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Design and Development of Symbol Based Services for Persons with Complex Communication Needs

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Abstract:

Augmentative and alternative communication (AAC) supports communication process of people who have communication disabilities and is based on the use of symbols. Multidisciplinary research is undertaken aiming to explore and create interoperable and scalable symbol based communication services for different user devices. The paper introduces model of the platform architecture for developing and deploying symbol based communication services and describes a model of adaptive symbol based AAC application.

Keywords:

Augmentative and Alternative Communication, Symbol, ICT

1. Introduction

In the time where a large part of social interaction is happening online, whether via e-mail, online forum and chat systems or social network websites, users with special needs are often excluded because of technological and functional limits which are imposed by the dedicated solutions they use. This digital exclusion is preventing individuals with disabilities from having socially active and independent lifestyle (*European Commission, 2010*). AAC users think that the technology and AAC solutions "must support full participation in all aspects of 21st century life" (*Williams, Krezman and McNaughton, 2008*). In 2005, European Union started the "i2010" initiative which promotes "e-Accessibility" with the goal to enable access to ICT applications, services and devices to people with disabilities (*ISAAC, 2013*). The art and science of augmentative communication and assistive technology is still a developing field (*Burkhart, 1993*).

Augmentative and alternative communication (AAC) methods - based on graphic and textual symbols rather than written words to represent certain objects, actions, or concepts - are highly beneficial and in certain cases critical for speech, literacy, learning, employment and quality of life for persons with complex communication needs. While the causes for disability are many (e.g., Down syndrome, Autistic Spectrum Disorder, Alzheimer's disease, severe intellectual disabilities, complex physical disabilities), demographic data show (estimated) 3 to 5 potential AAC users per 1000 of general population (*Stančić et al., 2013*). Considering accessibility for people with disabilities can clarify and simplify design for people who face temporary limitations (for example, injury) or situational ones (such as divided attention or bad environmental conditions, bright light or not enough light etc.) (*Williams, Krezman and McNaughton, 2008*). Taking into account the significant involvement of experts, caretakers, and user groups in Croatia, there is a market niche for development, customization, and maintenance of ICT (Information and Communication Technology) enabled AAC services. Such services can fulfill a wide range of needs, allowing users to achieve a higher degree of accountability, planning, organizing ideas, efficient execution of activities, increased creativity, communication skills and literacy.

2. Problem Statement

Augmentative language or assistive technology system means using the multiple systems, which is vastly more effective than use of a single system. AAC systems are diverse The symbols used in AAC include gestures, photographs, icons, signs, pictures, line drawings, letters and words, which can be used alone or in combination. System choice depends on the individual's situation, environment, needs, fatigue, and the communication partners.

The most important part of the HCI (Human Computer Interaction) process using symbol based AAC applications and services for touch screen mobile devices is happening on the screen – from browsing the symbol based content to the symbol selection process and sentence construction. It is therefore essential that the design and display of symbols and user interface is suitable to the screen specifications. There is a growing number of portable devices that are coming to market with touch screen interface and mobile operating system – from mobile phones and tablets, to e-readers and digital cameras, many of which use different display technologies and sizes. Previous research has been done in order to conduct enabling technology assessments (*Dolić, Pibernik and Bota, 2012*). Even in the same category of devices, manufacturers are using different screen sizes and display technologies to diversify their product lines or to cut costs. Unlike dedicated AAC solutions, where the manufacturer has full control over device specifications and software implementation, AAC applications and services for mainstream mobile devices should have functionality on wide range of display types, sizes, resolutions, color spaces and refresh rates.

Because of such variety of devices, there is a need for an unique approach to design and development of symbol based AAC applications and services for Croatian users. In order to get a better insight into the problems that Croatian AAC users are facing when using available solutions, a survey has been conducted. In the second phase of this research - an AAC application user interaction model was developed. Hybrid architecture is presented in Car et al. (2011) as well as the technical platform for symbol based ICT applications/services. At the end, the model of adaptive symbol based AAC application has been conceived.

3. Experimental

3.1 SURVEY OF CROATIAN AAC USERS

In order to get a better insight into the problems that Croatian AAC users are facing when using available solutions and to get a deeper understanding about their possibilities, needs and requirements, an online questionnaire has been

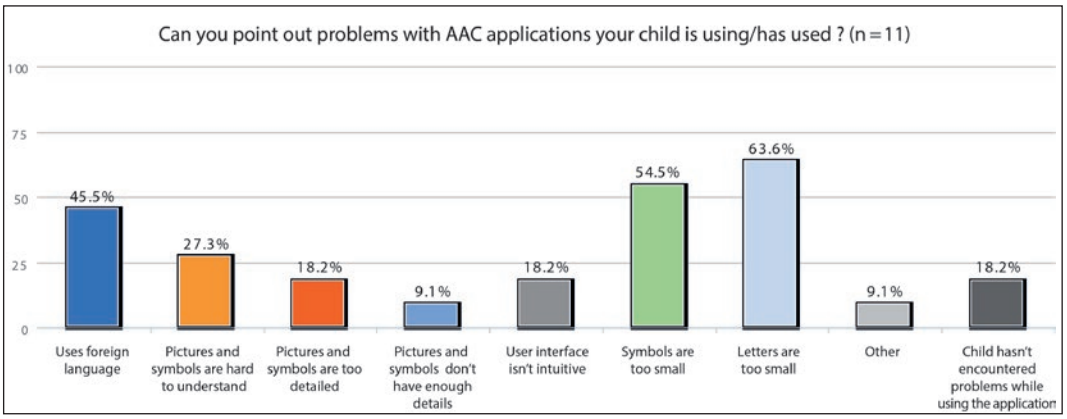

Figure 1. Problems that users are having with current AAC applications

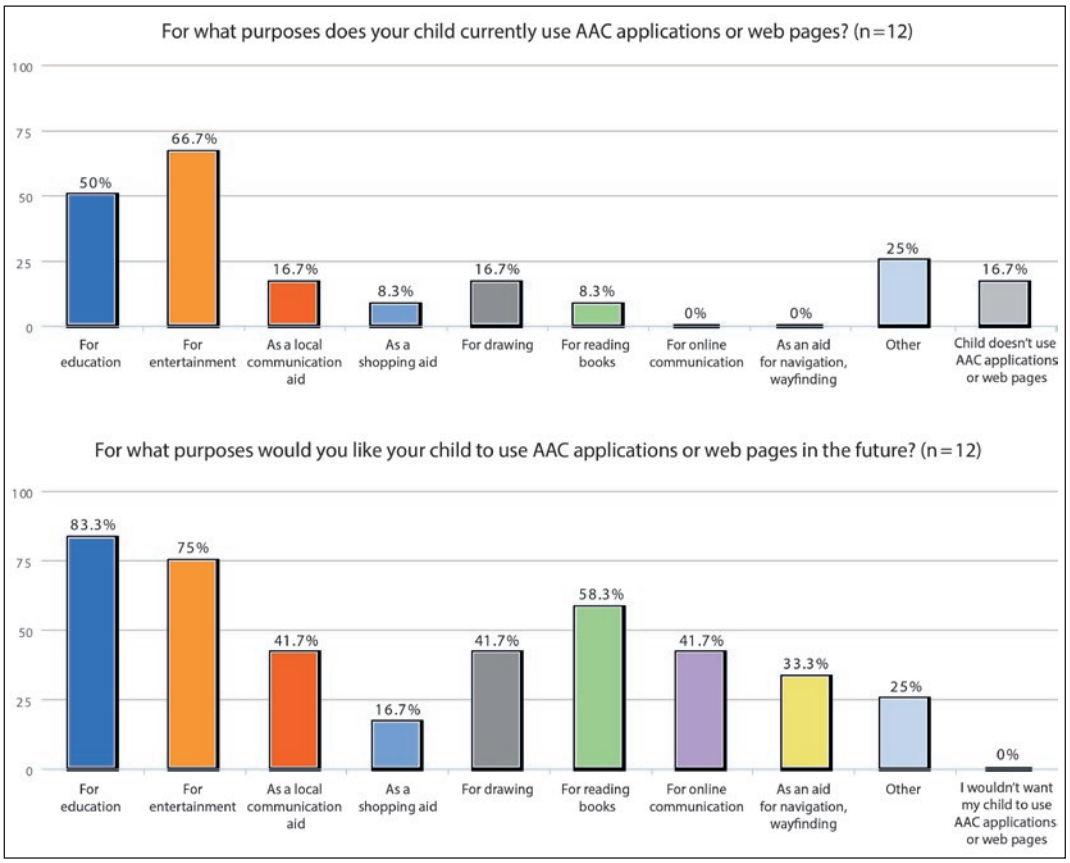

Figure 2. Current and desired use of AAC applications and web pages

distributed to the parents of current and potential symbol based AAC system users in the period from 15th April to May 27th 2011. The questionnaire consisted of several general questions about children, which were followed by questions about technologies, AAC applications and programs children are using in their daily activities, and technologies and programs parents would like their children to use. There were a total of 15 respondents, with 11 having male and 4 having female child with disability with age ranging from 5 to 21 years old. Only 3 of 13 respondents answered that their child is using a dedicated AAC device, out of which only one child uses communicator (a device allowing person with complex communication needs to attract attention, make requests, choose or reject something). Parents identified small size of letters (7 answers) and symbols (6 answers) as main problems with AAC applications child is (or was) using (Fig. 1). Only 2 parents consider that their children haven't encountered any problems while using available AAC applications.

Currently, children are mainly using AAC applications and web pages for entertainment (8 answers) and education (6 answers) and no one is using it for online communication (Fig. 2). All respondents want their children to use AAC applications and web pages in the future, with increased interest for use in education (10 answers), entertainment and book reading, but also for online communication, as a communication aid, for drawing and as a navigation aid (Fig. 2). All parents own a PC with internet access, with only one third of them having at least one smartphone device in their household (Fig. 3). Neither respondent owned a mainstream tablet device.

3.2. AAC APPLICATION – USER INTERACTION MODEL

In order to enhance the use of enabling technology to support learning, communication and independent living of persons with complex communication needs the user interaction model was developed.

This model presents possible interaction channels between AAC users and particular AAC application. It is applicable to any application that is or will be implemented within AAC software platform aimed for the component based development and deployment of interoperable and scalable symbol based services (*Burkhart, 1993*).

Interaction between AAC user and the AAC application is enabled by computer, smart phone or tablet. Input devices are mouse, keyboard, touchscreen and microphone. Output devices are screen and loudspeaker. Devices differ basically in the operating system, screen size, and the size of the device.

AAC applications' users could be either registered users who create their profile through registration process or non-registered users working in offline mode. Basic element of this model is an image. Augmentative and alternative communication is based on the use of graphic and textual symbols (rather than written words alone) to represent certain objects, actions, or concepts. There are available different commercial and non-commercial symbol galleries or collections of downloadable images representing different symbols. Also, users can possess their own private symbol

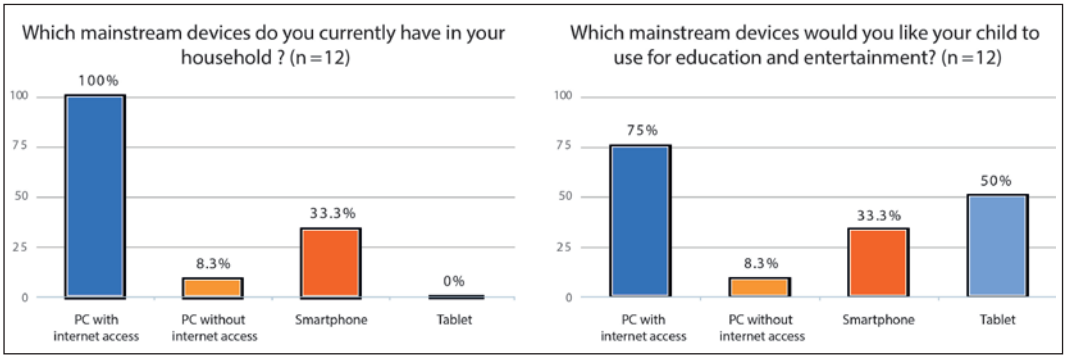

Figure 3. Current and desired mobile devices

galleries with symbols having specific meaning for them (photos or specifically created images). Images are either stored locally on the device or downloaded from the Web. AAC applications should support loading of this images.

With each image, a text-label should be associated describing the meaning (word or the phrase) of a symbol. Text is entered into provided text editor with limited amount of characters. Each image has associated sound. For creating sound meaning of the symbol either text-to-speech is used or sound is downloaded from the web. Also, users should be able to record their own sound and save it as an audio description of the symbol.

Applications should support easy adding of new symbols or changing the existing by making new associated sound or text-label.

At the application output, images are displayed either sequentially or several symbols at once. Number of images displayed at one screen should be set as the parameter within the application. Text-labels turning on/off should be supported. Sound is associated with displayed symbol.

AAC application-user communication model is presented in the Figure 4.

3.3 HYBRID ARCHITECTURE FOR SYMBOL BASED PLATFORM

It is well understood that the Quality of Experience (QoE) of an ICT application or service depends on the context of use, which is, to a certain extent, determined by the application domain. Hence, it is recommended to take into consideration the targeted application domain when designing the application/service. Application domains are typically multifaceted ranging from unidirectional to bi-/multi-directional services adopting different content modalities. As a result of Croatian multidisciplinary cooperation of university scientists in the field of electronic engineering and computer science, education and rehabilitation science, psychology and graphic technology; three different categories of AAC ICT applications/services are identified:

- native applications fully implemented on the particular mobile device
- distributed applications with hybrid architecture with native user interface implemented for the particular operating system and mobile device (web, Android, iOS)
- cross platform distributed applications with hybrid architecture.

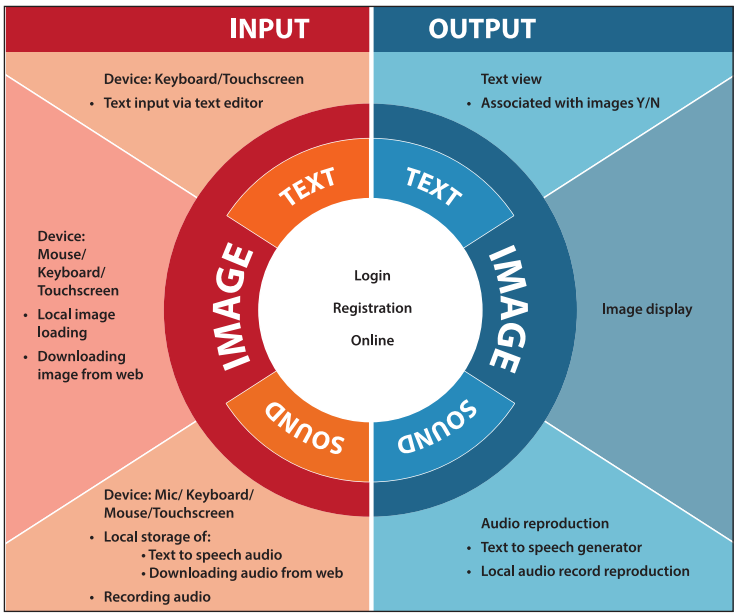

Figure 4. AAC application-user communication model

Hybrid architecture is presented in Car et al. (2011) as well as the technical platform for symbol based ICT applications/services.

Hybrid architecture combines web service and web application with stand-alone client application used for accessing services integrated within the platform. Architecture is shown in Fig. 5 and contains client and server side. Server side is web application containing Presentation control layer, Logic layer and Data layer.

Presentation control layer contains standard presentation logic and AAC symbol based platform presentation logic. Standard presentation logic is responsible for application representation in standard formats (e.g. HTML) which can be accessed with web browser. The other part of presentation layer, AAC platform presentation logic is responsible for adding specific custom tags to standard presentation view. Custom tags are strongly defined and their purpose is to describe user interface. Custom tags are unique and they are not in collision of any kind with standard HTML tags. Client side consists of AAC platform client application which is thin client capable of establishing connection with AAC platform server and interpreting receiving tags (both HTML and custom tags). By interpreting custom tags client application provides visually identical and recognizable user interface. Client application must be implemented for each platform and each operating system but only once. Once developed client application is able to interpret every user interface module (e.g. button, text field etc.) so adding new functionality does not require new client application.

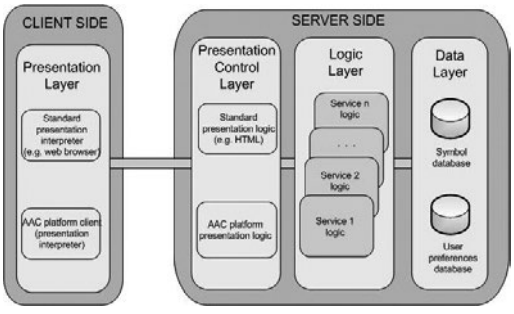

Figure 5. Hybrid architecture for symbol based platform (Car et al., 2011)

By using hybrid architecture it is possible to develop and deploy new AAC services only on server side regardless technology and to reuse already developed components.

If user accesses platform web application through standard web browser (from any device) HTML page and service will be displayed in standard web browser. But if user has installed on his device specific AAC platform client application, he/she will be able to use full potential of service.

3.4. USER–CENTERED APPROACH FOR DESIGN OF THE SYMBOL SYSTEM AND GRAPHICAL USER INTERFACE

The idea from the graphics design viewpoint is to develop a system of symbols as a part of the platform. This database of symbols can later be used by developers for implementation in various AAC applications based on the platform.

The design process is user-centered and it features a series of User Experience (UX) and other research methods, so users and their assistants will be included from the beginning and give feedback through the whole process (Figure 6). The first step is to collect data about users and their habits in using existing AAC systems through questionnaire, interview and focus group methods. After all necessary data is gathered and processed; several persona profiles will be created to aid the designers in planning and development of both symbol communication system and GUI. Several different symbol prototypes will be developed, varying in complexity, style and iconicity. Some prototype symbols, which present complex concepts and ideas, will also use simple animations. Prototypes will then be tested and evaluated on users using iconicity and transparency tests, interviews and questionnaires, various user observation methods and eye-tracking. Using the evaluation results, best prototype will be selected and further developed into symbol communication system. The goal is to develop symbols that can be used by users with different types of disabilities, and therefore can adapt to specific user needs or technical

specifications of the platform. Each symbol will feature adjustable properties such as color and contrast adjustments for visually impaired users, size adjustment for users with motoric and visual disabilities, and animation speed adjustment for symbols that feature it. It will also be possible to turn off the animation without losing basic symbol functionality. These adjustable properties can also be employed to adapt symbols for display on different screen types, such as mobile phone or e-ink screens. They will also be adjusted for various printed materials. Majority of the symbols will be highly iconic, with visual consistency and optimal complexity. They will be developed with the Croatian users in mind, and will therefore be adapted to their cultural and linguistic specificities.

After the development of the symbol system, the graphic design team, in collaboration with programmers and users, will design the remaining parts of Graphical User Interface (GUI) and adopt it for presentation on different devices. The process will start with card sorting tests on users which will aid development of the GUI prototype. During the development, the team will use heuristic evaluation and task analysis. After the prototype is completed, it will be tested and evaluated by users using eye tracking, user observation, task scenario testing and response time measurements. The results will be used to adopt the GUI design, and develop its final version.

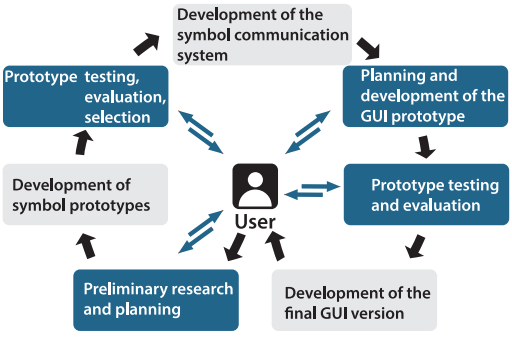

Figure 6. Model of GUI design process

3.5 THE DESIGN OF THE ADAPTIVE SYMBOL SYSTEM

The graphic symbol design is fundamental for the usability of a communication system, especially when users are children in need of associating graphic signs with objects, people and actions from their environment more easily (*Garcia, Badre and Stasko, 1994*). In order to create emotional connections and motivate children's interaction with the system in a pleasurable way, the design of the symbols has to be aesthetically pleasing and quickly recognizable (*Zwaga and Easterby, 1978*). This adaptive symbol system is designed by Faculty of Graphic Arts' experts to be implemented in future ICT services. It will be used on modern mobile devices, laptops, desktop computers and in print media; in other words, it will be optimized for various screens and printers (*Gittins, 1986; ISO, 2007*). Some of the main advantages of this model, when compared to the other models, is visual adaptability, responsiveness, consistency and possibility of animation. It is tailored to Croatian users, but can be adapted to other nationalities as well (*Norman, 1986*). The evaluation of usability and accessibility is relatively new in the field of alternative and augmentative communication and for that reason the evaluation methods have to be adapted to persons with complex communication needs and their personalities (*Vredenburg et al., 2002*). In order to determine the principles of design, especially the complexity of the basic line construction and visual style, children with special needs ages 6 to 14 were taken as test subjects. Three different categories of symbols were created: animal, object and human face. The test subjects were asked to rank nine prototypes for each category (*Bewley et al., 1983*). Prototypes differed in terms of complexity of line construction (simple, medium complex and complex) and style (technical, realistic and cartoon). On the basis of the research results we can conclude that users prefer complex and medium complex symbol design, while in terms of style their preferences tended towards realistic visual representation. Simple symbols ranked lowest with our test subjects (Fig. 7).

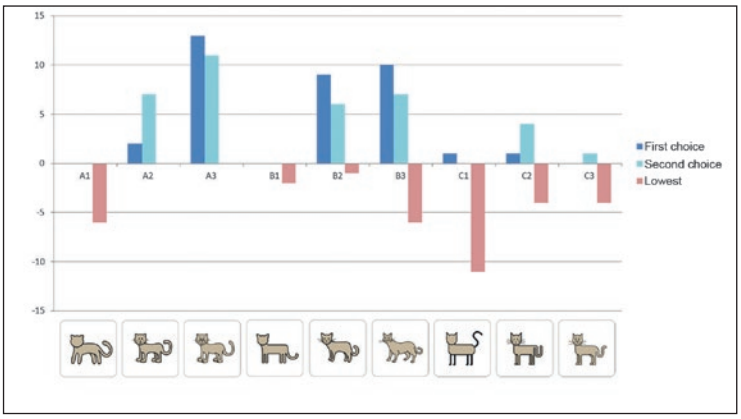

Figure 7. User's preferences in terms of symbol design

These results determine the final design principles for the basic linear construction of the symbols (Fig. 8). Afterwards, the primary pallet of colors and the typography for symbol titles will be defined.

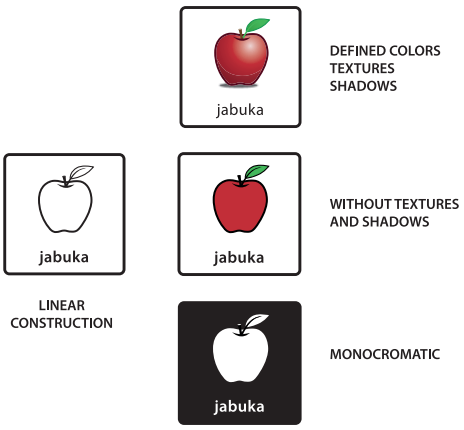

Figure 8. The Adaptive Symbol System graphics

3.6 MODEL OF ADAPTIVE SYMBOL BASED AAC APLICATION FOR MAINSTREAM MOBILE DEVICES

The proposed model is an adaptive system that will adjust the display of the symbols and user interface to the specifications of the device as well to the capabilities and preferences of the users (Fig. 9).

The system will use specially developed symbols which will enable change in size without significant quality loss. Each symbol will have three different visual variations – utilizing full 16 million color palette, utilizing limited color palette and black-and-white variation. Each variation will be able to feature animation of the graphical objects. User would be able to use symbols from an online repository or store them for local use.

Upon first use of the system, user, or his assistant, would set his preferences about symbol type, size, GUI layout and use of colors and animation. System would then upload the preferences to an online database.

Upon installation on a new device, the program will automatically set minimum symbol size based on the screen resolution, maximum number of displayed symbols based on the screen size and minimum symbol size, color reproduction based on the screen's color space specifications and possibility of animation based on the screen refresh rate and device's processing power. These settings will then be combined with user preferences to create the final display of the symbol based AAC application on the device. Users preferences cannot exceed boundaries that the program determined based on the system specifications.

When the application is used with another device, it will automatically optimize its display to suit the screen specifications and user preferences. This will enable users with multiple mobile devices to use same AAC solution on every device without having to manually set it up each time. Also, the program will work on most upcoming devices with same mobile OS, thus enabling AAC users to easily follow technological advancements.

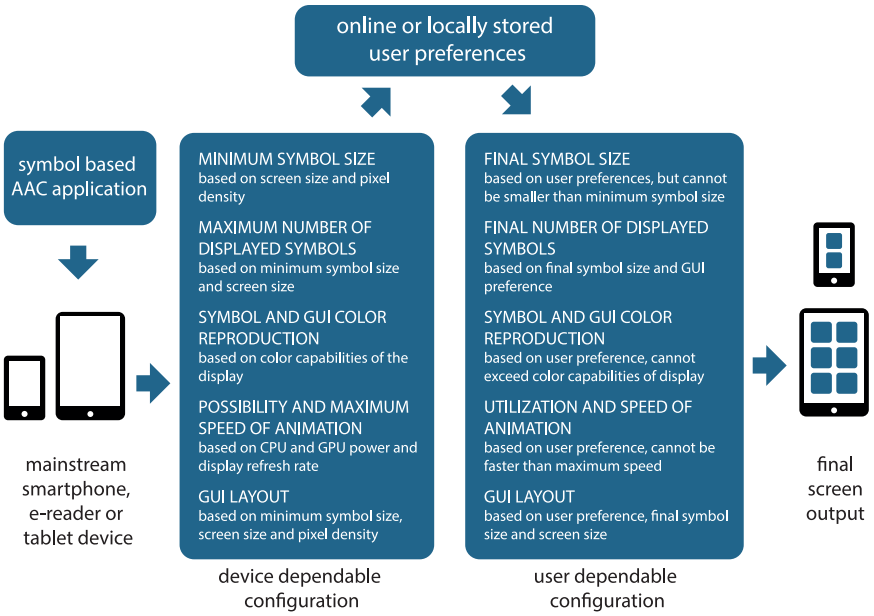

Figure 9. Model of adaptive symbol based AAC application for mainstream mobile devices

Since such system largely depends on user's preferences, requirements, possibilities and expectations of using such system with mainstream mobile devices, it is important to include the user in the design process using principles of User Centered Design (UCD). The importance of user feedback is often overlooked when designing such services, despite their requests that they need to participate in such projects (*Chisnell and Rubin, 2006*).

For this system to work, it is important that the specifications of mobile devices used meet some minimal requirements. Since they should offer similar level of functionality compared to dedicated mobile devices, they should have similar range of screen sizes, and similar or better hardware specifications. Also, since this is an adaptable system, it is important that the mobile operating system used works on several different devices and that it allows access to different hardware components. All this requires a more detailed insight into technical capabilities of dedicated and mainstream mobile devices.

4. Conclusion

The paper presents the system of symbol based services for persons with complex communication needs. The symbol based communication services is developed in order to support mobile AAC users working on different devices and technology platforms. From the development point of view, the platform is based on the component model and reuse of well tested components. Full platform utilization potential is strongly connected with the symbol system creation and graphical user design process. Some of the main advantages of this model, when compared to the other models, is its visual adaptability, responsiveness, consistency and possibility of animation. It is tailored to Croatian users, but can be adapted to other nationalities as well. Once implemented, the platform and related symbol system and user interfaces will have added value in term of improved accessibility and usability.

References

BEWLEY, W.L., ROBERTS, T.L., SCHROIT, D. AND VERPLANK, W.L., 1983. Human factors testing in the design of Xerox's 8010 'Star' office workstation. Proceedings of the ACM CHI'83 conference, Boston, MA, pp. 72–77.

BURKHART, L.J., 1993. What We Are Learning About Early Learners and Augmentative Communication and Assistive Technology. Available from: <http://www.lburkhart.com/gphb.htm> [Accessed 3/2013].

CAR, M. VUKOVIĆ, I. VUČAK, J. PIBERNIK AND J. DOLIĆ, 2011. A Platform Model for Symbol Based Communication Services. Proceedings of the 11th International Conference on Telecommunications ConTEL 2011. Graz: Graz University of Technology.

CHISNELL D. AND RUBIN J., 2006. Handbook of Usability Testing, Second Edition. How to Plan, Design, and Conduct Effective Tests. Indianapolis: Wiley Publishing, Inc.

DOLIĆ, J., PIBERNIK, J. AND BOTA, J., 2012. Evaluation of Mainstream Tablet Devices for Symbol Based AAC Communication. Lecture Notes in Computer Science 7327 - Agent and Multi-Agent Systems. Technologies and Applications 6th KES International Conference, KES-AMSTA. Heidelberg: Springer-Verlag.

EUROPEAN COMMISSION, 2010. eAccessibility – Opening up the Information Society. Available from: <http://ec.europa.eu/information_society/activities/einclusion/policy/accessibility/index_en.htm>

GARCIA, M., BADRE, A.N. AND STASKO, J.T., 1994. Development and validation of icons varying in their abstractness. Interacting with Computers, 1(2), p. 191

GITTINS, D., 1986. Icon-based Human-Computer Interaction. International Journal of Man-Machine Studies 24, pp. 519

INTERNATIONAL SOCIETY FOR ALTERNATIVE AND AUGMENTATIVE COMMUNICATION (ISAAC). Available from: <https://www.isaac-online.org/english/home/> [Accessed 3/2013].

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2007. ISO 22727:2007. Graphical symbols –

Creation and design of public information symbols – Requirements. Geneva: International Organization for Standardization

NORMAN, D.A., 1986. Cognitive Engineering. In: D.A. Norman and S.W. Draper, eds. 1986. User Centred System Design. Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 31-61.

STANČIĆ, J., FREY ŠKRINJAR J., CAR, Z., VLAHOVIĆ STETIĆ V. AND PIBERNIK, J., 2013. Systems of support for persons with complex communication needs. Accepted for 36th International Convention on Information and Communication Technology, Eletronics and Microeletronics 2013, Opatija, Croatia.

VREDENBURG, K., MAO, J., SMITH, P.W. AND CAREY, T. A., 2002. Survey of user-centered design practice. Proc. CHI 2002, CHI Letters Vol. 4, No. 1, pp. 471-478.

WILLIAMS, M.B., KREZMAN, C. AND MCNAUGHTON, D., 2008. Reach for the Stars: Five Principles for the Next 25 Years of AAC. Augmentative and Alternative Communication, 24 (3), p. 194

ZWAGA, H. AND EASTERBY, R., 1978. Developing effective symbols for public display. In R. Easterby and H. Zwaga, eds., 1978. Proceedings of a NATO Conference on Visual Presentation of Information, Het Vennebes, Netherlands, 1978. Sussex: Wiley and Sons Ltd.