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## Deliverable D3.3: WP3 Report

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### 1 Introduction

This document is the third deliverable of work package three – Modelling and Design. It covers white papers and paper submissions that have been produced and reviewed by the M-Zones partners and by international conferences. Purpose of this document is to evaluate the progress of the accomplished work regarding the modelling and the design of management concepts and systems for Smart Spaces. This document builds on the deliverable 3.1 (M-Zones white papers) and 3.2 (1<sup>st</sup> MUCS workshop). The general methodology for the quality assurance is defined in a quality document developed by the partners.

This deliverable evaluates papers that address items introduced in the next chapter, requirements and context. A number of papers have been written having a different scope, addressing items from workpackage and/or four. These papers have not been included in the evaluation of this deliverable, but will be found in D2.3 and D4.3 respectively.

### 2 Requirements and Context

The primarily goal of work package three is to provide guidelines, recommendations and rules for the modelling and design for solutions for managed zones. Targeted results are methodologies, design models, algorithms and processes that are based on the architectural approaches of work package 2 enabling to engineer a smart space instead of having it crafted. The criteria for including white papers in this document are that these papers need to deal with one of the following aspects of modelling and design:

- Object models – the composition of interacting objects that concentrates on clearly identified aspects of the real world
- Semantic information – beside concrete object models, that focus on the syntax of an object, the specification of a smart space must be qualified with semantic information

- Repositories – information bases and repositories for smart spaces in form of (usually distributed) virtual data store supporting the specific requirements of the research themes.
- Notations – languages that are used for the specification of smart spaces and M-Zones that can be either formal notations or semi-formal notations.
- Development tools – supporting the modelling as well as the design phases.
- Communication services, protocols, formats – mechanisms and data to be exchanged in order to allow management activities to disappear.
- Mathematical models – models of devices, systems, and networks that populate a smart space described in the language of mathematics, which facilitates analytical evaluation and comparison with model implementation within an experimental platform, that is computer simulation environment
- Core services – (probably) standardised services that allow M-Zones to be used and operated and that enable control of seamless interoperability as well as administration and maintenance of co-operation activities.
- Application Programming Interface(s) – define easy to use mechanisms to access resources of a smart space and its management for new service creation and deployment.

Following the evaluation of this paper, the M-Zones programme will be able to develop a holistic view on modelling and design aspects for the rest of the programme (three years).

### **3 Assessment Criteria**

The accomplished work in work package three is assessed by means of:

- Are the techniques for modelling and design used by individual projects clearly understandable for other, future developers of managed zones.
- Is a common understanding reached what modelling and design of Smart Spaces and M-Zones means?
- Is there a sound reasoning and a good understanding of the relevant state of the art?
- Is there a shared view of the problem domain addressed by the programme in order to encourage consistency and, where appropriate, convergence between work of different projects?
- Are given or identified problems solved based on WP2 results and did solutions feed into WP4?
- Is M-Zones going to establish a development framework(s), which can be seen as a set of models, rules and processes?
- Are the three major cycles of modelling and design (development, execution environment and deployment) addressed?

### **4 Overview of Papers**

The criteria presented above have been used to review draft whitepapers in an ongoing dialogue aimed at improving their overall research content. Below are summaries of the status

of these drafts based on this WP3 evaluation, though these may not accurately reflect the final drafts of the white papers included with this deliverable due to their ongoing refinement.

*Dynamic Composition and Personalisation of PDA-based eLearning – Personalised mLearning* (Brady et al 2004a) – this paper examines the usability of dynamically composed eLearning experiences on PDA devices. It introduces a hypermedia engine with its three different models and evaluates requirements for a user interface design. Results of this evaluation are then used to develop design patterns for PDA devices and an architecture for adaptive eLearning services. The paper concludes with trial and evaluation of the introduced research results.

*Automated Policy-Refinement for Managing Composite Services (Carey et al)* – this paper describes an architecture that introduces automated policy refinement for composite service management. The foundation of this work is web-services and web-service based service composition. Due to complexity of web-service, their management system increase in their complexity. Policy-based management and finite state machines are used to handle both complexities. Policy refinement is realised by a specific engine is supported by FSM models and high level policies and that can generate low level policies, which are further enforced in a web-service environment.

*An Active, Ontology-driven Network Service for Internet Collaboration (Lewis et al)* – this paper introduces an alternative approach to manage ontologies for collaboration over the internet. It analyses the user requirements, based on commonly used web portals and identifies the technical challenges. From this, it defines an architecture that enables ontology-based queries as well as dissemination of information and content-based networking. The paper concludes with a discussion of business models and roll-out scenarios

*Using Event Aggregation to Provide Autonomic Mixed Initiative Personalized Service Support in UbiComp Environments (O'Donnell et al)* – this paper focuses on the aggregation of personalised service information based on the observation of multiple events that can be aggregated to understand and react on user activities. The proposed architecture covers items such as intention and context and heterogeneous inputs. The paper concludes with a review of the undertaken experiments.

*Resolving Queries in a Heterogeneous Context Rich Environment (Power et al)* – this paper describes an approach to minimise the effort that has to be undertaken to make an application context-aware. It compares existing context approaches, discusses example scenarios and analyses the design and implementation of context-aware applications. The core part of the paper introduces the design of a context-aware device and a context-aware service. It concludes with query analysis and routing.

*Policy Driven Composition of Trustworthy Web Services (Quinn et al)* – this paper combines ontology and policy-based management for the management of trust. related work from the web-service area is analysed and an experimental approach for the combination is presented.

*Policy-based Access Management and Handover Control in Heterogeneous Wireless Networks (Murray et al)* – this paper proposes a policy-based management system to control network access. Intra-system handover is supported by a dynamic reservation of handover capacity throughout each network. The paper describes the employed mobility model and simulation model and describes the results of the network management experiments.

*Ad hoc Service Delivery (Cummins et al)* – this paper examines to what extent Jini can be used to bridge between classic network and computing equipment and handheld devices using mobile Java. Beside the introduction of the basic Jini architecture, the author describes implemented services and discusses results of the undertaken experiments.

*Access Control in Smart Space Environments (White)* – this paper describes the problem context of access control in Smart Spaces. Based on the assumption that Smart Spaces can be used as a mechanism for surveillance, the paper explains the need for less intrusive and more accurate forms of authentication. It outlines an Access Control Service for M-Zones

*Task Driven Service Composition for Pervasive computing environments (Davy)* – this paper describes an approach for using policy-based management combined with service semantics to compose services based on user tasks. It describes the planned test-bed and the research challenges of the proposed research work.

*Information Modelling for a Smart Space Personal Information Management System (Carroll)* – this paper identifies the need for an information model as basis to manage personal information with M-Zones. Information and data modelling is discussed based on CIM and Sid and the requirements of the information management system are explained. The paper describes work in progress and explains the challenges for a system architecture capable of handling the complexity of user information.

*The dynamic adaptation of security policies in pervasive environments, with contextual information as the catalyst (Barrett)* – this paper focuses on combination of three different fields: policies, security management and context information. Hereby, static policies are transformed to adaptive policies, using security as application domain and context as trigger to change the policies. The paper discusses the research challenges, the policy refinement process and provides a first approach for an architecture.

*Resource Discovery and Management Using Policies in Smart Spaces (Ghamri-Doudane et al)* – this paper introduces a policy-based management approach for the discovery and management of resources and services in Smart Spaces. It explains the complexity of the managed environment (Smart Spaces) and extracts what actually has to be managed within a Smart Space. The foundations of network mobility and resource discovery are described. The core of the paper is dedicated to the extension of COPS for service discovery and the integrated approach of the (WIT) M-Zones architecture and the COPS-SD based policy-based management system. Information modelling is realised using CIM.

## **5 Synthesis and Observations**

### **5.1 General Subjects**

Following the observations from deliverable 3.1, the ongoing work in M-Zones still focuses on the integration of management aspects that are normally separated in the control plane and in the management plane. More and more management functionality and intelligence is provided by the underlying network technologies, resulting in the need of a common access to this functionality as well as a common model of this functionality for management applications. The major observations from deliverable 3.1 are still hot topics within the M-Zones research:

- Address converged networks by means of data networks (IP), entertainment, information and telecommunication
- Introduce semantic information for usage and operation of services and systems and provide a holistic view of semantics for administration and maintenance

- Use of adaptive policies for usage, operation and control of services and systems
- Recognise the user as the central point of focus for service and system development
- Provide unified concepts for engineering services and systems (instead of crafting them)
- Offer concepts for modular services that enable (automatic) service composition

Within the last twelve months, the understanding of a Smart Space and an M-Zones has been harmonised among the partners and among the various application domains of the involved researchers. Based on the strawman definition of the basic terminology, the evaluated papers show that Smart Spaces are distinct technical environments with unique characteristics and that a common terminology is essential to understand the complexity of Smart Space management within a Managed Zone. Policy-based approaches and semantic description of management information have been widely adopted. Furthermore, it is understood that static policies are not sufficient for the management of dynamic Smart Spaces, especially when contextual information is available for the management activities. Adaptive policies require that a management system has detailed knowledge, not simply information, about the technical environment. This knowledge has to be communicated between different management systems and ontologies are still the technology to be used for this purpose. This qualifies ontologies to be an integral part of Smart Space modelling and design and, combined with different levels of policies, shows the necessity for establishing a process that uses knowledge to adapt policies according to business goals. The term autonomic computing and autonomic communication has been introduced in some of the paper as one approach for handling adaptive policies.

### **5.1.1 Terminology**

The papers show that there is a common understanding of what a Smart Space comprises and what the complexity of a Smart Space and its management consists of. The terms pervasive and ubiquitous computing are used synonymously, reflecting the common characteristic of both paradigms within a Smart Space. All papers adopt the definition of the straw man paper for a Smart Space and a Managed Zone. Task and adaptivity are re-used as seen in the telecommunication management area. Service composition is dominated by the web-service point of view. Smart service and smart device still lack a common understanding. Service interoperability is mostly viewed by means of common semantic descriptions, not protocols.

## **5.2 Specific Subjects**

Specific subjects cover the individual aspects of work package three as introduced in section two of this document. These aspects cover all three cycles of software engineering by means of development (object models, semantic information, repositories, notations, mathematical methods and tools), execution environment (APIs and core services) and deployment (tools and core services). It is commonly agreed that the engineering of a smart space will lead to loosely coupled components (compared to a monolithic M-Zones system). Here, the object models and the semantic information play the most important role in terms of development. For the execution environment, APIs and core services need to be harmonised. For the deployment of services, tools are the most important factor (but these tools can be domain specific and need not to serve a general purpose).

### **5.2.1 Object Models**

Object models used within the M-Zones research are dominated by web services and CIM and SID, respectively. Classic network and service management models (such as TMN, X.700, SNMP) and new developments (such as SMIng) are not used due to the lack of functionality for modelling Smart Spaces. For the used object models, the underlying paradigm is either ad-hoc, peer-to-peer based or client/server based. The classical manager/agent paradigm is not used in M-Zones. Modelling approaches such as MDA are (still) not considered. It seems to be essential for the next phase of M-Zones to integrate processes for modelling and design, using a certain object model, as the basis for an M-Zone system. First steps toward this have been done in mini projects, which will be evaluated by the next report.

### **5.2.2 Semantic Information**

Semantic information are part of the object model whereas the exchange of semantic information across domains is supported by ontologies. This approach can be seen in a number of papers. Object models are usually related to specific software or system technologies or to particular approaches to standardising interfaces. Ontologies are more suited to capturing and sharing conceptual information, however a dual approach allows the exchange and mapping between models using ontologies provided they have a grounding to a concrete object model of some kind. If a domain uses an object model that does not contain semantic information, this process is difficult if not impossible resulting in the lack of inter-domain management. This leads to the understanding that it is necessary to introduce semantic information within an M-Zone, if possible in the object model, if not in a separate repository.

### **5.2.3 Repositories**

M-Zones uses existing concepts for repositories of management information. Underlying technologies, such as UPnP and Jini provide information about the technical environment. Policy databases handle management strategies and standard databases offer user and application information. For the access of resources, dynamic and multi-source approaches are used. There is no progress for a global naming scheme of repositories or resources, because they are mostly hidden by Smart Spaces and exported by special components. Still, the combination of repository information with the employed object model and semantic information is an important trend that can be seen in the papers.

### **5.2.4 Notations**

M-Zones researchers are using standard notations, whereas XML is dominant to describe resources, preferences and services and policy-languages are dominant for describing management activities. Notations from management frameworks (ASN.1, GDMO, SMI, SMIV2) are not considered in the white papers.

### **5.2.5 Development Tools**

The current white papers do not focus on tool developed. However, they recognise the existence of tools for several modelling techniques (UML), standard IDEs (several JAVA IDEs) and standard tools (e.g. for processing XML documents).

### 5.2.6 Communication services, protocols and formats

Protocols are not a major research area within M-Zones largely because a service-oriented approach to interactions between components has been adopted. The ability to support late binding between service definitions and communication protocols, e.g. WSDL to HTTP, means that design effort is focussed on interface design requiring little custom protocol design. Most development employs standard protocols for the communication between implemented components and move the management functionality to the business process within the components. A management protocol has not been developed. The only exception is the use and the extension of COPS for policy-based management. Here, the given functionality was not sufficient for Smart Spaces. The three important subjects of protocols (data encoding, message format and protocol services) are not considered in the white papers. This might indicate that available protocols are sufficient for the configuration and operation of smart spaces.

### 5.2.7 Mathematical Models

Mathematical models play a subordinate role in the white papers. This might be based on the fact that adopted standards already provide the necessary mathematical foundation (such as seen in XML).

### 5.2.8 Core Services

The evaluated white papers show that security and control services gaining more and more attention within M-Zones. The core services developed are:

- Visualisation services (Ghamri et al, Brady et al 2004a, O'Donnell et al)
- Software deployment services (Ghamri et al, Cummins et al, Carey et al, Lewis et al,
- Adaptive services (Barrett, Davy, Carey et al, O'Donnell et al, Power et al, Murray et al)
- Automated service composition (Davy, Brady et al 2004a, Carey et al)
- Service discovery (and advertisement) (Ghamri et al, Cummins et al, Lewis et al, Power et al)
- Security and admission control services. (Murray 2004a, Barrett, White, Quinn et al)

### 5.2.9 APIs

Beside the availability of these XML APIs (and APIs for handling domain-specific XML documents), no other API is developed or introduced in the white papers.

## 6 Conclusions and Suggestions

The white papers evaluated in this document address a wide range of subjects and domain-specific solutions. The papers represent a mix of work in progress and mature research results from the last M-Zones phase. All developments address the objectives of work package three, whereas research for mathematical models and protocols has the lowest priority and object models (with architectures) and semantic information have the highest priority. Some answers to the questions of deliverable 3.1 can be given:

- What is the underlying metaphor (paradigm) of a smart space that needs to be addressed by engineering managed zones?

The complexity of Smart Space management is understood within different research domains and with specific view points. It seems to be necessary to look at common characteristics of these complexities in order to fully understand the managed area.

- Can we identify a meta model for loosely coupled components that enables interoperability, scalability and portability of these components?

There is no agreement on a common meta-model. Scalability is rarely addressed. Portability is becoming an interesting issue, by means of mechanisms to enable mobile policies and management activities. Interoperability is mainly addressed by the exchange of information supported by ontologies.

- To what extent do we need to incorporate semantic information into object models, repositories and formal notations?

This is still an important research question. It should be addressed keeping in mind that semantic information can also be found in the modelling and design tools employed in the actual process. It is commonly understood that semantic information are essential for an effective management of Smart Spaces.

- What are the novel management functions that are needed to use, operate, control, administer and maintain a smart space and a group of smart spaces?

Management functions have to be portable across domains. This impacts business modelling and makes global (at least inter-domain) naming and addressing of resources necessary.

- What services, protocols and formats must be provided by the underlying technical environment to enable managed zones?

The underlying technologies already provide services, protocols and formats. This question has to be partially re-phrased towards how existing services, protocols and formats can be accessed by M-Zones in order to fully exploit network capabilities.

Some new questions arise looking at the evaluated research papers and the underlying work:

- Will policy-based management be the dominant mechanism for managing Smart Spaces?
- What characterises ‘adaptive policies’, what mechanisms are used to adapt rules and what algorithms are important?
- How is the transformation across different levels of abstraction (ontology, object model, technical environment) organised?

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