ROBOTS IN ASSISTED
LIVING ENVIRONMENTS

UNOBTRUSIVE, EFFICIENT, RELIABLE AND MODULAR
SOLUTIONS FOR INDEPENDENT AGEING

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Guidelines for balancing between medical requirements and obtrusiveness

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Abstract

In the current report we have attempted to identify how to best approach the balance between medical requirements and obtrusiveness. Obtrusiveness dimensions have undergone a detailed analysis, considering their relevance to RADIO actions and how each can be addressed within the context of RADIO. We then identified interRAI items that could be potentially intrusive and commented on the type of information (from the technical perspective) that would be necessary to monitor the assessment items adequately. In this way we aimed to answer: **What are the technical solutions required to provide enough information to allow for sound medical decisions?** Although individual preferences make it impossible to construct a universal solution that can be used to maintain the balance between medical requirements and obtrusiveness, this report makes a significant contribution by establishing a framework that maps the choices that need to be made and assigns obtrusiveness indices to what is technically possible.

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Executive Summary

In the current report we have attempted to identify how to best approach the balance between medical requirements and obtrusiveness. The work described in this report builds upon Hensel's definition of obtrusiveness, which only includes privacy considerations but also those of physical, usability, human interaction, self-concept, routine, sustainability and function. These dimensions of obtrusiveness have undergone a detailed analysis, considering their relevance to RADIO actions and how each can be addressed within the context of RADIO. Moreover, we considered obtrusiveness in relation to both the users of RADIO and their visitors.

We concluded that while the utility and usability constructs of obtrusiveness can be dealt with, the design, development and evaluation of the technical methods, as well as the pilot studies of RADIO action, intrusiveness constructs involve a highly subjective factor that is dependent on individual perception. However, giving the choice to users to select only desired items to monitor comes with the risk of undermining system's utility.

Two actions can be taken towards eliminating risks to the utility of RADIO. First, users must be educated, in a simple yet truthful manner, about how privacy is preserved via technical methods. Most importantly, we can choose to use technical methods that guarantee maximum privacy preservation without compromising sound medical information. So the question we asked here was: **What are the technical solutions required to provide enough information to allow for sound medical decisions?**

To answer this question, we identified interRAI items that could be potentially intrusive, both because of the nature of the item (e.g. using the toilet) and because of the recording method (camera). Following that, we brought forward these items and further commented on the type of information (from the technical perspective) that would be necessary to monitor the assessment items adequately.

To sum up, a universal solution that can be used to maintain the balance between medical requirements and obtrusiveness cannot be constructed because it does not consider individual preferences. However, this report makes a significant contribution by establishing a framework that maps the choices that need to be made and assigns obtrusiveness indices to what is technically possible. This will enable making informed decisions about what technical solutions are needed for each given end-user, and also provides insights about which technical advancements will have the most impact.

Abbreviations and Acronyms

ADL	Activities of Daily Living
IADL	Instrumental Activities of Daily Living
interRAI	International collaborative to improve the quality of life of vulnerable persons through a seamless comprehensive assessment system. Cf. http://www.interrai.org
interRAI HC	The *interRAI* Home Care Assessment System
interRAI LTCF	The *interRAI* Long-Term Care Facilities Assessment System
AT	Assistive Technology
HRI	Human Robot Interaction
AAL	Ambient Assisted Living

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1 INTRODUCTION

1.1 Purpose and Scope

This report works towards determining the guidelines that will help the project balance between:

1. The clinical requirements, meaning the detection methods that guarantee that the RADIO system is a sound solution for recognizing functional activity patterns, acting as a first step towards an alternative solution to hospitalization and
2. The obtrusiveness and ethical requirements

More specifically, it will investigate the conditions and circumstances under which medical requirements necessitate obtrusive sensing and/or actuation; identifying cases when end-user reactions necessitate that the robot returns a "safe base" inside the home and an emergency notification is sent; and similar situations where the different requirements and considerations interact in conjunction with the end users' gender and social, cultural, and ethical background.

Based on the Task description above, we could differentiate three different levels at which the RADIO ecosystem could be prove to be obtrusive:

- At the level of *Sensing*; that is the raw data collection level. The main question is whether the sensing modality (audio, visual, depth/range sensor or smart home automation log) is obtrusive for the specific activity of Daily Living (ADL) or mood behavior item.
- At the level of *Acting* and *Access Control*; this level includes the actuation of the robot tasks such as detecting the elderly person, decisions about sending notifications to secondary users (relatives, caretakers, clinicians) and so on.
- At the level of *processing and networking the information*; this level ensures privacy throughout the processing of data pipeline and grants access only to authorized parties.

This deliverable is the first version of the report that specifically works towards defining any obtrusiveness fallacies taking into account the *Sensing* level, as well as the *processing and networking of the information.* . Moreover, we have set requirements that aim to balance medical requirements, and unobtrusiveness demands. Finally, it will also comment on issues related to *Acting* and *Access Control.* The final version of the report (Deliverable 2.7 due on Project Month 18) will enlist the final medical requirements description.

1.2 Approach

This report is prepared within *Task 2.3 Balancing between medical requirements, obtrusiveness, and safety.* It will investigate the interaction between safety considerations (for the end-user and the robot), medical data collection requirements, and unobtrusiveness and related sociological, ethical, and gender issues. Toward this goal, it will take into account

1. The findings of *Task 2.1* with respect to the medical importance of the various sensing and actuation capabilities of the system and
2. The findings of *Task 2.2* with respect to the obtrusiveness of these capabilities.
3. The sensing demands to record clinical items as enlisted in *Task 3.1.*

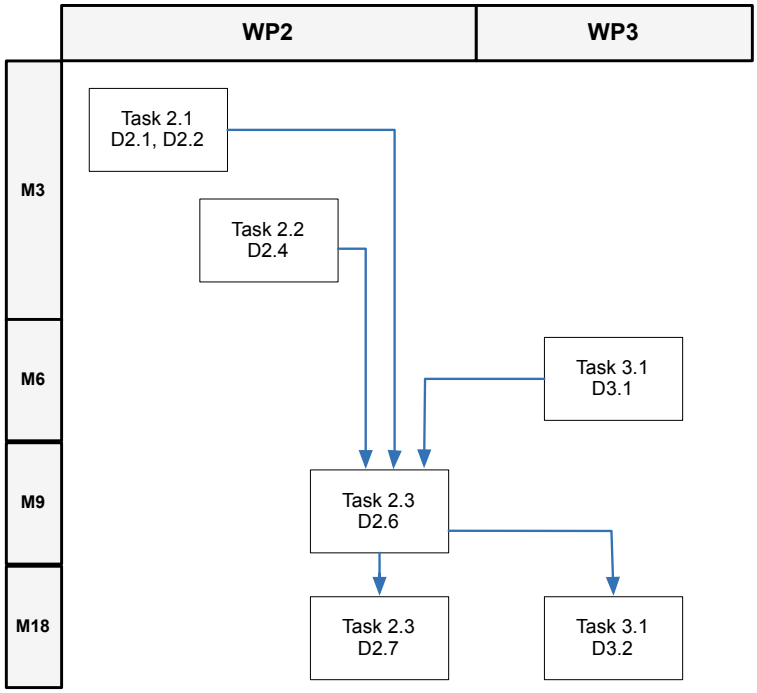

Figure 1: Dependencies between this deliverable and other deliverables.

Specifically, Section 2 builds upon the findings of *Deliverable 2.4 Actual and perceived privacy considerations and ethical requirements*, and extends the idea of obtrusiveness. Specifically, we describe the several dimensions related to obtrusiveness and comment on how RADIO tackles each one of them. Section 3 takes into account the interRAI items (clinical requirements as set in D2.2) along with the proposed sensing methods (D3.1) and assess whether the data collection in each case might be violating the need for unobtrusiveness. Section 4 brings forward the items marked in Section 3 as potentially" intrusive" and comments on the least obtrusive type of information (available to the system) that guarantees meaningful and sound clinical information.

1.3 Relation to other Work Packages and Deliverables

This deliverable is informed of *D2.2 Early detection methods and relevant system requirements, D2.4 Actual and perceived privacy considerations and ethical requirements* and *D3.1 Conceptual architecture for sensing methods and sensor data sharing.* It will be superseded by *D2.7 Guidelines for balancing between medical requirements and obtrusiveness II.* Moreover, the guidelines set on this deliverable should be applied in the preparation of *D3.2 Conceptual architecture for sensing methods and sensor data sharing II.*

The personal data retention and unobtrusiveness trade-off will be described in detail in the next version of this deliverable (in D2.7), which will elaborate this deliverable based on information from the RADIO ecosystem architecture (D5.1, due M12).

2 UNOBTRUSIVENESS REQUIREMENTS

This section aims at defining obtrusiveness and discussing how different notions related to obtrusiveness will be tackled by RADIO. While Deliverable 2.4 reviewed current studies of sociological, ethical, and gender issues associated with collecting information for medical purposes and investigated the impact of such sociological, ethical, and gender issues to the RADIO system‘s design, in this deliverable the notion of obtrusiveness is extended to include other dimensions as well.
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2.1 Introduction: Defining Obtrusiveness

The technological transition entails, among many things, the creation of new terms in language capable of designating precisely the ideas, objects or technologies. The word *obtrusive* is being used increasingly, in the fields of many new technologies, including information technology, automation and robotics.

Despite the importance of the attributes of the term *obtrusive* in these technological fields, there is still no clear definition. This term is used as an adjective for something too “apparent / prominent” with a “striking” or “conspicuous” no way acceptable or obstructive manner. It means something undesirably prominent, undesirably bulky. The adjective can refer to something undesirably prominent physically, psychologically, or both. Because these new semantic dimensions, are derived from the home automation and robotic technologies, it is why we have a real neologism.

In relation to the world of home automation / robotics, “obtrusiveness” might be more related to hardware than software. Even though there would be software “obtrusiveness” which would be mainly psychological, derived from complexity of using the program.

Examples of different uses in telemedicine are for instance that the term is sometimes applied as a criterion for successful implementation but also to mean that users did not have to operate the system. Other authors, however, use the term “obtrusive” to refer to the miniaturization of devices (specifically in the field of monitoring and capture of vital signs).

Regarding Assistive Technologies (AT), the notion of obtrusiveness could be described as a partial occupation of the discreet space of the users, either in physical, mental or psychological form, by an entity that is visible (even if in minimal dimensions) and tangible. The extent of the obtrusiveness depends mainly on the subjective perceptions of each user and his/hers level of discomfort.

Accordingly, when an AT entity occupies the personal space of the users (that mainly concerns issues of personal nature), we could then refer to this space as being intruded, in contrast to being obtruded. In other words, intrusiveness refers to AT’s entering the privacy dimensions and getting access to the personal data of the user.

The personal space relates to privacy matters but human relationships and personal roles also concern to issues of a personal nature, and any interference produced by AT’s could be also regarded as an intrusion in our personal (non private) space. The prefix of the terms *ob*-trusive and i*n*-trusive could explain the location of the problem as, outside versus inside, the person.

2.2 Background: Obtrusiveness and ambient technology

There are several studies aiming to study the perception of obtrusiveness in ambient technologies. Van Hoof et al. [9] aimed to register the perceptions of older users on ambient intelligence technology. Their findings showed that technology installations have to fulfill a number of

specifications in terms of the operation and the design in order to be useful and easily accepted by all users, especially with those with a cognitive impairment or sensory deficits. In terms of obtrusiveness, although the respondents made numerous remarks concerning the design, appearance, and implementation of the ambient intelligence technologies installed in the dwelling, the majority mentioned that the system went unnoticed or blended with the interior design. This observation is useful in helping us understand the priorities that older people place on assistive technology and the attention they primarily focus on that which is meant to facilitate them.

It is apparent that the widespread use of devices and technologies depends on their reliability, obtrusiveness and cost. For older people safety and usefulness rate higher than any possible inevitable compromise in privacy. In general, older adults are interested in technology applications for which they perceive a need.

Thielke et al's [23] study confirmed the fact that older adults will not adopt a health-related technology if it does not fulfil their current levels of need, no matter how unobtrusive, smart, affordable, or powerful the technology is. Therefore, the introduction of comprehensive packages of AT is not recommended without individual user assessment: the assessment of 'objective' needs has to be balanced by reference to the individual's perception of his or her own needs [24].

There has been little study, of older adults' views on obtrusiveness of aides that prolong their independence [25]. Demiris et al's study [26] conducted a series of focus groups to assess older adults' perceptions and expectations of specific smart home technologies. The results show that most participants acknowledged the need for a balance between the benefits of such monitoring, determined by level of need, and the perceived intrusion into their privacy. Regarding psychological obtrusiveness, it is interesting that some specific technologies for elderly contain stigmatizing symbols that can backfire the implementation of these "gerotechnologies" [28].

Home robots, alone or in combination with a limited set of sensors embedded in the home environment, have the potential to achieve effective monitoring of individuals in a rather unobtrusive way and with very limited likelihood of generating privacy concerns [27].

Hensel's work on the creation of a conceptual framework for the definition of "obtrusive" is the most valuable contribution so far in this field. In Hensel et al [13], fundamental dictionary definitions of "obtrusive" were used to develop the definition of obtrusiveness as a summary evaluation by the user based on characteristics or effects associated with the technology that are perceived as "undesirable and physically and/or psychologically prominent". The author suggests that we consider 4 assumptions: the first is that the variable is the result of an addition of features / effects (multicomponent) associated with the technology; second, it is a subjective term; third that the user is not the only subject but also involves all residents of the home; and finally that it is dependent on where the technology (home vs institution) applies. Specifically, 22 subcategories of obtrusiveness from the literature, were inductively grouped under eight dimensions which determine the user perception of obtrusiveness:

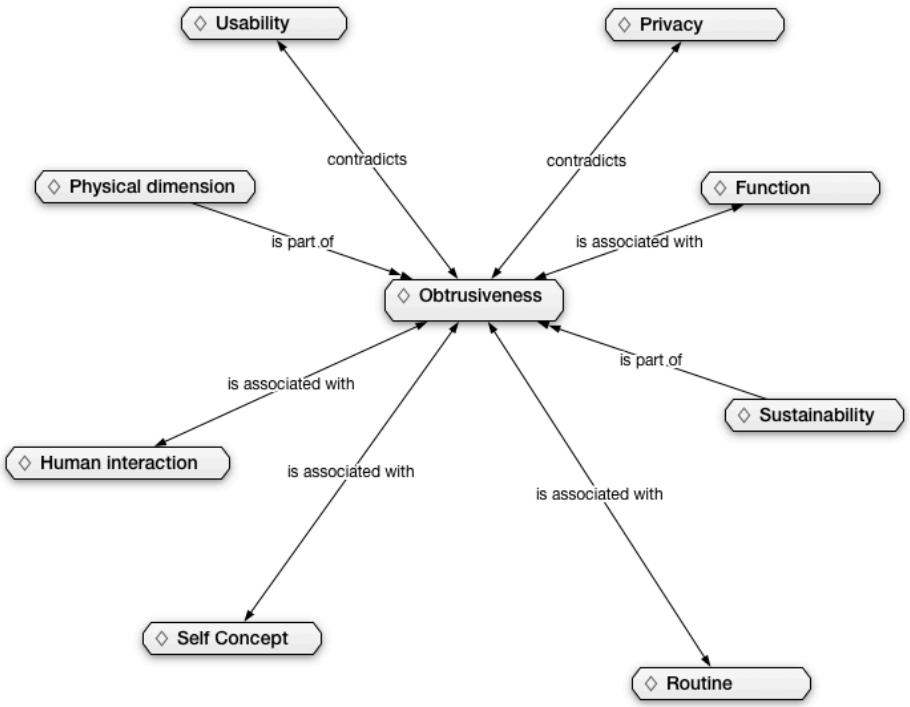

Figure 2. Semantic network for obtrusiveness.

1. *Physical dimension*: functional dependence, discomfort or strain, excessive noise, obstruction or impediment in space, aesthetic incongruence.
2. *Usability dimension*: lack of user friendliness or accessibility, additional demands on time and effort
3. *Privacy dimension*: invasion of personal information, violation of the personal space of home.
4. *Function dimension*: malfunction or suboptimal performance, inaccurate measurement, restriction in distance or time away from home, perception of lack of usefulness.
5. *Human interaction dimension:* threat to replace in-person contacts, lack of human response in emergencies, detrimental effects on relationships.
6. *Self-concept dimension:* symbol of loss of independence, cause of embarrassment, or stigma
7. *Routine dimension:* interference with daily activities, acquisition of new rituals.
8. *Sustainability dimension:* concern about affordability, concern about future needs and abilities

Based on the above concept paper, Courtney et al [14] did a secondary analysis of focus groups and interviews about the use of Assistive Technology use with older people in residential care in order to explore the depth and breadth of the obtrusiveness. This analysis confirmed to a significant extend the categorization made by Hensel et al [13], and showed that the 8 - dimensions conceptual framework for obtrusiveness appears well represented in the prior study's participant descriptions of factors influencing their acceptance of technology.

The need for the categorization of the different concepts of obtrusiveness is also confirmed in the literature review study made by Zwijsen et al, [31] which concluded that the notion of obtrusiveness as a concept that entails all ethical dimensions regarding user acceptance of AT devices, it rather complicates the debate rather than simplifying it. Subsequently, when discussing ethics, it thus advisable to disentangle the concept of obtrusiveness into its underlying components.

2.3 Analyzing obtrusiveness dimensions for RADIO

In the following we explore the details for each of the aforementioned dimensions and discuss how the RADIO project is going to tackle each one of them.

2.3.1 Physical dimension

The physical dimension of obtrusiveness includes the following parameters: functional dependence, discomfort or strain, excessive noise, obstruction or impediment in space, aesthetic incongruence.

A striking example of physical dimension obtrusiveness are wearable sensors, which can result in discomfort and inconvenience for users [18] especially when accuracy depends on body position placement. So, obtrusiveness takes a central role in the user's attention and concerns. Bergmann et al., [19] showed that the importance of form and aesthetics of the device could also link into the idea that the device should not affect normal daily behaviour. This implies that any device should be tested for a wide range of user specific activities in order to guarantee low obtrusiveness of the design throughout the day. Equally for general practitioners [20] when it comes to wearable sensors, obtrusiveness is important because a low level of obtrusiveness leads to better use of the sensor by the patient.

For this reason, sensors installed in the environment (smart houses) are an acceptable solution without impacting on the privacy of the tenant and without assuming an extra burden to bring sensors. However, elders expressed concern about the appearance of technology (for the prominence or interference) when they find it in their homes [21].

These results show the magnitude of the environment dimension (home versus institution) regarding "obtrusiveness" as previously described by Hensel. Some technologies could be implemented in an institutional scenario because the space in the nursing home is greater than in a private home. Moreover, this is also related to the concept of ownership. This can be phrased as follows: "In my home I would not like to have obtrusive prominent things around (because of aesthetics and potential damage), however in the Nursing Home I do not care, it is not my territory".

Concerning the discomfort or strain of users interacting with socially intelligent robots a relevant survey [32] showed that the majority of the subjects disliked the robot moving behind them, blocking their path or moving on collision path towards them. The majority of subjects experienced discomfort when the robot was performing a task within the social zone reserved for human–human face-to-face conversation (closer than 3m). Proximity between the robot and the user raises substantial questions about safety, and that is why [33] safety and dependability of the physical interaction have to be evaluated considering all the different components of a robot, from mechanisms to actuators, and from sensing to control.

For RADIO, it was decided that no wearable sensors would be introduced to the system. Moreover, there is a lot of effort put into having discrete and mobile sensors. Finally, issues pertinent to robot design (WP4) are: a) controlling the proximity of the robot to the user, b) robot movement noise.

2.3.2 Privacy dimension

2.3.2.1 Privacy definition

The first milestone in the legal definition of privacy goes back to 1890 when Warren and Brandeis [1] defined privacy as "the right to be alone", that is the right to protect one's private sphere against interferences from others, while Westin in 1967 [2], defined privacy as "the individuals' right to control the circulation of information concerning him or her". From them on, the concept of privacy has substantially progressed and analyzed due to the socio-economic development and the rapid advance of new technologies.

The many competing accounts of the nature and value of privacy can be divided into two main categories. Reductionists argue that privacy concerns are analyzable or reducible to claims of other values. On the other hand, the coherentists claim that privacy is a coherent and fundamental concept, whose value and importance are not derived from other considerations [3].

Daniel Solove [4] presented a more pluralistic and merging conception of privacy, understanding it "as a set of family resemblances not reducible to a singular essence". This pluralistic view of privacy has the advantage of examining concrete problems of privacy as interrelated yet distinct aspects of , something appropriate to the interpretation of privacy into the complicated world of assisted living technologies.

2.3.2.2 Privacy in Ambient Assistive Living Environments

As technology progresses, the rapidly evolving capacities of ambient assisted living systems to monitor, access and store personal data will always be under close and meticulous inspection as to how much they affect the end user's right to privacy. Several parameters influence the final typology and the characteristics of privacy settings in every user case. It is obvious that the different and versatile profiles of users compared to the complicated and not transparent function of the installations, are not compatible to a universal code regarding privacy and data protection. At this point as stated by Schulke et al, "a meaningful balance needs to be struck between privacy, security and safety" [5].

For acquiring the best possible result for users, and for exploiting the full potential of the technology's capacities, it seems very likely that the compromise of some aspects of privacy for the accomplishment of the best possible safety and monitoring conditions for the patient, will result in a trade-off between needs and privacy [6]. Coeckelbergh [7] argues that while privacy is one of the principles that should guide the design and use of ambient assisted living (AAL) technologies, it should not be the only one, as it needs to be balanced by healthcare principles.

Especially in the design of physically assistive robots the consideration of the privacy settings requires certain provisions should be taken by the designers in order to safeguard the privacy of the users, including the deactivation of video monitors during intimate procedures. Care must also be taken with protocols for touching, something that is a standard part of human caretaker training. [34]

Probably most of all, the tangible presence of the robot raises privacy issues. The option of the user to instruct the robot to withdraw, is a significant factor regarding privacy settings and a robot may be perceived as less of a privacy invasion than a person, especially in potentially embarrassing situations. [35]

Results from different surveys display older adult's perceptions of smart home technologies in relation to the loss of privacy and 24/7 monitoring as a way to ensure safety and security but also as an "equal threat to dignity in one's own home" [8], while the strong aversion to institutionalization

and the increased sense of safety and security among the respondents of another survey resulted in no concerns related to their privacy [9].

Nevertheless, here we have the following paradox: “while new technologies claim to help humans gain more control over the environments with which they interact, this control is supposed to be gained through a delegation of control to machines. In other words, control is to be gained by giving it away”. [10]

2.3.2.3 Awareness of technology

The privacy dimension goes further than the psychological dimension; it points actually to human dignity. This is particularly relevant in the field of measurement techniques throughout external non-wearable sensors because they are undetectable by the subjects. In this regard we must bring special attention to "awareness or acceptance of measurement" because without this element of a user’s approval we could violate the privacy or intimacy of the individual. Being "invisible" does not mean that the subject is not aware that a measurement is being taken.

Moreover, AAL environments are increasingly sophisticated and as such more difficult for users to fully understand. Privacy critics assume the ability of users to comprehend and make decisions regarding their privacy preferences and the privacy policies of different assisted living solutions and services [11].

Unless someone is cognitively impaired all users should make their own decisions, including exercising the right to make their own mistakes and take the consequences. Having control over the assisted living environments and robots preserves the notion of free will and self-determination for the patients and users, something that cultivates the ground for a smooth human machine interaction.

According to the SENIOR project discussion paper [12], a positive function of the right to privacy is connected to the obligation, falling upon third parties, such as state authorities or service providers, to enable the individual “to control access to information about him or her”.

2.3.2.4 Data protection

Data protection is critically connected with privacy. While continuous monitoring of homes and human activity can offer a safer environment for older people, many are wary of constant surveillance and the lack of control over data collected.

In terms of data protection, RADIO strictly complies to the Data Protection Directive (1995/46/EC) and the Privacy and Electronic Communications Directive (2002/58/EC), which currently address data protection, privacy and to a certain extent, security. Also, RADIO is following the recent (25-1-2012) proposal for a comprehensive reform of the EU's 1995 data protection rules in the adopted regulatory framework. Based on the above directives, the regulation of processing personal data is specifically stipulated. (see D2.4).

Another issue related to data protection is who gets access to them? In RADIO, an authentication and authorization scheme is foreseen that will ensure that only authorized users have access to private data. Moreover, data transmission should also be encrypted using end-to-end encryption schemes.

Finally, data protection must also be guaranteed when data over different RADIO deployments are requested for research purposes. Privacy protection in terms of data analysis will be tackled by:

a) Deciding the types of information collected, transmitted and retained. This document, in particular, defines the types of information that maintains the balance between medical requirements and obtrusiveness (please refer to Sections 3 and 4 for more details).

b) Storing and analyzing content locally to each RADIO home and only providing abstract analysis results outside of the RADIO home (WP5).
c) Restricting analysis in such a way that no individual data points (even abstract information) are requested but only their aggregates (WP5).

2.3.3 Usability dimension

Usability is based on the concepts of ease of learning, ease of use, flexibility and robustness. Obtrusiveness and usability have semantic connections. It is described as a dimension of obtrusiveness and vice versa, so that they have an inversely proportional relationship. However, we should not reject something potentially usable just because of its physical and psychological appearance.

It is very important to realize that usability is not only in the immediate application of technology but the final benefits achieved [15]. Branderbest (1982) for instance pointed out that usability defines the purpose of the system created. For this reason, the conceptual model of usability is not complete without the idea of utility [43]. However, for a long time, the concept of usability has been limited to ease of use and user friendliness (from the movement "patient-centred design movement " [44]).

In this field of usability, we must also highlight two aspects; one is that the elderly population, as shown by some studies, has expressed a priori a less perceived need and limited usefulness of technologies than adult population generally [28]. The second aspect is that, older people have different preferences, between robotics and human assistance, when they have to receive care. They prefer humans for personal care tasks and leisure, and robotics for more basic tasks such as manipulating objects or information management [16, 17].

Usability depicts the level of satisfaction of users concerning how easily or well he/she can perform a task with a device. Usability, therefore, is a factor concerning the user's acceptance or rejection of the device [36]. ISO 9241 [37] guidelines refer to usability as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

We must not forget also the fear many users may have towards the RADIO platform, especially those who are not accustomed to new technologies and even more to robotics. According to one study [38] "computer anxiety" can have a significant negative impact on attitude 'intention' 'behaviour' and 'performance' of the user.

Appreciating the importance of the usability dimension, RADIO pilot studies will focus, among others, on providing feedback about the user friendliness, accessibility, together with the time and effort demanded to use RADIO. More specifically, the formative phase of RADIO pilots tested an existing GUI to get feedback on usability requirements for designing RADIO's GUIs. Based on the results, RADIO GUI must satisfy several requirements such as, larger text fonts, more intense colour contrast, and more straight-forward navigation though several functions offered. The intermediate phase pilot study, will proceed by testing the usability of the first RADIO prototype, researching aspects of usability of the overall system. Summative phase RADIO pilots will measure the usability levels of RADIO system and robot in two settings, (FZ- home environment and FHAG - institutional care) with the engagement of older people from different social and cultural background. Piloting in two different environments under different conditions and with users with different needs will test the adaptability of the RADIO prototype to correspond in terms of easiness and usability to the users.

Finally, the usability of the system from the perspective of the caregivers will also going to be tested during the summative phase, focusing on evaluating the improvement in their quality of life.

2.3.4 Function dimension

The concepts related to this dimension are malfunction or suboptimal performance, inaccurate measurement, restriction in distance or time away from home, and perception of lack of usefulness. Malfunction or suboptimal performance of the equipment, especially for home users is a significant dimension. Especially in the home environment the level of autonomy of the users, may threaten – to a lesser or greater extent – their safety. It is apparent that in systems like RADIO there must be meticulous planning and provision in order "to solve these unforeseen situations without entering in malfunctioning states. This implies that these systems need to exhibit an intelligent goal-oriented behavior and yet still be response to changes in their circumstances". [39]

Nevertheless, from the system point of view, HRI should be considered as part of unpredictably changing environments. *"From this point of view, "failures" are events (e.g., contacts with a person, unexpected changes of user's mind, even users' mistakes) that cannot be ruled out in principle, and must rather be faced by suitable policies. The need hence arises for fault detection and for graceful fault management and recovery". [40]*

A question relevant to this discussion is "What level of inaccuracy in the various interRAI items could be acceptable?" In part, this question can only be answered after the development of the various methods related to monitoring of ADLs and mood behavior.

The technical evaluation of the RADIO solution will be realized in the framework of WP3, WP4 and WP6.

2.3.5 Human interaction dimension

This dimension refers to the threat to replace in-person contacts, lack of human response in emergencies, detrimental effects on relationships. Specifically, Courtney and colleagues reported that even if people were happy to adopt AT, they would still prefer a human response in the case of a crisis [14]. Interestingly enough, participants in the studies described did not report any effects on threat of replacement of in-person contacts and detrimental effects on relationships. However, this does not mean that these subcategories are not of concern, especially to RADIO because of the presence of the robot.

A major concern of researchers in Human Robot Interaction (HRI) is the loss of human contact and social interaction. The loss of social interaction can result in increased stress and cognitive decline. It seems that reduced social interaction can have a measurable impact on the health and well-being of the elderly, and reinforces the idea that depriving them of such contact is unethical [30]

The design of the robot, particularly regarding the human factor, is a key aspect of HRI. The robot's physical embodiment, form and level of anthropomorphism, and the simplicity or complexity of the design, are some of the key research areas needing further attention.

Approaches to social interactions with robots in HRI research can be categorized into three, not mutually exclusive, directions:

- Robot-centered HRI
- Human-centered HRI
- Robot cognition-centered HRI

Especially in the case of physically assistive robots, where users could be both vulnerable and dependent their physical and psychological needs must be respected in HRI design and implementation, the main concerns are: (a) the involvement of robots in particularly intimate activities such as bathing and sanitation; (b) direct physical contact between robots and humans, (c) the high

probability of patients' forming emotional bonds with robots in environments that otherwise may be lacking in human companionship. [41]

Concerning human centered HRI, anthropomorphism is a factor that significantly affects the HRI. Human-like robots might appear 'unnatural' and evoke feelings of repulsion in humans. [42]

Under this perspective, in HRI, the formation of emotional bonds might be inevitable regardless of the morphology of the platform and the direction of the design process towards encouraging or discouraging this [29].

RADIO further plans to evaluate this item during the *Summative Phase* pilot studies. Moreover, responsiveness of secondary users to alarms, as well as other actuation of the system will be dealt with in more details in the next iteration of this document (please refer to Section 1.1). Finally, in the current document we identify cases where safety alarms are necessary.

2.3.6 Self-concept dimension

This dimension of obtrusiveness is related to symbols of loss of independence, due to embarrassment, or stigma.

This construct goes with the concept of psychological obtrusiveness. As stated earlier, on some specific technologies for older people contain stigmatizing symbols that can backfire on the implementation of these "gerotechnologies" [28]. The more prominent the presence of a device is (obtrusiveness), the more negative its symbol is and the lower is its utility. Elderly people feel concern about dependency; their self-stem is compromised when they reveal technical aids in public. They try to avoid the use of those aids in a paradoxical mode. For instance, they are frequent fallers but they are reluctant to use zimmer frames or walking canes. The larger the technical aid is the greater the impact on self-esteem, as their dependency is more visible. This situation can also occur with small technical aids like hearing aids for deaf people.

RADIO will evaluate this item during the *Summative Phase* pilot studies.

2.3.7 Routine dimension

This dimension refers to interference with daily activities and the acquisition of new rituals. Questions relevant to this dimension are: "If the user has to setup the system (on daily basis) how is this going to affect his daily life? Will he have to wake up earlier? Before he goes out will he have to let the system know that he is going out? If I miss some activity for any reason will I have to let the system know that the activity was cancelled?'

RADIO can evaluate these issues especially in the case of RADIO deployments in private homes (FZ).

2.3.8 Sustainability dimension

This dimension of obtrusiveness relates to hesitating to make a commitment to a technology that is expensive to acquire and maintain or that might solve only short-term problems but would require a complete replacement to address future needs and abilities. Although well within the scope of RADIO, this dimension of obtrusiveness touches upon technical rather than ethical considerations. Specifically, affordability is one of our core objectives and has influenced several key decisions in system design (please cf. D4.1 *Physical Architecture* for more details):

- The RADIO gateway bridges three different networks (zWave, Bluetooth, and WiFi) allowing maximal flexibility to integrate off-the-shelf commercial components with more advanced experimental prototypes.

- The RADIO robot is based on the TurtleBot2, a low-cost robotic platform that gives a robust and affordable basis for experimentation.
- All sensors are developed using off-the-shelf sensing and computing modules, and effort is made to develop sensing algorithm that can execute on low-cost low-power computing modules.

Extensibility for future use cases and needs is also accommodated by establishing sensor signal processing pipelines that are developed as systems of re-usable services and processing components. In this manner, the monitoring equipment installed for the RADIO system can be re-used by other systems to satisfy further clinical requirements pertaining to different medical conditions and user needs. Although already taken into account in the current conceptual architecture (D3.1), this will be further emphasised in the revised conceptual architecture (D3.2).

2.4 Obtrusiveness and RADIO Home visitors.

The data collection of advanced activities of daily living (Activity Preferences and Involvement InterRAI items) have some obtrusiveness to others not just the selected participants. Interestingly this highlights the concept of obtrusiveness itself: subjective, multifactorial, environment dependent and multi-target (individual vs group).

To the best of our knowledge there is no literature related to this topic. The only relevant information we were able to spot is included in Cortney et al. [14] and actually comments on aesthetic incongruence:

> *…one participant described how distracting she found the assistive technologies in another resident's apartment: '[it] concerned me in M's room when I saw those things [motion sensors]. I thought that would—I would always be looking at them. And they said they could put it up higher on the wall. It's still there. You're still going to look at it'.*

From a data privacy perspective, the following directives are related to monitoring by CCTV and phone call recording. Data Protection Directive (95/46/EC) imposes broad obligations on those who collect personal data and confers broad rights on individuals about whom data are collected. Personal data is defined as any information relating to an identified or identifiable natural person (Article 2(a)). The Directive does not apply to the processing of personal data by a natural person in the course of a purely personal or household activity (Article 3(2).

2.5 Conclusions

Obtrusiveness is a subjective, multidimensional, environment dependent and multi-target (person vs residents) concept. In addition to its complex conceptual framework and definition it is not present in some languages of the RADIO partners. Due to these challenges we have opted for an operational definition for the RADIO project taking into consideration Hensel's semantic network where physical issues, privacy issues, usability, human interaction, self-concept, routine, sustainability and function are the main categories.

In the previous paragraphs, Hensel's dimensions of obtrusiveness were presented in a detailed way. Most importantly, we highlighted how each dimension is directed within RADIO. Table 1 summarizes the actions that RADIO has undertaken to ensure maximum satisfaction of unobtrusiveness.

While all obtrusiveness dimensions, can collide with satisfying medical requirements, it becomes apparent from Table 1 that some dimensions are more prone to be impacted upon by individual perceptions of obtrusiveness.

Let us consider the following grouping of the obtrusiveness dimensions:

a) Part I (Usability constructs): Usability / Physical dimension

b) Part II (Intrusiveness constructs): data and privacy, human interaction, self-concept, routine

c) Part III (Utility constructs): Function / Sustainable

Table 1. Obtrusiveness Dimensions and related RADIO actions

Obtrusiveness Dimension	RADIO actions	Comments
Physical	- Sensors: discrete, mobile, not wearable - Robot: control proximity to user (WP4)	Possible source of unavoidable obtrusiveness robot noise
Usability	- RADIO pilots (WP6)	
Privacy	- Analysis of the type of information available (this report) - Privacy preserving data management (WP5) - User: informed consent and option for selecting only desired components of the system.	Important to convey information to the primary end users about how privacy will be preserved during monitoring. Potential work within WP7.
Function	- Technical evaluation (WP3, WP6)	
Human interaction	- Evaluation during Summative phase pilots (WP6) - Specification of safety alarms (this document). - Detailed description of alarms and other related system actuations (*D2.7 Guidelines for balancing between medical requirements and obtrusiveness II*)	
Self-concept	- Evaluation during Summative phase pilots (WP6)	
Routine	- Evaluation during Summative phase pilots (WP6)	
Sustainability	- System designed to guarantee affordability via the design of the system - Extensibility for future use cases.	WP7 will describe how marketing success will be ensured by assuring that RADIO technology is "unobtrusive".

Usability and utility constructs contain a high degree of objectivity, in the sense that they are dimensions that can be controlled via:

a) Technical requirements, design and evaluations
b) Piloting the system.

On the other hand, the *intrusiveness construct* entails a high level of subjectivity that primarily depends on each individual's perception and definition of all related concepts (privacy, human interaction, self-concept, dignity and routine). To this end, defining a universal framework that satisfies the needs of every potential user would be impossible. Satisfaction of these dimensions of obtrusiveness could be achieved, to a large extent, by obtaining individual consent and providing the option of selecting only the components that one does not find obtrusive.

An underlying risk here is that system is limited to such a degree that its usability is completely undermined. So, how to keep the balance between having a system that provides sound medical information and preserves unobtrusiveness?

In terms of privacy preservation, there are technical methods that can provide solutions to safeguard this. These solutions vary from how much information (content: raw data or descriptive statistics) is made available to interested parties (clinical staff, caregivers) to where the data are processed (on the sensors or in a central processing unit) and how these are managed. The content of information particularly, plays a crucial role in medical decision-making. From a medical perspective **the technical solutions are required to provide sufficient information to allow for sound medical decisions**.

Thus, even though we cannot set a universal framework for satisfying obtrusiveness from the user's perspective, we can define at the same time, for each monitored item, what is the most privacy preserving method that provides sufficient medical information.

Of course, a challenge still remains as to how to educate end users about the extent that their understanding of privacy preserving methods, or lack thereof, does not compromise the usability of the system. In most cases, understanding of how technical methods work goes beyond the understanding of most users. A striking example is the use of visual sensors. A majority of people would think that having a camera monitoring them means disclosure of private moments in the form of video content. However, this is not necessarily true as the end product of data monitored via a visual sensor may only be a confirmation of the occurrence of an event. This example also points out that usually aside from what is recorded (for example a private moment), it is also important to consider the medium of recording (what sensor is used).

Finally, we also considered another aspect of obtrusiveness, concerning people visiting a RADIO home. Actions should be taken to ensure that RADIO does not become obtrusive to other people when they participate in activities with the RADIO user (such as leisure activities).

In the rest of the document, we first attempt to identify items that raise concerns of their obtrusiveness (from an intrusiveness construct perspective) (Section 3) and then we define the types of information that provide sufficient medical information (Section 4).

3 INTERRAI ITEMS AND OBTRUSIVENESS

The methods for extracting data for the required clinical information, meaning ADLs and mood behaviour were introduced in *D3.1: Conceptual architecture for sensing methods and sensor data sharing I.* In this section, we start by briefly describing these methods. We then go on to explore medical requirements (interRAI items) for their obtrusiveness (from an intrusiveness construct perspective) based on what and how it is recorded. As described earlier, this sort of exploration can be highly subjective. Our intention here is to identify items that could potentially cause conflicts before dealing with them in the next section.

3.1 Methods for Collecting Data for the Required Clinical Information

In the RADIO Home, data are collected by sensors that are either *fixed* or *mobile.* We discriminate raw data collection between four main sensing sources.

a) *Audio data*, collected by microphones. They are going to be used for audio events recognition methods, identifying or verifying speakers, and non-verbal mood behavior data. Moreover, audio data are going to be used for automatic speech recognition.

b) *Visual data*, collected by cameras. These data are going to be used for human motion and posture analysis, face detection, recognition and expression analysis, as well as for clothes recognition for changing clothing detections.

c) 3D / Range data, collected by 3D cameras and laser scanners. Range data from a laser range finder will also be used to recognize motion patterns.

d) Automation usage log, collected by Smart Home's automation (e.g. water usage). Smart Home automation can provide some information about some ADLs such as locomotion by presence sensors as well as about computer activity (power consumption) and bathing or toilet functions (water consumption).

In many cases visual and range data can be combined to detect humans in the environment as well as to extract motion-related information, such as walking speed and walking patterns.

A conceptual architecture of the RADIO sensor data analysis components is presented in Figure 3. The audio//visual/3D/range sensors are used to collect data use in three basic modules: 1) Audio feature extraction, 2) Body detection and 3) Face detection. Following these, higher level analysis is carried out. In the current report, however, we are only focusing on the *Sensing level* (raw data collection)

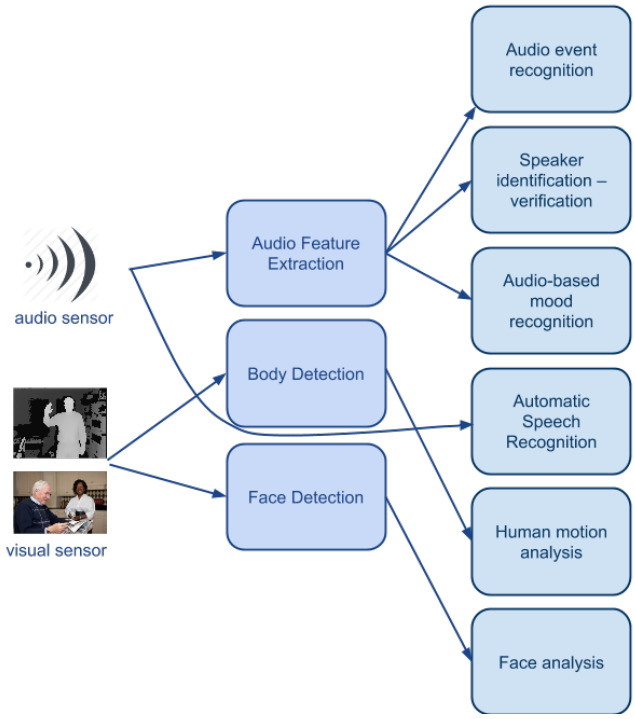

Figure 3.Conceptual architecture of the RADIO sensor data analysis components.

3.2 Obtrusiveness of recording interRAI items.

In this section we assume as a starting point the tables produced at D3.1 that analyze which sensor data analysis component is going to be used for monitoring the InterRAI items. We further mark the audio (A), visual (V) or 3D/range (DR) sensors and whether they are fixed sensors (FS) or mobile sensors (MS). Moreover, if some the Smart Home Automation Log (SMAL) can add information about an InterRAI item this is noted as separate comment.

We then go on by commenting about potential obtrusiveness conflicts. Moreover, we comment about the need of certain safety alarms in some cases.

Table 2. ADL Items and Obtrusiveness

Assessment Item	Name	Technology	Comments
ADL Self Performance	Bathing, personal hygiene	Audio event recognition	POTENTIALLY INTRUSIVE **Privacy Dimension** (Intimacy issues with visual recordings)
		Audio-visual event recognition (A HS) SMAL: Smart Light switch and water consumption.	
	Dressing upper body; dressing lower body	Clothes recognition (V/ MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (Intimacy issues with visual recordings)
	Walking, locomotion	Human pattern recognition (HPR) in range data and face identification (V-RD/MS)	
	Toilet transfer	Visual event recognition Simple proximity sensor (V-RD/HS)	POTENTIALLY INTRUSIVE Same issues as above **Privacy Dimension**
	Toilet use	Audio event recognition (A/HS) SMAL: Presence (proximity sensor) and water consumption.	POTENTIALLY INTRUSIVE Same issues as above **Privacy Dimension**
	Bed mobility	Visual event recognition (V/MS)	POTENTIALLY INTRUSIVE Same issues as above **Privacy Dimension**
	Eating	Visual event recognition (V/MS)	POTENTIALLY INTRUSIVE **Human Interaction Dimension** **Routine Dimension** (Depending on whether the user eats alone in own room or in common dining rooms in institutions. Suppose that a user has his meals (or other activities) in common areas in an institution. This should not be deprived because of potential interference with the privacy of non-users. In other words, the most unobtrusive way of monitoring should be guaranteed without changing the routine of the user, or obtruding his social interactions.
Locomotion and Walking	Timed 4-meter walk; distance walked	Human pattern recognition (HPR) in range data and face identification (V-DR/MS) SMAL: Presence.	POTENTIALLY INTRUSIVE **Privacy Dimension** (Concerns others privacy when visual recordings in common areas are operating.)
Activity Level	Total hours of exercise or physical activity in last 3 days	Visual (V/MS) SMAL: Presence, mobility at home. Where has been and when	
	Number of days went out of the house in last 3 days	Visual(V/MS) SMAL: Presence detection, arm/disarm.	

(Table continues from previous page)

Activity Preferences and Involvement	Cards, games, or puzzles; crafts or arts; reading, writing, or crossword puzzles	Audio-visual event recognition (A-V/ MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Computer activity	Audio-visual event recognition (A-V/MS) SMAL: Smart plug, energy consumption.	
	Conversing or talking on the phone	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Dancing	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Exercise or sports	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Gardening or plants	SMAL: Presence, energy consumption (water)	
	Helping others	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Music or singing	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Spiritual or religious activities	Visual event recognition, automatic speech recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Privacy Dimension** (group activity, consent from others)
	Watching TV or listening to radio	Audio-visual event recognition (A-V/MS) SMAL: Smart plug, energy consumption	
	Discussing and reminiscing about life	Automatic speech recognition (A /MS)	
Time Asleep During Day	Time Asleep During Day	Audio-visual event recognition (A-V/MS)	POTENTIALLY INTRUSIVE **Self-Concept Dimension** Symbol of ageing, could cause stigma)

Table 3. Cognitive and Mood Items and Obtrusiveness

Assessment Item	Name	Technology	Comments
Cognitive skills for daily decision making			
Memory/ recall ability	Procedural memory		
	Situational memory		
Periodic Disordered Thinking Or Awareness	Episodes of disorganized speech	Audio (A/MS)	
Acute Change in Mental Status from Person's Usual Functioning			
Indicators of possible depressed anxious or sad mood	Made negative statements	Audio (Speech) (A/MS)	
	Persistent anger with self or others	Audio (A/MS)	
	Expressions, including non-verbal, of what appear to be unrealistic fears	Audio-visual event recognition (A-V/MS)	
	Repetitive health complaints; repetitive anxious complaints and (non-health related) concerns	Automatic speech recognition (A /MS)	
	Sad, pained, or worried facial expressions	Facial expression analysis (V/MS)	
	Crying, tearfulness	Audio event recognition (A/MS)	
	Recurrent statements that something terrible is about to happen	Automatic speech recognition (A/ MS)	
	Withdrawal from activities of interest; Reduced social interactions		
	Expressions, including non-verbal, of a lack of pleasure in life	Automatic speech recognition (A/ MS)	
Behaviour Symptoms	Wandering	Visual (V/ MS)	
	Verbal abuse	Automatic speech recognition (A/ MS)	
	Physical abuse	Audio-visual event recognition (A-V/ MS)	POTENTIALLY INTRUSIVE SAFETY ISSUE / ALARM Immediate Action required **Privacy Dimension**
	Socially inappropriate or disruptive behaviour	Automatic speech recognition (A/ MS)	
	Inappropriate public sexual behaviour or public disrobing; Resists care	Audio-visual event recognition (A-V/ MS)	**Privacy Dimension**

Table 4. Health Conditions and Continence items and Obtrusiveness

Assessment Item	Name	Technology	Comments
Falls	Falls	Visual event recognition (V/ MS)	ACTION REQUIRED ALARM
Health Condition Frequency	Difficult or unable to move self to standing position unassisted; to turn self around and face the opposite direction when standing	Visual event recognition (V/ MS)	
	Dizziness		
	Unsteady gait	Visual and Human pattern recognition (HPR) in range data (V-DR/MS)	
	Difficulty clearing airway secretion; Constipation; Diarrhoea	Audio event recognition (A/RS)	
	Vomiting	Audio-visual event recognition (A-V/MS)	
	Difficulty falling asleep or staying asleep; waking up too early; restlessness; non-restful sleep; Too much sleep	Audio-visual event recognition (A-V/MS)	
	Aspiration, coughing while eating	Audio event recognition (A/MS)	
Dyspnea	Dyspnea	Audio and Visual for activities	
Fatigue	Fatigue		
Pain symptoms	Frequency with which person complains or shows evidence of pain (including grimacing, teeth clenching, moaning, withdrawal when touched, or other nonverbal signs suggesting pain)	Audio-visual event recognition (A-V/MS)	
	Consistency of pain	Audio-visual event recognition (A-V/MS)	
Continence	Bladder continence		

4 PRIVACY PRESERVATION METHODS & INTERRAI ITEMS

In this section, we start by briefly discussing some of the technical aspects of data processing that can be used to ensure privacy. We then present the types of information that can be expected from the RADIO system into a hierarchy of increasingly privacy-respecting information. We then proceed to comment what information type would be sufficient for medically sound observation relative to the interRAI items that raise concerns of privacy (Section 3)

4.1 Technical solutions of Privacy Preservation

4.1.1 Site of data processing

In RADIO, there is the requirement of having mobile sensors. Mobility allows the system to obtain the right angle perspective without worrying about the positioning of fixed sensors in each RADIO Home deployment.

In terms of privacy protection, one important consideration is the output of the *Sensing Level*. Previously we mentioned that the Sensing Level is related to raw data collection. The following technical solutions can be used to transmit and process the raw content:

- Transmitting raw content to be processed at the RADIO Home's central processor. No raw content leaves the RADIO Home, however transmission over the RADIO Home wireless network does take place and raises security concerns. Raw content is not stored, but is deleted from the central processor's disk as soon as processing is completed. This allows maximal flexibility over the kinds of processing that can be performed.
- Attaching each sensor to each own light-weight processing unit. No raw visual content is stored or transmitted, even within the RADIO Home network and all processing takes place in-memory immediately at the sensor. Only abstract derivative information extracted from the raw data leaves the confines of the sensor. This of course comes with the downside on not being able to extract any more information from the raw data, other than the predefined features extracted.

Especially for visual sensors, a further consideration is the level of visual detail left in the abstract derivative information above. Depending on the processing methods applied, this can range from visually meaningless representations (e.g., number vectors) to more concrete ones (e.g., silhouette analysis, as used for motion and posture analysis).

4.1.2 Types of Information

The information collected for RADIO can be presented in the following formats:

a) Raw data *(raw content)*,
b) A list of time-stamped activities (usage log)
c) Aggregates on the logs

Aggregates of log can vary from descriptive statics like an average to more abstract information such as confirmation or not of an event. For example, in the case of a visual sensor data the information can be an actual video showing a person walking 4 meters (raw content), a detailed log of all the transfers in meters completed during a day, or just a confirmation that a person has actually performed a 4-minute walk.

Here we should note that especially for the visual sensors there is an intermediate level between raw content and usage log, which deals with how visual data are represented, from pixelated representations to silhouette like ones.

A maximally privacy-respecting system would only provide aggregate information and, in fact, coarsely aggregated information (e.g. weekly Y/N). However, the different types of information provide different kinds of information. Raw (or almost raw) content can provide qualitative information, such as 'how well somebody did something'. However, it would be very difficult to automatically provide this information. On the other hand, usage log or aggregated types of information provide quantitative information. In some cases, a detailed log can hint at qualitative information, although the necessary qualitative information cannot be statistically extracted.

Based on the aforementioned, we can assign to interRAI items the types of information that best describe the assessed attribute and provide a sound basis for making medical decisions. For example, for all mood items it is important that the number of times the symptom is present, e.g. daily, present only once in the last 3 days. By contrast, in "bathroom usage" the qualitative information required cannot be safely inferred from quantitative information such as the mean number of bathroom usage events (usage log).

In the next session we revisit the tables of Section 3, but we confine them to include only the items that have been marked as potentially intrusive. This time we comment of the type of information needed to extract medically informative content.

4.2 Types of information and interRAI items.

Table 5. ADL Items and Types of information

Assessment Item	Name	Technology	Comments (Type of information required for medically sound assessment)
ADL Self Performance	Bathing, personal hygiene	Audio event recognition Audio-visual event recognition (A HS) SMAL: Smart Light switch and water consumption.	**(Almost) raw content.** Inference of occurrence of events (like showering, washing hands, brushing teeth etc.) is not satisfactory.
	Dressing upper body; dressing lower body	Clothes recognition (V/ MS)	(**Almost) raw content.** Change of clothes is not satisfactory. The qualitative information expected here is the correctness of dressing (e.g. not wearing a sweater inside out).
	Toilet transfer	Visual event recognition Simple proximity sensor (V-RD/HS)	**(Almost) raw content.** Inference of occurrence of events (like use of toilet inferred by flushing) is not satisfactory.
	Toilet use	Audio event recognition (A/HS) SMAL: Presence (proximity sensor) and water consumption.	
	Bed mobility	Visual event recognition (V/MS)	**Aggregate**. Time it takes to transfer from lying to stand position.
	Eating	Visual event recognition (V/MS)	**(Almost) raw content.** Inference of occurrence of event is not satisfactory. Qualitative information is required.
Locomotion and Walking	Timed 4-meter walk; distance walked	Human pattern recognition (HPR) in range data and face identification (V-DR/MS) SMAL: Presence.	**Aggregate** of time and distance.

(Table continues from previous page)

Activity Preferences and Involvement	Cards, games, or puzzles; crafts or arts; reading, writing, or crossword puzzles	Audio-visual event recognition (A-V/ MS)	**Aggregate** of event occurrence during the last three days.
	Computer activity	Audio-visual event recognition (A-V/MS) SMAL: Smart plug, energy consumption.	**Aggregate** of event occurrence during the last three days.
	Conversing or talking on the phone	Audio-visual event recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
	Dancing	Audio-visual event recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
	Exercise or sports	Audio-visual event recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
	Helping others	Audio-visual event recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
	Music or singing	Audio-visual event recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
	Spiritual or religious activities	Visual event recognition, automatic speech recognition (A-V/MS)	**Aggregate** of event occurrence during the last three days.
Time Asleep During Day	Time Asleep During Day	Audio-visual event recognition (A-V/MS)	**(Almost) raw content**. Aggregate of time spent sleeping is not satisfactory. Qualitative information is required.

Table 6. Cognitive and Mood Items and Types of information

Assessment Item	Name	Technology	Comments
Cognitive skills for daily decision making			
Behaviour Symptoms	Physical abuse	Audio-visual event recognition (A-V/ MS)	**Aggregate** of event occurrence during the last three days.
	Inappropriate public sexual behaviour or public disrobing; Resists care	Audio-visual event recognition (A-V/ MS)	**Aggregate** of event occurrence during the last three days.

5 OVERALL CONCLUSIONS

In the current report we have attempted to identify how to best approach the balance between medical requirements and obtrusiveness. We set as a starting point *D2.2 Early detection methods and relevant system requirements,* which set the LTCF interRAI assessment items as the medical requirements of the project and the discussion held in *D2.4 Actual and perceived privacy considerations and ethical requirements.* In this report we went further by considering a broader perspective of obtrusiveness that according to Hensel's work does not only include privacy considerations but also physical, usability, human interaction, self-concept, routine, sustainability and function ones.

In Section 2 we described each of Hensel's dimensions in a more detailed way and we considered how to best tackle each dimension within RADIO. Moreover, we have considered issues of obtrusiveness related not only to the users of RADIO but also to their visitors. We concluded that while utility and usability constructs of obtrusiveness can be dealt with in the design, development and evaluation of the technical methods, as well as via the pilot studies of RADIO action. Intrusiveness constructs involve a highly subjective factor that boils down to each individual's preference. Thus, defining a universal framework to satisfy the balance between obtrusiveness and medical requirements would be impossible.

Giving the choice to the users to select only desired items to monitor comes with the risk of undermining the system's utility. At this point two things can be done to deal with this peril. The first one is to educate people, in a simple yet truthful manner, about how privacy is preserved via technical methods. Most importantly, we can choose to use the technical methods that guarantee maximum privacy preservation without compromising the medical information. So the question we ask here is: **What are the technical solutions required to provide enough information to allow for sound medical decisions?**

To answer this question, in Section 3, we first identified interRAI items that could be potentially intrusive, both because of the nature of the item (e.g. using the toilet) and because of the recording method (camera). Following this, in Section 4, we brought forward these items and further commented on the type of information (from a technical perspective) that would be necessary to adequately monitor assessment items.

As mentioned in various parts of this document, a universal solution is impossible because it does not consider individual preferences. However, this report makes a significant contribution by establishing a framework that maps the choices that need to be made and assigns obtrusiveness indices to what is technically possible. This allows making informed decisions about what technical solutions are needed for each given end-user, and also provides insights about which technical advancements will have the most impact.

Naturally, there are numerous research questions that arise and could further contribute in refining such a framework. An interesting hypothesis to test could be that as you get sicker (more frail and dependent) you become more tolerant regarding intimacy issues (you accept the need for intrusiveness). In other words, could frailty modify user's perception of obtrusiveness? For instance, you come to accept being bathed/cleaned/taken care of (even the most intimate aspects of care) by nurses from different sex. Cultural differences must also be considered. An example related to the aforementioned examples and which illustrates the cultural differences is by whom a urinary catheter is inserted depending on the patient's sex. In the UK if you are male the urinary catheter will be inserted by a male nurse while in Spain there is no such consideration.

Another interesting research question is to contemplate these types of technological issues about obtrusiveness (privacy/intimacy) as part of the concept of advanced directives (before you lack - capacity to make decision due to dementia, for instance).

In the next iteration of this document we intend to further analyze the concepts of intrusiveness (Part II construct) dignity and intimacy. Based on those results we could then consider researching these concepts during the summative phase pilots through qualitative research methods such focus groups with participants. However, multi-cultural issues could not be tested due to the pilots occurring only in Spain and Greece. Actually, we cannot demonstrate any of these hypotheses due to the design methodology, as this was not the purpose of the research.

In the next iteration of this report, we will extend the list of ADLs to also include the instrumental ADLs and comment on their obtrusiveness. Moreover, we will elaborate the level of Acting and Access control of the RADIO system that is the actuation of the robot tasks such as detecting the elderly person, decisions about sending notifications to secondary users (relatives, caretakers, clinicians) and so on, always under the prism of obtrusiveness.

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