Integrating the USEFIL Assisted Living Platform; Observation from the Field

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Abstract— **Ambient assisted living (AAL) platforms are seen as a viable way for managing healthcare costs in an ever aging first world population. One of the most crucial parts of AAL development is the integration of the different developed components to a functional cohesive platform. Integration strategies are many and varied catering to different system needs. The USEFIL AAL system was conceived as a platform utilizing low cost "off-the-shelf" technology and providing an independent and healthy lifestyle to elderly people. This platform like several AAL platforms reached its system integration stage consisting of relatively few components. In that context technological hurdles have been resolved in the development process of each component. For that reason in the present work the focus is on relatively simple but crucial "observations from the field" taken during the USEFIL AAL platform's integration effort. The resulting guidelines for integration of AAL platforms are: A) Managerial clarity: Clearly defined roles both cross and within teams, robust avenues of interpersonal communication, detailed and flexible fiscal planning. B) Testing diligence: No assumptions should be made about the robustness of components or the triviality of tests. Component interconnection may lead to unexpected loss of functionality. C) Iterative functional testing: In the case of AAL systems with complex AI components the introduction of additional infrastructure may lead to significant differentiation in functionality a thing that needs to be tested and corrected if detected. D) Pre-pilot testing objectivity: Pre pilot users testing the AAL platform should be provided with minimal training in order to interact with the system as an ordinary user. Only that way they can provide genuinely original feedback. These guidelines while non-technical proved essential for the integration of USEFIL and could serve as a primer for avoiding pitfalls in the integration of similar AAL systems**

Keywords— **Ambient Assisted Living, Smart homes, preventative/participatory health systems, Equipment interconnectivity and Integration.**

I. INTRODUCTION

A. Context

Ambient assisted living platforms are beginning to emerge as a viable way for managing healthcare costs in an ever aging first world population [1]. A crucial part in the development of these platform is the integration of individual components in a functionally cohesive system

AAL systems consist of medical sensors, wireless sensor and actuator networks (WSANs), computer hardware, computer-networks, software applications, and databases, in order to provide services in an Ambient Assisted environment. [2,3]. After several years of maturation, still current AAL solutions are challenged in with issues such as unacceptable installation and deployment complexity, cumbersome user interfaces, security threats, lack of quality-of-user-experience, and higher costs [4].Having identified these issues several years ago, the USEFIL AAL system [5] was conceived as a platform utilizing low cost "off-the-shelf" technologies in order to develop immediately applicable services, to assist elderly people in maintaining an independent and healthy lifestyle and program of daily activities [6]. Its major expressed design specifications during the design of the system was both non-intrusive installation and Unobtrusive operation

In the present paper we demonstrate, through a series of "observations from the field" taken during the USEFIL AAL platform's integration effort, the challenges and their solutions in AAL integration work.

B. Integration Strategies

There are several integration methodologies in the literature [7] regarding the strategies that can be followed for integrating Information Technologies (IT) system. A brief overview of these, in the software domain is summarized in Table 1:

Table 1 Integration strategies for IT systems

Name	Description
Incremental	An iterative process, where one by one, the modules are integrated with existing, already integrated components, and after testing they are acknowledged as part of the whole system.
Top-down	A process where the hierarchically high level components, those that consist of different subcomponents are first integrated and then the subcomponents are integrated themselves.
Bottom-up	The opposite of the Top-down approach, where the hierarchically low level components are first integrated and then, subsequently the higher level components are pulled together to a cohesive whole.

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Sandwich	It is a Fusion of Top-Down and Bottom-Up approach where integration begins by integrating the highest and lowest hierarchically components simultaneously and then proceed to approach the middle hierarchical level of components.
Big-bang	When the interrelations between the components available for integration are such that there is no viable way to integrate piecemeal, then all the components are brought together simultaneously hierarchy and complexity levels.

Moving on to mixed hardware-software integration there are fewer and more general strategies for implementing integration [8] as summarized in Table 2

Table 2 Integration strategies for mixed hardware/software systems

Name	Description
Vertical integration	Integration by grouping smaller modules into independent entities of defined functionality (silos). Advantages include: Quick integration and small resource overhead. Disadvantages include: Limited scalability, reusability of components across different parts of the platform due to early lockdown of components in silos
Star–"Spaghetti" integration	Each module integrated individually to the rest of the system. Advantages include: Reusability and system scalability; each component is available at all times. Disadvantages include: Time and cost overheads; increase exponentially as components' number increases.
Horizontal integration	Integration through mediating specialized modules negotiating the interfacing of other modules according to predetermined constraints. Advantages include: Versatility and system specific customization. Disadvantages include: Extra development cost for components with no other purpose than integration

II. USEFIL INTEGRATION METHODOLOGY; THE PLAN

The USEFIL AAL platform

The USEFIL AAL platform as it reached its system integration stage consisted of relatively few components to be integrated to a whole. Off the shelf hardware like webcams or contemporary controllers like the MS Kinect were utilized as an unobtrusive set of sensors. Data from these sensors would be consumed and fused by appropriate software components [5] in order to be consumed by a decision support system providing real time decision making capabilities to the whole of the system [6]. Due to the rather sophisticated nature of the standalone modules, the number of hardware and software components that were to be integrated, were in the low tens. This coarse granularity of the available modules was also the deciding factor in the design of the integration plan that was followed for the whole system.

B. Integration Strategy

From the previous brief exposition of integration methods and the specifics of the USEFIL platform's granularity, our approach of choice for integration was a star integration strategy incorporating a Bottom-Up/Incremental Fusion. The outline of the integration method is presented in Figure 1.

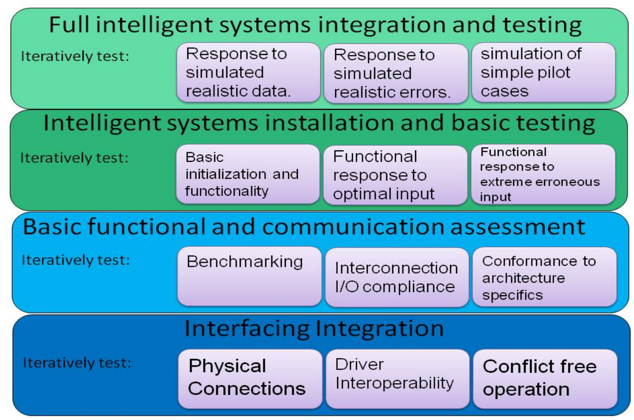

Fig. 1 USEFIL Integration scheme

C. Description of Methodology

First of all, in the interfacing layer integration the initialization and basic provisions of the hardware (including driver cross compatibility) would be tested. In this layer all subsystems are hierarchically on the same level, so the most appropriate method of testing that was chosen was an incremental iterative process with each major component integrated into the system, and then initialized in order to determine success of interfacing.

After the interfacing layer integration the design required basic functional communication assessment. This includes benchmarking and compliancy tests that assess basic functionality of each component and conformance to requirements set by the software designers. While this would have been tested for each singular component it was considered necessary to be repeated throughout the iterative integration process.

After the whole basic functional communication assessment the design required the installation and basic testing of the "intelligent" systems (those that would provide the high level assisted living functionalities such as alerts or recommendations). Testing at this level would only consist of extremely significant and extremely erroneous inputs from incrementally more devices of the platform in order to test both interfacing errors between the intelligent systems and the rest of the platform and to conduct a first level of robustness testing for these systems as well.

After systems installation and basic testing integration design requires the conduct of full intelligent systems integration and testing. In this phase with a fully functional system, the aim of the tests will be to ensure that the intelligent systems work within the requested specifications both with mock, pre-calibrated, realistic and no realistic, input. Additionally, in the context of pre-pilot testing the system would be tested in lab conditions with real users for preliminary UI feedback, along with realistic use data gathering.

III. INTEGRATION IN PRACTICE; OBSERVATIONS FROM THE FIELD

A. Managerial Considerations

Good planning can only be implemented by a sound project management infrastructure. In the USEFIL case that meant additional managerial provisions in order to avoid bottlenecks in communication and a constant infrastructure for collaboration and delegation of tasks within the integration framework. Constant communication and collaboration pipeline with regular teleconferences between all the partners and a clear delegation strategy was one of the most crucial components in the timely progress of the integration effort. Additionally a robust mitigation strategy for issues that might elude scrutiny, with detailed record keeping and accountability provisions ensured that any unresolved issues would be dealt with through a planned manner.

B. Technical Integration Considerations

In testing the system itself, while the integration team dies received functional components the quickest realization that emerged was that there is no guarantee that a component will work as planned when interconnected or when exposed to continuous use for extended periods of time. While stress tests have been conducted by the developers of the components, significant faults were discovered just by conducting simple burn tests (leaving the system on for prolonged periods of time) of different iterations of the platform.

C. Functional Integration Considerations

Functional testing is the part where the integration team has the bulk of its work. In that part of integration needs for additional infrastructure may arise, or corrections to the overall design may be done according to the realistic conditions that may emerge. For example, in the case of the USEFIL platform, the integration team, when faced with the technological need of cross platform, cross device communication and simultaneous sensor access by different services came up with a solution that has not been predicted because the technological details of the used components were not known at the time of architectural design. In that capacity it developed an input device sharing service [9] in order to facilitate the aforementioned communication.

The general observation that should be noted is that during functional testing, needs may arise for real implementational work for the integration team and resources must be provisioned for beforehand for such eventualities.

D. Pre-piloting Considerations

The pre-piloting stage of the USEFIL integration process consisted of exposing the system to a number of elderly users and receiving qualitative feedback about the platform's interface and some first preliminary sensor data from real user interaction (Figure 2). During this phase, through natural curiosity and exposed to a new environment, participants inquired about everything in the environment but care was taken not to provide them with so much information that would create ad-hoc expert users who would reflect the team's preconceptions.

The first results from this pre-piloting stage were extremely encouraging with the elderly users being satisfied with the user experience and sometimes even being impressed with the capabilities of the platform. A video of a part of such a pre-pilot episode where an elderly user is experiencing the exergaming platform repurposed for USEFIL is hosted in [10].

It should be noted that these pre-pilots will be followed by a rigorous pilot testing phase where integrated systems will be installed in elderly users' residences for a significant amount of time (1-2 months) and will be tested both for efficacy and for usability.

Fig. 2 Pre piloting the USEFIL system. Introducing real users in a lab conditions provides both UI insights and reveals functionality discrepancies that would not be determined otherwise.

IV. CONCLUSIONS

The experience from the integration effort in the USEFIL project has provided some interesting insights regarding the integration challenges of such platforms. With the rapid technological advance in IT tools, integration becomes systematic and codified regarding workflows and design [7]. Emerging infrastructures as the Internet of Things [11] with its rapid realization of standardization of metadata lead to an environment where technological hurdles are becoming ever easier to overcome. The non-technological hurdles in an integration effort remain.

In light of the USEFIL experience, regarding AAL integration if one is to formulate a suggestion list these would be:

Managerial clarity: Clearly defined roles both cross and within teams, well defined and robust avenues of interpersonal communication and detailed and flexible fiscal planning.

Testing diligence: No assumptions made about robustness of components, or triviality of tests. Bringing together hardware and software components can break one of them due to something as trivial as bad spatial configuration of sensors.

Iterative functional testing: Introduction of additional infrastructure may lead to significant differentiation in functionality which, in the case of AAL systems with complex AI components can compromise the functional integrity of the platform.

Pre-pilot testing objectivity: Pre pilot users should be provided with minimal training to interact with the system as an ordinary user. Only that way their feedback will be genuinely original instead of reflecting the developers' own usage patterns.

The above considerations while quite straightforward may save time and resources by ensuring that an AAL system reaches the pilot trials stage as a complete and robust system and that post integration issue resolution can be reduced or avoided by the diligent application of them.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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