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Authors(s)	Tynan, Richard, O'Hare, G. M. P. (Greg M. P.), O'Grady, Michael J.
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Agency, Ambience, Assistance: A Framework for Practical AAL

Richard Tynan, G.M.P. O'Hare, and Michael J. O'Grady

Abstract Ambient Assisted Living (AAL) is a societal imperative in many countries due to their aged demographic profile. Ambient Intelligence (AmI) offers a viable and intuitive framework by which such systems may be realised in practice. However, a number of issues must be addressed if AmI is to become sufficiently mature and robust to support AAL. One such issue is the seamless combination of services, based on a diverse range of embedded artifacts, such that AAL systems can be rapidly designed, implemented and deployed. This paper considers, albeit briefly, issues pertaining to the design of an intelligent middleware solution for the provision of AAL services.

1 Introduction

Viewed objectively, Ambient Intelligence (AmI) may be perceived as the latest computing usage paradigm that will change the way people live, work and play forever. Many other paradigms have promised a similar panacea: ubiquitous computing, pervasive computing and wearable computing amongst others. All have fallen far short of what their proponents and evangelists promise, though time may remedy this. The reasons for this unfilled potential are open to debate, and beyond the scope of this discussion. However, the question arises as to whether AmI will suffer a similar fate. It may well do so; however, it has one critical advantage that the others did not have at their inception. The realisation of AmI as a valid paradigm would, if realised in its entirety, serve as a foundation for the practical deployment of Ambient Assisted Living (AAL) systems. The deployment of such systems is perceived by many as a societal imperative in the coming decade, and this can only occur if many of the issues that hinder the development of practical AmI systems are successfully addressed.

Richard Tynan · G.M.P. O'Hare · Michael J. O'Grady
CLARITY: The Centre for Sensor Web Technologies, University College Dublin, Belfield, Dublin 4, Ireland, e-mail: {richard.tynan, gregory.ohare, michael.j.ograde}@ucd.ie

2 Ambient Assisted Living

Ambient Assisted Living (AAL) has been conceived as a potential solution to a suite of problems expected to arise in the coming years due the increasingly aged profile of many national populations. It proposes the harnessing of a range of technologies to assist the aged in the course of their everyday activities, for example, in the home, in the workplace or at leisure [AALIANCE(2010)]. If successful, AAL should enable people to live independently for longer. A number of benefits accrue from such an approach, but from a government perspective, cost may be perceived as the most important.

An AAL solution does not demand the availability of an AmI framework. However, if the AmI vision of intuitive and intelligent interaction with a range of embedded computational artefacts was to be achieved, it would indeed form a cornerstone for the deployment of AAL systems. But a number of issues need to be resolved by the research community before this can occur. One of these issues concerns the seamless integration of the diverse range of information sources, for example, embedded sensors, such that activities and contexts can be identified with a reasonable degree of certainty. One approach to this is the development of an open, scalable and extensible middleware solution that provides a uniform view of a range of disparate embedded artefacts such that services based on these artefacts can be rapidly assembled and deployed to meet the diverse contexts and needs in which AAL systems must be deployed.

3 Agent-based Middleware

In order to bring the components together into a coherent distributed application, a middleware based on intelligent agents has been created called SIXTH. We have adopted an agent based approach to underpin our middleware for a number of reasons. Firstly, it may not be practical to collect all information about the environment in order to reason about the optimal course of action. Agents can be used when decisions must be made with incomplete environmental information. A related benefit to using distributed agents is that in-situ reasoning can limit data traffic and improve the responsiveness of the system. The optimal course of action may not be one action but rather a set of actions that may be carried out sequentially or concurrently. Such planning can facilitate optimal system performance when plans are shared and can allow the agent to reevaluate its current plan.

Current middleware offerings for sensor networks tend to encompass systems that can aid application development to any system between the application and the operating system of the sensor. While this broad definition includes many solutions, there are a number of common goals: to facilitate application development and to provide the capability of deploying a sensor network with little in depth knowledge of WSNs. The SIXTH Middleware is in keeping with these existing high level goals of WSN middleware but also provides additional capabilities not currently present:

modularity, flexibility, reusability, openness, extensibility, universality, multiple abstractions and dynamic reconfigurability.

The middleware architecture that we adopt in this work partitions the network according to the capabilities of the devices. At the top level, devices with the most resources co-operate using our full SIXTH middleware and intelligent agents to deliver system level adaptation. At the intermediate level are devices capable of supporting intelligent agents but not the complete middleware. Finally, devices who operate using a basic embedded Operating System such as TinyOS or Contiki are in the lowest partition.

One of the primary goals of SIXTH is to facilitate the creation of reusable components capable of intelligent behaviour which can be brought together to form one or more applications. The SIXTH middleware is therefore the collection of components along with their integration framework, which in our case is OSGi. On a macro level this means that the application uses the agent-based middleware components and the integration framework and each component may form part of many applications. Given the uniqueness of the sensor devices, it is important that many applications can coexist on the same sensor infrastructure and we achieve this through the use of a Multi Agent System (MAS). The in-situ agents can be augmented with additional agents as device becomes part of new distributed applications.

When creating applications for devices with sufficient processing capabilities, such as the Sun SPOT or iMote2, SIXTH provides support for the development and deployment of intelligent agents. Specifically, it supports the construction of Agent Factory Micro Edition (AFME) agents [Muldoon et al(2006)Muldoon, O'Hare, Collier, and O'Grady]. AFME is a minimised footprint agent platform that facilitates the execution of intelligent agents on resource constrained devices. Broadly speaking, it conforms to the semantics of the Agent Factory Agent Programming Language [Collier(2001)]. Agents adopt beliefs, which represent their model of the world, and use these beliefs to determine a set of commitments. Commitments represent an intended course of action and will be revised throughout execution as circumstances change.

AFME incorporates functionality for intelligent scheduling, dynamic role adoption, and resource bounded reasoning. These capabilities provide agents with the capability to dynamically alter their behaviour and computational overhead in accordance with quality of service requirements, such as application lifetime requirements. For instance, when power is running low on nodes, agents will reduce their computational overhead by executing their reasoning algorithm less frequently. Additionally, using the resource-bounded reasoning capabilities, agents will drop commitments with a low priority or utility value.

Devices that are unable to support a MAS such as those based on TinyOS or Contiki are incorporated into the overall distributed application through a well defined set of APIs that provide high level abstractions for the application developer. By partitioning the devices of an AAL system into three tiers, we provide functionality in a modular way which can be reused in many different contexts not just AAL.

4 Home Instrumentation and Beyond

In order to evaluate our intelligent middleware in real world context, we have implemented an embedded sensor system which consists of the following elements: passive infra red to detect presence in a room, microphones to sense the ambient sounds in the patient/users home, light and temperature sensors to sample environmental conditions, air quality sensors, contact and pressure sensors to detect users location on furniture, cameras to monitor user and guests movements, energy and water monitoring to understand appliance activity and usage patterns.

Using this wide range of devices we can develop our reusable intelligent components, deploy them for testing and redeploy them in a different application domain e.g. environmental monitoring. The middleware and intelligent behaviour remains static while the embodiment of the system changes. Reasoning about sampling rate and optimal power usage can be reused with simple reconfiguration of the Quality of Service (QoS) impacts of its decisions to be considered by the agents.

5 Conclusion and Future Work

Ambient Assisted Living is fast becoming a necessity worldwide as the average lifespan of citizens increases. AAL applications are a natural testbed for AmI research, however the development of these systems can be hindered by complexity and limited nature of the devices which the application is based. Our work to date has focussed on the development of an agent based middleware that can facilitate the deployment of intelligent distributed applications in the AAL space. Crucially, this middleware is built on the guiding principles of modularity, abstraction, reusability and flexibility which will allow the intelligent agents to be reused in other contexts thus shortening the development time and burden of AmI applications.

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