M ZONES

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1 Introduction

This document reviews from a WP2 perspective the whitepapers produced in the M-Zones programme at the end of July 2003 and forms part of the programme's research quality assurance process.

The overall goal of the quality assessment process conducted collectively by WP2, 3 and 4 is to provide a mechanism for incrementally improving the quality of the research work conducted in M-Zones. This is performed by guiding the development of a set of research whitepapers towards completion for each co-released WP2, WP3 and WP4 deliverable, of which there are two a year starting from July 2003. This guidance complements that of individual supervisors of researchers, but also through collective peer review of papers, which aims to assess and improve the quality of the resulting research. Specific aims of this process are:

- To provide feedback to researchers on how their research work as presented in the whitepapers can be improved to represent high-quality research work.
- To provide a mechanism for the project, theme leaders, researchers and supervisors to monitor improvement in the research output of individuals, theme teams and the project as a whole.
- To provide an opportunity for individual researchers to be involved in peer-review of research output.
- To provide an accurate view of the progress of individual items of research over the course of the project.
- To provide a mechanisms for selecting whitepaper to be published on the M-Zones web-site
- To help groom whitepapers into a form suitable for submission to publications, conferences, workshops etc.

WP2 is primarily concerned with ensuring that all research work has a clear statement of it assumptions and context, thus providing a high level architectural view of the research from a number of viewpoints, which are described in section 2. Section 3 details the specific assessment criteria used for WP2. Section 4 presents the overall results and observations from the assessment of the whitepaper submitted with this deliverable. Finally, section 5 presents a current synthesis of the work in the whitepapers on requirements and context. This is not an attempt to define an overall view of M-Zone's concepts, but aims to provide a concise feel of the direction in which the research, as represented by this initial set of white papers, is progressing. It should not therefore be interpreted as definitive or prescriptive, but as an aid to an understanding of the project's overall requirements and context and to assist individual researchers within the project in identifying further potential synergies.

2 Requirements and Context

The following assumptions underlie the selected approach assessing research work WP2:

- The Adaptive Smart Space Management problem can be addressed through several different architectural approaches.
- The project needs some level of coherence in the architectural approaches taken across the partners.
- Partners may prefer differing, but equally valid sets of requirements and contexts due to disparate motivating business models, implementation technology selections and research topic choices – the resulting heterogeneity should be exploited in attaining comparative architecture-related results

The following the viewpoint headings used to structure the WP2 assessments. It is likely that initially not all the whitepaper produced will address all of the suggested viewpoints, depending on the approaches taken by individual researchers. For instance technology driven approaches may have little to say initially about business models or reuse of models. Equally a business-driven approach may not yet have resolved technology or notational issues.

1. **Business/Organisational:** This assesses the different types of business organisations and human actors (or business roles) that have a stake in each strand of research. This may include different types of users of smart spaces, operators of smart spaces, providers of services and developers of smart space components. This viewpoint should capture the relationships between these roles, e.g. who buys what from whom, who has responsibilities or obligations to whom, who employs whom etc. Understanding this viewpoint benefits from scenarios capturing the dynamics of relationships between business roles and the distinctness of the roles, in terms of the different benefits they get from the relationships. More depth can be added to this viewpoint by describing business processes involved in the approach, the relationships between the processes (e.g. what signals and information are passed between them) and which business role are involved with which business processes.
2. **Logical/Structural:** This addresses the structure of functional and informational elements of any system following the suggested research. This should aim to support the subdivision of the development of the system into units addressable by different development actors, e.g. between developers concerned with networking, HCI and database system aspects. This viewpoint should also capture the broad structure of any common computing or communication platform upon which intended application components will be developed. Concepts in this viewpoint should be defined in a

manner that is independent of the implementation technology, with the aim being to potentially support multiple technology bindings to these logical concepts.

3. **Technological:** This addresses the binding of elements from the Logical/Structural viewpoint to specific implementation and communication technologies. It should describe the technology or range of technologies applied in following the architectural approach, and the benefit provided by the technological approach taken. Technologies would typically be specific programming languages, communication platforms and protocols. A specific research strand may support more than one set of technology bindings. This viewpoint should also capture the approach taken to mediating between different technology bindings.
4. **Reusable Elements:** This covers any existing models, e.g. service definitions, information models, device profiles, software components, policy/business rules etc, that conform with the research strand and which are available for reuse. Initially this viewpoint will be restricted to references to models from outside the project, but over the project lifetime it may relate to the output of other research strands in the project.

3 Assessment Criteria

This is the first draft of suggested quality assessment criteria to be use when assessing Research Theme whitepapers under WP2. The goals of WP2 are:

- To ensure all the researchers form holistic view of the problem area they are addressing with their research, considering from a number of viewpoints. This consolidated, multi-view description of each piece of research work is what is meant by the "architectural approach".
- To ensure that the architectural approach taken in describing what each piece of research is based on sound reasoning and a good understanding of the relevant state of the art.
- To assemble a shared view of the problem domain addressed by the project in order to encourage consistency and, where appropriate, convergence between the work of different researchers.

This paper suggests how whitepaper authors to help WP assessors in identifying where criteria are addressed. It also suggests some assessment criteria that related to general research quality be used to cover issues that may not fall into specific WP areas, and might otherwise be missed.

These criteria aim to guide work towards a holistic approach that considers the problem from several angles. These criteria therefore seek answers to the 'what?' and the 'why?' of the research work. They are not aimed at assessing the development of the solution taken to the research problem (see WP3 which addresses the 'how?') or the scientific/experimental approach taken to evaluating the solution (see WP4 which addresses 'is it any good?').

Business/Organisation Viewpoint

2.1: Are the beneficiaries of a solution to the problem domain clearly identified, e.g. in terms of specific types of individuals, communities and organisations?

2.2: Are the roles taken by beneficiaries in the problem domain clearly described in terms of the activities they wish to perform, e.g. through exemplary scenarios or more formally through use cases?

Logical Viewpoint

2.3: Are the first class logical concepts in the approach identified and well defined, e.g. networks, services, terminals, tasks, activities, objects, classes, components, processes?

2.4: Are the relationships between first class concepts clearly described?

2.5: Is any overall structural grouping of first class concepts described, e.g. layers?

Technology Viewpoint

2.6: Are any technology selections made clearly reasoned in support of research aims?

2.7: Have alternative technology selections been considered?

2.8: Have known deficiencies in selected technologies been acknowledged and their relevance assessed?

Reuse Viewpoint

2.9: Has the relevance of any existing work, e.g. solution, techniques, standards or research results, that is employed in describing the problem domain been clearly reasoned and the work correctly referenced?

2.10: Has any work relevant to the problem domain been missed, if so what?

4 Quality Assessment

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 WP2 evaluation, though these may not accurately reflect the final drafts of the white papers included with this deliverable due to their ongoing refinement.

Investigating Macro and Micro Mobility in Smart Environments (Barratt and Carroll 2003a) The paper outlines a scheme for integrating the existing mechanisms of mobile IP for macro mobility and cellular IP for micro mobility. The paper envisages the latter being operated by individual smart space operators and the former being operated by organisations such as today's mobile telephony service providers. This integration aims to provide seamless roaming for mobile IP clients. The benefit to existing cellular operators of deploying mobile IP is clearly explained, though the benefit to smart space operators (as cellular IP operators) is not well explored in business terms.

Assurance Management in Smart Spaces (Carey et al 2003a) This paper outlines an architecture for the policy based management of composite services. This aims to allow users and administrators to specify management policies for composite services, in particular related to quality of service assurance. Such composite services may potentially span services provided by separate organisations. This paper outlines an architecture relating composite services, their constituent services, the components that implement atomic services, the policies that manage those services and the underlying component behaviours and information model shared between all these elements. Adoption of DAML-S for defining services and the DMTF'S CIM for the shared information is proposed, though no candidates for the policy model are adopted.

The Components of a Smart Space Platform for Smart Service Deployment (Cawley 2003a) This paper describes some requirements for a service oriented smart space platform and identifies a set of platform services useful for developers of smart space application services. Platform services are identified as: database, presence, profile, accounting, notification and submission services. These seem to be primarily for support of a single organisational domain and the federation of such service between smart space operators is not addressed. CORBA and J2EE services are described and presented as possible means of implementing the smart space platform services, though no concrete mappings are presented.

Service Delivery in Wireless Ad Hoc Networks using Jini (Cummins and O'Reilly 2003a) The paper motivates the use of Jini for smart spaces, but though it mentions its use in wireless service provision scenarios, the benefits are described more from a technical point of view than from that of potential beneficiaries such as service and client software developers or smart space administrators. The process of deploying, discovering and invoking a Jini service is clearly explained, though the issues impacting on the designers of Jini services and clients are not explored very deeply. Through there is some discussion of suitable Java VM platforms for different hardware platforms, in particular wireless PDAs, alternatives to Jini such as JXTA and service brokering or trading platforms, e.g. UDDI, are not discussed.

Characteristics of a smart device and smart device operation (Davey 2003a) This paper presents an outline abstract model for a smart space device, and as such does not address itself to specific business or user problems. The model of a smart space device is clearly broken down into power, communications and state operation components, though details of how these interrelate are not fully addressed. The model aims to be technology independent and no technology binding are suggested. The model presented seems to be based on concepts form the DMTF CIM and possibly some OSI System Management models, but the relationship is not clearly explained.

Beyond the role model: Organisational modelling in policy based management systems (Feeney 2003a) This paper describes a policy based approach to managing the resources and operation of an organisation using community-oriented policy rules. The approach aims to make explicit the responsibility and delegation relationships between groups in an organisation, and therefore directly relates policy-based management to different organisational types. As yet the work focuses on analysing communities within a single organisation rather than the interactions between communities in different organisations, though the explicit delegation of responsibilities between communities should minimise the need for any related changes. This work is currently at the stage of a conceptual architecture with some initial design work presented on the rules for applying PONDER style policies to communities.

Usability of Mobile Devices and intelligently adapting to a User's needs (Green and Finnegan 2003a) This paper describes both usability issues for adaptive user interaction technologies for small profile devices and also the use of an Ambient Intelligence Engine (AIE) which uses concepts from fuzzy logic and neutral net to extract context information from the users use of existing application. The discussion of usability issues addresses problems faced in improving the usability of small profile devices likely to be used in interacting with smart spaces and the use of sonically enhanced keys as a solution. The AIE is presented in more detail, giving an outline of the node and connection weighting model used to build a picture of a user's application usage. The AIE provides an API to allow application developers to build and query such a model. Implied in this paper is the notion that context information gathered by the AIE may be use adaptive interaction techniques, though this needs to be explored further.

Policy based Admission Control across heterogeneous wireless networks (Murray and Pesch 2003a) This paper presents a scheme for policy based admission control of roaming users to wireless networks of different types, including GPRS, WLANs and UMTS. The paper also touches upon the use of policy-based selection of networks by user terminals. The paper adopts the IETF policy architecture and describes the policy parameters that form the major characterisation of the problem, e.g. network condition, handover latency etc. It describes how policy decision points and enforcement points would be placed in the mobile station and base station to support policy-based admission control and network selection, though only admission control is the subject of the further experimental work presented.

Present and Future Organisational Models for Wireless Networks (O'Connor and van der Meer 2003a) This paper provides a discussion of the potential ways in which business models for the provisioning of wireless networks may evolve, with particular emphasis on the integration of cellular (GSM) and wireless LAN provision. The paper outline some of the issues involved in such integrated service offering including the need for reasonable cost models, end to end QoS management and attractive applications, though it does not address fully the challenge posed by roaming between free access WLANs and peer to peer wireless communications.

Towards a Natural Interface to Adaptive Service Composition (O'Donnell et al 2003a) This paper presents a scheme where inference of user intent from multimodal sensor input is use to drive a service composition engine, which utilises pre-existing service composition patterns. The primary beneficiary is the smart space user, who is able to request service in a much more natural manner, e.g. through speech or gestures. As well as accepting input from sensors monitoring the user, the intent inference system is also structured to accept input on context systems, user schedules and historical information of previous inference attempts. This work also identifies the need for a well defined model for specifying the tasks that are generated by intent inference and passed to the service composition engine. This may for the basis for an open task model that can be used to provide vendor independence between these two solutions. The service composition engine assumes a service-oriented architecture that allows constituent services to be provided by different organisations. This approach addresses the specification of service composition patterns in an open manner, such that they can be developed and then reused by separate parties. Currently this work is at an analysis stage and no concrete technology selections have been made, though a service oriented architecture is assumed as the underlying infrastructure, e.g. web services.

Semantically Driven Service Interoperability for Pervasive Computing (O'Sullivan and Lewis 2003a) This paper examines the scale of the interoperability problem faced in ubiquitous computing and suggests that conventional, standard-based approaches to interoperability will prove insufficient in addressing this. Instead a more dynamic approach to interoperability is proposed, based on the composition of service oriented architectures and explicitly modelled semantics using ontologies. A roadmap is presented showing the impact of this approach on smart space service users, developer of atomic services and those who compose services. Specific issues in terms of engineering semantic services and dynamic service interoperability are discussed. The former is presented in general terms only but the technology selection of topic maps and XSLT are given for the service interoperability solution.

Topic Maps for Context Management (Power 2003a) This paper proposes the use of topic maps to provide a unifying layer for the seamless querying and monitoring of context information from multiple sources. The approach assumes that context information will come from a wide number of sources and be used by applications from a wide number of sources. Different sources of context information may structure that information in different way, but this approach proposes using topic map representations of differing meta-data to facilitate their merging and to provide a common mechanism for querying them, aggregating low-level context data, supporting access control and assigning degrees of confidence to context information. Little is presented yet in terms of API functionality for the developers of context-aware applications and the internal structure of the proposed context management service.

Ultra Wide Band Communication Literature Review (Rulikowski 2003a) This paper presents a literature review of UltraWideBand (UWB) radio interfaces, addressing a number of technical issues in the design of and experimentation with UWB as radio interfaces for peer-to-peer sensor networks. This is motivated by UWB's good indoor propagation, power efficiency and awareness, three dimensional tracking capabilities, high data rates and resistance to eavesdropping. This work does not yet proposed a specific solution, though several problems related to UWB implementation are identified.

Technologies for Engineering Smart Spaces with special focus on integration of middleware and management; Middleware and Management Standard Bodies and Standards; Middleware and Management Concepts, Characteristics, and Integration (van der Meer 2003a, b and c). These papers provide a tutorial style review of distributed system and management technologies, primarily those that have undergone some form of standardisation. It covers the work of the DMTF, TMN, ODP, IN, OMG, TM Forum, TINA-C and W3C (van der Meer 2003b), addressing issues related to the engineering of management system such as models, interfaces, protocols and services (van der Meer 2003c). (van der Meer 2003a) described different approaches to addressing these issues in middleware suitable for management systems. Though these papers provide excellent tutorial material, they do not yet relate themselves to the specific problems of adaptive smart space management.

5 Synthesis and Observations

The following sections outline some initial observations on common or parallel threads identified to date across these white papers within the WP2 area.

5.1 Business Viewpoint

A number of business models are adopted in this body of research and can be split into two broad approaches. The first addresses smart spaces operated primarily by the owner of the containing premises, primarily for the benefit of people working in or visiting those premises. These tend to centrally funded schemes, where little consideration is needed of charging individuals for their use of the smart space. Such solutions tend to be based WLAN technology. The second approach tends to focus more on the provision of access networks across a number of smart spaces by a specialised access network provider. This tends to be a more commercially-oriented approach, with users being charged for wireless access network usages and also, potentially for the use of application services via that network. This model relies on an integration of WLAN with cellular, primarily 3G technology. (O'Connor and van der Meer, 2003) address some of the tensions between these two model, especially those caused by the high cost differential between 3G and WLAN in the consumer-funded models, and the resulting competitive problems involved in co-existing with the centrally-funded model in the same space. This paper points to the close integration of value added services with tight QoS assurances as being the way forward in justifying wireless access charges in the consumer funded model.

5.1.1 Multi-Provider Service Provision

Underlying all of the white papers is an acknowledgement that at any point in time the service provided to the user of a smart space must consist of services from a number of providers. The differences in the business models used to address this centre on the roles played by whoever is providing local wireless access service. The papers that specifically take a service-oriented approach, by allowing several services to be used together, implicitly support service integration across providers. However, technological issues have an impact here, since while a WSDL/SOAP approach makes the difference between access service in the local domain or in external domains fairly transparent, this may not be the case for Jini (Cummins and O'Reilly 2003a). The problem of matching semantics between information originating from different providers is addressed in relation to context information in (Power 2003a) and for service descriptions in (O'Sullivan and Lewis 2003a).

5.1.2 Development Business Models

Understanding the business motivations of those involved in developing the various components, infrastructure platforms, services and applications of smart spaces will be vital. This is reflected in many of the white papers, primarily in the manner by which different platform and application components interact, e.g. through the sharing of service specifications, APIs, policies, information models and ontologies, all of which are discussed to various extents below. No common model of development related roles has yet emerged, though we could expect such roles to include:

- Smart space device developers (e.g. of sensors, actuators, embedded processors, laptops etc).
- Application service developers.
- Infrastructure developers (e.g. of wireless networks and distributed computing platforms).
- System integrators (often conducting service composition activities).

- Developers of community agreements on service descriptions, policy vocabularies and information models (including ontologies), e.g. international standards bodies, industrial fora and application specific interest groups.
- Smart space administrators (deployers of devices and services and authors of policy rules).
- Smart space users.

A roadmap is presented in (O'Sullivan and Lewis 2003a) of how certain development roles will evolve with the emergence of semantic service definitions and their use in automated service composition. This envisages system integrator roles becoming increasingly redundant, while smart space users play a bigger role in defining and managing the automatically composed services they require. The role of smart space device developer will become increasingly similar to application service developers, while both role will have increasing involvement in developing shared design time and runtime knowledge in their domains.

5.2 Logical/Structural Viewpoint

Overall, apart from tendencies to adopt a service-oriented and policy-based approaches in several whitepapers (see below), no strong architectural concepts have yet been identified that satisfactorily address the whole range of issues of concern to the project. The following subsection address some common threads that have emerged.

5.2.1 What is Adaptive Smart Space Management ? – the Logical Service/Management Separation

The issue of how to characterise the logical separation between service capabilities and management ones do not seem to be adequately addressed in these white paper, indicating that a clearly defined separation may be difficult to define given the range of functionality and the dynamism of services and networks in this domain. Separations based on user roles, with functionality being used by the end user being classified as 'service' and those used by administrators being 'management' become blurred as we aim to give the user more control over the behaviour of the services they use. The functionally based separations used in the telecommunication industry become less useful as smart space encompass centrally funded as well as commercial services and as the mix of ownership of resources in an instance of service usage become more complex. (Carey et al 2003a) implies a separation based on service composition specifications defining the service and policy specifications defining the management, but such separation based on the software implementation technology used will frequently conflict with user's perception of what are service concern and what are management concerns. (Davey 2003) defines both state based and service based mechanism for interacting with smart space devices, which are reminiscent of management and service interfaces respectively in telecommunications system. However no such functional separation is claimed. For the time being, therefore, we will restrict ourselves to saying that Adaptive Smart Space Management is the study of the mechanisms that make adaptive behaviour in smart spaces possible.

5.2.2 The Service oriented approach

Several papers adopt a service oriented approach to providing useful functionality to users in space spaces. This is primarily motivated by the fact that local capabilities and user needs will

vary so widely as users move from space to space that stand-alone applications will not be able to adapt sufficiently dynamically. As argued in the (O'Sullivan and Lewis 2003a), the required adaptive behaviour will provided by the dynamic composition of available services, automated by using machine processable semantics of the constituent services. (Carey et al 2003a) uses this assumption to argue that QoS assurance of user services in smart spaces requires QoS assurance of composite services. (O'Donnell et al 2003a) place dynamically generated composite services as the disposable output of adaptive service generation mechanism that interprets user intent. (Cawley 2003a) discusses a service oriented platform for developing smart space applications while (Cummins and O'Reilly 2003a) explores in more depth the use of Jini as a mechanism for providing access to service-oriented capabilities in an ad hoc wireless network.

5.2.3 Policy based Adaptivity

Policy-based techniques have been widely applied to the management of networks and to access control for computing resources, however their flexibility in changing system behaviour at runtime has promoted their adoption in several of the adaptive solutions suggested. (Feeney 2003a) proposes that policies enable the evolution and management of organisational operation, with community-oriented policies adopted to overcome the deficiencies of existing role-based management approaches. (Murray and Pesch 2003a) propose the use of policies for both access control and network selection as users roam between wireless networks of differing types and capabilities. (Carey et al 2003a) proposes that policy rules are applied to a QoS management for composite services and then refined to policy rules that correspondingly effect the behaviour of the constituent services. This latter work may provide some interesting insight into the links between the service-oriented approach and the adaptivity promised by service composition and adaptivity provided by policy-based management.

5.2.4 Standardised Interoperability, Shared Knowledge and Adaptivity

As agued in (O'Sullivan and Lewis 2003a), the explosion of functionality and integration implied by ubiquitous computing may cause interoperability based on standards to become insufficient. This issue can be characterised by the amount of common knowledge needed by two pieces of software to interoperate and cooperate on a task that must be exchange between their developers of that software at design time and how much can be exchanged between the software at runtime. Adaptive techniques place an increasing emphasis on the latter, with reflection, i.e. the exchange of meta-information, being an important feature of the service-oriented approach. This is visible in the emphasis on the publication and exchange of service descriptions (O'Sullivan and Lewis 2003a)(O'Donnell et al 2003a)(Cummins and O'Reilly 2003a) and policy rules (Carey et al 2003a) (Feeney 2003a) (Murray and Pesch 2003a).

5.3 Technological Viewpoint

The set of white papers encompasses an impressive array of technologies relevant to smart spaces spanning the communications and application layers.

5.3.1 Mobility across Heterogeneous Networks

A key feature of this project is its aim to address the mobility of users between smart spaces, which inevitably entails the mobility of user between different types of network technologies and wireless networks in particular. (O'Connor and van der Meer 2003a) addresses the

resulting business issues involved trying to integrate the high operating and licensing cost of the cellular network with the low operating costs and dispersed ownership of wireless networks operating in the unlicensed bands. (Murray and Pesch 2003a) addresses the resulting problem for dynamic complex decision making needed for both admission control by service providers and network selection by service users. (Barratt and Carroll 2003a) address the problems of combining wide area and local area wireless IP networks where different techniques for IP address allocation and resolution are used. These whitepapers all address provider operated wireless network, however equally important to smart spaces are ad hoc and peer-to-peer wireless networks. Service location over such network is addressed in (Cummins and O'Reilly 2003a) while UltraWideBand technologies suitable for future, high density peer-to-peer wireless networks is reviewed in (Rulikowski 2003a). It is worth noting that the explicit protocol binding that is a key aspect of the service-oriented approach, makes this application level architecture amenable to a wide range of underlying network technologies. However, the differing QoS, reliability and connectivity characteristics of these different network technologies cannot be made completely transparent to the service-oriented application layer

5.3.2 Service and Component Technologies

The service oriented approach assumes that service functionality will be implemented from a wide range of sources. This is similar to assumptions of component-oriented software development, as a result of which many application component platforms seamlessly incorporate service-oriented features. (Carey et al 2003a) discussed how the management of service compositions is ultimately mapped onto the management of components implementing individual services and the underlying component platform (or container). (Cawley 2003a) discusses the use of both CORBA and J2EE conformant platforms as sources of the services required for the proposed smart space application platform. (Carey et al 2003a), (O'Donnell et al 2003a), and (O'Sullivan and Lewis 2003a) all discuss the use of WSDL/SOAP/HTTP as the service delivery mechanism, though it is useful to note that WSDL can be bound to other application protocols. (Davey 2003a) suggests a model for a smart space device that bears many similarities to a service offering component, though specific technology bindings are not presented.

5.3.3 Knowledge Representation Technologies

As discussed previously, most forms of adaptivity examined in these whitepapers involve the exchange of machine processable knowledge between software entities at runtime, including service definitions, policy rules and shared information models. While such exchanges aim to reduce the dependence on the knowledge that must be exchanged at design time, it does itself require standardisation on how to represent knowledge. XML has provided a strong grounding for such knowledge language standardisation, and its usage is indicated in numerous whitepaper for various types of knowledge representation. However, to enable machine processing of the semantics of shared data (i.e. to move from data processing to knowledge processing) requires structuring information using common ontological principles so that reasoning can be performed on relationships and constraints between concepts and that concepts from a wide range of existing ontologies can be exploited in this. Several white papers make use of ontology based knowledge representation. (Power 2003a) proposed using Topic Maps to dynamically form ontologies of context information to assist in the querying and maintenance of such information. In (O'Sullivan and Lewis 2003a), Topic Map representations of services are used to automatically generate interoperability gateways between services with differing semantics. In (Green and Finnegan 2003a), knowledge on

users' application usage patterns is captured in a node-connection format similar to Topic Maps, but with fuzzy logic style weighting allocated to connections. (Carey et al 2003a), (O'Donnell et al 2003a) and (O'Sullivan and Lewis 2003a) all suggest using semantic service descriptions to aid various aspects of service composition in smart space. As management information models form an existing application specific body of knowledge as described in (van der Meer 2003c), their use in some whitepapers is significant, especially the DMTF Common Information Model which is used in (Davey 2003a) and (Carey et al 2003a). DAML-S, which is a semantic service description language built on the DAML+OIL ontology language, is seemingly the primary candidate here. Finally, rules are a further bit of executable knowledge that may be exchanged and processed at runtime. Currently, rules are mostly visible in the form of policy rule which have their own specialised languages such as PONDER as mentioned in (Feeney 2003a) and the IETF rule schema used in (Murray and Pesch 2003a) and (Carey et al 2003a).

5.4 Reuse Viewpoint

As with all sound research, these whitepapers make strong use of existing research results and use the presence of existing systems to some extent or other in defining their individual problem domain. However, there are few common threads emerging at this point in the selection of common implementation technologies, protocols or distributed processing platforms. This is not of to great a concern since the focus on open mechanisms for knowledge representation described above leave much potential for interoperability between applications, while the almost universal use of in IP networking layer offers a variety of options for network interoperability.

6 Conclusions

The white papers accompanying this deliverable address a wide range of issues related to the project problem domain. Though much of the work is at an early stage many of the WP2 criteria have been well addressed, allowing us to identify a number of interesting research questions, answers to which may emerge across the project in addition to the specific topics pursued by individual researchers. A selection of such questions are:

- How can commercial mobile service providers use the integration of quality of service and novel applications to attract subscribers to use the unlicensed band in the face of free access competition?
- How does peer-to-peer and ad hoc networking impact on the design of application services?
- How can runtime bindings between services and different network types be effectively configured?
- How can knowledge be easily shared between individual developers and between software entities to avoid the constraints of slowly developed standards while encourage enough conceptual convergence to avoid a chaotic body of reusable knowledge?
- What level of commonality is possible or useful between knowledge-based representations of services, shared information and behavioural rules?

7 References

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