Augmentative Requirements Engineering

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Getting Closer to Sensitive User's Needs

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Abstract. The widening digital divide in today's interconnected world is more than an access issue in terms of technology availability and affordability. Concerns like media accessibility, information mobilization and consciousness need to be approached comprehensively, especially when dealing with sensitive user groups. Discovering, understanding and efficiently implementing proper requirements for augmentative and alternative communication is essential for supporting the users with complex communication needs in their everyday life, from work engagement to personal settings. By enforcing the usage of information and communication technologies to help solve these issues, users' needs and desires have to be analyzed carefully, by learning from educational, psychological and rehabilitation methods from other fields already deeply involved with life-care for these people. Augmentative requirements engineering is a requirements engineering framework that provides a holistic view on requirements for augmentative and alternative communication services, concerning sensitive users' abilities and needs, service domain and associated intermediary users. The new paradigm is experience-driven from a series of concluded projects and implemented applications for various user groups in Croatia.

Keywords: augmentative and alternative communication, requirements engineering, e-accessibility, appropriate technology, complex communication needs

1 Introduction

Over the past few years, the interconnected world has witnessed continued growth in the uptake, availability and affordability of information and communication technologies (ICTs). At the end of 2013, around 2.7 billion people have been using the Internet, while the number has gone up to 3 billion by the end of 2014 [1]. Even though the progress is evident on a yearly basis, there are digital divide challenges that still need to be addressed: 4.3 billion people are still not online, and 90% of them live in the developing world. Moreover, the digital divide is not just an access issue, but also concerns with information accessibility, information utilization and information receptiveness. More than just accessibility, individuals need to know how to make use of the ICT tools once they exist within a community [2].

In order to bridge the gap, a multidiscipline approach is needed to provide means in helping sensitive users, like persons with complex communication needs (CCNs), learn and utilize the technologies to which they do have access, but fully accepting the health and well-being status of every individual, along with his/her capabilities. Understanding users' needs becomes even more challengeable when developing ICT solutions for people with disabilities. Even more, it seems that ICT has the potential both for enhancing access to different services for people with disabilities and for creating more division and new forms of exclusion. Therefore, it seems crucial to continuously address the issues of accessibility and usability as technology continues to develop and spread and as new technologies emerge [3]. As ICT inevitably plays an essential role in supporting daily life in today's digital society, European e-inclusion policy [4] aims to achieve that "no one is left behind" in enjoying the benefits of ICT, focusing on participation of all individuals and communities in all aspects of the information society. E-accessibility is considered a key priority in various global programs for supporting ICT innovations, which recommends that additional efforts need to be made to promote the development of assistive technologies that are tailored to help people with special needs access ICTs. Web accessibility is stated as one of the main building blocks for establishing e-accessibility, in order to entail major social and economic gains for people with disabilities, among others, making them more active as workers or consumers. Although public strategies and policy recommendations cover this topic to some extent [5], and some solutions are offered [6], many methodological and practical challenges regarding the ICT development process still exist, especially for its earliest phases, like requirements gathering, specification and verification, and ICT service design.

Bridging the gap from requirements to design and implementation of proper software solutions is often a challenge dealt with methods and tools that tend to trace the status of requirements throughout the software development cycle, but these approaches do not help when requirements are gotten wrong at the first place. Quarter of a century ago, Frederick Phillips Brooks, Jr. made the following statement in his well-known and widely discussed IEEE Computer journal paper [7]: "The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is as difficult as establishing the detailed technical requirements, including all the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later."

Surely, research and practice in the requirements engineering area, for a few decades now, fully acknowledge the importance of planning and analysis in early phases of software development. However, gathering the right requirements and providing solutions for them in a traceable and manageable manner has to be achieved through an optimal development pace, resulting with shippable software systems people will gladly use [8]. In order to provide a qualitative and quantitative ground for building more usable and accessible ICT services for people with CCNs, this paper proposes a requirements engineering (RE) framework that provides a holistic view on requirements for augmentative and alternative communication services, concerning sensitive users' abilities and needs, different service domains and associated intermediary users.

The structure of the paper is the following: section 2 provides a context of augmentative and alternative communication, while section 3 gives a background on relevant last year's statistics regarding people with disabilities in Croatia, and corresponding inclusion policies, both national and European. Section 4 discusses the requirements engineering approach to this challenge, while the next section provides a experience-driven overview of concluded projects and applications implemented in Croatia that support augmentative and alternative communication for various user groups in different service domains. Section 6 describes the principles of so-called augmentative requirements engineering. The last section summarizes the findings and comments future work in the area of ICT-assisted augmentative and alternative communication.

2 Augmentative and Alternative Communication

Communication is essential for active participation in everyday life, from work engagement to personal settings. Nevertheless, some people may not have the communication skills to meet all of their needs, due to their developmental (e.g. Down syndrome, cerebral palsy) or acquired disabilities (e.g. multiple sclerosis, stroke). Significant impairments prevent these persons to communicate in a conventional manner. In order to cope with their disabilities and support their complex communication needs, the area of clinical practice called augmentative and alternative communication (AAC) has been established to improve effectiveness of communication by using symbols, aids, techniques and strategies [9]. Augmentative and alternative communication (in some literature referred as "alternative and augmentative communication") represents a set of tools and strategies that individuals, not being able to rely on their natural speech to communicate, use to solve everyday communication challenges. Everyone uses multiple forms of communication, such as speech, a shared glance, text, gestures, facial expressions, touch, sign language, symbols, pictures, and speech generating devices, based upon the context and the other party in communication, in order to make them understand each other [10].

AAC is considered one of three main categories ICTs can play in fulfilling educational needs of children with disabilities, along with the compensation uses (e.g. technical assistance that enables active participation in reading or writing) and didactic uses (e.g. using ICTs as a didactical tool to enable a more inclusive learning environment) [11]. Such special educational requirements of children with disabilities caused by a functional limitation are often called special educational needs (SENs), and are both diverse and varied [12]. Some usability studies [13] show that even though product features are considered "accessible", consumers with disabilities may still have difficulty using it easily and efficiently. It is recommended to consider access issues as the products are being tested and developed, and measure both accessibility and usability in tests that include people with a broad range of disabilities. It is often the case that the cost of specialized, aided AAC devices is too high for the limited functionality they offer. It seems reasonable to build AAC services based on information and communication technologies (ICTs) [14], especially for mobile computer devices.

3 Croatia: Overview on Disability

As defined by the International Classification of Functioning, Disability and Health (ICF), disability is the interaction between individuals with a health condition (e.g. cerebral palsy, Down syndrome and depression) and personal and environmental factors (e.g. negative attitudes, inaccessible transportation and public buildings, and limited social supports). Based on the estimations of the United Nations (UN), more than 1 billion people or 15% of the world's population are living with disabilities today. In all regions, persons with disabilities are disproportionately represented among the poorest segments of society. Additionally, it is estimated that 80% of persons with disabilities reside in developing countries [15]. The World Health Organization (WHO) reports the number of persons with disabilities is on the rise, partially due to aging populations, chronic health conditions and improved access to health care [16].

According to the Croatian "Census of Population, Households and Dwellings 2011", the total population of Croatia is 4,290,612. The population density is 75.8 inhabitants per square kilometer, and the overall life expectancy in Croatia at birth is 75.7 years. Since 1991, Croatia's death rate has continuously exceeded its birth rate; the natural growth rate of the population is currently negative [17].

According to the Croatian Disabilities Registry [18], by March 12, 2015, there were 508,350 disabled persons living in Croatia, from which 306,614 were male (60%), and 201,736 were female (40%). Therefore, around 12% of Croatian population are disabled persons (male 7.1%; female 4.7%), compared to 16.6% in EU27. Croatia is also one of 25 EU Member States that have accepted the UN's Convention on the Rights of Persons with Disabilities (CRPD), with the core concepts of self-determination, participation and inclusion for people with disabilities, namely "those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others".

Table 1. The number (and percentage) of persons with disabilities in Croatia, by the type of their impairments; data on March 12, 2015, adopted from [18]

Type of impairment	*Number of persons*	*%*
Locomotor system impairment	146,359	28.8
Multiple impairments	143,192	28,2
Psychological disorder	124,080	24,4
Other organs and organic system impairment	114,225	22,5
Central nervous system impairment	90,878	17,9
Cognitive impairment	23,618	4,6
Speech and language impairment	20,471	4
Visual impairment	17,039	3,4
Hearing impairment	12,633	2,5
Peripheral nervous system impairment	11,946	2,3
Congenital anomalies and chromosomopathies	9,253	1,8
Pervasive developmental disorder (autism)	1,461	0,3

As seen in Table 1, the most common types of impairments that people with disabilities in Croatia have are locomotor system impairments and psychological disorders. Around 28% of people with disabilities in Croatia have multiple impairments, which presents even a greater challenge to provide means of augmentative and alternative communication to them.

4 Requirements and Design Approach

Discovering, understanding and efficiently implementing proper requirements for augmentative and alternative communication is essential for supporting the users with complex communication needs in their everyday life, from work engagement to personal settings. Many traditional software engineering (SE) approaches are documentation-oriented, usually conforming to some heavyweight processes. On the other hand, agile approaches declare customer satisfaction as their highest priority, through early and continuous delivery of valuable solutions, while embracing requirements change, even late in development [19]. Practically all requirements engineering (RE) paradigms put the customer in central place, trying to deal with other challenges in the same time, like requirements change, too complex specifications, not testable requirements, etc. Considering specificity and the sensitive nature of target user groups, as well as their limited abilities and special needs, and required service features also, it is necessary to make a thorough analysis and define challenges and potentials of adequate requirements elicitation techniques that would properly incorporate multidisciplinary approach during development process.

The following analysis of issues and challenges is given for the requirements engineering phase within the AAC service development for people with complex communication needs, taking into consideration both functional and nonfunctional service requirements:

- Requirements gathering – usual methods, such as interviewing or role playing, cannot be universally applied. The crucial fact for people with complex communication needs is that every person has his/her special needs and specific abilities, not allowing for them to be treated the same way as other AAC service users. Some directions can be driven from experiences of educational, psychological and rehabilitation methods from other fields already deeply involved with life-care for these people.
- Requirements specification – regarding to some extent limited abilities of this target group, it seems reasonable to assume that they need “as simple as possible” set of functional requirements (FR) in order to use some service. However, this does not mean simply reducing already existing set of functions for non-disabled people using the same service, but establishing full understanding which functions are necessary for them, what is the order of function usage, their possible combinations allowed and/or disallowed, etc. Also, non-functional requirements (NFR), such as those regarding performance, security and trust, have to be carefully considered and analyzed, first separately and then in combination with the set of FRs, in order to provide a robust, but trustworthy and yet usable AAC service.

- Requirements verification – if a presumption that the functional requirements dropping in a number and complexity shows to be valid for ICT services for people with complex communication needs, then some formal methods (e.g. Event-B [20]) and tools (e.g. ProR [21] and Rodin [22]) can be utilized in order to prove the simple formal requirements models for logical correctness. Nevertheless, these statements need to be thoroughly checked through experiments and case studies.

Regarding the design phase within the AAC service development, there are certain issues regarding the production cost and active user participation using "Design for all" principle. User centered design in this case has to be planned carefully, accepting common approaches from other involved fields and experts, including educators, rehabilitators, caregivers, etc. These experts are not mandatory well-skilled with advanced AAC services or ICT services at all, so educating them also seems as a challenge. Design of AAC systems and services should cope with all of person's major disabilities, in order to provide a mean for successful communication, but not emphasizing some other user's inability in the same time. For example, if a non-talking child with severe motor impairments is given a communicator application [23] to e.g. pick his favorite food, the major button on user interface should be adjusted in a way that the child can reach it [24], otherwise the service is not usable for him.

In order to match the type of given impairment with desired AAC functionalities, we have put together a brief mapping of AAC service features and person's impairments that shows which service feature is more suitable to be used as input or output by which impairment. Table 2 shows the most common types of impairments, along with typical input/output features of AAC services.

Table 2. Input and output AAC service features most suitable for each person's impairment

Type of impairment	*Input Features*	*Output Features*
Locomotor system impairment	Adjustable GUI; Execution by a voice command; Stylus pens as pointers (hand-held, mouth sticks, mounted on the head, etc.)	Text-to-speech; Sound effects
Psychological disorder	Picture selection; Object tracking (e.g. eyeball, human position, body parts, etc.)	Visual attention; Sound imitation
Cognitive impairment	Known photos and symbol selection	Photos, symbols; Audio messages
Speech and language impairment	Sign-to-speech; Signs, message composition; Icon sequencing	Texting; Speech; Symbol composition
Visual impairment	Vibration-by-selection; Simple GUI with large elements; Voice commands	Sign-to-speech; High-contrast
Hearing impairment	Text and symbols; Touch and vibrate; Texting, word prediction	Text and symbols; Visual effects

Some other existing impairments, such as central or peripheral nervous system impairments, other organs and organic system impairments, and congenital anomalies and chromosomopathies, may partially find suitable AAC service features among the ones given, but previously have to be thoroughly analyzed on case-by-case basis. Special consideration should be given to pervasive developmental disorders, like autism, in order to fulfil these person's needs and wants. Also, for persons with multiple impairments, it is advisable to prioritize which impairment is the most necessary to be augmented, and to develop the AAC service with such given input and output features. Further evaluation of such AAC services while in usage can guide further user interface development and customization.

Regarding the type of AAC devices, introduction and wide-spreading of new mobile devices, such as tablets and smart phones, can serve as enabler for these AAC services. It is inevitable fact that mobile computers are getting more popular and affordable by the continuous growth and availability of ICT infrastructure worldwide [1]. The goal of AAC is utilizing the most effective communication possible to aid AAC user express his/her needs and wants, and conduct social contacts.

5 ICT-Assisted AAC in Croatia

Half a decade ago, there were practically not any ICT-assisted AAC services and applications being developed for Croatian market and Croatian cultural environment, although the need was eminent [18], especially with around 10% of all elementary school children being children with special needs, according to Croatian Association for Professional Help to Children with Special Needs statistics. Therefore, multidisciplinary scientists in electrical engineering and computing, graphic technology, education and rehabilitation, speech pathology and psychology have joined forces in developing interoperable and scalable platform for symbol based communication services capable of implementation on various user devices [25].

As one of the results of the project "ICT systems for people with complex communication needs", financed by the University of Zagreb Development Fund, The AAC Body of Knowledge has been developed, containing basic information needed for effective development and implementation of AAC systems based on ICT. It is available in Croatian only, serving as a multi-disciplinary repository of definitions and references to existing sources of information related to AAC, referencing all previously stated research fields [26]. Its sole purpose was to be a reference point for introducing interested stakeholders in the domain of AAC, and to be continuously updated with the new results in research, development and practice for ICT-assisted AAC.

As described in previous section, AAC systems and services can offer various communication methods, depending on the type and severity of user's disability. In order to adjust the graphical user interface (GUI) to users' needs, skills and limitations, AAC services can recognize and quantify user's skills on using the interface, like in the developed Calibrator service [23]. Calibration process here was being done by calculating UI parameters to optimize the symbol size, object position on screen, contrast and background, and choosing the most suitable symbol gallery (Figure 1).

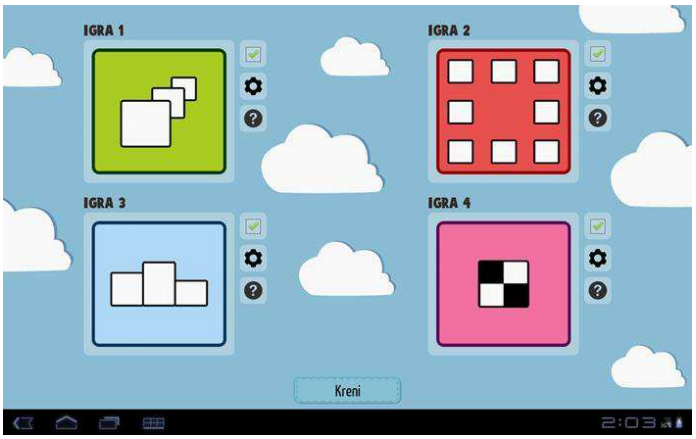

Fig. 1. The Calibrator service, for optimizing: the symbol size (1), object position on screen (2), choosing from the most suitable symbol gallery (3), and contrast and background (4); from [23]

Given the fact that specialized, aided AAC devices, by that time available on the market, have provided foreign language support only (e.g. "Talking Photo Album" in English) and had to be specially ordered from abroad, it was reasonable to set a common ground for building a national ICT-assisted AAC research and development community in close cooperation with users and user representatives, like parental organizations, associations for people with special needs, etc.

One of the most used AAC applications developed within the project was Mathematical Carousel (shown on Figure 2), which helps preschool and school-aged children learning and exercising the basic mathematical operations, involving three activities: counting, equality of sets and basic math operations using numbers or symbols.

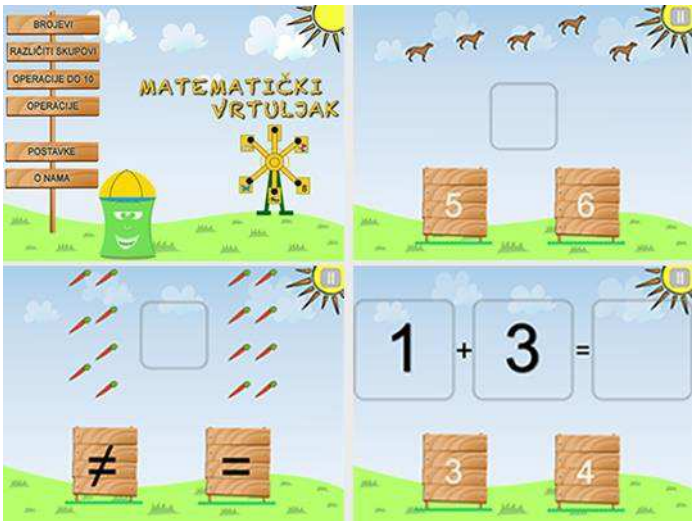

Fig. 2. The Mathematical Carousel, developed for iOS and Android and as a Web application

Based on the results of successful academic cooperation, the "ICT Competence Network for Innovative Services for Persons with Complex Communication Needs" has been established [27, 28] with participation of higher education institutions and knowledge-based small and medium enterprises. They aimed to make a joint effort in development, customization, and maintenance of ICT-assisted AAC services to be used by caretakers or organizations for inclusion of persons with CCN, such as inclusive preschools, primary and secondary educational institutions, social welfare institutions, specialized hospitals, polyclinics and specialized day-care centers. In the following table (Table 3), we have provided an overview of some implemented ICT-AAC applications by their input and output features, and supported platforms and operating systems. Applications developed for Android and iOS can be used on smartphones and tablets running these operating systems. The main interaction with all applications is done by the touch interface on device screen.

Table 3. Overview of some implemented ICT-AAC applications by their input and output features and supported platforms / OSs

Application name	*Platforms/OSs*	*Input Features*	*Output Features*
Communicator	iOS, Android	Symbols (photos, images) selection; Adjustable GUI	Voice and sound representation of symbols (audio recordings)
Mathematical Carousel	iOS, Android, Web	Numbers or symbols (images) selection; Setting only some math operations	Graphical animations; Sound and music response
Letters	iOS, Android	Symbols (visual) selection; Terms selection; Adding new symbols (photos, images, auditory) and terms; Adjustable GUI	Audio recording for every symbol; Terms overview
e-Gallery	iOS, Android	Photos selection; Adding photos and related text and audio recordings; Adjustable GUI	Audio recording for every photo
Mathematical Playground	iOS, Android, Web	Numbers or symbols (images) selection; Adjustable GUI	Sound representation of correct or incorrect answers
Vocals	iOS, Android, Web	Symbols (visual) selection; Adjustable GUI	Audio recording for every symbol
Memory	iOS, Android	Symbols (visual) selection; Adding new symbols and words; Adjustable GUI	Sound representation of symbols and words (pronunciation)

Parents and representatives of parental organizations for children with developmental delays, based on their daily experiences living with and taking care of their children, recommended that AAC applications use big images without distracting details, and avoid secondary motives. Also, simple and visually clear font, such as Arial, should be used, while the red color is advisable for emphasizing individual letters or words, being the quickest to reach the child's brain due to its frequency [29]. Among high priority requirements related to the teaching materials for children complex communication needs are incorporated pictures, text and audio records, such as voice recordings or text to speech, prepared and categorized according to the communication disabilities and frequency of use. In order to collect and analyze all these requirements efficiently, and also manage them through the AAC service development cycle, we have looked into RE applicability for ICT-assisted AAC.

6 Requirements Engineering for ICT-Assisted AAC

When supported by ICT services, the field of AAC suitably falls into human-computer interaction (HCI), a mature research discipline that offers numerous approaches for development of efficient user interfaces and means of people interacting with technology. In order to develop such services that support and enhance AAC, principles of requirements engineering have to be applied. We can refer to ICT-based AAC services as services that enable symbol-based human-to-human communication and human-computer interaction in a networking environment [30]. We are tackling needs and perspectives for using such services to supplement, not replace, some of the aids usage by persons with disabilities, which can be especially helpful for the ones with multiple impairments.

This represents a HCI design challenge regarding the technology in domestic life, community settings as well as working surroundings, with significant RE challenges that call for proper design and usage of questionnaires and surveys, as well as some other ethnographically-inspired methods such as narrative-based methods and mixed methods, taking also the ethical concerns into account.

In order to tackle this challenge, we propose new paradigm of requirements engineering for AAC, or so-called augmentative requirements engineering (ARE) [31], that will allow holistic view on AAC service requirements concerning users abilities and needs, service domain (such as communication, education, entertainment) and associated user supporters (such as rehabilitators, educators, family). Directions for augmentative requirements engineering for ICT-assisted AAC services for the target groups should strive towards user-centered design principles. Although user-centered design is an established area of HCI research and practice, we are proposing some additional and other-angle insights to the topic.

By building-up the ARE framework (as shown in Figure 3) from the basis of already outlined usability requirements taxonomy [32], here we provide an overview of what we consider to be influential factors for proper usability and accessibility requirements specification for an AAC service planned to be developed for a person with complex communication needs.

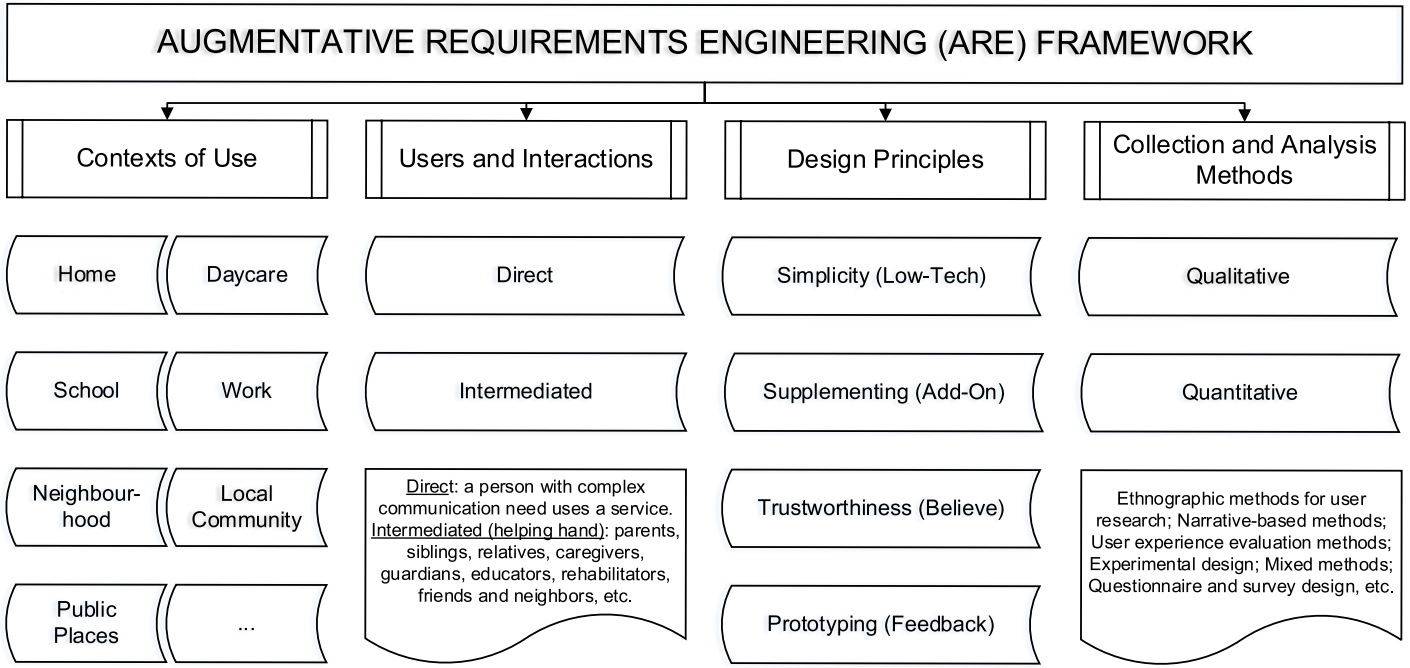

Fig. 3. Augmentative Requirements Engineering (ARE) framework overview

The ARE framework is described in more details in the following subsections, providing insights for each of four framework aspects in dealing with AAC service requirements:

- Contexts of use of an AAC service by a primary user, a person with CCNs,
- Users and their interactions, both with an AAC service and intermediated users,
- Design principles: describing Simplicity (or Low-Tech), Supplementing (or Add-On), Trustworthiness (or Believe) and Prototyping (or Feedback) design principles of the AAC service, and
- Collection and analysis methods: commenting on qualitative, quantitative and mixed methods usage for AAC service requirements collection and analysis.

6.1 Contexts of Use

If we observe a target user of AAC service to be a minor, e.g. Down-Syndrome child, we can recognize at least three contextually different locations (in terms of the context as constantly changing user environment [33]) of his/her daily life:

- Home, as a place of living in a family surroundings with at least one other person,
- School (educational and/or rehabilitation center), as a place of making educational and rehabilitation efforts for the person's benefit,
- Other social places, such as places for neighborhood and community gatherings, shops in the nearby area, etc.

Usability requirements for an AAC service can be very different, depending on the context of the AAC service usage. E.g. classroom can already have several high-tech aids and solutions for communication support, which can be sufficient for communication in this context. Home is the place where user presumably has developed the highest social closeness with others, and communication with no technology support at all or with low-tech methods could successfully apply. In some other social places user behaves by engaging in social etiquette routines, where some suitable and simple AAC services could be of great help.

6.2 Users and Interactions

There are few ways in which user can typically interact with an AAC service [34]:

- Direct interaction between the primary user and a service,
- Intermediated interaction, where intermediary user stands as a helping hand between a primary user and a service, because of some inability of a primary user to bring out a direct interaction.

Examples of intermediary users of mobile AAC service are: parents and relatives, caregivers and guardians, educators and rehabilitators, friends and neighbors, etc. Studies have shown [34] that intermediated access creates a multiplier effect for the benefits of technologies through sharing, with intermediary-users acting as gateways between

unconnected households and ICTs. The notion of intermediary user introduced into AAC service environment has a direct impact on usability and accessibility requirements, being considerably different than in the direct interaction scenario. Designing AAC services for multiple users that take part in various interactions puts up even more challenges in the whole AAC design and development process.

6.3 Simplicity (or Low-Tech) Principle

In order to gain a valuable insight to the users' needs, it is advisable to take some time observing reactions from their surroundings to the emerging communication needs. E.g. experienced parents and caregivers, knowing their protégés well, can show us practical guidelines and even fully operational solutions to the specific communication challenge in a simple, "pen-and-paper" environment (similar to low-tech prototyping) without any significant aid of technology. This could provide us with additional useful information about usability and accessibility needs and perspectives.

6.4 Supplementing (or Add-On) Principle

It should be reasonably stated to all the stakeholders from the beginning of the AAC service development process that development and deployment of new AAC services will not exclude the need for traditional and non-ICT means of daily communication. Moreover, AAC service should be made as a solution simple enough to be accepted by the user, and powerful enough to supplement some specific user' communication needs. In order to gain valuable insights in such interactions, conducting some Wizard of Oz research experiments could be very useful.

6.5 Trustworthiness (or Believe) Principle

Applying one of the known trust models to AAC services, we may consider the services trustworthy if they: (1) have ability to fulfill requests in a given domain, (2) have integrity to provide proper results as stated, and (3) are benevolent – act in user's best interest [35]. Although gaining user's trust in a particular service is influenced by many factors, some common sense relations, like including intermediary users (parents, teachers) into the trust chain can show benefits for accessibility challenges.

6.6 Prototyping (or Feedback) Principle

Integral parts of every proper user experience (UX) design process are wireframes, mockups and prototypes [36]. As the design process is not linear, going back-and-forth using this approaches may be often the case, and also confusing. While the wireframing approach can fit into our Simplicity (or Low-Tech) principle, mockups should be used to show the basic functionality of AAC application, while adding visual richness, and prototypes should allow users to experience actual content and interact with the UI.

6.7 Qualitative Methods

Some core qualitative user research methods, like observations and interviews, are widely known to research communities around the world, and their applicability to AAC service design is also inevitable. In order to understand users and their behaviors in the everyday contexts, ethnographic methods have been adopted and adapted into software requirements discipline [37]. Ethnographic methods for user research is the common name for ethnographically-informed user research methods used for the purposes of technology design and evaluation.

Another set of qualitative methods are narrative-based methods, used to elicit narratives or small stories from participants. The approach uses various specific techniques, like critical incident technique, diary studies, cultural probes [38] and explorations of user-generated content, such as that shared online. Narrative-based methods seem more appropriate to be used with intermediated users, than the primary users themselves. Their insights are surely valuable to inform AAC service design and/or AAC service in use.

6.8 Quantitative Methods

Quantitative methods have been commonly used in HCI research, such as using statistical methods, or experimental design [39]. Experimental design starts defining the intended contribution of the research agenda, following with experimental design and variables definition, continued by analysis of data, and discussing the issue of reliability and validity of given results.

Some user experience evaluation methods may deal with quantitative data collection, if e.g. the purpose of the AAC service evaluation deals with pragmatic factors such as time and financial constraints [40]. Also, if structured properly, surveys, questionnaires [41], and scales can be very useful methods for getting the quantitative data from the stakeholders, which should include primary and intermediated users.

6.9 Mixed Methods

Mixed methods approach combines quantitative and qualitative techniques at all stages of designing the research or development study. Designing such a study involves setting up the research questions, sampling and data collection and analysis, and reporting of the results.

The holistic framework for understanding the design of any piece of empirical research [42], including qualitative, quantitative and combined, can be consulted in order to find the set of techniques most suitable for planning a particular AAC service design research.

7 Discussion

Natural language requirements may be too demanding for managing throughout the development process, so it is advisable to provide a tool with an appropriate, machine-processable way of specifying and storing them [14]. One of the industry-candidates for requirements specification is Requirements Interchange Format (ReqIF), the emerging standard that provides interoperability with other authoring requirements management tools in industry [21]. ReqIF is basically XML-based file format used to exchange requirements, along with its associated metadata, in an open, non-proprietary and tool-independent manner. One of the main ReqIF features is hierarchically structured specification of uniquely identified requirements that have associated attributes to them and established relations between them. ProR is Eclipse-based tool for requirements engineering that supports ReqIF, aiming to provide reliable traceability between natural language requirements and formal models [22].

On the example of a symbol-based e-mail client [46], we have provided for people with special needs as a communicator service run on a tablet, we present a part of usability requirements (in the form of title: description) for this AAC service, regarding the following usability requirements types:

- Accessibility, e.g. Position of the screen: "User has a possibility to choose which position or positions of elements on the screen are the most accessible to him/her",
- Aesthetics, e.g. Symbol gallery: "User has a possibility to choose which set of symbols to use from a gallery of available symbols",
- UI consistency, e.g. Size of GUI elements: "User has a possibility to choose from different sizes for GUI elements",
- Ergonomics, e.g. First entry field focus: "When a symbol-based dialog box is opened, the focus shall be on the first entry field, in the top position of the dialog box",
- Ease of use, e.g. Help options: "The application has to offer a "Help" menu with proper instructions for users".

In the process of building requirements specification in ReqIF format, every requirement has a certain number of attributes that specify it in more details, e.g. requirements source, creation date, owner and status. The given requirements specification can be exported as the corresponding ReqIF file, which serves as an input for further design and development process [47], e.g. selection process from the AAC component pool, which can ease and speed-up process of finding and evaluating software components matching specified usability requirements [32, 48].

After configuring, customizing and using the ProR tool to gather and specify service requirements into the ReqIF project, the example of these usability requirements specification for a given AAC service is shown on Figure 4.

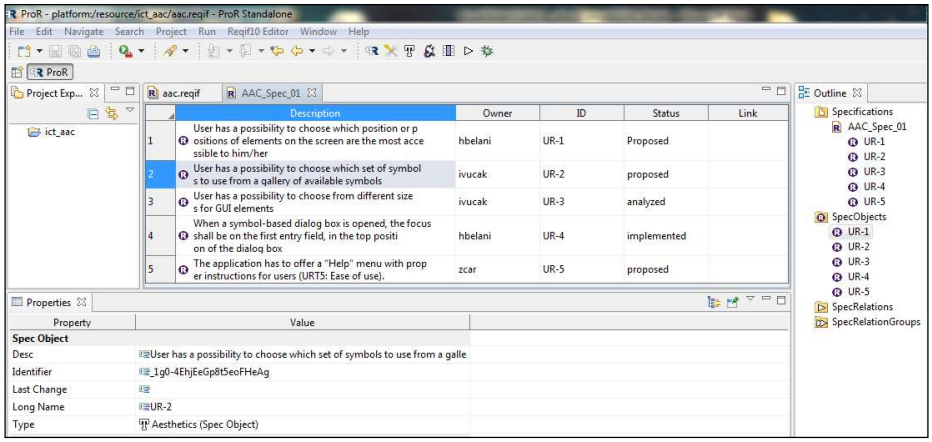

Fig. 4. Requirements specification in ReqIF format in ProR tool

8 Conclusion

In this paper we have discussed the appropriateness of known requirements engineering techniques, inherited from software and systems engineering, for developing information and communication technology (ICT) services for people with complex needs. We have outlined augmentative requirements engineering (ARE) for ICT service development process, which should strive to fulfill the principles of user-centered design (UCD), in a broader sense than accessible design or barrier-free design: equitable use, flexibility in use, simple and intuitive, perceptible information, tolerance for error, low physical effort, size and space for approach and use.

Aiming to answer the challenge regarding the technology in domestic life, community settings as well as working surroundings, for users with complex communication needs, this requirements engineering framework aims to incorporate educational, psychological and rehabilitation methods from other fields already deeply involved with life-care for these people, as well as other ethnographically-inspired methods. Moreover, this book chapter will provide data evidence gathered from a series of concluded AAC projects and implemented applications for various user groups and service domains.

Future work plans involve developing an ARE toolset for platform-based ICT-assisted AAC service development and establishing proper development processes accordingly, in terms of efficiency and effectiveness. For collecting and maintaining the knowledge about requirements for a shared set of AAC service functionality and software assets using a common means of production, the research from the area of software product lines may be applicable [43]. Requirements engineering for platforms is a discipline full of challenges [44], and some platform models for symbol based communication services are already being introduced [25] and user devices evaluated for AAC applications usage [45].

One of the research directions could focus on component development with effective user interface design for persons with complex communication needs, along with developing a software tool supporting the method. The ARE model will take into account the context of service usage, the user profiles and their interaction possibilities with the service as well as service design principles emphasizing usability and accessibility. By systematic usage of accessible interface elements according to the universal design principles, the proposed method will aim to help development process stakeholders in decision making about design possibilities of user interfaces in order to facilitate effective development of software service significantly adjusted to the person with complex communication needs.

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