deploys the concepts on a next-generation, mobile IPv6-based infrastructure. This separation allows Daidalos to come up with conceptual incentives that can be applied to an IP-based network, but is also suited for a clean-slate design of the Internet. The latter deployment is in part a proof of concept and the experiences gained from an evolutionary deployment will provide vital practical feedback about the suitability of the concepts.

Daidalos separates the network operator/provider challenges into 3 areas: access network, inter-operator aspects, and pervasive support components – and this last one associated to the service provision environment, as depicted in Figure 1. In each area, different technologies will be deployed and optimised for transport, including mobility, QoS support, [1] unicast as well as multicast and broadcast [2]. QoS is assured with a core based on Differentiated Services with implicit and explicit signalling. On top of Daidalos, traditional bulk-data flows as well as real-time multimedia, VoIP and SIP-based communications will be supported. In the following subsections, we first describe the 5 overall concepts of the Daidalos architecture and then describe how these concepts are applied to the 3 areas in more detail.

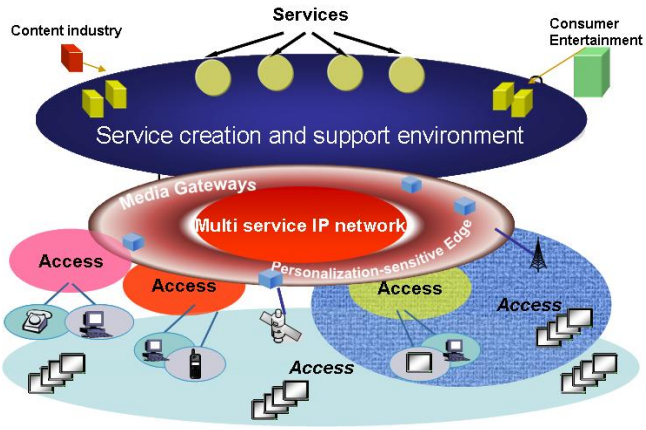

Figure 1: Architectural separations in Daidalos

B. *Daidalos overarching concepts*

The following 5 core concepts for the Daidalos architecture:

- **MARQS**: (Mobility Management, AAA – Authentication, Authorisation, and Accounting –, Resource Management, QoS and Security) supports functional integration for end-to-end services across heterogeneous technologies.
- **VID (Virtual Identity)** separates the user from a device, thereby providing flexibility as well as privacy and personalisation.
- **USP (Ubiquitous and Seamless Pervasiveness)** enables pervasiveness across personal and embedded devices, and allows adaptation to movement, changing contexts and user requests.
- **SIB (Seamless Integration of Broadcast)** integrates broadcast at both the technology level, (e.g. DVB-S/T and -H) and at the service level (e.g. TV, carousels and datacast).
- **Federation** allows network operators and service providers to offer and receive services, allowing players to enter and leave the field in a dynamic business environment.

Figure 2 presents a different view of the architecture, where its more relevant entities are identified. In the figure, one can

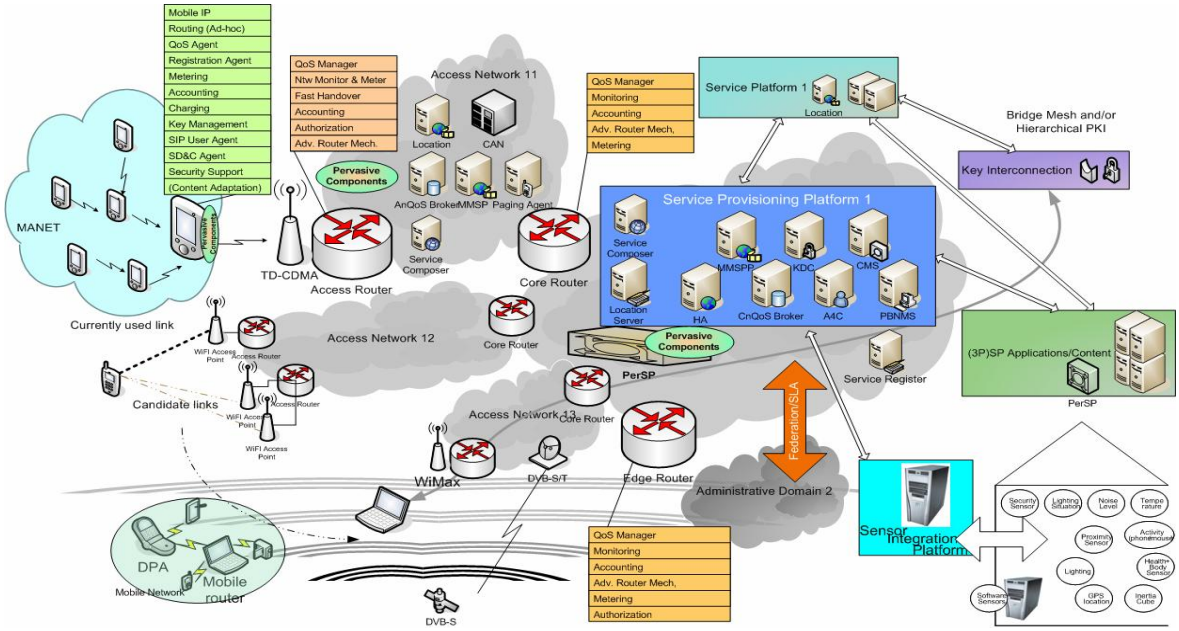

Figure 2: Daidalos Architecture

identify the "access networks", the "multiservice IP network" already associated with the "service environment" (the central administrative cloud, with the Service Provisioning Platform). In reality, for a telecom operator, some of its key services are precisely the basic communication facilities. The figure further identifies a large set of technologies supported in the project, from unicast technologies (DVB), to traditional wireless technologies (TD-CDMA, WiFi, WiMax), but also encompassing self-organized environments (both sensor and ad-hoc nodes), and mobile networks.

C. *Access network architecture*

In the access network, Daidalos separates the activities into 6 different modules: Terminal Mobility (TM), Moving Networks Integration (MNI), Ad-hoc Integration (AHOI), Quality of Service (QoS), Security (Sec) and Broadcast (BC). These modules are deployed on various physical entities, such as mobile terminals, access routers, access points, home agents, or QoS Brokers. In spite of all the hype with respect to mobility requirements, we argue that the physical distribution of components per entity will be stable to a large extent. This stability will prevail regardless of the architecture scenario with the exception that some modules may not be deployed if the network does not aim to support some functions.

D. *Inter-operator architecture*

Daidalos divides the overall next-generation network into administrative domains that can cooperate when there is a service level agreement and a trust relationship between them. Daidalos defines a inter-operator architecture termed Service Provisioning Platform (SPP) that allows the different components in the various domains to interact. The SPP is comprised of services for QoS, Network Management, Network Monitoring, Security, Authentication, Authorisation, Accounting, Auditing, Charging (A4C), and Multimedia and provides the tools for creating services and applications on top of integrated heterogeneous access networks. Moreover, it defines functionalities and interactions necessary within and between access networks to support seamless user mobility, terminals, multimedia sessions, and services between administrative domains. The architecture is open, modular and extensible for future refinement, incorporating optimised mechanisms and processes. From the start, Daidalos assumes different control entities for SIP-based traffic (typically multimedia) and legacy applications (typically web and email). The MMSP entities act as multimedia service controllers for multimedia traffic.

Inter-operator modules are mostly deployed on border routers and the SPP. The exact deployment strongly depends on the business scenario (the architecture instantiation). Thus, modules will be placed inside different servers, in different administrative domains as a function of the overall interaction of the business scenario.

E. *Pervasive support architecture*

Daidalos takes a service-oriented approach to pervasive computing [3]. The pervasive support architecture consists of two parts: a service management infrastructure and an infrastructure running user devices. The former provides ubiquitous access to services. The functional entities termed PSM (Pervasive Service Management) run on top of the PSPP (Pervasive Service Provisioning Platform). The PSM discovers services available to a user at any time, composes atomic services into composed pervasive services, and provides runtime mechanisms to support the usage of the best available devices for each pervasive service. A part of the service management infrastructure includes the basic infrastructure for using multiple virtual identities for preserving user privacy. The user device infrastructure aims at

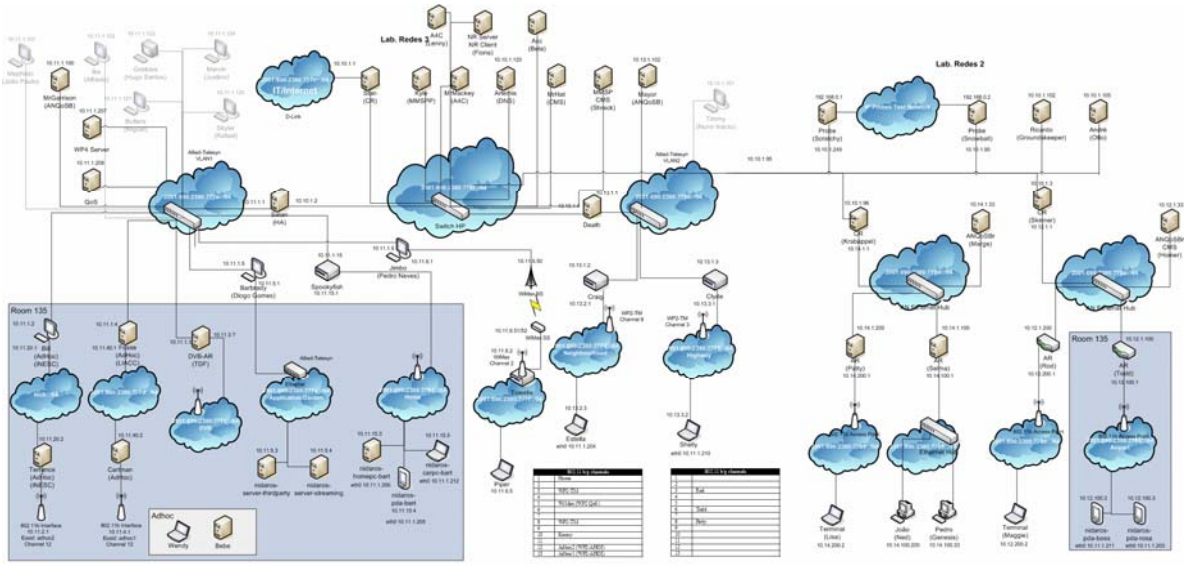

Figure 3: Testbed scenario instantion

supporting context-aware interaction with pervasive services. This infrastructure includes the functional entities Context Management (CM), Personalisation (P), and context-aware VID (virtual ID) negotiation. This architecture provides for a set of enabling services to provide the best user quality.

Context aspects are an essential part inside Daidalos, and in fact are reinterpreted along the multiple layers. The pervasive support environment, takes in information coming from different layers (network availability, signal strength, user preferences), and processes it at different levels, in order to provide the best communications experience at each time.

IV. Instantiations

The Daidalos architecture was designed to be potentially instantiated in different environments and for different business models.

For that Daidalos defined two main scenarios: automotive and university (or virtual company) usage. This aimed at a user-centric approach to validation. In order to keep the user in focus, Daidalos then developed a set of futuristic scenes about user activities in a "Daidalos-enabled network". These scenes cumulatively led to the setup of a validation environment, nicknamed Nidaros. Nidaros defined a possible realization of Daidalos architecture, which represented an environment dominated by a major operator, and providing multimedia and interactive services to university students. In Nidaros, the user can access newscast services, video stream services, buddy finders, or videoconferencing facilities.

This scenario, and some added functionalities, were instantiated in a prototype test bed. This test bed was designed in order to be able to fulfil two separate but complementary functions: the Nidaros instantiation, and specific test environment for specific sub-systems.

The test bed is schematically presented in Fig. 3, and is a fairly complex network. Most Daidalos developments are integrated in the test bed, and all major subsystems mentioned in section III are able to run independently under supervised control. Due to its research nature, Nidaros infrastructure requires expert operation for control purposes, currently. This testbed covers aspects of: ad-hoc networks, WiFi technologies, interactive and streaming multimedia, efficient handover techniques (including network-initiated and mobile-initiated functionalities), QoS-enabled applications, A4C support, secure registration, privacy and personalization. Multiple applications are able to be run on this environment.

V. Conclusions

Daidalos provides a next-generation integrated network architecture from an operator point of view. The architectural concepts support mobility, pervasiveness and QoS in wired and wireless networks. Its concepts are currently applied on a mobile-IPv6 based network.

More research is now necessary for each of the Daidalos key concepts and their combination. The expertise achieved in this first phase already indicates the large potential that the Daidalos overall goals have, but also shows that several technologies need to be re-addressed to be fully exploitable in a heterogeneous, horizontal, user-oriented, world.

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