ADVENT: A SYSTEM ARCHITECTURE FOR ADVANCED MONITORING OF ELDERS WITH CHRONIC CONDITIONS

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ABSTRACT

This paper introduces the ADVENT project that focuses on providing a comfortable, safe and secure environment, supporting daily living of elders, while empowering their mobility and independency. We present a generic system architecture that emerged from user and system requirements analysis (ADVENT is currently in the beginning of its design phase), which consists of four parts: i) the home monitoring environment, ii) the mobile personal monitoring and support, iii) the service deployment platform and iv) the communication infrastructure. These system parts are further described and several implications, considerations and challenging issues from the ADVENT perspective are discussed. In addition, some design and development directions that will be carefully examined and thoroughly evaluated in the next phases of the project are highlighted.

Categories and Subject Descriptors

C.0 [**General**]: System Architectures
J.3 [**Life and Medical Sciences**]: Health
K.6.1 [**Management of Computing and Information Systems**]: Project and People management – *System analysis and design*

General Terms

Design

Keywords

Healthcare, Ambient Assisted Living, Home Monitoring

1. INTRODUCTION

According to the 2012 EU Ageing Report, the part of European population aged over 65 will almost double by 2060 - rising from 87.5 million in 2010 to 152.6 million - while the number of older people (aged 80 years and above) is projected to increase even more, almost tripling from 23.7 million in 2010 to 62.4 million in 2060 [1]. Simultaneously, medical practices have evolved and the current senior population is ripping the benefits of advanced clinical treatment approaches and is determined to stay active as long as possible.

Along with the population ageing trend there is an increased manifestation of chronic disorders that come as a consequent of the higher life expectancy and greatly affect the quality of life both for elders and their equally old spouses or relatives that undertake the responsibility of care provision. This drastically evolving situation calls for new solutions towards improving the quality of life, supporting health needs, facilitating concepts such as "aging well" or "healthy aging", and maintaining the social participation of the elders.

As a result, there is now a market for health devices and services that support seniors in their home environments, providing services such as: medication schedule reminders, monitoring of vital signs, and dispatching of medical alerts in the case of emergency situations such as falls and accidents. These health

solutions have already started to gain significant commercial interest and are in most cases realized using Information and Communication Technologies (ICTs) that effectively support seniors to "age in place". Usually, comfort and ease of use is paramount for the elder and their families when searching for the right monitoring solution, while the cost is another determining factor.

The independence of seniors both in their home environment and outside, as active participants in their community activities, has been a clear focus of what is referred as ICT enhanced active and independent living. These technology enhanced solutions have to cater both for the security of the monitored person but also for the overall safeguarding of his health status, monitoring critical parameters and keeping health professionals and caretakers well informed. Intuitive and convenient alerting during emergency situations has to be coupled with the identification of the elder's profile particularities along with fast access to up-to-date critical medical data. This combination poses many challenges – technological, organizational and ethical – and for this reason, no dominant technological solution or commercial product has yet prevailed.

Conceptualized within this aforementioned framework, ADVENT is a project funded by the Greek Secretary of Research and Technology under the Programme "COOPERATION II", focusing on providing a comfortable, safe and secure environment, supporting the daily living of elders, while empowering their mobility and independence. It will develop a home monitoring healthcare solution for elders with chronic conditions, based on advances in ICT fields such as wireless sensor networks, decision support mechanisms and mobile services. ADVENT is now entering the system design phase, following its requirements collection phase that has just finished. In this paper, we present the high level system architecture that is reflecting the results of the system and user requirements analysis. This analysis narrowed the initial system concept down to distinct parts that were used as building blocks for the main system architecture components and communication mechanisms. In addition, we discuss the required features, several challenging issues and potential research directions for the main system parts and components.

2. RELATED WORK

The field of home monitoring has received much attention and numerous research efforts focused on creating ICT solutions to support elders in their home environment. The objectives of these efforts converge into building intelligent environments to assist elders' daily living and keep them safe through continuous monitoring and appropriate situation-dependent care provision, in order to maximize their independence and self-efficiency, as well as extend their stay in their inhabitance area for as long as possible.

One of the first initiatives in this field is the Aware Home [2] developed at Georgia Institute of Technology in the U.S. During this project a two-floor house was constructed as a living lab for conducting experiments in the implementation of technologies for successful living. Among others, there was developed, a "smart floor" through which the identity and location of the inhabitants was recognized based on their footsteps, and various services, such as the recovery from memory lapses. The goal was to gain knowledge on the activities of the occupants and create services for maintaining independence and improving the quality of life of older people.

Likewise, the ERMHAN platform [3] provides a comprehensive set of medical services for monitoring and assisting patients during their stay at home , while supporting independent actioning and mutual cooperation of medical care providers for the provision of an integral treatment. It offers basic and general purpose services for sharing information, distributed and multi-channel personalized access to patient medical records and real-time monitoring and alarm management per patient . The developed services include personalized access to medical patient records, determination of time intervals for measuring various physiological parameters, notifications for the health status of the elders and alarms in case of abnormalities.

Another project sharing some common objectives with ADVENT is the SmartAssist [4] in the context of which a socio-technical platform based on wireless sensors at home is presented. This project is mainly focusing on monitoring elders for subtle long term changes in health status. Within ADVENT however, a much wider range of signals is to be acquired and analyzed, thus offering much more information and thus more accurate monitoring of the user's status. Furthermore, Wireless Sensor Networks (WSNs) are to be investigated in more detail and play a much more significant role not only with respect to data acquisition, but with regards to their processing as well. This processing can yield significant benefits both with respect to the monitoring process itself but to the network performance and behavior as well.

In the context of the ALLADIN project a home care system for monitoring elders suffering from dementia was developed [5]. Combining explicit information gathered from neuropsychological assessment questionnaires and physiological parameters' measurements explicitly performed by elders, as well as implicit feedback provided by an actigraphic device the respective system evaluates elders' health status and produces appropriate alarms when necessary. In addition, elders' carers are also monitored and several external services, such as education and physical exercise are integrated to the pure medical monitoring.

The ADVENT project introduces a user-centric technological solution for the provision of a coherent set of personalized generic services to elders that may face multiple chronic conditions and daily living limitations that come naturally due to aging. Rather than focusing on a specific disorder as the above approaches, it targets the provision of a modular service package that can be applied to a wide range of persons that need constant monitoring and tactical care provision. It promises a novel framework that will integrate information from a plethora of heterogeneous sources, such as bio-sensors, context data, kinetic activity monitoring, personal archived data and subjective feedback to provide automated assistance to the elderly at home and improve their quality of everyday living.

3. ADVENT SYSTEM ARCHITECTURE

The high level architecture of the ADVENT system is depicted in Figure 1. It is composed by four parts, which are the home monitoring environment, the mobile personal monitoring and support, the Service Deployment Platform (SDP) and the communication infrastructure. This section provides an overview of these system parts, while the following sections provide a more detailed description of them.

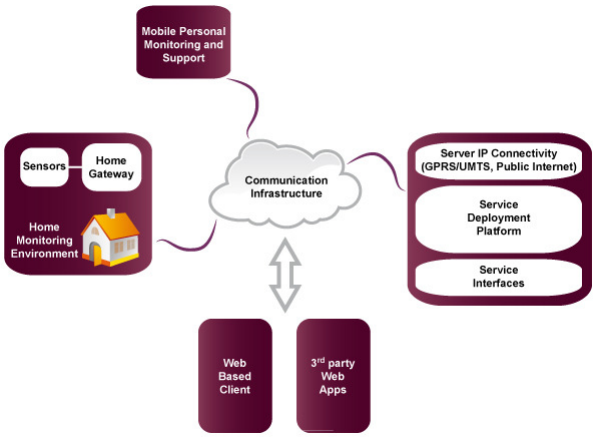

Figure 1. High level ADVENT system architecture

The home monitoring environment includes the sensor networks that provide physiological, kinetic and ambient data to the home gateway, which is responsible of collecting, pre-processing and transmitting the sensor data to the SDP for further processing. In addition, it offers adequate interfaces, through which the elders receive/provide feedback and interact with the system.

The mobile personal monitoring and support sub-system is in charge of collecting data when the elder is outdoors, while it is able to complement the indoor sensors as well. It communicates directly with the SDP offering a group of mobile services.

The SDP provides most of the system's functionality. It highlights functions such as user modeling, knowledge representation, health assessment, context reasoning and service personalization. Moreover, a critical role of SDP is to provide service interfaces (APIs) enabling service provisioning to the end users and allowing 3rd party service providers to integrate their services into the ADVENT system.

Finally, the communication infrastructure is used to establish sessions between the home gateway and the SDP for bidirectional data transmission. It supports transparent communication over both mobile networks (e.g. 3G and 4G) and terrestrial ones (e.g. DSL) and offers web-based interfaces for elders' caregivers that facilitate their interaction with the ADVENT system.

3.1 Home Monitoring Environment

In order for the ADVENT system to be well accepted by the users the home monitoring environment is of cornerstone importance since it comprises the part of the platform that actually comes in direct contact with the user all the time the system is used. Therefore, critical aspects must be considered, studied and carefully addressed so as to result into an efficient, comfortable, non-intrusive system. In this section, the main requirements of the home monitoring environments that will effectively drive the research, design and implementation phases regarding this critical part of the system are presented.

In the context of the ADVENT system both physiological and environmental signals are to be acquired by a home gateway. Aiming towards this goal nowadays WSNs appear as a prominent solution, on one hand, offering significant advantages while, on the other, posing limitations that must be taken into consideration. WSNs comprise one of the most rapidly evolving research areas attracting active interest both by the academic and industrial areas.

One the most interesting application scenarios concern the enhancement of quality of life, independency and in general well being of elderly people in home [6-7].

One the most significant advances making this goal possible, over the last year, are the advancements in designing and implementing highly integrated embedded systems and miniaturized wireless nodes. These advancements allow the node to acquire a wide range of signals, processes them, store and most importantly efficiently convey them wirelessly to other nodes or/and aggregation points. Offering the latter capabilities has lead to significant advancement in various networking areas especially focusing on physical, MAC and routing layer of the ISO/OSI networking model [8-9]. However, in order to offer all the above while being energy efficient, cost effective and of low complexity implies that all operations must rely on limited resource components especially regarding processing capabilities, memory availability, wireless channel bandwidth availability and most important energy availability. Here it must be noted that nowadays prominent solutions are based on simple 8 or 16bit Micro Controler Unit (MCU) architectures of 8-16MHz frequency, available memory in the order to 10Kbytes and power source such as 2AA battery or even less in many cases [10]. Therefore, careful consideration is given to the ADVENT home monitoring environment so as to end up with a practical and useful system as indicated in the following paragraphs.

Sensors:

The use of sensors in the context of ADVENT system requires their acceptance in the elders' home area or even on the elder (in case of physiological signals sensors must be in direct contact with the elder) for extended period of time. Therefore, a critical requirement is to be as non-intrusive as possible. They must adopt an adequate design and be small enough enabling them to be worn for extended period of time causing minimum discomfort. Also, the number of the sensors comprises a critical factor so that the user is not disturbed by their presence in the home environment. Additionally, sensors must operate with minimum configuration requirements from the elders or their family. For example, an on/off operation should be enough so that the elder can have the option to deactivate them at will.

Communication capabilities:

As mentioned before probably the most attractive characteristic of WSN nodes is the ability to send wirelessly and effectively acquired data. Consequently, the adopted communication technology must be able to offer the required bandwidth, robustness and time constrained characteristics to convey physiological (e.g. ECG signals and blood pressure), environmental (e.g. temperature and luminance) as well as kinetic (e.g. accelerometer) signals. A critical selection concerns the communication technology upon which wireless data transfer will be based. Two prominent protocols that will be evaluated with respect to the ADVENT objectives are the well known IEEE 802.15.4 and the Bluetooth. Respective evaluation will also take into consideration several performance and behavior features such as:

- Robust data transfer
- Time constrained communication capabilities
- Security provision
- Energy consumption with respect to node lifetime

Processing Capabilities:

Although limited MCU's are of limited capabilities it is required that adequate processing capabilities must be home environment monitoring subsystem so as to acquire data, store and transmit data. Furthermore, it must be able to accommodate required algorithms related to either communication tasks or/and data processing ones.

Lifetime Capabilities:

Driven by the fact that the operation of WSN nodes comprising the home monitoring environment is based on small batteries it is easily understood that extending the lifetime of nodes represents a critical aspect of efforts in ADVENT system. Different avenues can be followed in this context. On one hand, the effectiveness of different components (i.e. wireless transmission radio, MCU, sensors etc.) will be evaluated so that with respect to the appropriate battery selection extended periods of operations without the need for recharging could be offered. On the other hand, efficient data processing techniques will be evaluated leading to lifetime extension and this enhancing the non-intrusiveness of the ADVENT system.

Extendible and Flexible Architecture:

Aiming to offer a long life cycle system, it is important to anticipate future development and extensions. Therefore, features regarding the extendibility and flexibility of the ADVENT system are also taken into consideration. It is important to note that these feature are related both with the hardware and software aspects of the system. As far as the software development is concerned, following an open source approach facilitates the development of efficient algorithms and programs and allows the handing of new sensors and/or applications. Expendability with respect to hardware relate to the provisioning of integration capability of new sensors acquiring different types of data or offering advanced capabilities.

3.2 Wearable Device for Mobile Services

During the last few years many vendors have started to develop and commercialize medical alerting solutions under the common typification of Personal Emergency Response Systems (PERS). PERS products utilize the principles of AAL environments to deliver telecare services directly to consumers, while retaining their separation from medical monitoring. Hence, in most cases PERS systems are provided as a closed solution, without offering personalization adaptations driven by the health condition and the health monitoring status of the elder. This has created a significant efficiency gap given the significant link between seniors and chronic diseases. Therefore it is expected that Emergency Services will increasingly have to be integrated with healthcare monitoring. The market transition from safety focused products, such as PERS, toward integrated health monitoring solutions for seniors living in their home environment, is growing rapidly. Market research [11] anticipates that monitoring devices will grow to more than 36 million units in 2017, up from under 3 million units in 2011. The same report predicts that over the same period, wearable wireless devices will almost double their share in the home monitoring sector, from 12% to 22%.

The ability to employ mobile telephony and mobile data communications technologies, using wearable solutions that are comfortable and can help seniors extend their ability to live independently both indoors and outdoors, is crucial for the acceptance and success of the proposed solutions for the elder but also for their families and care givers. There is a significant market potential that is yet to be taped by mobile operators working out common business collaboration schemes with healthcare service providers. Machine-to-Machine (M2M) business models that have been successfully established in application domains such as asset tracking and fleet management can also have significant impact in facilitating the independent living of the elder.

Acknowledging the aforementioned framework, the ADVENT Mobile Personal Monitoring and Support subsystem will be provided through a GSM/3G/4G enabled wearable mobile device that will be deployed in tandem with a dedicated Mobile Support Data Center, integrated with the ADVENT SDP, using predefined service interfaces, as depicted in Figure 2. The adopted design approach is based on an open service oriented architecture scheme that will not only ensure the geographic independence of the proposed solution, but also its sustainability and extensibility with additional healthcare services that can be mixed and matched in the future, using common programmable service interfaces.

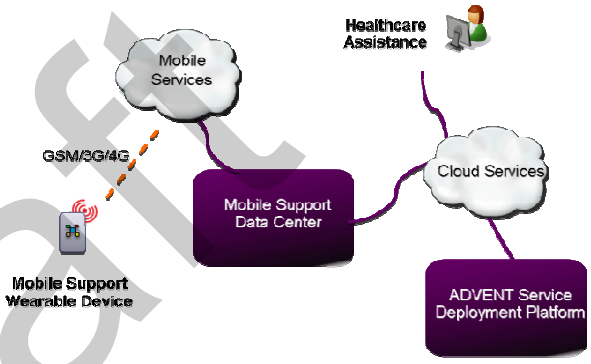

Figure 2. High level architecture of the Mobile Personal Monitoring and Support Subsystem

In this setting, the ADVENT Mobile Wearable Support Device will act as the gateway for mobile service provisioning, when the elder is away from home and can be monitored through the mobile cellular network, while it has the ability to complement the WSN in indoors elder monitoring. This device will encompass both telephony and messaging capabilities (GSM) as well as mobile IP Data Services (e.g. GPS location tracking), in order to support the full spectrum of a mobile Personal Emergency Response System (mPERS). In addition, the device will be coupled with the health monitoring services of ADVENT, thus offering a holistic approach to elder monitoring and support.

More specifically, the core set of features that will be served by the Mobile Personal Monitoring and Support subsystem, are summarized below:

- Emergency 'alarm button' service and ability for emergency calls with only one button
- Notification service that will be triggered in case the elderly exits a designated geographical area / region outside his home environment – geofencing,
- Notification service that will be triggered if the elder is detected motionless for a prolonged period of time,
- Issuing of alarm after detection of sudden accelerated move or fall inside or outside the house,
- Notifications and alerts issued by ADVENT SDP, and

- Automated support information on operating parameters of the device, such as battery charging.

Choosing a dedicated wearable device to augment the ADVENT home monitoring services in outdoors settings, is an approach that can be more easily accepted by the elder persons, in comparison with the same services offered via screen based solutions (e.g. smart phone applications). AAL research has indicated that screen based solutions tend to be eventually discarded due to usability [12] as well as to issues related to cognitive and motor skills degradation [13], often associated with elder who also suffer from chronic diseases.

3.3 Service Deployment Platform

The Service Deployment Platform essentially comprises the ADVENT system's middleware offering the core functionalities for service delivery to elders and their caregivers. Concerning the development of such AAL middlewares several approaches exist in the literature relating both to the implemented technologies and the required software components. Some of the widely adopted technological approaches for middleware development are web based platforms exploiting semantic web technologies [14], the agent technology used for the development of distributed software components that have the ability to act autonomously and flexible while complying with the objective aims for which they were designed [15] and the OSGi service platform [16] that offers a computational environment for networked services, which is standardized and middleware component oriented.

From a technological infrastructure perspective, a critical issue that ADVENT will tackle refers to upgradeability and extendibility, in order to address smooth integration of additional hardware and software components or replacement of the already existing ones. These features are required so that the provided services and applications will always reflect the evolving needs and requirements of the end users. In addition, we adopt an open approach incorporating well-defined APIs to enable flexible and effective hardware integration that will allow added value service provisioning through hybrid architectures.

Since the ADVENT system includes several subsystems that need to interact, an important factor for its effective operation is interoperability. To achieve this, appropriate technologies should be employed to address heterogeneity between applications running in different devices and frameworks. Towards this direction, we have adopted a web-based approach that offers a standardized way for communication and interaction through web services. Another factor that is be considered concerns run time system adaptation through implicit dynamic reconfiguration capabilities. This could be necessary for example, in case of component or power supply failures.

On a functional level, a continuous elder status assessment is required, which implies the interpretation of sensor readings to reason over the current elder status. In ADVENT, the term elder status encompasses three different types of statuses namely health, kinetic and environmental. Various techniques and algorithms may be utilized to assess the elders' status, but these depend on the amount and type of parameters that have to be considered in the reasoning process. Another issue that is taken into account is the degradation and the need for classification of each of the assessed statuses. In this context, a careful selection of the most suitable solution in terms of efficiency and accuracy will be made, through the evaluation of a wide range of machine learning algorithms (e.g. association rules, bayesian networks etc.) and other reasoning techniques, such as ontology based reasoning and fuzzy logic.

Knowledge representation is a key-feature in order to describe information in a semantic level and obtain an interoperable representation of diverse data coming from heterogeneous sources. This process is mainly performed using ontologies that prevail among other techniques facilitating knowledge reuse and sharing among system components and count classes, inheritance, relationships between classes and instances as some of their major components. We examine several existing third party ontologies, putting our effort on designing and developing an enhanced model to achieve the systematic representation and processing of the elders' user models, health condition parameters and contextual information. We envisage the following ontologies: (a) Medical domain ontologies to encode health-related information, (b) Service ontologies to describe the services offered by the system (c) Ontology alignments to serve in matching heterogeneous domain and service ontologies (d) Policies to encode decision making and privacy enforcement policies.

Decision making and feedback provision focuses on determining the actions that have to be performed according to the identified elder status and forwarding the appropriate feedback to elders and caregivers. In general, this function employs simpler data processing algorithms with the most popular approach being 1st order logic rule-based algorithms. In addition, the decision making is based on policies that reflect the medical protocol and define specific actions that have to be performed in given situations. Defining decision making and feedback provision policies will be a critical task aiming to deliver an integral care plan for the creation of a comfortable and safe environment for daily living of the elders. However, this function comes with various puzzling issues like the selection of the most appropriate person among a group of caregivers that will be notified, based on several criteria, such as availability.

Service personalization is an intertwined function with user modeling. User models contain various types of information regarding the user they represent, such as demographic and medical data, health history recordings and preferences. This information is used to tailor the offered services according to the specific needs and requirements of end users and adapt the system functionality to meet elders and caregivers' preferences. The ADVENT system considers personalization in many levels throughout the service delivery process including content and means of feedback presentation, means of user-system interaction, elder status assessment, offered care plan design and types of notification and reminder services. For this purpose, a systematic process of user modeling will be implemented considering implicit information obtained through the elder monitoring process and explicit information directly acquired from the elders through the respective interfaces.

For the needs of the ADVENT system, user models will vary according to the end user and are classified in two categories, which are the elder model and the caregiver model (i.e. relatives and physicians). User models contain different types of information according to their category, some of which are summarized in the following list:

- Personal data (e.g. name) - Role
- Medical record (e.g. disorder history, allergies, family health history etc.)
- Context-related data (e.g. e.g. normal and abnormal values of measured physiological parameters, care provision plan)

- Policies (e.g. decision making and feedback provision policies)
- Preferences (e.g. hierarchies of notifications and alerts priorities in a NTAP group basis and service-related preferences)

3.4 Communication Infrastructure

As depicted in Figure 1, the ADVENT system communication infrastructure's main objective is to provide reliable, transparent, efficient and secure communication among a wide range of different entities such as: the home environment, the mobile gateway, the SDP, as well as third party systems and applications. Aiming to provide high degree of flexibility with respect to the technological approach that each entity's design and implementation will be based on, the communication infrastructure follows a component based approach utilizing web services, in order to provide the required communication capabilities.

Additionally, nowadays various communication technologies can be used to provide the required point-to-point IP connectivity ranging from typical wired DSL connections to state-of-art wireless connection based on 3G/4G technologies. In order for a system like ADVENT to be successful and meet adequate widespread, it must be able to deliver its services regardless of the particular connection characteristics and requirements or limitations posed by each particular user. Consequently, an increased effort is put so that the communication infrastructure will offer the required connectivity in a transparent manner to the end users. This characteristic pertains also to the communication reliability, since a particular technology (e.g. DSL home connectivity) may be rendered not operable for various reasons. In such a case, immediate and seamless switch to an alternative connection technology (e.g. 3G/4G) would be a significant added value.

Furthermore, depending on the actual data monitored, the number of sensors deployed as well as the sampling frequency and sample size, a considerable amount of data may be demanded to be transferred at any given time from the home area of the user to the service deployment platform. With respect to the communication infrastructure, the required bandwidth and reliability mechanisms will be offered to guarantee that all data are transferred without losses over the IP public network. Even in case of data losses, recovery mechanisms will mitigate, as that may result to performance degradation.

Additionally, cases where data transfer towards the SDP must meet specific delay constrains are considered. Based on the pre-processing results of the collected data at the home gateway, specific alarm events may be triggered that are conveyed to the SDP as soon as possible so that appropriate actions will be taken. These alarms may potentially concern dangerous health situations (elevated hear rate, excessive duration on immobility) and property conditions (increased temperature, open door/windows during a cold night) of the elders home environment. In such cases, Quality of Service (QoS) requirements pertaining to time constrained communication capabilities are of critical importance for service delivery.

The ADVENT system communication from the home gateway to the SDP is realized through GPRS/UMTS Public Internet. Consequently, proper mechanisms are in place to enforce approved communication flows between the interconnected systems residing in the home monitoring environment and the SDP. Any such flow control restrictions may include keeping healthcare controlled information from being transmitted in the clear to the Internet, blocking outside traffic that claims to be from within the SDP and not passing any requests to the SDP that are not originated from authenticated home gateways. Virtual Private Networks (VPNs) - private networks that are created via tunneling over a public network that is usually the Internet - may be established between the Home Monitoring Environment and the SDP.

In this way, a secure communication infrastructure will be offered that does not require from the ADVENT system to depend on any external networks, across which the VPN transits to protect the confidentiality and integrity of information transmitted. VPNs establish tunnels that are separate logical channels between endpoints and in combination with appropriate protocols support verification of the identity, integrity and confidentiality by encrypting the traffic through the public network, within the VPN. Of course, high level encryption of data transmitted and state-of-the-art mechanisms (e.g. SSH network protocol, SFTP data transfer protocol) will be deployed, offering maximum privacy to sensitive personal data of the user.

3.5 Security Framework

3.5.1 Risk Assessment & Prioritization Approach

In today's world electronic information and malicious threats, organizations that handle patients' information are finding that a reactive, bottom-up, technology-centric approach to determining security and privacy requirements is not adequate to protect the organization and its patients. To avoid breaches of sensitive information and other types of security incidents, such organizations should take a proactive, preventive approach with attention to future security and privacy needs, in a way that maximizes the reduction of business risk. Such a top-down approach should be based on risk assessment in order to mitigate risk through a selection of a combination of administrative, physical, and technical security controls.

One widely recognized method for determining an organization's security and privacy requirements for such an approach is driven by Greek applicable regulations ([L_2472/1997] [17], [L_3471/2006] [18]); standards such as the International Standards Organization's Management Systems [ISO27000] [19]; and principles such as European Union (EU) Directives ([D_95/45/EC] [20], [D_2002/58/EC] [21], [D_2011/24/EU]) [22].

Risks identified during the security and privacy risk assessments shall be modeled and prioritized based on probability and business impact, while they will be compared to baselines of risk appetite and mitigated by applying security and privacy countermeasures.

3.5.2 Security Objectives

Through this process, the following ADVENT security related objectives will be accomplished:

- **Availability** – The ongoing availability of systems addresses the processes, policies, and controls used to ensure authorized users have prompt access to information. This objective protects against intentional or accidental attempts to deny legitimate users access to information or systems.
- **Integrity of Data or Systems** - System and data integrity relate to the processes, policies, and controls used to ensure information has not been altered in an unauthorized manner

and that systems are free from unauthorized manipulation that will compromise accuracy, completeness, and reliability.

- **Confidentiality of Data or Systems** - Confidentiality covers the processes, policies, and controls employed to protect information of external parties and ADVENT against unauthorized access or use. The ADVENT applications will access and use information about the patient that is sensitive e.g. health status. Actual or perceived risk of such information being available to unauthorized personnel will affect negatively the acceptability of the ADVENT solution.
- **Accountability** - Clear accountability involves the processes, policies, and controls necessary to trace actions to their source. Accountability directly supports non-repudiation.
- **Assurance** - Assurance addresses the processes, policies, and controls used to develop confidence that technical and operational security measures work as intended. Assurance levels are part of the system design include availability, integrity, confidentiality, and accountability.

3.5.3 Security Controls Selection

This process will result in the proper security controls selection that shall mitigate identified risks to a acceptable levels. The Advent controls bouquet shall be a selection from the below mentioned control groups (non exlusive):

- **Access Control -** The goal of access control is to allow access by authorized individuals and devices and to disallow access to all others.
- **Access Rights Administration -** Access rights to resources shall be restricted to minimum required following a formal process of enrolment, authorization, authentication, and monitoring.
- **User Authentication -** Authentication is the verification of identity by a system based on the presentation of unique credentials to that system. The unique credentials are in the form of something the user knows, something the user has, or something the user is. Those forms exist as shared secrets, tokens, or biometrics.
- **Device Authentication -** Device authentication typically takes place either as a supplement to the authentication of individuals or when assurance is needed that the device is authorized to be on the network.
- **Encryption -** Encryption is used to secure communications and data storage, particularly authentication credentials and the transmission of sensitive information.
- **Security Monitoring -** Security monitoring focuses on the activities and condition of network traffic and network hosts.
- **Activity Monitoring -** Activity monitoring consists of host and network data gathering, and analysis. Host data is gathered and recorded in logs and includes performance and system events of security significance.
- **Log Transmission, Normalization, Storage and Protection**

4. DISCUSSION AND CONCLUSION

In this paper, we introduced the ADVENT project objectives and presented its high level system architecture as this emerged from the analysis of user and system requirements. This architecture consists of four generic building blocks that will be further analyzed and fragmented during the project's next phases, in order to include all involved components in a more detailed view. These components may have been delineated by the development requirements, but several adjustments and additions are expected to take place according to the system's evolving needs and evaluation results.

The system's design phase revealed several opportunities for improving the system's functionality and consequently the range and quality of the provided services. The most characteristic case concerns the integration of the mobile personal monitoring and support sub-system to the service delivery platform. This has proved to be a very critical task as it will grant adaptation features to the offered mobile services. The mobile personal monitoring and support sub-system on its own is not capable of reasoning over the required actions that have to be performed according to the collected information. Thus, connecting it with the SDP will augment its service capabilities and offer the opportunity to address potentially dangerous situations while the elder is located outdoors.

Another important issue concerns the level of user involvement in the process of collecting information to reason over the elders' status. The impact of the level of user participation in systems' efficiency and effectiveness and, more specifically, the elder status assessment accuracy has been a subject of extensive research. However, there is not any clear difference between systems that allow an increased level of user involvement in the health management and care provision processes and systems that mostly act in an automated fashion. In ADVENT we currently consider a rather limited user participation, which is located at feedback provided in the context of reminders and notifications services.

The vision of ADVENT is the simplification of the technological part for the consumer, i.e. the elder, their families and their caregivers. We believe that irrespective of the underlying technologies, the developed system must interface with the elders in a way that the elders can understand, accept and endorse its functionality and services. For this reason, the user interfaces will be designed as simpler and user-friendly as possible to serve an increased ease and practicality in their use. A clear focus of ADVENT is the interaction of the monitored person with the system, developing means for seamless dialogue and intuitive functionalities' control. Therefore, several means of user-system interaction will be examined, such as text and speech, to meet different situation specific needs and requirements.

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