7.
Our Proposal's Evaluation

> *"A good tool is an invisible tool. By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good tool -- you look at the world, not the eyeglasses."*
>
> *Mark Weiser, "The World is not a Desktop," Perspectives article for ACM Interactions, 1993.*

In this Chapter we focus on the evaluation of the proposed approach. First of all, we present an overview of the case studies we developed during our research. After this presentation, we concentrate our attention on the evaluation process by following the guidelines proposed by (Travassos et al. 2001) in order to establish the main goal, determine the competences that must be analyzed, selecting the participants, performing the tests and analyzing the results.

Although we performed the described evaluation process for each developed case study, basically in this Chapter we present the evaluation process performed in our latter iteration of our latter case study (i.e. the dental clinic case study). Therefore, our main goal is to analyze some competences based on different quality criteria (e.g. adaptability, usability, dependability and response time). The analysis is centered on how the dental clinic's stakeholders perceived these competences. Moreover, we calculated the dedication time and team effort for each discipline considering this case study. We also illustrate how our results influenced other research groups. Finally, Section 7.8 presents some closing remarks.

7.1.
Overview of the Developed Case Studies

We already presented the *Ubiquitous Application Engineering* for the dental clinic case study. However, we also developed various ubiquitous applications from different cognitive domains throughout our research at PUC-Rio and UofT in order to: (i) construct the proposed building blocks; (ii) apply them to different ubiquitous applications development; (iii) evaluate our proposal centered on user satisfaction and other issues that directly impact it; and (iv) evolve the building blocks by refining them according to the obtained results. Figure 7.1 briefly illustrates some ubiquitous projects we developed between 2007 and 2011. More details can be found by consulting (Serrano et al. 2011a; Serrano and Lucena 2011a, Serrano and Lucena 2011b, Serrano and Lucena 2011c, Serrano and Lucena 2010a, Serrano and Lucena 2010b, Serrano et al. 2009 and Serrano et al. 2008).

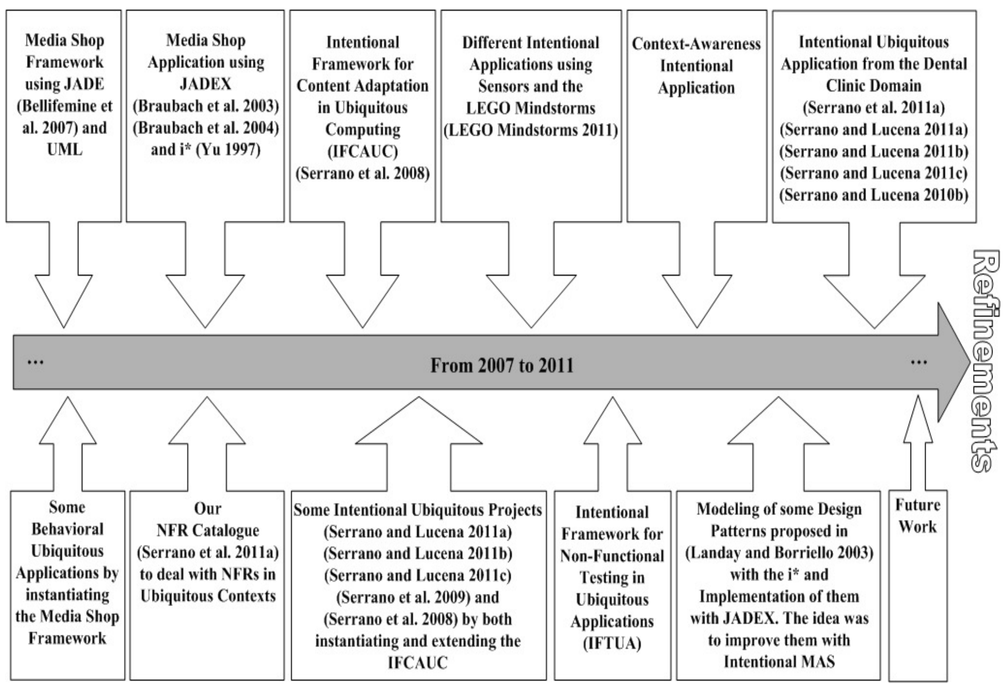

Figure 7.1 – Some projects developed from 2007 to 2011

We started by developing a Media Shop Framework based on the JADE Platform and the UML Modeling. At that time, our focus was on ubiquitous applications implemented by using behavioral-based MAS and modeled with the UML Use Case Diagrams, Classes Diagram, and Sequential Diagram. We instantiated the Media Shop Framework to implement three e-commerce ubiquitous applications.

In order to improve the cognitive capacity of the software agents in ever-changing contexts, we decided to develop intentional-MAS-driven ubiquitous applications by using the BDI Model proposed in the JADEX Framework and the intentional modeling with the i* Framework.

We observed that the results obtained by us during the building blocks intermediary versions' evaluation significantly improved by applying the BDI Model and the i* Modeling, especially if we considered the user satisfaction issue. Based on this observation, we decided to investigate the use of intentionality from the requirements to code in ubiquitous contexts. Therefore, we worked on the first version of our NFR Catalogue to deal with non-functional requirements. This version has been refined since 2007. We also developed the first version of our **I**ntentional **F**ramework for **C**ontent **A**daptation in **U**biquitous **C**omputing – i.e. IFCAUC, which was instantiated for different intentional ubiquitous projects. The acquired experience was used to evolve the IFCAUC's first version as well as other intermediary versions of it.

Moreover, we explored different resources (e.g. sensors and actuators) by using the LEGO Mindstorms kit (LEGO Mindstorms 2011) in the development of intentional ubiquitous applications. Here, we investigated some pervasive issues in ubiquitous contexts by using, for example: smart-doors, light sensors, sound sensors, color sensors, touch sensors and ultrasonic sensors.

In addition, we constructed other intentional frameworks (e.g. an **I**ntentional **F**ramework for Non-Functional **T**esting in **U**biquitous **A**pplications (IFTUA)) as well as other intentional ubiquitous applications (e.g. an intentional context-awareness ubiquitous application). Furthermore, we modeled and implemented some design patterns (Landay and Borriello 2003) by respectively using the i* Framework and the JADEX Framework. Finally, we concentrated our efforts on the development of an extensive ubiquitous application from a dental clinic cognitive domain. In this dental clinic project, we applied the most recent version of our building blocks – presented in this thesis – to the development of this intentional-MAS-driven ubiquitous application from the requirements elicitation to the evaluation process.

It is important to keep in mind that the history of the results obtained by qualitatively evaluating all developed case studies helped us to: (i) evaluate the proposed building blocks; and (ii) evolve them by refining their conceptual models as well as their technological support sets based on the users' considerations/observations.

As our reused-oriented approach for incremental and systematic development of intentional ubiquitous applications is centered on these building blocks, such qualitative evaluations – after various iterations from 2007 to 2011 – also helped us to evaluate our proposal as a whole. This was especially so if the intentional-MAS-driven ubiquitous application developed by following the proposed guidelines could deal with the content adaptability, invisibility, usability, dependability, response time, mobility and their correlated ubiquitous competences centered on the user satisfaction issue. As follows, we described some details of the evaluation process by taking into consideration only the dental clinic case study in order to improve the understandability.

7.2. Competences Determination for the Dental Clinic Case Study

In order to perform a qualitative evaluation, we determined the competences for the dental clinic case study based on different quality criteria (e.g. adaptability, invisibility, usability, dependability, response time and mobility). These quality criteria directly impact user satisfaction, especially in ubiquitous contexts. The analysis of these quality criteria was centered on how the stakeholders perceived the competences. Moreover, we graphically represented the results with histograms (Pereira 2004) and polygons of frequency (Pereira 2004). Furthermore, we analyzed them by using a measure of central tendency (i.e. the median (Pereira 2004)).

Table 7.1 describes these competences as well as presenting some related competences (e.g. unperceivable, user friendliness, availability, performance, and location). The idea was not to evaluate the competences by using rigorous tests. It is important to remember that the evaluation of these competences (i.e. quality criteria) is subjective. In other words, it is difficult to precisely evaluate them. Our purpose was just to materialize some of them by using tests that made it possible to investigate how the participants perceive these competences while using the ubiquitous application. Thus, we followed some suggestions proposed in (Landay and Borriello 2003).

Table 7.1 - Description of the analyzed competences

Competence	Meaning	Correlated Competences
Behavioral-Agent-Based Adaptability	The ability of adjusting, modifying or re-modeling the content for different purposes, conditions, situations and contexts by using behavioral software agents.	-
Intentional-Agent-Based Adaptability	The ability of adjusting, modifying or re-modeling the content for different purposes, conditions, situations and contexts by using intentional software agents.	-
Invisibility	Quality criterion used to evaluate if something is disturbing the users or distracting her/him with things that are both easily to solve or extremely complex. The former does not demand the user's intervention. The latter will probably not be solved by the user, who – in most of the cases – is not an expert. However, it is important to distinguish Invisibility and Transparency. Transparency is also a quality criterion with a positive connotation. It defends that the users have the right to know what is going on – e.g. who is manipulating the users' data.	▪ Unperceivable ▪ "Unseeable"
Usability	Quality criterion that assesses how easy the application's interfaces and services are to use.	▪ User Friendliness ▪ Errors Feedback
Dependability	Quality criterion that shows the reliability of someone/something to others based on her/his/its integrity and truthfulness. It also concerns if someone/something is safety, protected against danger/damage/loss and/or does not implies on catastrophic consequences to someone/something that must be protected.	▪ Availability ▪ Confidentiality ▪ Integrity ▪ Accountability ▪ Prevention ▪ Safety
Response Time	Quality criterion used to determine how fast some aspect of the application is performed under a particular situation.	▪ Performance
Mobility	Quality criterion used to evaluate if someone has mobility while using a service. It depends on the service omnipresence and its portability for different devices.	▪ Proximity ▪ Location

7.3.
Simulated Environment for the Dental Clinic Case Study

The environment to perform the tests was based on simulated stations, running the JADE-LEAP Platform and the JADEX Framework. The main container is located on a notebook with *2.53GHz Intel Core 2 Duo P9500 Processor, 3 GB of RAM, 320 GB Serial Ata Hard Drive and Windows 7*. The remaining stations – in which the specifications varied from *1.6 GHz Intel Centrino M Processor 730, 1GB of RAM, 100GB 4200 Hard Drive and Windows XP* (worst machine) to *1.83GHz*

Intel Centrino Duo T2400 Processor, 2GB of RAM, 120GB Hard Drive and Windows Vista (best machine) – run containers from other platforms, distributed in various smart-spaces. They simulated different ubiquitous devices, such as different models of simple cell-phones, Smartphones, palms, notebooks and others. We also performed tests with real mobile devices (e.g. Nokia N95 and Blackberry models) by integrating them with the MAS Platform. Figure 7.2 illustrates the simulated environment.

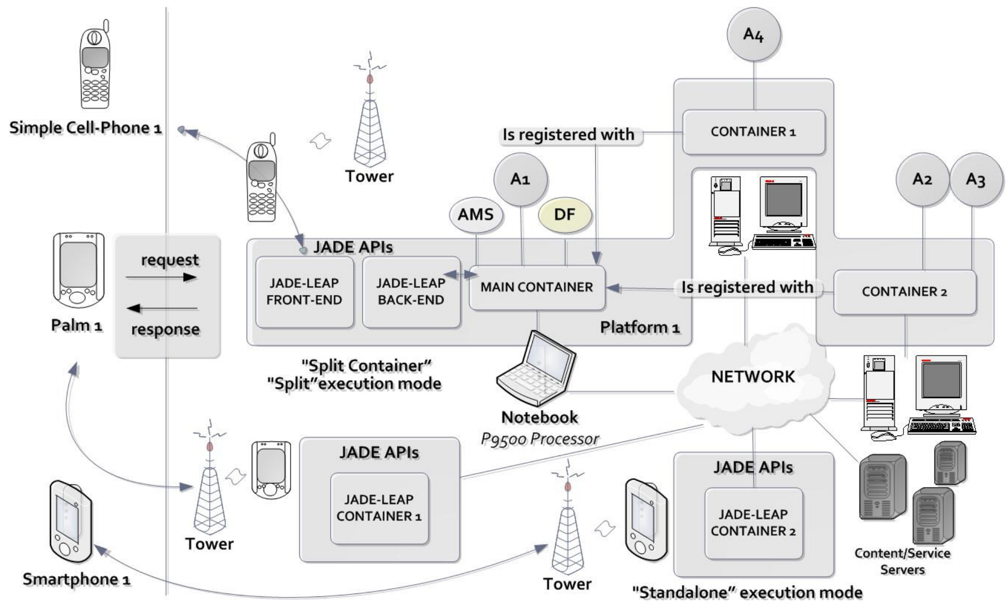

Figure 7.2 - Simulated environment to perform the evaluation process

7.4. Participants for the Evaluation of the Dental Clinic Case Study

In the dental clinic application's evaluation, the participants were the stakeholders of the dental clinic, such as: dentists and patients. In the latter iteration of the dental clinic's systematic development process, the group of participants in the qualitative evaluation are composed of ten stakeholders, including one dentist, one attendant and eight patients. They were invited to participate in several tests to evaluate user satisfaction. Other stakeholders preferred to observe the tests. All of them were volunteers in our evaluation process. Moreover, the volunteers participated by using the developed dental application without training. They only received some instructions about the purpose of the tests and an overview of how the tests would be conducted. Therefore, the tests were based on the stakeholders' activities; more precisely by considering the activities they perform at the dental clinic. Each participant filled out a copy of the questionnaire shown in Table 7.2.

Table 7.2 - Questionnaire of the participants

Questionnaire for the Participants
Please, answer the questions below by choosing an alternative: You are a: ( ) Clinic's Patient ( ) Clinic's Dentist ( ) Clinic's Professor ( ) Other ____________________ How do you classify your experience on using devices to access specific services (e.g. download an image)? ( ) Excellent ( ) Good ( ) Regular ( ) Poor ( ) Very Poor What do you think about using devices to perform some clinic's activities (e.g. registration in the dental clinic)? ( ) It is an excellent idea! ( ) It is great! ( ) I have some doubts… ( ) I do not agree… Thank you very much for your participation!

The participants' knowledge about using devices to perform simple daily tasks (e.g. pay a bill, download a music/video/file and access their e-mails) was also determined before the evaluation process. The results are presented in Figure 7.3 by summarizing the profile of the participants. The greater part of the volunteers declared themselves to be users with good experience, regarding the use of electronic devices to access services provided by the *World Wide Web*. Moreover, they also were positively inclined to use their personal devices to perform the activities associated with the dental clinic. Therefore, the participants' profiles were favorable for the dental clinic ubiquitous application under evaluation.

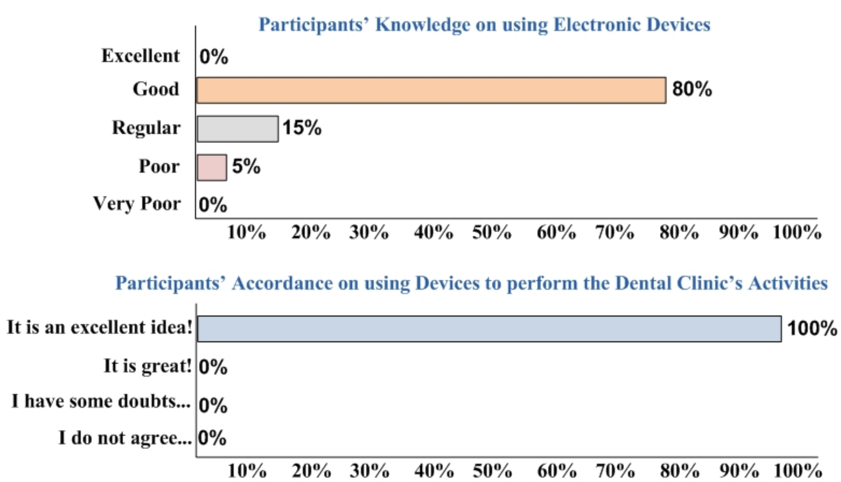

Figure 7.3 - Results based on the participants' knowledge on using electronic devices and their accordance on using them to perform the dental clinic's activities

We offered to the participants a classification system containing seven categories: Excellent (Ex), Very good (Vg), Good (Go), Regular (Re), Poor (Po), Very poor (Vp) and Unacceptable (Un). Interacting with the dental clinic ubiquitous application, the participants classified each competence based on their own satisfaction. For our purposes, it means that we were concerned about the ability to satisfy the user according to her/his expectation and by respecting her/his preferences. In order to collect the data, we combined specific techniques (e.g. open/closed questionnaires, interviews and observations) with tests performed in the simulated environment.

As mentioned, among other tests, we evaluated the users' satisfaction focused on how the participants perceived the pre-defined competences. First, we compared the users' satisfaction by using a dental clinic case study developed with behavioral agents (not shown in previous Chapters) and another one developed with intentional agents (extensively shown in previous Chapters). In the former development, we did not use the intentionality and the BDI model to develop the software agents. In the latter development, we improved the cognition of the software agents by designing and implementing them based on intentionality. The agents' reasoning was developed to achieve the user's goals centered on her/his beliefs, desires and intentions. In both situations, not intentionality-driven and intentionality-driven, the agents considered the ubiquitous profiles (e.g. users' profiles, device profile, network profile, content profile and contract profile) to make decisions at runtime. Thus, the content adaptability and the context awareness issues were carefully investigated in these developments. Moreover, we were concerned about invisibility, usability, dependability, response time and mobility issues. The analysis of the results is briefly presented below for all these competences.

7.5.
Analysis of the Results for the Dental Clinic Case Study

For the dental clinic case study, we present the frequency of each category (Ex, Vg, Go, Re, Po, Vp and Un) by considering that the same participant – normally a patient, an attendant or a dentist – took part in different evaluations. In other words, the same participant could evaluate the same competence more than once by using, for example, different devices. From Figure 7.4 to Figure 7.9 we graphically illustrate the obtained data by using histograms and polygons (Pereira 2004). Calculating the median of each histogram – by considering the areas of the vertical bars – it belongs to the excellent category in all analyzed cases as shown in: Figure 7.4 for the Adaptability; Figure 7.5 for the Invisibility; Figure 7.6 for the Usability; Figure 7.7 for the Dependability; Figure 7.8 for the Response Time; and Figure 7.9 for Mobility. Simplifying the analysis, it means that most of the users classified these competences as excellent.

According to our purposes, the adaptability means the ability of the behavioral or intentional agents to perform all necessary content adaptations (e.g. resizing, transcoding and others) by taking into consideration the user's preferences and the features of the device she/he was using at the moment of the content request (e.g. dental educational videos and x-rays). Details can be found in (Serrano and Lucena 2011a) and (Serrano et al. 2008).

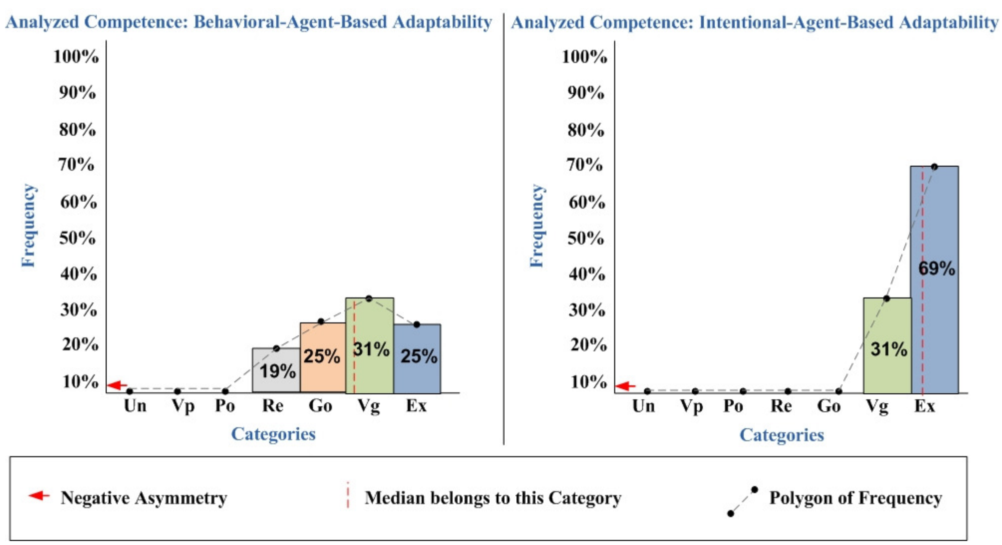

Figure 7.4 - Frequency Distribution based on the evaluations of the *Behavioral-Agent-Based Adaptability* and the *Intentional-Agent-Based Adaptability* competences

On one hand, in the behavioral-agent-based adaptability evaluation: 25% of the performed tests were evaluated by the participants as *Excellent*; 31% were evaluated as *Very Good*; 25% were evaluated as *Good*; and 19% were evaluated as *Regular*. On the other hand, in the intentional-agent-based adaptability evaluation, 69% of the performed tests were evaluated by the participants as *Excellent*; and 31% were evaluated as *Very Good*. The participants also evaluated other competences that impact on the adaptability issue, such as the adequacy of the received contents centered on their preferences (e.g. color, resolution, size, format and others). Considering that both histograms have a negative asymmetry (Pereira 2004), when we analyze the median, it belongs to: the very good category for the behavioral-agent-based adaptability; and the excellent category for the intentional-agent-based adaptability. It is important to notice that the user's satisfaction significantly increased by using intentional agents.

Regarding invisibility (Figure 7.5), the results were truly surprising in view of the fact that all of the participants evaluated this competence as *Excellent*. In this case, we were specifically testing if the application did not disturb the users with configuration problems between devices and services, communication protocols in different smart-spaces, services usage and other complex tasks. These tasks were delegated to the intentional agents in order to avoid disturbing the users. The results led us to believe we are going in the right direction by using a reasoning and learning engine driven by intentional agents centered on capability-based and fuzzy-logic-based support sets.

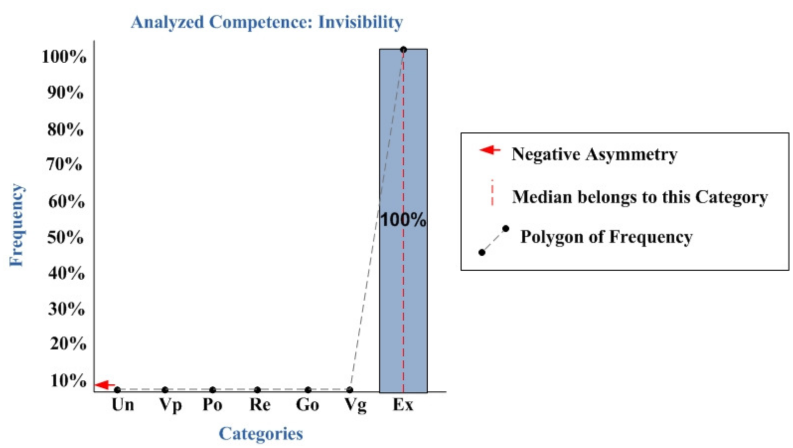

Figure 7.5 - Frequency distribution based on the evaluation of the *Invisibility* competence

As presented in Figure 7.6, the usability results were: the participants evaluated 62% of the performed tests as *Excellent*; and 38% were evaluated as *Very Good*. Here, we tested, for example: (i) if the participants had problems while using the device to access the offered contents and services; and (ii) if they enjoyed the interfaces, which were adapted at runtime in order to be visualized from their devices. Details of this dynamic interface adaptation process can be found in (Serrano and Lucena 2011b).

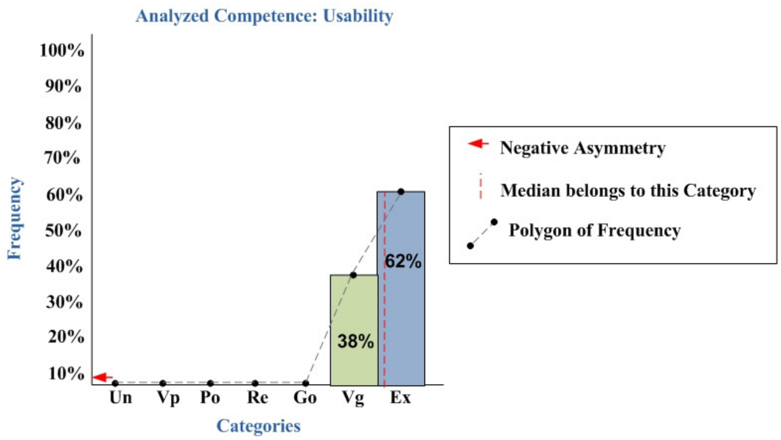

Figure 7.6 - Frequency distribution based on the evaluation of the *Usability* competence

The dependability evaluation (Figure 7.7) investigated if the users trusted the intentional agents engine in order to deal with their private data as well as to represent them in the domain under analysis – i.e. the dental clinic domain – by making decisions as their personal agents. The results were: the participants evaluated 69% of the performed tests as *Excellent*; and 31% were evaluated as *Very Good*.

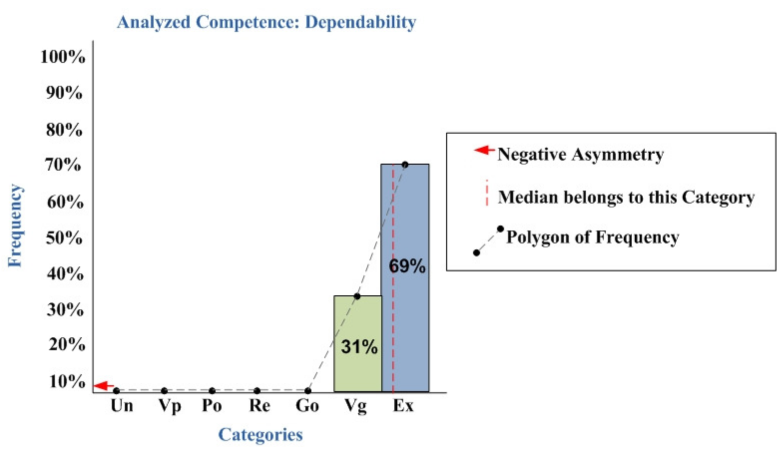

Figure 7.7 - Frequency distribution based on the evaluation of the *Dependability* competence

In the response time evaluation (Figure 7.8), the results were: the participants evaluated 62% of the performed tests as *Excellent*; 25% were evaluated as *Very Good*; and 13% were evaluated as *Good*. In this case, we tested the users' satisfaction centered on the response time of the intentional agents engine from the request of the service (e.g. patient registration) by the user to its complete execution by respecting the ubiquitous profiles information as well as the desired quality criteria for the service (e.g. price and security).

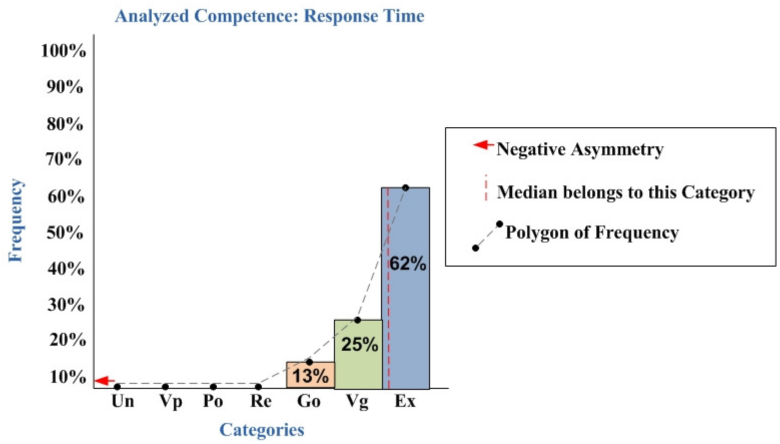

Figure 7.8 - Frequency distribution based on the evaluation of the *Response Time* competence

The mobility evaluation (Figure 7.9) investigated if the patients, dentists and attendants had mobility while using the offered services. Therefore, the participants also considered the service omnipresence and the service portability for different devices. Moreover, other issues that directly impact mobility were also evaluated, such as how the dental clinic ubiquitous application dealt with the user's location issue or the device's disconnection problem. As we were using the network and a MAS Platform, the device was integrated with a specific container of this platform by using the JADE-LEAP execution modes, performed by intentional agents. Therefore, if the user was connected to the network, her/his interface agent was capable of finding a container on the MAS Platform; to integrate the device with this container; to associate this device with a specific personal agent and its unique identifier; and to access the dental clinic's services independently of the user's location. Details about intentional mobile agents in ubiquitous systems can be found in (Serrano and Lucena 2011c). Furthermore, when we simulated the disconnection problem after, for example, a service request, the personal agent performed the tasks that were independent of the user's feedback. After that, it basically maintained itself in standby by awaiting/waiting that the device – associated with the service request and its identifier – was connected again. When this connection occurred, the agent continued the process in order to complete the desired request. In the mobility evaluation process, the results were: the participants evaluated 80% of the performed tests as *Excellent*; and 20% were evaluated as *Very Good*.

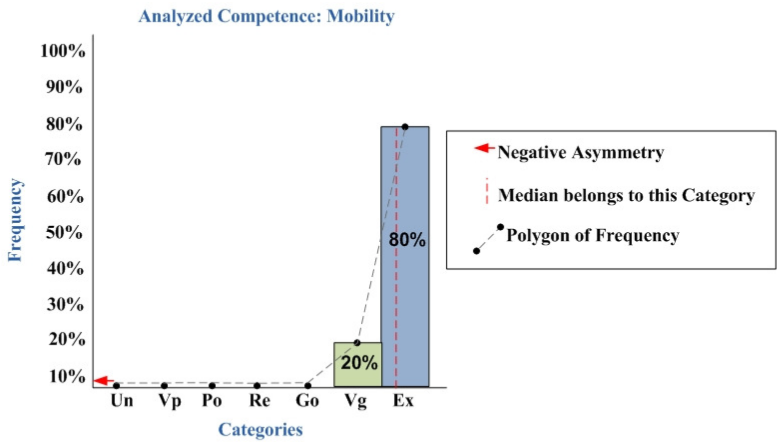

Figure 7.9 - Frequency distribution based on the evaluation of the *Mobility* competence

It is important to mention that we performed – throughout our experimental research from 2007 to the end of 2010 – this kind of analysis for each ubiquitous application developed by following our approach or an intermediary version of it. Based on the acquired results, we concluded that our efforts in applying intentional agents to ever-changing environments seem to contribute to the user satisfaction – an intrinsic concern in ubiquitous applications. Moreover, the experimental results allowed us to believe that we are moving in the right direction, which is also confirmed by investigating the literature, more precisely the research groups in Artificial Intelligence and Requirements areas that provide contributions based on intentionality. Finalizing the evaluation, the next Section shows the dedication time and team effort, which were analyzed for each discipline of the life-cycle during the dental clinic ubiquitous application's development.

7.6. Dedication Time and Team Effort for each Discipline of the Life-Cycle

In the dental case study, we also calculated the dedication time and team effort to perform each discipline of the proposed life-cycle. The team was mainly composed of one Ph.D Student (with full-time dedication throughout the development), one Ph.D Student (with partial dedication, focused on offering some observations and suggestions) and three Masters Students (with partial dedication, focused on the instantiation of some frameworks – e.g. IFCAUC).

For the Early Requirements discipline, we basically had for the dedication time and team effort evaluation:

- Approximately 34% of the team's effort was dedicated to perform 65% of the Early Requirements in the Requirements Phase.
- Approximately 5% of the team's effort was dedicated to perform 20% of the Early Requirements in the Design Phase.
- Approximately 3% of the team's effort was dedicated to perform 10% of the Early Requirements in the Code Phase.
- Approximately 5% of the team's effort was dedicated to perform 5% of the Early Requirements in the Evaluation Phase.

Figure 7.10 graphically illustrates these results centered on the dedication time and the team effort. In the Requirements Phase of our approach, 65% of the performed activities were associated with the Early Requirements discipline in the dental clinic case study.

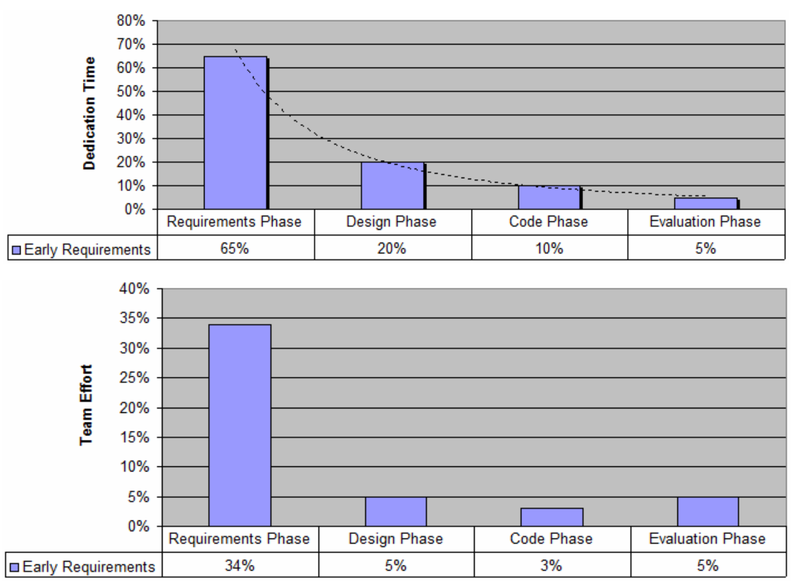

Figure 7.10 - Dedication time and team effort for *Early Requirements* discipline

Moreover, we calculated that 34% of the team's effort was used to perform these activities. The dedication time as well as the team effort to perform the Early Requirements discipline decreased in other phases of the proposed approach (e.g. Design, Code, and Evaluation).

For the Late Requirements discipline, the results are:

- Approximately 44% of the team's effort was dedicated to perform 60% of the Late Requirements in the Requirements Phase.

- Approximately 7% of the team's effort was dedicated to perform 20% of the Late Requirements in the Design Phase.
- Approximately 5% of the team's effort was dedicated to perform 15% of the Late Requirements in the Code Phase.
- Approximately 5% of the team's effort was dedicated to perform 5% of the Late Requirements in the Elaboration Phase.

Figure 7.11 illustrates the results centered on the dedication time and the team effort for Late Requirements discipline.

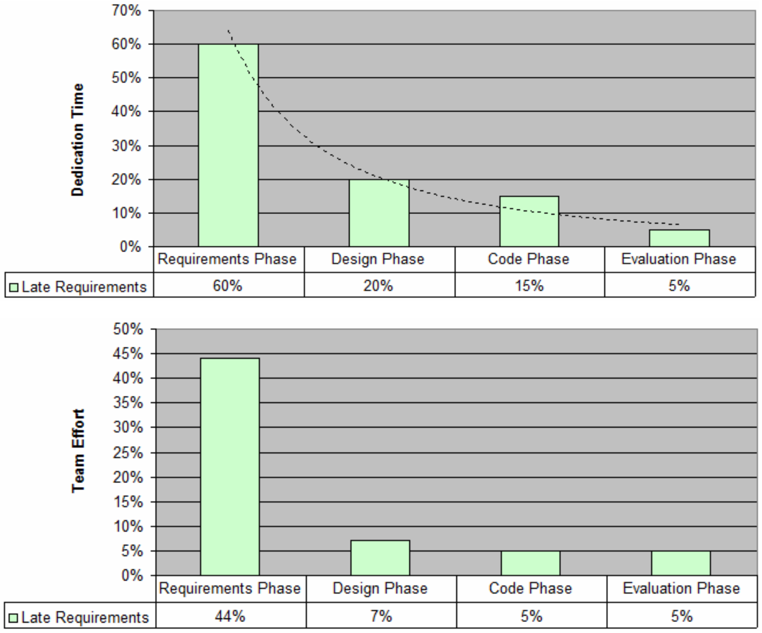

Figure 7.11 - Dedication time and team effort for *Late Requirements* discipline

For the Architectural Design discipline, the results are:

- Approximately 10% of the team's effort was dedicated to perform 10% of the Architectural Design in the Requirements Phase.
- Approximately 33% of the team's effort was dedicated to perform 70% of the Architectural Design in the Design Phase.
- Approximately 5% of the team's effort was dedicated to perform 15% of the Architectural Design in the Code Phase.
- Approximately 5% of the team's effort was dedicated to perform 5% of the Architectural Design in the Elaboration Phase.

Figure 7.12 illustrates the results centered on the dedication time and the team effort for Architectural Design discipline.

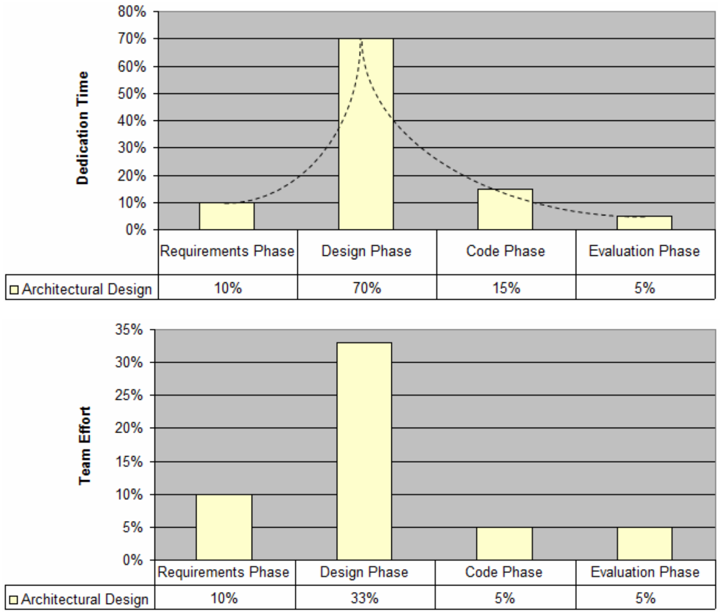

Figure 7.12 - Dedication time and team effort for *Architectural Design* discipline

For the Detailed Design discipline, the results are:

- Approximately 5% of the team's effort was dedicated to perform 5% of the Detailed Design in the Requirements Phase.
- Approximately 35% of the team's effort was dedicated to perform 60% of the Detailed Design in the Design Phase.
- Approximately 10% of the team's effort was dedicated to perform 30% of the Detailed Design in the Code Phase.
- Approximately 5% of the team's effort was dedicated to perform 5% of the Detailed Design in the Elaboration Phase.

Figure 7.13 illustrates the results centered on the dedication time and the team effort for Detailed Design discipline.

For the Implementation discipline, the results are:

- Approximately 5% of the team's effort was dedicated to perform 5% of the Implementation in the Requirements Phase.
- Approximately 15% of the team's effort was dedicated to perform 20% of the Implementation in the Design Phase.
- Approximately 65% of the team's effort was dedicated to perform 65% of the Implementation in the Code Phase.

- Approximately 12% of the team's effort was dedicated to perform 10% of the Implementation in the Evaluation Phase.

Figure 7.14 illustrates the results centered on the dedication time and the team effort for Implementation discipline.

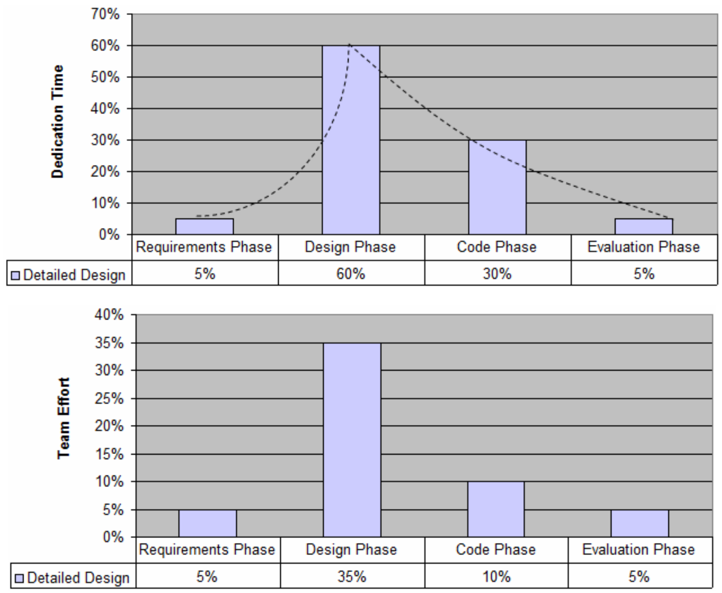

Figure 7.13 - Dedication time and team effort for *Detailed Design* discipline

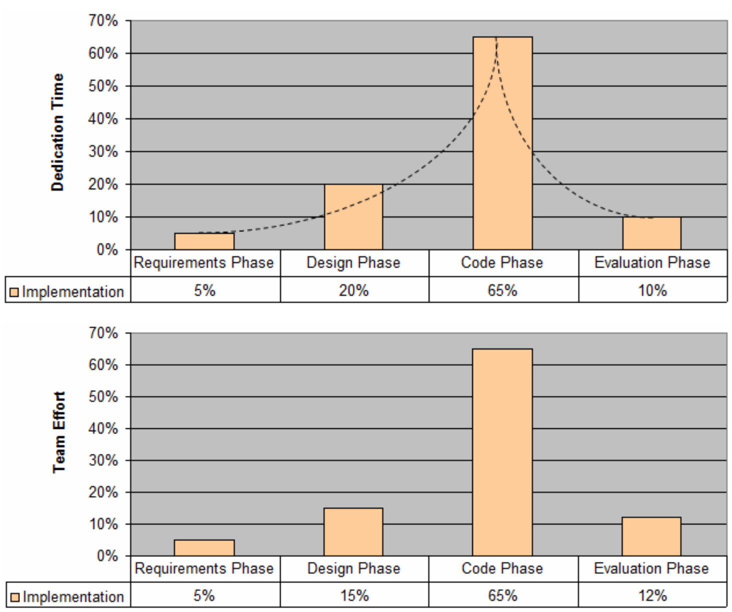

Figure 7.14 - Dedication time and team effort for *Implementation* discipline

For the Test discipline, the results are:

- Approximately 2% of the team's effort was dedicated to perform 2% of the Test in the Requirements Phase.

- Approximately 5% of the team's effort was dedicated to perform 10% of the Test in the Design Phase.
- Approximately 12% of the team's effort was dedicated to perform 28% of the Test in the Code Phase.
- Approximately 68% of the team's effort was dedicated to perform 60% of the Test in the Evaluation Phase.

Figure 7.15 illustrates the results centered on the dedication time and the team effort for Test discipline.

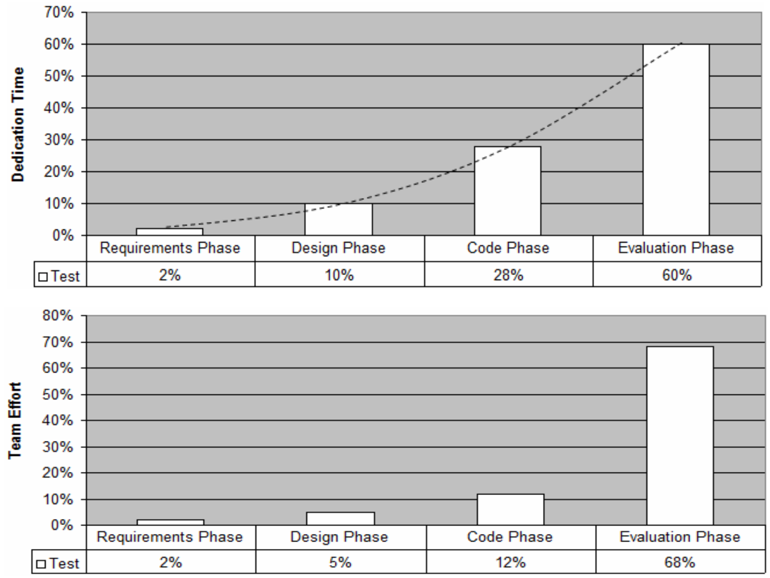

Figure 7.15 - Dedication time and team effort for *Test* discipline

7.7. Third Party Point of View

To illustrate how our results influenced other research groups, therefore contributing to the validation of our work, we can describe the experience we have had with a member of a Research Group at the LNCC – **L**aboratório **N**acional de **C**omputação **C**ientífica. This collaborative work has been underway since the second period of 2008, during the *Software Engineering of Multi-Agent Systems* discipline at PUC-Rio. We developed a context-awareness intentional application by using an intermediary version of our building blocks. We also investigated the concept of grid to deal with the distribution issue in ubiquitous contexts. In this project we supervised the afore mentioned LNCC member by also making available our building blocks, namely: the *Intentional Modeling*

Building Block, the *Integration Building Block*, and particularly the *Intentional Agents' Reasoning Building Block.*

Based on the excellent results obtained in this project, the LNCC's member decided to work with those support sets in his own Crowd Simulation field of research. In 2010, his research group published a paper (Costa et al. 2010) based on the i* modeling, the JADEX BDI Model and other computational support provided by us. In this paper, his research group – an association between the LNCC, the **U**niversidade **F**ederal **F**luminense (UFF) and the Centro Universitário (FEI) – presents a framework for crowd simulation in the game area. In the group's proposal, the game's characters are represented as intentional agents – as suggested by our guidelines. These agents reason and learn by adapting themselves according to the virtual atmosphere under analysis.

The authors argue – among other positive considerations – that the application of the i* modeling to their approach helped them to model different agents' strategic plans and the dependencies between various "Character" agents and the virtual environment in which they will perform their actions. They also model different non-functional requirements of the virtual atmosphere, such as: temperature and humidity. Their "Character" agents make decisions – at runtime – by considering these criteria.

Moreover, the JADEX BDI Model contributed to the development of human-like synthetic characters by allowing that these intelligent entities have realistic behaviors in the virtual atmosphere. Among other abilities, the "Character" agents adapt their actions according to the information given in this ever-changing atmosphere. Figure 7.16 shows their "Character" agents' model for crowd simulation mainly centered on *Inference*, *Decision*, *Learning* and *Planning*.

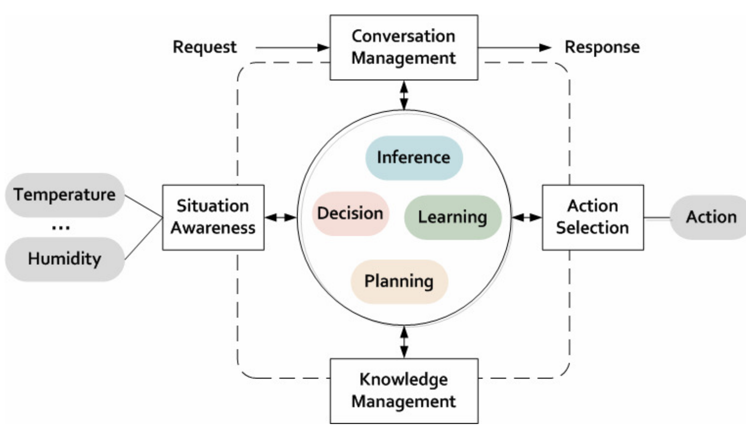

Figure 7.16 - Intentional agents' model for crowd simulation

To illustrate some details, the *Decision* is made by intentional agents "on the fly" in order to select an *Action – Action Selection* – according to the situation under analysis – *Situation Awareness*. The action's selection and the situation's analysis are centered on the JADEX BDI Model by selecting a plan from a plan library to achieve the specified goal. This selection also takes into consideration the *Temperature*, the *Humidity* and other criteria of the environment.

The main purpose of the group is to support the development of games based on real-time strategy simulation. According to their experimental work, the combination of the i* Modeling at a higher abstraction level and the JADEX BDI Model at the lower abstraction level seems to be adequate to both: (i) model – in the requirements and design stages – the rationale of the agents by focusing on different alternative tasks; and (ii) deal with unpredictable situations by deciding – at runtime – which task will be performed.

Furthermore, the LNCC's member continually sends us – by e-mail and Skype – his positive feedback on using our guidelines to make this combination viable in his research projects. This collaborative work represents for us the first feedback of our efforts in dealing with ever-changing situations by applying intentional Multi-Agents Systems. This feedback as well as the peer-review analysis of our papers describing the offered building blocks – published in Proceedings of International Conferences and Brazilian Symposiums, Conferences and Workshops – significantly increased our confidence about evolving our reuse-oriented approach by refining the existing reusable building blocks based on third party experimentation.

7.8.
Closing Remarks

In this Chapter we present the evaluation process performed in the last iteration of the dental clinic ubiquitous application's development. We describe how we have: (i) determined the competences (e.g. adaptability, invisibility, usability, dependability, response time, and mobility); (ii) selected the participants; (iii) simulated the evaluation environment; and (iv) analyzed the results based on how the users perceived those competences while using the ubiquitous application under analysis. Basically, we conducted the evaluation process by using qualitative analyses centered on those competences that directly impact on the user satisfaction. In order to facilitate the evaluation, we suggested a system with seven categories – *Excellent*, *Very Good*, *Good*, *Regular*, *Poor*, *Very Poor* and *Unacceptable*. We also graphically represented the obtained results in histograms based on the frequency of each category for each analyzed competence. Therefore, we calculated the median of each histogram. It allowed us to conclude that the median belongs to the excellent category for all histograms.

Although we presented the results for the dental clinic case study, it is important to consider that we applied the same qualitative evaluation process to all developed case studies from 2007 to 2011. The history of excellent results based on our experimental research motivated us to continually evolve the proposed intentional-MAS-driven engine, which seems to be in the right direction by contributing, for example, to the user satisfaction in ever-changing contexts.

In addition, we analyzed the dedication time and team effort for each discipline of the life-cycle based on this case study. Furthermore, we illustrate how our results influenced other research groups. The excellent results lead us to believe that our reuse-oriented approach provides a suitable and interesting intentional-MAS-driven technological set to deal with some common ubiquitous concerns (e.g. content adaptation, mobility, heterogeneous devices, invisibility need and ever-changing contexts) centered on the user satisfaction.