PROJECTE DE FI DE CARRERA

TÍTOL DEL PFC : Messenger Visual, a pictogram-based Instant Messaging service for individuals with cognitive disability

TITULACIÓ: Enginyeria de Telecomunicació (segon cicle)

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Resum

Al llarg del temps les persones discapacitades han patit exclusió social a causa de les limitacions pròpies de la seva condició. Per exemple, les persones sordes no poden veure les notícies a la televisió a causa de la seva deficiència auditiva. Si bé aquesta situació d'exclusió social ha millorat gràcies a l'esforç realitzat per adaptar els diferents serveis —avui dia la majoria de programes de televisió incorpora subtítols o bé traducció simultània a llengua de signes—, l'arribada d'Internet, així com la resta de tecnologies de la informació i les comunicacions, suposa un nou repte de cara la inclusió de les persones discapacitades.

Tenint en compte la situació actual d'exclusió digital que pateixen les persones que pateixen algun tipus de discapacitat aquest projecte presenta el Messenger Visual, un servei de missatgeria instantània basat en pictogrames per a persones amb discapacitat cognitiva. El projecte Messenger Visual es composa de dues parts. D'una banda, el servei de missatgeria instantània que s'ha dissenyat per suportar els requeriments de la comunicació basada en pictogrames. D'altra banda, el client de missatgeria instantània que s'ha dissenyat tenint en compte els requeriments d'usabilitat de la interfície d'usuari de les persones amb discapacitat cognitiva.

Finalment el projecte també presenta la metodologia de recerca que s'ha seguit per avaluar el funcionament del Messenger Visual amb un grup d'usuaris amb discapacitat cognitiva, així com els resultats obtinguts. El procés d'avaluació s'ha dut a terme durant sis mesos amb sessions quinzenals d'una hora de duració on hi han participat dos grups d'usuaris de la Fundació El Maresme amb diferents perfils discapacitat cognitiva. Aquestes sessions han permès entendre de més a prop els requeriments d'accessibilitat de la interfície d'usuari de les persones amb discapacitat cognitiva, així com conèixer com es comuniquen mitjançant pictogrames.

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Overview

Along history disabled individuals have suffered from social exclusion due to the limitations posed by their condition. For instance, deaf people are not able to watch television programs because of their sensory limitation. Despite this situation has improved thanks to the efforts in adapting the different services —today the majority of television programs offer subtitles or simultaneous translation to sign language—, the arrival of the Internet, as well as the rest of the information and communication technologies, poses new risks to the inclusion of disabled individuals.

Taking into account the present digital exclusion situation of disabled individuals this project presents Messenger Visual, an Instant Messaging service based on pictograms for individuals with cognitive disability. Messenger Visual is composed of two different parts. On the one hand, the Instant Messaging service has been designed considering the requirements of communication based on pictograms. On the other hand, the Instant Messaging client has been designed taking into account the user interface usability requirements of individuals with cognitive disability.

Finally, the project presents the methodology that we have used to evaluate Messenger Visual with a group of individuals with cognitive disability, as well as the results we have obtained. The evaluation process has lasted for six months and one-hour fortnightly sessions have been held with two groups of individuals from Fundació El Maresme with different cognitive disability profiles. These sessions have allowed us to gain better understanding of the user interface accessibility requirements, as well as to know how individuals with cognitive disability communicate using pictograms.

"*The brick walls are there for a reason.*
The brick walls are not there to keep us out;
the brick walls are there to give us a chance
to show how badly we want something."
— The Last Lecture, **Randy Pausch**

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I would also like to thank Marc Miquel for his contribution in the evaluation of the project; his work showed me the importance of taking into account the users' early in the development phase. Apart from that, during all the time we have studied together he has proved to be a good person and a better friend.

I also appreciate the support received from people at Fundació El Maresme, specially Marc Iñiguez, Diana Font, Sandra Delgado, Núria Vilà and Esteve Buscà all along the development of the project. Furthermore, I would like to thank all the users at Fundació Maresme who have patiently endured the process of evaluating the software and have contributed with their feedback to improve it.

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To all of you and to those who I haven't explicitly mentioned but have somehow contributed that I am now writing these lines, *thank you*!

Pere Tuset Peiró
Granollers, February 10, 2011

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CHAPTER 1. INTRODUCTION

This chapter introduces the motivation behind the development of the project, the objectives that it intends to achieve and the work related to the topics that it addresses. The chapter also states the contributions that have been proposed derived from the research conducted and presents the structure of the document. The chapter is structured as follows. Section 1.1 presents the motivation that contributed to the development of the project. Section 1.2 states the objectives of the project and presents the approach adopted to develop it. Section 1.3 presents the work related to the topics of the project. Section 1.4 presents the contributions of the project. Finally, Section 1.5 outlines the structure of the document by presenting an overview of the chapters of which it is composed of.

1.1. Motivation

Almost ten percent of the world's population live with some type of disability [1]. One common aspect of people who have a disability is that they are prone to be excluded from society due to their condition. For instance, people who use a wheelchair due to their physical condition usually experience difficulties moving around cities because streets are often not properly adapted to their mobility requirements. Another example of such exclusion situation are deaf individuals, who cannot watch television programs due to their sensory condition. But despite the exclusion situation is still far from being optimal, efforts are being put to bridge this gap. Today most cities have mobility plans that enable people with limited mobility to move around without physical barriers, and television broadcasts now include textual subtitles or real-time sign language translation so that people who cannot hear are able to watch it.

But the era of information and communication technologies, which we are still beginning to embrace, poses new challenges to the social inclusion of disabled people. These new technologies, specially computing devices and the Internet, have made a revolution in the way and pace at which we access information and communicate with our relatives and acquaintances. Today it is becoming common for people to access real-time information on the Internet from a mobile telephone while commuting to work on a bus or train. And despite the shift from analogue to digital technology has eliminated some accessibility barriers [2], as information can be easily converted into text, voice or other formats thanks to the decreasing cost of technology, the risk of exclusion from the digital society is still a critical issue for disabled people.

The condition of disabled individuals adds accessibility requirements to devices and software that enable access to the information society that are not met by today mass consumption technologies [3]. For instance, individuals who have suffered a CerebroVascular Accident (CVA) have trouble interacting with computers through its main input devices, namely the keyboard and the mouse. The design of these devices does not take into account the requirements of individuals with reduced mobility. Another example are individuals with cognitive disability who have trouble using modern operating systems and mainstream software, such as Microsoft Windows and Microsoft Office. The design of

the user interface of actual software is based on abstract concepts and metaphors, like *windows* and *icons*, that are difficult to understand for these group of individuals.

Nevertheless, it is widely recognized that with appropriate adaptation of its input devices and software, disabled individuals can largely benefit from accessing the information society [4]. Being able to access real-time information and communicating with relatives and acquaintances not only reduces the risk of suffering social exclusion, but it also increases the autonomy of disabled individuals. The problem, though, is that adapting such devices and software to the requirements of disabled individuals has high economic costs involved and low revenue rates, so consume market manufacturers and developers are not very interested. Therefore, projects funded by public organizations that take into account the special requirements of disabled individuals to access the information society need to be developed to reduce their risk of suffering from digital exclusion.

1.2. Objectives

The idea to build an Instant Messaging service to enable individuals with cognitive disability communicate using a pictographic system emerged almost two years ago at *Fundació El Maresme pro persones amb disminució psíquica* [5], a non-profit institution from Mataró that promotes the social integration of people with cognitive disability and their families through the process of learning and working. Pedagogues and social educators at *Fundació El Maresme*, who teach students with cognitive disability a pictographic system with the aid of computer software named Boardmaker [6] as a part of their educational curriculum, came with the idea to build a software that would enable their students to communicate using a computer by means of exchanging pictograms.

Considering the idea that emerged at *Fundació El Maresme* this project aims to design, implement and evaluate Messenger Visual, an Instant Messaging service based on pictograms that enables users with cognitive disability to communicate with their family and acquaintances over the Internet using a computer. Thus, the project has three ultimate objectives:

- **Social**: Approach information and communication technologies to individuals with cognitive disability to reduce the risk of becoming excluded from the digital society.
- **Technical**: Develop an Instant Messaging service that uses pictograms as the main communication system and provides a user interface adapted to individuals with cognitive disability.
- **Scientific**: Understand how individuals with cognitive disability use the Instant Messaging service to communicate with their relatives and acquaintances using pictograms.

In order to accomplish this objectives we have set the following tasks:

- Familiarize with the main cognitive disabilities and the impairments that pose onto the individuals.

- Understand how individuals with cognitive disability communicate using a pictographic system.
- Understand how individuals with cognitive disability use information and communication technologies.
- Understand how Instant Messaging services are designed to support real-time communications.
- Develop an Instant Messaging service that supports a pictographic system as the main communication system.
- Develop an Instant Messaging client that considers the user interface requirements of individuals with cognitive disability.
- Evaluate how individuals with cognitive disability interact with the Instant Messaging client user interface.
- Evaluate how individuals with cognitive disability communicate using the pictogram-based Instant Messaging service.

Taking into account the objectives and the tasks described above, the following approach will be used to develop the project:

- Literature survey to become familiar with the main topics of the project, including Cognitive Disability (CD), Augmentative and Alternative Communication (AAC), Instant Messaging (IM) services and Human-Computer Interaction (HCI).
- Analysis of requirements to design an IM service that supports pictographic systems as the main communication system.
- Analysis of requirements to design an IM client that supports the user interface requirements of individuals with cognitive disability.
- Technological review to choose the most suitable technologies to implement both the IM service and the IM client.
- Development of both an IM service and an IM client taking into account the requirements of individuals with cognitive disability.
- Evaluate how individuals with cognitive disability interact with the IM client user interface and communicate using pictograms.

1.3. Related work

As stated in the Motivation section, the special requirements to access information and communication technologies of disabled individuals are not met by today consume market devices and applications. And due to the high economic costs involved in the process and

the low revenue rates derived from a sparse market, manufacturing and developing companies are not interested in adapting their devices and applications. This situation makes disabled individuals vulnerable to becoming excluded from the digital society, which in turn reduces the independence of the individual and causes social isolation. In order to overcome this situation some research projects funded by public organizations and developed by universities and research institutions around the world are making significant progress in approaching information and communication technologies to disabled people.

One of the first projects to consider the inclusion of disabled individuals to the new information and communication technologies is the World Wide Augmentative and Alternative Communication (WWAAC) project [7], funded by the European Union Information Society Technologies (IST) Initiative in the 2001–2004 period. The WWAAC project developed guidelines that designers and engineers can apply to make information and communication technologies more accessible to individuals with communication impairments. Within the project researchers also designed, implemented and evaluated a web browser prototype that takes into account the accessibility requirements of disabled individuals. The web browser enables users to connect their Assistive Technology (AT) devices to interact with the browser user interface and textual information is replaced with a pictographic AAC system whenever possible to easy accessing the information.

Another great example of how adapting information and communication technologies to disabled individuals can enhance their autonomy is the work developed by Gregor *et al.* [8] in 2006. In their research they developed three different applications adapted to individuals with different accessibility requirements to new information and communication technologies. On the one hand, SeeWord is a reading and writing aid designed for individuals with dyslexia that supports for personalization of the user interface to each individual requirements. On the other hand, they developed a web browser and an electronic mail client for elder people that uses an over-simplified user interface that lacks of implicit metaphors thus facilitating the process of accessing information in the Internet and communicating with relatives and acquaintances.

Last but not least, one prime example of how adapting information and communication technologies can approach disabled individuals to the digital society, thus helping to reduce social isolation, is the project developed by Rouien Zarin [9] for the Institute of Design in Umea, Sweeden, and the Sweedish Institute for Special Needs Education. Mejla Pictogram 2.0 is an electronic mail client that uses a pictographic system as a replace to written language to enable electronic communications for individuals with cognitive disability. The email client is designed using a participatory design technique to identify the accessibility requirements of the target group and is based on a "*whatever works*" policy regarding the use of the pictographic system in order to maximize the number of potential users that can benefit from the software.

1.4. Contributions

Considering the novelty of a pictogram-based IM service for individuals with cognitive disability, during the development of Messenger Visual we have prepared and submitted three contributions to international conferences and workshops related to the topics of

the project. These contributions are listed next in descending order of publication and are included in the appendices at the end of the document.

1. Pere Tuset. *Modeling individuals with written language related cognitive disabilities to personalize a pictogram-based Instant Messaging service*. In UMAP '11: Proceedings of the 19th International Conference on User Modelling, Personalization and Adaptation. Girona, Spain, July 2011.

2. Pere Tuset, Juan Miguel López, Pere Barberán, Léonard Janer, Cristina Cervelló-Pastor. *Developing Messenger Visual, a pictogram-based IM service for individuals with cognitive disability*. In IWAAL '11: Proceedings of the 3rd International Workshop on Ambient Assisted Living. Málaga, Spain, June 2011.

3. Pere Tuset, Pere Barberán, Léonard Janer, Sandra Delgado, Esteve Buscà, Núria Vilà. *Messenger Visual: a pictogram-based IM service to improve communications among disabled people*. In NordiCHI'10: Proceedings of the 6th Nordic Conference on Human-Computer Interaction, pp. 797–800. Reykjavik, Iceland, October 2010.

1.5. Structure

The structure of this document reflects the order that has been taken to approach the different topics related to the design, implementation and evaluation of Messenger Visual, a pictogram-based IM service for individuals with cognitive disability. The document is structured as follows:

- *Chapter 2* gives the reader a background on the main topics that are discussed along the project, including CD, AAC, IM services and HCI.

- *Chapter 3* presents the design of Messenger Visual, an IM service that uses a pictographic system to enable communications and an IM client that takes into account the user interface accessibility requirements of individuals with cognitive disability.

- *Chapter 4* presents the research methodology and the results obtained from evaluating Messenger Visual with two groups of individuals with cognitive disability from Fundació El Maresme.

- Finally, *Chapter 5* presents the conclusions outlined from the development of the project and identifies the work that remains to be done in the future.

CHAPTER 2. BACKGROUND

This chapter reports on the conducted literature review about the main topics related to the project. The chapter is organized as follows. Section 2.1 introduces Cognitive Disability (CD) and the main causes that have an effect on the cognition capabilities of individuals. Section 2.2 presents Augmentative and Alternative Communications and the main pictographic systems that are available today for individuals with Cognitive Disability. Section 2.3 describes Instant Messaging services including the main proprietary and standard Instant Messaging protocols that are used nowadays. Finally, Section 2.4 introduces Human-Computer Interaction and the main research methodologies that are used to develop and evaluate projects taking into account the requirements of target users.

2.1. Cognitive Disability

A disability is defined as an impairment or lack in any of the common human abilities that makes carrying out daily activities more difficult or even impossible. Depending on the ability of the individual that is affected disabilities are classified into physical, sensory, cognitive, emotional or developmental. Physical disabilities include any impairment that limits the motor capabilities of the individual. Sensory disabilities affect the individual capabilities to perceive the outside world. Cognitive disabilities are those that limit the ability to develop tasks that depend on basic mental processes. Emotional disabilities are those that affect the psychological pattern of the individual. Finally, developmental disabilities refer to an alteration in the normal development process of an individual.

Depending on its cause disabilities can be classified into hereditary, acquired or natural. On the one hand, hereditary disabilities are those caused by a genetic or chromosomal disorder acquired through the genetic material of the progenitors or due to a mutation. For example, the decreased ability to perceive color differences is mostly often of a genetic nature. On the other hand, acquired disabilities are those developed by events that occur during the lifetime of an individual. For instance, a car accident can render an individual in a wheelchair as the result of a spinal cord injury. Last but not least, natural disabilities are those that are developed as a part of the ageing process. For instance, as individuals grow old they become prone to developing degenerative diseases like Parkinson's disease.

Cognitive disability is a generic term that describes individuals who have substantial limitations in developing tasks that depend on basic mental processes such as attention, memory and language. Due to their condition individuals with cognitive disability have problems to develop tasks that require from understanding abstract concepts or making generalizations between contexts. Due to their condition, individuals with cognitive disability also have problems to develop tasks that require from social interaction. In the end, these limitations can dramatically reduce the self-confidence and autonomy level of individuals with cognitive disability.

As with the other types of disabilities, cognitive disability can be hereditary, acquired or developed due to natural factors. Also, depending on the limitations that pose onto the

individual, cognitive impairments are further classified into mild, moderate, severe and profound [10]. Today there are many diseases that cause cognitive disability, but each has its own causes and poses different limitations to the individual. The most typical causes of cognitive disability are Acquired Brain Injury (ABI), Alzheimer's Disease (AD), Autism Spectrum Disorder (ASD) and Down Syndrome (DS). These diseases and the effects that pose on the cognitive abilities of the individual are briefly described in the next subsections.

2.1.1. Acquired Brain Injury

ABI (Acquired Brain Injury) is a brain damage either caused by a traumatic injury, for instance a car accident, or a non-traumatic injury, for instance a CerebroVascular Accident (CVA). Even though ABI does not directly affect intellectual capabilities, it usually poses physical, sensory and cognitive limitations to the individual. On the one hand physical limitations affect motor capabilities, including difficulties to control and coordinate actions. On the other hand sensory limitation may include visual and audition deficits which difficult interaction with the external world. Finally, cognitive limitations include attention, memory and language impairments that difficult the individual's ability to express their thoughts. In the end, such physical, sensory and cognitive impairments restrict the self-care and social functioning which ultimately has a negative impact on the individual behaviour.

2.1.2. Alzheimer's Disease

AD (Alzheimer's Disease) is a neuro-degenerative disease that causes dementia to individuals. AD was fist described by Alos Alzheimer, a German psychiatrist and neuropathologist, in 1906. The initial symptoms of AD are difficulties in recalling recent observed facts due to the impossibility of the brain to acquire new memories. As the disease advances, additional effects to the brain become relevant including language breakdown and long-term memory loss which, in the end, renders the individual completely dependent on a caregiver. The causes of AD are not yet well understood and today there is no known cure to the disease. The epidemiology of AD is around three in one thousand and the rate doubles each five years. Once individuals are diagnosed with AD the mean life expectancy is around seven years, though a low number of individuals have lived up to fourteen years after the diagnostic.

2.1.3. Autism Spectrum Disorder

ASD (Autism Spectrum Disorder) is a generic term that refers to individuals that have qualitative social interaction and communication disorders, accompanied with restricted interests and a repetitive behaviour. There are three main forms of ASD classified today: Autism, Asperger syndrome and Rett syndrome. In general individuals with ASD process sensory information including sound, touch and vision differently to normally developing children. This condition makes it difficult for individuals with ASD to interact and communicate with the external world, for instance maintaining social relations. Recent statistics

reveal that the affectation of ASD is close to eight per one thousand births. Nevertheless, with proper education programs and behavioural therapy at early life stages, individuals with ASD can acquire self-care and social skills to become fully integrated in society.

2.1.4. Down Syndrome

DS (Down Syndrome) is a genetic condition named after John Langdon Down, the British physician who first described the syndrome back in 1866. DS is caused by the presence of an extra copy of the twenty-first chromosome, which causes physical alterations and cognitive impairments to the individual. Physical alterations of individuals with DS include a characteristic round face and poor muscular tone, whereas cognitive impairments include a lower than average Intelligence Quotient (IQ). Individuals with DS also have additional health concerns such as a higher risk of congenital heart defect and thyroid dysfunctions, which in the end imply a shorter life expectancy. Today the incidence of DS is around one per seven-hundred births. Nevertheless it is widely recognized that with proper family support and education individuals with DS can become fully integrated in society.

2.2. Augmentative and Alternative Communication

Communication is the basis of human relations as it allows individuals to exchange information and convey feelings. Human communications are based on symbolic representation that allows expressing both concrete and abstract concepts, as well as situating these concepts temporally and spatially. In order to convey full significance to the message humans communicate using verbal and non verbal messages. Verbal and non verbal communication can be further classified into vocal and non vocal, depending on the medium that is used to transmit the message. On the one hand verbal vocal communications are speech, whereas verbal non-vocal communications is written language. On the other hand, non-verbal vocal communications can be variations in the volume or tone, whereas non-verbal non-vocal communications is usually referred as body language.

For regular individuals that share the same language the most common way of communication is speech combined with non-verbal clues, either vocal or non vocal, that help adding significance to the message that is to be transmitted. For instance, when two individuals that know each other meet they will usually say "*Hello*" and wave their hands to welcome each other and smile as a means of expressing happiness for the fortunate encounter. Written language is also commonly used to communicate, but only when the individuals that are communicating are separated either temporally or spatially. For instance, one individual can write a letter to a relative that lives in another place in order to communicate or another individual can write a book that contains a history so that other people that will read the book can access the history.

But to those individuals that have some disability, either physical, sensory or cognitive, speech or written language are not always suitable to communicate. For instance deaf individuals cannot use oral language because they are not able to hear, whereas blind individuals cannot use written language because they are not able to see. Thus, considering

the importance of communications in human relations, alternative mechanisms to enable disabled individuals communicate have been proposed along history. These alternative communication mechanisms for individuals with some disability are commonly referred as Augmentative and Alternative Communication (AAC). Augmentative and Alternative Communication (AAC) is a set of methodologies to complement or replace written or spoken communications for those individuals that have such abilities impaired, either temporarily or permanently, due to injury or illness [11].

AAC are usually referred as aided verbal communications which means that, either vocal or non vocal, it provides with a set of mechanisms that allows disabled individuals communicate, thus enabling them to participate in their social roles and activities, including interpersonal interaction, learning, education and many others. The most widely-known AAC system is Braille for blind individuals. Braille replaces traditional orthographic written language, for instance letters, numbers and punctuation marks, with small raised dots on the paper that represent the same symbols so that blind individuals can read by means of touching the paper. Another widely-known AAC system is sign language for individuals that have a hearing impairment. Sign language replaces speech with visual patterns generated with the movement of hands, arms or body, as well as facial expressions, so that deaf individuals can communicate.

But for individuals with cognitive disability neither Braille or sign language are suitable because their limitation is the ability to understand orthographic representations. One AAC specially suited to individuals with cognitive disability are pictographic systems. Pictographic systems are built upon drawings or images that represent real objects or abstract concepts to enable individuals communicate. Communication using a pictographic systems usually consists of individuals selecting pictograms from a set of possibilities with the aid device which can either be low or high technology, for instance a cardboard or a computer. Today there are many different pictographic systems, which are classified according to their transparency level; the level of resemblance between the pictograms and the objects or concepts they represent. The most common pictographic systems are described in the following subsections.

2.2.1. Blissymbols

Blissymbols is a pictographic system created by Charles K. Bliss back in 1949 and later revised in 1965. The main goal behind Blissymbols is to have a simple pictographic system that can be used to communicate in cross-cultural environments. To achieve this purpose Blissymbols are inspired in ideograms from the Chinese writing. Thus, Blissymbols contains around one hundred abstract symbols, including lines, arrows, geometric forms and numbers, that are combined together to form pictograms with full meaning. Blissymbols are then combined together using its own syntax to form sentences. But due to its ideographic nature Blissymbols are the least transparent of the presented pictographic systems, though are more transparent than traditional orthographic symbols.

Figure 2.1: An example of the Blissymbols pictographic system. The sentence represented by the pictograms literally translates as *"I want to go to the cinema."*.

2.2.2. PicSyms

Picture Symbols (PicSyms) is a pictographic system developed by Faith Carlson back in 1986. The PicSyms Categorical Dictionary contains approximately eight-hundred and fifty pictograms that are grouped by semantic categories. The main characteristic of PicSyms is that pictograms are hand-drawn and that drawing details, such as realism and trace, depend on the abstraction level of the concept being represented. Though PicSyms were originally developed for young and adults that could not communicate using speech, studies and practice has shown that they can also be successfully applied to individuals with cognitive disability thanks to its good transparency level.

Figure 2.2: An example of the PicSyms pictographic system. The pictograms depicted correspond to *Mother*, *Cat*, *Rain*, *Come* and *Confused*, respectively.

2.2.3. Picture Communication Symbols (PCS)

Picture Communication Symbols (PCS) is a pictographic system created by Roxana Mayer-Johnson back in 1981. The core PCS library is formed by approximately five thousand full-colour and black-and-white pictograms, which are accompanied with the orthographic representation of the image in different languages. PCS pictograms come classified into eight categories: Social, People, Verbs, Descriptive, Foods, Leisure, Nous and Miscellaneous. Today, PCS is one of the most used pictographic systems in the world thanks to its high transparency level and a software named after Boardmaker [6] that enables users to create pictogram-based messages using a computer.

2.2.4. Aragonese Portal of Augmentative and Alternative Communications (ARASAAC)

Aragonese Portal of Augmentative and Alternative Communications (ARASAAC) [12] is a pictographic system developed in 2008 by Centro Aragones de Tecnologias para la Educación (CATEDU), a non-profit organization that develops educational materials for people

Figure 2.3: An example of the PCS (Picture Communication System) pictographic system. The pictograms depicted correspond to *Clown*, *Hungry*, *Rain* and *Sun*, respectively.

that have special communication requirements. Today the ARASAAC pictographic system is formed by more than twenty thousand full-colour and black-and-white pictograms, which are classified into forty-one categories. According to their transparency level ARASAAC pictograms are very similar to PCS pictograms, though they are not accompanied with the orthographic representation of the image and are distributed under a Creative Commons BY-NC-SA license [13].

Figure 2.4: An example of the ARASAAC pictographic system. The pictograms depicted correspond to *Camping*, *Cold cuts*, *Sunny* and *Flu*, respectively.

2.3. Instant Messaging services

Instant Messaging (IM) services are designed to enable users communicate over a public data network, usually the Internet, by means of exchanging real-time text messages. To enable communications with relatives and acquaintances IM services allow users to maintain a contact list and to exchange presence messages to know when contacts become available. Regarding communication, IM services support both one-to-one and multi-party messaging. One-to-one chats enable two users to exchange text messages privately, whereas in multi-party messaging two or more participants join a virtual room to communicate. Nevertheless, IM services have evolved and now offer features other than text-based communication, such as audio- and video-conference, file transfers and shared desktop, among others.

Today IM services derive from the Internet Relay Chat (IRC), which is a real-time synchronous conferencing service on the Internet based on textual messages. IRC was developed in Finland in 1988 by Jarkko Oikarinen as a replace for an old chat program for UNIX operating systems called MultiUser Talk (MUT). The IRC was mainly designed to support group communications in discussion rooms called *channels*, though it also supported individual communications by means of using private messages. IRC was originally defined in Request for Comments (RFC) 1459, which was later replaced by its subsequent revisions RFC 2810, RFC 2811, RFC 2812 and RFC 2813. Today, IRC remains in use though it has been largely replaced by IM services.

In general IM services use a client-server architecture to operate. On the one hand, IM service providers host a series of servers dedicated to providing the basic features of IM, such as user authentication and message routing. Two approaches exist regarding the server architecture: symmetric and asymmetric. In the symmetric approach all the servers perform the same functions, whereas in the asymmetric approach each server is dedicated to a particular task. On the other hand, IM clients provide a graphical interface that enables users to login to the service, manage the contact list and communicate with other users. In order to communicate both servers and the clients share an IM protocol that defines how to exchange messages.

Today most IM services are run by Internet-based companies, such as America OnLine (AOL), Yahoo and Microsoft. The protocols that support such IM services, as well as the clients and servers that enable users communicate, are proprietary and their specifications are not publicly available. For instance, the IM service provided by AOL is based on the Open Service for Communication in Real-time (OSCAR) protocol whereas the IM service provided by Microsoft is based on the Microsoft Notification Protocol (MSNP) protocol. To provide for an open alternative the Internet Engineering Task Force (IETF) had two groups dedicated to Internet-based IM services, obtaining a general model [14] that was later adopted by two IM protocols, namely SIP Extension for Instant Messaging and Presence Leveraging (SIMPLE) and eXtensible Messaging and Presence Protocol (XMPP). These IM protocols are described in the following subsections.

2.3.1. Microsoft Notification Protocol (MSNP)

MSNP, also known as Mobile Status Notification Protocol, is an IM protocol developed in 1999 by Microsoft to support the .NET Messenger Service. Since its first version, named after MSNPv1, the protocol has undergone several modifications to add new features and the current version of the protocol is MSNPv19. As usual with Microsoft products, the official specification of the protocol remains proprietary and closed, so that only official IM clients provided by Microsoft can connect to the service. Nevertheless, some unofficial implementations of the protocol have been reverse engineering, thus enabling third-party IM clients connect to the .NET Messenger Service.

The MSNP protocol consists of a set of commands that are exchanged between the IM client and server over a TCP/IP connection. To transport the commands MSNP uses the HyperText Transfer Protocol (HTTP) protocol combined with an eXtensible Markup Language (XML) syntax. In order to support the basic IM features the MSNP architecture is based on two entities: the Notification Server (NS) and the SwtichBoard (SB). On the one hand, the NS is responsible of handling the authentication of clients and the exchange of presence information between users and contacts. On the other hand, the SB is in charge of routing messages between clients and supporting additional services such as file transfer, shared blackboard and video-conference.

2.3.2. Open Service for Communication in Real-time (OSCAR)

OSCAR is an IM protocol developed by AOL in 1997 to support their IM services named after ICQ[1] and AOL Instant Messenger (AIM). Similarly to MSNP, the official specifications of the OSCAR protocol remain proprietary and closed to try to keep third-party companies to implement compatible clients. Only Apple and Google have contracts that allow them to use OSCAR in their IM clients, namely iChat and Google Talk. Nevertheless, as happens with MSNP, several parts of the protocol have been reverse-engineered by the community and unofficial clients that can connect to ICQ and AIM exist.

To support for the basic IM features OSCAR relies on three protocols, namely Frame Layer Protocol (FLAP), Simple Network Atomic Communication (SNAC) and Type, Length, Value (TLV). On the one hand, FLAP is a binary protocol that relies on TCP/IP to support the low-level communication features of the IM service. On the other hand, SNAC is the basic communication unit between IM clients and servers. Finally, TLV is the protocol used to transmit textual data in an organized format. In order for IM clients to communicate OSCAR defines a two entities: Basic OSCAR Service Server (BOSS) and Buddy Art (BART). BOSS is the server that supports the basic IM features, whereas BART is server that provides access to download resources.

2.3.3. Session Initiation Protocol (SIP) Extensions for Instant Messaging and Presence Leverageing (SIMPLE)

SIMPLE is a set of extensions to the Session Initiation Protocol (SIP) protocol to enable support for the basic features of IM services, such as presence notifications and exchange of text messages. SIMPLE is an open standard proposed by the IETF in 2002 and is currently specified in RFC 3428 [15]. On its behalf, SIP is an open standard proposed by the IETF in RFC 3261 [16] back in 2002 as a text-based control-plane protocol to support for establishing multimedia sessions, such as audio- and video-conferences, over the Internet. To support for session description SIP is based on Session Description Protocol (SDP), which is defined in RFC 2327 [17].

The support for presence notification in SIMPLE is split into three specifications. First, the *Core Protocol Machinery* defines the extensions to support for subscriptions, notifications and publications between User Agent (UA)s. Second, the *Presence Documents* defines the procedures and formats to encode presence information into XML documents that are later transported using SIP messages. Third, the *Privacy, Policy and Provisioning*, defined in RFC 4825 [18], establishes a framework to enforce policies that ensure that presence information is only accessed by those UAs that have been authorized.

Regarding message exchange, SIMPLE defines two operational modes: the page mode and the session mode. In the page mode, defined in RFC 3428 [15], the message exchange is done through the SIP method *MESSAGE* without maintaining a session between both UAs. In the session mode, instead, a negotiation between both UAs is carried out to establish an IM session using SDP signalling. Once the session is established IM

[1] ICQ is an homophone for "*I seek you*".

messages between both UAs are exchanged using SIP messages with the Message Session Relay Protocol (MSRP) protocol, which is defined in RFCs 4975 and 4976 [19, 20].

2.3.4. eXtensible Messaging and Presence Protocol (XMPP)

Similarly to SIMPLE, XMPP is a protocol to support for the basic features of IM services, such as presence notifications and exchange of text messages. XMPP is an open standard proposed by the IETF back in 2002 and is currently defined in RFCs 3920, 3921, 3922 and 3923 [21, 22, 23, 24]. XMPP derives from Jabber, an IM protocol originally defined by Peter Saint-Andre [25] with the support of the open-source community as a free alternative to existing proprietary IM protocols, such as MSNP or OSCAR. Today XMPP is used in various IM services such as Google Talk and Facebook.

IM services based on the XMPP protocol rely on a decentralized client-server architecture, though it is technically possible to use completely decentralized architecture by means of using Peer to Peer (P2P) technologies. Similarly to the electronic mail architecture, in a decentralized IM client-server architecture each client connects to a server that is responsible of handling the basic IM features, such as presence notifications and exchange of text messages. To enable clients exchange presence notifications and text messages with clients connected to a different server, each server adds messages routing features to ensure that messages are delivered.

To support for presence notification and message exchange XMPP is based on XML streams. Each stream acts as a container of one or more XML elements or *stanzas* between two entities of the IM network. The protocol defines three core *stanza* types: *Message*, *Presence* and *IQ* (Info/Query). First, the Message *stanza* is used as a push mechanism to transmit information from one entity to another, similarly to mail communications. Second, the Presence *stanza* acts like a broadcast publish-subscribe mechanisms that allows multiple entities to receive presence information from a given entity to which they have subscribed. Finally, the IQ *stanza* lets different entities make requests and retrieve responses.

2.4. Human-Computer Interaction

Human-Computer Interaction (HCI) [26] is an interdisciplinary research field that lays within many other scientific disciplines such as computer science, engineering, sociology, psychology and communication, among others. The discipline was officially established in 1982 when the first conference on Human Factors in Computing Systems was held in the United States, though some authors had already worked in projects that encompassed the main topics of HCI. In general terms, HCI seeks to understand how humans, either a single individual or a group, interact with computing devices, ranging from a desktop computer to a mobile phone, in order to be able to develop computing systems that are better suited to the task and the context that they are designed to.

Though the HCI is young compared to other established research disciplines, its importance is gaining relevance as computing devices have become ubiquitous in our society and play a critical role in different environments. For instance, computers are used to supply the medicine dosage to patients in a hospital because they can perform such a repetitive tasks very precisely, both in time and quantity. Nevertheless computers need to be programmed in order to perform the task, which may lead to fatal consequences if any error occurs during the process. But, traditionally, computers are traditionally designed by scientists and engineers who are usually not aware of the task and context requirements for which the computer needs to be designed for.

In order to provide with a consistent knowledge of how humans interact with computing devices HCI researchers use the systematic observation, measurement and experiment techniques established by the scientific method back in the seventeenth century. Two different approaches exist depending on the type of data that is used to describe the phenomena and its relationships: qualitative and quantitative research methods [27]. On the one hand, quantitative research methods are based on gathering and processing numerical data by means of using mathematical techniques. On the other hand, qualitative research methods are based on gathering and processing non-numeric data, for instance by means of exploring interviews transcripts.

Today there are different renowned quantitative and qualitative research methods [28] that enable HCI researchers to understand how humans interact with computing devices depending on the task and context in which are used. For instance, quantitative research methods include surveys and statistical analysis, whereas qualitative research methods include case studies, action research and ethnography, among others. Although there are many different research methodologies in HCI, in the next subsections we briefly present those that have been used during the development of the project, namely Ethnography, Participatory Design, Questionnaires and, finally, Statistical Analysis.

2.4.1. Ethnography

In HCI ethnography is a qualitative research methodology that intends to involve engineers with the real users, tasks and context before the development of the actual computing system and software begins. This approach is specially interesting for computer system and software designers as most of them is not familiar with the specific users, context and tasks that the computing system and software has to be developed for. By means of using ethnography designers can understand how users interact with the computing system or software in a real context, thus becoming aware of how to build a computing system or software that is better suited to perform the task it is designed for.

One example of using ethnography to get an understanding of the users, tasks and context is the design of the onboard computing system and software of a modern airplane. Most computer engineers are not aware of how to fly an airplane, not to mention the emergencies that may occur during a flight. By means of using ethnography engineers get to understand how pilots interact with the onboard computing systems and software during a flight, thus making it possible to make a design that better suits the requirements of the users, the tasks and the context.

2.4.2. Participatory Design

In HCI participatory design or User Centred Design (UCD) [29] is a qualitative research method that aims to include the users in the design process. The aim of this approach is to overcome the difficulties that designers have to face when designing computing systems or software for a particular group of individuals, as the requirements and preferences of the target collective are often not obvious. To compensate for their lack of knowledge, designers openly invite users to participate actively during the design process. With this approach end users can give their opinion early in the design process to ensure that the system or software will meet their preferences and requirements.

One example of using participatory design to include users in the process of designing computing systems and software is Citilab, a centre for digital and social innovation located in Cornellà de Llobregat, Barcelona. At Citilab users from all the ages are encouraged to actively participate in workshops aimed to develop products and services related to the information and communication technologies. With this approach researchers are able to interact directly with the end user to take into account their requirements and preferences early in the design process.

2.4.3. Questionnaire

In HCI questionnaires are a qualitative research method that intends to collect information about how users of a computing system or software perceive its usefulness. The researcher prepares a set of questions regarding how the system or software is used in a daily basis to carry out the tasks it is designed for, as well as the positive and the negative aspects of using the computing system or software in the context. The researcher then gathers together a group of users and asks the questions that have been prepared beforehand. Once the answers are merged together the researcher can identify aspects that need to be modified to improve the overall user experience.

One example of using questionnaires to understand how users perceive a computing system and software are the surveys in the Android Market. When a user tries to remove an application from the mobile phone the software asks the user to provide a numeric score and a reason for uninstalling it. This information is then gathered together and used for two main purposes. On the one hand it enables the Android Market administrators to detect applications that are inappropriate. On the other hand it provides feedback to the software developer to improve the application.

2.4.4. Statistical Analysis

In HCI statistical analysis is a quantitative research method that intends to apply statistical methods, such as Analysis of Variance (ANOVA), to extract valid conclusions about of how users interact with computing systems and software. To test their hypothesis researchers set up an experiment and find subjects that want to participate. In order for the conclusions to be valid, the experiment needs to be correctly defined and the subjects shall be

numerous and representative of the population that is to be studied. Once the data is collected researchers apply the statistical methods mentioned above to find out whether their hypothesis is valid or not and extract generic conclusions.

One example of using statistical analysis to collect information about how users interact with a computing system or software is the tool included in Microsoft Office. After asking the user for permission to anonymously report the information collected to Microsoft, the tool starts gathering information about how the user interacts with the graphical interface. The information of all the users is then merged and allows researchers to understand which actions are the most frequent to provide for shortcuts that make the software easier and faster to use.

CHAPTER 3. MESSENGER VISUAL, A PICTOGRAM-BASED INSTANT MESSAGING SERVICE

This chapter presents the development of Messenger Visual, an Instant Messaging service that supports communications based on a pictographic system for individuals with cognitive disability. The chapter is organized as follows. Section 3.1 introduces how we have adapted an Instant Messaging service to the requirements of individuals with cognitive disability. Section 3.2 presents the design of the Instant Messaging service that supports communications using a pictographic system. Finally, Section 3.3 presents the design of an Instant Messaging client that takes into account the user interface accessibility requirements of individuals with cognitive disability.

3.1. Overview

As described in the Background section, Instant Messaging (IM) services [30] enable users to subscribe to presence updates of other users and to exchange text-based messages with them over a public data network, typically the Internet. To enable for such features most IM services today rely on a client/server architecture, though there are some IM services that are based on a Peer to Peer (P2P) architecture. On the one hand, IM servers enable users to connect to the IM service and provide means of routing presence updates and text messages between users. On the other hand, IM clients enable users connect to the IM service and provide with a user interface that enables them to communicate. In order to work together IM clients and servers use a common protocol that defines how to exchange presence updates and text-based messages.

But up to today, there is no single IM service that is adapted to requirements of individuals with cognitive disability. This lack of IM services adapted to individuals with cognitive disability worsens the exclusion situation from the information society of these collective, which in the end limits their autonomy and reduces their social integration. Therefore, this project aims to design and implement Messenger Visual, an IM service that is adapted to the requirements of individuals with cognitive disability. Similarly to other IM services, Messenger Visual shall enable the same features of other common IM services; users shall be able to subscribe to presence updates from other users and to shall be able communicate with them.

Therefore, to adapt an IM service to the requirements of individuals with cognitive disability we plan to follow a twofold approach. On the one hand, we plan to adapt the IM service by means of replacing text-based messages with a pictographic communication system. On the other hand, we plan to design a user interface for the IM client that supports pictographic communication systems and is easy to use taking into account the requirements of the target collective. With this twofold approach we will meet both the communication and accessibility requirements of individuals with cognitive disability. Overall, this will improve the exclusion situation of individuals with cognitive disability, as well as enhance their au-

tonomy and social integration. The design of both the IM service and client to support the requirements of individuals with cognitive disability is described in the following sections.

3.2. Pictogram-based Instant Messaging service

This section presents how we have designed Messenger Visual to support the basic features of an IM service and the communication requirements of individuals with cognitive disability. We start by presenting the requirements of that have been taken into account in the design process, to then describe the architecture of the IM service and the protocol that enables communications using a pictographic system.

3.2.1. Requirements

The two main requirements of Messenger Visual is that it shall support the basic features of IM services and that it shall replace written communications with a pictographic communication system. On the one hand, support for the basic features of IM services includes creating a user account and logging in to the IM service, as well as adding and removing contacts from the contact list, sending and receiving presence updates from the contacts in the contact list and, finally, sending messages to and receiving messages from contacts. On the other hand, support for communication based on a pictographic system includes enabling individuals to exchange pictogram-based messages, as well as updating the pictographic communication system according to the needs of each individual or group of individuals with cognitive disability.

But the fact that the IM service shall support communications based on a pictographic systems add additional requirements that are not obvious to solve. On the one hand, in an IM service that uses a pictographic system the users shall have the pictograms needed in order to communicate with each other. On the other hand, considering that there are many different pictographic communication systems and that each individual or group of individuals shall use the pictographic system that better fits their communication requirements, the IM service must remain independent of the pictographic communication system. Finally, considering that the pictographic communications systems are not static but in continuous evolution, the IM service shall support a mechanism to update the pictographic communication system to the IM clients.

3.2.2. Architecture

In order to support for the IM features we have decided to base Messenger Visual on the eXtensible Messaging and Presence Protocol (XMPP) protocol [31]. The main rationale behind this decision is that XMPP is based on standards and offers a client/server architecture that is flexible, scalable and secure. Therefore, Messenger Visual is build upon a client/server architecture in which the XMPP server enables users to connect to the IM service and provide means of routing presence updates and text messages between users.

But in order for the IM service to support the requirements of communications based on a based on a pictographic system we have followed the approach that is described next.

First of all, to enable support for communications based on a pictographic system users shall have the pictograms needed to communicate. To provide the users with the required pictographic system we have considered two different alternatives: personalize the pictographic system for each individual or have a shared pictographic system for all the users. The former alternative eases that pedagogues and social educators can exactly define which pictograms should the pictographic system include with relation to their actual knowledge and update it according to their learning process. The latter alternative intends to provide more communication freedom to the user by means of providing all the pictograms that may be required to communicate.

Each of these approaches has positive and negative aspects that shall be taken into account before making a decision. On the one hand, personalizing the pictographic system for each individual may lead to have users that are not able to communicate because they do not share the same pictograms. On the other hand, having a complete pictographic system may have a negative impact on the communications interactivity, as users will have to spend more time browsing for pictograms. Finally, considering that actual pedagogic trends regarding pictographic communication systems state that it is better to provide all the pictograms to enhance the learning process of users, we have decided to implement a shared pictographic system.

Second, to support updates for the pictographic communication system we have considered two different approaches: a centralized pictographic system or a distributed pictographic system. On the one hand, in the centralized architecture the pictographic communication system is stored in a centralized server and clients download the pictograms required to communicate on demand. On the other hand, in the distributed architecture clients have a local copy of the pictographic system that is synchronized with the server. Despite it requires of an additional synchronization mechanism we have decided to use a centralized architecture to store the pictographic system because it is more flexible and saves bandwidth for both the server and the clients.

Third, in order to store the pictographic system we have also considered two alternatives: store pictograms as files classified into folders or store pictograms in a relational database. The former is straight forward to implement as storing files in the hard drive is supported by any modern programming language. The latter requires to define and implement both the physical and logical models of the database and to store and read pictograms as objects. We have finally decided to store the pictographic system in a relation database not only because it provides a more organized structure, but because it offers better performance when dealing with small objects [32].

Finally, to enable support for updating the pictographic system to IM clients we have designed and implemented an Internet service that enables pedagogues and social educators to upload the pictograms remotely. Once the pictograms are uploaded the service creates the relational database with the corresponding categories and pictograms, and starts notifying IM clients that a new version of the pictographic communication system is available through the multi-conference feature of XMPP. Once IM clients get the notification that a new version of the pictographic communication system is available, i.e. when

a user connects to Messenger Visual, they start downloading it using the GET method of the HyperText Transfer Protocol (HTTP) protocol.

Therefore to implement the architecture of the Messenger Visual IM service we have used two off-the-shelf servers, as depicted in Figure 3.1. On the one hand, to enable support for IM features in Messenger Visual we have decided to use an open source XMPP server named after OpenFire. On the other hand, to enable for updates of the pictographic communication system we have decided to use an open source Java 2 Enterprise Edition (J2EE) server named after Glassfish. Finally, to implement the relational database that stores the pictographic communication system we use SQLite, an open source database manager. Nevertheless, all the components that have been used to implement Messenger Visual can be easily replaced by others. For instance, OpenFire could be replaced by Jabberd, Glassfish could be replaced by Jabberd and SQLite could be replaced by MySQL.

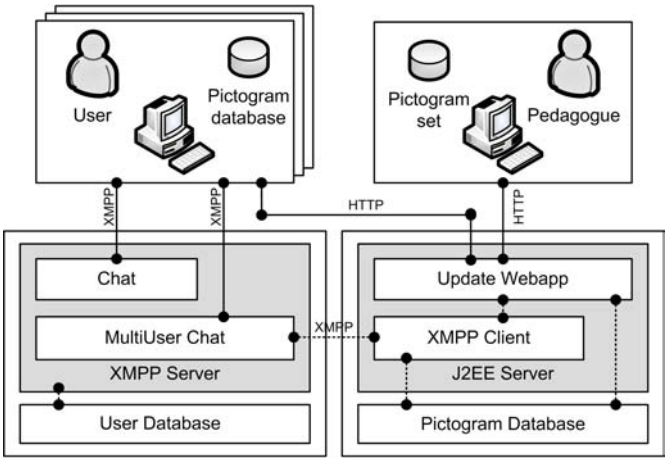

Figure 3.1: The architecture of Messenger Visual. OpenFire, an open source XMPP server, enables the Instant Messaging features whereas an Glassfish, an open source J2EE server, enables support for updating and downloading the pictographic communication system. Finally, the pictographic communication system is stored in a relational databased implemented using SQLite.

3.2.3. Protocol

In order to support for communications based on a pictographic system we have considered two different alternatives, eXtensible Markup Language (XML) and JavaScript Object Notation (JSON). After comparing both alternatives we have decided to use XML because it is simple, self-describing, standard, self-describing and extensible. Apart from that, XML offers better support for internationalization, for instance the representation of Chinese characters. Furthermore, the XMPP IM protocol is based on XML streams which means that using XML to support communications based on a pictographic system suits the IM protocol that is transporting the messages between users. All this characteristics ensure that the IM service remains independent of the pictographic system used to communicate, as described in the requirements.

The XML syntax to describe pictogram-based messages, shown in Figure 3.2, is composed of a root element, named after *message*, that contains one or more pictographic

elements that represent the pictogram-based message that the user wants to transmit. In turn, each pictographic element of the message contains one or more child elements, named after *pictogram*, that uniquely identifies a pictogram within the pictographic system database. With this approach we ensure that the IM service remains independent from the pictographic communication system that individuals use to communicate among them. Nevertheless, as Messenger visual will be initially evaluated with two groups of individuals with cognitive disability from Fundació El Maresme, we have decided to implement the Aragonese Portal of Augmentative and Alternative Communications (ARASAAC) pictographic system to support communications.

```
<message from="peretuset@messengervisual.net" to="robertoromero@messengervisual.net">
  <pictogram id="34" category="beings" text="you" />
  <pictogram id="67" category="actions" text="go" />
  <pictogram id="82" category="places" text="cinema" />
  <pictogram id="54" category="time" text="tonight" />
  <pictogram id="29" category="questions" text="question" />
</message>
```

Figure 3.2: The representation of a pictogram-based message using XML. Each message is represented by a *message* element that contains one or more *pictogram* elements that uniquely represent one pictogram and the text associated to it.

3.3. Pictogram-based Instant Messaging client

This section presents how we have adapted an IM client to support the basic features of an IM service, as well as the communication and user interface requirements of individuals with cognitive disability. We start by presenting the requirements of that have been taken into account in the design process, to then present the architecture of the IM client and the main windows that compose its user interface.

3.3.1. Requirements

There are two main requirements that the IM client has to support to be compatible with the Messenger Visual. Similarly it to the IM service, the IM client shall support the basic features of IM services and it shall support communications based on a pictographic communication system. The former includes creating a user account and logging in to the IM service, as well as adding and removing contacts from the contact list, sending and receiving presence updates from the contacts in the contact list and, finally, sending messages to and receiving messages from the contacts. The latter includes enabling individuals to exchange pictogram-based messages, as well as updating the pictographic communication system according to the needs of each individual or group of individuals.

But differently to the IM service, the IM client has to meet the user interface accessibility requirements of individuals with cognitive disability. Meeting the user interface accessibility requirements of individuals with cognitive disability is not obvious as even in reduced groups of users with similar disability profiles the differences in written language and computer usage skills are notorious. For instance, some users might be able to understand

written language whereas others may not only be unable to understand it, but become a source of cognitive overload that makes interacting with the user interface of the IM client more difficult. Therefore, we have carefully studied how the user interface of IM clients is designed and we have worked together with the pedagogues and social educators to find a design that suits the majority of individuals with cognitive disability.

3.3.2. Architecture

To develop the IM client for Messenger Visual we have decided to use Java 2 Standard Edition (J2SE) technology by Oracle. The main rationale behind this decision is that Java is multiplatform, thus ensuring that any individual with access to a computer can use it regardless of the operating system that is executing. For instance, we have successfully tried the Messenger Visual IM client in three different mainstream operating systems including Microsoft Windows, Apple MacOS X and GNU/Linux with no additional problems.

Apart from that, to support for the different requirements to develop the IM client we have used additional Application Programming Interface (API) anf framework. For instance, in order to support for the XMPP protocol that enables the basic features of IM services of Messenger Visual we use the Smack API [33]. Smack is an open source XMPP client library developed in Java by the Ignite Realtime community. To support to access the pictographic communications system database we use Hibernate [34]. Hibernate is an open source Java persistence framework developed by the JBoss community.

Additionally, to support for encoding and decoding the XML messages that represent pictogram-based communications we use Document Object Model (DOM) from the Java API for XML Processing (JAXP) framework [35]. JAXP is a library that enables validating and parsing XML documents using Java. Last but not least, to design and implement the user interface of the Messenger Visual IM client we use the Swing framework. Swing is a widget toolkit part of the Java Foundation Classes (JFC) developed by Oracle that enables developers creating Graphical User Interface (GUI) using Java.

Regarding the architecture of the IM client, its design is based on the Model-View-Controller (MVC) pattern that enables decoupling the user interface from the domain logic. Apart from MVC, we also use extensive usage of other design patterns such as *Singleton*, *Observer* and *Builder*. Additionally, we use a layered approach to distinguish from the different responsibilities, e.g. communications, database access, user interface, etc. Last but not least, to perform tasks that require additional computing time we use threads to ensure that the interface remains responsive to user actions.

Finally, we have decided to distribute the Messenger Visual IM client under the GNU Public License (GPL) version 2 license. The main rationale behind this decisions is that the GPLv2 license ensures that the software remains free to anybody that wants to use it or contribute to it with new features. For instance, both the source code and a compiled version of the IM client for Messenger Visual are freely available through the *Càtedra de Programari Lliure* of the Universitat Politècnica de Catalunya (UPC) [36].

3.3.3. User interface

To adapt the user interface to the requirements of individuals with cognitive disability we have started by analysing how other common IM clients are designed. We have found out that most IM client are organized in three windows, a window to enforce access control, a window to manage to contacts list and, finally, a window to chat with contacts. Thus, we have arranged the user interface of the IM client into three main windows that provide access to the basic IM features, namely login, contacts and conversations. With this approach we have then worked towards providing an interface that replaces textual information with visual information throughout the different windows that form the user interface. Finally, we have also ensured that the different windows that compose the user interface of the IM client do not include any elements that may cause cognitive overload to individuals with cognitive disability, such as context menus or scrolling bars. The design of the three windows is thoroughly described in the following subsections.

3.3.3.1. Login window

The login window, depicted in Figure 3.3, enables users to select their profile and login to the IM service. Taking into account the requirements of individuals with cognitive disability, we have replaced the common login mechanism, based on a username and password, with a matrix that contains the pictures from all the user profiles that have previously logged in to Messenger Visual using the IM client. Once an individuals selects the user profile he/she may login to the IM service by clicking into his/her picture. Apart from enabling the users to login to the IM service, the login window also enables individuals to create a Messenger Visual user account by filling in a form with their personal information and a picture, as well as their username and password.

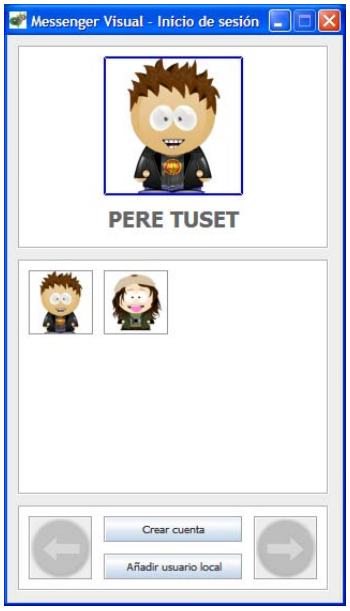

Figure 3.3: The login window of the Instant Messaging client. Taking into account accessibility requirements, individuals with cognitive disability may login to the Instant Messaging service by selecting their profile from a matrix of users profiles.

Once individuals have selected their user profile a password window appears, as shown in Figure 3.4. The password window enforces access control to the IM service to ensure that users are not impersonated by other individuals. Taking into account the accessibility requirements of individuals with cognitive disability we have based the password on a combination of four digits. Users may select the appropriate combination of digits by pressing the numbers on the pictogram-based keyboard presented on the screen and, once finished, they shall confirm in order to start the login process using the confirmation pictogram. Nevertheless, in order to better suit the requirements of individuals with cognitive disability the numeric combination could be easily replaced by other pictograms that form a password that is easier to recall, for instance animals.

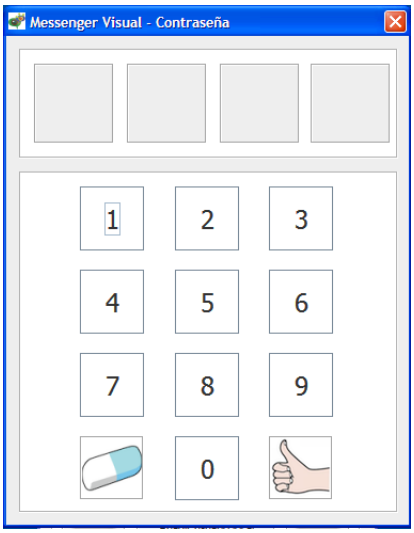

Figure 3.4: The password window of the Instant Messaging client. The password is based on a combination of four digits taking into account the accessibility requirements of individuals with cognitive disability.

3.3.3.2. Contacts window

The contacts window of the IM client, as displayed in Figure 3.5, enables users to manage their contacts list, e.g. the relatives and acquaintances that the user can communicate with. The contacts window is organized as follows. The top side of the window contains a representation of the current user, including its name and a picture. The middle side of the window contains the contacts list with a representation of the users, including its name and a picture, that are currently online. Finally, the bottom side of the window contains two buttons to navigate the contacts list, a button to invite new users and a button to logout from the IM service. Thus, whenever a contact becomes online a virtual representation of the user is added to the contact list, whereas if a user becomes unavailable the virtual representation is automatically removed. In order to start a conversation users may click on the picture of the desired user and a conversation window will open.

Figure 3.5: The contacts window of the Instant Messaging client. The window contains all the user contacts that are currently connected to Messenger Visual and enables individuals to start a conversation with them.

3.3.3.3. Conversation window

The conversation window of the IM client, depicted in Figure 3.6, enables users to send and receive pictograms-based messages. The conversation window is organized as follows. The top side of the window contains the categories in which the different pictograms are classified and two buttons that enable scrolling. The left side of the window contains the basic pictograms that are used to communicate, for instance the pictograms that correspond to *Hello*, *Bye*, *Yes*, *No* and *Thank you*. The right side of the window contains the pictograms that belong to the category that is currently selected, as two buttons that enable scrolling. Finally, the bottom side of the window contains the space to compose the messages, as well as the icons to send a message and delete the last pictogram. Last but not least, the central part of the window contains the message historic, a space where the last messages that have been send and received are stored.

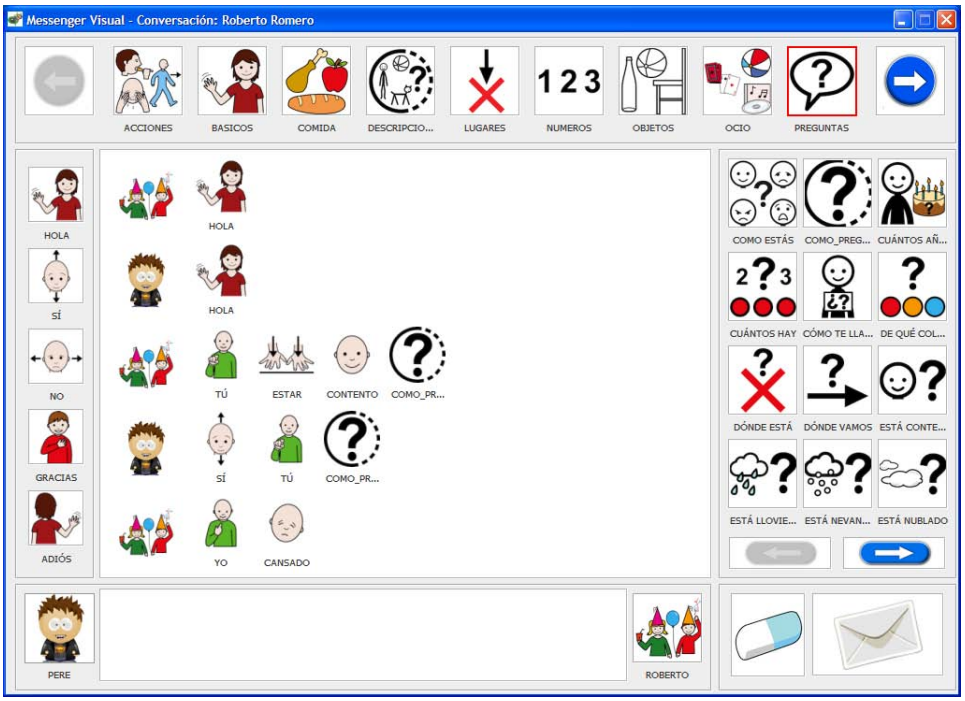

Figure 3.6: The conversation window of the Instant Messaging client. This window allows users to compose, send and receive pictogram-based messages to communicate with their relatives and acquaintances over the Internet.

CHAPTER 4. EVALUATING MESSENGER VISUAL WITH COGNITIVELY DISABLED INDIVIDUALS

This chapter presents the evaluation of Messenger Visual with a group of cognitively disabled individuals from Fundació El Maresme. The chapter is organized as follows. Section 4.1 introduces the process that we have used to evaluate Messenger Visual with individuals with cognitive disability. Section 4.2 describes the research methods that we have used to obtain information from the evaluation process. Finally, Section 4.3 presents and discusses the results that we have obtained from the evaluation process by using the research methods.

4.1. Overview

Considering that the Messenger Visual Instant Messaging (IM) client will be used by individuals with cognitive disability to communicate with their relatives and acquaintances, it is important to take into account their requirements early in the design process. The main rationale behind taking this approach is that a large number of projects developed for individuals with cognitive disability end up being unused or becoming abandoned because its design fails taking into account the requirements [37] of the target collective.

To overcome this situation, we plan to follow an evaluation procedure that has two main objectives. On the one hand we want to evaluate how individuals with cognitive disability interact with the user interface to correct bugs in the software and detect user interface elements that can be improved to better suit their usability requirements. On the other hand, we want to explore how individuals with cognitive disability communicate with their relatives and acquaintances using picotgram-based IM service.

Therefore, after setting up the IM service and developing a first prototype of the IM client we, together with pedagogues and social educators, set up an evaluation procedure with two groups of individuals with cognitive disability from Fundació El Marseme. Fundació El Maresme is a non-profit organization that promotes the social integration of individuals with cognitive disability and their families. The users that will participate in the evaluation sessions have been selected to be representative.

The evaluation sessions, which last for around one hour, have been conducted fortnightly during six months and have counted with the participation of two groups of users with cognitive disability from Fundació El Maresme. The first group of users is composed of five members, one man and four women, that belong to the Servei de Teràpia Ocupacional (STO) and have an age between 20 and 43 years. The second group of users is composed of seven members, four men and three women, that belong to the Servei Ocupacional d'Inserció (SOI) and have an age between 21 and 28 years old.

There are different reasons to use a reduced group of individuals for the evaluation procedure. First of all, the availability of individuals with cognitive disability that are willing to become involved in such kind of study is scarce. Furthermore, the availability of computers at Fundació Maresme is also short; in fact during the evaluation users had to share a computer in pairs. Finally, the diversity of cognitive disability profiles even in a short group of users is large, which limits the applicability of our research methodology.

Regarding the cognitive disability level of users, the members of the STO group have a disability level equal or higher than 65%, whereas the members of the SOI group have a disability level equal or higher than 33%. Nevertheless, the individuals that compose both groups of users that participate in the evaluation sessions have a background in using computers as they have used them as a part of their educational curriculum. Finally, individuals that participate in the evaluation sessions also have good communication and interpersonal skills.

Finally, during the evaluation sessions a pedagogue, Sandra, and two social educators, Juan and Cecilia, have been present in order to provide support to the users. The pedagogues and social educators have also taken notes regarding the relevant events that have emerged during the evaluation sessions. These notes have then served as feedback to correct the bugs that have been detected and to introduce changes to the user interface to better suit the accessibility requirements of individuals with cognitive disability.

4.2. Evaluation methodology

To evaluate how individuals with cognitive disability use Messenger Visual to communicate with their relative and acquaintances we have used two different qualitative research methodologies, namely interview and ethnography. On the one hand, interview has enabled us to gain understanding of the relevant events that pedagogues and social educators have come across during the evaluation sessions. On the one hand, ethnography has enabled us to approach the evaluation sessions and observe how individuals with cognitive disability communicate using Messenger Visual.

4.2.1. Interview

Taking into account that cognitive individuals have impairments that limits their ability to communicate and their interpersonal skills [38], we decided to conduct informal interviews with the pedagogues and social educators from Fundació El Maresme. These interviews have been focused on understanding the process of approaching IM services to individuals with cognitive disabilities. Despite all the users that participate in the evaluation process are already familiar with the computer, most of them was not familiar with IM services.

The first thing we learned from the interviews with the pedagogues and social educators is that in order to help individuals with cognitive disability understand the paradigm of IM services they used an analogy from the real world. First of all they build a book, shown in Figure 4.1, which is organized into categories and contains all the pictograms that users

need in order to communicate. The pictograms are arranged in twelve different categories, such as *Food*, *Sports*, *Transportation* and *Weather*, among others.

Figure 4.1: A book that contains the pictograms that users need to communicate. The pictograms of the book have been selected by pedagogues and are arranged into twelve different categories, for instance *Food*, *Sports* and *Weather*, among others.

To build the pictogram book pedagogues and social educators decided to use the Aragonese Portal of Augmentative and Alternative Communications (ARASAAC) pictographic system because the pictograms are transparent and very similar to the Picture Communication Symbols (PCS) pictographic system. Furthermore, the ARASAAC pictographic system is distributed under a Creative Commons license. The book contains around four hundred pictograms which have been carefully selected to provide the users with the minimum vocabulary set that they may require in order to communicate with their relatives and acquaintances.

Once the book containing the pictograms was ready, pedagogues and social educators built a letter and an envelope that serves as the post-office communication metaphor. The letter and the envelope, combined together with the pictogram book, enables individuals to compose pictogram-based messages, put them inside the envelope and send them to each other across the post-office. With this approach individuals with cognitive disability can understand the paradigm of IM communications using pictograms.

Once the users had understood the IM communication paradigm they started using the Messenger Visual IM client in a computer to communicate among them using pictograms. To make the transition easy for the users, during the first session the pedagogues and social educators from Fundació El Maresme prepared a set of cards containing questions and answers, shown in Figure 4.4, that were distributed among users. With this approach users could familiarize with the user interface of the Messenger Visual IM client.

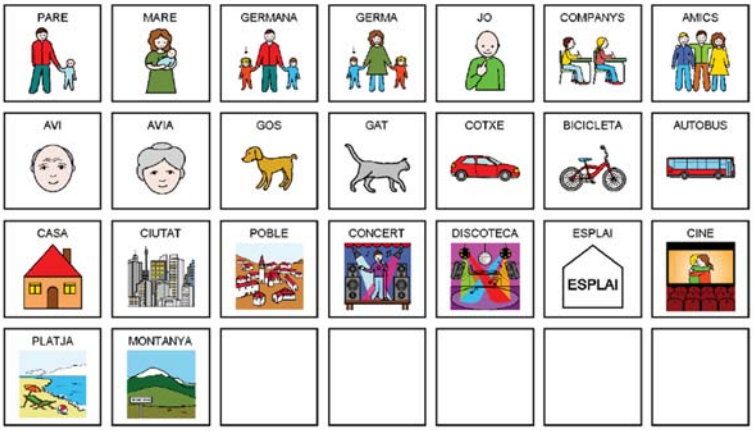

Figure 4.2: A group of ARASAAC pictograms that have been included in the book. The book contains around four hundred pictograms classified into twelve different categories that have been selected by pedagogues to provide the minimum vocabulary set that is required to communicate.

Initially the evaluation sessions were held in a single room which was shared by the members of both groups. But soon after starting to use the Messenger Visual IM client, pedagogues and social educators discovered that users preferred to interact with each other directly. For instance, users would send a pictogram-based message and then start to talk to each other about the message. To solve this inconvenient each group of users was moved to a separate room in order to resemble the physical distance of IM communications, as shown in Figure 4.5.

4.2.2. Ethnography

Apart from the informal interviews conducted with pedagogues and social educators from Fundació El Maresme, during the evaluation sessions we have also had the chance to become personally involved with the two groups of users that evaluate Messenger Visual. Specifically, we have had the chance to join two different evaluation sessions; the first one at the beginning of the evaluation process and the other at the end.

During the two sessions that we have become involved with the groups, the users did not seem to bother about our presence and acted normally. As users arrived to the two contiguous rooms we introduced ourselves and waited for the session to begin. While waiting the users sat with their partner in a computer and discussed about the news, for instance the result of the football matches.

When the evaluation sessions begin each pair of users login to the IM service using one of their accounts and selects the users with who they want to chat with. Usually pedagogues and social educators have to interfere in the decision process to ensure that individuals with the same conversation level communicate with each other as, otherwise, some communication problems may arise during the conversation.

Figure 4.3: A real-world analogy of the Instant Messaging paradigm. In order to explain individuals with cognitive disability how Instant Messaging services work, pedagogues and social educators from Fundació El Maresme built a letter and an envelop that enables users to send and receive pictogram-based messages across a post-office.

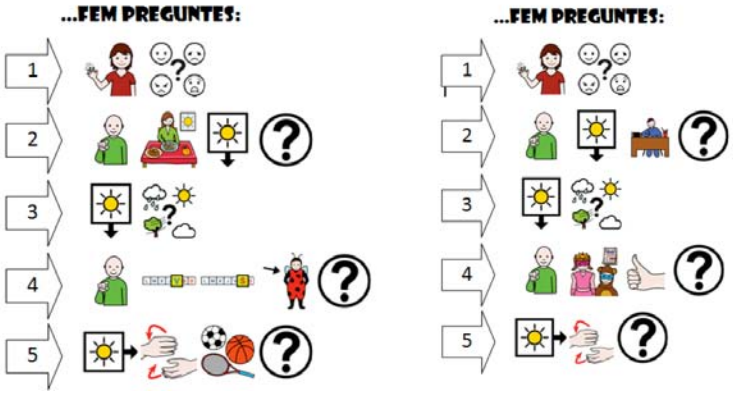

Figure 4.4: A card that contains questions to start a pictogram-based conversation. Pedagogues and social educators from Fundació El Maresme have used this method during the first evaluation sessions to help individuals with cognitive disability communicate.

During the evaluation session each pair of users decides which are the topics they want to talk about and discuss about the pictograms that are needed to compose a message. While awaiting for the reply, users talk to each other or to the users nearby. While the users are chatting between them, pedagogues and social educators wander from room to room helping the users that require from assistance.

Finally, when the pedagogues and social educators indicate that the time is over each pair of users says goodbye to each other and close the IM session. After shutting down the computer users stand up and leave the room in an orderly fashion. Sometimes, though, the pedagogues and social educators allocate extra time to enable users finish their conversations if they consider that their behaviour deserves gratification.

Overall, the ethnography methodology has enabled us to observe in first person how individuals with cognitive disability interact with the IM client user interface to communicate with their relatives and acquaintances using pictogram-based messages. Furthermore, the ethnography approach has also enabled us to get a better understanding of the com-

Figure 4.5: A classroom with a group of users from Fundació El Maresme. The two groups had to be separated into different rooms to resemble the physical distance of Instant Messaging communications.

Figure 4.6: A group of cognitively disabled individuals using Messenger Visual. During the sessions a pedagogue and two social educators are present to assist the users and take notes about the evaluation process.

munication problems that arise from the fact that the communications are based on a pictographic system.

But aside from the technical aspects, the ethnography has also allowed us to get closer to the individuals that form the two groups of users that evaluate the pictogram-based IM service. Becoming to realize that, despite all of its bugs and opportunities for improvement, Messenger Visual is actually useful to enable individuals with cognitive disability communicate with their relative and acquaintances has been one of the most inspiring moments of the project.

4.3. Results

After six months of evaluating Messenger Visual with the two groups of users from Fundació El Maresme using the methodologies described in the previous subsection we have observed that all the users, regardless of their type and level of cognitive disability, have been able to use the IM client to communicate using pictograms with their relatives and acquaintances.

The main rationale behind this fact is that the user interface of the IM client has been designed taking into account the accessibility requirements of individuals with cognitive disability. First of all, the pictograms have been arranged into categories following a model that users are already familiar with because they have previously used Boardmaker [6]. Second, the user interface does not contain elements that have hidden or implicit behaviour, such as context menus or scrolling bars, that might cause cognitive overload to the users. Third, textual information is accompanied with graphical representation of sufficient size, for instance a picture is used to represent a user profiles, thus easing recognition of interface elements.

Nevertheless, during the evaluation we have also come across some aspects, either related to how individuals with cognitive disability interact with the user interface or communicate with their relatives and acquaintances by means of using pictograms, that are worth mentioning. These aspects are presented and discussed in the following subsections.

4.3.1. User interface

Regarding the user interface of the IM client, during the evaluation with individuals with cognitive disability we have observed some aspects that might need to be changed in order to improve the overall usability.

On the one hand, we have observed that there are some elements of the user interface that may have an inconsistent behaviour which may lead to confusion to some users with cognitive disability. One example of such elements are the buttons that enable scrolling in the different user interface windows. The scrolling buttons in the login and the conversation window operate in a right and left fashion, whereas the scrolling buttons in the contacts window operates in an up and down fashion. Despite that during the sessions we have not observed significant problems using the scrolling buttons, regardless of the user cognitive disability profile, it seems interesting to redesign in order to improve the consistency of the user interface.

On the other hand, we have found out that there are some tasks that at this moment of time are not suitable to be performed by individuals with cognitive disability, regardless of their type and level of cognitive disability. For instance, creating a new user account requires from introducing textual parameters, such as the name and surname, and locate the profile picture in the hard drive. Another example is adding a contact to the contact list, which requires from introducing textual parameters, in this case the username. Therefore, creating a new user account or adding a user to the contact list requires from the intervention of a pedagogue or social educators, which limits the independence level of users.

4.3.2. Pictogram-based communications

Regarding how individuals with cognitive disability use the pictogram-based IM service to communicate with their relatives and acquaintances, during the evaluation we have come across two important aspects that need to be taken into account.

On the one hand we have observed that the communication skills of the individuals have a great impact on the interactivity of pictogram-based conversations, but in a way that was not expected *a priori*. At first we imagined that those users with higher communication skills would find it easier to communicate, as their ability would enable them to navigate across the different categories to select the appropriate pictograms faster. Nevertheless, during the evaluation we have discovered that despite being faster at selecting pictograms, those individuals with higher communication skills tend to spend more time composing a message because they create more complex messages that require from more pictograms. Instead, individuals with lower communication skills create messages that are simpler and, thus, spend less time composing a message. In the end, we have discovered that this has a negative impact on advanced users, as having to wait for the reply leads to distraction.

On the other hand, we have observed that there are some special situations that make pictogram-based conversations become stalled and require from the intervention of pedagogues or social educators in order for the users to take up the conversation again. For instance, if a user sends two consecutive messages without waiting for the reply the user at the other side of the conversation, which may be writing the reply to the first message, becomes confused and the conversation gets stalled. This situation can happen for two main reasons; if a user sends an incomplete message by mistake and then sends the correct message, or if a user sends a message but does not receive a reply in a relatively short period of time and sends another message. Despite this situation is not very common and is largely dependent on the communication skills of each user, we have discovered that it is a factor that has a negative impact on the users as it causes frustration.

CHAPTER 5. CONCLUSIONS AND FUTURE WORK

This final chapter presents the results that have been achieved during the development of the project and the work that is left for the future. The chapter is structured as follows. Section 5.1 presents the conclusions outlined from the development of the project and Section 5.2 identifies the work that remains to be done in the future.

5.1. Conclusions

This document has presented Messenger Visual, an Instant Messaging (IM) service based on pictograms for individuals with cognitive disability. As we have described along the text Messenger Visual combines two concepts, IM services and Augmentative and Alternative Communication (AAC) systems, in order to enable individuals with Cognitive Disability (CD) communicate over the Internet with their relatives and acquaintances. To enable such an opportunity we have designed and developed both an IM service and an IM client. On the one hand, the IM service has been adapted to support pictograms as the main communication system. On the other hand, the IM client has been developed taking into account both the requirements of pictogram-based communications and the user interface accessibility requirements of individuals with cognitive disability.

Apart from designing both an IM service and client, we have also evaluated Messenger Visual with two groups of individuals with cognitive disability from Fundació El Maresme. During the sessions that we have conducted the users have had the chance to use Messenger Visual to communicate in real world situations, which has given us the chance to detect and correct both functionality and accessibility aspects of the IM service and the IM client. The evaluation sessions have also enabled us to observe how users with cognitive disability communicate using a pictographic communication system, which has lead us to discover some aspects that remained unknown up to today. For instance, the main findings that we have encountered during the evaluation of Messenger Visual with cognitively disabled individuals from Fundació El Maresme are:

- Communication skills of the individuals with cognitive disability have a great impact on the interactivity of pictogram-based conversations, but not as we expected initially. Individuals with higher communication skills tend to spend more time composing a pictogram-based message, which in the end leads to distractions that reduce the interactivity of conversations.
- Unexpected situations, such as receiving two consecutive messages, confuse the users at the other side of the conversation and make the conversations become stalled, which requires from the intervention of pedagogues or social educators. Despite the situation is not frequent and depends on the individual communication skills, it is a factor that causes frustration to users.

All in all, we conclude that from the technical point of view we have successfully designed an implemented an IM service that replaces text-based communications with communications using a pictographic system, as well as an IM client that takes into account the user interface accessibility requirements of individuals with cognitive disability. Also, from the scientific point of view, we have provided further understanding of the communication and user interface requirements for individuals with cognitive disability that may be useful to other software developers for designing services targeted to such collective. Finally, from the social point of view, we state that Messenger Visual may help integrate individuals with cognitive disability in the information society, as it enables them to communicate with their relatives and acquaintances over the Internet by means of using a computer.

Last but not least, regarding the environmental impact of the project we state that the main resource usage is the eXtensible Messaging and Presence Protocol (XMPP) server that supports the Messenger Visual IM service, as well as the electricity consumption that it requires to operate. Therefore, in order to minimize both the computers and the electricity consumption required to provide the service we have decided to collocate the XMPP server in a virtual infrastructure. With this approach the electricity consumption is shared among all the virtual servers that are run in the same physical server, thus resulting in a lower overall environmental impact of the project.

5.2. Future work

Despite Messenger Visual is already in a working state at Fundació El Maresme, during the evaluation of the project we have come across some aspects of the IM client that may need to be changed in order to improve the accessibility for individuals with cognitive disability. For instance, the first version of Messenger Visual uses an access control mechanism that is based on selecting the user profile from a local user database and introducing a four-digit numeric password based on pictograms. Although initially this access control mechanism seemed suitable for individuals with cognitive disability, we soon discovered that the memory impairments posed by their condition limited its effectiveness, as users tended to forget their password and social educators had to restore it manually every time.

To improve this situation we have analysed all the access control mechanisms that are used today [39] taking into account the accessibility requirements of individuals with cognitive disability and the economic costs involved to implement the solution. Biometric access –such as fingerprint or voice recognition– and token-based access –such as RadioFrequency IDentification (RFID) or Near-Field Communications (NFC)– alternatives were analysed but not considered as a valid solution due to the high economic costs of the hardware required or its suitability considering the target collective. Finally, we have decided to implement a novel access control mechanism based on Quick Response (QR) Codes. Each user has a token, shown in Figure 5.1, that contains his personal information and a QR Code with the user account information to login to the IM service.

Once the user starts the IM client the software accesses the camera installed in the computer and the user has to show his or her personal token. As soon as the software detects and decodes the QR code the login procedure is triggered and the user is authenticated to the IM service, as shown in Figure 5.2. And the token is not only used to provide access

Figure 5.1: The token that enforces access control to login to Messenger Visual. The token includes the basic user information, i.e. name and surname, and a QR Code that contains all the required information, i.e. server name and port, to login to the IM service.

control to the IM service, but also to enable users add contacts to their contacts list. Whenever a user wants to add a relative or acquaintance to their contact list he or she asks the other user to come and show the token to the IM client. Once the QR Code is detected and decoded, the information of the other user account is used to start the two-way handshake mechanism to add a new contact to the contacts list.

Figure 5.2: The access control mechanism based on QR Codes. The access control window contains a frame that displays the video feed from the camera. A background thread captures still images from the video feed and tries to find and decode a valid QR Code. Once the QR Code is decoded it triggers the login mechanism to authenticate the user to the IM service.

We believe that this novel access control mechanism based on QR Codes eases the login procedure to the IM service, thus making it more accessible to individuals with cognitive disability. Nevertheless, this approach has some downsides regarding the overall security level of the IM service. If a user loses the personal token, which is a plausible situation considering the memory limitations posed by their condition, anybody with access to the IM client could impersonate the user and communicate with their contacts. Therefore it is important to design and implement a mechanism that enables users to revoke their personal token in case it gets lots to ensure that it is not used improperly. Nevertheless, at

this moment of time such mechanism is not yet implemented and, thus, this task is left as future work.

Another important aspect that we consider to be interesting to explore in the future is extending the evaluation procedure. Today, all the knowledge we have about how individuals with cognitive disability communicate with their relatives and acquaintances using the pictogram-based IM service is limited to the qualitative information that we have obtained through applying the research methods previously described. To overcome this situation we have implemented a logging tool that registers all the information related to how users interact with the IM client user interface to communicate. For instance, each time a user adds or removes a pictogram from the current message the logger registers an action into the log file. Also, each time a user sends or receives a pictogram-based message the logger registers an event into the log file.

All this information, collected over multiple sessions and for different user profiles, will enable us to explore different quantitative parameters that help us understanding how individuals with cognitive disability communicate using pictogram-based messages. For instance, we have plans to study whether the average number of pictograms in a message or the percentage of pictograms that users require to communicate increases over time, as an indicator of the users learning to communicate using pictograms. To our knowledge, there is no single piece of research today that has studied how individuals with cognitive disability communicate using pictograms with the aid of an IM service. Therefore, considering the novelty of these results, we plan to publish the main findings of our study in international renowned conferences or journals.

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ACRONYMS

AAC Augmentative and Alternative Communication. 3–5, 10, 37

ABI Acquired Brain Injury. 8

AD Alzheimer's Disease. 8

AIM AOL Instant Messenger. 14

ANOVA Analysis of Variance. 17

AOL America OnLine. 13, 14

API Application Programming Interface. 24

ARASAAC Aragonese Portal of Augmentative and Alternative Communications. 11, 12, 23, 31

ASD Autism Spectrum Disorder. 8, 9

AT Assistive Technology. 4

BART Buddy Art. 14

BOSS Basic OSCAR Service Server. 14

CATEDU Centro Aragones de Tecnologias para la Educación. 11

CD Cognitive Disability. 3, 5, 7, 37

CORE Computing Research and Education Association of Australasia. 47, 53, 63

CVA CerebroVascular Accident. 1, 8

DOM Document Object Model. 24

DS Down Syndrome. 8, 9

FLAP Frame Layer Protocol. 14

GPL GNU Public License. 24

GUI Graphical User Interface. 24

HCI Human-Computer Interaction. 3, 5, 15–17

HTTP HyperText Transfer Protocol. 13, 22

IETF Internet Engineering Task Force. 13–15

IM Instant Messaging. 3–5, 12–15, 19–27, 29–40

IQ Intelligence Quotient. 9

IRC Internet Relay Chat. 12

IST Information Society Technologies. 4

IWAAL International Workshop on Ambient Assisted Living. 53

J2EE Java 2 Enterprise Edition. 22

J2SE Java 2 Standard Edition. 24

JAXP Java API for XML Processing. 24

JFC Java Foundation Classes. 24

JSON JavaScript Object Notation. 22

MSNP Microsoft Notification Protocol. 13–15

MSRP Message Session Relay Protocol. 15

MUT MultiUser Talk. 12

MVC Model-View-Controller. 24

NFC Near-Field Communications. 38

NordiCHI Nordic Conference on Computer-Human Interaction. 47

NS Notification Server. 13

OSCAR Open Service for Communication in Real-time. 13–15

P2P Peer to Peer. 15, 19

PCS Picture Communication Symbols. 11, 12, 31

PicSyms Picture Symbols. 11

QR Quick Response. 38, 39

RFC Request for Comments. 12, 14, 15

RFID RadioFrequency IDentification. 38

SB SwtichBoard. 13

SDP Session Description Protocol. 14

SIMPLE SIP Extension for Instant Messaging and Presence Leveraging. 13–15

SIP Session Initiation Protocol. 14, 15

SNAC Simple Network Atomic Communication. 14

SOI Servei Ocupacional d'Inserció. 29, 30

STO Servei de Teràpia Ocupacional. 29, 30

TLV Type, Length, Value. 14

UA User Agent. 14, 15

UCD User Centred Design. 17

UMAP User Modelling, Adaptation and Personalization. 63

UPC Universitat Politècnica de Catalunya. 24

WWAAC World Wide Augmentative and Alternative Communication. 4

XML eXtensible Markup Language. 13–15, 22, 24

XMPP eXtensible Messaging and Presence Protocol. 13, 15, 20–22, 24, 38

APÈNDIXS

APPENDIX A. NORDICHI 2010

This appendix includes the short article "*Messenger Visual: a pictogram-based IM service to improve communications among disabled people*" [40] that has been presented at Nordic Conference on Computer-Human Interaction (NordiCHI) the past October in Reykjavik, Iceland. NordiCHI is ranked as a C conference according to the Australia Computing Research and Education Association of Australasia (CORE) ranking.

Messenger Visual: A pictogram-based IM service to improve communications among disabled people

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ABSTRACT
This paper presents a pictogram-based instant messaging service that intends to bridge the social and digital gap of people with cognitive impairments. By means of using pictograms as the communication language and by tailoring down the interface to suit pictogram-based communication requirements, the service allows users to exchange real-time messages across the Internet to communicate with their relatives and acquaintances. Through our initial evaluation procedure with a group of eleven users with different types and degrees of cognitive impairments we show that a pictogram-based instant messaging service has a great potential to improve their communicative capabilities, as well as to enable their personal and social development.

ACM Classification Keywords
K.4.2 [Computers and Society]: Social Issues – Assistive Technologies for persons with disabilities

Author Keywords
Assistive technologies, user-centered design, pictogram-based communication, instant messaging services.

INTRODUCTION
Communication is the basis of human relations as it allows people to exchange information and convey feelings. For the last fifty years means of communication have rapidly evolved thanks to the progress of technology, thus changing the way people interact and leading to a new understanding of social relations. Nowadays mobile communication devices and social networks [4] allow users to ubiquitously keep in touch with their family and friends and share their experiences and feelings in a fast and easy way.

But disabled people have not yet started to benefit from such (r)evolution due to two main reasons. First of all, disabled people suffer from inner communication limitations depending on the type and degree of their condition; e.g. people with Down syndrome have written and spoken language impairments. Secondly, modern electronic communication devices pose an important accessibility barrier due to the design of its user interfaces; e.g. for people that suffer from cerebral palsy it is difficult to use the keyboard or mouse as input devices to a personal computer. These limitations affect self-esteem and reduce self-sufficiency of disabled people, thus increasing the risk of suffering social exclusion. Moreover, not being able to use modern communication technologies also increases the risk of suffering digital exclusion.

Therefore, approaching new communication technologies to disabled people is crucial to enable their personal and social development in the digital era. This is the main objective of Messenger Visual: to reduce the social and digital gap of people with cognitive impairments by means of using a pictogram-based instant messaging service.

NordiCHI 2010, October 16–20, 2010, Reykjavik, Iceland.

RELATED WORK

Messenger Visual is built upon two main concepts, Instant Messaging (IM) and Alternative and Augmentative Communication (AAC), to build what is known as an assistive technology (AT); a technological device or piece of software that aims to help users with special needs in their daily life [3]. On the one hand, instant messaging [6] is a communications service that enables individuals to privately exchange real-time text messages with their relatives and acquaintances over a public data network, usually the Internet. Nowadays, instant messaging services are widespread around the globe and used by more than 100 million users. The most used instant messaging services are AOL Instant Messenger (AIM), Microsoft Messenger (MSN) and Yahoo! Messenger (YMSG), despite they are proprietary and not standardized. On the other hand, alternative and augmentative communication [2] is a set of methodologies to complement or replace written or spoken communications for people that have such abilities impaired, either temporarily or permanently, due to injury or illness. Alternative and augmentative communication combines both technological and non-technological elements to build messages that enable people to participate

more fully in their social roles and activities, including interpersonal interaction, learning, education and many others. One form of alternative and augmentative communications are pictogram-based languages [11], which are built upon images that represent objects, actions or ideas to ease communications for people with cognitive impairments that affect written or spoken language.

Considering the union of both concepts, Messenger Visual extends the use of instant messaging services to people with cognitive impairments by means of including pictogram-aided communication. To our knowledge there is no single project that has yet combined pictograms with an instant messaging service for such purpose. In [7] the authors use the idea of a pictogram-based instant messaging service, but their application is only used to investigate how people from different countries that do no share a common language can break communication barriers when using pictograms as the communication language. Another example is [8], in which the authors develop a pictogram-based communication aid to interact with the user, but in this case the device does not allow users to communicate with other users through an instant-messaging approach. Finally, Tee *et al.* [10] use pictograms to build a visual recipe book to help people with language impairments develop their cooking skills but, again, the aim of the project is not to enable user communications.

SERVICE ARCHITECTURE

This section presents the software architecture of Messenger Visual. As in other existing instant messaging services, our project is based on a client/server architecture and uses a MVC (Model-View-Controller) design pattern with three layers –communication, data and presentation– to enable the software to be flexible, extensible and scalable. Also, to ensure interoperability among different operating systems, the entire project has been developed using Oracle Java 2 SE technology.

Communications layer

The communications layer, represented in Figure 1, allows users to login to the instant messaging service, see their contacts presence status and exchange real-time messages. To support such requirements we use the Extensible Messaging and Presence Protocol (XMPP) [9], an open instant-messaging protocol standardized by the IETF (Internet Engineering Task Force) in RFC (Request For Comments) 3920 [5]. XMPP uses decentralized client/server architecture, with the server acting as a relay, that enables reliable and scalable presence updates and message delivery between users. The protocol also addresses the authentication and privacy issues of using an instant messaging service in a public data network such as the Internet. To implement the communications layer we use OpenFire as the instant messaging server and the Smack API (Application Programming Interface) to implement the client communication primitives in Java.

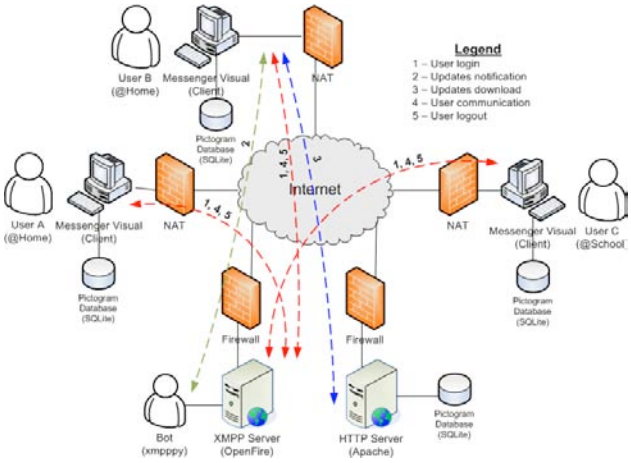

Figure 1. Messenger Visual client/server communications architecture based on the XMPP protocol. An XMPP server on the Internet allows users to login and exchange both presence status and communication messages. On the other side the users' client, developed in Java, provides a graphical interface to communicate to other users using pictogram-based messages that are represented using an XML syntax. Finally, an HTTP server enables pictogram database updates triggered by an XMPP bot.

Data layer

The data layer is built upon the communications layer and serves two basic purposes: storing pictograms in a database and representing pictogram-based conversations between users. On the one hand, within the database, pictograms are classified into different categories according to their common characteristics and stored together with other relevant information, e.g. pictogram name. For instance, the pictogram corresponding to the word *sun* is classified into the *weather* category and includes the written representation so that it can be used in the user interface to ease comprehension of users not familiar with a pictogram-based communication system. To implement the database we use SQLite, an embedded relational database management system available on the public domain. On the other hand, to transmit pictogram-based messages using the communications layer we have designed and implemented an *ad hoc* message description syntax based on XML (eXtensible Markup Language) that is both flexible and lightweight. This enables to easily add new features to the service while maintaining a low bandwidth footprint on the Internet connection.

Presentation layer

The presentation layer, depicted in Figure 2, is built upon the data layer and presents the user with an interface that allows executing the basic tasks of an instant messaging service; logging in to the service, sending and receiving messages from other users, etc. As in other instant messaging clients, the interface is divided intro three main windows: login window, contacts window and dialogue window. All along the presentation layer, written language has been replaced by pictograms to enable cognitively

Figure 2. Dialogue window allows users to communicate by means of exchanging pictograms. The user interface is made up by five key elements. The top row contains the categories in which pictograms are classified. The left column contains the most frequent pictograms in a conversation. The right matrix contains the pictograms that belong to the active category. The central part contains the actual conversation. Finally, the bottom row contains the pictogram input space to write a message.

impaired users interact with the software without reading or writing; for instance, passwords are introduced by using a combination of pictograms to form a passphrase. The pictograms used in the project are those provided by ARASAAC (Aragonese Portal of Augmentative and Alternative Communication) [1] instead of the proprietary PCS (Pictogram Communication Symbols) or Bliss pictograms [11]. ARASAAC pictograms are distributed under a Creative Commons (BY-NC-SA) copyleft license that allows free use and distribution as long as the credit is given to the authors, there is no commercial profit and the derivative works are shared under the same license.

EVALUATION PROCEDURE

Despite the fact that Messenger Visual is still at an early development stage, at this moment it is already in use at Fundació El Mareme, a non-profit social institution that promotes the education and integration of cognitively impaired people and their families. There are currently two groups of users with different types and degrees of cognitive impairments, five and six users in each group respectively, who are holding one-hour fortnightly sessions to evaluate the social and technical aspects of the project (Figure 3). To resemble the physical distance of instant messaging communication the two groups are located in separate rooms and chat to users in the other room. For the sessions we only use a reduced subset of around four hundred pictograms classified into fourteen different categories to help users become familiar with the communication environment. The pictograms and categories have been chosen with the guidance of a pedagogue to cover the basic conversational vocabulary. Finally, all the sessions are supervised by social educators that are responsible of instructing the users in their task and of taking notes of relevant events that are then used as feedback by engineers and pedagogues to improve the software and the evaluation protocol.

After three months, the first qualitative results show that users are able to communicate using the pictogram-enabled instant messaging service and that, according to a conducted survey, they find it both interesting and entertaining. Nevertheless, during the tests we have observed two remarkable aspects:

- It makes a significant difference whether users know a real-world analogy of the instant messaging paradigm before making use of it. Those who are previously presented with the post-office metaphor –including the message, the envelop and the postman– find it less frustrating to communicate using the computer than those who did not receive such explanation beforehand. We believe that this is strongly related to the user not fully realizing that the person on the other side of the conversation was actually reading or composing a message. To overcome this situation we plan to add chat state notifications in future versions of the software.
- User communicate skills are relevant to the ability to make use of the pictograms to communicate, but in another sense than we expected at first. Users with higher communicative skills tend to form more elaborated messages, thus spending more time in the process, whereas users with lower communicative skills make simpler messages that are faster to be built and easier to be read. Therefore, having more elaborated messages has a negative impact on communication interactivity, which, in the end, causes frustration to the users waiting for an incoming message. To overcome this situation we plan to arrange the users chatting to each other according to their communicative skills in future experiments.

Figure 3. A group of cognitively impaired users during the evaluation procedure. Juan, the social educator, instructs them how to use Messenger Visual to communicate using pictograms and takes notes that will be used as feedback.

FUTURE WORK

It has now been over a year since we started designing, developing and evaluating the project. Today we already have a working prototype and an evaluation protocol that allows us to study how users with cognitive impairments use the instant messaging service to communicate. But at this moment of time there are still many issues that remain to be implemented and explored.

From the software point of view, and considering that the evaluation results obtained so far are only subjective, the next step is to implement a statistical module that will allow us to gain quantitative knowledge about how the users communicate by using the pictogram-enabled instant messaging service. Our plan is to focus on relevant metrics such as the mean time to write a message, the average length of a message or the top-used pictograms in a dialogue to investigate how users become familiar with the interface, the pictograms and the categories, as well as how using a pictogram-enabled instant messaging service affects interactivity and responsiveness between the users.

With regard to the evaluation procedure we have plans to extend the experiments to new groups of users within the institution as well as to conduct experiments with users at their homes, where they will be able to interact with their relatives and acquaintances in daily situations. In this way we will have the opportunity to gain insight into how users communicate with the instant messaging service in a more realistic environment. Overall, this will allow us to extract valuable conclusions about how different kinds of cognitively impaired users use Messenger Visual to communicate in different situations, which, in turn, will be key to improve certain parts of the user interface according to their requirements.

CONCLUSIONS

This paper has introduced Messenger Visual, an instant messaging service that uses pictogram-based communications to reduce the digital gap of people with cognitive impairments. According to the results of our preliminary evaluation we conclude that the application has a great potential to improve communicative capabilities of its users, as well as to enable their personal and social development. All in all, the most valuable findings of our study are that a beforehand real-world analogy of the instant messaging paradigm helps users to understand the communication framework they are involved in, and that the user communicative skills are relevant to the ability to use the pictograms to communicate. Nevertheless, more development and research needs to be conducted to further enhance the service functionalities and to understand its implications regarding the target collective.

Finally, we believe that the benefits from the service can be easily extended to people with other types and degrees of disabilities if the user interface is properly adapted. For instance, users with reduced mobility could benefit from the sweep-and-click technique to select the pictograms using a switch or people with visual impairments could take advantage of integrated pictogram-to-speech features.

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APPENDIX B. IWAAL 2011

This appendix includes the long article "*Developing Messenger Visual, a pictogram-based IM service for individuals with cognitive disability*" that has been submitted to be presented at International Workshop on Ambient Assisted Living (IWAAL) the following June in Málaga, Spain. IWAAL is ranked as a B conference according to the Australia CORE ranking.

Designing Messenger Visual, an Instant Messaging service for individuals with cognitive disability

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Abstract. Considering the importance of Internet-based communications in our society, the lack of Instant Messaging (IM) services adapted to individuals with cognitive disabilities that have difficulties to use written language creates a situation of exclusion that has a negative impact on their daily lives. To alleviate this situation we present Messenger Visual, an IM service that uses pictograms as the main communication system. Along the paper we introduce the main design aspects of an IM service to support pictogram-based communications, as well as the design and evaluation aspects of an IM client that takes into account both the pictogram-based communication and the user interface accessibility requirements of individuals with cognitive disabilities.

Keywords: instant messaging services, augmentative and alternative communication, cognitive disability, user-centered design.

1 Introduction

Almost ten percent of the world's population lives with some type of disability [1]. One common aspect of individuals who have a disability is that they are prone to be excluded from society due to their condition. And despite efforts are being put to bridge the gap the exclusion situation is still far from being optimal, especially if we consider the digital society we are embracing. Today, albeit the shift from analog to digital technology has eliminated some accessibility barriers [2] as information can now be easily transformed into different formats, individuals that live with a disability are also left apart from the digital society because most technology still fails to meet their accessibility requirements [3]. This situation needs to be addressed, as it reduces the independence of disabled individuals and causes social isolation.

One prime example of digital exclusion are individuals with cognitive disabilities, who due to their condition suffer from attention, memory and language impairments that difficult daily activities such as task planning and information processing [4]. Despite most of them is capable of using technological devices [5] the software that enables access to Internet services, such as web browsers to access the World Wide Web (WWW), fails to take into account their requirements. For instance, the user interface of mainstream web browsers, such as Internet Explorer or Mozilla Firefox, uses abstract concepts like tabs that are not easy to understand for such users. And the remaining Internet services, such as email or instant messaging, are not in a better state if we consider that information is usually presented in a textual format.

This situation can be improved by developing user-centric software that takes into account the requirements of individuals with cognitive disabilities. This enables them to participate in the digital society [6], thus improving their independence and reducing social exclusion. For example the WWAAC (World Wide Augmentative and Alternative Communication) project [7], funded by the European Union, developed a WWW browser that uses pictogram-based Alternative and Augmentative Communication (AAC) to represent the information. But, to our knowledge, today there is no single Instant Messaging (IM) service that meets the communication and user interface requirements of individuals with cognitive disabilities.

In this paper we present Messenger Visual, an IM service that enables individuals with cognitive disability to communicate over the Internet. The main differential aspect of Messenger Visual is that it replaces textual messages with pictograms-based messages, while providing the basic functionality of an IM service. We have also developed an IM client that takes into account the user interface accessibility requirements of individuals with cognitive disabilities. Finally, we have also evaluated the IM client using a user-centered approach, where users with cognitive disability have tested Messenger Visual as a regular activity.

The rest of the paper is organized as follows. Section 2 gives background related to the topics of the paper. Section 3 presents the design of a pictogram-based IM service to enable people with cognitive disability to communicate over the Internet. Section 4 presents the design of a pictogram-based IM client using a user-centered approach. Finally, Section 5 states the conclusions outlined from the development and evaluation of the project, and identifies the work that remains to be done in the future.

2 Related work

IM services [8] are designed to enable users to exchange near real-time presence information and text-based messages over a public network, usually the Internet, to communicate with their contacts. In general IM services rely on a client-server architecture to operate; IM servers provide features such as user access control and message routing, whereas IM clients provide a graphical interface for users to communicate. Nevertheless, IM services have evolved and now provide features other than text-based communication, such as audio and video chat, file transfers and shared desktop, among many others.

Today most IM services are run by Internet-based companies, such as AOL, Yahoo and Microsoft. The protocols that support such IM services, as well as the clients that enable users to communicate, are proprietary and their specifications are not publicly available. To provide for an open alternative the IETF (Internet Engineering Task Force) had different groups dedicated to Internet-based IM services, obtaining a general model which was later adopted by two IM protocols, namely SIMPLE (SIP for Instant Messaging and Presence LEveraging) and XMPP (eXtensible Messaging and Presence Protocol). SIMPLE provides a set of extensions to SIP (Session Initiation Protocol) to support IM services, whereas XMPP derives from Jabber, an IM protocol based on XML (eXtensible Markup Language) which was initially designed by the open-source community [9].

Augmentative and Alternative Communications (AAC) [10] is a set of methodologies to complement or replace written or spoken communications for those individuals that have such abilities impaired, either temporarily or permanently, due to injury or illness. One form of AAC are pictogram-based communication systems, which are built upon drawings or images that represent real objects or abstract concepts to enable individuals share internal states, feelings, ideas and experiences. Communication using pictograms usually consists of individuals selecting elements from a set of possibilities with the aid of an Assistive Technology (AT), which can either be low or high technology (i.e. a cardboard or a computer).

Today there are many different pictogram-based communication systems, which are usually classified according to their transparency level; the level of resemblance between the pictograms and the objects or concepts they represent [10]. For instance, Rebus is a pictogram-based language developed by Woodcok to teach reading to children. PIC (Picture Ideogram Communication) was developed by Maharaj and its main characteristic is they have a reverse contrast, i.e. white on black. Blissymbols was developed by Karl Blitz and is based on the ideographs of Chinese writing. Finally, PCS (Picture Communication Symbols) was developed by Roxana Mayer-Johnson and today is one of the most widely thanks to its transparency level.

3 Design of a pictogram-based Instant Messaging service

This section presents the design of Messenger Visual, an IM service that uses pictograms as the main communication system. As any other IM service Messenger Visual shall support all the basic IM features [8], such as creating user accounts and logging in to the service, as well as adding/removing contacts, sending/receiving presence updates and sending/receiving messages to/from users in the contact list. To implement the basic IM features of Messenger Visual we use XMPP (eXtensible Messaging and Presence Protocol) [11] because it is based on standards and provides a decentralized client-server architecture that is flexible, scalable and secure. But the fact that Messenger Visual shall support pictograms as the main communication system adds additional requirements to the IM service. These requirements and the methodology to integrate them into the IM service are described next.

The first requirement of a pictogram-based IM service is that users shall have a pictogram set available to communicate. To support such requirement there are two

alternatives; having a personalized set of pictograms for each user or having a pictogram set that is shared among all users. The former allows pedagogues to define exactly which pictograms each user should have and to tailor it according to their learning process, whereas the latter gives more freedom to the user as they have the chance to access all the pictograms to communicate. Nevertheless, both approaches have counter sides. On the one hand, having a personalized pictogram set might limit conversations between users as some pictograms might not be available to some users. On the other hand, including a complete pictogram set may have a negative impact on interactivity, as users might need to spend more time browsing for pictograms. But considering that actual trends in pictogram-based communication state that users should have a full set of pictograms available to communicate in order to promote their independence and support their learning process, we decided together with pedagogues to have a shared pictogram set among all users.

Taking into account that pedagogues shall select the pictographic system that is most suitable to users according to their personal preferences and previous knowledge, the second requirement of a pictogram-based IM service is that it shall remain independent of the pictographic system that users use to communicate. Furthermore, considering that elements within the pictographic system include both graphical and textual representation of the pictogram itself, the IM service shall also remain independent of the textual representation of such pictograms. To satisfy this design requirement we have developed a syntax based on XML (eXtensible Markup Language) that is able to represent pictogram-based messages unequivocally. Despite both XML and JSON (JavaScript Object Notation) are platform and language neutral, we have decided to use the former instead of the latter because it has better support for internationalization, i.e. textual representation of Chinese characters, and parsers are readily available. The XML syntax, shown in Figure 1, defines that each pictogram-based message is represented by a message element, which may contain one or more pictogram elements to represent pictograms within the message.

```
<message from="carolnogueras@messengervisual.net" to="isaacfernandez@messengervisual.net">
  <pictogram id="34" category="beings" text="you" />
  <pictogram id="67" category="actions" text="go" />
  <pictogram id="82" category="places" text="cinema" />
  <pictogram id="54" category="time" text="tonight" />
  <pictogram id="29" category="questions" text="question_mark" />
</message>
```

Fig. 1. Pictogram-based message representation using XML. A message element has a source and a destination and is composed of one or more pictogram elements. Each pictogram element contains a unique identifier, as well as the category it belongs to and the text associated to it.

Finally, considering that the vocabulary included in the pictogram set may change over time, the third requirement of a pictogram-based IM service is that it shall provide means for pedagogues to update it. Two alternatives have been considered regarding the architecture to enable automatic pictogram updates; a centralized and a distributed approach. In the centralized architecture the pictograms set is stored in a server and retrieved by IM clients on demand. In contrast, in the distributed architecture each IM client has a local copy of the pictogram set that is synchronized with the server. In spite of requiring an additional synchronization mechanism, as pictogram set updates needs to be notified to IM clients, we have decided to use a

distributed architecture because it reduces the network bandwidth requirements as pictograms are readily available to clients. To implement the pictogram set we use a relational database instead of separate files organized into different folders, because it is easier to maintain and offers performance advantages [12]. Finally, the protocol to enable pictogram database synchronization is based on XMPP to distribute update notifications among IM clients and HTTP (HyperText Transfer Protocol) to retrieve the pictogram database from the server, as represented in Figure 2.

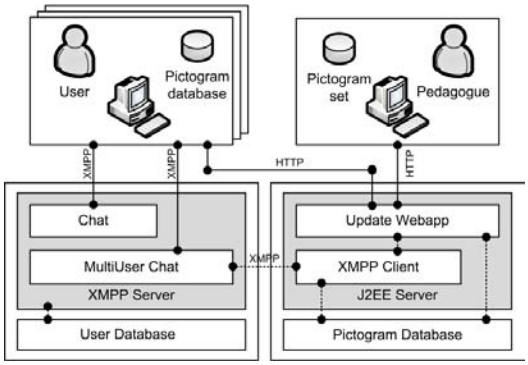

Fig. 2. Messenger Visual service architecture. XMPP supports the basic IM features, as well as pictogram-based communications and pictogram database update notifications. Whenever an update is triggered clients download the pictogram database from the server using HTTP.

4 Design of a pictogram-based instant messaging client

The next step to enable individuals with cognitive disabilities communicate using the pictogram-based IM service is develop an IM client that meets pictogram-based communication requirements and provides a user interface that suits user requirements. As a first step, the requirements for a standard IM client were analyzed. In this sense, we found that the user interface of an IM client is organized to provide for a series of basic functionalities, such as access control, contacts management and chat conversations [8]. Although a first prototype of the IM client had already been implemented [13] it didn't completely meet the requirements of cognitively disabled users and, thus, required further analysis and development.

From this analysis we decided that the user interface should be organized with the same structure as a common IM client. Taking end user capabilities into account, the user interface should also be limited only to the strictly necessary elements to carry out the actions that users can perform in an IM service. Moreover, the user interface should be designed to be as simple as possible, avoiding the use of complex metaphors and without including hidden or implicit elements. In this sense, the user interface should be an almost completely visual interface. Written language might be included, but only as a support for social educators and users with some written language communication skills. Furthermore, elements in the user interface should be organized according to the requirements of the pictographic system, i.e. categories.

Albeit the IM service has been designed to remain independent from the pictographic system employed by users to communicate, we have initially decided to use a specific pictogram set as the IM client is to be evaluated with users at Fundació El Maresme, a non-profit organization that intends to promote the social integration of users with intellectual or cognitive disability and their families. To decide which set of pictograms should be used, we considered that users are already familiar with PCS (Picture Communication Symbols) because they use a piece of software called Boardmaker [14] in their daily activities. But considering the fact that PCS pictograms are licensed, and taking into account that ARASAAC (ARAgoneSe portal of Augmentative and Alternative Communication) pictograms [15] are similar but licensed under a Creative Commons BY-NC-SA license, we have finally decided to implement ARASAAC as the pictographic system of Messenger Visual.

The design of the IM client using a user-centered approach with users from Fundació El Maresme was conducted in fortnightly one hour long sessions that lasted for six months. During the sessions users were located in different rooms to resemble physical distance and pedagogues and social educators were present. These sessions served to evaluate the IM client in order to provide feedback about its possible shortcomings. After some iteration in the user interface design process, a first fully functional prototype that met all of the abovementioned requirements was developed.

To enforce access control the IM client provides two different windows, as shown in Figure 3. First of all, the login window allows users to select their profile from a matrix of local user profiles stored in the computer. The window also provides a mechanism to create a user account or add an existing account to the local user profiles. Once users have selected their profile they must provide their passphrase in the password window to log in. Considering usability requirements the passphrase is based in a combination of four numeric digits represented by pictograms.

Once users have logged in a window to manage contacts appears. The window contains a list with all the contacts that are currently online and is updated whenever a contact logs in or logs out. Taking into account usability requirements the contacts in the list are represented by the user picture and full name. The contact window also provides a mechanism to add and remove contacts from the list. To start a new conversation with a contact from the list a user has to click on the contact picture.

Finally, the chat window allows users to communicate by means of exchanging pictogram-based messages. According to the ARASAAC pictogram structure, the top of the interface contains the categories in which pictograms are classified. On the left side the most frequent pictograms appear in order to easy the composition of common messages. On the right side the pictograms that belong to the active category are displayed. On the bottom lies the pictogram input space to write a message. Finally, the central part of the window contains the actual conversation the user is holding.

Fig. 3. Messenger Visual client user interface. The login window enables individuals to select their profile using a picture from the local user profile matrix, whereas the password window enables users to type in their four-digit numeric passphrase using pictograms.

5 Conclusions and future work

This paper has presented Messenger Visual, an IM service that enables individuals with cognitive disability to communicate over the Internet using pictogram-based messages. Along the text we have described and discussed the decisions to make Messenger Visual support the basic requirements of an IM service, as well as how we have enabled support for pictogram-based communications. We have also presented an IM client adapted to the requirements of individuals with cognitive disability and we have evaluated it using a user-centric approach. The evaluation has provided feedback that indicates that cognitively disabled individuals are able to communicate using pictograms, thus enabling social interaction and promoting digital inclusion.

Nevertheless, during the evaluation we have detected that some parts of the IM client user interface might need to be changed in order to increase usability. Some elements present a functionality that can be interpreted in different ways, thus becoming a possible source of confusion to users. For instance, buttons to navigate the contact list at the contact window operate in an up and down fashion, whereas buttons to navigate categories and pictograms in the chat window operate in a left and right fashion. Despite we have not observed important difficulties using such interface elements during the evaluation, we believe that redesigning those elements to provide more consistency will lead to an interface that is more usable by individuals.

Finally, all the knowledge we have today about how individuals with cognitive disability use Messenger Visual is based on qualitative research methods, such as interviews and ethnography. Thus, we are developing a tool to automatically collect and process statistical information about how users interact with the IM client user interface to communicate. For instance, we plan to explore parameters such as the average number of pictograms per message or the percentage of pictograms that users

require in a conversation. This information, collected over time, will provide a deeper understanding of how users with cognitive disability communicate using pictograms.

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APPENDIX C. UMAP 2011

This appendix includes the short article "*Modeling individuals with written language related cognitive disabilities to personalize a pictogram-based Instant Messaging service*" that has been submitted to be presented at the Doctoral Consortium of the User Modelling, Adaptation and Personalization (UMAP) conference the following July in Girona, Spain. UMAP is ranked as a B conference according to the Australia CORE ranking.

Modeling individuals with written language related cognitive disabilities to personalize a pictogram-based Instant Messaging service

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Abstract. Individuals with cognitive disabilities may be excluded from the information society because mainstream software and information present in such media does not meet their accessibility and communication requirements. To improve this situation, we have successfully developed and evaluated Messenger Visual, an IM service that replaces written communications with a pictographic communication system and provides a user interface that has been designed taking into account the accessibility requirements of the final users of the service. But considering the great diversity of individuals with cognitive disabilities, the only chance to provide a user interface that is correctly adapted to the requirements of each individual is through modeling and personalization. In this sense, it is necessary to develop appropriate guidelines for developing user interfaces that are better suited to the requirements of the target collective.

Keywords: Cognitive disabilities, Augmentative and Alternative Communication, Pictographic communication systems, Instant Messaging services, User modeling, User interface personalization.

1 Introduction

Today individuals with cognitive disability may become excluded from the information society as many of its services, e.g. the World Wide Web (WWW), are not properly adapted to their requirements [1]. On the one hand, their condition poses additional user interface accessibility requirements that are not met by mainstream software, e.g. web browsers. On the other hand, most communications in the Internet are based on the use of written language, which in some cases further limits their ability to access the information present in such media. This digital exclusion situation limits the autonomy of individuals with cognitive disability and increases their social isolation.

One alternative to overcome this exclusion situation is to adapt or develop new software that takes the accessibility requirements of individuals with cognitive disabilities into account. For instance, user interfaces that use complex metaphors should be avoided as it may be cause cognitive overload to the user. But adapting the user interface of the software is not enough, especially considering the

communication requirements of individuals with cognitive disabilities. Therefore, Augmentative and Alternative Communication (AAC) [2], such as pictographic communication systems, need to be introduced in the software as a replacement for written language. Up to today, different proposals have been made in this direction. For instance, the World Wide Augmentative and Alternative Communication (WWAAC) project [3] developed a pictogram-based web browser for individuals with cognitive disability. Another interesting project is the Mejla Pictogram [4], a pictogram-based electronic mail client for individuals with cognitive disability.

But there are some information society services that have not yet been adapted or created with support for individuals with cognitive disability. One of these cases is Instant Messaging (IM) services [5], which are designed to enable users exchange near real-time presence information and text-based messages through the Internet to communicate. In this direction we have developed Messenger Visual [6], an IM service based on a pictographic communication system and an IM client that takes into account the user interface accessibility requirements of individuals with cognitive disabilities to enable them communicate with their relatives and acquaintances. Nevertheless, considering the great diversity of individuals with cognitive disabilities, there is a need for personalization of the user interface to provide with a valid alternative for a larger portion of the population [7]. But designing a user interface for individuals with cognitive disability is a difficult task, mainly due to the lack of suitable design guidelines.

2 Adapting an Instant Messaging service to individuals with cognitive disabilities

In order to adapt an IM service to the requirements of individuals with cognitive disability we have followed a twofold approach. On the one hand, we have replaced written communication with a pictographic communication system to suit their communication requirements. On the other hand, we have properly adapted the user interface of the IM client to suit their accessibility requirements. With this approach we have successfully implemented Messenger Visual and evaluated it with two groups of individuals from Fundació El Maresme, a non-profit organization that promotes the social integration of individuals with cognitive disabilities.

To evaluate how individuals with cognitive disabilities use Messenger Visual to communicate using pictograms, we have organized fortnightly one-hour long sessions with two groups of individuals with different types and degrees of cognitive disability. To extract conclusions from the evaluation we have used two qualitative research methods. On the one hand, we have used ethnography to become involved in the sessions and observe how individuals with cognitive disability interact with the user interface to communicate using pictograms. On the other hand, considering the communication limitations of individuals with cognitive disability [8], we have conducted semi-structured interviews with pedagogues and social educators.

The results of our research confirms that all the users that have participated in evaluating Messenger Visual have been able to communicate using pictograms by means of interacting with the user interface of the IM client. Nevertheless, our

observations also show that, even in groups of individuals that have a similar level of cognitive disabilities, there is a huge diversity in pictographic system communication skills and their ability to interact with the user interface of the IM client.

3 Modeling individuals with cognitive disability to personalize the Instant Messaging client user interface

Considering the huge diversity of individuals with cognitive disabilities that may use Messenger Visual, it seems fairly necessary to develop mechanisms that enable personalizing the user interface of the IM client. The ultimate objective of personalizing the user interface is to better adapt the IM client user interface to the accessibility requirements of individuals with cognitive disability.

The first step towards personalizing the user interface of the IM client is to model the requirements of different individuals with cognitive disability. For instance, there are individuals with cognitive disabilities that are able to read textual messages, whereas others are unable. With this approach, different generic profiles that contain the basic requirements of the user interface can be created. As an example, a user profile may determine that the user requires from textual representation of the different user interface elements, i.e. the pictograms, in order to promote his/her learning process.

Once the generic user profiles have been created taking the diversity of individuals with cognitive disabilities into account, a syntax to describe the requirements of such profiles needs to be defined. The syntax to describe user profiles has to fulfill two basic requirements. On the one hand, it shall be able to describe all the elements of the user interface that may require from personalization and which types of personalization allow. On the other hand, the syntax must enable a quick processing by software, as it will have to be processed each time the IM client is started. In order to define the syntax, we plan to use eXtensible Markup Language (XML), that offers both language flexibility and ease for machine interpretation. Finally, after the syntax to describe user profiles has been defined, a module capable of adapting the user interface according to the requirements specified in the profile is to be developed.

4 Conclusions and planned work

Up to today, the main contributions of our work have been the design and evaluation of a functional IM service that replaces written communications with a pictographic communications system suitable for individuals with cognitive disability that lack of written communication skills. To our knowledge, this is the first IM service with such characteristics and, during the process, we have had to overcome two main problems that were not previously pointed out. On the one hand, we had to adapt the IM service to meet the requirements of pictographic communication systems. Adapting the IM service has supposed developing a pictogram representation syntax which, in turn, has required that all IM clients must share the same pictographic system. On the other

hand, we had to personalize the IM client user interface to suit the accessibility requirements of different end user profiles.

In order to gain better understanding of how individuals with different cognitive disabilities related to written language profiles communicate using pictogram-based messages, we are currently developing a logging system that enables us to capture information about how users interact with the IM client user interface in a real-world environment. The aim of this approach is to receive feedback on how users communicate with each other in order to detect previously not considered user interface related problems [9]. This approach will be complemented with interviews with pedagogues and final users whenever possible.

Evaluation performed in real world environment has pointed out that even in user groups with similar cognitive disability levels, there is a great diversity regarding individual written language skills. Issues related to computer usage have also raised a question regarding user performance with the IM client user interface. All this facts have proven the necessity to provide proper adaptation mechanisms to personalize the user interface for the full range of potential users. With this in mind we plan to classify the different user profiles, according to their written communication and computer usage skills, and then create a syntax that enables to describe such user profiles using a machine readable format. Based on the user profile described using this syntax, the user interface of the IM client can be personalized to better suit the specific requirements of each individual. Finally, from the experience gained through adapting the IM client, we plan to develop appropriate guidelines to help software designers creating user interfaces that are better suited to the requirements of individuals with written communication related cognitive disabilities.

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