proc. of the IEEE International Workshop on Management Issues and Challenges in Mobile Computing - MICMC 2005, Nice, France, 15 May 2005.

Using CIM Extensions to model Managed Entities in Heterogeneous Networks

Wojciech Dziunikowski[1], Jacek Wszołek[1], Pedro Gonçalves[2], Sonny Rasmussen[3]
Antonio Cuevas[4], Rui P. Lopes[5], Vítor Roque[2], José Luís Oliveira[2]

[1]AGH University of Science and Technology, Poland
[2]University of Aveiro, DET/IT, Portugal
[3]UHC, Denmark
[4]University Carlos III, Madrid, Spain
[5]Polytechnical Institute of Bragança, ESTiG, Portugal

Abstract—**This paper is devoted to the definition of management information which models specific functionality of the entities that build Daidalos European Project. This management information will be used in policy–based management system (PBNMS) to manage QoS aspects of the network functionality.**

Index Terms— **PBNM, Management Information, CIM, WBEM**

I. Introduction

Daidalos (**D**esigning **A**dvanced network **I**nterfaces for the **D**elivery and **A**dministration of **L**ocation independent, **O**ptimised personal **S**ervices) is an EU Sixth Framework Programme Integrated Project that aims at building a framework for the seamless integration of heterogeneous network technologies upon which users can enjoy a wide range of personalized services such as voice, data, and multimedia services [1]. Daidalos is leading to the rethinking of network architectures, necessary to create a new generation of user-centered manageable communication infrastructure for the future. Support for user mobility is the key aspect of this solution. Network and service operators must be able to develop new business activities and provide profitable services in such an integrated mobile world. The introduction of such enhancements will require sophisticated management systems.

This paper presents the ongoing work that has been done inside the Daidalos project especially concerning management aspects and the strategy to follow a policy-based network management (PBNM) approach. While the work is still far from the end, the obtained results in context of the inherent complexity of the Daidalos network indicate for a very promising environment to the adoption and wide use of PBNM concepts.

II. Daidalos network architecture

The Daidalos network is divided in the three different parts: the Core Network (CN), the Access Network (AN), and Application Garden (AG), as it is illustrated in the Fig. 1.

The CN is an IP network where resources are managed in an aggregated basis and it is supported by differentiated services (diffserv) [7]. It interconnects the access networks, the application gardens as well as the foreign domain networks. The connectivity between ANs and CN is realized through Edge Routers (ER). Inside the core network, resource allocation is managed through a specialized entity – the Core Network QoS Broker (CNQoSBr). Besides QoS, several other management functions are being dealt by the following entities: Central Monitoring System (CMS), Authentication, Authorization, Accounting, Auditing and Charging System (A4C) and Multimedia Service Provisioning Platform (MMSPP).

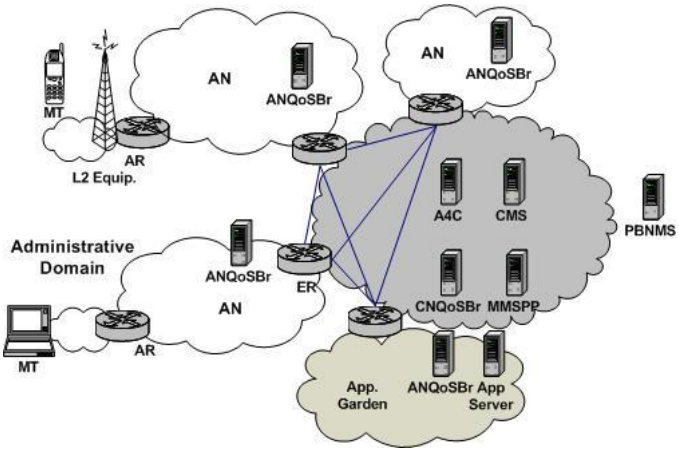


Fig. 1 - Daidalos' Management Architecture. The network is organized in Core Network (CN), Access Network (AN), and Application Garden (AG).

The AN resources are managed in a per-flow basis by a local QoS Broker (ANQoSBr). The AN topology may have several Access Routers (ARs), Core Routers (CRs) and Access Points (APs). The ANQoSBr is responsible for the AR and the CR configuration and management in order to grant QoS to the

network clients. The ANQoSBr is also responsible for the admission control over the new packet flows in the AN; once a Mobile Terminal (MT) tries to establish a new session, the AR intercepts the session packets and requests the broker for the admission or rejection of the session. The ANQoSBr analyses the resource usage of its domain and returns the appropriate answer to the AR. The CNQoSBr can periodically update core network resources parameters that are propagated to each edge router that assures the interface with ANs. The information concerning the resource distribution among the ANs is distributed by the CNQoSBr in order that ANQoSBr could adapt the traffic created in its network to the new resource distribution.

The AG is a special case of an access network that supports application servers, service proxies and content adaptors, but not end users. Although, Daidalos Architecture is open to support any business model, we foresee that the more promising one is the UMTS-OSA like, where the Network Provider is an aggregator of Services and applications thanks to SLAs signed with the Services Providers. Services Providers equipment may be located in the Application Garden.

III. Daidalos Policy Based Network Management System

To deal with the complex Daidalos architecture, a sophisticated management system is needed. It has been shown that the policy based approach to network management is a very promising solution [3]. Therefore, it was decided to follow this approach in Daidalos. Several standardization organizations are focusing its effort on this subject e.g. Telemanagement Forum, IETF, DMTF. It was decided to adopt DMTF approach called Web-Based Management (WBEM) to Daidalos requirements [6]. WBEM is a set of standards developed to unify the management of distributed computing environments [4][5]. For modeling of management information a Common Information Model (CIM) is used. CIM consists of Core Model, Common Model and extension schemas [2]. One of the CIM extension schema is devoted to policies.

Although WBEM do not strictly covers all aspects of policy based management system, (e.g. conflict detection, policy distribution are not ensured) it provides a flexible framework which can be used to build a real PBNM system. Additionally, a quite stable and mature open-source implementations of this concept are available, which will ease the evaluation of the proposed concepts in the working environment.

A. Daidalos PBNMS Architecture

On the basis of WBEM concept a new Daidalos PBNMS architecture (Fig. 2) is proposed.

The Graphical User interface (GUI) allows a network operator to introduce new rules and policies to the system. The communication between GUI and PBM Server is based on CIM-XML over HTTP [5]. PBM Server is responsible for proper installation of policies in the Policy Decision Points (PDPs) i.e. QoSBrokers, MMSPP, A4C and CMS. Additionally, policies are stored in Policy Repository, which provides a directory service using Lightweight Directory Access Protocol (LDAP).

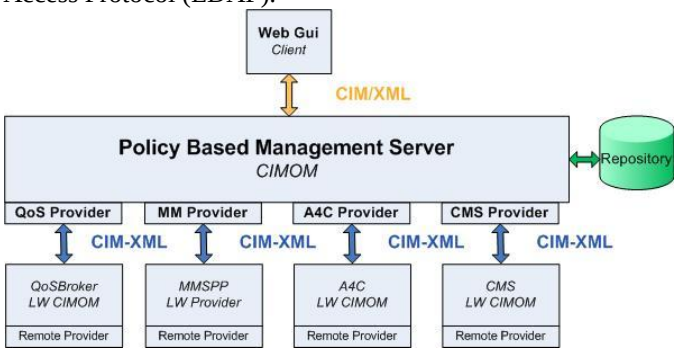


Fig. 2 - Daidalos PBNMS architecture.

PBM Server is build upon the CIM Object Manager (CIMOM). In each PDP there is a local CIM provider which ensures a mapping of CIM classes, instances and operations received from PBM Server to the commands and data models specific for each PDP. The PDP on the basis of the information received from the PBM Server configures its depended PEPs. The communication between PBM Server and CIM providers is also based on CIM-XML over HTTP.

IV. Daidalos CIM extensions

Considering the novelty of the Daidalos entities new management information models are needed. Due to the adoption of CIM the new classes modeling the managed entities are being defined as CIM extensions. Actually, Daidalos CIM extensions consists of 9 packages (Fig. 3).

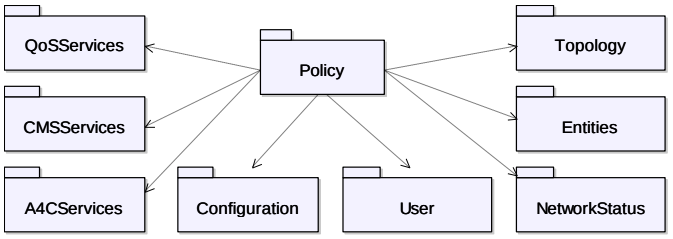


Fig. 3 – Packages organization of the Daidalos CIM Extensions.

Classes included in packages *User*, describing Daidalos network user, and *Topology*, regarding network topology are common for all subsystems and will be presented in more details in Section IV.A. In Daidalos, the main focus is put on management of QoS and monitoring aspects of network functionality. Therefore, the class hierarchy from packages *QoSServices* and *CMSServices* will be analyzed in Sections IV.B and IV.C, respectively. Package *A4CServices* will contain classes relevant for A4C subsystem. Package Configuration contains classes related to specific set of configuration parameters of Daidalos entities. Package *Entities* contains classes modeling specific Daidalos network entities like QoSBrokers, AR, MT etc. Package *NetworkStatus* is devoted to the information about the available, as well as already used network resources. Using all of these packages, new classes extending the CIM_Policy extension schema will

be defined in package *Policy*. These classes will allow operator to build new conditions, actions, rules and policies specific for Daidalos purposes.

Regarding the class naming the following convention was undertaken: class names with prefix "D_" specify classes defined as Daidalos CIM Extensions and class names without this prefix specify original CIM classes.

A. *Common Extensions*

Fig. 4 presents the main class diagram of *User* package, which is used to model the user related aspects in Daidalos network. From the network point of view each user has assigned a specific profile - the Network View User Profile (*D_NVUP*). This profile contains user home address called Virtual ID (*VID*), and care of address (*CoA*), and A4C certificate (Artifact).

In order to make user management more scalable each user is assigned to a specific group (*Group*). Each group is characterized by different set of parameters (*D_DaidalosGroupInformation*) which contains specific privileges (*D_Privilege*). Class *D_Privilege* is defined in *A4CServices* package. Class *D_DSCPPrivilege* inherits from *D_Privilege*, and describe which DSCP codes can be used to mark user flows, what amount of bandwidth can be assigned to the session initiated by the user (*MaxUpBW*, *MaxDownBW*). It also contains information about a charging type (*ChargingType*) and about a period when this privilege is valid (*PeriodOfDay*).

In order to reserve resources system must be aware of network topology and the usage of resources in every transport class assigned to every interface. Because topology from CIM_Network schema is insufficient, the Daidalos topology CIM extension is proposed (Fig. 5).

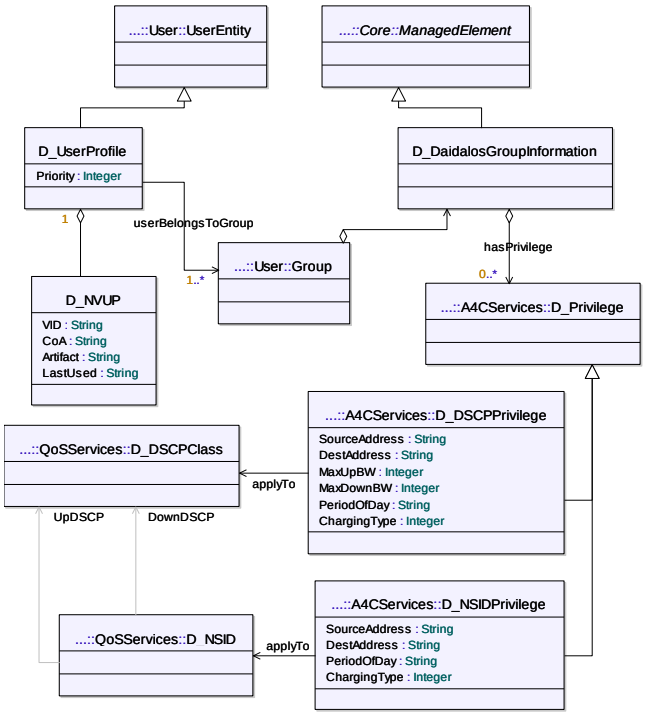


Fig. 4 - The main class diagram of *User* package.

Network topology consists of network nodes (*D_Nodes*), which are derived from abstract class *D_Entity*, modeling each Daidalos entity. Network node can be either router (usually) or any other Daidalos entity (QoSBroker, CMS, etc). Each network node has one or more physical interfaces (*D_PhysicalInterface*) with appropriate capabilities (*D_PhysicalInterfaceCapability*). Physical interface has one or more logical interface (*D_LogicalInterface*). Both logical and physical interfaces inherit from *D_Interface*. It is abstract class representing interface of Daidalos entity. The link between nodes is always point-to-point link and for outgoing direction is fully described by *D_LogicalInterface* parameters in the local node and for incoming direction by *D_LogicalInterface* parameters in the remote node. Instance of *D_ResourceStatus* class describes the resource status of the interface in outgoing direction.

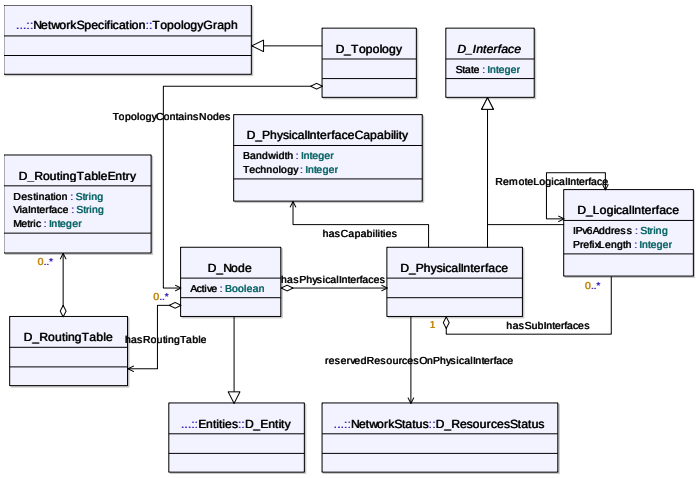
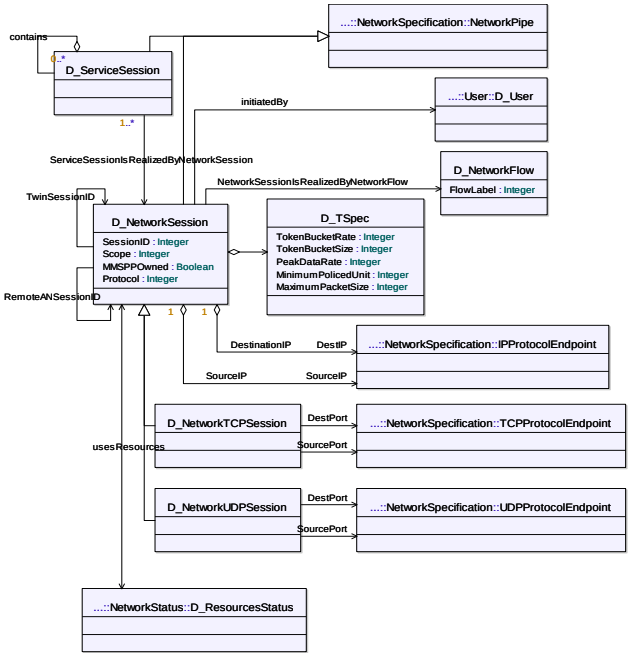


Fig. 5 - The main class diagram of *Topology* package.

B. *Extensions regarding QoS*

The main QoS aspects in Daidalos network are related to network session (*D_NetworkSession*), which is the heart of class diagram in Fig. 6. Each session is identified by a source and destination IPv6 address (*IPProtocolEndpoint*), its identifier, scope and protocol used. Additionally there is an information about the type of the session: is an MMSPP involved in establishing the session (*MMSPPOwned* – true) or not (*MMSPPOwned* – false).

Each network session is realized using specific network flow (*D_NetworkFlow*) identified by a flow label. Actually two classes are derived from *D_NetworkSession*, which identify TCP and UDP sessions. In order to start session ANQoSBr must reserve resources. This is done on the basis of current resource status (*D_ResourcesStatus*) on the whole path of initiated session. As a result of reservation, *D_ResourceStatus* attributes assigned to interfaces of hop routers along the path between source and destination are changed and specific access router configuration is enforced



(admission control) according to the traffic specification (*D_TSpec*).

Fig. 6 - The main class diagram of *QoSServices* package.

D_RoutingTable represents routing table stored in the router. It is used to discover which routers are involved in transmission of packets belonging to specific session. This information is required by ANQoSBr during the admission control process.

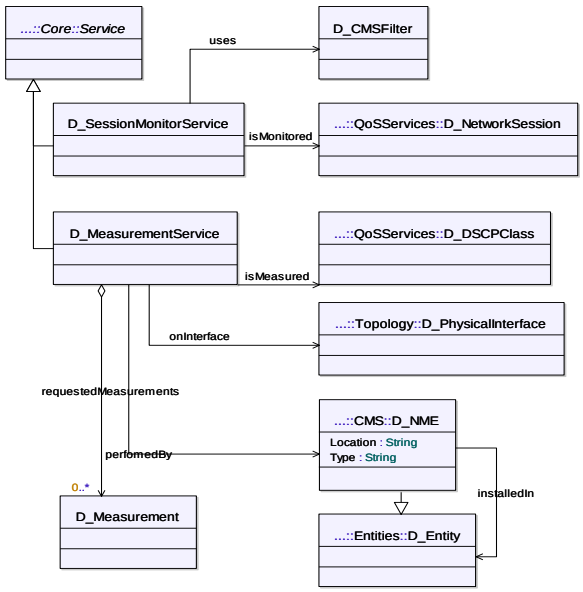
C. Extensions regarding Central Monitoring System

From the management point of view CMS is a system which has two main functions; session monitoring (*D_SessionMonitorService*) and measurement service (*D_MeasurementService*). Each accepted session is monitored by CMS according to defined filter (*FilterSettings*) and inactivity timeout. If there is no traffic passing belonging to that session for a longer time than inactivity timeout the reservation for the session is deleted.

Measurement service is responsible for all measurement in Daidalos network. Measurements are described by *D_Measurement* class and are associated with *D_PhysicalInterface* class (Fig. 7), which models an interface monitored by Network Monitoring Entity (*D_NME*).

D. Extensions regarding A4C

Daidalos A4C architecture is based on IRTF's AAA architecture and although IRTF's follows a policy-based approach in their architecture [8] PBNM aspects are not very mature except for accounting [9]. A4C Policy aspects related to *D_NetworkSession* will be handled by the Daidalos operator and aspects related to *D_ServiceSession* can be shared between the Daidalos operator and the service provider. Service Providers can be seen as generalization of MMSPP, thus the A4C policy model can mimic the model employed to represent joint MMSPP and A4C aspects. Like QoS, A4C



policies will use *D_User* Package but they will employ both network and service related parameters.

Fig. 7 - The main class diagram of *CMSServices* package.

V. Conclusion

In this paper we have presented an on-going work inside the Daidalos project that uses the policy-based network management paradigm based on WBEM and CIM. Behind the usage of this technology framework an important modeling work must be done to cope well with all the active entities that are part of such a heterogeneous network as Daidalos.

In this paper we presented a set of CIM extensions that allow representing the main management concepts like Topology, Services and Users, and specific operational entities related with QoS and Monitoring.

Acknowledgement

The work herein presented was developed in the scope of the DAIDALOS project (IST-2002-506997), funded by the European Community, under the Thematic Priority 'Information Society Technologies' of EU Framework Programme 6 for Research and Development.

References

[1] Daidalos project, "Designing Advanced network Interfaces for the Delivery and Administration of Location independent, Optimised personal Services", http://www.ist-daidalos.org/.

[2] Common Information Model (CIM) Specification – Version 2.7. 2003, Distributed Management Task Force, Inc.

[3] J. Strassner, Policy-Based Network Management: Solutions for the Next Generation. 2003: Morgan Kaufmann.

[4] J. Thompson, Web-Based Enterprise Management Architecture. IEEE Communications Magazine, 1998. 36(3): p. 80-86.

[5] Web-Based Enterprise Management (WBEM) Initiative. 2004, Distributed Management Task Force, Inc.

[6] OpenWBEM project, http://www.openwbem.org/, 08/12/2004

[7] S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang, W. Weiss, “An Architecture for Differentiated Services”, RFC 2475, IETF, December 1998.

[8] C. Rensing, H. Hasan, M. Karsten, B. Stiller ”A Survey on AAA Mechanisms, Protocols, and Architectures and a Policy-based Approach beyond: A^{x}”, ETH - Zurich, May 2001

[9] T. Zseby et al., “Policy-Based Accounting”, RFC 3334, IETF, October 2002.