

M-Zones Programme Work Plan

Proposal for Restructuring

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Section 1: M-Zones Work Plan

1.1 Changes to Work Plan

A review of the programmes work plan was conducted mid-way through the first year and several changes have been made. These are intended to support the progression of work in the form of a coordinated research programme rather than in a system development style waterfall model favoured by the previous work plan. The new work plan therefore focuses on supporting the research work of individual researchers through project-level knowledge sharing and peer-review of work, exposure of work to researchers outside the project, coordinated comparison and refinement of core research concepts and coordinated support for experimental platforms, through both implementation test beds and simulations.

Broadly the changes in emphasis are:

- Work packages have been restructured with a focus assuring high quality of research activities.
- Research Themes that cover the scientific challenges have been promoted to provide the primary means for coordinating research work in specific sub area of the project.
- Research topics, defined and pursued by individuals or small groups, provide the fine-grained structure that help the structuring of Research Themes.
- The structure of the Research Themes will be periodically reviewed (at least annually) to accommodate changes to the body of Research Topics and in the state of the art at that time.

Specific changes to the work plan are:

- WP 2, 3 and 4 have been redefined, WP6 has been dropped.
- WP0 and WP1 remain largely unchanged, as has WP7, which is now relabelled WP5
- WP2, WP3 and WP4 now report together twice a year in a coordinated deliverable.
- Full plenary meetings are restricted to four times a year. Two meetings will be associated with the joint WP2/3/4 deliverable reporting (one of which will also coincide with the annual report). The other two will be workshops for detailed presentations of work conducted, plans made for individual research topics and themes and will also provide a forum for researchers to identify synergies between their individual projects and facilitate the forming of work collaboration to leverage the opportunities provided within the interdisciplinary team. At least one of these workshops will involve external participants.

The current work plan and any changes will be presented every year in the annual report.

1.2 Overview & Strategy

1.2.1 Overview

The M-Zones Research Programme plans to develop novel **information and communications management technology** to support **dynamic, integrated management of participants, information appliances, and smart space**

infrastructure. The M-Zones Research Programme is a multi-disciplinary, inter-institutional research programme that will engage in fundamental research in **Management and Control systems for integrating Multiple Smart Spaces¹**. This research programme advances the existing long established (10 years) research collaboration between the research team leaders at WIT and TCD and also the recently established collaboration between the research groups at WIT and CIT. The result is a major programme of interdisciplinary research collaboration between the three participating institutions in order to achieve the programme goals. The technical background and expertise of the participants is ideally suited to achieving the goals set by the M-Zones research programme.

The programme research themes of Management and Control of Networks and Information Services, Inter Domain Collaborative Management, Smart Space Technology, Wireless Devices and Network Design are already well-established research areas of the M-Zone research team. The individual research groups and their members have been involved in a large number of national and international research programmes funded both by the European Union, national government and industry. As part of previous and ongoing research programmes the participants have worked collaboratively with research teams both nationally and internationally and are highly regarded in their research communities.

The programme also has the support of two leading smart space research centres, namely FhG-FOKUS in Berlin and BT Research Labs in UK, who will act as external collaborators in the M-Zones programme. Each of these institutions has proposed formal collaboration agreements for the M-Zones research programme and have previously collaborated with the M-Zones partner Universities/Institutes. These external collaborators have been chosen for their complementary research expertise and focal interest.

The Research Challenge

Current research has focused on applications within individual Smart Spaces. Such 'smart' applications would include novel interaction/communication mechanisms like AT&T's active badge project, which investigated context aware computing platforms, or technologies to support individual 'smart' services e.g. cyber meeting spaces, image recognition, eye tracking etc. [ATT, BT, NIST]. However, these single, isolated smart spaces are of limited benefit. ***The real challenge is to enable the dynamic integration of smart spaces, which enable mobile people and devices to roam across such spaces whilst maintaining communication and information services.*** Mobility is a defining factor of the way people are working and living today. Thus supporting seamless roaming of both users and devices, between different administered/owned smart spaces will help enable the true benefit of mobile working. The ability to dynamically integrate private (e.g. within a home or office), semi private (e.g. within public transport vehicle, library) and public (e.g. park, square) smart spaces is a key element in realising effective mobile working and living.

The major problem for the realisation of Integrated Smart Spaces is the lack of an open management infrastructure within and between such smart spaces. DARPA (Defence Advanced Research Projects Agency, USA) has singled out the (network) management problem inherent in managing smart spaces/embedded systems as the most important challenge facing telecommunications service managers for the next decade. The latest prediction for the Internet is that Information Appliance (e.g. palmtop computers, Internet enabled mobile phones) sales will outnumber Computer sales by 2002. In the world today ONLY 2% of all processors are currently network addressable, 98% processors are embedded! It is these embedded processors, which will be the information sources within smart spaces.

¹ **Smart Spaces** are environments with traditional computing hardware as well as embedded computers, information appliances, and multi-modal sensors allowing people to perform tasks efficiently by offering unprecedented levels of access to information and assistance from computers.

1.2.2 Goals of M-Zones Research Programme

The overall goal of M-Zones is to:

Undertake fundamental research into novel management infrastructures to enable collaboration and management, between and within Smart Spaces.

Within the overall goal of the programme, M-Zones will:

- Take a holistic view of Smart Space Management by representing them as Managed-Zones (**'M-Zones'**), which encompass one or more smart spaces and the context of these spaces e.g. participants, information resources, time, IT infrastructure etc. M-Zones represent domains of management in which Smart Spaces can be managed and between which participants/devices roam and dynamic service provisioning can be supported.
- Provide insight into the infrastructures and technologies to provide dynamic, real-time management within and between M-Zones.
- Adopt a 'policy-based management approach' to support dynamic monitoring, configuration, control and co-ordination of these management zones. The management systems will be particularly sensitive to unique properties of smart spaces including: large-scale numbers of embedded processors/information appliances, mobility, wireless communication, temporal properties and the potential for 're-programming' of the smart spaces.
- Develop a Smart Space management framework based on standards and best practice from both the Telecommunications and IT standardisation work such as TeleManagement Forum, Object Management Group, ETSI and ITU telecommunications standards.
- Foster close collaboration among the research groups, which comprise experts in management & control systems, smart spaces, wireless systems and networks.
- Enable exchange of researchers between sides and foster external collaboration with international centres of excellence.

1.3 Research Programme Description

1.3.1 The Research Challenge

Smart Spaces

Many groups working on smart spaces have focused on supporting single applications in intensively instrumented spaces, reducing many of the management problems, which arise only from more general scenarios. The MIT Media Lab, for example, has conducted extensive work on highly enabled spaces for children (*KidsRoom*); INRIA with smart offices (*INRIASmartOffice*); the University of Reading with invisible building control (*WarwickImplants*); and (interesting for being an outdoor system) a group at the University of Lancaster with an electronic context-aware tourist guide (*TouristGuide*). All the major corporations are also active in this applications area, with major initiatives being announced by (amongst others) Sun, Microsoft, Ericsson, Nokia, Orange and Intel.

Such spaces have significantly simpler management requirements than the general case in which we are interested, since it is possible to constrain the nature and behaviour of the devices in the space very closely. The general case — where the population of devices in a space is highly dynamic and largely unconstrained — opens up major research challenges. Without a structured approach to management these challenges must be handled ad hoc by individual architectures or applications — a phenomenon we may observe in a number of current projects building smart-space infrastructures (*ContextToolkit* and *MetaGlue*).

More interestingly, the behaviour of devices in a smart space is affected by a number of factors not directly related to the devices concerned but rather determined by the use of the space in terms of task allocations and architectural morphology. Knowledge about the tasks undertaken within a space can be used to inform management decisions about what devices are likely to appear and the anticipated requirements (*CoenStopWorrying*). Equally, the way in which an architect designs a space (or set of spaces) radically affects the movement potential, communication patterns etc. which are possible within it (*SpaceIsTheMachine*). This makes managing the smart space a major challenge in holistic systems engineering as well as in telecommunications.

Management

The development of an agreed set of standards to support the management of telecommunications networks and services has been a major objective of the telecommunications community since the early 1970s. Telecommunications management may be defined as supporting the operation and maintenance of networks and services.

Today's telecommunications management systems are required to:

- Support the interoperability of systems from a hierarchy of network and service providers, service brokers and application service providers. Service provided to the end customers are realised from a combination of service offerings from these different players.
- Support the co-existence of Internet based services next to traditional telecommunications services.
- Support customer roaming and customer service and service provider selection.
- Support the development of Customer Service Level Agreements and Policy management systems.

A major problem with the interconnection of smart spaces is the lack of a Smart Space management infrastructure. The choice of telecommunications management as the basis for the development of M-Zone management solutions is based on the similarity of requirements on the stability and maturity of today's telecommunications networks.

Wireless Network Management

The state of the art of wireless communications management can be described along two lines, that is management protocols and wireless network technologies. Two primary protocols are currently used to implement network management functions, the Common Management Information Protocol (CMIP) and the Simple Network Management Protocol (SNMP). CMIP is an all-encompassing management standard with wide use in telecommunication networks and demands significant processing capabilities restricting its use to more powerful network nodes. The Internet-based SNMP is a lightweight protocol, which makes it suitable for implementation on nearly all devices. Its success in assisting the dramatic Internet explosion has led to its adoption for next generation wireless networks. Mixed management of SNMP and CMIP networks and achieving a common view across these technologies is currently an area of significant research interest. A more recent initiative from the Distributed Management Task Force (DMTF) proposed the use of Web and XML technologies for the modelling and management of networks and applications. However, this work is still maturing and has not addressed the issues of smart spaces and wireless networks

Wireless network technologies include cellular and personal communication networks, wireless local area networks (WLAN), and short-range wireless mobile ad-hoc networks (MANET). The management requirements between cellular networks and WLANs and MANETs are quite distinct. Cellular networks are installed in a planned fashion and controlled by a single network operator, whereas WLANs and MANETs are often installed by their respective users in an ad-hoc fashion. This creates the design requirement that these systems can operate and be managed in a distributed and self-organising fashion. This requirement for self-organisation and self-management without human intervention is a major focus of research in wireless systems management (*IETFmanet*, *IETFdesman*). Within this context, radio resource management is of critical importance as a system's frequency spectrum is limited and therefore has to be managed in an efficient manner in order to allow many users to use the system simultaneously while still maintaining the guaranteed quality of service. Location management is a further vital aspect in all wireless networks due to the mobility of users. It is therefore significant to the objectives of the M-Zones programme as delivering telecommunications services to mobile users across smart spaces is highly location dependent. Within this context, location management makes use not only of the wireless communication system infrastructure but will also utilise technologies such as GPS and sensors.

The scope for research in the area of wireless communication management within the M-Zones programme will address the need for self-organisation and self-management of wireless systems. The research challenges are to provide homogeneous management across a range of functionally distinct wireless communication system architectures, ranging from GSM and UMTS to Bluetooth, and wireless networking configurations from planned cellular networks to self-organising wireless ad-hoc networks; to develop management functions, which can facilitate end-to-end quality of service across heterogeneous wireless communication systems while users are on the move as well as to manage efficient sharing of the limited frequency spectrum among a large number of wireless devices from smart cell-phones to wireless multi-modal sensor; and to develop management algorithms that can be implemented on wireless devices with battery power restrictions and limited processing capabilities.

1.3.2 Research Programme Approach

The programme takes an approach that directly supports the development of high-quality individual research while ensuring productive collaboration between researchers. Research Themes will be used to focus research activities along axes where most collaborative synergy can be obtained. Work packages will be used to coordinate the expression and understanding of common concepts and the development and sharing of processes, tools, software and other experimental infrastructure such as implementation testbeds and simulators.

A rolling state of the art survey will capture the management requirements for Smart Spaces and the technological and scientific development that show promise in addressing them. Scenarios will be used to elicit requirements and to focus research activities, including evaluation. Scenarios will be developed with particular focus on the Home, Work and Educational Smart Spaces. The objective is to identify a set of common requirements for each of these Smart Spaces with a view of mapping these requirements to telecommunications management requirements and appropriate management solutions. The objective is the application of best practice from telecommunications management standard solutions for the development of initial management architecture.

A number of scenarios will be developed to support the identification of requirements for inter-domain communication between Smart Space domains. The development of prototype implementations (test beds) is envisaged to gain competence, industry recognition, and identify the standardisation and measurement issues in pervasive computing.

The programme will establish Smart Space test beds at WIT, TCD and CIT. The programme will minimise duplication of effort by developing test-bed resources and resource themes that build on the established expertise within the institutions. The focus of the TCD team will be on Education Smart Spaces and Information Management, WIT will emphasise the management of a Workplace Smart Space and issues associated with performance and security, while the emphasis in CIT will be on the management of wireless communications and Smart-Space in the home. The test beds will be linked providing access to results from each site.

Access to expertise will be shared through the establishment of joint research teams comprising of staff and students from each of the test sites. This will provide shared access to the test-beds and the sharing of expertise across the three locations. It is also proposed that research students from each of the three research centres will perform part of their research work at the other centres.

The work programmes for the test-beds will be developed jointly to ensure maximum co-ordination between the research centres. A number of joint trials will be planned particularly in the area of inter domain management.

1.3.3 Research Programme Themes

The M-Zone research programme is structured into a number of research streams, which are described here as research themes. These research themes represent the main scientific and technical issues to be addressed in the development of ubiquitous management for smart spaces. Ubiquitous management serves as an umbrella for investigations targeting the integration of separated or already converging technologies. This includes network connectivity and configuration, managing a smart space, and interoperability and co-operation between M-Zones. The research themes are intended to provide concepts and solutions for the usage, operation, control, administration, and maintenance of smart spaces, in other words the establishment of managed zones.

The research themes, enable researchers from the three partners to interact and cooperate to particular research topics and scientific challenges without the strong boundaries of formal work packages. In the current stage of the project, we have identified three major research themes. These themes will be reviewed and if necessary revised within the

project life cycle in order to adapt them to the developments of the international research community. On the other hand, these themes can be used as an instrument to influence international research activities. Therefore, researchers from the international collaborating research centres will also contribute to a number of the research themes.

The identified research themes are the following:

- Managing Dynamic Environments (lead partner CIT)
- Adapting to a User's Needs (lead partner TCD)
- Seamless Engineering of Open Smart Spaces (Lead partner WIT)

Managing Dynamic Environments

The focus of managing dynamic environments theme is to develop a framework for the management of dynamic environments where different technologies inter-work to give smart connectivity to users, user applications or devices. The theme will be driven by concepts broadly in the areas of policy-based management, context aware computing and networking technologies. Scenarios demonstrating the application of smart environments will be developed in theory and possible implementations thereof will be investigated.

The objective of the theme is not limited to development of architectures to deliver Internet connectivity to users. It extends beyond conventional connectivity in that it aims at providing not just connectivity, but communication, between devices that users encounter in their day-to-day life. The environment needs to be aware of what the user wants and also what it can deliver. It should be able to receive and analyse the feedback it receives from the user. The feedback should enable the environment to decide if its analysis of the needs of the user was correct. If the analysis of the user needs was inaccurate, then the environment should learn and improve on its knowledge of user needs. To achieve this, sensors, processors and actuators will need to be embedded in everyday products and devices. An Ultra WideBand (UWB) transceiver system is being designed and implemented as a system on a chip that will offer the possibility of interworking the millions of sensors that will be used to provide information about the environment. There will also be a need to design interfaces, using which, the user will be able to interact with its environment. The interfaces will need to be simple to interact with and may have the capability to understand speech, actions etc., though the active interaction from the user side is aimed to be kept at its minimum. The interface will adapt to the user's context, learn through use and automate trivial tasks. The current theme on managing dynamic environments will have an interaction with theme 1 which focuses on adopting to users' needs and will be able to define and design such interfaces. The environment will need to hold information about its users and structure it so that the data collected from one source can be reused for a separate task, thus narrowing the gap between what it offered to the user and what the user actually wanted.

The support for smart environment will be enabled by intelligent software and involve using a heterogeneous network of devices with varying levels of intelligence. The network medium will be both wired and wireless. Many communication technologies like bluetooth, WLAN, UMTS etc. will have to be used depending upon the environment. For example, appliances may communicate with each other using bluetooth, while WLAN could be used to give the user high speed connectivity to the Internet when the user is near a hot spot or, using UMTS if WLAN is not available.

The theme will also investigate the impact of the high volume of traffic that will result from the environment aiming to provide advanced context aware services to its users. Research on network specific issues like intelligent call admission control strategies will enable the environment to choose, for example, the air interface to use when more than one are available. Such decisions, whether network or environment initiated, will need to take into account the network perspective as much as the user perspective, for the network to operate efficiently. The analysis of these issues will also be based on network specific strategies such as call admission control, which the network could decide using policy

based rules.

Adapting to a User's Needs

This theme investigates techniques and models that support the autonomous adaptation of systems to match user needs to available service capabilities and the current context. Autonomous adaptation by system is essential in smart spaces, where the user's context and the operating environment are constantly changing due to movement of the user, movement of the user's peers and volatile load and connectivity characteristics. This theme focuses on aspects of adaptivity that are driven by implicit rather than explicit direction from the user and which therefore need to rely heavily on context information and learnt user patterns.

Mechanisms for adaptation may reside within a single software application, however smart space users will often not have continuous access to a stable, fully functional set of applications, and will have to work in environment with disparate sets of available application functionality. One way this functional heterogeneity is addressed in this theme through taking a service-oriented approach. This involves modelling and accessing of application functionality through well defined interfaces expressed in a common format such as the Web Service Description Language (WSDL), which despite its name is compatible with protocols in addition to HTTP. A service-oriented approach allows for the dynamic assembly of available services into composite services that may be designed on the fly to meet current user needs.

Service interfaces at the level of WSDL provide only syntactic interoperability information. For services to be involved in any autonomous adaptation they must expose richer semantic information about the functionality they offer, in a form that can be exchanged and reasoned about by automated reasoners and other forms of adaptive agents. Many previous efforts to model such semantic have suffered a focus on one domain and hence a limited scope of applicability. The expansive array of user tasks and application domains that can benefit from smart spaces requires an approach where domain specific models are not restricted by implicit assumptions. The use of ontologies is therefore of interest in this theme, since they provide taxonomical information on a domain accompanied by inference rules which can be used reasoning agents.

The context in which adaptivity is performed is of vital importance in ensuring adaptive behaviour accurately reflects the user's needs. The interpretation of user actions is highly dependent on a good understanding of the context in which those actions are performed. Context can also be historical, based on past user behaviour and feedback from users on related adaptive actions, thus allowing adaptive systems to improve their accuracy through learning. As context information must present a view of the real world, this is an ideal area to exploit the ability of ontologies to model aspects of the real world.

The management of adaptive services is addressed in the theme "Managing Dynamic Environment", which addresses the mechanisms for exerting explicit human control over the collective behaviour of adaptive systems and the technological mechanisms that support them. The engineering concerns related to the development of adaption-ready services and the ontologies which they use are addressed in the theme "Seamless Engineering of Open Smart Spaces".

Seamless Engineering of Open of Open Smart Spaces

As Managed Smart Spaces are interconnected, the challenge is to ensure that a seamless flow of users (people and devices) across the Smart Spaces is provided to give seamless M-Zone interoperability. The creation of such an environment is a major challenge for the future direction of smart spaces.

At present, the smart space research community has not addressed the issue of smart space interoperability. However, the telecommunications management community has addressed in considerable detail the issue of inter-domain management systems for co-operating management domains. Analyses of the requirements for the creation and

management of such interoperability/co-operation may be discussed in the context of the functional areas of fault configuration accounting, security and performance. While there are important differences between the systems, the telecommunications management approach is a valid starting point for the development of solutions for the seamless interoperability of M-Zones.

Security Requirements: All smart spaces and the information contained therein must be managed against unauthorised access and manipulation through the application of an appropriate security policy. Users entering the M-Zone must be validated and requests for access to information must be authenticated.

Information Management: The seamless interoperability of M-Zones must include a framework of access and manipulation and sharing of information between the co-operating zones.

Adaptive Information Delivery: using knowledge of people, place and devices is an important issue for the development of seamless M-Zone interoperability. The issue of what information is accessed from an external M-Zone and how this information is presented to the end user is an important management consideration. When roaming, information such as user profile information may be made available to the visiting M-Zone to support user service requirements. The transformation of information from one zone to another and the management of the persistence and integrity of information is a major management challenge. In many cases, information may be integrated to provide additional context to the end user. The management of information modification in response to external operation must also be addressed.

Performance Management: M-Zones must co-operate to support user performance requirements as they migrate from one M-Zone to another. A common example is the mobile phone scenario where users who roam expect that there is no loss of service quality as they move from one operator domain to another. The problem of mobility between M-Zones is more challenging. Unlike the single service scenario of today's mobile phone network, the user will require access to a set of services. In addition, access to mobile information is greater and more complex.

Configuration Management: As in the mobile phone environment M-Zones need to be configured to support user (people and devices) into and out of M-Zones. Issues such as IP address allocation and Bandwidth allocation need to be addressed against the user service requirements.

Business Process Models: Just as is the case in the development of solutions for the development of interoperable telecommunications networks a business process model can be developed to support the interoperability of M-Zones. The TMForum Business Process Model is a good starting point for the development of such a model.

Several infrastructure concepts that underpin inter-domain management in telecommunications are also very valuable in realising co-operating M-Zones. These concepts include SLA negotiation, policing and enforcement, as well as real time selection, deployment and enforcement of operational policies within a managed area.

Standardisation work on interoperability issues for telecommunications network is a valid starting point for addressing the M-Zone requirements. However, there are a number of important differences that make the M-Zone environment particularly different. The first of course is the non-hierarchical nature of any future M-Zone environments. Also, a more lightweight solution will probably be more appropriate.

Summarizing this research theme, the major challenges are to handle information access (across smart spaces), personal communication (e.g. user-centric approaches) and to enable remote facility control. At the current stage, information access and management is provided by the exchange and the evaluation of profiles. Personal Communications require investigations on how the relationships of a user to one or more smart spaces can be modelled and what management services are needed to support this very user.

1.4 Programme Work Plan

This section outlines a detailed work plan for this programme with provisional deliverables. As the programme spans a period of four years it is not sensible to assume that the deliverable schedule will be sufficient. Therefore the Work Package on management details a structure for updating the deliverable requirements as dictated by new requirements as the programme progresses. In contrast to the research themes, which targeting the scientific challenges, the work packages are an instrument to provide a permanent control of the quality of the programme itself.

The realisation of solutions for the interconnection and management of smart spaces requires the co-operation of research teams with expertise in a number of key technical areas such as wireless communications systems and networks, information management and telecommunications networks and service management. The proposed research programme incorporates research teams with the required areas of expertise. Hence the logic behind a joint proposal from research groups from WIT, CIT and TCD. The partners, based on previous experience in the management of multiparty collaborative research projects, have put together a work package framework that is designed to maximise the level of interaction between the research teams and maximise the output from the work programme. The complexity of the research challenges, which must be addressed by today's third level research community points to the importance of the establishment of such trans-institutional research initiatives. This work programme is seen as a platform for the development of a formalised long-term integrated research programme between the three research teams and their international partners.

The research work programme is supported through the definition of a set of work packages. Six work packages are proposed. WP0 is responsible for the overall management of the research programme. WP1 is responsible for ensuring that the work plan reflects the state of the art in research into smart spaces and associated research themes. The research programme will be developed within the context of three work packages, where each of them focuses on an individual aspect of ubiquitous management. These three work packages reflect the state of the art as gathered in WP1. The main scientific research work packages are WP2, WP3 and WP4. The main focus of WP2 is to express and coordinate architectural approaches for the research themes. WP3 takes these approaches and uses them to design models, algorithms and processes that address specific research challenges within the research themes. WP4 conducts the experimental validation of the developed concepts through the formation of experiments, which will be executed within computer simulation and/or physical test-bed environments. WP5 is responsible for the evaluation of the research results and the dissemination of these results through workshops, conference and journal papers and a project website (www.m-zones.org). Figure 1.1 defines the interrelationship between the work packages and shows how the research themes are integrated into the programme. Each work package will produce reports as a means to make available the results of the research programme and allow evaluation and feedback particularly from our international expert partners (BT and FhG-Fokus).

In order to optimally utilise the available expertise of the three participating research groups in addressing the research challenges of the M-Zones programme, joint research groups from researchers of all of the three partners will be formed to carry out the tasks of work packages WP1 to WP5. Each group will have one of the principal researchers nominated as leader (see work package description), who will be responsible for ensuring that the work package plan is carried out according to specification and that objectives are achieved. In order to maximise the benefit of having the right expertise among the three partners, researchers from each partner will be spending some time at one of the other partners research laboratories as required.

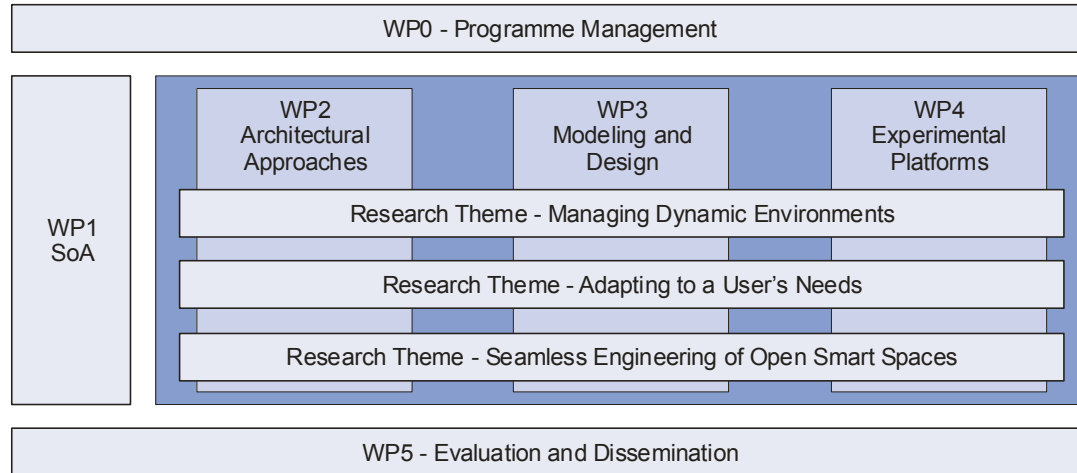


Figure 1.1: Interrelationship between the work packages and research themes

1.4.1 WP0– Programme Management

The philosophy of this work package is to build a coherent team between the three institutions, maximising the synergies available within the programme while allowing partners to focus on their core areas of expertise.

The programme management will consist of three committees:

1. Programme Management Committee (PMC)

This committee will comprise of one representative per partner, responsible for the strategic direction of the programme resolving any resource or other conflicts arising from the technical work. Dr W. Donnelly (WIT) will chair this committee.

2. Technical Co-ordinating Committee (TCC)

This committee will comprise of the leaders of the currently active technical tasks, responsible for co-ordinating the research and ensuring dissemination of results within the programme. V Wade (TCD) will chair this committee.

3. Dissemination Committee (DC)

This committee will comprise of one representative per partner, co-ordinating the interaction of the programme with the wider international academic community. It is particularly responsible for ensuring that the project has identified and developed interfaces to key drivers within the smart space community whether through the standards bodies or international research groups. Dr D. Pesch will chair this committee.

In addition each partner will appoint a Site Manager to co-ordinate spending and activity at each partner site, acting as a single point of contact for programme information at that site.

The work packages will produce an annual report that will be available to the HEA and its nominated experts for review and evaluation. The annual report will incorporate information on the progress made to the realisation of the research programme objectives during the reporting period. It will also address the key drivers and collaborations developed throughout the reporting period. It will conclude by providing an overview of its work plan for the next period, including information on any major technical developments that can impact on its programme goals.

The revised programme plan, and deliverable list, as well as archive copies of existing deliverables and working copies of new deliverables will be made accessible securely via a web interface. This on-line area will serve as a virtual focal point for the programme.

On the issue of IPR (Intellectual Property Rights) WIT, TCD and CIT have a proactive policy with regard to protection of intellectual property, patenting and fast tracking of discovery to industry. Each institution has a process in which its researchers, as well as the institution, may benefit from earning on royalties. The procedures applied in any area of M-Zones will be those of the parent institution that are responsible for that research area.

Deliverables (Number, Due time in months from programme start):

D0.1 (T0+12):	Year One: Annual Report
D0.2 (T0+24):	Year Two: Annual Report
D0.3 (T0+36):	Year Three: Annual Report
D0.4 (T0+48):	Year Four: Annual Report

The regular Annual Reports will summarise the progress made in the programme by each partner and will be reviewed by the Programme Management Committee. They will be available to the HEA for external scrutiny if required.

WP0 Co-ordinator: WIT (Dr W Donnelly)

1.4.2 WP1 - State of the art

Workers in any "hot" research area need continuous exposure to and analysis of activities in the wider community. This work package will provide an initial review of the state of the art in key areas, and ensure that this information is kept up-to-date on a rolling basis. The intention is to ensure that the programme's work is not "blindsided" by industrial developments or emerging standards. By maintaining a rolling surveillance activity the programme will avoid becoming "fossilised" at an early stage of device evolution - unacceptable in a fast-moving area. The expense is a slightly more complex development environment.

The State of the Art (SoA) reviews will be conducted around research themes and constituent topics. Contributions will be developed that review specific pieces of existing work, taken from scientific papers, reports and information of the WWW. Researcher will review work in a specific area of interest to them and provide a synthesis of the state of the art. Peer review of these reviews and syntheses will ensure the work performed will be of sufficient quality to support future publications.

Deliverables (Number, Due time in months from programme start):

D1.1 (T0+9):	Year One: Smart Space Technology Report 1
D1.2 (T0+35):	Year Three: Smart Space Technology Report 2

Technology reports will survey recent developments in the field and if necessary feed back into a programme re-definition phase to re-address the new situation.

WP1Co-ordinator: TCD (D O'Sullivan)

1.4.3 WP2 – Architectural Approaches

This WP aims to elicit and monitor the architectural approaches taken within the different Research Themes. This is done with the goal of identifying, expressing and examining similarities and differences between different architectural approaches. Where similarities

exist between architectural approaches the potential for merging approaches will be examined. Where differences exist these shall be investigated in order to extract any fundamental differences in approach. This iterative process of architectural reflection, reconciliation and refinement will provide ongoing improvement in the shared understanding of the various research directions conducted under the M-Zones programme. This is essential in providing the context good communication of results within the programme and to external parties – especially when considering the eclectic range of research activities conducted under the programme. This understanding will also help identify new, complementary lines of research and their relationship to existing research activities.

As different researchers will start their research from very different directions, a viewpoint oriented approach will be adopted to defining the different architectural approaches. These viewpoints must span a variety of concerns from business/social aspects, to logical/structural aspects, expressive and methodological techniques and engineering/technology issues. Orthogonal to these viewpoints, consideration must be given to the human experience of different roles that will benefit from the intended research results, from end users to developers to administrator/operators. No viewpoint will be considered pre-eminent, so individual descriptions can start from one viewpoint and gradually consider issues in the other viewpoints. Depending on the viewpoint(s) from which descriptions start some unevenness in the level of detail to which different descriptions cover different viewpoints will be expected at different points in time. The aim, however, is that all approaches should eventually form an opinion on all the viewpoints, so that for example, research driven from business level concerns must at some point address technology issues, while technology-driven research must at some point express the business domain to which it applies.

A core part of describing the architectural approaches within the individual research themes will be assembling and growing a shared model of the ubiquitous management problem domain. Such a shared model must capture a minimal set of concepts that define the problem domain and establish sufficient common understanding so that the different architectural approaches can be more readily compared and contrasted. The problem domain model will entail the definition of common concepts, e.g. ‘Smart Space’, ‘User’, ‘Service’ and the relationships and constraints that exist between them. In addition, scenarios may be produced to further explain and detail the problem domain. The description of individual architectural approaches will use of problem domain model as a context and may refine the common scenario to explore further the subset of the problem domain that a particular architectural approach is used to research. The problem domain model will be refined over the lifetime of the project to reflect the emerging research results, changes in the state of the art and refinement and reconciliation of the different architectural approaches.

Deliverables (Number, Due time in months from programme start):

D2.1 (T0+13):	Architectural Approach Report
D2.2 (T0+18):	Architectural Approach Report
D2.3 (T0+23):	Architectural Approach Report
D2.4 (T0+30):	Architectural Approach Report
D2.5 (T0+35):	Architectural Approach Report
D2.6 (T0+42):	Architectural Approach Report
D2.7 (T0+47):	Architectural Approach Report

These deliverables will be generated jointly with corresponding WP3 and WP4 deliverables.

WP2 Co-ordinator: TCD (Dr. Dave Lewis)

1.4.4 WP3 – Modelling and Design

This work package develops guidelines, recommendations and rules for the modelling and the design of software solutions for managed zones. Targeted results are methodologies, design models, algorithms and processes that are based on the architectural approaches of WP2. The focus of this work packages is to enable the realization of M-Zones for small, single smart spaces as well as interconnected 'island' and probably huge and complex environments. The current work in this area can be seen as a variety of individual analysis and design to build smart spaces. They are crafted rather than engineered. Improving this situation, in order to allow organisations accurately to predict the behaviours and limitations of systems and their evolution, is the core target for the programme. The major question of this work package is: How to solve the problem, based on WP2 and as a basis for WP4?

This work package will examine a number of possible approaches to this problem, eventually. Among the approaches we consider potentially valuable, is a set of guidelines for systems designers contemplating new smart spaces and related services. The identification of relevant concepts and tools is part of such guidelines.

To model smart spaces with an aim towards ubiquitous management, this work package needs to investigate:

- 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.

The outcome of this work package can be described in form of sets of models, rules and processes, which may be combined into development frameworks that can be used by developers inside and outside the programme to develop systems that benefit from the validated architectural approaches of WP2 and that can be validated using the experimental platforms of WP3.

Deliverables (Number, Due time in months from programme start):

D3.1 (T0+13):	Modelling and Design Report
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D3.2 (T0+18): Modelling and Design Report

D3.3 (T0+23): Modelling and Design Report

D3.4 (T0+30): Modelling and Design Report

D3.5 (T0+35): Modelling and Design Report

D3.6 (T0+42): Modelling and Design Report

D3.7 (T0+47): Modelling and Design Report

These deliverables will be generated jointly with corresponding WP2 and WP4 deliverables.

WP3 Co-ordinator: WIT (Dr. Sven van der Meer)

1.4.5 WP4 – Experimentation Platforms

In order to test and evaluate the management concepts and algorithms that are being developed within the M-Zones research programme, experimental platforms are required to provide implementation and experimentation environments. Essentially two types of experimentation platforms are envisaged, physical test-beds and software platforms based around computer simulation.

One goal of this work package is to construct and maintain an evolving set of test-bed environments, in which experimentation with the tools, algorithms, and technologies that are being developed is possible. Having multiple test-beds, each focused at a partner's core area of expertise, allows for more extensive testing and parallel evaluation.

The key requirements of each test-bed are as follows:

- Each should provide multiple management "zones" with differing characteristics, including a private zone (limited-range interaction), a virtual zone spanning sites, and a public zone allowing access by non-validated users.
- Each should be equipped with a variety of devices from the two main device categories: immobile devices (devices which can move but tend not to) and mobile devices (devices which can move and do). A range of device complexities must also exist, ranging from fully functional computers down to barely-intelligent artefacts.
- Finally, each should include a range of software systems interacting with the management platform. Each piece of technology added to a test-bed will be characterised according to the models developed in WP3.

The initial selection for technology will derive from the initial state of the art review, with subsequent upgrades (expected at roughly nine-month intervals) being guided by the ongoing reviews. As a side benefit, integrating new equipment into the test-beds will provide valuable information as to how well technologies can be made to interact and what barriers exist to their deployment.

Complementary to physical experimentation platforms purely virtual testing environment will be developed to carry out experiments that cannot be conducted on the physical test-beds due to non-availability of technology, size of the experiments or cost reasons. The advantages and disadvantages of simulation are that it allows experimentation with far larger and more complex systems than can be constructed by a small project, can explore the implications of yet-to-be-realised developments, but does not necessarily give insight into the engineering aspects of deployment. For this reason a combined testing and simulation framework is to be preferred.

Simulations will be driven as far as possible by the characterisations of devices deployed

within the test-beds, or with hypothesised characteristics of devices. The characterisation will include all required management and usage parameters. The simulation environments will be used to explore the impact of different management policies on the ability of a particular system to meet its target objectives, and conversely will allow a priori estimates of the scalability characteristics of systems under given policy constraints.

Deliverables (Number, Due time in months from programme start):

D4.1 (T0+13):	Experimentation Platform Report
D4.2 (T0+18):	Experimentation Platform Report
D4.3 (T0+23):	Experimentation Platform Report
D4.4 (T0+30):	Experimentation Platform Report
D4.5 (T0+35):	Experimentation Platform Report
D4.6 (T0+42):	Experimentation Platform Report
D4.7 (T0+47):	Experimentation Platform Report

These deliverables will be generated jointly with corresponding WP2 and WP3 deliverables.

WP4 Co-ordinator: CIT (Dr. Dirk Pesch)

1.4.6 WP5 – Evaluation and Dissemination

The final work package of the programme will collect together the evaluation aspects of the entire programme. This is preferable to individual, per-package evaluation tasks as it allows the results of experiments to be analysed against a complete set of deliverable technologies.

Evaluation will be based around a set of scenarios - "stories" describing possible interactions with a smart space. These should be based on the common problem domain scenarios used in WP2. Each scenario will be explored using the different techniques under investigation: modelling, simulation and (where possible) implementation.

For example, one core scenario involves student interaction with a wireless teaching environment. Modelling this system allows us to locate the scalability (and other) boundaries of the system; simulation allows us to test it against varied sizes and behaviours of student populations under controllable conditions; implementation removes the predictability and provides for extra phenomena to be discovered in real life.

This work package is also responsible for the dissemination of the project results through conferences, workshops and journals as well as through submissions to key standardisation work. In addition an interactive website will be developed to support interaction between the project and other internally renowned research teams within the area of smart space management. By its nature the identification of the dissemination channels is well be carried out in real time. At the end of each year a report will be produced in the form of a deliverable indicating the dissemination activities carried out within the previous 12 months.

Deliverables (Number, Due time in months from programme start):

D5.1 (T0+28):	Initial Evaluation and Dissemination Report
D5.2 (T0+35):	Intermediate Evaluation and Dissemination Report
D5.3 (T0+44):	Final Evaluation and Dissemination Report

WP5 Co-ordinator: WIT (M Ó Foghlú)

1.4.7 Work Package Orchestration

Work packages are largely intended as a means for quality control of the results of work of the research themes. The work packages 1 and 5 (management and dissemination) run for the whole life cycle of the programme. The three 'core' work packages 2, 3 and 4 have started in December 2002 and are active until the end of the programme. The work package 1 has started at the beginning of the programme and will stop after two years. Figure 1.2 indicates the approximate periods of activity within the work packages.

	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4
	June 2002		June 2003		June 2004		June 2005	
	T0+0	T0+6	T0+12	T0+18	T0+24	T0+30	T0+36	T0+42
WP0								
WP1								
WP2								
WP3								
WP4								
WP5								

Figure 1.2: M-Zones Phase 1 & 2 work package activity

WP1 will provide the initial focus of activity with a review the state of the art. WP1 has a cycle of 18 months along the typical time line of major technological changes. The main research and design work packages, WP2 to WP4, have been in the second and third quarter of 2002 respectively, once the review of state of the art has delivered the initial focus and the main body of research staff are available.

Figure 1.3 shows the distribution of deliverables for each work package. These deliverables are structured along the work packages to allow quality control of the research work. Work package leaders are responsible for ensuring the quality of research theme contributions to these deliverables related to the aspect the work package addressed. Work package leaders will therefore have to work closely with research theme coordinators in the deliverable editing process. Every year one of the WP2/3/4 deliverables will coincide with the annual report and provide supporting information for it.

These deliverables are combined with workshops to circulate the new developments and knowledge between all partners and between invited or interested international research groups. For the deliverables and the workshops we suggest the following mechanism. We will have four meetings a year. The first meeting, mid of February, is an internal M-Zone meeting that prepares the first report of the three work packages. The second meeting, scheduled for the first week of May provides a workshop where the reports of the work packages are presented and where a work plan for the next 6 months is to be agreed. The actual reports must be provided prior to this meeting. The next two meetings, scheduled for the start of September and the beginning of November, are used to prepare and to present the next series of reports. Following this scheme, all work packages (2-4) publish their reports on the same meeting by means of a workshop twice a year. Depending on the actual outcome of the work in a work package, the focus of a workshop can be assigned dynamically. This scheme provides the necessary freedom for the basic research the programme dedicated to without losing the possibility of a permanent control of the quality of the research work.

month no.	date	WP0 Programme Management	WP1 SoA	WP2 Architectural Approaches	WP3 Modelling and Design	WP4 Experimentation Platforms	WP5 Evaluation and Dissemination
7	Dec-02						
8	Jan-03						
9	Feb-03		D1.1				
10	Mar-03						
11	Apr-03						
12	May-03	D0.1					
13	Jun-03			D2.1	D3.1	D4.1	
14	Jul-03						
15	Aug-03						
16	Sep-03						
17	Oct-03						
18	Nov-03			D2.2	D3.2	D4.2	
19	Dec-03						
20	Jan-04						
21	Feb-04						
22	Mar-04						
23	Apr-04			D2.3	D3.3	D4.3	
24	May-04	D0.2					
25	Jun-04						
26	Jul-04						
27	Aug-04						
28	Sep-04						D5.1
29	Oct-04						
30	Nov-04			D2.4	D3.4	D4.4	
31	Dec-04						
32	Jan-05						
33	Feb-05						
34	Mar-05						
35	Apr-05		D1.2	D2.5	D3.5	D4.5	D5.2
36	May-05	D0.3					
37	Jun-05						
38	Jul-05						
39	Aug-05						
40	Sep-05						
41	Oct-05						
42	Nov-05			D2.6	D3.6	D4.6	
43	Dec-05						
44	Jan-06						D5.3
45	Feb-06						
46	Mar-06						
47	Apr-06			D2.7	D3.7	D4.7	
48	May-06	D0.4					

Figure 1.3: Distribution of Deliverables