Estudo e Proposta de um Framework para o Design de Interfaces de Usuário Ajustáveis

Este exemplar corresponde à redação final da Tese devidamente corrigida e defendida por Vânia Paula de Almeida Neris e aprovada pela Banca Examinadora.

Campinas, 01 de julho de 2010.

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Tese apresentada ao Instituto de Computação, UNICAMP, como requisito parcial para obtenção do título de Doutor em Ciência da Computação.

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"A diversidade é o local da arte".

Albert Camus (1913-1960), escritor francês.

Resumo

A socialização dos sistemas computacionais trouxe um desafio a mais para os pesquisadores de Interação Humano-Computador: como prover interfaces que propiciem acesso ao maior número possível de usuários independentemente de suas capacidades sensoriais, físicas, cognitivas e emocionais? Um dos caminhos que se apresenta é desenvolver sistemas flexíveis, i.e. que permitam modificações em seu comportamento durante a interação, oferecendo ao usuário a possibilidade de ajustar a interface de acordo com as suas preferências, necessidades e situações de uso.

O design de interfaces flexíveis, que façam sentido e sejam acessíveis a mais pessoas, demanda abordagens que permitam conhecer e formalizar os diferentes requisitos de interação, definir funcionalidades e determinar o comportamento ajustável do sistema. Soluções encontradas na literatura relacionadas ao tema interfaces ajustáveis, (ou *tailoring* em inglês) enfatizam questões relacionadas à infra-estrutura necessária para o ajuste, não tendo sido encontrados trabalhos que apoiassem os designers de forma prática durante o processo de concepção dessas interfaces. Esta tese propõe e apresenta um *framework* para o design de interfaces de usuário ajustáveis, denominado PLu*R*aL. O termo *framework* é utilizado aqui no seu sentido mais amplo como uma estrutura composta por diretrizes, mecanismos, artefatos e sistemas usados no planejamento e na tomada de decisões de design. O PLu*R*aL adota uma perspectiva sócio-técnica para a concepção das interfaces ajustáveis e uma visão abrangente dos requisitos de interação, incluindo aqueles que são controversos ou minoritários e advindos não somente de usuários, mas também de diferentes dispositivos e ambientes de interação. Aspectos semânticos, pragmáticos e o impacto social da interação também são considerados. Por fim, o comportamento ajustável do sistema é modelado utilizando-se o conceito de normas.

O referencial teórico–metodológico adotado para o trabalho de pesquisa envolveu as disciplinas de Interação Humano-Computador e Semiótica Organizacional. A construção do *framework* foi pautada por 2 estudos de caso envolvendo populações de usuário heterogêneas em contextos de sistemas de governo eletrônico e de rede social inclusiva. A validação do *framework* foi realizada com 17 designers e os resultados sugerem uma avaliação positiva considerando a utilidade, flexibilidade para apoiar mudanças, liberdade de criação e satisfação com as propostas de design resultantes.

Palavras-chave: Interfaces ajustáveis, *tailoring*, Design para Todos, Interação Humano-Computador, Semiótica Organizacional.

Abstract

The socialization of computer systems has brought a new challenge to Human-Computer Interaction researchers: how to design interfaces that provide access to as many users as possible regardless of their sensory, physical, cognitive and emotional characteristics? One approach to answer this question is to develop flexible systems, i.e. those that allow changes in their behavior during the interaction, offering users the possibility to tailor the interface according to their preferences, needs and situations of use.

The design of flexible interfaces, which make sense and are accessible to more people, demands approaches to understand and formalize the different interaction requirements, define functionalities and determine the system tailorable behavior. Solutions found in the literature about tailorable interfaces have focused on the infrastructure needed to offer flexibility and works to support designers in a practical way during the conception of such interfaces were not found. This thesis proposes and presents a framework for the design of tailorable user interfaces, named PLu*R*aL. The term framework is used here in its broadest sense as a structure consisting of guidelines, mechanisms, artifacts and systems used in design planning and decision-making. PLu*R*aL adopts a socio-technical approach to design tailorable interfaces and a comprehensive view for interaction requirements, including those that are controversial or from minority, and arising not only from users, but also from different devices and interaction environments. The semantic, pragmatic and social impacts of the interaction are also considered. Finally, the behavior of the tailorable system is modeled using the concept of norms.

The theoretical and methodological references adopted in this work involved the disciplines of Human-Computer Interaction and Organizational Semiotics. The framework's construction was guided by 2 case studies with heterogeneous populations, in the context of electronic government and inclusive social network system. The framework's validation was performed with 17 designers and the results suggest a positive evaluation considering the usefulness and flexibility to support changes, freedom to create and satisfaction with the final design proposals.

Keywords: Flexible interfaces, Tailoring, Design for All, Human-Computer Interaction, Organizational Semiotics.

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AJAX	Asynchronous Javascript And XML
CEP/FCM	Comitê de Ética em Pesquisa vinculado à Faculdade de Ciências Médicas da UNICAMP
CIDARTE	Cidadania com Arte. Cooperativa de artesanato da Vila União – Campinas/SP
CPqD	Centro de Pesquisa e Desenvolvimento em Telecomunicações
DOM	Document Object Model
FAN	Flexibility through Ajax and Norms. Nome de um framework para a implementação de soluções ajustáveis.
FAPESP	Fundação de Amparo à Pesquisa do Estado de São Paulo
FUNTTEL	Fundo para o Desenvolvimento Tecnológico das Telecomunicações
HCI	Human-Computer Interaction
ICE	Interface Configuration Environment
ICM	Interface Conceptual Model
ICT	Information and Communication Technology
IBGE	Instituto Brasileiro de Geografia e Estatística
IRC	Informatics Research Center
IT	Information Technology
LIBRAS	Língua Brasileira de Sinais
MEASUR	Methods for Eliciting, Analyzing and Specifying Users' Requirements
MONA	MOdelador de Normas para interfaces Ajustáveis
NAM	Norm Analysis Method
NBIC	Norm Based Interface Configurator
NIED	Núcleo de Informática Aplicada à Educação
OS	Organizational Semiotics
PACFILMO	Pessoa, Ação, Coisa, Freqüência, Interação, Local, Métodos ou meios, Objetivo. Nome de uma técnica que usa cartões para elicitação de seqüências de ações.
PAM	Problem Articulation Method
PD	Participatory Design

PHP	Hypertext Preprocessor. Linguagem de programação para aplicações web.
SAM	Semantic Analysis Method
SE	Software Engineering
SNS	Social Network System
SO	Semiótica Organizacional
SOAP	Simple Object Access Protocol
STID	Soluções de Telecomunicação para a Inclusão Digital
TIC	Tecnologias da Informação e Comunicação
UIAM	User Interface Abstract Model
UID	User Interface Design
UIML	User Interface Markup Language
UML	Unified Modeling Language
UNICAMP	Universidade Estadual de Campinas
WAI	Web Accessibility Initiation
W3C	World Wide Web Consortium
XML	eXtensible Markup Language

Capítulo 1

Introdução

Atualmente, diversos serviços vêm sendo oferecidos à população via computadores e internet como: pagamento de contas, comunicação com amigos e com instituições públicas e privadas, procura de empregos, acesso a informações, entre outros. No entanto, apesar da redução dos preços dos computadores, da implantação de telecentros e *lan houses* e da disseminação de telefones celulares, a grande maioria da população brasileira ainda não se beneficia desses serviços. O que se percebe é que as interfaces de usuário, da maneira como são concebidas hoje, não favorecem a interação da população de maneira geral ao não considerarem as diferentes necessidades dos usuários presentes na população.

Nesse contexto, este trabalho se propôs a investigar como desenvolver interfaces de usuário que atendam às diferentes possibilidades de interação, seguindo os preceitos do Design para Todos (Connell *et al.*, 1997). Um dos caminhos que se apresenta é desenvolver interfaces que sejam ajustáveis, i.e; que permitam modificações em seu comportamento em tempo de uso, para propiciar o acesso aos serviços à maior extensão possível de cidadãos.

Esta tese, composta por uma coletânea de artigos, reconstrói o caminho para a proposta e validação de um *framework* para o design de interfaces de usuário ajustáveis. Em especial, este primeiro capítulo apresenta de forma sintética na seção 1.1 o contexto, a motivação e a problemática tratados nesta tese. Já na seção 1.2 são especificados os objetivos e a abordagem de pesquisa utilizada e na seção 1.3 são apresentados os artigos que compõem esta tese.

1.1 Contexto, Motivação e Problemática

Participamos hoje no Brasil de um cenário de vastas diferenças sócio-econômicas, culturais, regionais e de acesso à tecnologia e ao conhecimento. Cerca de 26% dos brasileiros são considerados analfabetos funcionais[1], entendidos como a população com mais de 15 anos de idade e menos de 4 anos de escolaridade. De acordo com o censo de 2000, 14,5% da população tem algum tipo de deficiência[2] e dados do Ministério da Ciência

[1] http://portal.mec.gov.br
[2] http://mj.gov.br

e Tecnologia mostram que 54% da população nunca usaram um computador e 67% nunca navegaram na Internet[3].

De acordo com o 4º Desafio da Sociedade Brasileira de Computação[4] – Acesso Participativo e Universal do Cidadão Brasileiro ao Conhecimento, esse é um cenário para o qual não existem experiências nas quais possamos nos inspirar, onde o desafio é único: fazer com que as Tecnologias da Informação e Comunicação (TIC), via suas interfaces de usuário, beneficiem o conjunto dos cidadãos, promovendo o processo de constituição de uma sociedade mais justa e aberta às diferenças (Baranauskas e deSouza, 2006). Assim, se faz necessário estender os sistemas computacionais ao cidadão comum, em sua diversidade, respeitando suas diferenças. O mesmo desafio ressalta o design de interfaces de usuário como uma de suas principais motivações, apontando o Design para Todos e as interfaces ajustáveis como alvo de pesquisa de ponta na área de Interação Humano-Computador (IHC).

Abordagens mais tradicionais de design ainda se baseiam em um conjunto de habilidades padrão, desenvolvendo interfaces para os usuários médios, entendidos aqui como aqueles que se encaixam no desvio-padrão de uma distribuição normal de usuários. Fischer (2001) usa a expressão "mito do usuário médio" para se referir a isso. Seguindo os preceitos do Design para Todos (ou Design Universal) (Trace, 2006), devemos desenvolver sistemas que possibilitem o acesso ao conhecimento de maneira não discriminatória e que façam sentido para o maior número possível de usuários de acordo com suas capacidades sensoriais, físicas, cognitivas e emocionais. Além disso, as soluções de design devem preparar os usuários para a interação com outros sistemas computacionais, fomentando a autonomia e apoiando a inclusão digital.

Neste trabalho, investigamos soluções ajustáveis como uma maneira de viabilizar o Design para Todos, no contexto da diversidade brasileira, oferecendo ao usuário a possibilidade de modificar a interface de acordo com as suas preferências, necessidades e situações de uso.

Tailoring é a expressão utilizada na literatura para definir a atividade de modificar uma aplicação computacional de acordo com o seu contexto de uso (Kahler *et al.*, 2000). Sistemas que permitem *tailoring* oferecem aos usuários a possibilidade de ajustar o software às suas preferências pessoais ou a modificações nas tarefas, depois do sistema já ter sido implementado (Slagter *et al.*, 2001). *Tailoring* envolve o conceito de "projetar para a mudança", de tal maneira que os sistemas possam prover a flexibilidade de serem adaptados para atender a contextos organizacionais ou cenários de uso diferentes, não antecipados ou modificados (Henderson *et al.*, 1991). É importante ressaltar que atividades relacionadas ao conceito de *tailoring* não envolvem apenas mudanças estéticas nas interfaces de usuário como alteração de cor ou tamanho de fonte, embora as incluam também. A visibilidade de novas funcionalidades, que se tornem pertinentes em novos contextos de uso, bem como a otimização de tarefas também são possibilidades incluídas no conceito de *tailoring*.

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[3] CGI - Comitê Gestor de Internet, do Ministério da Ciência e Tecnologia, 2006.
[4] Grandes Desafios da Computação no Brasil 2006-2016. São Paulo, 8 e 9 de maio, 2006.

O design de sistemas ajustáveis demanda novas metodologias para lidar com os vários requisitos e funcionalidades que podem ser alterados durante o tempo de uso. Pesquisas no tema têm focado em questões técnicas relacionadas ao desenvolvimento dessas aplicações, por exemplo, em infra-estruturas necessárias para permitir os ajustes (cf. Bonacin e Baranauskas, 2005; Macías e Paternò, 2008). Alguns trabalhos investigam os fenômenos envolvidos em *tailoring*, como as razões que levam os usuários a modificar um sistema (cf. Mackay, 1990; Oviatt *et al.*, 2004; Rivera, 2005). Outros trabalhos exploram mecanismos específicos que permitem a adaptação utilizando menus e botões (cf. MacLean *et al.*, 1990, Park *et al.*, 2007). Há também trabalhos que classificam os diferentes tipos de adaptação (cf. Mørch, 1997, Neris e Baranauskas, 2007) e poucos discutem o design dessas aplicações (Germonprez *et al.* 2007; Wulf *et al.* 2008; Neris e Baranauskas, 2009a). Especialmente no âmbito do design, as pesquisas têm sido centradas em princípios para orientar os designers faltando, portanto, abordagens práticas com métodos e artefatos que apóiem o processo de concepção de interfaces ajustáveis.

1.2 Objetivo e Abordagem de Pesquisa

Frente à motivação de buscar soluções que apóiem o desenvolvimento de sistemas que façam sentido e sejam acessíveis aos cidadãos, o objetivo geral desta tese foi investigar novas soluções para o conceito de *tailoring*, de forma a auxiliar designers na criação de interfaces que se ajustem a diferentes cenários de uso, em particular aqueles com grupos heterogêneos de usuário. Nesse sentido, este trabalho propõe um *framework,* denominado PLu*R*aL*,* que apóia o projeto de interfaces ajustáveis adotando uma visão abrangente dos requisitos de interação, incluindo aqueles que são controversos ou minoritários e advindos de diferentes usuários, dispositivos e ambientes de interação. O termo *framework*[5] é utilizado aqui no seu sentido mais amplo como uma estrutura composta por diretrizes, mecanismos, artefatos e sistemas usados no planejamento e na tomada de decisões de design.

O PLu*R*aL está organizado em 3 pilares: o 1º (Descreva as necessidades) elicita os signos de interesse no domínio, sejam eles relacionados a usuários, dispositivos ou ambientes onde a interação pode ocorrer e formaliza requisitos não-funcionais que devem ser contemplados pela solução ajustável. O 2º pilar (Defina as funcionalidades) utiliza dois métodos da Semiótica Organizacional que permitem uma visão abrangente e consistente do domínio facilitando a especificação de funcionalidades. O 3º pilar (Determine o comportamento ajustável), a partir de diferentes representações de design, formaliza um conjunto de normas que especificam o comportamento ajustável do sistema.

A abordagem de pesquisa adotada incluiu uma revisão crítica da literatura, resultando em uma nova classificação para *tailoring* (Capítulo 2) e a proposta de *features*

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[5] O termo *framework* é definido pelo dicionário Cambridge como "*1. a supporting structure around which something can be built; 2. a system of rules, ideas or beliefs that is used to plan or decide something*". Aqui o termo já aparece instanciado no contexto da computação.

que as interfaces ajustáveis podem ter (Baranauskas e Neris, 2007). No entanto, para se alcançar o objetivo desta tese, se fazia necessário conhecer as diferentes competências de interação presentes na população brasileira. Nesse sentido, o conhecimento apresentado na literatura não foi suficiente e a estratégia adotada considerou a participação em 2 estudos de caso envolvendo populações de usuário heterogêneas e explorando os cenários de sistemas de governo eletrônico e de rede sociais inclusivas.

O primeiro estudo de caso foi realizado durante os meses de agosto de 2007 a março de 2008, no contexto do projeto STID – Soluções de Telecomunicação para a Inclusão Digital[6]. Trata-se de um projeto do CPqD-FUNTTEL que visava investigar soluções de telecomunicações para governo eletrônico, focando em usuários com baixo letramento, idosos e deficientes auditivos e visuais. Na etapa de "novos modelos e linguagem de interação", houve uma parceria do CPqD com o NIED – Núcleo de Informática Aplicada a Educação da Unicamp, que permitiu investigar soluções de design que fizessem sentido para o público-alvo do projeto. A abordagem adotada pelo grupo do NIED utilizou os referenciais da Semiótica Organizacional e do Design Participativo.

As atividades participativas foram conduzidas em um telecentro no bairro da Vila União, município de Campinas-SP, denominado Centro de Referência da Juventude (CRJ). Para se investigar as diferentes necessidades de interação, foi constituído um Cenário* - um grupo de 12 pessoas que pode ser entendido como um microcosmo da população, uma vez que foi formado levando-se em conta proporcionalmente a diversidade sócio-cultural da população brasileira. Considerando dados do IBGE[7], foram verificadas as porcentagens da população referentes a gênero, idade, grau de letramento e renda familiar e esses números foram utilizados para selecionar os usuários chamados a participar do grupo. Tal iniciativa contou com o apoio da Secretaria de Cidadania, Trabalho, Assistência e Inclusão Social, da Prefeitura de Campinas. Mais detalhes sobre a formação do Cenário* foram relatados por Baranauskas *et al.* (2008).

Vale ressaltar que, considerando as premissas do Design Participativo, um conjunto de 10 a 15 participantes tem tamanho e representatividade adequados para embasar os estudos de caso (Neris *et al.*, 2008, Baranauskas *et al.*, 2008). Além disso, a heterogeneidade no Cenário* foi aspecto fundamental para a investigação que se queria realizar. Alguns dos participantes, por exemplo, nunca haviam utilizado um computador, enquanto outros já possuíam experiência digital. A presença desses indivíduos digitalmente letrados é importante no Design para Todos, pois o sistema resultante deve atender a letrados e iletrados, pessoas com deficiência ou não, homens e mulheres, etc. Resultados advindos das atividades realizadas nesse primeiro estudo de caso são relatados no Capítulo 3 desta tese. Além desse, um conjunto de requisitos e diretivas de interação considerando a diversidade da população brasileira pode ser encontrados em Neris *et al.*, (2008).

O segundo estudo de caso foi realizado durante os meses de novembro de 2007 a abril de 2010, no contexto do projeto e-Cidadania: Sistemas e Métodos na Constituição de uma Cultura mediada por Computador, financiado pelo Instituto Virtual de Pesquisas

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[6] http://www.cpqd.com.br/1/4342+projeto-stid-telecentros-inclusao-digital-stid.html
[7] Instituto Brasileiro de Geografia e Estatística

FAPESP-Microsoft Research. O e-Cidadania visava investigar a constituição da cultura digital a partir da construção conjunta de soluções de interação e de interface considerando competências de usuários em nossa sociedade (incluindo analfabetos e pessoas com deficiência). Um conjunto de pesquisadores de diversas áreas, como computação, educação, mídias e antropologia, juntou-se a um conjunto de pessoas de diversos segmentos de organizações sociais locais, para design e desenvolvimento de um sistema de rede social inclusiva.

Um sistema denominado Vila na Rede[8] foi desenvolvido no âmbito do e-Cidadania, tendo também como referenciais a Semiótica Organizacional e o Design Participativo. Um conjunto de 15 usuários formado por representantes de grupos da comunidade como da Associação de Moradores, Cooperativa de Artesanato, Cursinho popular etc. foi convidado a participar do projeto. Mais detalhes sobre os perfis dos participantes podem ser encontrados em Hayashi *et al.* (2009).

A participação no e-Cidadania permitiu experimentar possibilidades para elicitação e formalização de requisitos de interação advindos da diversidade e melhor investigar a aplicabilidade do conceito de normas para a formalização do comportamento ajustável (Capítulo 4). Mais recentemente, o Vila na Rede tornou-se um sistema ajustável, utilizando o PLu*R*aL para o design e o FAN (*Flexibility through Ajax and Norms)* para a implementação. O FAN é uma infra-estrutura desenvolvida por Fortuna (2010) em um projeto de mestrado paralelo a esta tese. A proposta de ajuste, implementada no Vila na Rede, foi avaliada com usuários finais participantes do projeto e-Cidadania (Capítulo 6).

Além da participação nos 2 estudos de caso, esta tese foi beneficiada por um estágio no *Informatics Research Centre* (IRC) na Universidade de *Reading* – Inglaterra, entre os meses de novembro de 2008 e maio de 2009, sob a supervisão do Diretor do IRC, Prof. Kecheng Liu. O IRC é um centro de referência no estudo e aplicação do referencial da Semiótica Organizacional em diversas áreas como Engenharia de Sistemas, Prédios Inteligentes, *Benchmarking*, Computação Social e Informática em Saúde. Hoje, o IRC é parte da *Henley Business School* e desenvolve atividades de educação em pós-graduação com cursos de Mestrado acadêmico e profissionalizante e Doutorado. Também desenvolve atividades de pesquisa em parceria com indústrias oferecendo cursos de especialização e projetos para transferência de tecnologia. Trata-se de um ambiente multidisciplinar que reúne pesquisadores de diversas partes do mundo, o que beneficia a troca de experiências.

A realização do estágio no IRC foi fundamental para a formalização do PLu*R*aL. A participação nas diversas atividades de pesquisa como seminários, grupos de estudo e projetos com a indústria, aprofundou os conhecimentos em Semiótica Organizacional, mais especificamente nos métodos *Problem Articulation*, *Semantic Analysis* e *Norm Analysis* e no conceito de normas que embasam o *framework* proposto.

Por fim, após a formalização do *framework*, um estudo de viabilidade foi desenvolvido com 17 alunos da pós-graduação do Instituto de Computação da UNICAMP, que cursaram a disciplina de Semiótica da Interação Humano-Artefato Digital, oferecida no

[8] www.vilanarede.org.br

2º semestre de 2009. A formalização do PLu*R*aL e os resultados da avaliação são descritos no Capítulo 5.

Este projeto segue a Resolução 196/96 referente à ética em pesquisas evolvendo seres humanos, tendo sido aprovado pelo Comitê de Ética em Pesquisa vinculado à Faculdade de Ciências Médicas (CEP/FCM) da UNICAMP, sob o número de protocolo FR–108332.

1.3 Estrutura da Tese

Esta tese é composta por 8 capítulos, sendo que os capítulos 2, 3 e 4 apresentam artigos publicados em conferências. Os capítulos 5 e 6 apresentam artigos submetidos a periódicos e o capítulo 7 traz um artigo aprovado em conferência, mas ainda não publicado. O capítulo 8 conclui este trabalho. Na seqüência, são apresentadas as referências e sínteses ressaltando as contribuições dos artigos:

> [Capítulo 2] Neris, V. P. A.; Baranauskas, M. C. C. (2007) End-user Tailoring: a Semiotic-informed Perspective. In: International Conference on Organisational Semiotics (ICOS 2007), Sheffield-England, p. 47-53.

O levantamento bibliográfico realizado neste trabalho permitiu observar que as classificações propostas para *tailoring* focavam no esforço que o usuário deveria fazer para modificar o sistema (escolhendo parâmetros ou escrevendo código, por exemplo). No entanto, se pensarmos em *tailoring* como uma forma de atender a requisitos de interação bastante diversificados, como aqueles presentes na população brasileira, e com o foco de estender o uso de sistemas computacionais a um maior número de pessoas, se faz necessário adotar uma visão que considere o sistema inserido em um contexto social. Assim, esse artigo apresenta uma classificação para *tailoring* que tira o foco do esforço para ajustar e discute as possibilidades de ajuste considerando mudanças que podem acontecer nos três níveis do sistema de informação (informal, formal e técnico). A visão sócio-técnica explorada nesse artigo e a adoção da SO como referencial teórico embasaram as demais contribuições desta tese.

> [Capítulo 3] Neris, V. P. A.; Baranauskas, M. C. C. (2009b) Designing E-government Systems for All – A Case Study in the Brazilian Scenario. In: IADIS[9] International Conference WWW/Internet 2009, Rome-Italy, p. 60-67.

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[9] http://www.iadis.org

O Capítulo 3 relata uma parte dos resultados do 1º estudo de caso, no qual soluções de interface considerando também idosos e pessoas com deficiência foram geradas. O artigo apresenta um modelo de interação para sistemas de governo eletrônico e sua aplicabilidade para gerar soluções de design. No contexto desta tese, as soluções de design para uso em computadores *desktops* foram empregadas para estudos da infra-estrutura proposta por Bonacin et al (2007), que aplica o conceito de normas para gerenciar modificações nas interfaces. Alguns métodos e artefatos da SO, como a Escada Semiótica (Stamper *et al.*, 1998), e técnicas do Design Participativo, como o BrainDraw (Muller *et al.*, 2001), são utilizados para lidar com informações da diversidade, e que posteriormente foram incorporados no PLu*R*aL.

> [Capítulo 4] Neris, V. P. A.; Baranauskas, M. C. C. (2009a) Interfaces for All – A Tailoring-based Approach. In: International Conference on Enterprise Information Systems (ICEIS 2009), Milan-Italy. LNBIP-Enterprise Information Systems. Springer, 2009 v. 24. p. 928-939.

O Capítulo 4 relata a abordagem inicialmente adotada para se desenvolver protótipos ajustáveis do sistema Vila na Rede, no contexto do 2º estudo de caso. A abordagem considera atividades em 3 grandes fases do desenvolvimento de sistemas computacionais: elicitação de requisitos, design, e construção e validação. Como no 1º estudo de caso, as funcionalidades do sistema já haviam sido definidas pelo CPqD, aqui houve a necessidade de se conhecer melhor o domínio da aplicação (redes sociais inclusivas) e nesse sentido 2 outros métodos da SO foram empregados: *Semantic Analysis Method* (SAM) e *Norm Analysis Method* (NAM). Nesse momento, observou-se que a especificação de normas, complementando a modelagem semântica, aprofundava conhecimentos sobre o domínio e apoiava a especificação de funcionalidades. Essa experimentação foi fundamental para a formalização do 2º pilar do PLu*R*aL.

> [Capítulo 5] Neris, V. P. A.; Baranauskas, M. C. C. PLu*R*aL – a Framework for Designing Tailorable User Interfaces. Submitted to a journal.

O PLu*R*aL considera a interação entre usuários e sistemas computacionais como um fenômeno no que há um compartilhamento de signos e que é afetado por diversos fatores como: familiaridade com dispositivos, intenção de uso, questões afetivas e condições ambientais. Adotando uma visão sócio-técnica para o design de sistemas ajustáveis, o *framework* foi organizado em 3 pilares que apóiam o designer em descrever as necessidades de interação, definir as funcionalidades do sistema e determinar o comportamento ajustável. Os resultados de uso do PLu*R*aL sugerem uma avaliação positiva considerando sua utilidade, flexibilidade, liberdade de criação e satisfação com resultados.

[Capítulo 6] Neris, V. P. A.; Fortuna, F.; Bonacin, R.; Baranauskas, M. C. C. Addressing Diversity in Social Network Systems with a Tailoring-based Approach. Submitted to a journal.

O Capítulo 6 trata da utilização do PLu*R*aL e do FAN (Fortuna, 2010) para tornar o sistema Vila na Rede ajustável. O PLu*R*aL foi utilizado de forma participativa, e a elicitação de partes interessadas, a aplicação do SAM e NAM e o desenho de soluções ajustáveis contou com a participação de usuários. Após o design seguindo o PLu*R*aL, alguns recursos ajustáveis foram implementados usando o FAN, o que permitiu testar a viabilidade da solução com usuários reais. Os resultados indicam satisfação com a possibilidade de mudar o sistema, principalmente com os recursos adaptativos.

[Capítulo 7] Neris, V. P. A.; Baranauskas, M. C. C. (2010) User Interface Design informed by Affordances and Norms Concepts. To be published at the International Conference on Informatics and Semiotics in Organizations (ICISO 2010), Reading-England.

O capítulo 7 apresenta um protótipo da ferramenta MONA (MOdelador de Normas para interfaces Ajustáveis). Uma vez que no PLu*R*aL a formalização do comportamento ajustável das aplicações se dá por meio de normas, a MONA permite que, a partir de um desenho abstrato da interface, o designer especifique as diferentes representações que um dado elemento pode assumir. Além disso, a partir das análises dos Diagramas de Ontologias e soluções de design obtidas durante o estudo de viabilidade do PLu*R*aL, foi possível perceber uma certa relação entre tipos de *affordances* e a forma como são representados nas interfaces. Assim, uma arquitetura para apoiar o design e construção de interfaces ajustáveis, a partir da modelagem do domínio, é proposta considerando as ferramentas SONAR (Bonacin *et al.*, 2004), para o desenho de ontologias, e MONA, para a especificação do comportamento ajustável, além da infra-estrutura NBIC/ICE (Bonacin *et al.*, 2007) para gerenciar o comportamento ajustável em tempo de interação.

1.3.1 Outra forma de ler este trabalho

A composição de uma tese seguindo o formato de coletânea de artigos permite que se visualize a evolução do trabalho, uma vez que mostra os resultados preliminares e evidencia as sub-etapas que levaram a esses resultados. Caso essa seja a intenção de leitura, recomenda-se que os capítulos sejam lidos na seqüência em que foram organizados nesta tese.

No entanto, caso se queira ler esta tese seguindo moldes mais tradicionais, a Tabela 1.1 sintetiza uma possível estrutura considerando as grandes áreas de um trabalho científico em computação.

Tabela 1.1 Grandes áreas de um trabalho científico em computação e seções desta tese.

Áreas de um trabalho científico em computação	Conteúdo abordado nesta tese	Seções
Síntese do levantamento bibliográfico	Breve retrospectiva sobre *tailoring*	2.2
	Sistemas de governo eletrônico para todos	3.2
	Design para todos	4.2
	Revisão da literatura sobre *tailoring*, considerando as visões de uso, design e implementação	5.2
	Design Participativo	6.2.1
	Affordances e normas	7.2
Apresentação do referencial teórico	Cebola Semiótica	2.4
	Semiótica Organizacional – teoria	5.3
	Problem Articulation Method (PAM)	5.3.1
	SAM	5.3.2
	NAM	5.3.3
	Escada Semiótica	5.3.4
Descrição dos estudos de caso	STID	3.3
	e-Cidadania	4.3 e 6.1
Formalização de resultados	Classificação para *tailoring* baseada em semiótica	2.4
	Construção de interfaces ajustáveis para governo eletrônico	3.3
	Uma abordagem para a construção de interfaces para todos	4.3
	Um *framework* para o design de interfaces ajustáveis	5.4
	Relação entre *affordances* do domínio e interface de sistemas web	7.3
Avaliação da viabilidade	Uso do *framework*	5.5
Aplicação e avaliação (com usuários finais)	PLu*R*aL aplicado ao Vila na Rede	6.3 e 6.5
Suporte computacional	Protótipo MONA	7.4
Conclusão	Síntese das contribuições, análise crítica e trabalhos futuros	8

Capítulo 2

End-user Tailoring: a Semiotic-informed Perspective

2.1 Introduction

Currently, more and more people use the Internet for different activities such as bill payments, communication with friends and at work, finding a job etc, and they use different devices in different places as desktops at home or even at public kiosks, notebooks, palm tops and cell phones. The socialization of computer systems brought a new challenge to Human-Computer Interaction (HCI) researchers: how to design interfaces that are easy to use by so many people with the most different profiles, in different situations of use? The natural answer to this question seems to be to offer the end-user the possibility of adapting the interface to his preferences, needs and situations of use. Nevertheless, the solutions to this have not been that simple.

Tailoring is the expression used in literature to define the activity of changing a computer application according to its context of use (Kahler *et al.*, 2000). Applications that allow tailoring offer to end-users the possibility to adapt the software to their personal preferences or changes in the task, after the software implementation (Slagter *et al.*, 2001). Tailoring involves the concept of "design for change", offering the flexibility of being adapted to different organizational contexts or not anticipated situations of use, or those that have changed (Henderson and Kyng, 1991). The main benefits that can be obtained with this type of flexibility, emphasized by literature, are: more efficiency (Mackay, 1991), more satisfaction of use (Rivera, 2005) and a smaller learning curve when an application is replaced (Ma *et al.*, 2003; Rivera, 2005).

While the term tailoring has been well accepted and used, some related concepts can also be found such as: customization, end-user modification, extension, personalization etc. In this work we will use the terms tailoring or adaptation as synonymous and the focus is on the tailoring that is done explicitly by the end-user and not automatically by the software.

Although the concept of tailoring in Computer Science is not new (some of the first papers date from 1987, as we will show in next section), the solutions of adaptation, already implemented in some applications, have not been effective. Two main problems still persist: (1) interfaces do not communicate clearly the possibility of been tailored; (2) and when they do, they ask for skills that unsophisticated users don't have.

Researchers from Software Engineering (SE) and HCI fields have been studying ways to design better solutions for providing tailorable interfaces. While SE researches focus on the technical perspective, considering architectural, consistency and maintenance aspects, HCI researches have focused on classifying groups of users and considering the skills those users have to have to be able to adapt the software applications. This paper aims at bringing to end-user tailoring research a new discussion: the social aspect in equal footing to the technical one.

Some researchers have already claimed that information systems development should have the social reality as its natural foundation (Winograd and Flores, 1986). Mackay (1991) has shown that users only tailor an application if they recognize a relation of short-term investment for a long-term potential benefit. Thus, this turns to be a great challenge for HCI researchers. We argue that by having a broader understanding for the Information Technology (IT), and by considering the social aspects involved in the creation and usage of software applications, we could have better chances to provide the software applications with effort less ways of tailoring them.

The discussion about the social aspects in tailoring is inspired by the Organizational Semiotics (OS) discipline (Liu, 2000). OS studies organizations based on the fundamental observation that every organized behavior is affected by the communication and interpretation of signs by people, individually or in groups. Semiotic approaches make possible an inter-personal, social and cultural perspective, focusing on the expression and interpretation of software interface elements (Oliveira and Baranauskas, 1998).

This paper is organized as follows: section 2.2 presents a short retrospective of end-user tailoring; section 2.3 discusses the motivation to the social perspective for tailoring; section 2.4 presents a new categorization for tailoring considering OS approach and section 2.5 presents conclusions and future works.

2.2 A Short Retrospective of End-user Tailoring

One of the papers that initially inspired many other works in end-user tailoring was Trigg and others' at XEROX (Trigg *et al.*, 1987). In 1987, they identified four different ways the NoteCards hypermedia system could be adapted: (1) a flexible way – some objects could be used in ways different from provided; (2) a parameter-based way – users could choose alternative behaviors; (3) an integration-based way – other components could be integrated in the system and (4) a tailorable way – users could build parts of new software. For Trigg *et al.*, tailorable is the term used to refer to the adaptation that demands the construction of new code on the part of the user. In this paper, we use the term tailorable in a broader sense, involving all the adaptations users can do.

Mackay (1991) conducted a study to investigate the way users tailor software applications. She got important results which help to understand the motivations a user could have regarding tailoring: (1) users need a reason to tailor software applications; they tailor to maintain stable usage patterns, retrofitting new software to be like the old one they are already used to; users tailor when they discover that they were doing something repeatedly and chose to automate the process; and (2) the technological factor most quoted as a barrier for tailoring was the fact that it is hard to modify; individually the most cited answer was lack of time.

Mørch (1997) classified end-user tailoring in three levels: (1) customization, (2) integration and (3) extension. Customization is defined as "modifying the appearance of presentation objects or editing their attribute values by selecting among a set of predefined configuration options". Integration is "creating or recording a sequence of program executions that results in new functionality which is stored with the application as a named command or component". Extension is an "approach to tailoring where the functionality of an application is improved by adding a new code". Mørch definitions consider that there is a "use distance" between the user and the presentation objects and a "design distance" between presentation objects and the implementation code; these tailoring categories bridge these distances.

Stiemerling *et al.* (1997) published their studies about the design of a tailorable search tool for Groupware. They were strongly concerned with showing how end-user tailorability could be accommodated with the participatory design approach. Also, some questions about the process of developing tailorable applications were addressed, such as: how can the designer capture diversified and future requirements and how can s/he distill the necessary range of flexibility from these requirements?". They argue in favor of a heuristic approach to capture requirements and suggest that one should take into account factors that drive organizational changes. They point out the necessity of a more refined taxonomy for end-user tailoring and more formalism than empiricism to get user requirements.

Costabile *et al.* (2003) mention that users change themselves as they use the system and, as they change, they will use the system in new ways. Therefore, this becomes a natural motivation for tailoring. They call "coevolution" this phenomenon of adaptation of users and systems and argue that there are two main sources for coevolution: (1) users' creativity, that means users may devise novel ways to exploit the system in order to satisfy some needs not considered in the specification and design phase and (2) users acquire habits and may follow some interaction strategy to which they are accustomed. Considering the practice of workshops, they set a process to develop tailorable applications also using participatory design.

Other works have focused on Software Engineering aspects concerned with the challenges of providing support for developing such applications, especially considering the development of platforms for mono and multi-devices (Mejuev, 2003) and new technologies (Mørch *et al.*, 2004).

2.3 A Case for a Semiotic-informed Approach to Tailoring

When the tailoring idea first appeared in the late 80's, the main challenge was the definition and development of an adaptable system where an end user could produce a new system behavior without the help from programmers or designers. The technical problems to the development of such software system and how customization would happen used to be the main focus.

Later on, with the dissemination of standard applications as word processors and spreadsheets, the necessity of studying the phenomena involved in tailoring came true: why do users take the decision to tailor? What are the main motivations to tailor? What are the factors that would help? Some works argue that languages for tailoring should be task-specific, meaning that the primitive of the languages should correspond to tasks in the application domain. The focus on the tasks was the first step in the direction of considering the users' needs rather than the technological aspects involved in making an application tailorable. The emphasis on task-orientation was considered the condition for success of end-user tailorable applications; so much that some researchers use to believe that if a user was engaged in performing a specific task associated with a certain system use, s/he would be motivated to understand the problem and to learn how to tailor the application, even if s/he had to learn a formal language. Real life experience has shown that this did not occur.

The problematic related to tailoring involves many complexity levels, but one basic question remains: how to communicate to users the possibility of tailoring? Mackay (1991) has shown that many users do not know what can be customized and how to do that. Some of the reasons pointed out are the absence of documentation and the absence of users' expectation in customizing the application. Also, questions about changing management should be considered, as how to notify and follow changes, how to offer support to changes in documentation and in use.

In this work we argue that designing applications that make possible some level of tailoring by the end user should consider aspects such as: (a) system architecture and also questions regarding implementation, to provide the possibility of changing the application; (b) documentation and the expression of the possibility of tailoring, so that users could know what to change and how; and also (c) aspects regarding the social impact of possible changes.

A motivation for considering Semiotics in the project of the user interface of tailorable applications rests in the fact that interface elements do not exist as "physical" objects, but as signs. By using Semiotics, the human-computer interaction can be understood through complex processes. Such processes, analyzed only according to the perspective of engineering, have been interpreted as purely syntactic phenomena. The analysis using Semiotics rescues the primary function of computer systems as vehicles of signs and supplies an adequate vocabulary that makes possible the agreement of computer systems in function of other types of systems of signs (Oliveira and Baranauskas, 1998; Nadin, 1988).

OS is a discipline that has roots in Semiotics applied to organizational concepts and processes. OS studies the nature, characteristics, function and effect of information and communication within organizational contexts. An organization is considered a social system in which people behave in an organized manner by conforming to a certain system of norms. These norms are regularities of perception, behavior, belief and value that are exhibited as customs, habits, patterns of behavior and other cultural artifacts (Liu, 2000).

An organization can be seen as an information system where agents employ signs to perform purposeful actions. Some of the organization functions are of high regularity, and have rules that can be clearly formalized. Within the formalized part of the job, a fraction of it may be highly repetitive and can be automated by computer-based systems. Therefore, any technical system is just part of a formal part of the organization which is, in turn, part of the total organization (Liu, 2000).

HCI issues as well as organizational aspects are fundamental for solutions enabling tailoring by the end-user (Baranauskas and Neris, 2007). Semiotic concepts and methods could help designers to consider the social aspects involved in the development of tailoring applications. The theoretical basis we are considering for understanding tailoring within a Semiotic frame has a twofold motivation: (1) end-user tailoring applications should communicate the possibility of customization – in OS approach the computer system is developed as part of the organization. All meanings, beliefs, intentions, commitments, expectations should be investigated during the system conception. Also, communication flows in a shared system of signs. OS, as Semiotic discipline, gives us methods and artifacts to work with the signs of interest; (2) to get the most of satisfaction and efficiency of use by tailoring an application, current systems demand abilities that unsophisticated users may not have. In fact, the greater benefits of adaptation are only gotten with deeper modifications in computer systems, and to do these deeper modifications end users need to learn a programming language. OS approach stresses the distinctions as well as the interdependent links between the organizations, the business processes and the computer system. The notion of human responsibility and possibility of delegation of functions to a computer system is clarified. It is expected that by knowing the responsibilities, designers could model systems in a way that the benefits of adaptation could be reached without the necessity of having to program the application.

The next section presents the concept of the Semiotic "Onion" established by Stamper (1992) to represent metaphorically the context of application software and discusses a new classification for end-user tailoring considering the social aspect impacting in the software application, in equal footing to the technical considerations.

2.4 A Semiotic-informed Categorization for End-User Tailoring

In the OS approach, an organization and its information system are considered as a social system in which human behaviors are organized by a system of norms. In the OS context, an organization is understood as any information system in which people use signs for communication towards purposeful and coordinated actions. In this sense, any technological artifact, e.g. a software application, is embedded in a formal system that, by its turn, exists in the context of an informal system. Figure 2.1 shows the "Organizational Onion" to represent the three levels of information systems: the informal, formal and technical: (1) informal information system – here the organizational culture, customs, values are reflected as beliefs, habits and patterns of behavior of each individual member. At this layer meanings are agreed, intentions are understood and beliefs are formed. Commitments with responsibilities are made, altered and discharged in this context through negotiation, discussions and physical actions. Oral culture plays an important role in this level; (2) formal information system – rules and procedures are created to replace meanings and intentions. The rules and formal procedures specify how the work should be carried out and how the task should be performed; (3) technical information system – represents the computer application placed inside the formal system layer. The technical system presupposes a formal system, just as a formal system relies on an informal system (Stamper, 1992; Liu, 2000).

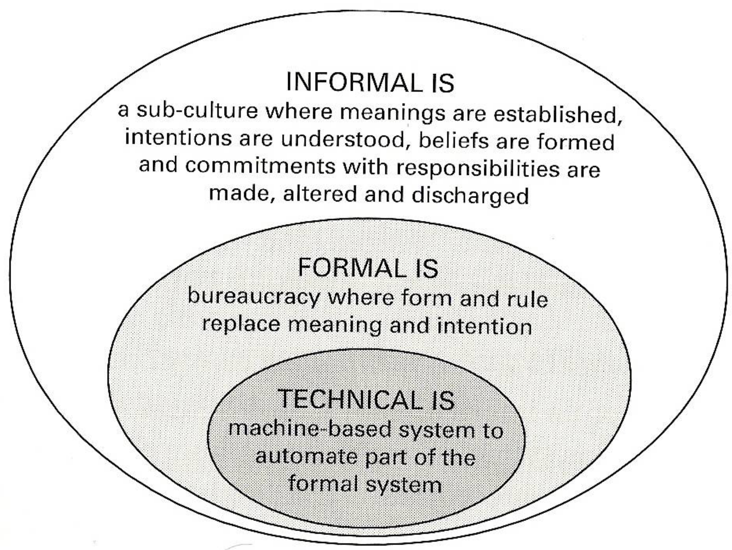


Figure 2.1 Organizational Onion (Stamper, 1992).

The Semiotic-informed categorization for tailoring that is proposed in this paper considers the impact of the potential changes not only in the software application, but in the whole organization. The possibilities of tailoring are offered in the user interface as a reflection of changes that can happen in any of the three layers of the information system. Also, adaptations that happen in the technical layer reflect in the formal system, in the same way as modifications in the formal system reflect in the informal system. This wider view of end-user tailoring demands the designers' knowledge about the sub-culture and rules of the organization to reflect them in the software application in order to provide end-user tailorable applications that demand less effort to be adapted.

In the following sections we present three categories of adaptations we are considering in the end-user tailoring proposed in this work. The categories are based on: Technical Changes, Formal Changes and Informal Changes in the system as a whole. The main characteristic of this categorization is that the scope of possibilities for changes is provided according to the Organizational Onion concept.

Technical Changes

Technical changes, as proposed in this work, impact mostly in the software application interface elements, reflecting in its aesthetic elements as color, forms and positions of the interface elements. These changes may not impact directly in the business process. Tailoring in this level involves allowing users to place things where they want, at least in one dimension but preferably in two; adapt the size and shape of interface elements. To exemplify, let's consider two scenarios, one in the context of e-gov and another in the business context: (1) E-gov organization - Consider an organization with students, parents, teachers and school directors. At a certain period of time, parents should make reservations of places for their children at school. Directors should plan how many classes will be offered and assign classes to teachers. Also, directors schedule classes for a group of students. Parents choose the school for their children and can reserve a place for the first year only for children that are already seven years old. Teachers control students' presence; (2) Business organization - Consider an organization with salesmen, customers, accountants and government. The prices of goods are calculated considering taxes. The accountants determine how taxes will impact in the store's business. Salesmen should consider taxes while receiving payments. Government determines taxes.

Considering these scenarios technical changes could be: (1) E-gov organization – One of the teachers prefers to see the name of the students on the right at the screen and not on the left; or one parent wants to be called attention to the box that shows next parents meeting date and he wants to change the interface element size; (2) One of the salesmen thinks that the font size is too small and he wants to change the font size of interface elements so next time he gets back the font size as adapted for him. End-user tailorable applications may allow users to place things where they want and also change the interface elements size and shape (Baranauskas and Neris, 2007). These changes may not affect directly any business process. However, it is necessary to clarify that even when considering that the adaptation is restricted to the user that made it, meaning that the result does not appear to other users, the formal layer can be indirectly affected by the transformations that happen to the individual because of the technical change. This happens because when an adaptation is made both, the software application and the user, change in a co-evolution process (Costabile *et al.*, 2003). For example, users can make tasks faster or can be more satisfied by technical changes and this can impact in the business process. The main characteristic to classify a possibility of adaptation as a technical change is that it is not likely to directly affect any business process.

Formal Changes

Formal changes have direct impact in the business process. The cultural aspects, values, and beliefs of the organization are still the same, but the business understanding may have changed. Formal changes refer, for example, to different ways of performing tasks. Formal changes may involve providing a way for the user to "record" a sequence of actions of their choice, and a way to easily "play them back" at any time; allowing users to control communication with the system, allowing users to create or adjust interface elements that are related to the task that is being carried on.

Formal changes for an end-user tailorable software application, considering the scenarios previously described, could be: (1) E-gov organization – The system was developed in away that users could send messages to other users; however the director frequently needs to send information collectively to all teachers, he wants to create a group and send a message to many people at once. (2) Business organization - The accountant would like to be informed when the sales of the day are higher than the average and this was not a business rule when the system was developed; or the store is in a new advertising campaign and all the reports should use the new logo.

End-user tailorable applications may allow users to create new interface elements related to the task that is being performed and record and play back a sequence of actions of their choice (Baranauskas and Neris, 2007). These kinds of adaptations can be used to reflect changes in the business process. They can be used to enable changes in the way tasks are performed. Also, formal changes can indirectly affect the informal layer, considering the impact of the modification of the business rule in the group or in the society. Moreover, it can also indirectly affect the technical layer as the adaptation will be expressed in the software application. The main characteristic to classify a possibility of adaptation as a formal change is that it affects directly the business process.

Informal Changes

Culture, customs and values of the organization are different now. Informal changes consider software adaptations that reflect changes in beliefs, habits and patterns of behavior of each individual member that affect the organization as a whole. Informal changes should enable the users to add their own comments to software artifacts and to share them with all the organization or even make adaptations that affect the interface elements that are seen by the others.

Informal changes for an end-user tailorable software application for the organizations previously described could be exemplified as: (1) E-gov organization – One teacher is having problems to insert the students' absences in the system. After learning how to do it, he decides to share his knowledge with other teachers writing some comments close to the interface elements involved. (2) Business organization - One accountant built a new kind of report in the system and saved that in a way that the other accountants could use it.

End-user tailorable applications may allow users to add comments to interface elements and share their adaptations with other users (Baranauskas and Neris, 2007). This type of adaptation is directly related to the Organizational Onion informal layer. They can be used to cause changes in the beliefs and influence the behavior of the organization members. Also, informal changes can indirectly affect the formal layer and consequently the technical system layer, considering the impact of these modifications in the business rule and in the software application. What characterizes a possibility of adaptation as an informal change is that it may affect directly the organizational customs, beliefs and patterns of behavior.

Figure 2.2 illustrates the semiotic perspective for end-user tailoring, considering the Organizational Onion structure and respective tailoring features.

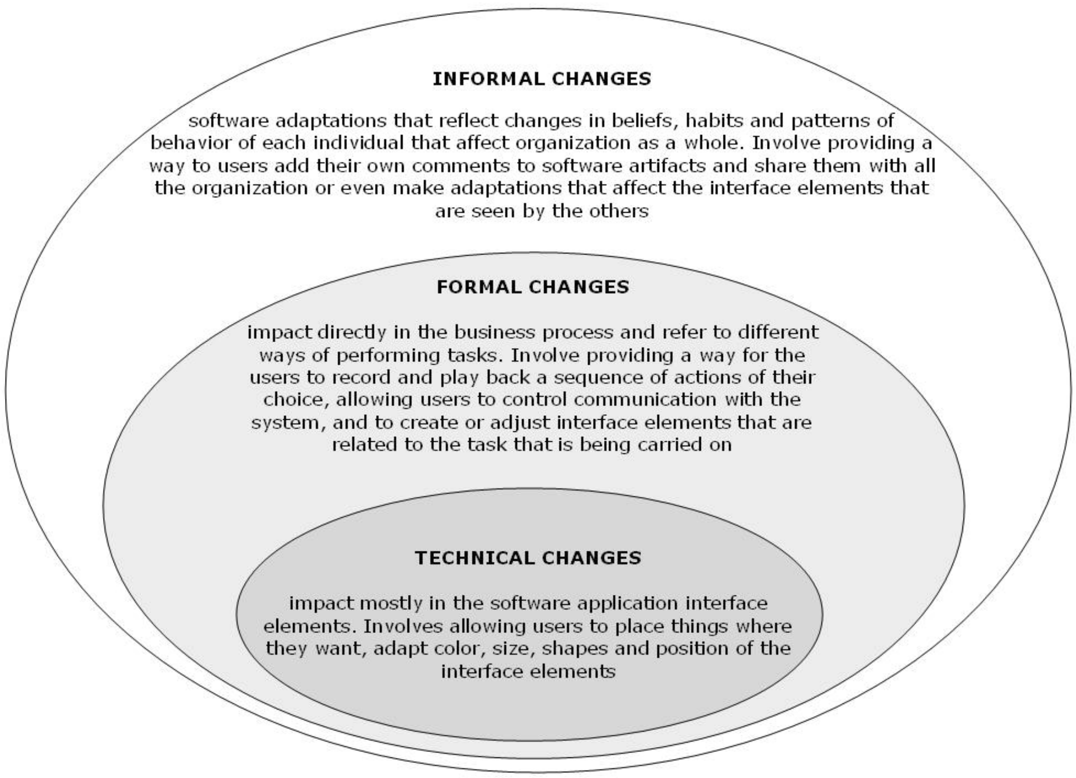


Figure. 2.2 A Semiotic-informed categorization for end-user tailoring.

It is important to note that this classification does not invalidate others already developed for end-user tailoring. Comparing this to Mørch's (1997), we can say the two categorizations are orthogonal to each other. The three levels he defined (customization, integration and extension) can be applied to each level defined here. The Semiotic-informed categorization for end-user tailoring may contribute to the design and development of tailorable applications as (a) it considers tailoring from the point of view of the impact of prospective changes in the social context of the system usage; (b) designers concerned with the sub-culture and rules of the organization could develop a deeper understanding of the users' needs in a way to anticipate the possibilities for changes in the system that could interest the end user not only individually, but as part of the social group; (c) by taking a view of the interactive system embedded in the organization's formal and informal layers, the designer is likely to conceive interface elements in a way the user could effortlessly perceive the tailorable features and adapt the system.

2.5 Conclusions

End-user tailoring is still a challenge for HCI researchers as the solutions of "personalization", already implemented in some applications, have not been as effective as first imagined; user interfaces do not communicate clearly the possibility of been tailored; and when they do, they ask for skills that unsophisticated users don't have.

This paper investigated a Semiotic-informed categorization for end-user tailoring. This categorization has methodological reference to the OS discipline. The Semiotic-informed categorization for end-user tailoring as discussed in this work may be considered a starting point to bring social aspects into consideration for end-user tailoring.

The next steps in this work involve studying the process of tailoring considering it as an organizational problem. The three levels of the Organizational Onion can also be viewed recursively to a deeper understanding of agents and affordances involved in the tailoring process. Also, we intend to investigate a norms-based way of implementing tailorable features in software applications.

Capítulo 3

Designing E-government Systems for All – A Case Study in the Brazilian Scenario

3.1 Introduction

A variety of e-government services has been offered to the population through the Internet. However, these services are not accessible to everyone. User interfaces, as designed today, hardly enable interaction for all, as they do not reach the different interaction needs present in the population, especially in social contexts of developing regions.

Brazil, as some other developing countries, is characterized by vast differences related to socio-economics, culture, and geography as well as to the access of technology and knowledge. According to the Brazilian Internet Steering Committee, by 2008, 49% of the Brazilian population had never used a computer and 57% had never used the Internet. In the group that had never used a computer, there are 84% of illiterates, 94% of elderly and 74% of people from D and E socio-economic classes.

Aligned with the precepts of Universal Design (Connell *et al.*, 1997) we must develop systems that allow interaction without discrimination and that make sense for the largest possible audience. One way of achieving this objective, in the context we are addressing, is to develop interfaces adjustable to different interaction possibilities.

Tailoring is the expression used in literature to define the activity of changing a computer application according to its context of use (Kahler *et al.*, 2000). Applications that allow tailoring offer to end-users the possibility to adapt the software to their personal preferences or changes in the task, after the software implementation (Slagter *et al.*, 2001).

This paper presents an approach and case study we have developed to design tailorable interfaces for two e-government services, in the Health and Social Security fields, aiming at the Digital Inclusion of Brazilian citizens. The approach is based on Organizational Semiotics (OS) and Participatory Design (PD) to elicit users' and system's requirements; an interaction model is proposed and tailorable solutions that fit different interaction needs are instantiated. Prototypes that resulted from the model were evaluated with representative users.

The paper is organized as follows: Section 3.2 presents the work background and a summary of the theoretical references; Section 3.3 describes how the tailorable solution was developed including the formalization of an interaction model, the design of different user interfaces and the adoption of an infra-structure to support the tailorable application; Section 3.4 discusses the results and Section 3.5 concludes.

3.2 E-government Systems for All

Literature has shown different reasons why some e-government projects still have not obtained success (e.g. Dada, 2006). Besides problems related to infra-structure (associated to hardware and network), the design of user interfaces that make sense for the citizen is still a challenge, especially in developing countries (Pieterson *et al.*, 2007; Hornung and Baranauskas, 2007). One of the reasons that can be mentioned is that each (possible) user deals with technology considering his/her previous experience with technology (or lack of it), educational and cultural backgrounds, etc demanding contextualized solutions.

In addition, according to Layne and Lee (2001), the omnipresent nature of the Internet may be misleading in that any service can be accessed by anybody from anywhere, anytime. Moreover, they affirm that though the concept of e-government is very persuasive in increasing efficiency and effectiveness of government, the services should be available to one hundred percent of citizens for e-government initiatives to be successful.

The development of interfaces for all (including illiterates, elderly and people with disabilities) is a grand challenge as design problems still persist if we consider each particular users group (cf. Neris *et al.*, 2008). In some cases, the use of assistive technologies (such as screen readers or automatic translators) and adherence to the recommendations of accessibility found in literature are not sufficient for the effective interaction of these users. We argue that it is necessary to bring these people to the design process to really understand their needs, designing with them. Moreover, once the different needs were recognized, a tailorable solution can be built to get the e-government systems closer to the diversity in the population.

Actual solutions regarding personalization or customization for e-government are mostly related to contextualized information (e.g. Grandi and Scalas, 2005) or specific services provided to a target group of citizens (e.g. Guo and Lu, 2007). This paper addresses the problem of designing e-government systems that could be tailored to different interaction needs providing access to as many citizens as possible.

Regarding methodology issues, Axelsson and Melin (2008) formalized an emergent framework for citizen participation and involvement in e-government and recommended PD as a reference for supporting the design of such applications. Moreover, we have adopted artifacts from OS, applied in a participatory way, to support the elicitation and formalization of requirements and design solutions. OS is a discipline that has roots in Semiotics applied to organizational processes. An organization is a social system in which people behave in an organized manner conforming to a certain system of norms. Human-Computer Interaction understood through Semiotics reveals its complex processes; such processes, analyzed only according to the perspective of engineering, have been interpreted as purely syntactic phenomena.

3.3 Building Tailorable Interfaces for E-government

Our participatory approach to tackle the problem of building tailorable interfaces for the e-government services considered a multidisciplinary team including designers, people from the media studies, educators, developers and community leaders (here, this group is named "design team"). Two main types of participatory activities were developed during the process, as follows:

- Participatory practices with a group of 12 people representing different cultural, social and economical aspects. We named this group "Scenario*". It was formed considering numbers from the IBGE (Brazilian Institute of Geography and Statistic) in terms of gender, age range, literacy and income per family. The practices were done in a period of 8 months and took place in a telecenter. More details regarding the Scenario* can be found in Baranauskas et al (2008).

- Participatory workshops with a group of 30 people related to STID project. The group consisted of designers, software engineers, anthropologists, educators, people from the media studies, developers, managers and user representatives. The professionals were from a private company as well as from universities. Three workshops were conducted during the project and they took place at the company.

3.3.1 Defining an Interaction Model

To address the digital inclusion respecting the different interaction abilities, it is necessary to elicit the different interaction needs and build different interface solutions that could fit them. It is important to provide all users with access to the same information, identical whenever possible, equivalent when not possible (Connell *et al.*, 1997).

To define an interaction model, it is necessary to have a clear understanding regarding the interaction context, including knowledge about the users' interaction needs and also the system requirements. In this sense, our first step towards an interaction model was to clarify the problem and delimitate the scope of the solution, considering technical questions as well as aspects related to the digital inclusion. Hence, a 1st. participatory workshop was conducted, in which the Stakeholders Identification technique (Liu, 2000) was applied. In addition, the Evaluation Framing (Baranauskas *et al.*, 2005) was used to elicit problems and possible solutions related to the stakeholders. Figure 3.1a shows a moment in the 1st workshop, when the participants were filling out the OS artifacts.

As a result of the 1st. workshop, 42 interested parties were made explicit in the Stakeholders Identification Chart; they included: illiterates, elderly, people with disabilities, users' families and suppliers, health agents, governmental workers, free software developers, social institutions, non-governmental agencies, universities, W3C, governmental units, among others. By using the Evaluation Framing, important problems (P) and some possible solutions (PS) were discussed, including:


(a)


(b)

Figure. 3.1. Moments of the (a) 1st workshop and (b) 3rd workshop.

- P: social invisibility of illiterates – PS: bring illiterates to the design process and work with social groups that help in low-literacy communities;
- P: how to design an interface solution that could be used in other e-government services? - PS: define an interaction model that allows the interface solution to be re-used and define flexible user interfaces;
- P: how to deal with users that are afraid of technology? - PS: telecenters have an important social role bringing people closer to technology, but it is necessary to create a welcome environment for those that are afraid of technology.

Other important aspect for the definition of an interaction model is the knowledge of users' abilities and difficulties to interact with the software application. For that, participatory practices were conducted with users from the Scenario* to explore their relation with digital artifacts and language skills. Table 3.1 exemplifies some of the activities done and the related results. The participatory practices helped to understand the logic of users' interaction and to formalize some interaction requirements and possible design solutions. For example, for users who are not familiar with the technology, backspace and space keys should be distinguished in the keyboard (for other examples see Neris *et al.*, 2008).

Considering a common view of the problem and a better understanding about users' abilities, the 2nd participatory workshop was planned. For this workshop, relevant information was classified using the Semiotic Framework (Stamper *et al.*, 1998) considering its six levels of information. This classification supported a broader analysis, going from the physical and empirical levels (e.g. the need of Internet access infra-structure, personal earphones, etc.), to syntactic (e.g. adoption of an inclusive linguistic pattern; resources to make the font size bigger, etc.), semantics (e.g. interactive messages and content adapted to different linguistic levels, regionalisms, etc), and the pragmatic and social levels (e.g. questions related to privacy and comfort). The Semiotic Framework was taken to the 2nd workshop and discussed with all the participants. Further, a Requirements Chart was filled out in a participatory way. After the 2nd workshop a complete list of requirements was defined.

Table 3.1. Activities, techniques and results obtained within participatory practices

Activity / Technique	Description / Results
Successful and unsuccessful stories with digital artifacts (storytelling)	Warming-up activity in which participants tell stories about their relation with digital artifacts. It allowed to know which artifacts were most used and how. Also, main interaction problems with these artifacts were cited.
Panels game	Participants were divided in groups. Each group should represent a simple sentence (related to the domain) with pictures and symbols, so that the other groups could identify it. It was possible to identify meaningful vocabulary and metaphors.
Logging in (interaction with computers)	Participants interacted with four logging systems prototypes. The prototypes asked different interaction skills, applying only text, others with multimedia and sign language. Also, simulation of supportive hardware was tried. Interaction requirements were identified.
Building an interface (design with pictures)	Working in groups, participants received a description of a task and were asked to build a user interface, drawing or using given pictures. It allowed the identification of meaningful interaction elements and the interaction logic.

Finally, bearing in mind the scope of the project (1st workshop), users' abilities (participatory practices) and software requirements (2nd workshop), a 3rd workshop was conducted to elicit design concepts and solutions for interface proposals. Participants were organized in groups and the BrainWriting and BrainDrawing techniques (Muller *et al.*, 2001) were applied. Figure 3.1b shows a snapshot of the 3rd workshop. Concepts included vocabulary comprehension and its consistency, and the use of multimedia for promoting access to different users. From the drawings, it was possible to identify common interaction areas and navigational structures.

Considering results of the three workshops and of the participatory practices, an interaction model for e-government applications was proposed. The model has two parts: the Interface Conceptual Model (ICM) and the User Interface Abstract Model (UIAM). ICM presents essential concepts, principles and guidelines. Table 3.2 presents its four principles.

Table 3.2. Principles of ICM.

Principle	Description
1. Intelligibility	The design solution should facilitate the citizen's understanding about the e-government services and also about his/her rights and duties. Information should be accessible, not only regarding the presentation format, but also considering a meaningful vocabulary. The interface design and its related content must support the citizen's learning process.
2. Procedure visibility	The navigational structure should be oriented by the governmental service procedure, offering clear and direct access to information and functionalities.
3. Flexibility	E-government services should be available for all citizens, without discrimination. User interfaces should be tailorable to fit different interaction profiles.
4. Redundancy	To support different interaction profiles, information should be available through different formats and media. Redundancy should be understood as presenting the same information in different ways.

The UIAM is composed by a static model (represented by a wireframe and UIML description - User Interface Markup Language) and a dynamic model (described by a States Diagram). While defining UIAM, the design team considered that, for inclusion purposes, the interfaces should prepare users to interact with other web applications as well. For that, web standards were applied when possible.

Considering the categorization of Beaudouin-Lafon (2004) for interaction models, a good model should present a balance between descriptive, evaluative and generative powers. In the proposed interaction model for e-government applications, the ICM, composed by concepts, principles and guidelines, presents high descriptive and evaluative powers. On the other hand, the UIAM, with the static and dynamic models, presents high generative power.

3.3.2 Designing the User Interfaces

With the interaction model, it was necessary to instantiate it and get interface solutions that could fit the different interaction requirements. The inputs for getting diverse user interfaces were: the design proposals obtained from the 3rd workshop, knowledge obtained from the participatory practices and previous knowledge from the design team (from literature and also background).

Aiming at designing the interfaces as close as possible from the users' real world, a few metaphorical interaction resources were added:

- Icon "i" (from information) starts videos with an avatar or real person which gives information about the related function. Icons "i" were associated to important interaction options;
- Icon "read" (represented by a loud-speaker) starts an audio file with the corresponding text information associated;
- Icon "TV" (represented by a small TV) turns Portuguese videos on or off;
- Icon "LIBRAS" (from Brazilian Sign Language and represented by a hand-sign of the letter L) turns LIBRAS videos on or off;
- Icon "T" (from text) shows or hides the legend area.

Besides, considering the different interaction needs, some other interaction resources were implemented, e.g.:

- The videos may be played automatically each time a new page is loaded (useful for illiterates and inexpert users);
- Navigation between interaction elements by tab key was carefully designed and it was possible to automatically play the audio file for the "read" option (useful for those with difficulties to use the mouse and also by illiterates);
- Skip links were available (useful for screen reader users);

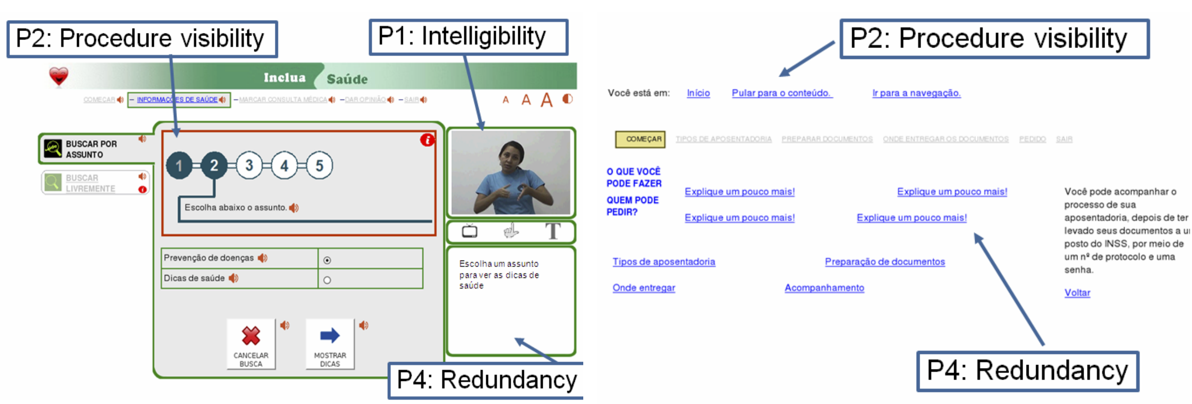
• Font size and contrast options may be optional (as they are not meaningful for screen reader users, blind people or those that do not have sight problems);

• Areas to show videos may be optional (as they are not meaningful for screen reader users or for those that are not interested in extra information);

• LIBRAS videos may be played by default in some cases (instead of videos in Portuguese. However, it is important to note that some deaf people prefer the videos in Portuguese for lips reading).

Figure 3.2 shows two snapshots of the same interface to illustrate the application of the ICM principles. In Figure 3.2a it is possible to see numbers representing the steps in a path to perform a task. Together with the menu bar they respect Principle 2 – Procedure visibility. Also there is a video in LIBRAS for those who need sign language for communication. The legend shows the same content in Portuguese, applying Principle 4 – Redundancy of information in different media. Figure 3.2b shows the same interface as it is perceived by screen reader users. It is possible to see skip links on the top and also how the option "i" (extra information) is offered, which is an instance of Principle 4.

Another important aspect is the entry of data by users that are not literate in Portuguese. At first, the design team considered the use of voice/speech. However, it was not possible to find a mature technological solution that could be applied without compromising the users' confidence in the system. According to the e-government services requirements from the company, users were asked to type simple data as the number of the social benefit or date information. Our experience in the Scenario* showed that, even without being fully literate, users are able to copy a sequence of characters or type some personal information (e.g. their birthdates).



(a) (b)

Figure. 3.2. (a) Health system screenshot and (b) Social System screenshot for screen reader users.

Design proposals were made for desktop applications, touchscreen and for a new apparatus that is a mixture of a telephone and the device used for voting in Brazil. Paper prototypes were built for all the proposals and the desktop applications were also prototyped using XHTML.

3.3.3 Building a Tailorable Solution

To offer universal interface solutions, providing different and suitable forms of interaction requires an infra-structure which allows managing the changes and altering the system in real-time. Literature shows some infra-structures to be applied (cf. Macías and Paternò, 2008; Wulf *et al.*, 2008; Bonacin et al, 2007).

Bonacin's infra-structure proposes the use of norms to manage the possibilities of tailoring. Taking into account concepts from OS, this infra-structure considers that as norms describe beliefs, expectations, commitments, contract, law, culture, as well as business, when a norm is changed or adapted in a specific context, the system should also be modified. In this sense, this infra-structure was chosen as the norms approach supports the modeling of the different interaction needs, in a broad sense.

The diagram of Figure 3.3 shows how the infra-structure proposed by Bonacin et al (2007) was applied. The designer enters norms in a software application named norms editor (e.g. Always "user_cintia", system "egov" should "use_libras" – terms in "" are affordances that the designer defines). The NBIC (Norm Based Interface Configurator) receives the norm specification in Deontic logic, manages the norms persistence, and also transforms them into a platform specific language that can be interpreted by an inference machine on ICE (Interface Configuration Environment). Then, the ICE receives context information from the application, evaluates the norms related to context by using the inference machine (JESS – JAVA rule engine) and returns to the application an action plan with the changes to be done.

In the e-government service side, an Interface Manager Module (IMM) was implemented to receive the action plan and to trigger the actions on the user interface. In a simple scenario, receiving an action "use_libras", IMM would change the argument "type of video" to LIBRAS. Also, IMM captures the context (e.g. the user is Cintia) and send information to ICE.

The tailored interfaces were evaluated regarding usability and emotional value. The usability was evaluated by an external evaluator considering 3 main groups (illiterates, blind and deaf people), totalizing 34 people. According to interaction needs previously identified by an interview, one specific tailored version was presented for interaction. However, because of redundancy, users could select different ways to interact. From the usability tests, improvements in each tailored interface were identified. Moreover, some users made satisfactory comments regarding items tailored for them (e.g. skip links for scream reader users). According to the evaluation report, specially the multimedia options (e.g. available by the option "read") were largely used by the illiterates. The same happened in the tests with deaf people that also used the same resource that was, of course, tailored for video in the Brazilian sign language.

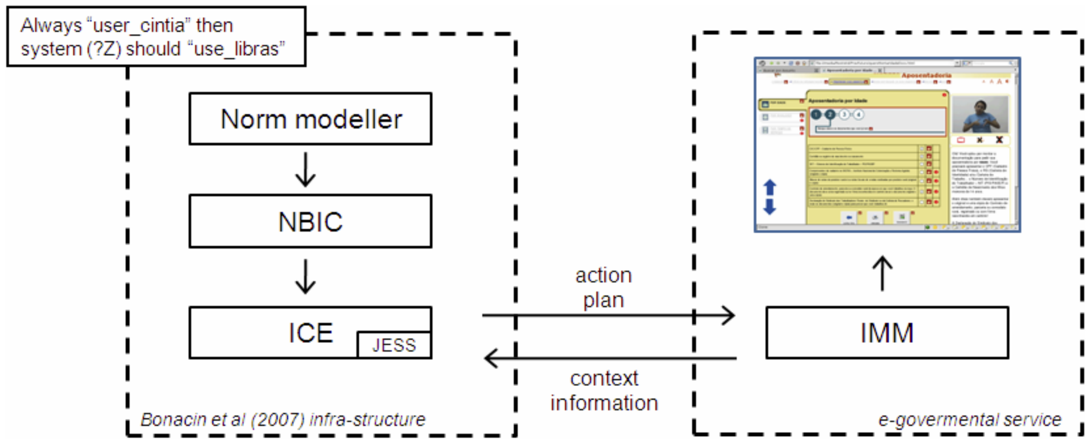


Figure 3.3. Infra-structure adopted to manage tailoring.

In addition, the design proposal was evaluated with users from the Scenario*. A framework adapted from Chorianopoulos and Spinellis (2006) considered 3 levels of emotional responses (visceral, behavioral and reflexive) and allowed the design team to classify the design proposals and bring up hypotheses related to the acceptance of each interface. These hypotheses supported changes in some interfaces especially those with too much content (cf. Hayashi *et al.*, 2008c).

3.4 Discussion and Conclusion

The participatory practices in the Scenario* showed that to consider digital illiteracy we must go beyond interaction restrictions related to the use of hardware (mouse and keyboard) and the understanding of the "web language" and navigational resources (links, buttons, icons, scrollbar). One of the main problems is related to the comprehension of the content that is available. However, this is an individualized process that can be only started if information is accessible considering the different interaction needs.

Another challenge of developing solutions for digital inclusion in Brazil is that not much has been done regarding the interaction skills of the Brazilian citizen still out of the digital world. Our approach to deal with this problem was to bring representatives of these users to the design process. It was necessary to re-evaluate and adapt the traditional design techniques which were proposed in a very different context. As an example, the Panel's game was inspired in Paulo Freire's (1921-1997) educational method, in which the first step is to search for meaningful words and themes related to the students' life. Transporting this concept from the educational field to the design of web applications, vocabulary and metaphors were elicited.

This case study involved many different professionals with different profiles and also expectations regarding the solution. OS, as the methodological reference, supported the problem clarification and determination of the solution scope, helping to answer questions as who are the interested parties?, what are the main problems involved? Also, requirements elicitation was supported by the use of the Semiotic Framework and the final tailorable solution was built considering the concepts of norms. Furthermore, the workshops were an opportunity to share views and obtain a mutual understanding about the project, a fundamental aspect in a research and practice approach.

Furthermore, Dubberly (2008), in his search for a model of innovation, defined that innovation happens through a process which can be managed. This process starts with the community observation, what leads to insights which create value with consequences for the community. The approach applied in this case study goes in the same direction as Dubberly proposes. The observation of the Scenario* and the workshops supported the insights that leaded to the interaction model and the tailorable design solutions. The prototypes developed and also the experience of 8 months in a mutual-learning process created valuable consequences for all the involved people.

Finally, it is important to emphasize that the universal design solutions should prepare the users to interact with other Web systems as well. This is a key aspect considering digital inclusion. Universal design is related to the right to choose the interaction style which is more suitable for each user. The design of interfaces that could be used by all citizens is still a challenge, as not much is known about the interaction abilities of the digitally excluded. Also, it is necessary to search for ways to develop universal design solutions that do not discriminate and that can promote the constitution of a fair society.

This paper presented an approach to develop e-government interfaces for users with different interaction needs following the precepts of Design for All. This approach is based on bringing the users to the design process and using a theoretical reference that allows a socio-technical vision to the problem. It proposes the development of interfaces that can be tailorable, as a way to implement solutions that are for all. An interaction model from e-government service applications was formalized and an infra-structure was used to experiment a tailorable solution. Tailorable versions to illiterates, deaf and blind users were tested considering usability, accessibility and emotional response. The results suggested that tailored interfaces were essential to promote the access and to bring the e-government applications closer to the users' needs.

Further work includes longitudinal studies required for correlating tailoring and the acceptance of e-government systems.

Capítulo 4

Interfaces for All - A Tailoring-based Approach

4.1 Introduction

Nowadays, many services have been offered to the population through computers and the Internet: bills payment, communication with friends and institutions, searching for a job, among others. Besides the reduction in computer prices, the dissemination of cell phones and the implementation of telecenters and Internet cafes, many people still do not benefit from these services, especially in developing countries. One of the problems is that the way user interfaces are designed today, do not favor the interaction of the population in general by failing to consider the different users needs in the population.

Following the precepts of Universal Design or Design for All (Trace, 2006), we must develop systems that allow access to knowledge without discrimination and that make sense for the largest possible number of users according to their different sensory, physical, cognitive and emotional abilities.

Eliciting the interaction abilities present in population is essential to develop systems that can be used by the largest extension possible of users. However, the interaction needs may change over time and in different scenarios of use. Thus, in addition to offering various forms of interaction, systems should be adjustable so that they could accommodate the non-anticipated needs and the users' evolution (Costabile *et al.*, 2003).

Tailoring is the expression used in literature to define the activity of changing a computer application according to its context of use (Kahler *et al.*, 2000). Tailoring involves the concept of "design for change", offering the flexibility of being adapted to different organizational contexts or not anticipated situations of use, or those that have changed.

To offer systems that allow tailoring requires a logical structure to manage the possibilities of changing and an architecture that allows altering the system at the time of use. Current research on tailoring has focused on technical issues to enable adjustable applications (e.g. Macías and Paternò, 2008; Wulf *et al.*, 2008). However, improvements in aspects of implementation have not resolved the issues of design to make this technology accessible to all, including people with disabilities, elderly, illiterate and non-expert users.

We believe that the development of systems that intend to be for all requires a socio-technical vision for the problem. E-Cidadania is an ongoing Project in Brazil, in which we are experimenting with the design for all in a demanding context of the population of users involved (e-Cidadania, 2006). To deal with this challenge we have chosen the reference of Organizational Semiotics (Stamper *et al.*, 1998; Liu, 200) (OS), allied to methods and techniques of Participatory Design (Schuller and Namioka, 1993) and Inclusive Design (Connell et al, 1997; Melo and Baranauskas, 2006) to clarify the problem, model the context and elicit users' and system's requirements with the direct participation of those involved. This work presents the approach we are using in the context of e-Cidadania Project to build interfaces for all tailorable to everyone.

The paper is organized as follows: Section 4.2 presents some related works and a summary of the theoretical reference; Section 4.3 describes the approach, considering 3 main phases and exemplifies each of them. Section 4.4 discusses some lessons learned and Section 4.5 presents some conclusions.

4.2 Background Work and Theoretical Reference

According to the Center for Universal Design from the State University of North Caroline-USA, the Design for All is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. The design of Interfaces for All aims at addressing efficiently and effectively the problems arising from the users' different interaction abilities (Stephanidis, 2001).

Connell et al (1997) have defined some principles and guidelines for developing universal products. They are related to the equitable use, meaning that the design should be useful and marketable to people with diverse abilities; design should be flexible to accommodate a wide range of individual preferences and abilities, products should be ease to use and intuitive, the design should communicate necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities, among others.

The development of Interfaces for All is still a challenge as design problems persist even if we consider some particular users groups (cf. Neris *et al.*, 2008). In some cases, only the use of assistive technologies (such as screen readers or automatic translators) and adherence to the recommendations of accessibility found in the literature are not sufficient for the effective interaction of these users (Melo and Baranauskas, 2006). Melo and Baranauskas (2006) show the need to bring these people into the design process to understand their needs and to design with and for them.

One way of developing Interfaces for All is to offer to the users the possibility of tailoring the interface according to their preferences, needs and situations of use. However, tailorable interfaces already present in some interactive systems have not shown effectiveness (Wulf *et al.*, 2008). In general, the interfaces do not clearly communicate the opportunity to be tailored and, when they do, they require skills that non-sophisticated users do not have. Thus, it is necessary to investigate new approaches for the design of tailorable systems focusing on Interfaces for All.

Literature shows some works that have used the Participatory Design discipline to design tailorable systems (Kjǽr and Madsen, 1995; Costabile *et al.*, 2003). The contexts experienced in such works were related to business environments, with focus on well-established communities of practices and interaction requirements different from those considering illiterates and non-expert users. Moreover, the context of this research involves other kinds of differences, besides the issue of disability itself; it is necessary to know the different interaction requirements (social, cognitive, emotional etc.) that characterizes the target users. In this sense, we have chosen a theoretical reference that presents a socio-technical vision to the development of information systems, as shortly described following.

4.2.1 Organizational Semiotics

OS is a discipline that has roots in Semiotics applied to organizational processes. It studies the nature, characteristics, function and effect of information and communication within organizational contexts. An organization is a social system in which people behave in an organized manner conforming to a certain system of norms. These norms are regularities of perception, behavior, belief and value that are expressed as customs, habits, patterns of behavior and other cultural artifacts (Stamper *et al.*, 1988; Liu, 2000).

By using Semiotics, the human-computer interaction can be understood through complex processes. Such processes, analyzed only according to the perspective of engineering, have been interpreted as purely syntactic phenomena. The analysis using Semiotics rescues the primary function of computer systems as vehicles of signs and supplies an adequate vocabulary to understand the relation between computer systems and other sign systems (Nadin, 1988).

Stamper has proposed a set of methods to support the use of OS concepts for modeling information systems, named MEASUR - Methods for Eliciting, Analyzing and Specifying Users' Requirements (Stamper *et al.*, 1988). Our approach to build Interfaces for All, builds on 3 MEASUR methods: Problem Articulation Method (PAM) – to identify the main topics related to the context, allowing a clear understanding of the problem; Semantic Analysis Method (SAM) – to focus on the agents and their pattern of behavior (named affordances) to describe the organization and its information system functions in ontology charts; Norm Analysis Method (NAM) - usually carried out on the basis of the result of SAM to specify the condition and constraints on the behaviors. The next section presents a practical application of these methods in the context of design for all at e-Cidadania

4.3 Building a Tailorable Application

The development of a technical system that intends to be inclusive and suitable for as many people as possible faces the challenge of eliciting different interaction requirements and designing proper user interfaces. Moreover, the construction of a tailorable solution also faces the need of software architecture capable of managing the different interaction options. Figure 4.1 presents the main phases, and the related inputs, of our tailorable approach to the development of Interfaces for All. Next sub-sections present details of each main phase, which are exemplified by the activities conducted in the context of e-Cidadania.

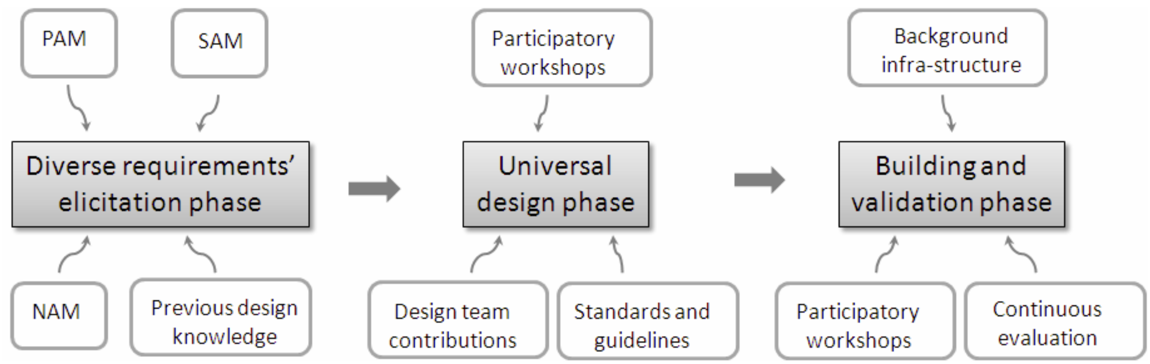


Figure 4.1.A tailorable approach for building Interfaces for All.

E-Cidadania involves a multidisciplinary team investigating the relationship people establish in their informal communities organized around some special interests, how they use societal artifacts, including computational technology, aiming at the design and development of a social network system (e-Cidadania, 2006). The team involves designers, software engineers, anthropologists, educators, people from the media area, developers and community leaders. From the community of prospective users, 15 representatives were invited, including weavers, hairdressers, maidservants, retirees, teachers from a pre-college school, telecenter monitors, government representatives among others.

4.3.1 Gathering requirements from the diversity

Requirements elicitation is a fundamental phase in any development cycle. Moreover, while developing a universal design, requirements elicitation turns to be even more important. Besides the challenge of eliciting different interaction needs, the designer may be dealing with users s/he does not know much about. Interfaces that intend to be for all extrapolate the well-known frontiers of the office applications. Our approach to deal with these not well-known interaction needs is to bring these users to the design process.

Also, interfaces for all ask for an elicitation approach that considers more than just technical issues. MEASUR allows us to clarify the problem, elicit semantic information and define the responsibilities and related agents. With this clarified view of the context, we can determine which actions will be executed by the system. The definition of responsibilities is essential for tailorable systems once there are many agents with their different interaction needs that ask the system a different interaction behavior. Although the MEASUR methods can be applied in different orders, in our approach we have used PAM, SAM and NAM in this order.

In the e-Cidadania project, PAM was used in a workshop format with the Stakeholder Analysis Chart (see Figure 4.2a) and the Evaluation Framing Chart. The activities lasted three hours and they took place at the CRJ – Centro de Referência da Juventude (Youth Reference Center). Chairs were arranged in a semi-circle in front of the artifacts hung on one of the walls. Post-its were distributed to the participants who would write their ideas on them and hand them to be posted on the artifacts (cf. Hayashi *et al.*, 2008b).

The Stakeholder analysis guide us to think about stakeholders that are directly responsible for the system – called actors, also about clients and suppliers, partners and competitors, as well as community and government interested or affected by the system. In e-Cidadania, 59 different stakeholders were mentioned, including housewives, elderly, people with disabilities, health agents, community leaders, neighborhood associations and religious institutions.

The Evaluation Framing Chart allows the elicitation and discussion of problems and issues the mentioned stakeholders would face, as well as ideas and solutions for these problems. With this chart, we intend to extract the main issues that should be considered while developing the system. For example, in e-Cidadania project, participants reported concerns related to low educational level and literacy proficiency of the prospective users. For these problems, they pointed out the use of audio-visual content and accessible vocabulary as possible solutions. Considering the universal design principles, these requirements can be supplied on a tailorable solution. Also, questions related to the environment and financial support were mentioned.

The second method used in the elicitation phase was SAM. We applied SAM as it was originally proposed, with its four major phases (cf. Liu, 2000). However, for the first stage in the semantic analysis, which is problem definition, we used the description that participants of the workshop wrote about their concepts of an inclusive social network. From their definitions, the design team generated the affordances candidates, grouped them and drew an Ontology Chart for inclusive social networks. Figure 4.2b shows part of this Ontology Chart (for the complete chart, cf. Neris *et al.*, 2009a).

From Figure 4.2b it is possible to see that the root element “society” affords “person”, “group” and “thing”. “Person” and “group” afford “membership”. This relation is important to represent the digital inclusion process. In this scenario, “group” represents any set of people, including that group that has access to information and communication through computers. This represents that any technical system that intends to support inclusive social networks should make “membership” possible which implies in important design issues regarding accessibility and universal design.

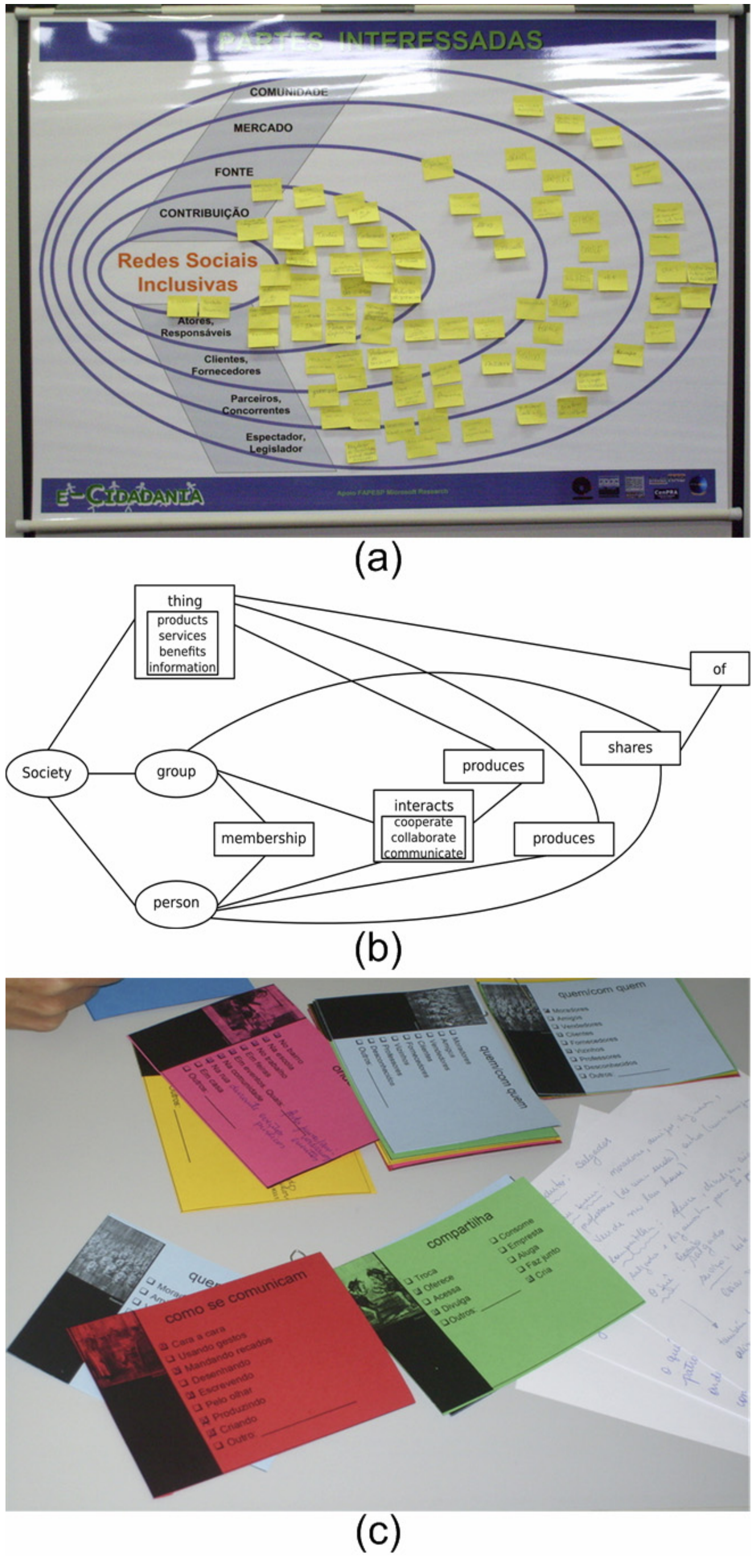


Figure 4. 2. (a) Stakeholder Analysis Chart. (b) Part of the Ontology Diagram. (c) Cards used in the second workshop

“Person” and “group” also afford “interaction”. Furthermore “interaction” and “thing” afford “produces”. These relations represent that interacting, in such modes as communicating, cooperating or collaborating, the groups are able to produce things that can be products, services or even information. These different interaction modes demand different functionalities to support them. For example, to allow communication, users should be able to share a system of signs, which will be possible only if the user interfaces make sense to each of them.

The next step in our approach was to elicit the different ways people interact, communicate, and collaborate, to cite some of the interaction modes. Our intention was to clarify the notions of responsibilities to define the tailorable behavior. A second workshop was proposed and conducted to elicit their norms and start application of the NAM. For this workshop, the original group of participants was extended with people chosen by their roles and activities performed in the target community, as a result of the stakeholders analysis of PAM.

For the second workshop, we have adapted a technique from the Participatory Design field known as "CARD" (Muller *et al.*, 1997). As in the use of the CARD technique, the participants were given cards and through them they were able to organize their ideas and present their storytelling experiences. Differently from CARD, new categories were created in order to capture information regarding the way they organize themselves in social networks from the resulting stories. The new categories were inspired on the elements of the Ontology Chart (built as a result of the SAM) and they arose from the statement of the question: “Who shares what with whom, when, how, where, using what and why?”. Figure 4.2c shows some of the cards used. After the workshop, the design team worked on the analysis of each story and a group of norms was elicited. From the 21 stories reported, 37 norms regarding the community social dynamics were defined. Table 4.1 illustrates some norms obtained.

In the process of writing norms, the first step was to identify the main actions in each story, listed in the <action> column. Then, the responsible for the action was identified and put in the <agent> column. Subsequently, we analyzed the deontic operator, i.e. the information whether the agent must (as obligation), must not (as prohibition) or may (as permission) perform the action. Finally, we recognized the triggers, which were written in the <condition> and <state> columns (Hayashi *et al.*, 2008a).

It is important to notice that the set of norms represents what the community has been doing up to now. For example, from the last line of Table 4.1, we can see that announcements about the CIDARTE’s parties are made by posters or face to face and also via email. The analysis task leads us to think about ways to support the announcements with tools to make the information accessible to more people (including the digitally illiterate). Also, from the third line of Table 4.1, it is possible to notice that different means of communication should be provided. As the students from Manga class communicate by drawing, the technical system should provide a tool for drawing or at least the possibility of uploading and publishing images. Moreover, from this set of norms, we can see that some users would like to draw, while others prefer to write or talk, indicating different functionalities the system should provide.

Table 4.1. Examples of norms from e-Cidadania project.

whenever <condition>	if <state>	then <agent>	is <deontic operator>	to <action>
Always	before using someone else´s knowledge	a person	must	ask permission to that person
During events or daily at CRJ	there are young people interested	teachers	may	offer Manga class using paper, pen and posters
Always	there is a former student of Herbert Souza course and s/he wants to cooperate with community	this former student	may	share knowledge about the course with current students at the school in person, using phone, paper and pen, television, board, computer/ internet.
Always	there is an event	CIDARTE coordinator	must	share with the group information about the event. S/He may use posters, face-to-face communication and also email.

The last input in the elicitation phase is the design team previous knowledge regarding the application domain. This knowledge may also include the users and the business rules, based on experience, literature review or even from design activities or internal workshops (for tailoring elicitation patterns, cf. Baranauskas and Neris, 2007). As outcome of the diverse requirements' elicitation phase, the design team can formalize the requirements in a format suitable to the specific types of requirements.

4.3.2 Designing a universal solution

In the proposed approach, after getting a requirements list, it is time to investigate how these functionalities can be offered following the precepts of the Design for All. Universal solutions should provide the same means of use for all users: identical whenever possible; equivalent when not (Connell *et al.*, 1997). One way to achieve this is to define a conceptual model that should be followed while designing any part of the system. The formalization of the conceptual model should consider information from PAM (especially from the Evaluation Framing, where the main problems where pointed out), SAM (by the affordances from the Ontology Diagram) and NAM (by the norms that represent the expected behavior). Also, previous design knowledge should be considered. From the conceptual model it is possible to think about the different representations (interface elements or media) we may have on the interfaces.

A third workshop was conducted in the e-Cidadania project to explore user interface design solutions with the parties. We applied a Participatory technique called BrainDrawing (Muller *et al.*, 1997), a method that allows a rough design of user interfaces through a cyclical brainstorming. In the BrainDrawing, each participant starts a drawing in one sheet of paper. After a short period of time, the participant gives his/her sheet to the next participant which will continue the actual drawing. Each drawing, at the end, is a fusion of ideas from everyone involved and each design is unique because it had a different beginning.

The workshop started with a brief statement describing one of the scenarios of use for the prospective system. The participants were organized into 5 groups. After the BrainDrawing, each group discussed the drawing results and get to one consensual solution that they presented to the other groups. During discussion, we could identify the essential interface elements and interaction styles that the inclusive social network system should offer.

Figure 4.3 shows 3 of the 5 consolidated designs. In the pictures, it is possible to see that the groups have chosen different navigational structures – Figure 4.3 (a) shows a linear menu while in (c) it is possible to see a circular menu. Also, there are different positions for some interaction areas – Figure 4.3 (c) shows the announcement in a central position and (b) shows the announcement area positioned on the left side. Differences appeared also in the way people would communicate. In one of the proposals, users could communicate writing messages (like in a chat) while in another, only a telephone number should be presented.

From the workshop it was possible to obtain many design ideas and also a refinement of the requirements. However, to obtain the universal design proposal, the design team has to work on the available design ideas. In this sense, another input in our approach is the Design team contributions.

Another important source of knowledge that contributes to the design phase is the group of Standards and guidelines related to accessibility (cf. http://www.w3.org/WAI; http://warau.nied.unicamp.br). A universal solution has to be accessible as a pre-requirement. Therefore, it is important to follow the recommendations and consider efficient assistive technologies and techniques (cf. Hornung *et al.*, 2008).

As outcomes of the design phase, the conceptual model can be formalized in a design rationale format, for instance. Interface design proposals can be represented by sketches or low fidelity prototypes.

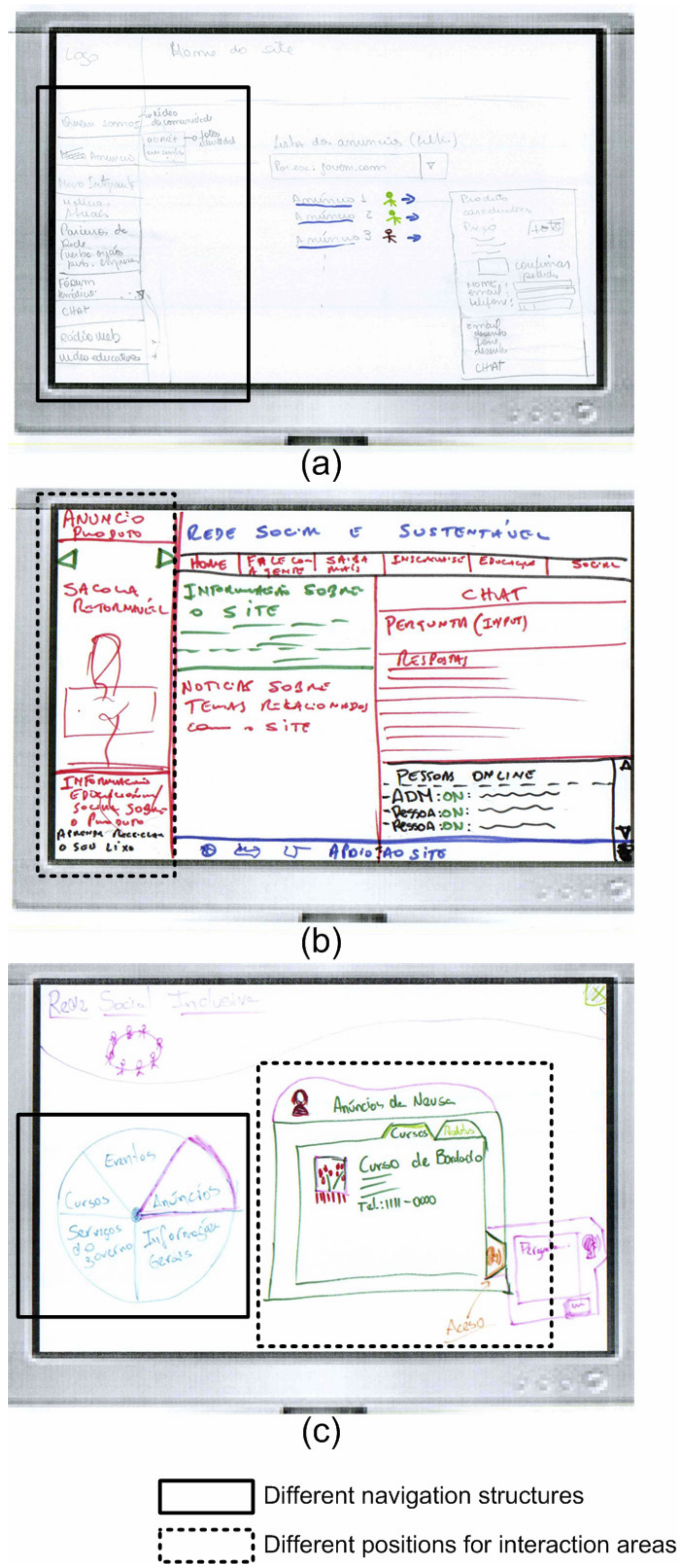


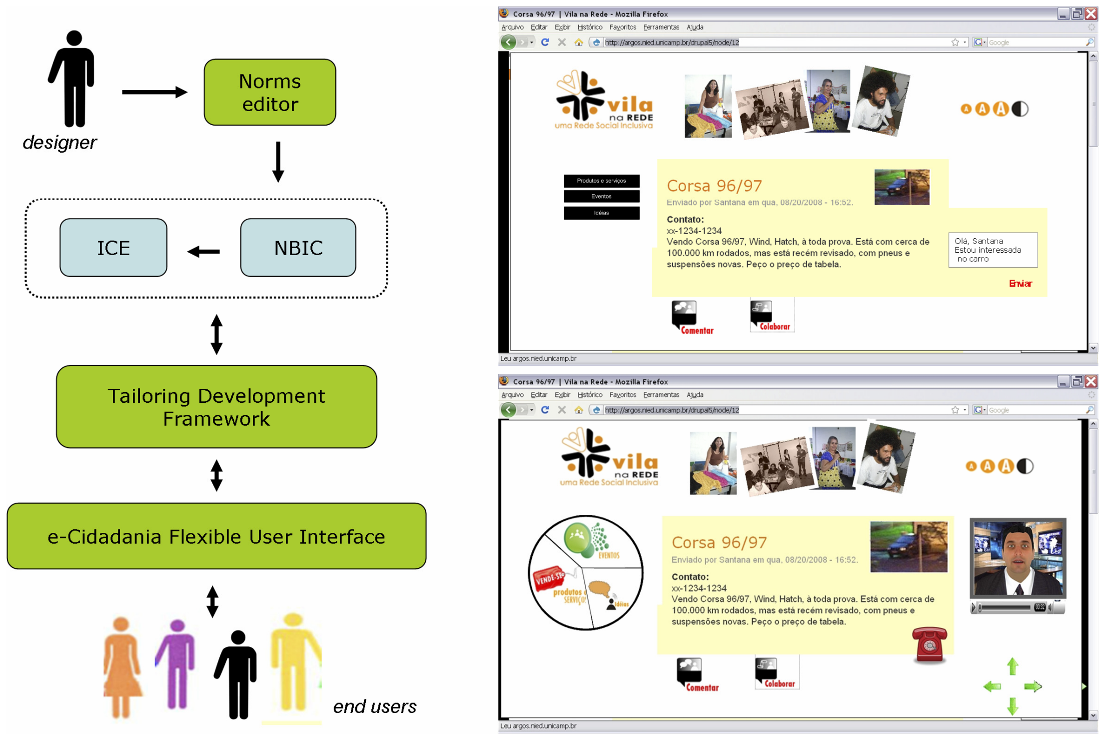
Figure 4.3. Some design proposals obtained with the BrainDrawing technique.

4.3.3 Building and evaluating the solution

After obtaining the conceptual model and a proposal for the design of the user interfaces, it is possible to prototype the application. Considering software engineering principles, it is important to formalize all the information acquired aiming at the coding phase. At this point, Use Cases and System Sequence Diagrams can be specified (cf. Sommerville, 2000). However, offering universal interface solutions, providing different and suitable forms of interaction requires an infra-structure which allows managing the changes and altering the system at the time of use. Literature shows some possibilities of infra-structures that can be applied (cf. Macías and Paternò, 2008; Wulf *et al.*, 2008; Bonacin *et al.*, 2007).

In e-Cidadania project, we are using Bonacin’s infra-structure because it also considers OS as a reference and proposes the use of norms to manage the possibilities of tailoring (Bonacin *et al.*, 2007). Figure 4.4a shows the architecture defined for tailoring-based solutions in the e-Cidadania project. The designer enters norms in a software application named norms editor. The NBIC (Norm Based Interface Configurator) receives the norm specification in Deontic logic, manages the norms persistence, and also transforms them into a platform specific language that can be interpreted by an inference machine on ICE (Interface Configuration Environment). Then, the ICE receives context information from the Tailoring Development Framework, evaluates the norms related to context by using an inference machine and returns to the framework an action plan with the changes to be done (Bonacin *et al.*, 2007). The framework works with a content management system, in e-Cidadania case - the Drupal, and makes available tailorable user interfaces. Figure 4.4b shows examples of interfaces with different interaction elements. One solution presents a linear menu while the other one provides a circular menu. Also, in the first one, information is accessible by text, while in the other one there is a space for a virtual actor that can speak or make signs.

In addition to the building of the design proposal, evaluation is also an important aspect to consider. In the context of e-Cidadania, evaluation is being considered in two moments: during participatory workshops, where some evaluation frameworks can be applied, as the Self Assessment Manikin (cf. Hayashi *et al.*, 2008c), and in a continuous on-line evaluation in which more longitudinal studies can be done. In continuous evaluation, expected results are the identification of user behaviors, learning curves, communication styles, etc. Relevant data to be captured are individual as well as group interactions; data can be captured using embedded tools that gather user statistics respecting the users' privacy (Santana and Baranauskas, 2008).



(a) (b)

Figure 4. 4. (a) Architecture proposed for tailoring in the e-Cidadania project. (b) Instances of tailorable interfaces.

4.4 Discussion and Lessons Learned

The development of Interfaces for All demands a clarified view of the problem and of the different interaction requirements present in the users population. From the stakeholders and problems/ solutions mentioned here, it is possible to see how PAM supports the elicitation of different stakeholders and between them, the diversity of users. Further, Connell *et al.* (1997) indicate that during the development of a universal solution, designers should also incorporate considerations related to economics, engineering, culture, gender and environmental issues. The Evaluation Framing Chart supports the elicitation and discussion about these topics in a participatory way.

Moreover, the involvement of the different users is a crucial aspect in the proposed approach. In this sense, it is important to point out the need of providing a warm and non-intimidating environment for the workshops. Also, it is necessary to use an accessible vocabulary and open to everyone the opportunity to speak. For instance, in some of the definitions users wrote about inclusive social networks (that were used in SAM), their grammar mistakes did not prevent them to express a high level of maturity and consciousness regarding the topic.

From the elicited requirements, we could notice the need of using different media to make information accessible in a universal way. In addition, redundancy showed to be necessary for the universal design. For instance, for the interaction of the illiterate or with low literacy people it is possible to find in literature works that consider interfaces without text as a possible solution (cf. Neris *et al.*, 2008). However, despite these interfaces allow users to access content by images and sounds, they do not provide the contact with the text, a key element in promoting the ability to read. User interfaces should be also considered as means of promoting the intellectual growth of the users.

Besides that, it is important to emphasize that the universal design solutions, when possible, should prepare the users to interact with other systems. This is a key aspect considering digital inclusion. Finally, Interfaces for All are related to the right to choose the interaction way which is more suitable for each user. In this sense, universal design solutions should always provide means to users benefit from technology despite any previous background.

4.5 Conclusions

This paper brought to discussion the problem of designing for a diversity of users competencies typical of contexts of digital divide. The complexity of the social scenario which includes people not familiar with technology suggests the need of approaches for requirements elicitation that traditional methods from Information Systems and Software Engineering fields do not reach. The paper described the approach we are investigating in the context of the e-Cidadania project, which brings prospective users to the design process and uses a theoretical reference that allows a socio-technical vision to the problem. The requirements elicitation, design and building phases were presented, exemplified and discussed.

The approach we proposed here is to build Interfaces for All, tailored to each one. By applying this approach in the e-Cidadania project we were able to identify issues that could be missed out in a strict technically-based approach (e.g. the needs of asking permission before using someone else's knowledge), especially regarding how to make the solution tailorable. Further work includes the evaluation of the tailorable behavior of the system to different types of social norms generated by the users.

Capítulo 5

PLu*R*aL: a framework for designing tailorable user interfaces

5.1 Introduction

As computers are becoming ever more present in people's lives, the diversity of interaction requirements to be addressed in their design is growing rapidly. From desktops to cell phones or interactive tables, people from office workers to many different users, including the elderly, illiterates, and nonexpert users, all with different physical, cognitive and emotional abilities, can be interacting with computational systems on the street, in a bus, or anywhere. The myth of the median user (cf. Fischer, 2001) has faded, and design for the diversity of users is a reality we must face.

Besides the diversity arising from the diverse use contexts, it is important to consider the mutable and evolving nature of Information Systems. As users evolve, e.g., develop new cognitive models about the task, the artificial artifact should be sufficiently flexible to accomplish this (co)evolution (Simon, 1969; Winograd and Flores, 1986; Fischer, 2001). When systems are stuck, users get frustrated, the system is considered out of date, and more money and effort are expended.

One way of coping with diverse and mutable systems requirements is to offer the possibility of tailoring user interfaces according to their preferences or needs. Applications that allow tailoring offer to end-users the possibility to adapt the software to their personal preferences or changes in the task after the software is implemented (Slagter *et al.*, 2001). Tailoring involves the concept of "design for change", offering the flexibility of adapting to different organizational contexts and to changed or unanticipated use situations (Henderson and Kyng, 1991). It is important to note that activities related to the concept of tailoring involve not only superficial changes in user interfaces such as changing color or font size, although we include them as well. The visibility of new features that become relevant in new contexts of use and task optimization are also possibilities inherent to the concept of tailoring.

The design of tailorable systems demands new methodologies to cope with the diverse requirements and functionalities that can be changed during their usage lifetimes. Research on tailoring to date has predominantly focused on technical issues, e.g., the infrastructure needed to enable changeable applications (cf. Bonacin and Baranauskas, 2005; Macías and Paternò, 2008). Other works have investigated the phenomenon regarding tailorability, e.g., the reasons that lead users to tailor (cf. Mackay, 1990; Oviatt *et al.*, 2004; Rivera, 2005); several have focused on some specific mechanisms that allow tailoring, e.g., menus and buttons (cf. MacLean *et al.*, 1990; Park *et al.*, 2007), while some classified the different types of tailoring (cf. Mørch, 1997, Neris and Baranauskas, 2007) and a few have discussed the design of these applications (Germonprez *et al.*, 2007; Wulf *et al.*, 2008; Neris and Baranauskas, 2009a). Especially in areas concerning design, the works to date have focused on principles to guide designers; studies regarding practical approaches to support design decisions for tailorable applications have been lacking.

Unlike conventional applications, when designing tailorable systems, designers must foresee different possibilities of use, including the evolution of users and use in different devices and environments. This need demands a sociotechnical view, considering a broader and deeper understanding of the domain and the context of use. This work presents PLu*R*aL – a framework for supporting the design of tailorable applications. The framework is rooted on Organizational Semiotics (OS) ideas and the techniques and methods proposed are organized into three pillars which support the elicitation of the diverse interaction requirements, a deep understanding about the domain and the system's functionalities and the specification of the system's tailorable behavior.

PLu*R*aL was used by 17 graduate students taking the role of designers. The design solutions obtained showed flexible resources in their applications, consistent with the domain and diversity of interaction requirements. This paper is organized as follows: Section 5.2 is a literature review considering the different aspects related to the design of tailorable applications; Section 5.3 introduces the theoretical reference; Section 5.4 presents PLu*R*aL and the set of methods and techniques for each pillar; Section 5.5 reports the validation process and the applicability of the framework; Section 5.6 summarizes and discusses the results; and Section 5.7 concludes and suggests further work.

5.2 Literature review

Although other terms such as customization (e.g., Stallman, 1981; Mackay, 1990; Macías and Paternò, 2008), personalization (e.g., Sieg *et al.*, 2007, Findlater and McGrenere, 2009) and adaptation (e.g., Trigg *et al.*, 1987) can be found in literature with similar meaning, the term tailoring has appeared in most of the works on the subject (e.g., MacLean *et al.*, 1990; Henderson and Kyng, 1991; Mørch, 1997; Wulf and Golombek, 2001; Bonacin and Baranauskas, 2005; Germonprez *et al.*, 2007). Moreover, according to Germonprez *et al.* (2007), tailoring is a long-standing and consistent term found in several disciplines; therefore, tailoring is the term used in this work.

Systems that allow tailoring appeared in the early 1980s. Stallman pointed out that the EMACS editor offered extension mechanisms: "several small extensions may be made without the need of programming. They are called customization and are very useful" (Stallman, 1981). In this first stage, the technical problems in the development of such software systems were the main focus. In the 1990s, with increasing industrial demand resulting from the spread of personal computers in companies and the dissemination of standard applications such as word processors and spreadsheets, tailoring was seen as an approach to enable greater efficiency in performing office tasks.

Relatively new are approaches that consider a sociotechnical view to the problem and define patterns and principles to support the design of such applications. Figure 5.1 compiles aspects highlighted in the literature considering three views: use, design and implementation.

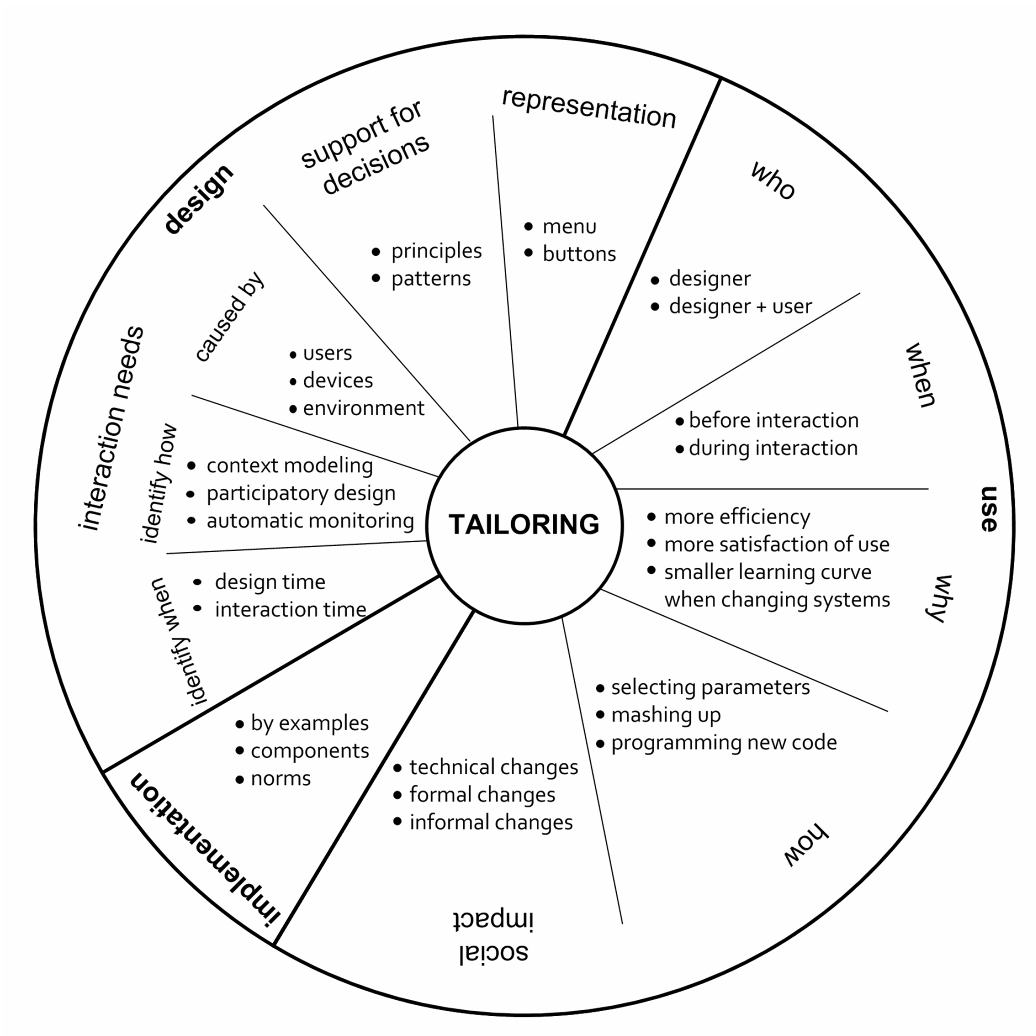


Figure 5.1. Tailoring views with the main aspects highlighted in the literature.

5.2.1 Use view

Regarding the usage aspect, *who* is in charge of tailoring? Basically two approaches can be found in the literature. In the first, designers determine the tailorable versions that are presented to users, who passively “receive” the system tailored to their needs and cannot change it. This is generally done when the users’ roles are very well defined (e.g., system administrator and general users) or when the context is captured and the system adapts itself (e.g., websites that change their presentation when accessed by cell phones browsers). The second approach considers users actions explicitly. For instance, Fischer *et al.* (2004) proposed a meta-design approach in which users become co-designers not only at design time but throughout the lifecycle of the system, i.e., "designer + user" tailor the final system.

The time aspect is related to the moment *when* the interface is tailored. It can be done before the interaction, i.e., when the user starts to (re)use the system, it is already tailored (e.g., functions are available only to a specific user profile). Tailoring can be done during the interaction, when the user changes the system and the results appear immediately (e.g., activation of a high-contrast option in a website), or in adaptive[10] systems that capture data and change its interfaces during the same interaction section.

Mackay (1990) investigated *why* users tailor systems. The main motivations she found were that users tailor to maintain stable usage patterns, retrofitting new software to resemble an old one they are already used to; users also tailor when they discover that they have been doing something repeatedly and choose to automate the process. Henderson and Kyng (1991) also showed that tailoring is driven by the user's needs and, therefore, is usually prompted by the users. Costabile *et al.* (2003) emphasize the "coevolution" phenomenon, i.e., users change themselves as they use the system, and as they change, they will use the system in new ways. Therefore, this becomes a natural motivation for tailoring.

The *how* aspect is related to the different ways a user can tailor an interface. Trigg *et al.* (1987) identified different ways the NoteCards hypermedia system could be adapted, going from the use of objects in a different way to codification to obtain new software components. Fischer and Girgensohn (1990) proposed a taxonomy called "end-user modifiability" that considered changing parameters, adding functionalities to existing objects and creating new objects. Mørch (1997) classified end-user tailoring into three levels: customization (selecting among a set of predefined configuration options), integration (creating or recording a sequence of program executions) and extension (adding new code). Erickson (2008) considers customization (setting parameters), composition (linking existing components), expansion (creation of a new component) and extension (insertion of new code). Summarizing, we could say that users can tailor basically in three different ways: selecting parameters, adding or mashing up existing software modules (e.g., downloading and installing extensions or using APIs), or programming new code.

Thus far, the classifications regarding tailoring have focused on the efforts users should make to perform the changes. Neris and Baranauskas (2007) pointed out the need of considering the tailorable system in a context of use and proposed a classification that considers the *social impact* of the change. The classification presents three levels: technical changes (mainly impact the software application-interface elements, reflected in aesthetic elements such as color, forms and positions of the interface elements), formal changes

[10] A system is said to be adaptable when the user explicitly asks for the change and is adaptive when it automatically changes its behavior (Oppermann and Simm, 1994).

(impact the business process, e.g., with different ways of performing tasks) and informal changes (software adaptations that reflect changes in beliefs, habits and patterns of behavior of each individual member that affect the organization as a whole; e.g., users add their own comments to software artifacts and share them with the whole organization).

5.2.2 Design view

The works related to the design view were grouped considering three aspects: interaction needs (caused by and identified how or when), support for decisions and representation. Regarding *interaction needs caused by,* Obrenović *et al.* (2007) mapped "impediments" into four categories: equipment, environmental, social and user. They also mapped out modalities of interaction, representing assistive technology or the use of different media. In their model, the effect, which may be sensory, perceptual, motor, linguistic or cognitive, requires modalities and is affected by the impediments. Although Obrenović's work made a significant contribution in dealing with the different interaction needs, their proposal considers interaction from a purely syntactic perspective. Neris *et al.* (2008) have shown that the user's familiarity with the devices and their knowledge of the application domain meaningfully influence the impediments. Aspects related to semantics (meaning and beliefs), pragmatics (intention of use) and consequences of the interaction in the real world should also be considered. Finally, the social aspect is always related to a user or a set of users; therefore, in Figure 5.1, the aspects listed under interaction needs caused by are summarized as users, devices and environment.

The requirements arising from users, devices and/or environment can be identified during the design time or during the interaction time. Regarding the interaction needs identification, the *when* aspect is related to the *how* aspect. Approaches such as context modeling and Participatory Design (PD) (Schüller and Namioka, 1993) support the identification during design time. Alternately, an automatic monitoring (cf. Mobasher *et al.*, 2000) can support this identification during the interaction time. The term context modeling is used here instead of user modeling (common in traditional design approaches) as the design of tailorable applications may consider requirements arising not only from users but also from different devices and environments.

While facing the challenges of proposing tailorable solutions, the *support for decisions* mentioned in the literature consists mainly of principles and patterns. Baranauskas and Neris (2007) selected interaction patterns related to tailoring and, from these, proposed characteristics that interfaces allowing tailoring should have. Moreover, they proposed a set of elicitation patterns consisting of issues to be discussed with stakeholders during the elicitation of software requirements. Eriksson (2008) proposed usability scenarios for each different level of tailoring (customization, composition, expansion and extension) and compiled a set of usability and design patterns that could support design decisions and implementation. Beyond patterns, Wulf and Golombek (2001) proposed the principle of "direct activation", i.e., tailoring options should be presented close to where they will be used and preferably in a graphic way. Recently, Wulf *et al.* (2008) defined four main challenges that can also be understood as principles for design:

consistent anchoring, intelligibility, effect on visualization and fault tolerance. Germonprez *et al.* (2007) proposed a more extensive list with nine principles: task setting, recognizable components, recognizable conventions, outward representation, metaphor, tools, methods, functional characteristics and user representation.

Regarding the *representation* of tailoring options, MacLean *et al.* (1990) showed that when a user needs to tailor a system in ways beyond simple parameterization, advanced interaction skills are required. Aiming at making tailoring accessible to users without programming skills, they proposed an approach based on the creation of buttons that encapsulated relevant parts of the interaction (e.g., inserting a phrase that is repeated several times during the editing of a text by clicking a button). Recently, Park *et al.* (2007) studied issues related to performance and user satisfaction using tailorable menus. They compared adaptable (by dragging and dropping) and adaptive menus, and the results suggest that users preferred the adaptable one. Therefore, they concluded that a simple and easy way of tailoring combined with knowledge and motivation are essential considerations in the design of tailorable interfaces.

Finally, the literature on the design view shows the variety of aspects that influence a tailorable design, from the elicitation of interaction needs to decision support by patterns and principles and representation in the interface. Nevertheless, there is still a lack of practical approaches that support designers with methods, techniques and artifacts during the different stages of design.

5.2.3 Implementation view

Providing systems that allow tailoring requires a logical structure that manages the possibilities for change and an architecture that enables changes before or during the interaction time. Current research in infrastructure has explored client-server architectures.

Wulf *et al.* (2008) have chosen to enable tailoring using an infrastructure based on components. In their work, this metaphor goes beyond the issues of architecture and is maintained during the user interaction with the interfaces, requiring from users notions of componentization. Macías and Paternó (2008) proposed an approach based on rules that are automatically inferred from an example provided by the user. In their approach, users must change a web interface (altering the code directly or using an authoring tool) and send the modified page to a server. Through rules of inference and a reverse-engineering approach, the system identifies what has changed and updates the system's behavior. Bonacin *et al.* proposed an infra-structure based on the concept of norms used in OS. The infrastructure manages the norms' persistence, and, considering information from the context, interprets and infers the tailorable behavior. (Bonacin *et al.*, 2007; 2009).

The concept of norms is also adopted in PLu*R*aL but with emphasis on modeling the tailorable behavior from a design perspective. PLu*R*aL focuses on the design by considering a deep understanding of the interaction needs and domain affordances, an integrated vision for the tailoring representation and a norm-based specification for the tailorable behavior. Aspects related to the infrastructure are not part of PLu*R*aL, allowing the use of different architectures to implement the design solution. The next section presents some principles of OS that were adopted to support the design of tailorable user interfaces.

5.3 Theoretical reference

OS is a discipline that has roots in Semiotics as applied to organizational processes. It studies the nature, characteristics, function and effect of information and communication within organizational contexts. An organization is a social system in which people behave in an organized manner conforming to a certain system of norms. These norms are regularities of perception, behavior, belief and value that are expressed as customs, habits, patterns of behavior and other cultural artifacts (Stamper *et al.*, 1988; Liu, 2000).

According to the OS perspective, an organization can be seen as an information system where agents employ signs to perform purposeful actions. Some of the organizational functions are of high regularity and have rules that can be clearly formalized. Within the formalized part of the actions, a fraction of these may be very repetitive and can be automated by computer-based systems. In this sense, the software (technical system) is part of a whole information system and presupposes a formal system in which rules and formal procedures specify how the relations should be carried out and how the actions should be performed. Moreover, the formal system presupposes an informal system in which organizational culture, customs and values are reflected in the beliefs, habits and patterns of behavior of each individual member; at this level, meanings are agreed upon, intentions are understood and beliefs are formed. Therefore, OS provides a background that embodies knowledge and supports collaboration and reflection among people from the different disciplines involved in interaction design (Baranauskas and Bonacin, 2008).

Stamper proposed a set of methods to support the use of OS concepts for modeling information systems, named MEASUR - Methods for Eliciting, Analyzing and Specifying Users' Requirements (Stamper *et al.*, 1988). PLu*R*aL builds on three MEASUR methods: the Problem Articulation Method (PAM), the Semantic Analysis Method (SAM) and the Norm Analysis Method (NAM). Besides these methods, PLu*R*aL also benefits from the Semiotic Ladder.

5.3.1 PAM

PAM supports the identification of the main topics related to the context, e.g., stakeholders, action courses and bureaucracy, especially when the context is complex and still vague, allowing a more clear understanding of the problem (Kolkman, 1993). It aggregates several techniques as Unit System Definition, Collateral Analysis and Stakeholder Analysis; the last one is used in PLu*R*aL's first pillar.

Stakeholder Analysis proposes a model for identifying those who influence the (system) domain. Four main categories, presented in nested layers, represent the different information fields: actors and responsible parties (those who are directly involved with the problem), clients and suppliers (those who will effectively use the system or those who feed the system with information or services), partners and competitors (members of the market related to the system domain) and spectators and legislators (comprising not only those responsible for establishing the formal or informal rules but also the whole community that will receive the benefits or costs as a consequence of the implementation of the system). A chart can be used to support the stakeholders' identification.

5.3.2 SAM

SAM supports the analysis, specification and representation of an information system and is divided into four phases: problem definition, candidate-affordance generation, candidate grouping and ontology charting (Liu, 2000).

Affordance, a concept originally introduced by Gibson (1968) to express the behavior of an organism made available by some combined structure of the organism and its environment, was extended by Stamper (1993) to include patterns of behavior related to social interactions. SAM also considers the concepts of agents and ontological dependencies. An agent is a special type of affordance, referring to those who are capable of assuming responsibilities. Ontological dependencies are links between affordances or agents, implying that the existence of an element drawn on the right depends on the existence of a corresponding element on the left in a ontology chart. Considering a statement that defines the (design) problem, the main affordances in the domain are elicited. After identifying the affordances and agents and grouping them, an ontology chart is drawn. In the chart, affordances are represented as rectangles, agents as ellipses and the lines establish the ontological dependencies.

5.3.3 NAM

NAM is usually carried out on the basis of the results of SAM to specify the conditions and constraints on behaviors based on the norms concept. Norms are the rules that determine how social organisms interact and control affordances (Stamper 1993; Stamper *et al.*, 2000). They are related to how people behave, think, make judgments and perceive the world. Every norm can be written as IF <condition> THEN <consequence>. Behavioral norms, in particular, can be expressed in an extended format: WHENEVER <state> IF <condition> THEN <agent> IS <deontic operator: must, may, must not> TO <action>. With this last structure, it is possible to complement the ontology chart to specify how agents deal with affordances.

NAM consists of four steps for eliciting and formalizing norms: responsibility analysis, protonorm analysis, trigger analysis and detailed norm specification (cf. Liu, 2000). Each step assists the identification of parts of the norm. In particular, responsibility analysis aims at assigning the agents in charge of each action. Trigger analysis focuses on the conditions that should happen and thus the action that will be performed.

5.3.4 Semiotic Ladder

The Semiotic Ladder allows a refined classification of information considering six information layers (the physical world, empirics, syntactic, semantics, pragmatics, and social world) and has been used in different knowledge areas including Systems Engineering (cf. Stamper et al., 1988; Stamper, 1993; Liu, 2000) and interactive systems (cf. Baranauskas and Neris, 2007).

The three upper steps consider human information functions, i.e., the use of signs in communication, considering meanings, intention and social consequences. The *social* layer considers information about the effects of using signals and comprehends beliefs, expectations, commitments and culture. The *pragmatic* layer considers the purpose of using signs and relates to intentions and negotiations. The *semantic* layer deals with meanings, truth and signification. The three lower steps consider the IT platform and how signs are physically constructed, transmitted and structured. The *syntactic* layer is related to formal structure, language and logic. The *empirical* layer relates to patterns, channel capacity, redundancy and protocols. Finally, the *physical* layer considers speed, signals and hardware.

5.4 PLu*R*aL

Aiming at supporting the design of tailorable interfaces, this work proposes a framework to be used by designers that comprehends the interaction requirements for the generation of design representations and functional specifications including tailorable behavior. The term framework is used here in its broadest sense as a structure consisting of guidelines, mechanisms, methods and systems used in the design planning and decision making.

The literature review reveals the complexity of the issues involved in the design of tailorable interfaces, which demands:

- a social technical view;
- elicitation techniques that allow a comprehensive view of differences, including those that are unexpected, controversial or minority;
- interaction requirements that come not only from users but also from devices and environments;
- the semantics, pragmatics and social impact of the interaction;
- a clear and consistent view of the system domain to support foreseeing functionalities;
- tailoring representation assembled with the application design;
- mechanisms to model the tailoring behavior.

Moreover, it is desirable that designers feel secure but not as if their “hands were tied”. As creativity is an important aspect of design (Dorst and Cross, 2001) and design is not a linear process, a framework should allow modifications and an incremental approach. Taking into account these issues, this study proposes PLu*R*aL, as shown in Figure 5.2. The sociotechnical view is supported by the adoption of OS as a foundation for the design approach. Atop this foundation, PLu*R*aL has three pillars that support design for diversity: describe the needs, define functionalities and determine the tailorable behavior. The activities proposed in each pillar are described in the next subsections.

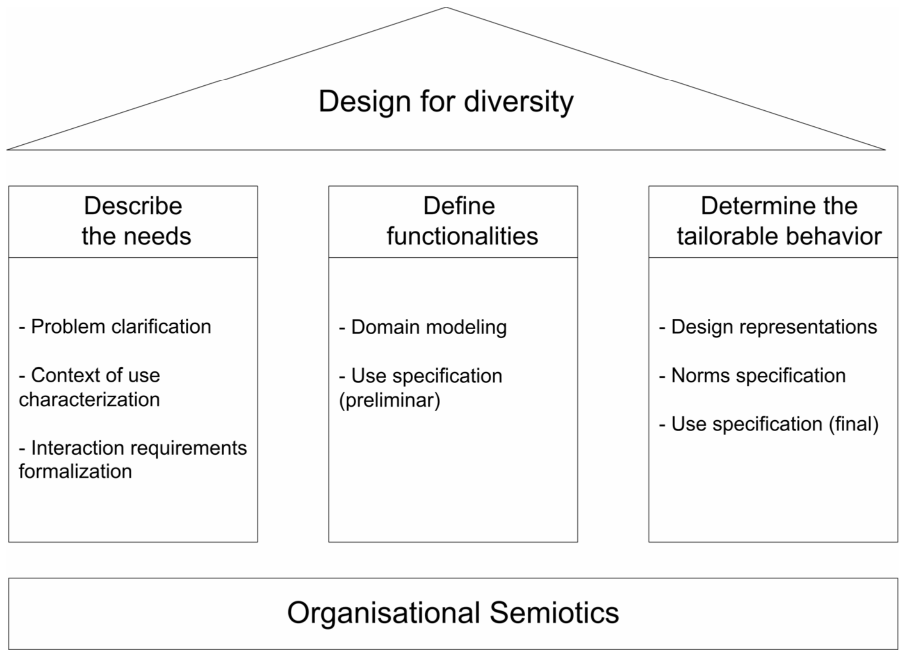


Figure 5.2. PLu*R*aL framework.

5.4.1 Pillar 1: Describe the needs

The objective of the first pillar is to provide a comprehensive view of the differences present in potential users and also in devices and environments where the system could be used. In this sense, the first activity intends to clarify the problem, realizing the limits of the solution. The Stakeholders Analysis (Kolkman, 1993), which supports stakeholders' elicitation and assesses how they impact the system design, was adopted here. The example shown in Figure 5.3 concerns a job-guide website intended for a government work center. Among the stakeholders listed are designers and programmers as actors, job candidates and companies as clients, city hall personnel and people from other employment programs as suppliers, and W3C and the employment ministry as legislators.

The Stakeholder Analysis technique was originally proposed to be used by an analyst (in the context of an organizational modeling) or a designer (Human-Computer Interaction context). However, Baranauskas and others (Baranauskas *et al.*, 2005; Bonacin *et al.*, 2006; Neris and Baranauskas, 2009a) have applied the same artifact in a participatory approach. Regardless, the task of classifying the stakeholders according to the layers contributes to clarifying the scope of the solution. Moreover, some of the stakeholders mentioned will interact with the system, which supports the beginning of PLu*R*aL's next activity.

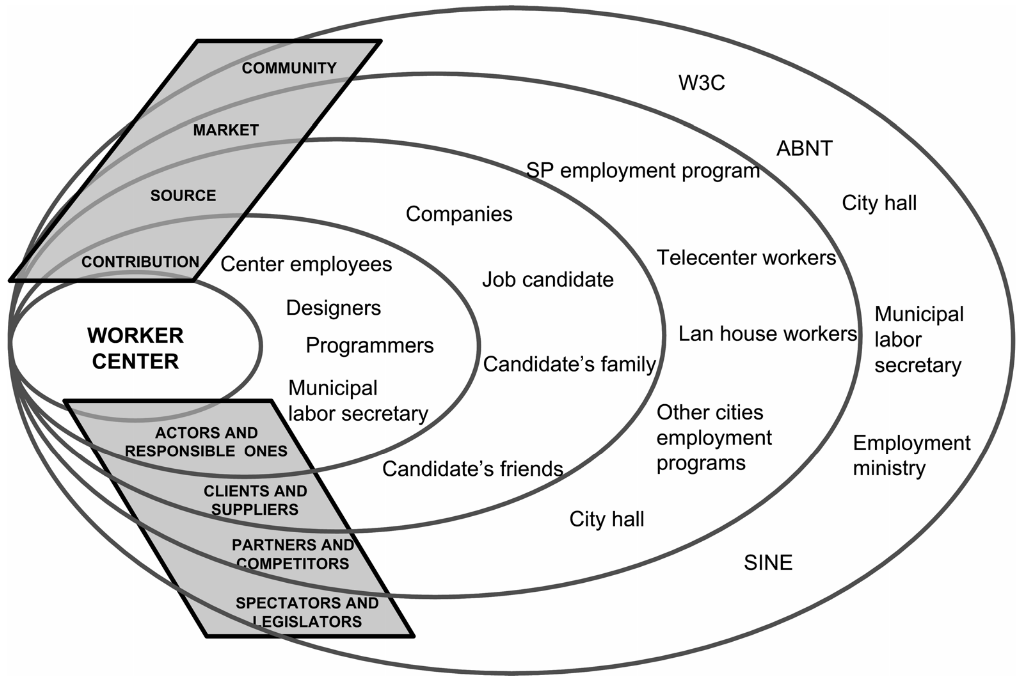


Figure 5.3. Stakeholder's chart for a job-guide website.

The second activity concerns the characterization of the context of use. As mentioned before, a system can be tailored to supply requirements coming from diverse users, different devices or changes in environmental conditions. Designers should not be looking only at the average but mainly at the diversity of needs. Therefore, a technique inspired on CARD (Collaborative Analysis of Requirements and Design (Muller, 2001)) was proposed. Three different types of cards were prepared (for users, devices and environment). Figure 5.4 illustrates the card for a users' group.

Besides the different physical characteristics and familiarity with devices, the user's card also considers differences in semantics (terms from the domain), pragmatics (intentions of use) and social impact. Moreover, the card allows the specification of differences regarding affective issues and knowledge about the system domain. The example shown in Figure 5.4 consists of characteristics of elderly patients considering a system to set appointments with a doctor. The aspects listed consider memory deficit as a possible physical characteristic, independence as a purpose of use and the impact in sociability that not going to the clinic may cause. It is interesting to note that the card allows a comprehensive specification, as characteristics of minority subgroups can also be considered. In the field "known devices", for example, it is possible to write down telephones (for those that only use telephones), but also desktops, as this device may be used by some elderly people.

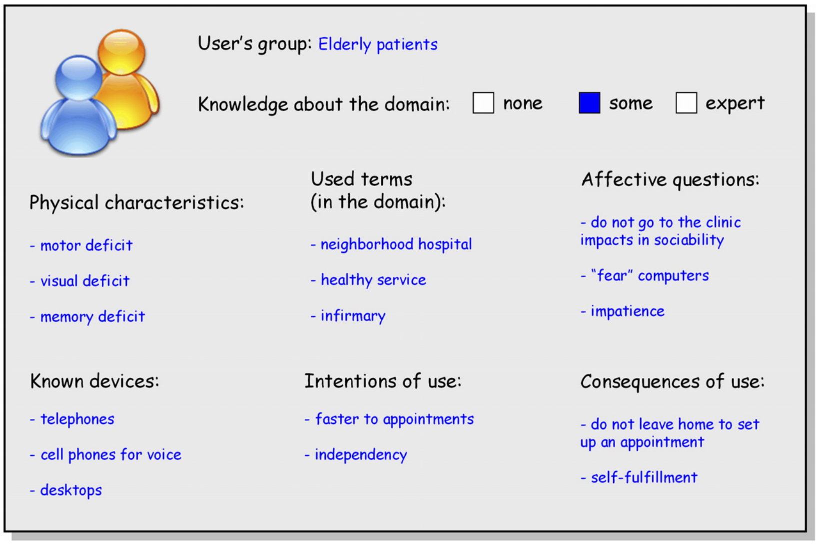


Figure 5.4. Card for user group characterization.

The card for devices considers some aspects mentioned in the (Composite Capabilities/Preference Profile from W3C, a data model that describes devices) and is composed of questions considering input and output features (e.g., keyboard, Braille display or the presence of speakers), physical characteristics (sizes, screen size) and processing capacity. The card for environment is composed of questions regarding noise, luminosity, network connection availability and predisposition to distractions. Filling out the cards can be done alone, with other designers and also in a participatory approach. Other fields can be added to each card according to the project's needs, and the cards can be grouped at the end of the activity forming a "context chart".

With a comprehensive view of the context of use and its peculiarities, it is possible to think about interaction requirements. Here PLu*R*aL prescribes another artifact from OS: the Semiotic Ladder (Stamper, 1988). Looking at the cards, designers are able to identify and distribute the interaction requirements in the Semiotic Ladder layers. Figure 5.5 shows a ladder partially filled in the context of the job-guide website. Requirements for adapting to cell-phone screen size (in the physical layer), offering textual and audio alternatives to video content (empirics), allowing tab navigation (syntactic), offering searching with informal terms (semantics), reducing anxiety and fostering self-confidence (pragmatics) and helping to rejoin the labor market (social world) were mentioned.

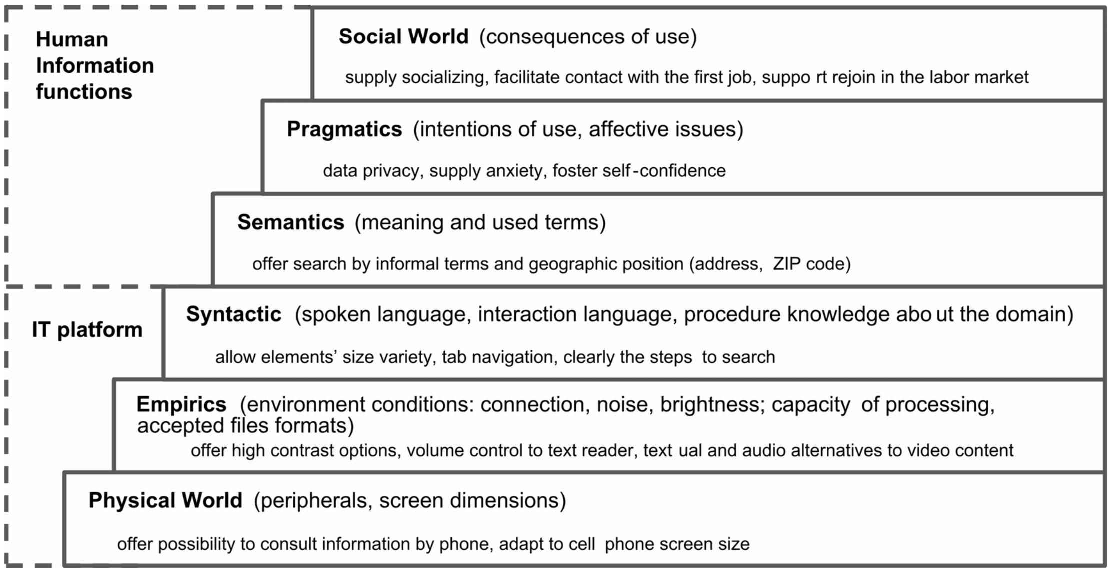


Figure 5.5. Semiotic Ladder with requirements for a job guide website.

5.4.2 Pillar 2: Define functionalities

Although tailoring applications may offer users the possibility of programming new features, it does not imply that designers' work is simplified. In fact, the opposite happens; the design of tailorable systems requires a thorough knowledge of the application domain to prepare this system for unforeseen functionalities and to support formal and informal changes (cf. Neris and Baranauskas, 2007).

In PLu*R*aL, two methods from OS are applied: SAM and NAM. Figure 5.6 shows an ontology chart for the job-guide domain. The worker center is an agent that is part of the nation (as it is a governmental agency), which is ontologically dependent on Society, the root. The chart also shows the relations characterizing the pattern of behavior "announces". The affordance "announces" exists only while the affordances "job offer" and "someone to announce" exist. Figure 5.6 also shows one norm associated with the affordance "announces". It specifies that an employee must always execute a certain pattern of behavior whenever a new valid offer arrives.

At this point, it is important to emphasize that the OS approach rescues the original sense of ontology as part of the philosophy that studies the nature of reality. It adopts a social-subjectivist stance and an agent-in-action perspective for ontology; i.e., each word or expression used is a name for patterns of behavior in the set of actions and events that agents experience. Therefore, the ontology chart is like a "snapshot" of the reality regarding that specific domain in which the prospective (software) system will be included. Moreover, the dynamic behavior in that reality can be modeled using norms.

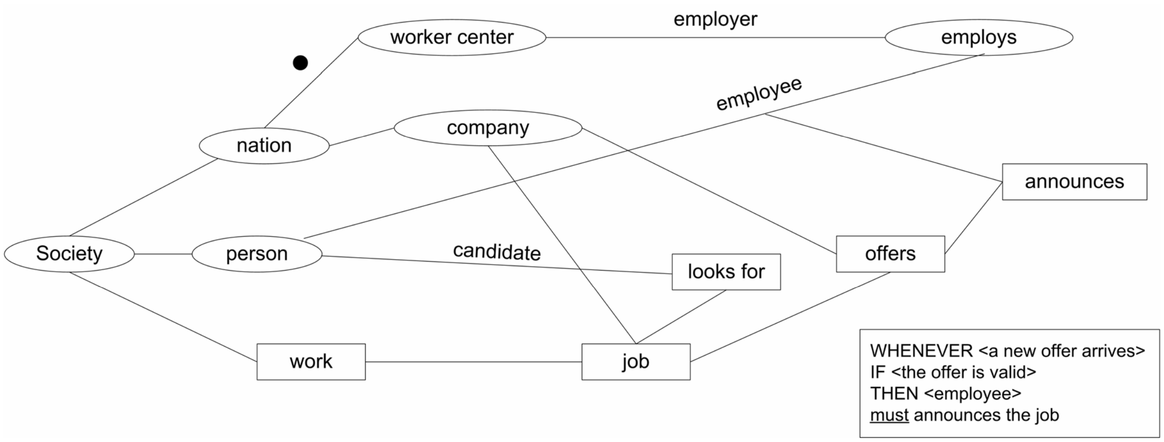


Figure 5.6. Ontology chart for a job-guide domain.

The methods and techniques employed up to this point represent the social context and provide designers with a consistent view of the domain. Furthermore, this information will directly support the specification of Use Cases, which is the purpose of PLu*R*aL's next activity. The Use Case describes the system's behavior under various conditions as it responds to a request from one of the stakeholders, called the primary actor. In this sense, they can be used to describe the interaction between users and any system (Cockburn, 2001). Use Cases are suggested as the artifact describing the functionalities in PLu*R*aL for three main reasons: they are well accepted by other members in a multidisciplinary team (especially by software engineers but also accessible to multimedia professionals); they describe the system from a black-box view, i.e., the flow of actions is delineated considering the interaction with users; and they allow the specification of exceptions and alternative flows, which is important when considering tailorable systems.

In PLu*R*aL, the recommendation is that the Use Cases be filled in starting at the end of the second pillar. At this moment, information such as use-case objective, preconditions and actors can be successfully entered. The fully filled version, including descriptions of the action courses considering the tailorable behavior, may be completed at the end of the third pillar, including the sequence of actions and alternative flows.

5.4.3 Pillar 3: Determine the tailorable behavior

One important step during user interface design is sketching, i.e., creating a representation of how the interfaces will appear. Although design involves creativity, there is always a commitment with the interaction requirements. Aiming at gathering design proposals that reach the requirements presented at the Semiotic Ladder (first pillar), an adaptation of the BrainDraw technique (Muller *et al.*, 1997) was proposed as part of PLu*R*aL. This technique allows a rough design of user interfaces through a cyclical brainstorming. Originally in the BrainDraw method, the scope of the design is elucidated (which interface or functionality should be drawn), and each participant starts a drawing on one sheet of paper. After a short period of time, the participant gives their sheet to the next participant who continues the actual drawing. Each drawing, at the end, is a fusion of ideas from everyone involved, and each design is unique because it had a different beginning.

In our adaptation, besides the blank sheets of paper, participants should be given a copy of the Semiotic Ladder with requirements in its six layers. Before each new round of drawings, participants were asked to look at the requirements list. At this stage, more universal solutions started to come up. After the drawing rounds, participants were asked to discuss the drawings and arrive at one consensual final drawing (a mix of the best ideas composing a new design). During the consensual stage, participants verified if all of the requirements were addressed in the final proposal; if not, they might draw how the system could be modified to include that specific requirement. Differently from the original process, at the end, participants had a consensual drawing expressing the tailorable behavior.

Simple drawings are insufficient to represent the diversity of facets a tailorable system may have, hence a more formal approach needed to be adopted. Once more, OS formed the basis of the solution, and the norm concept was again applied. As norms express how agents behave in society, the same structure was adopted to model the behavior of tailorable systems. An instance of the format proposed for behavioral norms was suggested for use considering context, functionality and interface elements, as follows:

WHENEVER (d, e, u) IF (f, r) THEN <system> IS <deontic operator> TO show ∑(i, m)

where:

d: device, e: environment, u: user

f: functionality, r: representation

i: interface element, m: mode (position, size, shape, color, type, instance)

The context is defined by a tuple formed by device, environment and user characteristics. When the condition is satisfied, i.e., the system starts a specific functionality in a specific representation (as the same functionality may have more than one user interface), then the tailorable system must, may or may not show a group of interface elements in a certain mode. The proposed format allows for modeling a great diversity of changes, as shown in Table 5.1. Designers can specify situations as simple as “every time the application is running on a cell phone, contrast option should be on” to more complex ones involving specific behavior to different interface elements.

Once the tailorable behavior has been modeled, it is possible to come back and finish the use-case specification, adding the actions and alternative paths. The following section presents the results of the use of PLu*R*aL, showing its applicability.

Table 5.1. Examples of norms representing a system's tailorable behavior.

Context			Condition		Tailorable behavior
device	environment	users	functionality	representation	element and mode
Cell phone	any	any	any	any	(any, contrast)
Computer	any	elderly	set appointment	confirmation	(sound file, "confirmation.mp3")
Computer	in the office	attendant	check appointment	appointment report	(language style, "formal_semantics.txt") & (logo, Healthy ministry)

5.5 PLu*R*aL in use

A feasibility study for PLu*R*aL was conducted with 17 (prospective) designers from the postgraduate course in Computer Science at UNICAMP-Brazil. The study followed the practices established by the Human Research Ethics Committee, and designers participated voluntarily.

The participants had different educational backgrounds and some experience with the design of interactive systems. Although many of them had never designed a tailorable system, they had experience as users of tailorable features. Their profiles were as follows: 71% male (n = 12); 53% between 20 and 25 years old (n = 9), 23% between 25 and 30 (n = 4), 12% between 30 and 35 (n = 2), and 12% older than 35 (n = 2). Regarding education, 76% had a B.S. (n = 13) and 24% an M.S. (n=4); 70% with a degree in Computer Science (n = 12), 18% in Media studies (n = 3), 6% in Architecture (n = 1) and 6% in Statistics (n = 1).

They evaluated their experience in designing interactive systems as follows: 29% had worked in companies for more than three years with the design of interactive systems (n = 5), 6% had worked in companies for less than three years with the design of interactive systems (n = 1); 23% had worked for more than three years designing interactive systems in research projects or in the academic arena (n = 4), 29% had worked for less than three years designing interactive systems in research projects or in the academic area (n = 5) and 18% declared that they had never worked with the design of interactive systems.

Regarding tailorable systems, 82% declared that they had never worked with the design of tailorable systems (n = 14), 12% had worked for less than three years designing tailorable systems in research projects or in academia (n = 2) and 6% had worked for less than three years designing tailorable systems in companies (n = 1). They classified their experience as users of tailorable system as: 41% sometimes use tailorable features (n = 7), 23% rarely use tailorable features (n = 4), 19% use tailorable features most of the time (n = 3) and 19% had never used tailorable features (n = 3).

The activities were developed from September to December, 2009 and started with the presentation of the following design problem: "Consider the problem of developing an e-government system or a social application. Imagine how a number of people with diverse physical, cognitive, affective and sociocultural characteristics will use the system. They may use different digital devices such as cell phones, computers, desktops, notebooks or netbooks or digital desks. Furthermore, they can interact in various locations, such as home, office or on the street."

After the problem presentation, PLu*R*aL was explained, and a simple example was shown. Designers then formed seven groups (four with three participants each, two with two participants each and one participant who worked alone) and were free to choose which system they would like to design. The systems chosen considered different domains: a public drugstore, a Portuguese study group, a social network of book readers, a polling system for digital TV, a traffic information system, a job guide and an interaction monitoring system.

After developing the activities in each pillar, designers filled in anonymous individual questionnaires, then each group presented its artifacts to the others, and general discussions were conducted. In the final section, each group presented an executable prototype.

During the activities relative to the first pillar, the Stakeholder Analysis technique supported the elicitation of users (as intended) and influenced the elicitation of environments and devices as well. Participants mentioned they were led to think about where those people would be interacting with the system and with which device (e.g., job candidates appeared in the Stakeholder Analysis chart, which led to telecenters or internet cafes as possible places to interact and using a desktop computer that may not have a sound card).

Participants also mentioned that the use of cards facilitated the comprehension of the domain and the filling in of the Ladder. One designer wrote: "Some items come directly out from the cards as intentions of use (pragmatics) and social implications. The physical and empirical layers were easily derived from the card for devices." However, the definition of the users' groups was not an easy task for some designers. They mentioned that the potential users were many and diverse, and it was difficult to select a criterion to divide the groups. In practice, it was shown that the best criterion is to consider the system domain. For the job-guide system, for example, the definition of user groups was based on age, literacy and familiarity with devices (important factors for entering the job market). Within these groups, other diverse aspects were also considered.

The groups that focused on tailoring to different devices had more requirements in the three lower layers of the Semiotic Ladder, while those that focused on diversity between users specified more requirements in the upper layers. Therefore, the distribution of requirements in the Ladder seems to indicate which part of the context is being better represented. Considering this information, designers could evaluate the extension of their understanding of the interaction needs before moving forward.

In the second pillar, the activities were about modeling the domain and specifying the use cases. Designers pointed out that SAM and NAM helped to understand the problem and see the software system as part of the whole information system. Moreover, the methods assisted the specification of use cases. They wrote: “the use-case generation was really immediate, as the two methods helped a lot to understand the problem and the system” and “the ontology chart with norms really helped to specify the use cases, e.g., actions and pre- and postconditions”. In contrast, learning how to make an ontology chart using the OS approach was not considered an easy task. In the OS approach, the relationships are established by considering an existential dependence (the affordance on the right ceases to exist if the affordance on the left does not exist), while in traditional computing modeling analysts are used to think in causal relationships. In this sense, designers wrote: “The artifact itself is not difficult. The complicated thing is to think considering existence” and “the greatest difficulty was the ontology chart. [It] makes you consider many ideas and sometimes I got confused”.

The third pillar was about determining the tailorable behavior. After a BrainDraw session guided by the Semiotic Ladder, designers established norms to the tailorable behavior. The norms specification seemed to have a direct and positive impact on the system implementation. About these norms, they said: “[the norms] help to us know when and what should be done”; “the main benefit is the clear organization about how tailoring will be, which guides the implementation”; “[the norms] helped us to imagine what the user would do in a similar way as the final result”.

At the end, the tailorable features identified and specified with PLu*R*aL were materialized in executable prototypes. Figure 5.7 shows interfaces from some of the prototypes developed. The traffic information system (Figure 5.7a) presents maps, which are generally complex interface elements if we consider physical and cognitive diversity between users. Designers then considered some semantic support represented by the use of textures and icons. A text emphasizing the main occurrences in the map is also offered through text (syntactic). In addition, besides options to change the font size and contrast, they offered the possibility to hear a map explanation. An avatar was added to support the interaction, and the information presented in the help function had different semantic levels.

The designers of the social network system focused on the different devices to interact with the system. Figure 5.7b shows two versions of an interface to read comments about a book. The picture on the left is a desktop version containing a long bar that expresses how the book has been evaluated by the readers. Additionally, the comments are on the same page beneath each other. In the cell-phone version (on the right), more than simply resizing elements, the structure also changed to better offer interaction according to the device characteristics. Comments are offered one per page with an easy navigation by the phone keyboard. A number expresses how the book has been evaluated, instead of the long evaluative bar.

The designers of the digital TV poll developed an adaptive system to consider the interaction needs arising from elderly and sign-language users (Figure 5.7c). The system initiates with the question being expressed by sound and text. The system then expects that users choose an answer and press a button in the TV control. If no interaction happens within a certain time, the system automatically repeats the question and elements in the interface are shown in a bigger size, to support people with poor vision. If no interaction occurs, a video in sign language then starts playing. If the user profile is already known by the system, the most adequate version can be offered by default. However, when the profile is not identified, the system offers the different interaction possibilities.

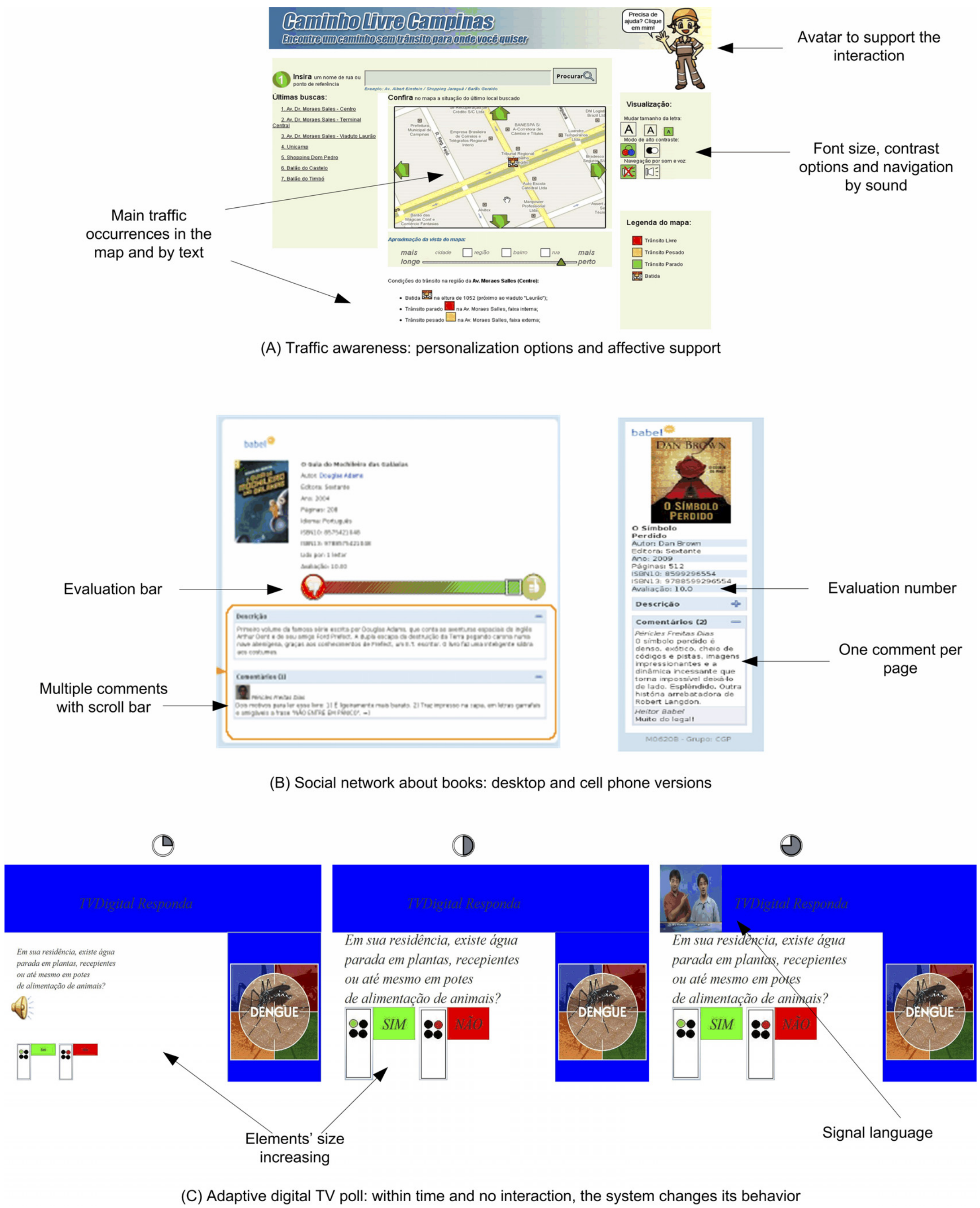


Figure 5.7. Tailorable systems designed using PLu*R*aL.

Besides qualitative data, PLu*R*aL was also evaluated by a five-level multiple-choice questionnaire. The questions considered the time spent to perform the activities, the ease of use, utility and designers' confidence. Figure 5.8 shows the results as percentages. For instance, regarding the time aspect, the graphic shows that 76% of the designers felt that the time spent (in relation to the quantity of interaction needs elicited) in the first pillar was valuable; 18% did not know how to judge this and 6% evaluated the time negatively (considering the time as too long).

The quantitative data suggest a positive evaluation for the utility of the methods and techniques and for the designers' confidence in the three pillars (acceptance > 75%). In particular, the third pillar with the norms representing the tailorable behavior was evaluated by 76% of the designers as useful or very useful and 83% said they were confident or very confident. The activities proposed in the first pillar were also well evaluated considering all of the analyzed aspects.

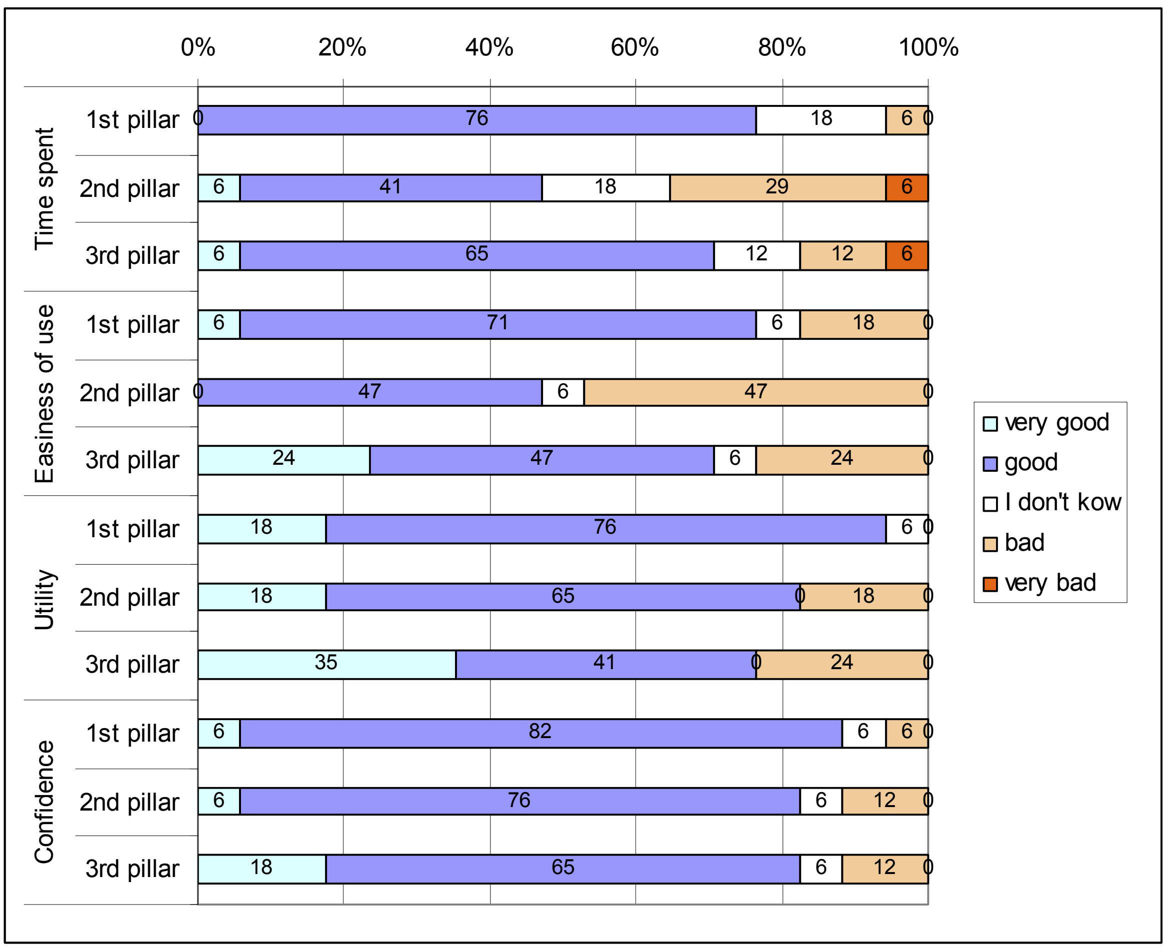


Figure 5.8. Time spent, easiness of use, utility and designer's confidence using PLu*R*aL

As mentioned previously, the methods recommended in the second pillar require a different way of handling modeling, which takes time and can be difficult in the first attempt. The quantitative data reflected what had been seen in the qualitative analysis. Only 47% of the designers considered the time spent in the first pillar was good or very good. Regarding the ease of use, there was a technical draw; 47% of the users considered the methods easy to use and 47% considered them difficult to use.

In addition to the analysis of each pillar, PLu*R*aL was evaluated considering several important characteristics for a framework that assists the design of user interfaces. Designers answered questions about the support for changes, creative freedom, satisfaction with results and if they would recommend PLu*R*aL to other designers. 89% of the designers said PLu*R*aL's support for changes in the design process was good or very good. Additionally, 89% indicated that PLu*R*aL did not restrict their freedom to create and were satisfied or very satisfied with the prototype's interfaces. Finally, 76% said that they would recommend PLu*R*aL to other designers.

5.6 Synthesis and Discussion

PLu*R*aL adopts a sociotechnical view, based on OS concepts, hence considers the software as part of a whole information system. Agents-in-action interact in sharing signs, which presupposes the physical means, empirics, syntactics, meanings and intentions, with consequences in the real world. Agents act following a certain system of formal or informal norms. PLu*R*aL's three pillars benefit from these ideas. The first pillar elicits the signs of interest in the domain (related to users, devices or environment) and formalizes nonfunctional requirements that the tailorable system should cope with. The second pillar benefits from two established methods from OS that allow a consistent view of the domain, including the norms that govern the agents' behavior, and assist the formalization of functional requirements. In the third pillar, the tailorable design solution is built up, and a norm-based structure formalizes the system's tailorable behavior.

Interaction between agents and the software system is considered a sign–sharing phenomenon influenced by several factors such as familiarity with devices, user intentions, affective issues, device characteristics and environmental conditions. Tailorable systems may be designed to deal with changes in all of these factors, and PLu*R*aL's approach to characterize the contexts of use (by cards) corresponds to this wide view. Important requirements related to privacy, socialization and self-fulfillment are elucidated using the cards and are formalized in the Semiotic Ladder. In addition, the results from the feasibility study suggested that the Semiotic Ladder supports an assessment of the range of diversity being covered.

Furthermore, it is important to emphasize that approaches that consider an average profile for characterizing users are likely insufficient to handle the diversity in a given context. A step forward in characterizing these differences was Personas (Cooper, 1999), which considers several distinct users while still creating archetypes, i.e., looking for the conventional characteristics and arranging a consistent profile (e.g., Mrs. Smith – an old lady that has never used a computer). However, the design for tailoring demands a more comprehensive view of the differences. The approach using cards considers several distinct groups and allows the specification of different aspects, even those that are controversial or come from the minority of people (e.g., elderly people with and without experience using computers).

Besides the elicitation of the diverse requirements, another important issue regarding tailoring is the representation of the tailoring options in the interface. Although PLu*R*aL does not guide how the tailoring options should be presented, the design solutions obtained with the modified BrainDraw show tailorable options in a cohesive manner with the other features of the system, aesthetically integrated and visible to users. This outcome may occur because the diverse nonfunctional requirements are considered beginning with the first sketches and in a unified way instead of designing the system and then thinking about the tailoring options.

PLu*R*aL approaches the tailoring behavior considering two complementary paths: the first draws from the modified BrainDraw method and norms. In OS, the original concept of norms is related to the organizational behavior, and the structure of behavioral norms requires an agent (affordance with responsibility) as the executor of the action. The same norm structure was adopted in PLu*R*aL intending to represent a certain behavior, in this case, the system behavior. The software system is an agent that will display a set of interface elements in a certain mode. This view considers the system as an active artifact capable of doing tasks in different contexts. However, it is known that the system software is not an agent in the way OS proposes, as the responsibilities always lie with the humans behind the system. Apart the conceptual issue, participants in the feasibility study pointed out that the formal structure helped with the system implementation. Furthermore, the use of norms to represent the system-tailorable behavior supports the description of a wide range of tailorable interfaces.

The application of SAM and NAM, although difficult at first attempt as the feasibility study pointed out, elucidates the “states” and “contexts” related to the affordances, supporting the use-case specification. Another interesting characteristic of these methods is that they clarify the agents and responsibilities in such a domain. Although PLu*R*aL does not differentiate between the design of adaptable and adaptive systems, more studies should be done to investigate if SAM and NAM support decisions on which features will be adaptable or adaptive in a tailorable system.

While PD was not used in the feasibility study, some of the artifacts and methods proposed in PLu*R*aL have their roots in the participatory approach. The cards and the modified BrainDraw, for example, can be used with end users, supporting a more realistic and democratic way to characterize the context of use and generate design representations. SAM and NAM have been already applied in a more democratic way in the e-Cidadania project: Systems and Methods for the Constitution of a Culture mediated by Information and Communication Technology (cf. Neris *et al.*, 2009a; Hayashi *et al.*, 2008a). Therefore, PLu*R*aL can be applied by a single designer, a group of designers and also in a participatory approach. Because PD deals with real users, instead of epistemic ones as in Personas, it increases the chances of viewing the unexpected, controversial and minority requirements. However, to achieve this more comprehensive view, variety should be considered when inviting people to the participatory workshops (cf. Neris and Baranauskas, 2009b).

Finally, we share with Fischer (2007) ideas related to the distribution of control among all stakeholders in the design process. PLu*R*aL is a practical approach with methods and techniques that support designers in considering diversity in design and offer to end users the possibility of tailoring the software according to their (new, previously misunderstood, not common and updated) interaction needs, extending design boundaries. Moreover, PLu*R*aL is consistent with what Harrison *et al.* (2007) called the third paradigm for Human-Computer Interaction, considering interaction as "phenomenologically situated" and supporting the creation of different meanings (by different users) in which the designed system and its context are mutually defining and subject to multiple interpretations.

5.7 Conclusions

Although the literature regarding tailoring presents results with diverse foci, there has been a lack of works considering methods and techniques to support designers in their practice. This paper presented PLu*R*aL, a framework organized into three pillars that support the designers in describing the (interaction) needs, defining functionalities and determining the (system) tailorable behavior. PLu*R*aL benefits from OS concepts and methods and shares with it a sociotechnical approach. The results from a feasibility study conducted with 17 designers suggest a positive evaluation considering PLu*R*aL's utility, flexibility in supporting design changes, creative freedom and satisfaction with the results.

PLu*R*aL contributed to the design of tailorable systems as it considered elicitation techniques, which allowed a comprehensive view of the differences, including those that are unexpected, controversial or raised by the minority; interaction requirements that come not only from users, but also from devices and environments; the semantics, pragmatics and social impact of the interaction and a norm-based mechanism to model the tailoring behavior. However, PLu*R*aL does not guide how the tailoring options should be presented in the interfaces nor supports decisions about which features will be adaptable or adaptive in a tailorable system.

Further work includes the development of a tool that aids designers in establishing the norms that express the tailorable behavior. Moreover, some artifacts and methods in PLu*R*aL seem to have an interesting evaluative power. Therefore, further studies can be done to assess the quality of tailorable systems.

Capítulo 6

Addressing Diversity in Social Network Systems with a Tailoring-based Approach

6.1 Introduction

Organized groups and communities typically have methods to spread news among participants, share information and exchange knowledge. Computer systems to support communication and cooperation in these groups, known as social network systems (SNSs), have grown exponentially in recent years. SNSs allow users to share any subject in a very different context than office work, making this technology attractive to ordinary people. Nevertheless, although SNSs should provide all people with the opportunity to benefit from their services and make the system part of their social life, the interactivity of the current SNSs meet the needs of only part of the population of prospective users (Neris *et al.*, 2009a).

In Brazil, for instance, we face a scenario where the population has a vast diversity of socio-economic and cultural situations, and diverse levels of technology and knowledge access. Demographic studies[11] show that 11.2% of the Brazilian population are considered illiterate (approximately 14.2 million); 14.5% (24.6 million) have physical impairments and 30.1% (52.5 million) live below the poverty line. Santana *et al.* (2009) evaluated the interactivity of 9 SNSs, considering the requirements for users with low literacy, some type of disability or little experience using computers. The results indicate that the resources available from those SNSs are insufficient to cope with the different interaction needs, highlighting the necessity to explore new design solutions so that these systems can reach more people.

The e-Cidadania research project (e-Cidadania, 2008) aims to contribute in this direction and investigates solutions for system interface designs that make sense to Brazilian citizens. The goal is to construct a culture mediated by information and communication technology in our society. This project has been developed by a multidisciplinary team, including prospective users and professionals from different research areas such as computer science, multimedia, education and anthropology. The project addresses one of the great challenges in computer science research in Brazil for the

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[11] Data from the 2008 National Survey by Household Sample, 2000 National Census and the Committee of Entities Combating Hunger and for Life (COEP, in Portuguese).

coming years: the "participatory and universal access to knowledge for the Brazilian citizen" (Baranauskas and de Souza, 2006). The project studies the relationships established around people in their informal networks and the way that they interact with each other and with technology. One of the project's outcomes is the *Vila na Rede*[12] system: an SNS that intends to be inclusive.

To cope with the different interaction needs of the population, following the precepts of the design-for-all principle, *Vila na Rede* has been developed as a tailorable system. Applications that allow tailoring offer the flexibility of being adapted to personal preferences, different organizational contexts, or unanticipated and changing use-cases (Henderson and Kyng, 1991). However, the design and implementation of tailorable solutions still brings some research challenges, such as how to specify the system's tailorable behavior, and how the system manages the various scenarios of use. We have been coping with these challenges by conducting workshops built upon techniques from Participatory Design (PD) and Organizational Semiotics (OS) concepts.

We argue that PD with OS can provide us with theoretical and methodological fundamentals to inform design decisions about which interface elements should be adjusted and how this should be done to fit users' needs. This work employs the concept of norms from MEASUR (Methods for Eliciting, Analyzing and Specifying User's Requirements) (Stamper, 1993) to describe which elements should be adjusted, and how and in which situations they should be adjusted, for each user or group of users. This paper shows how methods from PD and OS can be combined, adapted and used from the conception and design to the implementation and deployment of tailorable Social Network Systems. Two frameworks are proposed and described in this paper: the PLu*R*aL Framework for conception and design and the FAN Framework (*Flexibility through Ajax and Norms*) for implementation and deployment of the social system.

This paper details how the tailorable behavior of *Vila na Rede* was designed, implemented and evaluated in a feasibility study with end-users. The results suggest that the adopted solutions satisfied users with different interaction profiles. The paper is organized as follows: Section 6.2 presents some background and related work, including the OS basis that guided the design and implementation; Section 6.3 shows how the tailorable behavior was determined and represented in the interfaces; Section 6.4 explains how the solution was implemented; Section 6.5 presents how the tailorable interfaces were evaluated; Section 6.6 discusses the main challenges and results; and Section 6.7 presents conclusions points out directions for future work.

6.2 Theoretical and Methodological References

During the last 20 years, different design models emerged with various strategies to include the end user into the design process. These design models range from demographic research and marketing to user-centered design, participatory design, contextual design and others.

[12] http://www.vilanarede.org.br

Although these models differ in the way the user is considered, they all acknowledge the importance of including the user into the design process. However, placing the user at the center of the design process can have an effect of exclusion if the developed technologies do not consider the diversity of users with respect to their different perceptual, cognitive and physical capacities (Baranauskas *et al.*, 2006). Initiatives like Universal Design, Design for All, Accessible Design, and Inclusive Design emerged (cf. Newell and Gregor 2000) to deal with this problem.

An inclusive system should be usable by all people, to the greatest extent possible, without the need for new development, versions or specialized design (Connell *et al.*, 1997, Stephanidis, 2001). According to the principles established by the Universal Design Center, inclusive systems should allow equitable use, meaning that the design should be useful and marketable to people with diverse abilities; flexible to accommodate a wide range of individual preferences and abilities; easy to use and intuitive; and communicate necessary information effectively to all users, regardless of ambient conditions or the users' sensory abilities (Connell *et al.*, 1997). Moreover, according to Fischer (2001), which proposed the concept of meta-design, it is desirable that all users in a collaborative design process can express themselves and engage in personally meaningful activities. In this sense, the design needs to be renewed to consider the individualities and get closer to this more democratic view of interaction.

One approach to cope with the different interaction requirements present in a population is to offer tailorable systems that are capable of behaving in diverse manners according to the different contexts of use. Unlike conventional applications, when designing tailorable systems, designers need to foresee different possibilities of use, including the evolution of users and the use in several devices and environments. This involves both superficial changes in the user interfaces, such as changing color or font size and more substantial changes. Possible user interface changes inherent in the concept of tailoring include the visibility of new features that become relevant in new usage contexts and the optimization of tasks (Neris and Baranauskas, 2010).

Others have adopted a tailoring approach to deal with diversity. Recabarren and Nussbaum (2010) used Hostefed's cultural model to tailor web-forms. In the e-Cidadania project, we have been facing the challenge of developing an inclusive social network system through tailorable interfaces by adopting a participatory approach to the design with OS as a frame of reference, supporting a socio-technical view to the problem.

6.2.1 Participatory Design

The PD approach began in the early 1970s with manifestations in Scandinavia and in England. In Scandinavia, PD emerged to develop strategies and techniques that support the participation of workers and syndicates in the decision making process related to development of new technologies for workplaces (Schüler and Namioka, 1993). In England, PD started at the Tavistock Institute with a proposal for a democratic socio-technical approach to work organization. Later, Enid Mumford (1924-2006), inspired by these ideas, started to develop information systems in a participatory way (Mumford, 1964;

Mumford & Henshall, 1979). Following this work, Muller (1997) proposed a taxonomy of participatory practices to guide designers while choosing participatory activities. These practices are intended to be employed during the software lifecycle, considering the players involved in these activities.

The PD approach has been described in the literature as an interesting approach to design tailorable applications. MacLean *et al.* (1990) alluded that the Scandinavian approach could promote the establishment of a culture of tailoring. Kjǽr and Madsen (1995) reinforced the importance of PD to specify the requirements for flexibility, saying that "... flexibility is not related to the regular procedure or behavior pattern of doing things, but the unexpected, unprecedented, exceptional cases, situations and events experienced only by those who perform the work daily." They concluded that PD techniques might be applied to capture knowledge about the exceptional cases. Stiemerling *et al.* (1997) and Costabile *et al.* (2008) also adopted approaches based on workshops joining users, designers and software engineers in the task of designing tailorable systems.

Whereas these authors usually address design for work contexts, the e-Cidadania project faces the challenges of integrating ordinary people, in the context of their daily-life environments, into a system-design situation. In this sense, unlike the previous design situations, heterogeneity should be considered while inviting people for the participatory practices to achieve a more comprehensive view (Neris *et al.*, 2008; Neris and Baranauskas, 2010). Moreover, constructing a technical information system that considers the interaction requirements of a diverse population requires proper use of the participative approach. This requires, among others things, the adaptation of artifacts to be used in the workshops (Melo and Baranauskas, 2006), a welcome and warming environment, the use of accessible vocabulary and mutual respect among the parties (cf. Neris *et al.*, 2009b).

6.2.2 Organizational Semiotics

OS is a discipline that has roots in Semiotics, but applied to organizational processes. It studies the nature, characteristics, function and effect of information and communication within organizational contexts (Stamper *et al.*, 1988; Liu, 2000). From the OS perspective, an organization can be seen as an information system where agents employ signs to perform purposeful actions. Some of the organizational functions highly regular and have rules that can be clearly formalized. A fraction of the formalized set of actions may be very repetitive and can be automated by computer-based systems. In this sense, the software (technical system) is part of a whole information system and presupposes a formal system, in which rules and formal procedures specify how the relations should be carried out and how the actions should be performed. Moreover, the formal system presupposes an informal system, in which organizational culture, customs, and values are reflected as beliefs, habits and patterns of behavior of each individual member. At this layer, meanings are agreed, intentions are understood and beliefs are formed. Therefore, OS provides a background that embodies knowledge and support collaboration and reflection among people from the different disciplines involved in interaction design (Baranauskas and Bonacin, 2008).

A major concept employed in this work is the norm as described in the Norm Analysis Method (NAM) from MEASUR (Stamper *et al.*, 1988). Considering an organization as a social system, we can say that people behave in an organized manner conforming to a certain system of norms. These norms are regularities of perception, behavior, belief and value that are expressed as customs, habits, patterns of behavior and other cultural artifacts (Stamper *et al.*, 1988; Liu, 2000). Norms describe the relationships between an intentional use of signs and the resulting behavior of responsible agents in a social context.

According to Stamper *et al.*, (2000, p15), "norms can be represented in all kinds of signs, whether in documents, oral communication or behavior, in order to preserve, to spread and to follow them. However, one cannot always put hands conveniently on a norm, as one might grasp a document that carries information through an organization. A norm is more like a field of force that makes the members of the community tend to behave or think in a certain way."

Besides the description of the agents' responsibilities in the organizational context, Norm Analysis can also be used to analyze the responsibilities of maintaining, adapting and personalizing system features. Norms can be represented using natural language or Deontic Logic in the late stages of modeling. The following format is suitable for specifying behavioral norms (Liu, 2000):

<Norm>::= whenever <condition> if <state> then <agent> is <D> to do <Action>

where <D> is a deontic operator that specifies whether the action is obligatory, permitted or prohibited. The norms are not necessarily obeyed by all agents in all circumstances; they are social conventions (laws, roles and informal conventions) that should be obeyed. For example: a norm specifies that the agents are obliged to pay a tax; if an agent has no money, it will not pay, but usually there is a cost when an agent does not obey the norms.

As described in Bonacin *et al.* (2009), social knowledge is also important for constructing personalized user interfaces. These interfaces can represent users' preferences for how to interact; they determine aspects such as their preferences, capabilities, and intentions. These norms can be expressed as, for example, "I like blue" (preference), "I have difficulties using the mouse" (capability), "I am not interested in news" (intentions), "I access this web site only for paying the government tax" (intentions), etc. Norms can also represent actions that the organization and society as a whole expect from the user. For example, "whenever a citizen requests a medical examination, if the responsible Physician has free timeslots, he/she is obliged to confirm the appointment for the next available slot." In this example, we should expect that the system must provide the physician with a shortcut to complete the expected action.

Besides NAM, the Semantic Analysis Method (SAM) from MEASUR was also applied. SAM supports the analysis, specification and representation of an information system and is divided into four phases: problem definition, candidate affordance generation, candidate grouping, and ontology charting (Liu, 2000). Affordance, the concept originally introduced by Gibson (1968) to express the behavior of an organism made available by some combined structure of the organism and its environment, is extended by Stamper (1993) to include the patterns of behavior related to the social interactions. SAM also considers the concepts of agents and ontological dependencies. An agent is a special type of affordance that refers to those who are capable of assuming responsibilities. Ontological dependencies are links between affordances or agents representing that the element in the right can only exist during the existence of the element in the left. Considering a statement that defines the design problem, the main affordances in the domain are elicited. After identifying the affordances and agents and grouping them, an ontology chart is drawn.

Semantics has been used to support the development of tailorable systems. Torre (2009) presents a survey about semantics in adaptive social systems. The focus of his studies is to adapt, considering social annotations. Here, semantics have been used to model the domain, aiming to support designers with a comprehensive view that enables flexible design.

Based on OS ideas, Neris and Baranauskas (2010) proposed a conceptual framework for the design of tailorable systems, named PLu*R*aL. The framework is supported by three pillars. The first pillar brings out the signs of interest in the domain, related to users, devices or environment, and formalizes the interaction requirements that the tailorable system should cope with. The second pillar benefits from SAM and NAM (Stamper *et al.*, 1988; Liu, 2000), allowing a consistent view about the domain that assists the formalization of functional requirements. In the third pillar, the tailorable design solution is built and a norm-based structure formalizes the system's tailorable behavior.

PLu*R*aL was used in the e-Cidadania project to design the *Vila na Rede* tailorable behavior. Moreover, the concept of norm was used as the basis for the FAN framework, which implements and manages the tailorable characteristics of *Vila na Rede*, as described in the sections6.3 and 6.4 respectively.

6.3 Designing a tailorable social network system

From the OS perspective, a software system is always embedded in a social system, and therefore it is important to know its formal and informal basis. Considering this perspective, PLu*R*aL proposes a set of activities that can be applied by a single designer or a group of designers in a participatory way (Neris and Baranauskas, 2010). In the context of the e-Cidadania project, PLu*R*aL's main activities were conducted in participatory workshops that usually grouped about 30 people: 12-15 participants from the community and 14-18 researchers with different backgrounds in interaction design, software engineering, multimedia, anthropology and education. Focusing on diversity, the invited participants from the community had different profiles. Their ages varied from 18 to 61 years old. One participant was deaf. Regarding education level, three participants declared that they stopped at elementary school, five at high school, five at college, and two have graduate degrees (a master's degree or doctorate). Six users were not able to use computers without assistance.

The workshops generally lasted three hours and took place at the CRJ - *Centro de Referência da Juventude*[13], a public space supported by the local government. The CRJ is composed of a Telecenter, where the community has free access to computers and the internet, a public library, and rooms for community courses. The CRJ is strategically located near a main bus station, public schools and the neighborhood association, which benefits merging different community groups. The workshops followed the practices established by the Human Research Ethics Committee and were performed with compromise and respect between all parties.

The activities developed in each PLu*R*aL pillar are described in the following sub-sections, culminating with a set of norms that formalize the tailorable behavior of *Vila na Rede.*

6.3.1 1st Pillar - Describe the needs

The objective of the first pillar of PLu*R*aL is to have a comprehensive view of the differences between potential users and the devices and environments where the system could be used. In this sense, the first activity intended to clarify the problem and define the limits of the solution (Neris and Baranauskas, 2010). The Stakeholders Analysis technique (Kolkman, 1993), an OS artifact which supports the stakeholders' elicitation and assesses how they impact the system design, was applied in a participatory workshop. Chairs were arranged in semi-circles in front of the Stakeholder Analysis Chart, which was hung on one of the walls. Sticky notes were distributed to the participants (the community members and researchers) who wrote down their suggestions as stakeholders and pasted them on the chart. A picture of this workshop is shown in Figure 6.1a.

The chart aggregates four main categories of stakeholders, which are presented in nested layers representing different information fields: actors and responsible parties (those who are directly involved with the problem), clients and suppliers (those who will effectively use the system or those who feed the system with information or services), partners and competitors (members of the market related to the system domain) and spectators and legislators (including those responsible for establishing the formal or informal rules, and also the whole community that will receive the gains or losses as consequence of the implementation of the system). In total, 59 different stakeholders were mentioned, including housewives, the elderly, people with disabilities, health agents, craftswomen, community leaders, telecenter monitors, neighborhood associations, companies that developed other social network systems, W3C, city hall and the secretary of social assistance. A comprehensive list can be found in Hayashi *et al.* (2008b).

13 In English, Youth Reference Center

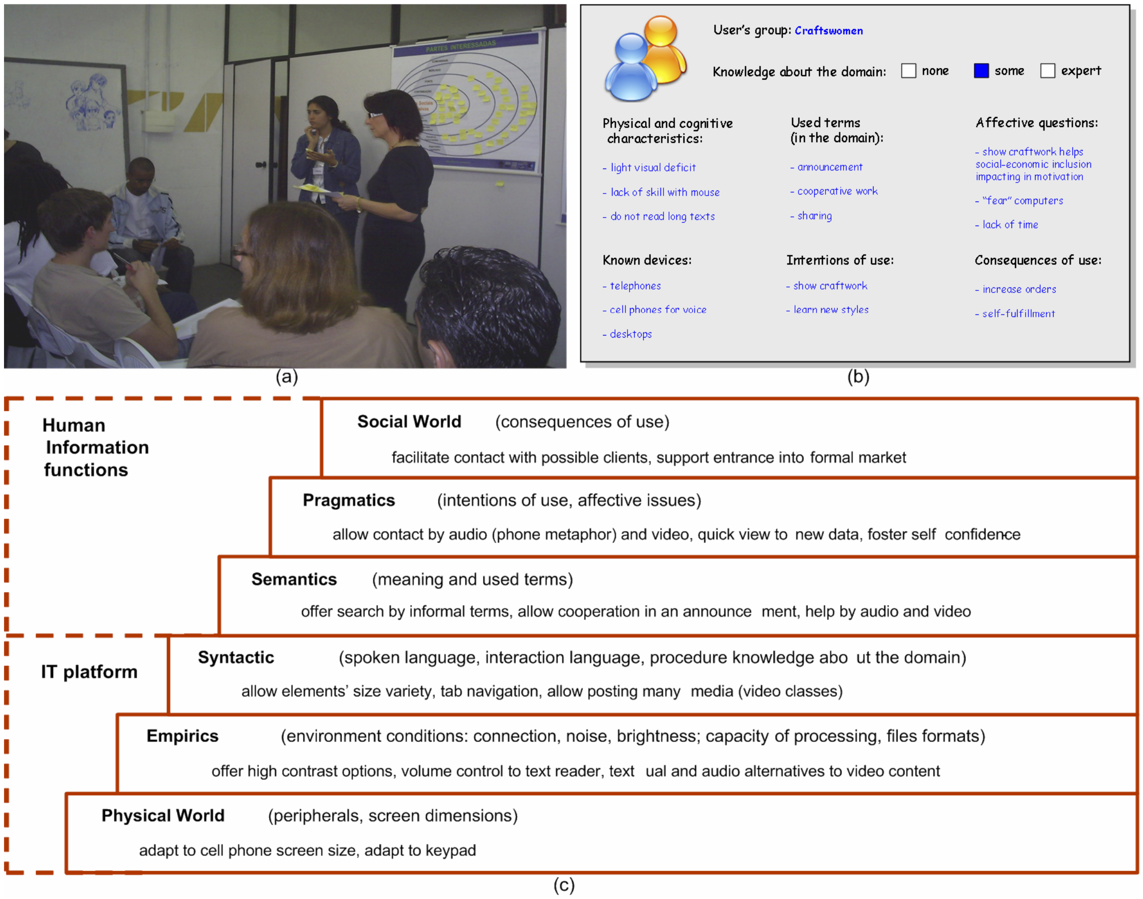

Figure 6.1. (a) Elicitating stakeholders, (b) Craftswoman group card and (c) Ladder with requirements.

The analysis of stakeholders elicited in a participatory way builds up the vision about the solution scope and emphasizes the need for a tailorable solution. Some of the mentioned stakeholders will interact directly with the system, triggering the next activity.

Considering that a system can be tailored to supply requirements coming from diverse users, different devices or changes in environmental conditions, PLu*R*aL proposes a set of cards to be used in characterizing the context of use. The card relative to the users, for instance, considers the different physical characteristics and familiarity with devices, differences in semantics (terms from the domain), pragmatics (intentions of use) and the social impact that may arise from these users' interaction. It also allows the specification of differences regarding affective issues and knowledge about the system domain (Neris and Baranauskas, 2010).

After analyzing the filled Stakeholder Chart, e-Cidadania designers selected those stakeholders that represent potential users and filled in cards relative to these users. Figure 6.1b shows a card filled for the craftswomen group. The card shows characteristics such as slight visual deficit (considering elderly craftswomen), familiar devices, such as telephones, cell phones and desktop computers (as some of them use computers at home), and specifies the intended use (to learn new styles of craftswork), and consequences of use (increased orders). Moreover, the associations mentioned in the Stakeholder Chart pointed out places where the system could be used (e.g., the telecenter in the neighborhood where the association organizes its meetings). As a result, designers also filled in cards that characterized the environments (e.g., telecenter, at home, on the street) and the devices that could be employed (e.g., desktops, cell phones).

With a comprehensive view about the context of use and its peculiarities, it was possible to think about interaction requirements. Therefore complete the first pillar, another artifact from OS was applied: the Semiotic Ladder (Stamper *et al.*, 1988; Liu, 2000), which allows a refined classification of information considering 6 layers of signs (physics, empirics, syntactic, semantic, pragmatics, and social world). Looking at the cards for users, environments and devices, designers identified and distributed the interaction requirements in the Semiotic Ladder layers. Figure 6.1c shows a ladder partially filled in with requirements coming from the Craftswomen group card. For instance, many women had a slight visual deficit, leading to a requirement to allow elements size variation at the syntactic layer; the affective issue related to fear of computers led to a requirement to foster self-confidence in the pragmatics layer.

Additional requirements compose the final Ladder, coming from the other cards and also considering information from literature, as those presented in Neris *et al.* (2008) and the design recommendations from the Web Accessibility Initiation – WAI from W3C[14]. In the context of an inclusive social network, the Ladder supported the visualization of different interaction requirements, especially those related to different terminology, indicating a need for formal and informal language styles, and the various intentions of use of the groups in the network (e.g., craftswomen want to increase orders, whereas people from the community school want to share educational information).

6.3.2 2nd Pillar - Define functionalities

Because the e-Cidadania project targets users that are not familiar with computers, a deep and shared understanding about the domain of social network systems is fundamental for a more inclusive solution. PLu*R*aL recommends the use of SAM and NAM (Stamper *et al.*, 1988; Liu, 2000), which were applied in a participatory way in the e-Cidadania project.

In the first stage of SAM, instead of defining the problem from the researchers' viewpoint, the design group used descriptions of inclusive social networks that were brought up in the first workshop. For example, one definition is “a group of people that interact sharing different elements without discriminating participants, i.e., when we mention 'inclusive' that means that everyone is part of that network and that the network has a common objective” (sic). From the participants’ definitions, the designers generated the affordances candidates, grouped them, and drew an Ontology Chart for inclusive social networks (cf. Hayashi *et al.*, 2008b), illustrated in Figure 6.2a.

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[14] http://www.w3.org/wai

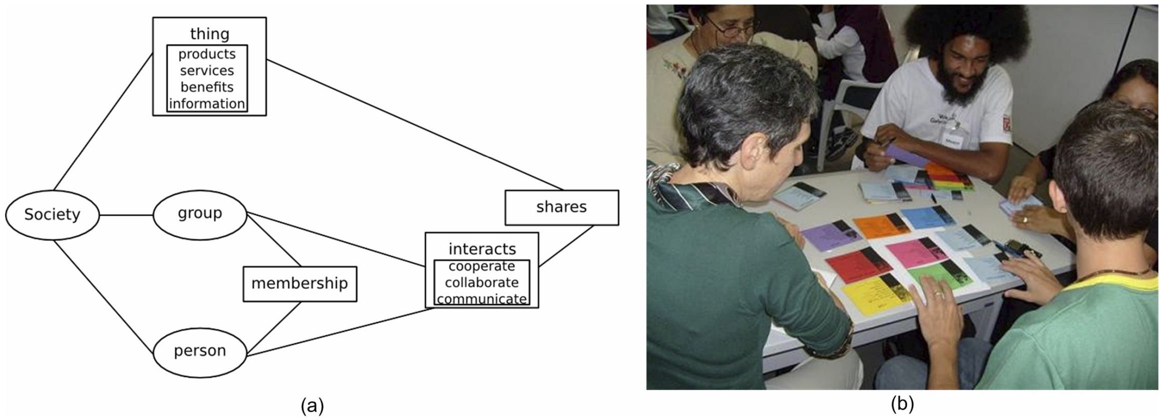


Figure 6.2. (a) An ontology chart for inclusive social networks (Neris *et al.*, 2009a) and (b) PACFILMO technique.

The root element ("society") affords "person," "group" and "thing". "Person" and "group" afford "membership". In this scenario, "group" represents any set of people, including those that do not have access to information and communication through computers. This represents that any technical system that intends to support inclusive social networks should make "membership" possible, implying an important design issues regarding accessibility and universal design. "Person" and "group" also afford "interacts". Furthermore, "interacts" and "thing" afford "shares," meaning that interacting in such modes as communicating, cooperating or collaborating, the groups and people are able to share things that can be products, services or even information. Therefore, from the workshop results, in an inclusive social network, every person can integrate into a group and interact to produce things that can be shared with other persons and groups (Neris *et al.*, 2009a).

The affordances in the ontology chart represent how the community understands the target application domain. Therefore, aiming at supporting the specification of functional requirements of a prospective software system, it is helpful to clarify the responsible agents and to elicit the conditions and consequences for each pattern of behavior. The technique suggested in PLu*R*aL (NAM) was applied in a participatory way. In a second workshop, the participants received cards, and through them they were able to organize their ideas and share their storytelling experiences. The cards represented categories inspired by the elements of the ontology chart that arise from the question: "who shares what with whom, when, how, where, using what and why?" (cf. Hayashi *et al.*, 2008a). Figure 6.2b is a photograph of participants discussing this topic during the workshop before filling in the cards.

After the workshop, the design team analyzed each story and a group of norms was elicited. From the 21 stories reported, 37 norms regarding the community's social dynamics were defined. For example, if there is an event, the craftswomen association coordinator must share information about the event with the group using face-to-face communication, posters and email. The norms represent how people act in real life and provide information about what functionality should be offered by the technical system to support peoples` actions.

From SAM and NAM, some functionality was defined and specified in use cases, e.g. an instant messaging tool embedded in the social network that allows users to talk using different media simultaneously, and a collaboration function that allows users to add contributions to other announcements. For example, someone could add a caption to an image or video, or could add a video using sign language to explain the content of the announcement.

6.3.3 3rd Pillar - Determine the tailorable behavior

After formalizing the functionalities, a prototype version of the *Vila na Rede* system was developed and the users could start interacting through the system. Figure 6.3a shows a snapshot of the system in which a list of announcements is presented. Although several features allow users with different profiles to interact, tailorable features are still needed to lead the design to a more universal solution.

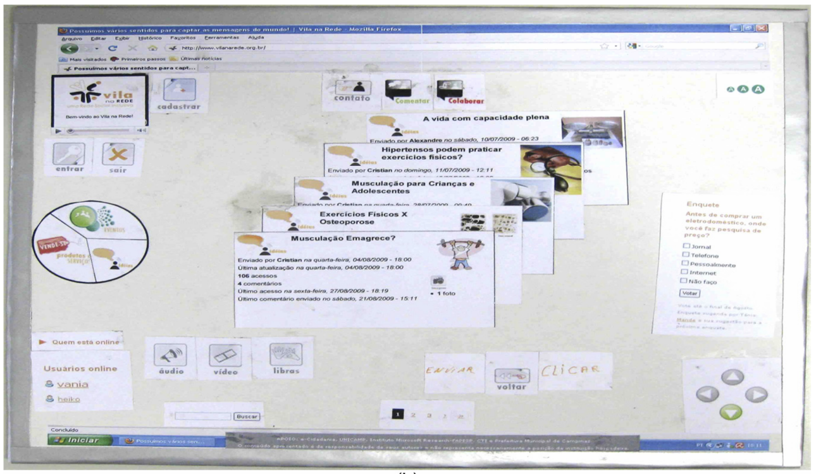
Regarding the third pillar of PLu*R*aL, users were asked to describe their preferred interface for listing announcements. In this activity, participants were divided into five groups following the characterization proposed by Neris *et al.* (2008), considering knowledge about the domain and ability with technology. G1 grouped those with less ability with technology, whereas G4 and G5 grouped those with incrementally more ability.

The participants received a kit with pictures of user interface elements in different colors and sizes, colored pens, pencils, erasers, glue, and a cardboard imitation of a computer screen with an opened browser window. Participants could use the pictures from the kit or draw new ones. The groups took about 60 minutes to compose an interface. Afterward, each group explained its proposal to the researchers. Figure 6.3b shows the interface built by G1 and 6.3c the one built by G4.

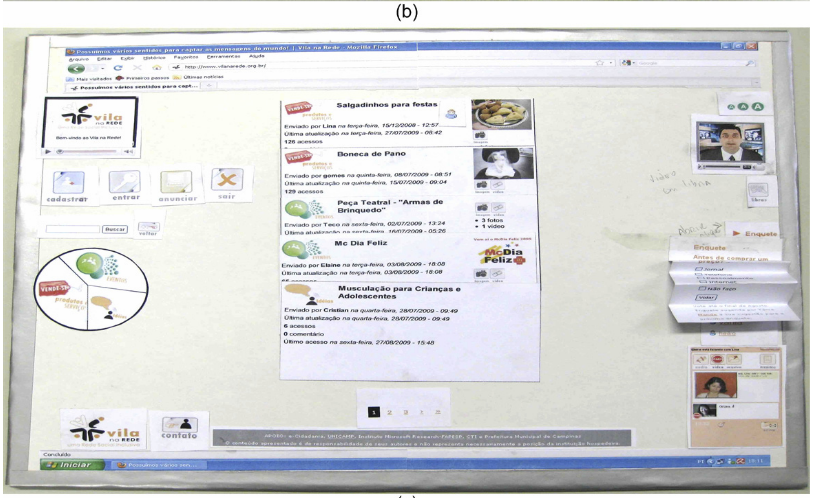
The design proposals analysis considered which interface elements were added and in which position and shape. All proposals included: the logo; registration, login and contact buttons; font size buttons; menu; list of who is online; and the poll tool. However, it is interesting to note that the logo was added in a video format (passing first ideas about the system) in two of the proposals. The menu shape also varied. In three of the five proposals, the menu appeared in a circular shape. Moreover, in one of the proposals, a new category was added, "all," which grouped the announcements from products and services, ideas and events. The buttons also varied in position, size and color.

Designers added navigational arrows to support users who were not familiar with scroll bars (see Neris *et al.*, 2008). These arrows showed up in the proposals of G1, G2 and G3, but were not added by the expert users. In addition, G4 suggested that the poll tool could be presented in a retractile shape, as is common in other web applications. Finally, the LIBRAS button was added in four proposals. In two proposals (G1 and G5, which included the deaf user), this button was large and place in the middle of the interface.

(a)



(b)



(c)

Figure 6.3. (a) Announcements list as presented at *Vila na Rede* and the same interface as users from G1 (b) and G4 (c) would like it to be.

These results demonstrate, at least, that *Vila na Rede* should "behave" in different manners to satisfy diverse interaction requirements pointed out by the participants of the workshop. To represent the diversity of facets a tailorable system may have, the norm format suggested by PLu*R*aL was adopted, as follows:

WHENEVER (d, e, u) IF (f, r) THEN *Vila na Rede* <must, may or may not> SHOW ∑(i, m)

where:

d: device, e: environment, u: user

f: functionality, r: representation

i: interface element, m: mode (position, size, shape, color, type, instance)

The context is defined by a *tuple* formed by device, environment and user characteristics. When this context is satisfied, meaning that the system starts a specific functionality in a specific representation, then *Vila na Rede* must, may or may not show a group of interface elements in a certain mode. Therefore, some norms representing the *Vila na Rede* tailorable behavior were formalized as exemplified in Table 6.1. Other interaction requirements arising from previous practices in the context of the e-Cidadania project were also considered, and a more comprehensive list of norms representing the *Vila na Rede* tailorable behavior can be found in Neris *et al.* (2010).

Table 6.1. Examples of norms representing *Vila na Rede* tailorable behavior.

Context			Condition		Tailorable behavior
device	environment	users	functionality	representation	element and mode
Computer	any	any	show_menu	div_menu	(menu, linear or circular)
Computer	any	deaf	any	any page with text	(LIBRAS button, big)
Computer	any	expert	navigation	div_arrows	(disable_button)
Computer	any	expert	poll	div_pull	(poll_presentation, retractile)

Once these norms specify the tailorable behavior, some design decisions had to be taken regarding how they would be offered to *Vila na Rede* users. The main interaction purposes are related to the network system main functionalities. Therefore, tailoring the user-interface is considered a side-activity. Thus, the design team decided to highlight the tailorable possibilities and offer them near the elements that would be changed in a way that would not interfere with the main system interactions. Figure 6.4 shows how the choice to change from the linear to the circular menu was offered. Figure 6.4a shows the button "Tailor" that was offered close to options that change the font size. After clicking "Tailor", the interface elements that can be changed are highlighted. Figure 6.4b shows the sign around the menu. Finally, by clicking on the upper button (indicating a circular menu), the menu changes to the circular format, as shown in Figure 6.4c.

Figure 6.4. Changing from the linear to the circular menu: (a) Button to tailor; (b) Linear menu highlighted, and (c) Menu changed to the circular format.

Especially considering users not familiar with computers, some tailoring options were designed to be adaptive[15], which means that they would be triggered by the system according to the users' performance with the system. Some of these adaptive scenarios considered information from the users' profiles. If a user marked that s/he always increases the font size, then the system would show the interface elements in a large size every time that user logs in. Also, if a user selected in her/his profile that s/he is an expert user, then the navigation arrows would be automatically disabled.

These results represent a design perspective for tailoring in the considered scenario; an infra-structure is adopted to implement the tailorable behavior as a next step. In the context of e-Cidadania project, an extension to the infra-structure proposed by Bonacin and Baranauskas (2005) was developed. Tests with prospective users were performed as described in the next sections.

6.4 Implementing tailorable interfaces using norms

Vila na Rede tailorable behavior was implemented using the FAN framework, which is an infrastructure developed to facilitate the development of flexible web interfaces. FAN supports developers with means to change the web interfaces in real-time, without the need to refresh the web page. From the viewpoint of the OS concept of norm, FAN is capable of: identifying and capturing interaction events; building and saving facts related to the captured events; communicating with a norm configuration environment; accessing and changing interface elements related either to styles or to the system behavior; running Javascript code, among others. The next sections describe the FAN architecture and how it was used to make *Vila na Rede* flexible.

6.4.1 FAN Architecture

Figure 6.5 shows the FAN architecture. The top layer in Figure 6.5 represents a web system interface. The central layer represents the framework architecture and its modules. The lower layer presents the NBIC/ICE system (Bonacin 2004, 2007), developed with Java EE (*Java Platform, Enterprise Edition*). NBIC (*Norm Based Interface Configurator*) is a tool for storing and managing norms and ICE (*Interface Configuration Environment*) is a tool that makes inferences, using the Jess inference machine, over norms stored by NBIC. ICE also creates action plans that describe adjustments that should be made to the system interface.

The FAN framework communicates with ICE via *web services*, using Simple Object Access Protocol (SOAP) (Newcomer, 2004). ICE then communicates with NBIC. The framework adjusts the system's web interface for each use context, based on Action Plans generated by ICE. By analyzing the Action Plan generated by ICE, the framework finds

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[15] A system is said adaptable when the user explicitly asks for the change and is adaptive when it automatically changes its behavior (Oppermann and Simm, 1994). Tailorable systems can be adaptable, adaptive or even mixed.

appropriate ways to modify the user interface because an Action Plan contains information regarding the use context of a certain user. An Action Plan tells the framework which interface objects should be displayed, where they should be displayed, and how they should behave.

The FAN framework is composed of four modules which are shown in Figure 6.5: the Perception Module, Users' Facts Storage, SOAP Client and Action Module. It is important to note that the framework is almost entirely independent of the system that uses it because its use does not imply changes to the core of the system. The framework is basically a collection of JavaScript code that is appended to web pages.

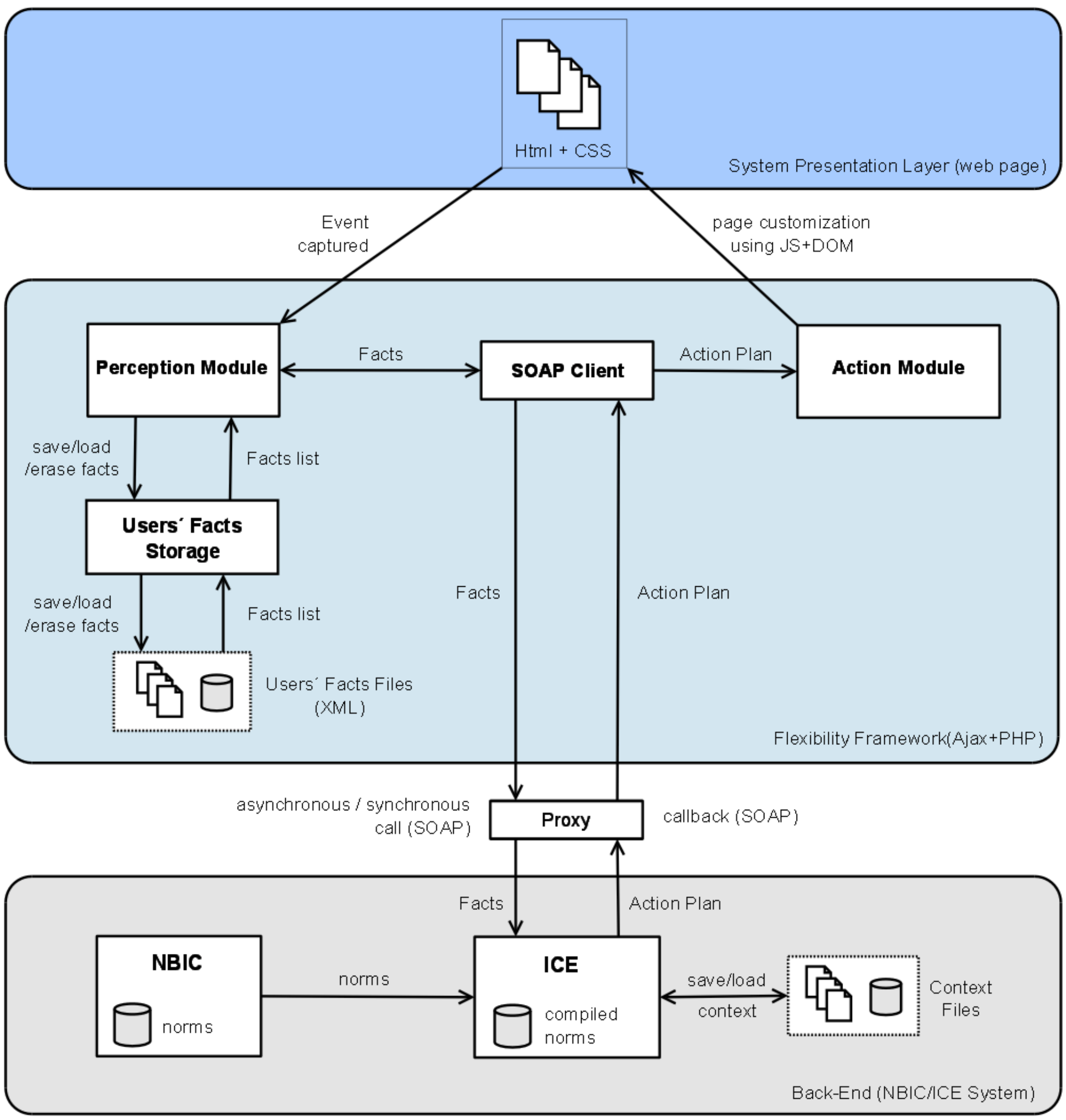

Figure 6.5. FAN architecture.

The Perception, SOAP Client and Action modules were developed with AJAX technologies. The Users' Facts Storage module was developed in AJAX and PHP. All JavaScript code runs on the client side and the PHP code runs on a server with the purpose of storing files generated by Users' Facts Storage. Besides these two technologies, the SOAP Client, using SOAP technology, was used to enable the communication between the framework and the NBIC/ICE system. A fourth technology, XML, was applied in the structure of files created by the Users' Facts Storage module. Another technology, JSON, was used in the communication between JavaScript and PHP code. A proxy was used in the communication between the SOAP Client module and the NBIC/ICE system to circumvent security issues related to JavaScript.

The Perception module has this name because its main function is to "perceive" certain interface events and start the interface adjustment process according to information about the perceived interface events. This module is connected to the system interface and it is triggered when certain events occur on the interface, according to the system's specifications. This module is also responsible for creating facts related to interface events and request the SOAP Client module to send the generated facts to ICE because the Perception module cannot directly access ICE services. The Perception component has two other important functions, related to the ability of the framework to save interface adjustments made by users. The Perception component can request Users' Facts Storage to search or store a list of facts in XML files associated to the current user and the current page the user is visiting. The Perception framework can also send facts returned by the Users' Facts Storage to the ICE service. These functions should be executed every time a page is loaded so that it will look and behave like it did on the last time the user visited or modified that page.

The SOAP Client module is responsible for performing communication between the FAN and ICE frameworks through SOAP requests. Basically, this module receives requests from other modules and forwards them to ICE. The SOAP Client receives the data returned by ICE and sends it to the modules responsible for processing the received data. The requests made to the SOAP Client can be synchronous or asynchronous. Requests made to the SOAP Client whenever a page is loaded, to adjust the page according to the adjustments previously made by the user, are made synchronously, for consistency. The requests made by Perception to the SOAP Client for each adjustment made by the user during his/her interaction with the page are asynchronous, so that the user will be able to navigate the page while the adjustment is being processed. The SOAP Client code was developed based on JavaScript SOAP client code developed by Matteo Casati (JavaScript SOAP Client, 2006).

The Action module has two main functions: analyze information contained in the Action Plan, and perform adjustments on the system interface according to the information contained in the Action Plan. An Action Plan is a XML file that stores information about adjustments that should be made on the interface and how these adjustments should be made. An Action Plan contains IDs of interface objects that should be modified. Depending on the type of each adjustment, an Action Plan may also contain attributes, with their values, of objects that should be modified, DOM operations and JavaScript code to be executed on the interface. Considering the information that may be contained in an Action Plan, the interface adjustments can be of 4 different types: (1) modification of an attribute of an element, (2) DOM operations using just one element, (3) DOM operations using two elements and (4) execution of a JavaScript code contained in the Action Plan or calls to JavaScript functions already implemented in the application.

During the analysis of the Action Plan, for each adjustment found, the Action module verifies the type of the adjustment. If the adjustment is of type 1, 2 or 3, as described above, the Action module accesses, using DOM, the interface elements involved in the adjustment operation. If the adjustment is of type 1, the attributes and values are modified. If the adjustment is of type 2 or 3, the Action module executes DOM operations with these interface elements. If the adjustment is of type 4, the Action module just executes, on the interface, a JavaScript code contained in the Action Plan or calls a JavaScript function already implemented in the application.

To make it easier to understand how an Action Plan works, we present two examples of adjustments that may be contained in an Action Plan. In the first example, an interface object with ID "object2" should be inserted inside another object with ID "object1" by using the DOM operation *appendChild(*). At the time the Action module finds this adjustment inside the Action Plan, this module will access the two objects involved in the adjustment operation using their IDs ("object1" and "object2") with the DOM operation *getElementsById()* and then the Action module will call the DOM function *appendChild()*, passing the two interface objects as parameters. In the second example, there is an adjustment that has a JavaScript code to be run on the interface. When Action finds this adjustment inside the Action Plan, it identifies the type of the adjustment. For this example, the adjustment is of type 4, so Action will then execute the JavaScript code contained in the Action Plan using the JavaScript function *eval()*. In the case Action finds an adjustment of type 1, it will just access an interface object using its ID and the DOM function *getElementsById().* Then, Action sets a new value for a certain attribute of the object, according to the attribute-value pair found in the Action Plan.

As soon as the Action module finishes iterating over all the adjustments contained in an Action Plan the adjustment process for this element is complete. The whole adjustment process is started for every fact generated by the Perception module.

The *Users' Facts Storage* module has three mains functions: store, read and erase facts in XML files. Every time the *Perception* module generates a fact, it sends that fact to *Users' Facts Storage*, which stores the fact in an XML file associated to the user that generated the interface event. When an adjustment is no longer necessary the *Users' Facts Storage* should erase the fact, associated to the adjustment, from the file associated to the current user and page. Then, the next time the user loads the page, that adjustment won't be made automatically; the interface will have its original appearance.

The XML files generated by the Users' Facts Storage module follow a clear pattern considering their structures and names. Because each file must keep a list of facts related to a particular user, and each event consists of a set of predicates, each predicate consists of an affordance and a number of factors, determined by the structure of each XML file. The name of each file must be associated with each user and each page of the system. The file names were constructed as follows:

<user_ID >-<page in which the change was done_ID >.xml

If a User whose ID is 55 performs a change on the page or node with ID 273, the name of the file generated will be "55-273.xml". This ensures that adjustments made by each unique user and each unique page will be recorded in a unique file. Some adjustments made by the User are applicable to all pages in the system, not just a specific page. To resolve this issue, it was decided that adjustments that apply to all pages should be written to a global user file, constructed as follows:

<user_ID >-global.xml

If the user previously mentioned, with ID 55, performs an adjustment on the interface that must apply to all pages in the system, which is called a global setting, this setting will be saved in a file named "55-global.xml". It is up to the designer of the interface to decide if an adjustment will be global or specific to each page. If desired, this choice can be left to the user.

Although FAN can be used to develop sophisticated features and behaviors, the complexity of its use is concentrated in the decisions of the designers and interface developers. The interface designer should set the norms that will govern the system's tailorable behavior. Interface developers should develop the features that are specific to that system in JavaScript. More details about FAN can be found in Fortuna (2010).

6.4.2 FAN Usage Possibilities

It is hard to list all the adjustments that may be made using the framework. Below is a list of some significant adjustments that the framework enables:

- Change attributes and style of objects;
- Drag-and-drop interface elements;
- Change an object's position via DOM operations;
- Insert, remove, show, hide, enable or disable interface objects;
- Permit adjustments made using JavaScript code, either using implementations already provided by the system or code contained in an Action Plan;
- Automatically modify an object after repetitive user actions.

To illustrate three possible adjustments that FAN can offer, Figure 6.6 shows a screenshot of *Vila na Rede* - a social network system in which users insert advertisements classified into different categories. It also shows some page customization options that FAN may enable, like changing the position of an object, hiding an element and changing the page structure by changing the display order of interface elements.

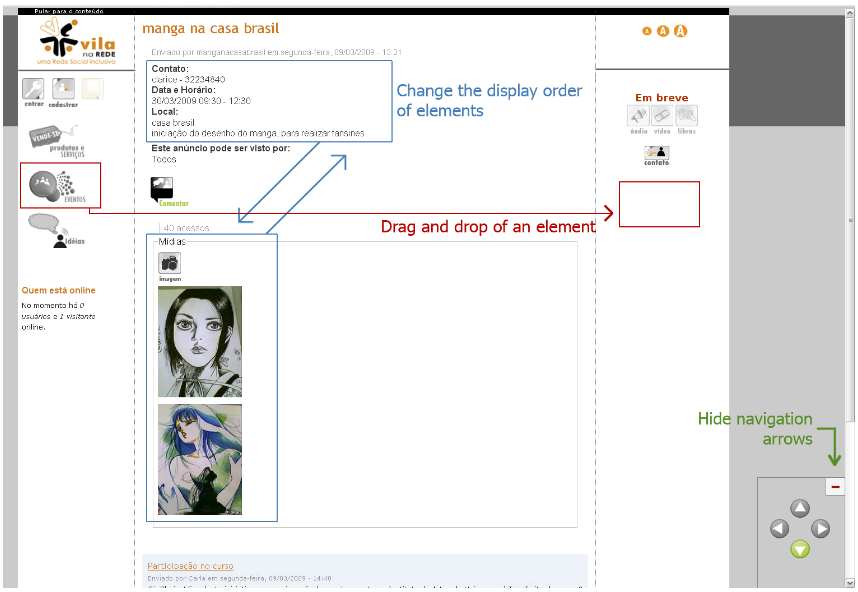

Figure 6.6. Screenshot of a social network system along with three interface adjustment options enabled by the FAN framework.

Figure 6.7 shows the result of the adjustments proposed in Figure 6.6. The image presents a customized page with appearance and behavior different from the original page (Figure 6.6). Another example feature of the framework is automatic modification of objects by perceiving repetitive user actions. If a user clicks a consecutive number of times in non-clickable areas when he or she tries to click or select a certain interface object, the framework can increase the size of interface elements to help the user, as shown in Figure 6.8. There is a norm determining that the size of the elements should be increased if the user has difficulty in navigating the page or if the user has some vision problems.

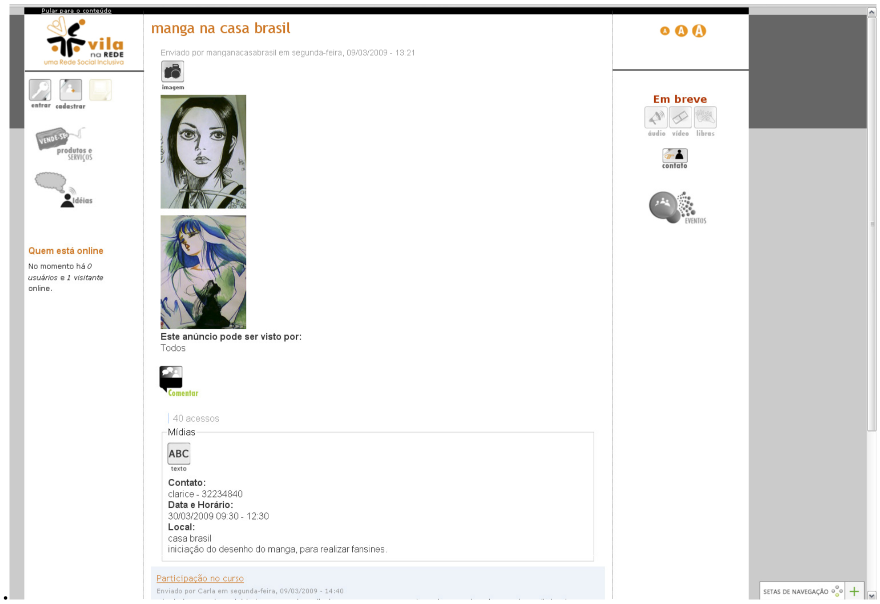

Figure 6.7. Customized page with look and behavior different from the original page, according to the adjustments proposed on Figure 6.6.

Figure 6.8. FAN Framework automatically modifying the size of elements based on a system norm that determines the execution of such actions.

More details about the framework, such as its architecture, implementation, features, tests results and a discussion of the advantages and drawbacks of the framework can be found in Fortuna (2010).

6.5 Evaluating the tailorable behavior

The system tailorable behavior was evaluated with users considering two scenarios: changing the menu format from linear to circular, and automatically resizing the font based on the user's profile. For the first scenario, we observed the time spent to change the menu and the users' impressions regarding the possibility to change something in the user interface. Considering the second scenario, we observed how users reacted when facing an automatic change in the interface.

A group of 7 users were observed. The users differed in gender (5 women and 2 men), age (from 22 to 61), education level (from uncompleted elementary school to graduate degrees) and professional activities (manga drawing teacher, house cleaner, telecenter monitor, seamstress, among others). The experience with computers also varied: three of them were self-described as naive with computers; two used computers sometimes; and two were considered experts. Their interactions were captured (mouse movements and keyboard entry) and the users' speech and face movements were recorded by a webcam. During the evaluation, the researchers observed the users reactions and freely talked to the participants, asking for more details when needed.

The first task was to change the menu from the linear format to the circular one. Users were advised that this action was possible in the system and were asked to discover how to do it. The users that were unfamiliar with computers scanned the screen looking for a new icon. As they could not find it, they asked for help and were directed to look close to where other options are offered, such as changes in the font size. After this orientation, they were able to change the menu on their own. The average time spent by these 3 participants was about 6 minutes. The other participants were able to find the link and change the menu with no help. The average time spent by the other 4 participants was about 2.5 minutes. One of the participants clicked on the tailoring button and saw the option to change the menu highlighted. Immediately following this, he started to look for other marks to change other elements. He mentioned, "I should go there," pointing to the button to change the menu from linear to circular, "to change the menu. Is there anything else I can change?"

The users' reaction to the option to change the menu was very positive; 6 users decided to keep the menu in the circular format. Figure 6.9 shows a sequence of screenshots and videos captured during a user's interaction. In Figure 6.9a, the user is looking for the tailoring activation element. In Figure 6.9b, it is possible to see a satisfied reaction when she sees the interface elements that would lead her to complete the task successfully. Finally, in Figure 6.9c, there is the final reaction when she saw the circular menu.

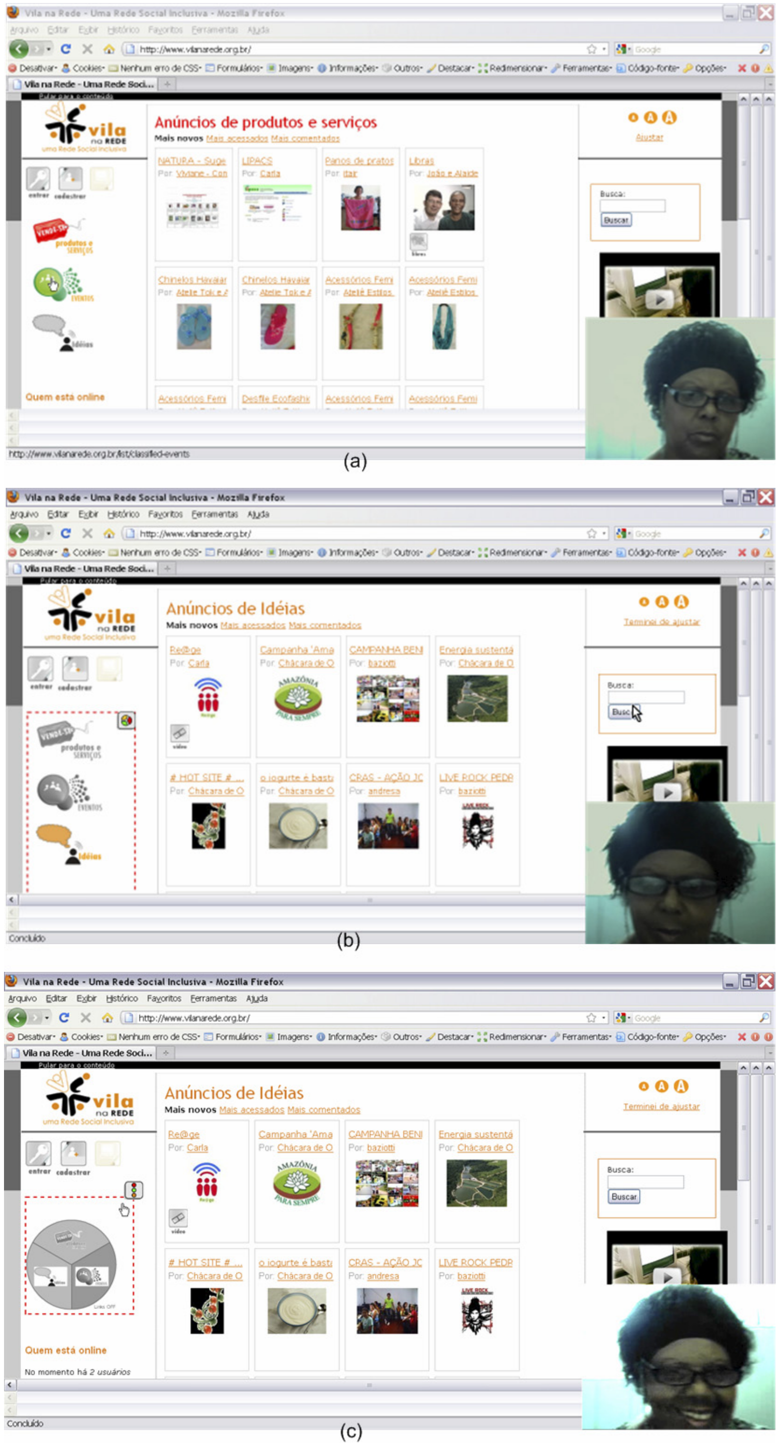

Figure 6.9. User interacting with the tailoring functionality: (a) looking for the tailoring link; (b) after clicking and realizing the option to change the menu and (c) when she saw the circular menu.

At the end of the first task, when asked about other features they would like to change in the system, the participants that were able to use computer autonomously mentioned changing the font or background color, removing the navigation arrows and help flags, and changing the order that the announcements are offered. The users that were unfamiliar with computers answered that they would not like to make changes and that the system is very good the way it is. When increasing the default size of the interface elements was suggested, these participants rapidly agreed that this change would be good.

In the second task, users were asked to log into the system and to observe the main interface. The automatic font resize was delivered to users that had selected the option "I always make the font size bigger" in their profiles. Four out of seven users noticed that the elements were bigger after the login. One of the inexperienced users mentioned: "I need bigger fonts; even more because I have vision problems. [...] For me this is excellent! The only thing is the increase could be bigger." This result indicates that the increase applied (13px to 14px) was not enough for all users, suggesting that different amplification rates are needed. However, the satisfaction with the automatic resize of interface elements was unanimous. Users mentioned that it was "excellent!", "cool!", "good" and "very practical."

The evaluation revealed areas that of the design that needed improvement. This included better symbolic representation for the activation of the tailoring functionality and to offer different automatic size amplification rates. After the evaluation, the tailoring options were left in the system, and in the following days, 21 users interacted with the functionality, performing at least one change. This data suggests the feasibility of offering a tailorable SNS that offers better interaction possibilities to users with different profiles. The main aspects and lessons learned from the design, implementation and evaluation of tailorable SNS are discussed in the next section.

6.6 Discussion

Social networks provide resources for maintaining social relationships, for finding people with similar interests, and for sharing content and knowledge endorsed by other users (Mislove *et al.*, 2007). This work defines an inclusive social network as a social network that enables every person to integrate into a group; every user can interact under a social protocol and a set of rules to promote the sharing of goods and ideas obtained through production and mobilization within these groups.

This work explored a tailoring approach to deal with the different interaction needs of a population in the context of a Brazilian inclusive social network system. Beyond the need to address accessibility requirements, the tailoring approach allows a more democratic view of the design of interactive systems. We agree with ideas presented by Fischer (2007), considering the concept of the meta-design. In this approach, users have more power, can override designers' decisions, and adjust the system according to their interaction needs. In this context, users can be seen as co-designers, leaving behind the role of mere consumers of technology. The system described in this paper allow users, for instance, to change the position of some interaction elements or even disable functions that do not make sense to them. Moreover, the tailorable approach makes it possible to present accessible options as videos in sign language for users who need them or to offer retractile resources to improve efficiency of use for expert users.

The role of co-designer, in fact, is encouraged during the whole development process. The adoption of the participatory approach brought the users into the process from the beginning. This directly impacted in the characteristics of the system. The concept of inclusive social networks leading to the collaboration and sharing of products and services, events and ideas is an example of those people's need reflected in the system. Many of the products and services offered in the *Vila na Rede* come from informal job activities. These people can benefit from ICT, e.g., to reach a larger audience for their products, and even stimulate those workers to get into the formal job market.

The experience reported in Section 6.3 shows the feasibility of adopting PLu*R*aL, with its OS ideas and artifacts, in a participatory approach. Section 6.4 describes how to realize and implement the design goals as web systems. Moreover, the results presented in Section 6.5 suggest that the experience of applying PLu*R*aL in a participatory approach was very positive and could handle diversity well. The expressive quantity of stakeholders, elicited by the designers, software engineers and end-users who joined the first workshop, supported the formalization of the different users' groups, environment and devices that characterized the context. With a wider view of the differences since the beginning of the process, the designers could foresee and implement more tailorable options.

However, despite the flexibility of PLu*R*aL and its support for the elicitation and formalization of the tailorable behavior, this method does not guide designers on how to present the tailorable options in the interface. In this sense, some design decisions were taken to make this technology accessible to ordinary users. The evaluation showed that users who are unfamiliar with computers looked for a graphical symbolization to start the process. Moreover, the users that are not familiar with computers seem to focus their attention on performing the main tasks in the system (reading, posting or commenting on an announcement). In this sense, an adaptable behavior can be used to offer the tailoring possibilities. However, the design has to be made to support these users in an evolutionary approach, until they are able to change the interface on their own.

Regarding the implementation aspect, FAN also proved to be a very flexible framework, allowing developers to change practically all the interface elements using simple norms. However, the effort of programming the JavaScript code that implements the tailorable behavior for each element is left to the application developer. Moreover, improvements can be done to facilitate the request synchronization from the Perception module to the NBIC/ICE via the SOAP client. Furthermore, it has been observed that FAN can take a few seconds to adjust the interface if there are many complex norms or if the server NBIC/ICE is installed in a machine with low processing capacity. Redundancy features, especially those to deal with low bandwidth and lost or corrupted packets, were not implemented yet.

The link between the more abstract norms and design decisions described by PLu*R*aL and the norms at the implementation level in FAN must be done by the designers and developers. This takes the form of developing JavaScript codes. In addition, it is necessary to define a schema for the identification of the HTML nodes to automatically link the action plan to HTML nodes and features. These activities can be costly and demand further research into new tools to supporting this process. However, these tools already give the designers and developers a complete path from the requirements elicitation to the implementation of the flexible interfaces.

Finally, inclusive solutions should allow users to interact in the manner that best suits them, with low or no additional effort. Some example tailored features include offering video in LIBRAS in a large, central position, providing user interface elements in a larger size, changing the element positions, enabling or disabling support for navigation, or even tailoring the website according to aesthetic preferences regarding menu format. PLu*R*aL and FAN are generic frameworks that can be applied in different scenarios which may require tailorable interfaces. Because PLu*R*aL is a participatory framework, the developed activities and workshops have to be modified according to the project constraints, such as time and user availability. The application of FAN in other scenarios is subject to technical constraints, such as rigid internet security polices which may restrict the execution of AJAX connections and JavaScript.

6.7 Conclusion and further work

In a web environment, there are different users with unique needs. This paper presented an approach to design and implement a social network system with tailorable characteristics aiming to deal with the different interaction needs present in a heterogeneous user population. The system tailorable behavior was determined using PLu*R*aL – a framework that considers a socio-technical view to the design problem. Moreover, the FAN framework was developed and implemented using the concept of norms to manage the system's tailorable behavior. The evaluation with end-users showed the proposal's feasibility. The results suggest that users with different profiles can benefit from a tailorable social network system. The tailorable options were made available in a real system and have been used by *Vila na Rede* members.

Further work should consider the design and development of a tool to support the formalization of the norms that determine the system tailorable behavior. This tool will support designers in the specification of norms from mockups with sketched interaction elements. Therefore, this tool could minimize the designer workload, as discussed in the last section. Future work can enhance FAN performance and integrate the framework with the semantic web. Instead of storing norms and facts inside files or databases with the NBIC/ICE system, we may use technologies like RDFS or SWRL (Semantic Web Rule Language) to store norms and facts on the web. Queries over norms may be done using SparQL, an RDF query language. Instead of using NBIC/ICE to make inferences over norms, we may use RDF/RDFS, OWL and SWRL, enabling users to store information about their needs.

Capítulo 7

User Interface Design informed by Affordances and Norms Concepts

7.1 Introduction

The pervasiveness of Information and Communication Technologies (ICT) in our daily lives emphasizes the necessity of technical systems aligned with people's intentions, beliefs and social commitments. Therefore, the design of these systems demands a deep understanding about the complex interaction process between humans and ICT. This understanding is only possible with a socio-technical perspective that considers ICT as part of reality, which is socially constructed.

Semiotics has been effectively used as a theoretical framework for supporting the interaction design (e.g. Nadin, 1988; Andersen, 1990; deSouza, 2005). Interaction between users and the technical system can be considered a sharing-sign phenomenon influenced by several factors as familiarity with devices, intention of use, affective issues, devices' characteristics and environmental conditions. Such phenomenon, analyzed only according to the perspective of engineering, has been interpreted as purely syntactic. The analysis using Semiotics reveals the primary function of computer systems as vehicles of signs and supplies an adequate vocabulary that makes possible the understanding of computer systems in terms of other types of sign systems (Nadin, 1988).

Organizational Semiotics (OS), in particular, is a discipline that explores the use of signs and their effects on social practices (Stamper *et al.*, 1988; Liu, 2000). OS provides a background that embodies knowledge and support collaboration and reflection among people from the different disciplines involved in interaction design (Baranauskas and Bonacin, 2008). In addition, OS supplies methods and artifacts that have been successfully used to clarify the design problem, extend context knowledge, formalize requirements and evaluate the design solution (cf. Liu *et al.*, 1998; Bonacin *et al.*, 2006; Rambo *et al.*, 2009; Neris *et al.*, 2010).

Human interaction with ICT relies on interfaces that allow the manipulation of signs which may be represented in different forms as text, pictures, sound and video, to name the currently popular ones. While designing interfaces, several decisions may be taken as which interface elements will be created to enable some type of interaction, where, which size, shape or color must have, among other characteristics. These decisions are generally left on the designers' hands or on user interface patterns detached from the application domain. Neris *et al.* (2008) have shown that the users' knowledge about the domain and their digital literacy highly influences the interaction. When users know about the system domain and the system design reflects the domain characteristics, the interaction process is facilitated. Therefore, we argue that more than context knowledge (as who is the user, devices' characteristics and environmental conditions), information about the system domain are influential for interface design decisions.

This paper presents an exploratory study to investigate how the concepts of affordances and norms may inform user interface design (UID). 17 designers were involved in a case study and 7 web design proposals were analyzed. The domain was modeled based on two methods from OS, Semantic Analysis Method (SAM) and Norm Analysis Method (NAM). Affordances and norms from the domain modeling were compared to those direct or indirectly present in the final UID. The preliminary results suggest a relation between some specific affordances and the place and presentation format of related elements in the user interface. Finally, a tool to structure interfaces is proposed and the interface elements characteristics are formalized by norms. The text is organized as follows: Section 7.2 presents the background concepts; Section 7.3 presents results of the case study to explore the relation of affordances and norms with UID; Section 7.4 presents a norm modeler tool as part of the process of constructing UID based on the concepts of affordances and norms; Section 7.5 concludes.

7.2 Affordances and norms

The concept of affordance was initially created by the perceptual psychologist J. J. Gibson (1968, 1977) as a word for the behavior of an organism made available that "implies the complementarities of the organism and its environment". As Gibson defined it, "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill". For Norman (1988, 2008), Gibson invented the word affordance "to refer to a relationship: the actions possible by a specific agent on a specific environment". According to Stamper (1988, 1996), the word affordance in Gibson's theory is related to the invariants we perceive that are significant for physical and biological reasons.

The term affordance started to be widely used in design after Norman's book (1988), in which he proposes the use of perceived affordances and the "thing" actual properties. According to him, affordances provide strong clues about how the thing could be possibly used, e.g. "plates are for pushing" or "slots are for inserting things". He argues that in graphical, screen-based interfaces, all that the designer has available is control over perceived affordances. The computer system, with its keyboard, display screen, pointing device and selection buttons affords pointing, touching, looking, and clicking on every pixel of the display screen. However, Norman clarifies later on (2004), even if users can click anytime and everywhere on an interface, it is strong to state that a graphical object on the screen "affords clicking". He emphasizes that the question is: "Does the user perceive that clicking on that location is a meaningful, useful action to perform?"

Stamper's (1988) extension to the concept of affordances better helps us to answer this question. According to Stamper *et al.* (2004): "All organisms, including human agents construct their perceptions of the only world they can know through their actions; they have to discover (or be taught, or inherit by instinct) what invariant repertoires of behavior the world affords them (= the affordances); then they populate their reality with those affordances that help them to survive". This perspective considers that the reality is socially constructed and relates affordances with patterns of behavior arisen from social interactions. Therefore, every affordance presupposes meaning and intention, what guides for example the click on an interface element.

OS proposes a method to support domain modeling by its affordances. SAM supports the analysis, specification and representation of a social system and is divided into four phases: problem definition, candidate affordance generation, candidate grouping and ontology charting (Liu, 2000). Considering a statement that defines the (design) problem, the main affordances in the domain are elicited. SAM also considers the concepts of agents and ontological dependencies. Agents are a special type of affordance which refers to those who are capable of assuming responsibilities. Ontological dependencies are links between affordances or agents representing that the element in the right can only exist during the existence of the element in the left. After identifying the affordances and agents and grouping them (if they have the same meaning), the ontology chart is drawn.

OS approach rescues the original sense of ontology as part of the philosophy that studies the nature of reality. It adopts a social-subjectivism stance and an agent-in-action perspective for ontology; i.e. each word or expression used is a name for patterns of behavior in the set of actions and events which agents experience. Therefore, the ontology chart is like a "snapshot" of the reality regarding that specific domain in which the prospective (software) system will be included. Moreover, the dynamic behavior in that reality can be modeled using norms.

Norms are the rules which determine how social organisms interact and control affordances (Stamper 1993; Stamper *et al.*, 2000). They are related to how people behave, think, make judgments and perceive the world. Every norm can be written as IF <condition> THEN <consequence>. Behavioral norms, in particular, can be expressed in an extended format: WHENEVER <state> IF <condition> THEN <agent> IS <deontic operator: must, may, must not> TO <action>. With this last structure, it is possible to complement an ontology chart by specifying how agents deal with affordances. Indeed, affordances by themselves express perceptual norms. They concern the ways in which we divide up the world into the phenomena to which we attach names. We can only represent norms explicitly when we have words to represent the perceptions underlying them (Stamper *et al.*, 2000). Moreover, evaluative and cognitive norms also compose a social psychological taxonomy of norms.

NAM consists of 4 steps for eliciting and formalizing norms: responsibility analysis, proto-norm analysis, trigger analysis and detailed norm specification (cf. Liu, 2000). Each step assists the identification of parts of the norm. In special, the responsibility analysis aims at assigning the agents in charge for each action. The trigger analysis focus on the conditions that should happen thus the action will be performed.

Both, affordances and norms, are powerful concepts to describe a domain and have been used to support the design of interactive systems (Bonacin, 2005; Neris and Baranauskas, 2009a). Nevertheless, it is still necessary to investigate whether these concepts may support interface design decisions. The next section presents an exploratory study in this direction.

7.3 SAM and NAM supporting UID

An exploratory study analyzed 7 user interfaces from prototypes developed by 17 (prospective) designers from the postgraduate course in Computer Science at UNICAMP-Brazil. The prototypes were developed following PLu*R*aL - a framework for the design of tailorable user interfaces based on Organizational Semiotic concepts (Neris and Baranauskas, 2010). PLu*R*aL is organized in 3 pillars: the 1st one brings out the signs of interest in the domain (being them related to users, devices or environment) and formalizes non-functional requirements that the tailorable system should cope with. The 2nd pillar benefits from SAM and NAM and allows a consistent view about the domain, including the norms that govern the agents' behavior, and assist the formalization of functional requirements. In the 3rd pillar, the tailorable design solution is build up and a norm-based structure formalizes the system tailorable behavior.

Designers worked in 7 groups (4 with 3 participants each, 2 with 2 participants each and 1 participant worked alone) and were free to propose a system design within the context of service applications for the Brazilian user. The systems chosen consider different domains: public drugstore, Portuguese learning support, social network about books, poll system for digital TV, traffic awareness, job guide and interaction monitoring system.

In this study, the ontology charts generated in PLu*R*aL's 2nd pillar were compared to the final user interfaces as described in section 7.3.1. The results observed and some preliminary conclusions are presented in section 7.3.2.

7.3.1 Method

The analysis aimed at evaluating if (and how) affordances and norms that represent the domain were expressed in the final user interfaces. Therefore, the adopted method considered the following steps: (1) the affordances represented in each ontology chart (an example is shown in Figure 7.1a) were divided into 4 categories: people (considering the roles derived from the affordance "person"), institutions (agents which are not person or person's roles), actions (affordances expressed by verbs) and substantives (affordances expressed by nouns); (2) Each final user interface was inspected and the main affordances expressed in the different interaction areas were elicited; (3) The affordances expressed in the interfaces were compared to those from the ontology charts, considering position in the interface and representation (which interface element was used: icons, links, buttons etc), as illustrated in Figure 7.1b.

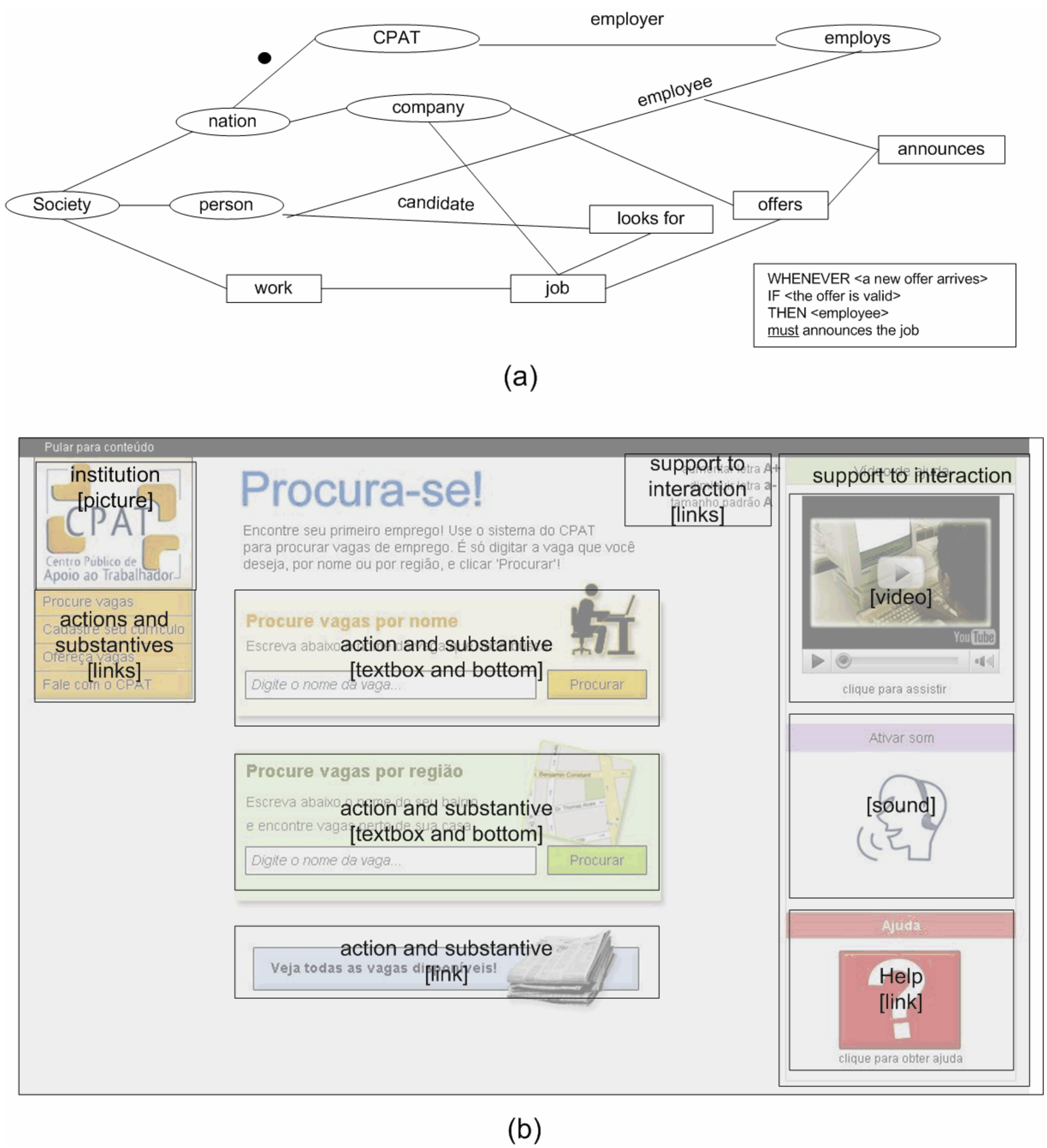

Figure 7.1. (a) Ontology chart for a job guide domain. (b) Final user interface with main reflected affordances.

7.3.2 Preliminary results

From the analysis of the ontology charts and user interfaces, some quantitative data were obtained as summarized in Table 7.1. Each line in the table represents one of the seven prototypes analyzed. The affordances in the ontology charts and user interfaces were counted considering the criteria expressed in section 7.3.1.

Table 7.1. Quantity of affordances related to the domain from the ontology chart vs. in the user interface

Ontology chart				User interface			
people	institutions	actions	substantives	people	institutions	actions	substantives
2	3	5	2	0	1	3	1
2	0	5	3	0	0	3	3
4	2	11	3	1	0	2	3
2	5	6	4	0	0	2	1
4	2	5	4	0	1	4	1
4	4	4	5	1	1	1	2
2	1	6	4	0	1	1	1

The first fact that can be observed (and was already expected) is that the quantity of affordances related to the domain in the user interface is smaller than in the ontology chart. As the ontology chart represents a domain, fraction of a reality, the technical system can support only part of the actions that the agents perform. However, in the user interfaces other affordances, not related to the domain, but related to the interface itself, emerge. Figure 7.1b shows on the right some affordances that were added in the interface to support the interaction itself. They represent actions such as increase the font size, change contrast or play a supportive video or sound. Table 7.1 considers only affordances related to the domain.

The affordances regarding people are essential to clarify the responsibilities in the domain and support the elicitation of the possible users. Though, they did not appear explicitly in the interface. In most cases, they represent the implicit agent interacting with the system. The only 2 people (traffic agent guide and a clinic attendant) that appear in the interfaces (as pictures) were added to assist the users as elements to activate help options or provide affective support.

Institutions, on the other hand, were represented in the user interface, mostly by their logos and on the left upper position or in the footer. However, the number of institutions represented in the interfaces could have been greater. Some representations for institutions (as the traffic regulatory body or the healthy ministry) were not added by the designers; maybe because it was an academic exercise. In a real life situation, as the services are supported by governmental agencies, their logos should have been placed.

The actions from the domain supported by the system were mostly represented by links and buttons (as look for, announce or comment). Moreover, they were placed on the left hand side or in the middle area (in the case of the main functionality), while the actions related to the interface itself or affective support were mainly placed on the right side. The substantives were generally presented with the actions, therefore on the left hand side or in the middle. While on the left, they were represented by text; but when in the middle, different types of signs were used as icons and symbols, or more specifically diagrams and emblems.

Regarding norms, two main types were specified by designers: perceptual and behavioral norms. The perceptual norms appear directly when thinking about affordances. Each word chosen to form the ontology chart represents how the domain is perceived and in most cases, the same words adopted in the chart were adopted in the interface. However, sometimes designers selected other terms (or even new terms show up), what suggests the need of refining the chart. Thus, UID, supported by information from the domain, not only benefits from the use of significant terms but also helps in the model refinement. This is an observation which corroborates with an incremental process of building the ontology diagram.

Deliberately, designers specified behavioral norms, expressing the conditions and consequences related to the actions presented in the ontology chart. According to the designers, these norms were very supportive to clarify the system functions and assisted the specification of use cases. They commented: "the use cases generation was really immediate, as the two methods [SAM and NAM] helped a lot to understand the problem and the system" and "the ontology chart with norms really helped to specify the use cases, e.g. actions and pre and post-conditions". However, this study did not provide evidences that behavioral norms directly supported decisions in the user interfaces. In addition, further studies may aggregate evaluative and cognitive norms to the investigation.

These preliminary observations suggest that some categories of affordances are represented in the interface by similar types of signs and are grouped in specific areas (e.g. institutions by their logos in the left upper side or in the footer; actions by textual links or buttons in the left side or substantives in the middle by different signs). Moreover, perceptual norms supported design decisions regarding the terms added to the interface. The next section presents a tool to help designers to structure interfaces and to define the behavior of each element using norms. This tool added to an ontology chart builder and NBIC (Bonacin and Baranauskas, 2005) to support the construction of tailorable systems from SAM and NAM.

7.4 MONA – a norm modeler for user interface

MONA (Portuguese acronym for norm modeler for tailorable interfaces) is a tool that helps designers to structure user interfaces based on the concept of wireframes. It allows the representation of interaction areas and support design consistency through several interfaces. Figure 7.2 shows a mock-up from MONA's main interface. Designers can specify the system being developed (e.g. Vila na Rede - an inclusive social network system that allows users to share products, services and ideas - http://www.vilanarede.org.br) and the functionalities being represented (e.g. comment_post). Some interaction areas as well as some interaction elements are available to compose the interface in a drag and drop style. The different interfaces for each functionality are drawn in individual tabs (e.g. comment_screen1).

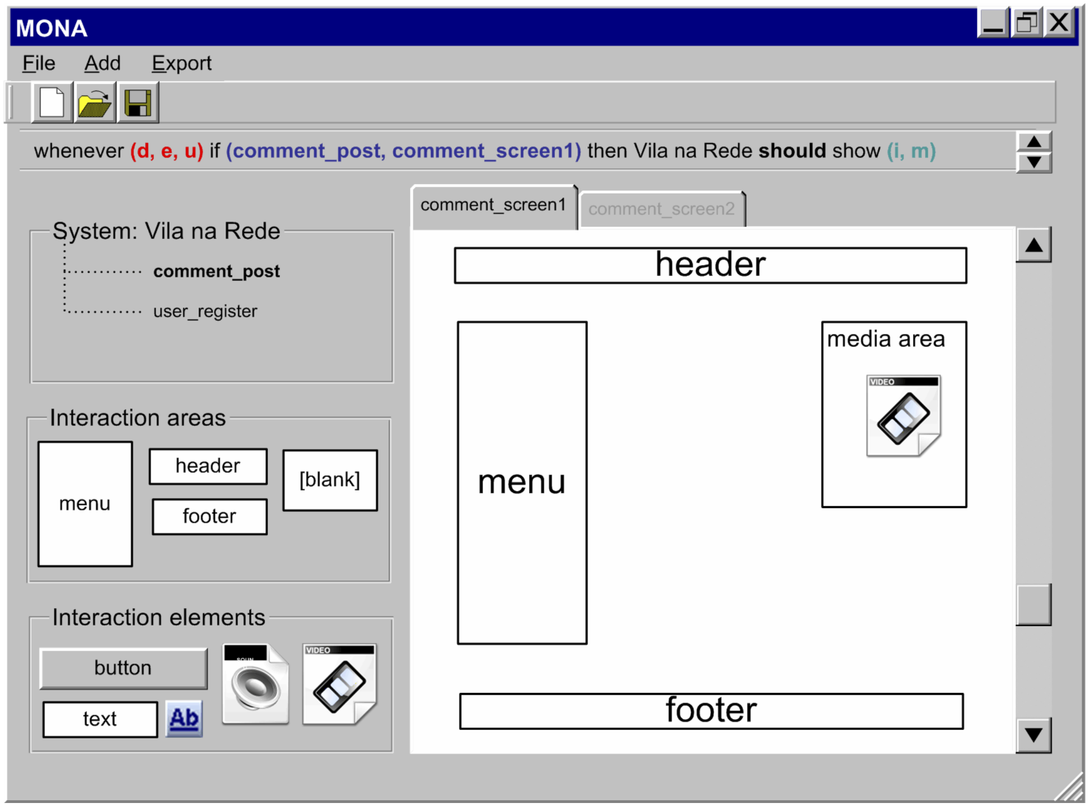

Figure 7.2. Mock-up of MONA.

However, only drawings are not enough to represent the diversity of facets a tailorable system may have, hence a more formal approach needs to be adopted. Once more, OS founded the solution and the norm concept was applied. As norms express how agents behave in society, the same structure was adopted to model the behavior of tailorable systems. An instance of the format proposed for behavioral norms is suggested considering context, functionality and interface elements, as follows:

WHENEVER (d, e, u) IF (f, r) THEN <system> IS <deontic operator> TO show ∑(i, m)

where:

d: device, e: environment, u: user

f: functionality, r: representation

i: interface element, m: mode (position, size, shape, color, type, instance)

The context is defined by a tuple formed by device, environment and user characteristics. When the condition is satisfied, i.e. the system starts a specific functionality in a specific representation (as the same functionality may have more than one user interface), then the tailorable system must, may or may not show a group of interface elements in a certain mode. The proposed format allows modeling a great variability of changes and designers can specify since simple situations as "every time the application is running on a cell phone, contrast option should be on" to more complex ones involving specific behavior of different interface elements (whenever (Computer, in the office, attendant) if (check appointment, appointment report) then drugstore_system should show [(language style, "formal_semantics.txt"); (logo, Healthy ministry)]. With MONA, designers can specify the behavior of each element by clicking on the interface element and specifying the norm.

It is important to mention that, in OS, the original concept of norms is related to the organization behavior and the structure of behavioral norms requires an agent (affordance with responsibility) as the responsible for the action. The same norm structure was adopted in MONA intending to represent a certain behavior; in this case, the system behavior. The software system is as an agent that will display a set of interface elements in a certain mode. This view considers the system as an active artifact capable of doing tasks in different contexts. However, it is known that the system software is not an agent in the sense OS proposes, since the responsibilities are always associated to the human agents behind the system.

Using MONA, designers start structuring the user interface from scratch. i.e. with no previous support. However, considering the results presented in section 7.3.2, MONA could support designers considering information from the domain. Figure 7.3 shows a process which considers 2 other tools as infra-structure: SONAR (Bonacin *et al.*, 2004) and NBIC/ICE (Bonacin and Baranauskas, 2005).

SONAR is an ontology chart drawing tool. It allows the specification of affordances, agents, roles, ontological dependencies and the norms related to them. In a drag and drop style, designers can rearrange the elements and may evolve the chart. SONAR also generates initial versions of UML class diagrams from the ontology chart (Bonacin *et al.*, 2004). Adding a syntactic parser to MONA, which may base the affordances classification as verbs and substantives; it could suggest a first structuring for the interface. People and institutions could be directly obtained from the ontology chart.

MONA can export the interface structure and norms expressing the elements behavior in a XML format that can be read by the webservices offered by the NBIC/ICE infra-structure. The NBIC (Norm Based Interface Configurator) receives the norm specification in Deontic logic, manages the norms persistence, and also transforms them into a platform specific language that can be interpreted by an inference machine on ICE (Interface Configuration Environment). Then, the ICE receives context information from the application, evaluates the norms related to context by using the inference machine (JESS – JAVA rule engine) and returns to the tailorable application an action plan with the changes to be done.

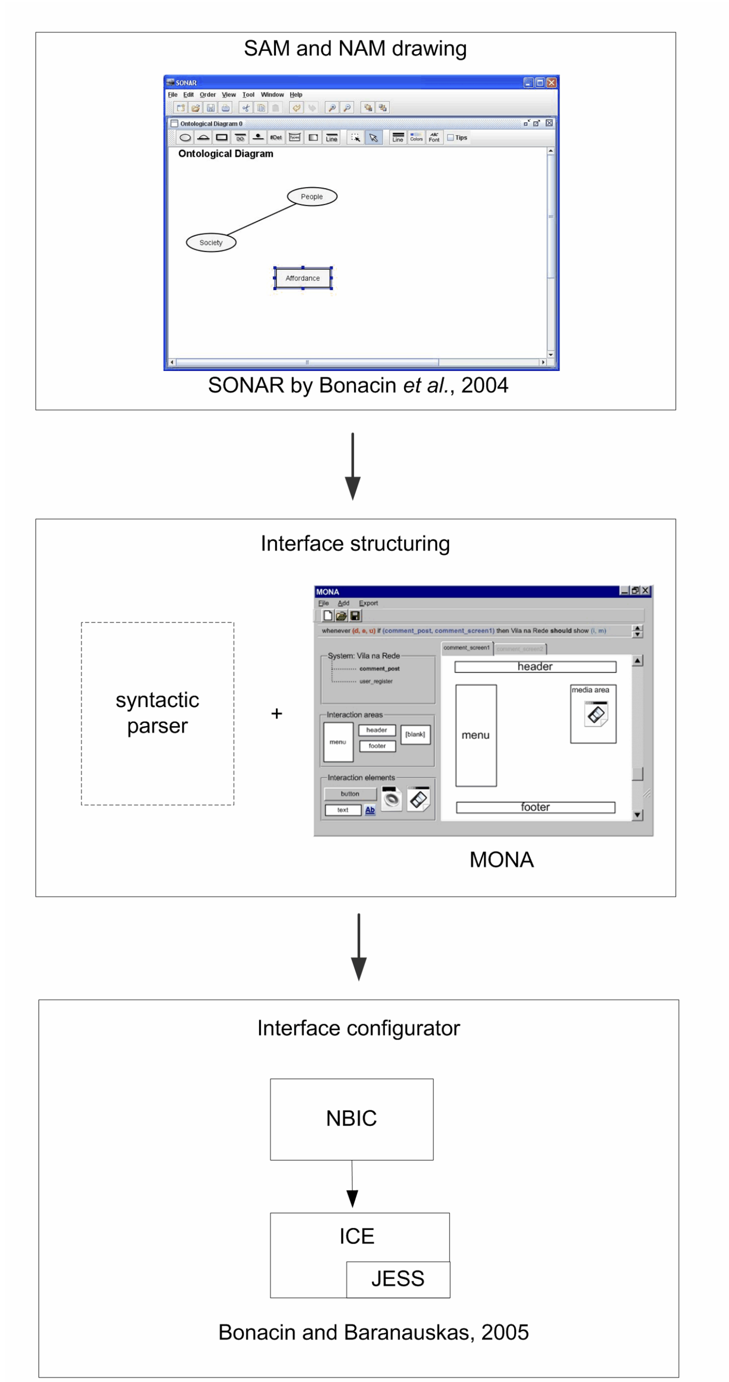

Figure 7.3. Modules to help designers to consider information from the domain in UID.

As suggested by Figure 7.3, information from the domain (modeled through SAM and NAM) supports the interface structuring (suggesting interface elements and position and also terms to be used) directly influencing the technical system behavior.

7.5 Conclusion

This paper presented preliminary results from an exploratory study about affordances and norms representing the application domain and user interface design decisions. The results suggest that some categories of affordances are represented in the interface by similar types of signs and are placed in specific positions. Moreover, perceptual norms support design decisions regarding which terms may be added to the interface. MONA, a tool to help designers to structure user interfaces and determine the behavior of each element using norms, was presented. Moreover, the interface structuring of a tailorable system was proposed based on information from affordances and norms.

As OS artifacts have been successfully used to help several UID activities such as clarifying the design problem, extending the context knowledge, formalizing requirements and evaluating the design solution, this paper advocates a possible support to user interface structuring. Once it was a first approach to investigate how affordances and norms may inform UID, the study does not make any assumption about the quality of the interfaces, which can be assessed in future investigations. Moreover, other types of norms may be studied specially aiming at the elicitation of non-functional requirements and their reflection on the user interfaces.

Capítulo 8

Conclusões

A pluralidade de cenários de uso nos quais os sistemas computacionais estão imersos atualmente exige novas formas de se pensar o design. Para uma sociedade mais justa, é urgente que se considerem as diferenças nos requisitos de interação e que se desenvolvam soluções que façam sentido e sejam acessíveis ao maior número possível de usuários. Um dos caminhos que se apresenta é desenvolver interfaces que sejam ajustáveis, i.e que permitam modificações em seu comportamento para atender as diferentes necessidades de interação. A revisão de literatura sobre sistemas ajustáveis mostrou que, apesar do tema ser de interesse da comunidade de computação, poucos trabalhos tratam do design dessas aplicações, não tendo sido encontrados relatos que orientem os designers de forma prática, com artefatos, técnicas e métodos. Para preencher tal lacuna, esta tese propôs o PLu*R*aL – um *framework* para o design de interfaces de usuário ajustáveis.

Este capítulo traz na seção 8.1 uma síntese das principais contribuições desta tese. A seção 8.2 apresenta uma análise crítica sobre o trabalho, considerando tanto o produto da tese (*framework*), como também o caminho percorrido para concebê-lo. A seção 8.3 traz reflexões sobre os trabalhos futuros.

8.1 Síntese das Contribuições

A principal contribuição desta tese é o PLu*R*aL – um *framework* organizado em 3 pilares: 1-Descreva as necessidades, 2-Defina funcionalidades e 3-Determine o comportamento ajustável), contendo um conjunto de artefatos, técnica e métodos para a descrição das necessidades de interação, definição das funcionalidades e determinação do comportamento ajustável do sistema. O PLu*R*aL foi utilizado por 17 estudantes de pós-graduação no papel de designers em um estudo de viabilidade e posteriormente aplicado para tornar o sistema Vila na Rede ajustável. Resultados preliminares da avaliação com usuários finais do Vila na Rede sugerem que os ajustes oferecidos fizeram sentido para um conjunto heterogêneo de usuários.

A determinação do comportamento ajustável do sistema, tratada no 3º pilar do PLu*R*aL, acontece considerando-se *sketches* das interfaces e posterior escrita de normas determinando as diferentes representações dos elementos de interface de acordo com o contexto de uso e funcionalidade do sistema. Nesse ponto, o designer pode ser auxiliado por um sistema que, a partir de desenhos abstratos da interface, gerencia a inserção de normas. Assim, outra contribuição deste trabalho é o protótipo inicial da MONA – um MOdelador de Normas para interfaces Ajustáveis.

Além do *framework* e do modelador de normas, esta tese apresentou uma nova classificação para *tailoring*, considerando os sistemas ajustáveis imersos em um contexto social e as mudanças no sistema computacional como um reflexo daquelas que ocorrem nos 3 níveis de um sistema de informação (informal, formal e técnico). Essa classificação contribui para mostrar a necessidade de se conhecer as características não apenas técnicas, mas também aquelas formais (leis e procedimentos) e informais (culturais) do contexto no qual o sistema está envolvido. O PLu*R*aL se beneficia dessas idéias e considera, durante o design, questões como intenção de uso, necessidades afetivas e conseqüências no mundo real, favorecendo a visibilidade de mudanças nos níveis formal e informal.

A participação nos estudos de caso permitiu a formalização de contribuições anteriores ao *framework* como a abordagem para a construção de sistemas para todos (apresentada no Capítulo 4) e um modelo de interação para aplicações de governo eletrônico (Capítulo 3). Com a aplicação do PLu*R*aL, foi possível observar que algumas categorias de *affordances* presentes em diagramas de ontologias, construídos sob a ótica de SO, são representadas na interface de usuário com tipos similares de signos e em posições específicas (como discutido no Capítulo 7). Trata-se de uma contribuição preliminar, mas que indica possibilidades de se explorar mais a relação entre modelagem do domínio (indo além de características apenas do usuário e considerando também as ações, instituições e demais *affordances* que compõem o domínio) e o design de interfaces.

Além das contribuições apresentadas nos artigos que compõem esta tese, outros resultados foram formalizados em temas correlatos, como um conjunto de padrões de elicitação para o design de interfaces de usuário flexíveis (Baranauskas e Neris, 2007); um conjunto de requisitos e diretivas de interação considerando a diversidade cultural e social da população brasileira (Neris *et al.*, 2008) e a especificação de atividades de IHC em um método ágil para aplicações sociais (Neris *et al.*, 2009b). Como resultados diretos ou indiretos da realização desta tese foram publicados: 1 artigo em periódico, 1 capítulo de livro, 12 artigos completos em anais de eventos, 10 relatórios técnicos.

8.2 Reflexões Finais e Lições Aprendidas

Discussões atuais sobre a forma como pesquisas em IHC vêm sendo desenvolvidas apontam que estamos vivendo a chamada “3ª onda” (Harrison *et al.* 2007). Comparada às 1ª e 2ª ondas, nas quais havia uma orientação para as questões de ergonomia e fatores cognitivos respectivamente, a 3ª onda trata da multiplicidade e do estabelecimento de sentido, na qual os artefatos e seus contextos estão mutuamente definindo e sendo sujeitos de diferentes interpretações. De forma pertinente a esse contexto, o PLu*R*aL orienta designers a reconhecer e lidar com a multiplicidade (de usuários, dispositivos e ambientes de interação), considerando as diferenças desde as primeiras atividades e pensando em requisitos de forma abrangente e consistente com o domínio. A multiplicidade também se reflete na forma como o PLu*R*aL pode ser utilizado, por apenas 1 designer ou por um grupo de designers, ou até de forma participativa, envolvendo usuários, engenheiros de software, profissionais de arte etc.

Além de coerente com o contexto de IHC, o PLu*R*aL tem características que permitem classificá-lo como de alto poder descritivo (habilidade de descrever uma significativa quantidade de interfaces) e avaliativo (habilidade para julgar diferentes alternativas de interface), considerando os critérios estabelecidos por Beaudouin-Lafon (2004)[16]. A estrutura de normas proposta no 3º pilar do PLu*R*aL permite descrever uma quantidade significativa de comportamentos ajustáveis considerando inclusive variações sutis no contexto (como mudança de luminosidade no ambiente ou habilidades motoras dos usuários). Além disso, permite especificar se o comportamento deve acontecer durante a execução de uma dada funcionalidade, um conjunto de funcionalidades ou durante toda a interação. Já o uso da Escada Semiótica para descrever os requisitos de interação advindos dos possíveis contextos de uso apóia o design para a diversidade (considerando desde questões com os dispositivos físicos até aquelas de significado, intenção e conseqüência social), mas também permite avaliar a extensão da solução ajustável e a comparação entre alternativas de design.

Ainda de acordo com o modelo de Beaudouin-Lafon, é desejável que o *framework* tenha também alto poder gerador (habilidade para ajudar designers a criar novas soluções de design). Nesse sentido, o término da implementação da ferramenta MONA pode aumentar o poder gerador do PLu*R*aL, uma vez que vai permitir a especificação de interfaces ajustáveis a partir de elementos de interação abstratos, gerenciar a especificação de normas e exportar o comportamento ajustável em XML para ser lido pela infra-estrutura NBIC/ICE, desenvolvida por Bonacin e Baranauskas (2005). As especificações das interfaces, bem como as respectivas normas, poderão ser salvas e re-utilizadas.

É importante salientar que o PLu*R*aL se beneficia de 2 artefatos (Partes Interessadas e a Escada Semiótica) e de 2 métodos da SO (SAM e NAM). O uso dos artefatos foi considerado fácil pelos designers participantes do estudo de viabilidade. No entanto, a aplicação dos métodos, em particular o SAM, foi considerada difícil, uma vez que exige uma mudança na forma de pensar durante a modelagem. Historicamente, as modelagens no contexto da computação consideram relações causais (e.g. aluno se matricula em disciplinas) e a modelagem proposta pelo SAM exige que se pense na existência de cada *affordance* e em suas relações ontológicas (e.g. o *affordance* matricular só existe enquanto os *affordances* aluno e disciplina existirem). Mais do que isso, o *affordance* aluno é uma especialização do *affordance* pessoa, o que já agrega à modelagem as características de pessoa (nome, data de nascimento etc); assim como disciplina pressupõe um responsável e

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[16] Os critérios de avaliação de Beaudouin-Lafon foram propostos para modelos de interação. Aqui, adotamos os mesmos critérios para avaliar o PLu*R*aL, uma vez que eles se aplicam perfeitamente a *frameworks* ou outras abordagens que guiam designers. Nas palavras do próprio Beaudouin-Lafon, "*the purpose of an interaction model is to provide a framework for guiding designers, developers and even users (in the context of participatory design) to create interactive systems*." Se considerarmos essa relação entre modelos de interação e *frameworks*, pode-se dizer que o PLu*R*aL adota o modelo de interação proposto por Baranauskas e Bonacin (2008).

assim sucessivamente). As relações existenciais amplificam a visão do domínio no qual o sistema computacional está ou será inserido, favorecendo a especificação de funcionalidades.

Nesse ponto cabe discutir a (in)dissociabilidade entre o *framework* e os artefatos, métodos e técnicas sugeridos. Cada pilar tem um objetivo bem determinado e um conjunto de atividades que o compõe. Dependendo do projeto em questão, o designer pode entender que outros artefatos, métodos e técnicas são necessários para a realização satisfatória de uma dada atividade; por exemplo, agregando o Quadro de Partes Interessadas (Baranauskas *et al.*, 2005) à clarificação do problema no 1º pilar. Considerando essa flexibilidade do *framework*, durante o design do comportamento ajustável do sistema Vila na Rede, ao invés de se aplicar o BrainDraw modificado como técnica para gerar representações de design no 3º pilar, optou-se por uma atividade com painéis e figuras de elementos de interação. Essa adequação foi realizada, uma vez que o sistema já estava concebido e os participantes da atividade tinham familiaridade com os elementos de interface utilizados. Da mesma forma, se um sistema já tem seu conjunto de funcionalidades bem determinado e especificado, tais informações devem ser utilizadas nas atividades do 2º pilar.

A nova categorização proposta para *tailoring* (apresentada no Capítulo 2) que considera que as mudanças na interface são um reflexo das modificações que acontecem nos três níveis do sistema de informação (técnico, formal e informal) é ortogonal às classificações já existentes na literatura. Considerando a classificação de Morch, por exemplo, que aponta três categorias de *tailoring* (customização: escolha de parâmetros, integração: uso de código existente e extensão: programação de novo código), é possível dizer que cada mudança, seja técnica, formal ou informal, pode ser realizada das três maneiras definidas por Morch. Assim, a classificação proposta nesta tese tem o objetivo de evidenciar o sistema ajustável inserido em um contexto social, enquanto que as categorizações apresentadas pela literatura, até então, focam no esforço para a realização do ajuste.

Ainda considerando os três tipos de mudanças apresentados na nova categorização para *tailoring* proposta nesta tese, pode-se dizer que a avaliação dos recursos ajustáveis do sistema Vila na rede, que foi realizada com usuários finais no contexto do projeto e-Cidadania (relatadas no Capítulo 6), focou em mudanças técnicas como a alteração na forma de um elemento de interação (menu em formatos linear e circular) e tamanho dos elementos (aumento automático da fonte). Mudanças dos tipos formal e informal seriam refletidas, por exemplo, em alterações no procedimento de publicar um anúncio (formal) ou na adequação do conteúdo a regionalismos lingüísticos (adequação cultural e, portanto informal). Dada a complexidade para implementação de ajustes dos tipos formal e informal, eles não foram incluídos no cenário de avaliação aqui relatado.

Por fim, é importante ressaltar 2 pontos fundamentais para a realização deste trabalho de tese: o contato com usuários reais nas atividades participativas e o estágio no IRC. O Design Participativo é uma abordagem trabalhosa que exige clareza no objetivo da atividade, criatividade, planejamento, produção do material, execução e registro das atividades, discussão, compilação, avaliação, entre outros. No entanto, participar do processo de criação conjunta, em um ambiente acolhedor e com materiais que facilitam a expressão (desenhos, cartões, figuras), enriquece profundamente a visão do contexto, favorecendo o design de soluções que façam sentido para público em questão. Em especial no contexto do design para a diversidade, o contato com pessoas que nunca tinham usado o computador, com diferentes níveis de letramento, idade, estratégias de comunicação etc, desmistifica a necessidade de uma abordagem assistencialista, que rotula e inibe, e reforça o respeito às diferenças e o compromisso com soluções de design que favoreçam o crescimento sócio-intelectual dos usuários.

O estágio no IRC agregou não apenas conhecimentos técnicos nas áreas de Semiótica e IHC, mas também outros fundamentais para a formação de um pesquisador, decorrentes, por exemplo, da vivência de um modelo de orientação diferente, organização de grupo e contato com a indústria. Da mesma forma, vale ressaltar que no Brasil, mesmo com menos recursos humanos e financeiros, faz-se pesquisa de qualidade e o benefício com estágios desse tipo é mútuo, o que pôde ser observado pelo interesse nas pesquisas aqui realizadas e nas várias apresentações solicitadas.

A receptividade de todos no IRC deve ser comentada como facilitadora nas atividades realizadas. Também a convivência com pessoas de culturas tão diferentes trouxe uma outra perspectiva para a questão da diversidade, fortalecendo ainda mais a motivação de se respeitar as características de cada indivíduo, que devem ser refletidas nas possibilidades de interação a serem oferecidas pelos sistemas computacionais.

8.3 Trabalhos Futuros

O design de soluções ajustáveis é um tema ainda pouco explorado, principalmente em contextos de diversidade; no entanto, tem crucial importância se considerarmos a pervasividade dos sistemas computacionais atuais e se quisermos que essas tecnologias sejam usadas pelo maior número possível de usuários. Assim, ainda há muito a ser feito relacionado com o tema em questão. A seguir, destacam-se alguns trabalhos de cunho teórico e metodológico e outros relacionados ao desenvolvimento e implementação.

Como trabalhos futuros de caráter teórico e metodológico, pode-se citar:

- Estudos sobre a representatividade das opções de *tailoring* na interface, que poderiam ser formalizados em um conjunto de padrões de interação;

- A formalização da extensão ao modelo de Obrenović *et al.* (2007), como discutido na seção 5.2.2. Aqui cabe um aprofundamento dos estudos sobre tipos de normas (e.g. perceptuais, comportamentais, avaliativas) e como essas podem informar o design;

- Estudo e proposta de um método de avaliação para interfaces ajustáveis. Abordagens tradicionais de avaliação focam na tarefa ou em aspectos dissociados de contexto como eficácia e eficiência de uso. O sucesso de sistemas ajustáveis está intimamente ligado ao contexto de uso e aspectos como pertinência e persistência do ajuste devem ser considerados;

- Aplicação do *framework* a outros domínios, em especial aqueles que em que haja grande variabilidade de ambientes de interação e dispositivos, como trabalhadores nômades ou prédios inteligentes.

Entre os trabalhos futuros relacionados a desenvolvimento e codificação, pode-se citar:

- Término da implementação da ferramenta MONA, considerando aspectos de persistência e comunicação com a infra-estrutura NBIC/ICE (Bonacin e Baranauskas, 2005).

- Testes de viabilidade da arquitetura proposta no Capítulo 7 a serem realizados em 3 etapas: 1) funcionalidade de desenho automático na ferramenta MONA a partir de um arquivo XML de especificação contendo elementos abstratos de interface e características (e.g. tamanho e posição); 2) implementação de uma base de dados com regras para os tipos de *affordances* e respectivas representações, como apontado no Capítulo 7 e 3) adoção de um *parser* sintático e geração automática de um arquivo XML com a especificação dos elementos abstratos da interface.

- Testes das soluções de design em plataformas que permitam tradução de interfaces de forma automática para diferentes dispositivos.

Finalmente, deve-se ressaltar que sistemas ajustáveis são uma forma de "distribuir o controle" sobre o design, como aponta Fischer (2007), e nesse sentido a concepção desses sistemas demanda uma visão ampla das possibilidades de uso. Assim, trabalhos nessa área podem se beneficiar de abordagens mais democráticas (como o Design Participativo), bem como de parcerias entre grupos de pesquisa com diferentes *expertise*.

8.4 Considerações Finais

O pluralismo da sociedade pós-moderna exige abordagens ao design de sistemas computacionais que considerem não apenas as questões técnicas, mas também aquelas de cunho sócio-cultural, econômico e ecológico. Os sistemas computacionais, que se tornam cada vez mais pervasivos e indispensáveis, somente servirão aos ideais de uma sociedade mais justa se estiverem disponíveis para todos. Esta tese compartilha com o ideal de sistemas computacionais que atendam cada vez mais usuários, independentemente de suas características físicas, cognitivas, emocionais, ou de necessidades de interação decorrentes de diferentes dispositivos em ambientes de uso diversificados.

Nesse sentido, reforça-se a necessidade de se considerar, durante o processo de design, os requisitos de usuários que tenham habilidades no uso de TICs, bem como os requisitos daqueles que ainda não estão familiarizados com as mesmas; idosos, pessoas com deficiência etc. Espera-se que as idéias aqui apresentadas apóiem designers nas tarefas de identificar as diferentes necessidades e formalizar um comportamento ajustável para os sistemas computacionais, respeitando e reconhecendo a riqueza da heterogeneidade e fomentando o crescimento intelectual de cada usuário.

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