Enhancing Collaboration in ASD-Centric Treatment Environments: A Proposed Architecture

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Abstract. There is a growing body of evidence that people diagnosed with Autistic Spectrum Disorder (ASD) is increasing each year. ASD is a neurodevelopmental spectrum disorder with overarching characteristics the abnormal social interaction, communication ability, patterns of interests, and patterns of behavior. Individuals with ASD are characterized by unique and divergent needs and requirements which make a generalized treatment approach obsolete. Early diagnosis and interventions in persons with ASD, along with a consistent and continuous monitoring of their situation by the dedicated care team may increase their learning abilities and social inclusion. In this respect, we propose an ASD-centric Computer Supported Collaborative Treatment Architecture which employs the notion of Virtual Care Teams and dynamic workflows. We analyze its various components and outline a set of services that have been adjusted on the qualities and limitations of the ASD sector. Through this architecture a continuous treatment with updated exchange of information, effective communication, prompt error handling, and improved decision making, can be achieved within and between the members of a care team. Finally, we present a real life case scenario which employs the particular architecture, encapsulating the arisen benefits of the proposed approach.

Keywords: eHealth, Autistic Spectrum Disorder, Collaboration, Virtual Care Teams

1 Introduction

Autistic Spectrum Disorder (ASD) is an overarching term that describes a group of developmental disabilities that include Autistic Disorder, Rett's Disorder, Childhood

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Disintegrative Disorder, Asperger's Syndrome, Pervasive Developmental Disorder, and Not Otherwise Specified (PDD-NOS) [1]. These neurodevelopmental disorders are characterized by severe and pervasive impairments that involve problems with social interactions, trouble in communication, and repeating patterns of behavior, interests and activities. ASD affect different people during their development and to different degrees. Symptoms and behaviors can vary, ranging from mild to severe. Although people with autism share some common characteristics (such as abnormal communication and social interaction, unusual behavior, unusual patterns of attention and learning qualities), no two individuals are the same. In addition, the pattern and extent of difficulties may change with development. Given this dynamic nature of diagnoses over time for autistic persons as well as the unpredicted behaviors and responses on particular sensor stimuli the treatment method should be dynamic and adapted always in their current state. It is generally agreed that no single intervention will suit all people with autism, and in addition any intervention can have negative as well as positive effects. No one approach is appropriate for all individuals on the autism spectrum or even for the same individual across his/her lifespan [2]. A range of interventions have been developed [3], and examples include those based on behavioral methods, education-based approaches and non-verbal communication systems. Choosing an intervention can be a difficult task as there are many different options available, they can be costly, and it is often difficult to determine which interventions will best suit a person with autism. Persons with ASD need individually designed interventions and supports and not rather what is available that may not meet their needs, which is sometimes the case [2].

Nevertheless, no intervention can have an actual effect, if there is not a comprehensive and continuous synergy among the involved care parties around the autistic person's treatment approach (i.e. family, teacher, therapist, psychologist, social worker, etc.) In other words, the collaboration among the social entities in which the autistic person lives and functions (that is Family, School and Community) should be well-coordinated, pragmatic, consistent, contingent, with a continuous exchange and update of related information and ASD-centric services.

Computer-mediated platforms have been shown to be a catalyst for increased social interaction in persons with ASD, even though that effect requires further study to be effectively employed as a therapeutic intervention [4]. Similarly, technology-based collaborative environments and systems could be proofed a profound solution and to have indisputable effects on an ASD person's development. In recent years, there is an increasing number of researches, studies and projects in Computer Supported Cooperative Work (CSCW) applications and systems in the eHealth [29] and Ambient Assisted Living [5] domains with successful and encouraging results with regards to treatment and social inclusion of patients and elderly people accordingly. In this respect, main purpose of this work is to propose an ASD-centric Computer Supported Collaborative Treatment Architecture (ASD-centric CSCTA). The particular architecture aims to identify the components and collaboration dynamics that enhance the services provision by an assigned Virtual Care Team (VCT) for the treatment of persons with ASD. Given the one-to-one treatment and therapy applied in such cases collaborative system will enhance decision-making through collaboration and a continuous update of the person with ASD state. This will enable the error-free efficient development and control of its situation.

2 The Importance of Collaboration and CSCW in ASD and eHealth

ASD is a complex lifelong disorder that has an intense impact on a person's development and is more common in males than females. Individuals with ASD, predominantly demonstrate strong deficiencies in many types of social behavior, social imagination and communication; also known as the "Triad of Impairments" [6]. Furthermore, they might indicate difficulties with self-motivation, severe deficits in turn-taking, joint attention and pointing, play, imitation, and self-initiated behavior [7]; impairments in reciprocal social interaction and communication, and restricted and stereotyped patterns of interests and activities as well as repetitive movements and resistance to change [8]; poor eye-contact and lack of face and body understanding, and difficulties on using verbal and non-verbal communication [6]; learning difficulties or learning disabilities [9]; and difficulties in creating and producing emotional understanding and expressions while they are unconscious of being able to exert control over their surroundings environments and obtaining coherent response, even in the cases when they themselves causing the events [10]. The complexity of these disorders necessitates a range of services that are tailored to the needs of an individual with ASD and his/her family, from screening and referral services through diagnosis, assessment for intervention planning, and treatment. Specific standardized instruments are available that aid the clinician in gathering relevant information and evaluating specific ASD impairments [11]. The comprehensive evaluation of a child with a suspected ASD may include speech, language, and communication assessments, cognitive testing, behavioral assessments, academic assessments, and a medical evaluation [12]. It is critical that these are identified so that appropriate treatment and services can be initiated based on the strengths of a person with ASD. These strengths and personality traits are considered vital to be identified, since based on these the intervention planning that will be applied for the treatment of the individual will be formulated [13]. Studies have shown that early identification of individuals with ASD can lead to earlier entry into intervention programs that support improved developmental outcomes [14]. Early intervention has been associated with gains in verbal and nonverbal communication, higher intelligence test scores, improved peer interactions, more effective learning and development of social abilities, and improved quality of life [15]. A substantial benefit also of early intervention is the positive impact on the family's ability to interact in a manner that facilitates and copes with their child's developmental concerns, and the greater understanding of their child's disability and how it interacts with family life [16].

It is widely acknowledged in the research community that generalization of methods and approaches in the individuals' with ASD treatment is neither feasible nor effective. A personalized (ASD-centric) and intensive treatment could be considered to have the most positive impact on the abilities of an individual with autism, applied on a continuous basis and with high synergy among the involved care parties [17]. Hence, families have to work collaboratively with professionals from i.e. school, community and special education, to integrate the various multidisciplinary assessment findings into a comprehensive profile of the individual's strengths and concerns. This profile becomes the family's basis for planning for the selection of

specific interventions. This synergy can promote discussion among the involved parties and add value to the collective expertise and the broad perspective of the interdisciplinary team, to ensure that the many needs of these individuals are met across multiple settings, and the identification of the best course of action has been framed [17]. Although a variety of service models have been described that focus on collaboration among medical and educational service professionals [18], one important component that should unite all these models is the reliance on the exchanged updated data and continuous support; in order to revise decision making and treatment planning. This collaboration and involvement allows for management and modification of treatment plans over time [19] and the provision of more accurate and comprehensive set of services.

The existing technological advancements, either Web based, desktop and/or wireless/mobile, are numerous; with several applications to offer synchronous and asynchronous (tele-) cooperation among the members of a dedicated care team. These efforts are lying mostly under the overarching research area of Computer Supported Cooperative Work (CSCW). Even though there is still no commonly accepted definition of CSCW [20], we could say that is an "umbrella term" that allow people from a variety of disciplines, with partially overlapping concerns, to cooperate and research issues of how to use computers to support activities of people working together. Suchman [21] describes CSCW as the design of computer-based technologies with explicit concern for the socially organized practices of their intended users. CSCW approaches have been in recent years extensively applied in the research domains of eHealth and Ambient Assisted Living (AAL), with a significant success. In this respect, an alternative term that has been proposed by Consolvo et al. [22], that is Computer Supported Cooperative Care (CSCC), includes the broad range of care-giving activities that a group does using technology, having in the center patients and/or elderly people.

The increasing number of different efforts that have been undertaken, in the fields of eHealth and AAL (as compared to ASD related attempts where, to the best of our knowledge, are more stand-alone and fragmented), are mainly interested in the in-house "independent living" [23]; the development of specific technologies for disabilities, i.e. dementia [24], and for addressing the needs of the users and lifestyle considerations [25]; the design of distributed integrated innovative services for elderly at home [26]; the investigation of technology that could enhance social and health care [26]; the socialization and daily monitoring of needs and requirements of the elderly in an outdoor environment [5]; and the support of the dynamic creation, management and co-ordination of virtual collaborative medical teams, for the continuous treatment of patients with chronic diseases (i.e. cancer) at home and specialist healthcare centres [28].

The particular considerations and applications are of extreme importance in our case, since many of the characteristics and the context of these areas, are similar to the ASD domain. Our main research concentration is to propose an architecture that supports active participation, communication, socialization, mutual assistance and self-organization; promoting seamless integration and interaction of different people (family members, education and community) at any time and any place and providing daily ASD-centric monitoring activity.

3 A Proposed ASD-Centric Computer Supported Collaborative Treatment Architecture

Considering the different requirements, needs and demands of the ASD domain this section outlines an ASD-centric Computer Supported Collaborative Treatment Architecture (ASD-centric CSCTA). It has its grounds on a CSCW system which has been successfully implemented in the domains of eHealth and AAL with significant acceptance and value to the use cases that has been applied (i.e. home care for cancer patients and socialization of elderly people) [28, 27, 5]. The main innovation of the proposed architecture lies at the services layer since it employs notions and techniques based on the specificities and contextual characteristics of the collaborative environment around a person with ASD (in section 4 we will analyze the notion of the ASD-centric Virtual Care Teams which supports the dynamicity of the workflows for the provision of services during a treatment session to an individual with ASD). Furthermore, it is based on IBM's reference architecture for Service-Oriented Architecture[2] (SOA). The goal of using SOA is to liberate the logic from the constraints of technology and to achieve reusability of components. Our technical approach combines Agile Software Development (ASD) and Model Driven Architectures (MDA). Agile software development focuses on optimizing quality of both software and documentation by facilitating a high level of interaction between members of the development teams and the end-users. Our system architecture is divided into 5 layers (see Figure 1): (a) *Presentation Layer*, hosts the Graphical User Interfaces (GUIs), that are personalized according to user's preferences and adaptable to any client (e.g. Mobile Device, Web browser, Desktop, etc.) according to the individual's needs maximizing the added value of the system; (b) *Interoperability Layer*, a toolset that enables the development of system components and services that use the same syntax and semantics, by utilizing information models and concepts from the underlying Information Middleware with application programming interfaces (API) and interface description languages (IDL); (c) *Service Layer*, figures as the primal innovation of the proposed architecture; implemented with the notion of ASD-centric Virtual Care Teams, dynamic workflows and a set of services that enhance collaboration dynamics among the prospective bodies that involved in the treatment of persons with ASD (it is further analyzed in section 4 of this paper); (d) *Information Layer*, hosts the Database Management System of the system (DBMS), that all the data are stored for the user management, profiling, collaboration features, virtual care teams, dynamic workflows, actions, questionnaires, etc. In our architecture, any DBMS can be utilized such as Oracle, Microsoft SQL Server and MySQL as long as all basic database functionalities are provided; and (e) *Security Layer*, ensures that the end user applications can be trusted with respect to confidentiality, integrity and availability. These three aspects are imperative to the personal information privacy and safety of the users. The security layer is designed to

[2] "Service-oriented modeling and architecture - How to identify, specify, and realize services for your SOA", Ali Arsanjani, SOA and Web services Center of Excellence, IBM. 09 Nov 2004: http://www-128.ibm.com/ developerworks/webservices/library/ws-soa-design1/

fulfill the domain requirements. It uses current and emerging security standards in order to create a platform that will reduce the time to market for software providers.

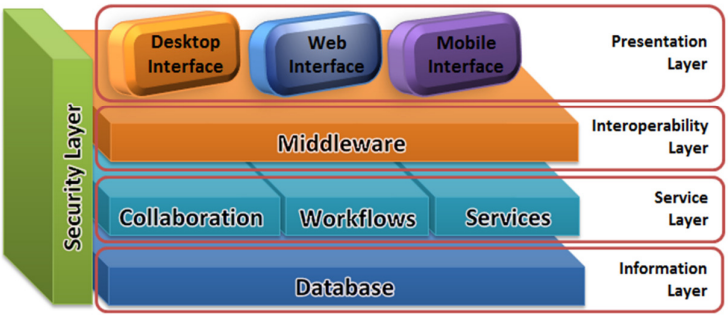

Fig. 1. An ASD-centric Computer Supported Collaborative Treatment Architecture

This layer constitutes a framework that supports PKI (X.509), ebXML framework (ISO 15000) and interoperability support for existing middleware security architectures.

4 The Enhanced *Service Layer* of the ASD-centric CSCTA

As it is clearly perceived so far the importance of one-to-one treatment for persons with ASD is of paramount significance. Hence, efficient approaches presuppose the formulation of multidisciplinary care teams that will combine knowledge and expertise towards the application of various interventions on an individual with ASD. However, formulating such an effective care team is not an easy task. Apart from the individualistic characteristics of a person with ASD, other issues i.e., concerning the services, communication patterns and the context of a unique case have to be analyzed and well defined in order to decide which members will finally constitute such a care team. Henceforth, embracing these needs and requirements, the "Service Layer" of the proposed ASD-centric CSCTA has been designed by utilizing the notions of ASD-centric Virtual Care Teams (in "Collaboration" component), the dynamic workflows (in "Workflows" component), and a set of ASD-centric services (in "Services" component), that are continuously exchanging vital information for the most efficient and effective provision of treatment to an individual with ASD (see Figure 2). The *Collaboration* component is responsible to provide all the collaboration mechanisms between the Virtual Care Team members. Such mechanisms are emails, SMS, messages, etc. The *Workflows* component is responsible to provide mechanisms for business process automation and business intelligence. It resembles the business processes layer in the SOA architecture, having an orchestration and coordination of the basic system services, but in a more dynamic and ad-hoc manner. The *Services* component hosts the basic services that provide all the functionality of the system [33]. These services can be called directly from the application or from a workflow, and even more from another service.

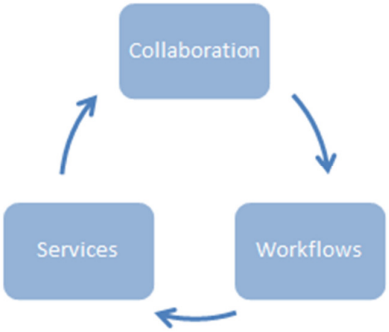

Fig. 2. The Enhanced Service Layer

Due to the peculiarity of the ASD domain, the arising contextual concepts and constraints infer to a specialized approach based on which the appropriate services will be devised for covering the needs of an ASD care team. In this regards, such an ASD-centric CSCTA should adhere to: (a) *Availability awareness*, the ASD-centric CSCTA must be aware of the user status (availability), in order to manage better any critical situations; (b) *Expandability*, an ASD-centric CSCTA has to be able to expand easily with new workflows and collaboration schemas; (c) *Easy information sharing*, users must be able to share the information they want (and nothing more) with other users, with minimum effort; (d) *Flexible messaging methods*, care team members are not always computer literate and the environment has to adapt to their communication skills. Some of them prefer the use of emails and others prefer the use of SMS text messages. The environment should be able to provide all means of communication; (e) *Availability*, an ASD-centric CSCTA has to be available 24/7 from anyplace and by any means. This brings in the wireless requirement as mandatory; (f) *Confidentiality*, collaboration messages must be confidential and only available to the intended recipients; and (g*) Security*, all collaboration messages must be secured (at least at a level acceptable to the ASD domain, given the National and/or EU policies and regulations). Most of these requirements/characteristics have been positively evaluated in the eHealth sector [28], and it is considered a motivating challenge to be applied in the ASD sector.

4.1 The "Collaboration" Component

It has been shown, in the eHealth (and more specifically in the chronic patients care) and Ambient Assisted Living (AAL) sectors, that the integration of all the aforementioned concerns under a common dynamic collaborative technological framework can be acceptable, successful and competent with the employment of Virtual Care Teams (VCT) [29]. Collaboration and virtual teams, abstractly, refer to the notion that a team of professionals decides to collaborate over the Internet and thus create a virtual team that eliminates the need of physical presence [28]. During the last few years there has been an increasing volume of literature on virtual organizations and virtual teams. This body of research generally agrees that virtual

teams consist of a collection of geographically dispersed individuals who work on a joint project or common tasks and communicate electronically. For example, Lipnack and Stamps [30] define a virtual team as "a group of people who interact through inter-dependent tasks guided by a common purpose" that "works across space, time and organizational boundaries with links strengthened by webs of communication technologies". The main benefit is that in a virtual team you can do what you can't do alone. The challenge of our time is to learn to work in virtual teams and networks while retaining the benefits of earlier forms. In time, virtual teams will become the natural way to work. Since many virtual teams do occasionally meet physically on predefined time intervals, they find themselves in the conventional face-to-face setting. It is generally agreed that a good virtual team is, in a way, a good team. Four words capture the essence of virtual teams: *people, purpose, links, and time*. *People* populate and lead small groups and teams of every kind at every level, from the executive suite to the subcommittees of the local school's parent association. *Purpose* holds groups together, which for teams mean a focus on tasks that makes work progressing from goals to results. *Links* are the channels, interactions, and relationships. The greatest difference between in-the-same-place teams and virtual ones lies in the nature and variety of their links. *Time* is a dimension common to schedules, milestones, calendars, processes, and life cycles [30].

Adapting the term into the context, needs and requirements of the ASD domain, we are suggesting the notion of ASD-Virtual Care Teams (ASD-VCT), that are focusing on treatment objectives for a person with ASD and consisted of members coming mainly from the three more important contextual-fields for such a person, the family, school and community. It is interesting to note that the physical distance among these team members define the urgency of the collaboration and the need for dynamicity. Indeed, virtual teams have been presented in the research literature as a communication intensive and a computer-mediated linked type of group. Electronic data interchange, computer-supported cooperative work, group support systems, as well as email, videoconferencing and teleconferencing facilities, to name but a few, enable people based in different locations to communicate and coordinate their actions with great speed and effectiveness [31].

4.2 The "Workflows" Component

Nowadays, utilization of workflows in CSCW environments is a trend, that handle the abovementioned requirements through the application of specialized techniques such as ad-hoc, recursive, event driven and time triggered [32]. Workflows are mainly used to determine the sequence of an operation in order to speed up procedures, enabling better handling of resources and reorganizing energy and information flows. In the ASD-centric CSCTA context, given the current evolution of wireless technologies, workflows application mainly aim to provide end users with an easier way to orchestrate or describe complex processing of data. Moreover, they establish the need for providing dynamic working environments (dynamic workflows) of different actors (VCT members) promoting effective collaboration among them, including the person with ASD, at any time, and any context (place). Furthermore, ASD-centric CSCTA that supports workflows should not have their syntactic and contextual rules and

processes hardcoded and predefined, but rather dynamic. By syntactic dynamicity (i.e configurable), we mean the ability of the workflow to change on demand during a task's execution (according to new requirements, i.e. some specialists might change rules based on a given situation).

4.3 The "Services" Component

Given the multidisciplinarity, dynamicity and constraints of the ASD sector, main objective is to comprehensively identify a number of services that could be successfully communicated within and between a specific ASD-centric Computer Supported Collaborative Treatment Environment on a continuous and consistent manner for maximizing, among others, communication efficiency and decision making in terms of time and accuracy. In this regards, a particular services model has been discussed by authors in [33], which has investigated the real user needs that are referring to an ASD-centric social community level, as well as the innovative cost-effective technologies which integrate personalized socialization services. Based on an extensive research on the individualistic and contextual characteristics of persons with ASD, literature review and interviews with specialists it has been proposed a set of services that utilize the basic notions of CSCW environments and are classified under five main categories: i) ASD Continuing Monitoring, ii) Collaboration Services, iii) Care & Wellness Services, iv) Socialization Services and v) Intervention Treatment Approach. The particular services are expressing the main outputs of the "Services Layer" and provide an added value to the communication among care parties, monitoring and error handling, decision making and social inclusion, improving the quality of life of the person with ASD.

5 A Conceptual Real Life Case Scenario: Marco

In this section we will present a real life scenario of an individual with ASD. We will elaborate on an instance of the intervention treatment approach that has been decided to be followed based on its initial diagnosis with the use of the proposed ASD-centric CSCTA and the formulation of the dedicated VCT around it. It has to be mentioned that, for ethical and confidentiality issues, the name, age and/or any other characteristics that could reveal the real identity of this person have been altered, without though deteriorating the validity of the case.

5.1 Marco's Short Profile Description

Marco is a 5 ½ years-old boy who was diagnosed with a Pervasive Developmental Disorder; he is receptive but not verbal (i.e. he understands but he cannot speak). He is hypotonic in the vocal apparatus and mouth, he has several verbal self-stimuli (sounds like howl) and flicker/flapping hands reactions.

Parents were unable to change Marco's behaviors and to communicate with him, with great frustration of the child and his family. The exact diagnosis received only 1

year later when social, speech and communication were totally degraded and the child had become not verbal. Doctors evaluated the clinical aspects while the speech, language, and communication assessments carried out by a psychologist specialized in autism evaluations using ad-hoc test and rate scales (Vineland Adaptive Behaviour Scales, PsychoEducational Profile (PEP 3) for the functional evaluation, etc.)

5.2 Marco's Intervention Approach

The beginning of the treatment was made through training programs that were functional to his age and living environments, for the development of his verbal speech. The programs aimed at creating the basic prerequisites for school learning, like: oral motor imitation, verbal imitation, matching letters, matching numbers, matching similar words (even not "real" words), matching word/word, receptive labels, expressive labels (reading and writing), and academic sequence of letters (once acquired: numbers, seasons, days, weeks, months). Such programs include *procedures for settle/remove the howling* through strategies such as: make the discrete trials faster (i.e. increasing the teaching pace) and provide a different "powerful" reinforcement (particularly interesting for the child) for trials without howling, and *procedures for settle/remove the flicker* through strategies such as: the teaching of an alternative answer which is incompatible with the flicker (i.e. teaching the child how to put his hands into his pockets; do cycling, if necessary teaching him to ride a bicycle).

A useful tool for monitoring problem behavior (used in Marco's treatment) is the *Antecedent-Behavior-Consequence (ABC)* Analysis (Table 1). *Antecedent* is the event or activity that immediately precedes a problem behavior; *Behavior* refers to an observed behavior; and *Consequence* refers to the event that immediately follows a response. This tool allows an observer to record descriptive information about a child in a systematic and organized way, recognizing emerging predictable patterns and then studying the strategy for modifying the behavior. The idea is that when problem behavior appears, there is an antecedent that triggers the behavior and a consequence that "maintains" the behavior. The therapists/caregivers may act on the environment for avoiding the antecedent to take place, eliminating the problem behavior.

Table 1. The ABC tool

Date/Time	Activity	Antecedent	Behavior	Consequence

Furthermore, consequences increase or decrease the probability that the analyzed behavior will occur again in the future. Hence, reshaping consequences allows to model the behavior, fading out inappropriate behaviors (even though this may be difficult at some point since usually requires the change of the response by the therapists/caregivers to a problem behavior).

5.3 Marco's Typical Treatment Scenario and Concerns

A typical treatment scenario for Marco, involves 5 team members plus the parents. The team members that are participating in this scenario are the Senior Therapist, Therapist A, Therapist B, Therapist C, and a Consultant, together with the child's parents. In this scenario (see Figure 3), Senior Therapist (ST) initiate Marco's therapy program, decided and prepared by the Consultant, and assign tasks to the Therapist A (TA), Therapist B (TB) and Therapist C (TC). TA carries out a training program called "Sequence of imitation with Blocks".

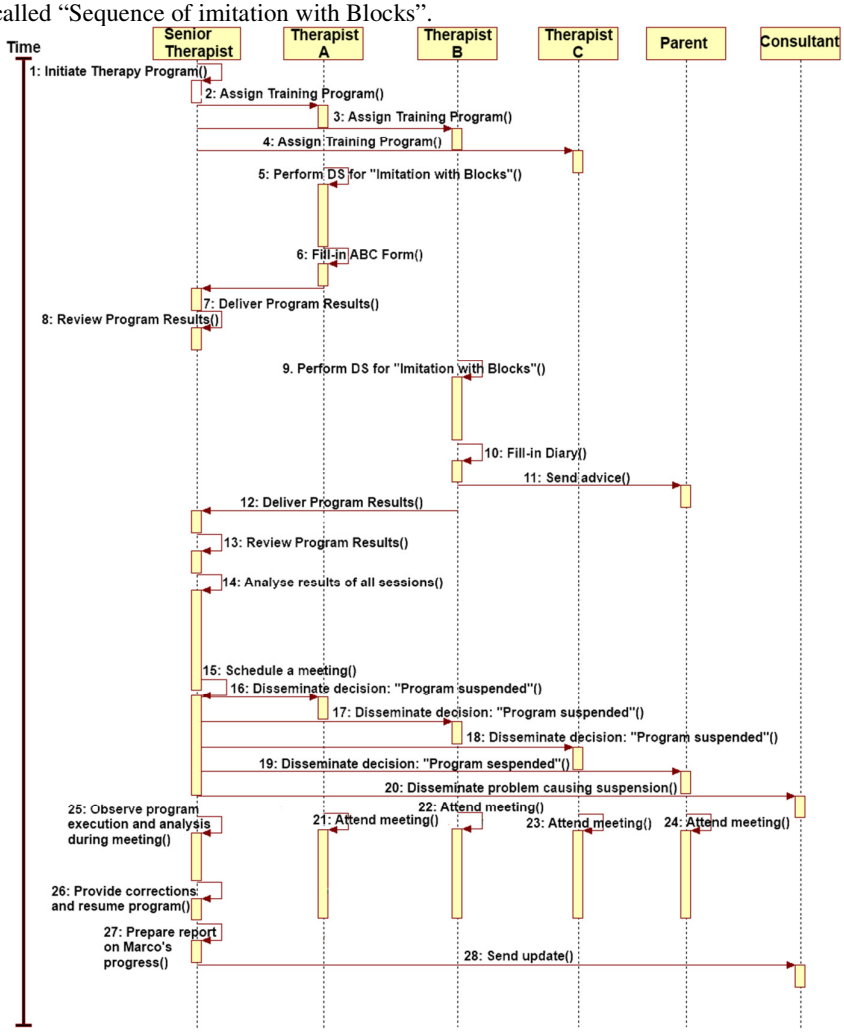

Fig. 3. Marco's Treatment Scenario UML

TA uses ABC analysis (see Table 1) in order to monitor any problem behavior and tries to reduce/eliminate it. The therapist monitors the problem behavior spending an additional time for filling the ABC (paper) form that has to be delivered to the ST for reviewing the results. During another therapy session, TB gives a discriminative stimulus (DS) that is not coherent with the DS Marco previously received by the TA. As a result, the child fails, the program does not progress and the child do not collaborate since there was not coherence. TB monitors the problem behavior spending an additional time for filling the ABC (paper) form. Furthermore, TB spends some time to advice the child's parents on their future behavior in order to advance child's progress. TB then also delivers the results to the ST for revision. When ST gathers all results, he analyses them and conducts a cross check on the findings.

ST identifies that the DS of the TB is not coherent with the DS previously the child received (from TA). He decides to suspend the program "Blocks" and schedules a meeting with all team members in order to find an optimum solution for this problem. ST calls all team members to inform them for the updated program and tries to schedule an appropriate time for the meeting. Later, ST calls the Consultant to update him on child's program and progress. During the meeting, team members gather and observe videos of various program executions on Marco and try to analyze his behavior. ST provides corrections and resumes the program. Finally, ST prepares a report based on the meeting, referring to the changes on the program and child's progress, and disseminates the results to the Consultant.

Observing the traditional treatment scenario above, we can distinguish some limitations on the existing operational workflow of the care team members. These limitations include communication restrictions, data integrity issues, data availability and data sharing problems. We can easily notice that each team member has to disseminate each session's results to the rest of the members via telephone or email, spending unnecessary time for propagating the results. Also, there are real life cases where the dissemination of results was not identical due to human error or mishaps and typos. Furthermore, another time consuming event is the meeting scheduling by the senior therapist. ST has to call all team members separately, in order to check their availability for each meeting. Many times, ST has to call back to rearrange the meeting and finally has to call each team member again to finalize the meeting. Such a task could be proofed frustrating and time consuming for the ST. In addition, therapists are attending sessions without the proper knowledge on previous sessions and thus the complete picture of child's progress. In our case, TB would have had consulted the ST before attempting to give a DS that is not coherent with previously DS of TA. Numerous cases show that a proper circulation of results could speed up children's progress. Through the implementation of the proposed ASD-centric CSCTA we tackle these limitations with the utilization of VCTs, a centralized knowledge base and a bouquet of ASD-centric services.

5.4 Optimizing Marco's Typical Treatment Scenario and Evaluation

In Figure 4, we illustrate the abovementioned scenario using the proposed ASD-CSCTA. For each individual with ASD we formulate a VCT by assigning users with roles that will participate in that specific team. All team members are equipped with

mobile devices (i.e. iPhones, iPads, Android phones, HTC windows mobile enabled, laptops, etc.) VCT members can access and update all information about their caring individual easily from anywhere and anytime (24/7) with the utilization of mobile technologies (i.e. GPRS, 3G, WIFI, etc.), depending on their authentication rights.

In our case, the ST instead of assigning separately the initiation of the program to each therapist, logs into the system (currently we are evaluating the proposed architecture with the use of a pilot system) and initiates Marco's therapy program (called "Sequence of imitation with Blocks"), where all the therapists (TA, TB, TC) are notified automatically. At a later stage, TA monitors the Marco's problem behavior that has been noticed and fills-in online the ABC form, which is available from the system under the child's diary. As expected, the results are instantly available to ST and he reviews the results without having to wait for the TA to deliver them in person. Similarly, during another session, TB gives a DS which was not coherent with the one the child previously received by the TA. As a result, the child fails (do not collaborate), and the program does not progress as planned. TB monitors the problem behavior and updates the ABC (online) form. The results are instantly available to the ST through the system, who reviews the outcome without having to wait for the TB to deliver them in person. In addition, ST easily gathers and analyses all results and conducts a cross check on the findings since they are all available to him through the system. The derived consensus with regards to the case progression is better supported and documented. We notice that by utilizing the messaging service of the proposed treatment environment, we save valuable time and effort (as it can also be observed by comparing the two Figures, 3 and 4).

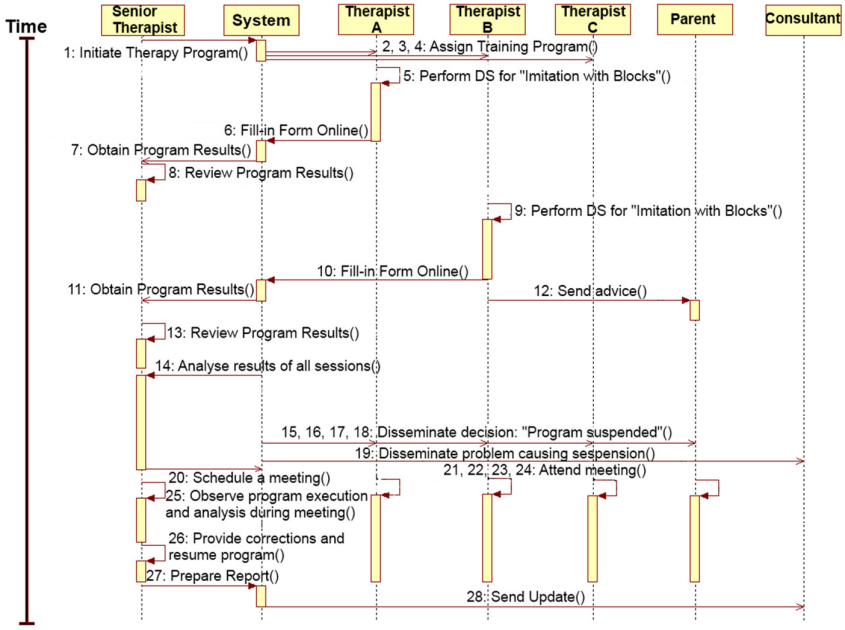

Fig. 4. Marco's Treatment Scenario UML using the ASD-centric CSCTA

The ST decides to update the program and the system alerts TA, TB, TC and child's parents about this change. The system also makes the ST's findings available to the Consultant. ST decides to schedule a meeting with the team members and he can do this easily since he can review each team member's schedule online. Their schedule is automatically updated by the system. During the meeting session, all team members observe videos of various program executions and try to analyze Marco's behavior. ST provides corrections and resumes the program. Finally, ST prepares a report on the meeting, with the changes on the program, and child's progress and uploads it to the system. The system makes also the updates available to the Consultant.

Comparing the two scenarios, we can easily identify an upgrade in the Quality of Data (QoD), Quality of Service (QoS) and security in the optimized version. This is achieved through the enhanced communication and coordination among the ASD-VCT's members, with the use of the pilot system and the functionalities: Schedule updates, messaging service between users, reminders and alerts. In a more detail, QoD has been enhanced due to the continuous real-time update of information, accuracy, completeness, constancy and relevancy. QoS has been advanced since the users are collaborating in more effective and efficient manner; while security is supported by the CIA triad (Confidentiality, Integrity and Availability), which describes the fundamental security principles in a sustainable information security framework [34].

Using the system in the second optimized scenario, we identify savings in Program Management, Schedule Management and Information retrieval, which can be estimated in terms of time savings and consequently cost savings. More specifically, it has been identified that (see Figure 4) there are:

(i) 3 savings in assigning the program to the therapists (steps 2, 3 and 4).
(ii) 2 savings in information retrieval from the system (steps 7 and 11).
(iii) 2 savings in informing the consultant on updates (steps 19 and 28)
(iv) 4 savings in updates on the program to the therapists (steps 15, 16, 17 and 18)
(v) 1 saving on scheduling a meeting and 4 saving on updating therapists' schedule.

A rough diagonal estimation shows that there is a significant average saving time of the total process. In order to have a more precise estimation, we have calculated the cost for each one of these 5 groups of savings. Lying on the valuable insight of the Marco's ASD-VCT, with regards to time and cost spent in each process-step, we were able to estimate the values for these groups, based on the formulas shown in Table 2.

Table 2. Marco's Treatment Scenario Groups of Savings: Estimated Time and Cost for each Process-Step

Groups of Savings	Formula for Calculating Estimation
(i) Program assignment by the senior therapist it takes on average 15 minutes through GSM telephony.	– Total saving time = $15_{minutes}$ * number of assignments – Total cost saving = Total saving time * (cost of GSM $call_{per\ minute}$ + rate of the senior $therapist_{per\ minute}$ + rate of the $therapist_{per\ minute}$)
(ii) In order for the senior therapist to get the	– Total saving time = $30_{minutes}$ * trips to

	result, all other therapists had to return the results (ABC paper form) in the headquarters. This procedure demanded a travelling time of 30 minutes and 20 Km on average.	headquarters – Total cost saving = (Total saving time * rate of the senior therapist$_{per\ minute}$) + (Traveling cost for 20 Km * trips to headquarters)
(iii)	The update of the consultant usually takes 30 minutes and usually with the use of GSM telephony.	– Total saving time = 30$_{minutes}$ * calls to the consultant – Total cost saving = Total saving time * (cost of GSM call$_{per\ minute}$ + rate of the senior therapist$_{per\ minute}$ + rate of the consultant$_{per\ minute}$)
(iv)	Each therapist's update on the program by the senior therapist takes an average time of 20 minutes, again through GSM telephony.	– Total saving time = 20$_{minutes}$ * calls to therapists – Total cost saving = Total saving time * (cost of GSM call$_{per\ minute}$ + rate of the senior therapist$_{per\ minute}$ + rate of the therapist$_{per\ minute}$)
(v)	The scheduling of a meeting is the most time consuming task. The senior therapist has to call each participant separately in order to arrange the time that is suitable for all. After the agreement (sometimes more than one phone calls is needed) he has to call again each one of them in order to notify them about the agreed time for the meeting. This task needs 30 minutes on average for each participant through GSM telephony.	– Total saving time = 30$_{minutes}$ * number of participants – Total cost saving = Total saving time * (cost of GSM call$_{per\ minute}$ + rate of the senior therapist$_{per\ minute}$ + rate of the therapist$_{per\ minute}$)

Henceforth, applying this conceptualization, in Italy, the estimated cost for the senior therapist is 18€/h, for the therapist is 12€/h, and for the consultant is 90€/h. We can also estimate the costs of supporting services, such as, telephone calls (average cost of 15c/min for GSM phone calls) and trips to visits (average cost of 10c/min or 15c/Km for gas). Furthermore, based on the team members experience the average phone call duration is 20 min and the average travel time is 30 min (approximately 20Km in urban areas). Most of the times in order for the team members to provide the above services a preparatory work has to be undertaken, as shown in Table 3.

Table 3. Cost (in EUROS) of preparatory work prior or after visit

Task	Duration (in minutes)	Cost for senior therapist	Cost for therapist	Cost for consultant
Office, discussion on patient issues, read patient notes, communication book entry	10	3€	2€	15€
Phone call to patient or his family	5	1.5€	1€	7.5€
Phone calls to other health professionals	5	1.5€	1€	7.5€
organize equipment	5	1.5€	1€	7.5€

Office work including updating patient notes, briefing team, communication book etc	15	4.5€	3€	22.5€

Finally, we calculated all other costs like traveling from/to persons' with ASD houses, from/to team members' houses and from/to headquarters, telephone costs, travel to obtain special equipment, etc. Therefore, in Marco's case, we have estimated (using the formulas in Table 2) the cost for each scenario (without and with the proposed system). In Table 4 we can view the costs in more detail for both versions of this scenario.

Table 4. Cost (in EUROS) of each scenario

Without the System				
Communication Costs	**Travelling Costs**	**Visits Costs**	**Other Costs**	**Total**
10 Calls (Steps: 2,3,4,11,16, 17,18,19,20,28)	2 trips to deliver the results (Steps:7,12)	2 Visits (Steps: 5,6,9,10)	3 reviews and a meeting (Steps: 1,8,13,14,15,21, 22,23,24,25,26,27)	
84,75€	**18€**	**60€**	**351€**	**513.75€**
With the System				
Communication Costs	**Travelling Costs**	**Visits Costs**	**Other Costs**	**Total**
1 Advice Parents (Steps: 2)	0 trips to deliver the results	2 Visits (Steps: 5,6,9,10)	3 reviews and a meeting (Steps: 1,8,13,14,21, 22,23,24,25,26,27)	
6€	**0**	**60€**	**351€**	**417€ (≈19,5% Savings)**

The calculated costs are divided into 4 categories. The Communication Costs, Traveling Costs, Visits Costs and Other Costs. The Visiting and Other Costs are not affected by the use of the system. As we can observe, the majority of the savings are mainly in Communication Costs where our system organizes all actions and speeds up communications and information sharing resulting to a cost decrease of 93%. In addition, the Traveling Costs for reporting back to the headquarters are eliminated with the use of the system. Finally, for this simple scenario, the total estimation is around 19.5% savings.

It can be easily noticed that these savings are of great importance, since the scenario instance we have used in this paper is small in scale. A normal full scale scenario consists of at least 3 therapists that are having 3-6 sessions per week each, for every child. The saving for communications only, for a sample of 50 children, can be escalated up to 20.000€ per month. In addition, there are many indirect and hidden cost savings such as traveling of trainers back to headquarters in order to obtain session of other trainers on the child that he is going to visit. There are also cases that

therapists did not return the results to the headquarters on time and as a result all other therapists went to a session without proper knowledge on child's progress.

6 Conclusion and Discussion

In this paper we have underlined the significance of continuous collaborative treatment provision to individuals with ASD. Given the differences, particularities and abnormal progression of ASD a personalized multidisciplinary collaborative intervention approach for persons with ASD is considered vital for their most effective development. It has been realized that early one-to-one treatment interventions, accurate exchange of information and prompt delivery of services to such persons increase their intellectual and social abilities and make them feel more comfortable and adapted to their contextual environment. Furthermore, the rapid advancement of desktop, Web-based and mobile / wireless technologies have created new opportunities and possibilities of designing sophisticated environments and systems that can capture the needs and requirements of these persons, since they are able to improve drastically the synergy and communication within and between the ASD-centric care teams. In this respect we have proposed an ASD-centric Computer Supported Collaborative Treatment Architecture which employs the notion of Virtual Care Teams and the provision of ASD-centric services over dynamic workflows. VCTs can significantly enhance the main strategies used by all care parties that are emphasized on collaboration in the sharing of information for data-based decisions regarding diagnosis, treatment planning, and intervention and ongoing monitoring in order to meet the medical and educational needs of persons with ASD. The latter conceptualization benefits are also grounded from the ongoing positive evaluation of VCTs in the eHealth sector.

More specifically, we have applied the proposed architecture in a real life case scenario instance, with the use of a pilot system, in order to initially evaluate its effectiveness and efficiency during a treatment process which is based on ABC analysis. It has been identified an upgrade in the QoD, QoS and security in the optimized version. This is achieved through the enhanced communication and coordination recognizing savings in Program Management, Schedule Management and Information retrieval, which have been interpreted in terms of time savings and consequently cost savings on an average of 19.5% of the total process.

Limitations of this study in terms of evaluation at the various levels of interest include not only the common problems of adopting information and communication collaborative technologies in the dynamic ASD environment (i.e. reorganization working process, phobia of technology, lack of trust, limited budget) but also to a missing universal legal ASD framework. In the ASD sector legal issues are essential due to the sensitivity of the individuals' with ASD data (health / medical records, diagnostic reports, etc.) Furthermore, factors like the need to full time personnel to manage IT problems, regular retraining users to constantly changing technologies and the high cost of wireless medium lead to enormous budgets that hampers most of the times the adequate adoption of such systems.

Nevertheless, the anticipated impact on the attitudes and benefits of persons with ASD could be perceived as multifold. Indicatively, we could say that it is expected

that the treatment will be more direct and sufficient since the person with ASD will feel safe and secure with the care team being around it on a 24/7 basis; the decision making with regards to the progression of this person will be enhanced and will be more accurate since there will be a live update of the exchanged information; the communication among the care team members will be more sound and prompt avoiding any delays in the whole treatment process while at the same time a more effective timely error handling will be achieved; the cost and effort of the care team members will be reduced, especially if they are in dispersed areas, without though jeopardizing the quality of the treatment.

Future work includes the extensive evaluation of the effectiveness and efficiency of the architecture at a conceptual (proof-of-concept) and as an application at a system level. Key research issues that need to be further addressed, among others, include: the support of continuity of care, by the VCTs to persons with ASD, at any given time, irrespective of locality, or cross country movement; improvement of communication within (virtual) care team members that constitute the context of the individual with ASD (home, school, community); improvement of the security and timely access to information, in accordance to the authorization roles' levels, through a unified information space (centralized database) centered around the person with ASD; improvement of the flexible collection of statistical data for further audit and research within the VCTs setting; improvement of decisions' making evaluation in terms of time and accuracy; improvement of cost effectiveness through improved communications and better planning services; etc.

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