Available online at www.sciencedirect.com
ScienceDirect
Interacting with Computers 19 (2007) 438–456
Interacting with Computers
www.elsevier.com/locate/intcom

Dependable domestic systems design: A socio-technical approach

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Received 1 October 2006; received in revised form 4 May 2007; accepted 10 May 2007
Available online 21 May 2007

Abstract

This paper describes a model that defines the attributes of domestic systems that lead to system dependability and a user-oriented specification method for support systems based on this model. We start by discussing technical dependability models and discuss how these have to be extended for use in a domestic context. We present an extended dependability model based on a socio-technical perspective. This extends the technical notion of dependability to take into account fitness for purpose, acceptability and adaptability. We then go on to discuss MDDS – a questionnaire-based method that reflects the socio-technical dependability model. It is intended for use by social care professionals who are specifying and designing support systems for older or disabled people. MDDS provides a basis for examining a design from a dependability perspective. We illustrate the use of the method and conclude with a discussion of its qualitative evaluation.

Keywords: Socio-technical systems; Domestic computer systems; System dependability; Design method

1. Introduction

Over the past 20 or so years, research in safety–critical control and protection systems has resulted in major advances in our understanding of the factors that lead to and that mitigate against system dependability. However, dependability issues are no longer solely the concern of control system developers – system dependability is now a key issue for almost all computer-based systems. In our work, we aim to extend methods and techniques for designing dependable organizational systems to simpler support systems that are used in the home.

Our research has been concerned with domestic alarm systems and with systems that provide assistance to people who suffer from some disability such as hearing, mobility, motor control, eyesight problems or cognitive impairment. Such systems are sometimes termed 'assistive technologies', although this term is not used in a consistent way across different professional disciplines. To avoid ambiguity, therefore, we use the term Home Support (HS) systems to refer to domestic systems that either sense their environment and inform some agent if problems arise or that provide support for users to carry out the normal activities of everyday life.

Home Support (HS) systems are critical systems because failure of these systems, at best, adversely affects the activities of everyday life of their users and, at worst, can cause real harm to the people that they are supposed to help. As improved medical technology prolongs life and an increasing proportion of the population are elderly, developing effective HS systems is essential to allow elderly people to live in their own home and maintain their quality of life.

In general, HS systems are constructed using off-the-shelf, electronic and mechanical components with, perhaps, some software to integrate different components. For example, if an older person has mobility problems, a system may be constructed that allows them to remotely open their door to allow visitors into their home. Such a system may include a video camera, speaker and microphone posi-

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doi:10.1016/j.intcom.2007.05.002

tioned by their door, a switching facility to allow them to see on their television who their visitor is and a motorized door-opener that can be remotely controlled from anywhere in their home. All of these devices may be integrated through a controlling software system.

The overall goal of our research was to investigate approaches to HS system design that lead to more 'dependable' systems. That is, systems that met some real needs of users and that they could trust to support these needs. Our view of dependability is socio-technical rather than technical. Dependability is not just about the hardware and software operating to specification but is also a reflection of how well the technical system fits into the environment where it is used.

Researchers have investigated the importance of the socio-technical issues in systems design for many years. The earliest work was probably that of Mumford in the 1970s (Mumford and Weir, 1979) but Suchman's seminal book (Suchman, 1987) brought socio-technical issues to the attention of HCI and computer science researchers. Since then, many researchers, particularly from the HCI and CSCW communities have carried out studies to help understand socio-technical environments (Heath and Luff, 1991; Bentley et al., 1992; Heath et al., 1994) and have looked at how to use this knowledge to support software design (Heath et al., 1994; Hughes et al., 1994, 1997; Viller and Sommerville, 1999; Crabtree, 2003; Jirotka and Luff, 2006).

The practical experience of one of the authors in working with older and disabled people using HS systems was that these were often unused because they were inappropriate for their operating environment (Dewsbury et al., 2004b). We wished to examine why unsuitable systems were installed and to develop a new approach that would address some of the problems that we perceived in HS system design.

With this overall goal in mind, we carried out several field studies where we looked at HS technology installed in people's homes and discussed with them how and when it was used (Dewsbury et al., 2004b). These studies showed that the systems usually operated as specified but were undependable in that they did not consistently provide the support required by their users. This was not an issue of usability but rather that the systems interfered with the normal activities of everyday life. The root of the problem was that many HS systems were designed around the disability of the user and did not take into account how these users lived their normal home lives and their wishes and needs for support (Dewsbury et al., 2004a).

We concluded that an extended notion of dependability for domestic systems that includes the user and the systems environment rather than positioning them outside the system boundary was required. When an HS system is installed in a domestic environment, we should not just be concerned with whether or not that system is failure-free insofar as the hardware and software behave as specified. Rather, the overall system dependability also depends on if, when and how that system is used. An HS system that is unusable in a particular context by a particular user or which does not improve the overall quality of life for a user *cannot and should not* be considered to be dependable, even if that system operates without technical failure.

The initial version of the dependability model was published in 2003 (Dewsbury et al., 2003). However, such a model, on its own, is divorced from practical design issues. Therefore, we further developed the model with the goal of discovering how to use it in practice to help with the design of HS systems. Our research objective was to develop a method that was derived from the model that could help social care professionals to design dependable HS systems.

This paper draws together our work on a socio-technical dependability model for HS systems and the associated method for supporting the design of HS systems. In the remainder of this paper, we briefly describe the 'traditional' techno-centric systems dependability model and discuss the weaknesses of that model as far as domestic systems dependability is concerned. We then go on to describe our extended dependability model for domestic systems dependability and discuss how this model has informed the design of MDDS. This is a user-centred method for supporting the specification of dependable HS systems that are intended to provide support for everyday activities. We explain how we have evaluated the MDDS approach and reflect on the strengths and weaknesses of both our model and the MDDS method.

2. Computer system dependability

The dependability of a computer system (software + hardware) reflects the extent that a system can be trusted to operate without failure in a particular environment. Laprie (Laprie, 1995) succinctly sums this up as:

> "Dependability is defined as that property of a computer system such that reliance can justifiably be placed on the service it delivers. The service delivered by a system is its behaviour as it is perceptible by its user(s); a user is another system (human or physical) which interacts with the former".

This view of dependability has been presented and refined in a number of papers by Laprie and his collaborators, with its most recent instantiation in a paper that defines concepts and a taxonomy for dependable and secure computing (Avizienis et al., 2004). Central to this notion of dependability is a dependability model or 'dependability tree' (Fig. 1) which summarizes dependability attributes, the means to achieve system dependability and the impairments to dependability.

Laprie suggests (Laprie, 1995) that dependability can be considered to be an amalgam of a number of different attributes.

- The readiness for usage leads to *availability*.
- The continuity of service leads to *reliability*.