REQUIREMENTS ENGINEERING FOR INTELLIGENT ENVIRONMENTS

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Abstract - **The field of Intelligent Environments (IE) is maturing to a level at which a range of sophisticated applications are emerging. Such systems aim to be context-aware, especially being adaptable to possibly unpredictable circumstances. An area of significant potential is that of 'ambient assisted living', with significant advances in fields such as smart spaces, classrooms, and assisted living space for the elderly or people with disabilities. In recent years, however, it has been recognised that numerous IE systems have been developed without adopting best practises from software engineering. The work presented here focuses on the requirements engineering stage and presents a framework for IE systems in which an intrinsic component is context-awareness. Whilst the framework is intended as a general IE model, we are currently applying it to the specific area of ambient assisted living and it is being employed on the POSEIDON[1] project. It is anticipated that such real world application of the model will help endorse its conception and facilitate further refinement of the framework.**

Keywords - Context-awareness, Intelligent Environment, Ambient Assisted Living

I. INTRODUCTION

By its very nature, an Intelligent Environment (IE) typically comprises a fusion of sensors, networks, intelligent software and end-user interfaces with intrinsically complex interoperability [1]. Deploying a reliable IE system can be critical. For instance, in the case of a pervasive system designed to facilitate ambient assisted living (AAL), in which the end-user could be vulnerable to some degree, a system failure could have disastrous consequences. There is an increasing acceptance that IE researchers and system developers share a responsibility to design holistically safer and more reliable systems. As part of this general ambition, the IE community has more recently commenced a discourse regarding the adoption of best practises that have evolved over several decades from within the software engineering domain [2]. This movement is still in its infancy and an early focus has been on the application of formal methods, and model checking in particular, in order to increase the reliability and robustness of software systems [3]. This work is noted in a relatively recent survey carried out by Preuveneers and Novais who present a view of established software engineering practises that have been applied specifically to Intelligent Environments [4]. In addition to some formal software engineering approaches, such as model checking, they identify work which has addressed the areas of component reuse and some work that is specific to requirements engineering, albeit with reference to ubiquitous computing in general rather than context-awareness specifically. What the survey by Preuveneers and Novais illustrates is that engagement with core software engineering principles has, to date, been quite limited within the IE community. The theme of this report is that of requirements engineering for context-aware systems, but it is the broad view of the authors that developers of all IE systems can potentially benefit from best practises established in many aspects of software engineering, and this needs to be a focus of IE system development in the years to come.

The remainder of this report is organised as follows: Section II describes related work addressing the concept of context-awareness within the realm of requirements engineering. This section concludes with a brief discussion of the similarities (and dissimilarities) between that work and our research. It specifically addresses the issues that present themselves with regard to the ambient assisted living paradigm which is a primary focus of the POSEIDON project. Section III describes our framework for requirements engineering for assisted living in an intelligent environment, and Section IV describes how the framework is currently being employed to steer the requirements engineering phase of the POSEIDON project. Finally, Section V concludes the paper providing an indication of how we intend to continue this work in the future.

II. REQUIREMENTS ENGINEERING AND CONTEXT-AWARENESS

A. Related work

The study of context-awareness has been an integral part of pervasive computing since its inception. In the past decade or so, effort has begun to be dedicated to aspects of requirements engineering of pervasive

[1] http://www.poseidon-project.org

systems that stipulate context-awareness. A typical approach has been to initially define features of context-awareness that are particular to the domain of study. A popular starting point has been to consider a general taxonomy of context-awareness, such as that described by Dey et al. [5] which comprises three distinct categories of context (i.e., computing, user and physical contexts). A number of groups have then sought to enhance the selected taxonomy for the specific demands of requirements elicitation. For example, the work of Hong et al. [6] aims at realising the definition of the three categories of context described by Dey et al. in terms of a seven-step meta-model. Their suggested framework is motivated by a desire to alleviate inadequacies in earlier human-computer interaction (HCI) theories when developing context-aware applications and, in particular, the notion that context-aware systems rely less on task-centric interaction behaviours than non-pervasive systems. A theme of their requirements elicitation meta-model is to consider issues of usability and user experience, and an important step in the process is the differentiation of specific target groups of users each with their own set of user (context) preferences. In a similar vein, a research method study by Kolos-Mazuryk et al. [7] resulted in a proposal for requirements elicitation based on the taxonomy of context-awareness proposed by Krogstie [8]. This work references the six context categories described by Krogstie's taxonomy (i.e., spatio-temporal, environment, personal, task-oriented, social and information contexts) to drive the design of customised stakeholder interview questions. They rationalise that the Krogstie taxonomy is the most complete of those surveyed and certainly it is evident from our own studies that although the taxonomy described by Dey et al. is more frequently cited, the Krogstie categorisation does effectively summarise a number of recurring themes in later work, such as possible social implications of context and temporal attributes of requirements.

Another common theme of previous study has been the implicit association of context-awareness with adaptability of the target system. That is to say, it is typically anticipated that a pervasive system should adapt to its environment as a consequence of context changes, some of which may be unpredictable. This premise is extended by Finckelstein and Savigni [9], who propose that requirements themselves can change during system execution, and for this reason it is important to distinguish between dynamic, context-driven requirements and higher order operational goals of a system. This idea is supported by Sutcliffe et al. [10] who propose a 'framework of questions' to drive their requirements engineering approach which consider (amongst other features) temporal concerns, i.e., change over time. Another prominent feature of this work is the idea of personalised user requirements. Sutcliffe et al. [10] argue that context-awareness taxonomies had previously been tailored to groups rather than individuals and they call their model 'PC-RE' (Personal and Contextual Requirements Engineering). Their work centres on applications related to assisted living whereby individual customisation of user requirements is deemed a priority, although such customisation would be derived by specialisation of a more general meta-model. They also specifically address the issue of changes in user characteristics (over time) as well as social and cultural aspects (possibly relating to geographical location) when considering bespoke individual requirements.

Another feature of the PC-RE technique is the use of a scenario-based analysis method. In their specific area of application, i.e., the use of assistive technology, Sutcliffe et al. [10] identify that a context-aware system might invoke several pathways, which may change over time but can exhibit some degree of predictability. The use of scenario-based requirements elicitation has also been prominent in the work of several other groups. The studies conducted by Seyff et al. centre around the design of mobile tools for 'in situ' context requirements discovery, whereby use-cases are used to automate provisional scenario walkthroughs prior to in-field adaptation of those scenarios [11, 12]. In their research relating to context adaptation, Sitou and Spanfelner note the usefulness of scenario-based approaches when changes in context are expected, or anticipated [13]. This thought raises the question of whether or not an adaptable system should endeavour to contend with all possible unexpected events or, perhaps within certain boundaries whereby a change in context is to some degree predictable, adapt according to reasonably well-understood domain-specific situations, e.g., the assisted living domain. Whilst accepting that exceptional events will always potentially occur, a scenario-based requirements elicitation technique appears promising for a domain that exhibits some level of predictability. The recent work by Saidat and Song [14] also adds support for this conclusion. Their domain of study is that of service-based applications (rather than Intelligent Environments per se), and their work has a strong focus on the concept of modelling context information to drive the strategy that a system might employ to 'self-adapt'. To this end they also argue that scenario-based elicitation approaches are useful when the context changes are predictable, or at least have a low degree of uncertainty. Another thrust of this work is the concept of (what the authors, Saidat and Song [14], term) 'requirements reflection', i.e., the notion that requirements that are engineered at design time may still require some level of 'runtime' reasoning, or refinement, to support dynamic context-driven changes in requirements, thus concurring with the earlier conclusions of Finkelstein and Savigni [9]. Key to supporting this is the ability to design a suitably dynamic requirements model against which the authors suggest that goal-oriented requirement engineering techniques offer promise due to their provision of suitable modelling semantics (i.e., appropriate use of established modelling nomenclatures). The adoption of model-based approaches (in the sense of incorporating both scenario and goal-driven requirements methods) is also reported by the earlier work relating to context-awareness by Sitou and Spanfelner [13], and more recently by Ruiz-Lopez et al. [15] who describe a goal-based method that targets non-functional requirements for ubiquitous systems.

The creation of models by employing diagramming techniques is a standard requirements elicitation practise and accordingly there has been some study of enhancing diagram notation for the purpose of assimilating a view of context-awareness. To this end, some of the earlier work (such as that reported by Martinez and Salavert [16] and work by Wagelaar [17]) has focussed primarily on modelling enhancements from the perspective of the software developer. However, there has been some work that addresses aspects of diagramming that could be of relevance to requirements elicitation in the sense that the diagram enhancements proposed relate to diagram styles that might be employed by a requirements engineer when communicating with a stakeholder. For example, Choi proposes an extended use-case format that includes context-specific annotations, alongside two other diagram models that fuse standard UML notations such as class diagrams and state-charts to illustrate context-aware services, i.e., different types of response that a system may make following a change of context [18]. Desmet et al. propose a bespoke vocabulary that could be used for modelling context-aware software requirements which includes a diagram style that is used to illustrate context adaptations [19]. This latter work relates more perhaps to the general area of modelling context, but cites a specific goal of addressing the requirements engineering phase. Certainly, research aimed at the inclusion of notational enhancements to cater for context-awareness within diagrammatic models used for requirements elicitation seems relatively sparse to date, and this is another area of potential for the application of software engineering practise to the domain of context-awareness and Intelligent Environments.

B. Prominent themes

In order to facilitate a mapping between our work and the research reviewed above, the following bullet list summarises the salient features of work involving requirements engineering for systems with a focus on context-awareness.

- A consideration, adoption and possible enhancement of a context taxonomy
- A general assumption is that systems need to be adaptable to be context-aware
- With regard to that work with an appreciable HCI focus, elicitation techniques used to capture end-user cognitive tasks require enhancement to account for context-awareness
- Identification of target user groups in contrast to individual user customisation of requirements, and an acknowledgement that contextual requirements for either profile may evolve over time (possibly as a consequence of age and experience)
- Requirements themselves may be context-driven and change dynamically (i.e., at runtime) thus making them distinct from higher order operational goals which do not
- A consideration of cultural context, including ethnicity, and to a lesser extent privacy (in the work to date)
- The adoption of goal-oriented requirements engineering where higher-order goals are apparent in the domain, and notably there is significant support for the adoption of scenario-based modelling, particularly if analysis of a specific target domain reveals a degree of predictability

In addition to the above themes that are prominent in previous work, it is also worth noting that there has been some research with regard to the development of tools and model notations. Whilst work in these areas exhibits merit, and offers further potential, these have been less prevalent strands of research with regard to context-awareness and requirements engineering.

C. Mapping to the IE domain

We next consider the prominent themes noted above with respect to our work. We have higher order objectives of engineering requirements for Intelligent Environments, but at this stage are specifically targeting the application area of ambient assisted living and aim to present an appropriate framework to support requirements engineering in this domain. In particular, we are currently working as part of the POSEIDON consortium towards a distributed technological infrastructure to foster the development of services (based on both static and mobile smart environments) which can support people with Down's Syndrome [20], and hence this work falls well within the AAL paradigm. Specifically, a central work-package of the project aims to deliver a context reasoning system, including the design of an ontology-based context language. In relation to the work reviewed above, the themes of the POSEIDON project have some affinity with the work by Sutcliffe et al [10]. Each incorporates a higher-order goal of 'empowerment' of an individual. In the case of the PC-RE model, the authors describe their approach as a general model rather than being dedicated solely to assisted living, but apply it to specific assisted living scenarios such as aiding a disabled user to make a journey with mobile technology (which relates closely to a specific goal of the POSEIDON project). Further aspects of the POSEIDON project are discussed below. In this section, the desire is to relate the more general features of the ambient assisted living domain to the prominent themes of context-aware oriented requirements engineering listed above. To this end, our studies indicate that within the ambient assisted living paradigm:

- Goal-oriented tasks are usually evident
- Contexts can vary significantly (depending on specified goals), and there can be an associated prioritisation of design and implementation activities in terms of the services associated with those contexts
- Depending on the nature of the assistance, there can be a clear demarcation between individual user requirements which demand a degree of personalisation, or customisation, and distinct user groups that support an individual who also present distinct sets of requirements
- If distinct target groups and individual stakeholders are identified, then a prioritisation of users and user groups (themselves) is typically demanded, with individual users taking precedence in the sense that they present the highest stakeholder value
- There can be important ethical issues, including the matter of privacy relating to context
- HCI and usability aspects carry high importance, and this includes aspects of modality, physical and cognitive skills, and experience. Accordingly, there is a strong association between requirements for interaction design and the design of appropriate user training support
- Delivery of an ambient assisted living system typically involves a distributed team with each participant providing specialist knowledge such that the requirements engineering approach requires harmonisation in terms of coordination, planning and management

The above list cites quite general features in an attempt to portray aspects common to the range of ambient assisted living application areas. The assisted living paradigm typically presents goal-oriented tasks and it seems clear, that with regard to requirements gathering, these can generally be supported by scenario methods. Furthermore, the decomposition of goals into discrete scenarios typically results in some degree of predictability, whether the result is successful completion of a goal or an alternative pathway is required due to an exceptional circumstance, albeit a predictable exceptional circumstance. So it is our view that the adoption of scenario-based elicitation techniques is appropriate for a general requirements engineering framework dedicated to Intelligent Environments and AAL systems specifically. However, in contrast to some of the cited work, we do not take the view that an assisted living system needs to be a completely adaptive system in terms of autonomously reacting to context. This ability would certainly be a desirable (and perhaps theoretical) goal as it is reasonable to expect that there will always be some probability of an unanticipated event within a goal-oriented scenario. However, assisted living systems are generally not theoretical models rather they address very much real-world and practical needs whereby a specific set of contexts can be identified, prioritised and employed within that environment. So whilst ambient assisted living systems embody the concept of the environment being intelligent and context-aware, it is typically within the confines of a predetermined set of objectives and the designers of such systems have a comparatively modest aim of intelligent assistance rather than striving for an autonomously reactive system.

Our studies within the assisted living domain do concur with the view that distinctions should be made between the bespoke requirements of individuals and those of specified user groups, thus agreeing to a large extent with the assertion made by Sutcliffe et al [10]. In particular, we envisage general categories of stakeholder profiles within which customisation will pertain to specific individual requirements. Taking stakeholder profiles a step further, we have identified five types of stakeholder that are typically represented within the assisted living domain and these are illustrated by Fig. 1. Within our stakeholder taxonomy there are three levels of end-user stakeholders, which we define as primary, secondary and tertiary users. A primary stakeholder profile will represent the individual for whom the 'assistance' is being targeted. If we take the POSEIDON project as an example, the primary users will be those individuals with Down's Syndrome. The secondary users will be people that have frequent contact with the primary stakeholder (typically day-to-day contact) such as friends, family members and dedicated carers, whilst the tertiary users would include a range of stakeholders with less frequent contact with the primary user, such as school teachers, employers and work colleagues etc. In addition to the three types of stakeholder that would ultimately interact with the Intelligent Environment, we define two further types of stakeholder with regard to the requirements engineering phase: the sponsors and the operational team. The sponsors of a system would typically be an organisation with a vested interest in the delivery of the system, such as a funding body or an associated society (e.g., the Down's Syndrome Society in the case of the POSEIDON project).

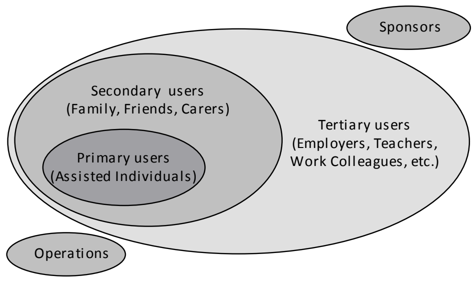

Figure 1. Categories of Stakeholder for AAL Systems

It should be noted that in the case of a dedicated support society, they would typically have contact with the primary User and would, therefore, be regarded as a tertiary stakeholder as well as a sponsor. The term 'operational team' refers to a broad spectrum of people that would include the analysts, designers, implementers, technical support, maintenance, project managers and those responsible for delivering training support. Of particular significance is that, whilst a primary stakeholder is identified, it will not necessarily be the primary user who collaborates in the core requirements elicitation activities. In fact, we assert that for primary users with cognitive disabilities it will be representatives from the secondary user classification that would not only communicate their own requirements, but would also play a significant role in communicating the requirements of the primary stakeholder. Furthermore, in these situations it is quite conceivable that tertiary stakeholders may also contribute to requirements gathering that is specific to the primary user.

We also agree with previous work that has concluded that social context can be an important aspect when customising requirements for individuals, and particularly privacy issues which may depend on context. Furthermore, we have identified a range of ethical principles that require consideration when designing an ambient assisted living system and regard it as a priority that a dedicated requirements model should address these principles. More specifically, within our research group we have created an ethical framework based on the principles that AAL systems should provide services which collectively are consistent with the following higher level ethical principles: non-maleficence and beneficence, user-centred multiple user groups, privacy, data protection, security, autonomy, transparency and openness, equality, dignity and inclusiveness of provision [21]. These principles are designed to protect users from informal and rushed system development. We believe these principles should be taken into account when developing AAL systems and this ethical framework overall should be used to inform development from early stages of gathering requirements and planning, to later stages of validation and deployment.

The review of related work above also promotes the importance of interaction design and usability with regard to context-driven requirements engineering. With regard to the field of ambient assisted living, we certainly view this as a critical component of requirements elicitation and this has specific importance with regard to the customisation of individual user requirements, i.e., the primary stakeholder. With regard to the POSEIDON project, the primary stakeholder will have specific interaction design requirements with at least some level of individualisation, but we also surmise this to be representative of assistive living requirements in general. Thus, a theme of requirements elicitation should be to gauge the level of general customisation of the human-machine interface that may be appropriate for all primary users against specific individual needs. For AAL systems, the term 'machine' really infers a range of distributed technologies for which there may or may not be an explicit human interaction. The nature of the individualisation of the human-machine interface will depend to a great extent on individual experience, skills, and familiarity with target devices and their associated modalities (i.e., the mode of interacting with the device). This idea of assessing more general requirements for a specific user group that can be refined, or tailored, to individual needs has been a theme of previous work [10, 13], and in principle we concur that this is applicable in the AAL domain, and particularly with reference to interaction design and usability issues. Previous work also inferred the necessity to adjust such customisations with time by suggesting that individual requirements evolve as the stakeholder ages, and this can manifest as either increased ability, i.e., experience and skill, or reduced ability, e.g., visual and aural acuity. We do not disagree with this concept but it does, however, suggest a requirements engineering method that addresses a form of ongoing context-change throughout the lifetime of a system. This either implies that requirements engineers would revisit the system periodically, or perhaps that the ability of a system to adapt its requirements with temporal context adjustments is closely aligned with the idea of an intelligent reactive system. There certainly may be logistical implications for the former approach, and we certainly view the latter approach as a fairly ambitious goal. With regard to the POSEIDON project specifically, we anticipate that the former approach of future review and refinement is more realistic. Accordingly, our general framework suggests a periodic review activity.

Another aspect relating to the requirements for the human-machine interface is that of user training, and this will naturally be closely aligned with system setup, system review and upgrades. The assisted living paradigm requires a consideration of user training requirements which will undoubtedly involve some degree of customisation appropriate to the user level, and again, with the primary user taking precedence. Bespoke training support should be designed according to the profile of the target user that presents itself when considering the interaction design aspects of the system. We view user training as a natural ally of the requirements engineering method employed for interaction design, and anticipate these aspects to be integrated as a core activity within our framework.

To conclude our mapping of prominent themes in requirements engineering relating to context, IE systems, and ambient assisted living, we note the practical aspect of managing requirements gathering with regard to a consortium of partners. It is very typical that an enterprise aiming to deliver an AAL system will involve a range of experts and it is highly likely that such participants will be distributed in some sense, possibly geographically, but almost certainly intellectually in terms of providing a spectrum of specialist knowledge. Thus, harmonisation of the requirements elicitation process is vital. In this sense, we really refer to higher-level management of the requirements gathering process that is likely to be distributed across the partners as well as the general management of the specified requirements themselves, and some consideration needs to be given to the inclusion of a mechanism to facilitate this within the general requirements engineering framework.

III. A REQUIREMENTS ENGINEERING PROCESS MODEL FOR AAL

We noted above that our research has similar themes to the work described by Sutcliffe et al [10]. They describe a layered model relating to spatio-temporal and individual concerns, but against this they illustrate a 'road-map' of specific investigation pathways, which they present as a form of guiding process. In particular, Sutcliffe et al. note that their PC-RE technique is designed to complement existing requirements engineering methodologies (such as the Volere approach [22]) rather than portraying it as a complete method itself. Thus, a range of established requirements elicitation techniques are employed, including scenario-based methods, and they reflect that that their model really aims to provide a framework of questions that drive the requirements investigation and interpret this as a checklist of issues rather than a 'prescriptive cook book' of steps to follow. In our 'roadmap' we also propose a series of concerns that are of particular relevance, but view our work as more of a process, perhaps best described as a recipe of steps, or activities, and for requirements engineering of IE systems in general we term this process 'Requirements for Intelligent Environments' (R4IE). For the more specific, or distinct, ambient assisted living domain we refer to the process as R4IE (AAL). Within that process we concur with the employment of industry-standard elicitation techniques, and perhaps by describing our framework as a process it may seem slightly more ambitious than the reflections made by Sutcliffe et al. However, whereas they were attempting to describe a more generally applicable approach, at this time we are targeting our model to a specific area, i.e., ambient assisted living. The R4IE (AAL) framework can be described as a form of workflow model, illustrated by Fig. 2, whereby we have identified six core requirements gathering categories against which dedicated requirements elicitation activities proceed. The six core requirements engineering activities are complemented by two further activities that play a vital supporting role: operational support and harmonisation. These are summarised, alongside the core activities, in Table 1. The first two activities listed in Table 1 essentially refer to the initial stages of the requirements gathering phase during which 'blue skies' thinking will be encouraged. All the activities listed in the table, and illustrated in Fig. 2 are not meant to be mutually exclusive or follow a synchronous process flow. Rather, activities can take place concurrently and iteratively. Central to the process is a determination of stakeholder profiles for those users who require context data capture (not all stakeholders will require context profiles). Creating a stakeholder profile is seen as consisting of four sub-activities. The first sub-activity is identifying the set of associated task/function requirements (a subset of the total tasks' requirements). This will involve scenario-based techniques. Ideally, goals will be identified for each of the profile tasks. The second sub-activity establishes the interaction design issues, i.e. the context interaction requirements for the primary and secondary users. Psychological questionnaires will be used to assess individual skills (cognitive, physical and perceptual). In addition, prototyping will be a key approach to ensure the context interactions are carried out and work as intended. The third sub-activity involves determining the ethical requirements. They will be established using the framework of ethical principles that is highlighted above. The final sub-activity captures the requirements for the profile for setting up, customising, training, monitoring the system and reviewing the system use. This sub-activity is intertwined with operational support requirements. Depending on the system design, some aspects of the delivery of these requirements will be carried out by operational support.

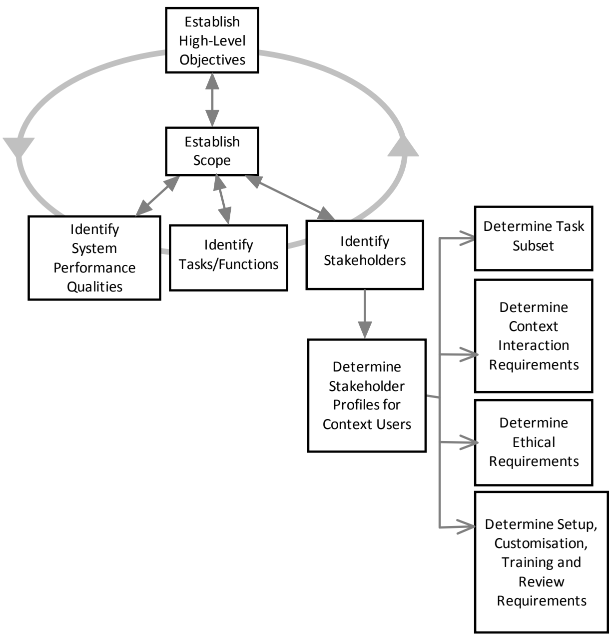

Figure 2. Core Activities in the R4IE (AAL) Framework

The primary thrust of the model described above is in identifying the context-awareness requirements. In turn these requirements will inform further engineering requirements for the system, for example, system security issues, reliability and resilience, and these will ultimately determine the system infrastructure.

TABLE 1. Summary of R4IE (AAL) Activities

Activity	Summary
Establish High Level Objectives	Specifically the main objectives of the project so that all parties understand the aim(s) and main goals.
Establish Scope	Establish system scope especially in terms of the boundaries of the project (i.e., what is inside the system and what is immediately external to the system).
Identify Stakeholders	All the parties with an interest in the system. See Figure 1, which shows the POSEIDON project's main stakeholders. Their requirements will be gathered using user interviews, observational techniques, focus group workshops and questionnaires.
Identify Tasks/Functionality	Depending on the nature of the target system, this might be initiated with the secondary and tertiary user groups. The use of scenario-based methods will be central to this activity.
Identify System Performance Qualities	Establish system performance qualities with quantified targets
Determine Stakeholder Profiles	Specifically those profiles which involve context-awareness. Sub-activities as follows: a. Determine task subset and the tasks' goals b. Determine context interaction requirements c. Determine ethical requirements d. Determine setup, customisation, training, system monitoring, and review requirements
Outline operational support	Determine technical support requirements for all aspects of the operational workload: delivery/setup, customisation training, system monitoring, review and potential upgrade requirements
Harmonisation	Involves managing the overall requirements process and requirements specifications (including future review), particularly with reference to a multi-disciplinary team that may or may not be distributed across different centres.

IV. APPLICATION OF THE R4IE (AAL) FRAMEWORK TO THE POSEIDON PROJECT

We intend to apply our requirements gathering framework to a number of projects. The first project we are considering is POSEIDON. The project is in its early stages and in terms of our framework the current focus is on the left hand side of Fig. 2. The first three main activities in Table 1 have been completed, being considered at early stages through the definition of the project and subsequent interaction with the European Commission (which is funding the project). Given that stakeholders have been clearly identified, the POSEIDON consortium is in the position to shift focus towards identifying the tasks/functionality and system performance qualities, and determining the stakeholder profiles, which represent the right hand side of Fig. 2. The POSEIDON consortium has designed online questionnaires which have been completed by over 300 users. Interviews have taken place with approximately 30 families and a user focused workshop has been organised. All these activities will allow the partners of the consortium to better clarify and specify the services to be implemented and their level of priority. The key areas of interest for the POSEIDON AAL system, i.e., where requirements are being given particular attention with regards to our framework, are (ordering from more generic aspects to more domain dependent aspects): human-computer interfaces, hardware platforms, usability principles to follow, relevant contexts and their associated services, ethical principles to follow, technical support provision, cost of ownership, socialisation and communicating with others, monitoring location and activity, day-to-day diary planning assistance, 'out of the ordinary' planning assistance, handling money, medical and food monitoring. These issues are starting to be explored through the user engagement activities described above approaching these topics in a series of refinements. Following the distribution of the initial questionnaire, and the compilation of returned data, the interviews offer an opportunity for discussing specific areas, especially with primary (and secondary) users, and the workshop will provide a more complex assessment of motor skills and dexterity and engagement with technologies.

V. CONCLUSIONS AND FUTURE WORK

This report describes ongoing work to develop a requirements engineering process for Intelligent Environments (IE), in which context-awareness is a primary feature, and a specific refinement of that model which targets ambient assisted living systems. There is some similarity with the PC-RE approach described by Sutcliffe et al. [10]. The PC-RE approach is designed to be generally applicable, i.e., to areas outside the IE domain, whereas our work is intentionally distinct in that sense, and it is initially targeting a specific field of IE systems, i.e., ambient assisted living. Although Sutcliffe et al. indicate a general framework, they do report on specific assisted living applications, and these have high-level themes, or goals, that address the idea of 'empowerment' of a disabled individual. We concur with this philosophy and in particular the POSEIDON project, on which the R4IE (AAL) model is being applied, shares these aspirations. A distinction between our framework and PC-RE is that our 'roadmap' prescribes a process of activities rather than a list of issues that aim to add further context to the requirements engineering. Within that process an important activity is stakeholder profiling, with individual user customisation as an important feature of those profiles, but for the ambient assisted living domain we have identified specific categories of stakeholders. Another salient feature of our work is the introduction of a core ethical model. Previous work has addressed the issues of social context (as an aspect of geographical context) and ethnicity. We have enhanced this idea with the adoption of a set of ethical principles within the overall framework that also considers the important issue of privacy. It is our intention to develop and apply the general R4IE model to a range of projects, but the first application of the model has commenced within the AAL domain and specifically the POSEIDON project. It is envisaged that this real-world application of the framework will endorse its conception and facilitate some further refinement of the model.

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