ANALYSIS OF USER-CENTERED FAILURE MECHANISMS IN NEW PRODUCT DEVELOPMENT FOR QUALITY IMPROVEMENT

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ABSTRACT

In the past, quality and reliability measures of products were mainly for technical component performances. However, today's global market conditions led to the realization that the dominating indicator of product quality and reliability is often customer satisfaction. This is justified by the industry where significantly rising numbers of products are being returned or being sought redress, which in fact technically function well according to specifications. Continuous influx of new technology, whilst creating huge opportunities for new product-market combinations, results in high levels of uncertainty about if/how/when users will adopt a product. In order to address such uncertainty, the complete end-user view and reasons for unexpected and dissatisfactory interactions of users with products should be well understood. Accordingly, this study proposes a user-centered failure classification model, to methodically analyze user-centered failure mechanisms. An exploratory analysis of field data provides encouraging preliminary findings about the applicability of this model in reality.

Keywords: user-perceived quality, failure classification, innovative product development

INTRODUCTION

The influx of technology, especially in today's consumer electronics (CE) world, is unprecedented. The digital, multifunctional, and wired/wirelessly networked products give rise to large and dynamically changing state spaces. Managing such complex state spaces of strongly innovative CE products is a challenge for manufacturers. Moreover, this challenge is intensified by the consequences of changing market trends, such as strong pressure on time to market due to competition among manufacturers, increasingly dispersed outsourcing activities and globalization of markets, and increasing customer demands. An implication of these circumstances has been observed in the adaptation of product development processes (PDPs) over the years. The formerly widely-used PDP models, such as the phase-gate model and the concurrent engineering model, have been overtaken by iterative development models that involve overlapping activities and evolving specifications during the process. While fulfilling the obvious needs of the ever more dynamic context, the adoption of iterative development models led to the realization of other concerns. These concerns, largely related to ensuring quality and reliability of products and services, revealed the need for timely and meaningful information flows: (i) internally among development activities (due to the many small feedback loops in iterative PDPs), as well as (ii) directly from the field to the manufacturing company (in order to counteract the technological, industrial, market uncertainties in strongly innovative PDPs).

Prior to the emergence of today's industrial conditions, failures encountered in products were predominantly technical component failures that displayed violations of product specifications (i.e. hard failures). However, the changing trends have resulted in a new class of failures (i.e. soft failures) that occur only due to the violation of explicit or latent user expectations and not the product's formal specifications (Brombacher *et al.*, 2005; Koca *et al.*, 2007). Currently soft failures are not identifiable or manageable through the existing quality and reliability approaches (Ouden *et al., 2006*). The overall aim of this study is to analyze failure mechanisms as experienced by end-users resulting from new product development (NPD), and to eventually help in enhancing the soft reliability of strongly innovative products. This specifically involves (i) *understanding* the reasons for the significantly increasing numbers of returned or reported products that in fact technically function well according to specifications; and then (ii) *developing an all-encompassing failure analysis framework* applicable to test and field failure data. An experiment on real field data provides preliminary findings from the application of the approach we developed.

The paper is organized as follows: The next section provides the setting of the problem domain. Here, the failure mechanism framework in which this research is positioned is introduced. Then the 'failure classification model' section proposes a new user-centered failure classification model. The fourth section presents the preliminary results from the application of the failure classification model on real field data and indicates ongoing activities for the model's validation. The final section concludes the paper.

FAILURE MECHANISM FRAMEWORK

A significant measure of quality and reliability to indicate success in today's competitive market is customer satisfaction. However, despite the concern to also enhance the appeal and usability of strongly innovative CE products, users increasingly seem to experience unpleasant or dissatisfactory interactions with technically sound products. Such unforeseen interactions constitute a large and increasing share of field complaints (Koca *et al.*, 2007), and hence pose a major threat for the imminent future of companies involved in NPD. This threat potentially induces not only loss of money and effort on the manufacturer's behalf, but also an eventual damage to the brand image. Consequently, it is necessary to adopt an expanded view of quality and reliability to include the end-user experience.

'Soft reliability' research complements the missing account of the end-user experience in the quality and reliability context. (Koca *et al.*, 2007) discuss the multidisciplinary nature of soft reliability and propose ways for the industry to better address it, so that the outcome is beneficial: (i) for the manufacturer in that product investments are made in the correct and relevant areas (e.g. not for product functionalities that users do not seem to be interested in), (ii) for the user in that the confusion due to the discrepancy between expectations and real product capabilities is minimized, and (iii) for the impetus of technological innovations (and hence their acceptance by society) in that the convenience offered is perceived as greater than its burdens.

There are three main drivers of today's NPD projects (i.e. technology, market, profitability) that are especially relevant for the rising amounts of soft failures. The first driver is *technology*. This driver contributes to the numbers of soft failures due to the complexity stemming from digital electronics commonly found embedded in multifunctional devices (vs. earlier systems based on mechanical and/or electrical mechanisms); wired or wirelessly networked devices that provide grounds for interoperability (vs. earlier systems designed to be more 'stand-alone'); and remote access to digital content that also involves security/privacy management issues. The second driver is the *market*. The occurrence of soft failures are fuelled by the pressures within the current market situation, such as poorer information flows among dispersed international business units; more competitors to take into account (e.g. rivalry between local and global brands for lower prices and longer warranties); more diverse and demanding customer requirements; and pressure on time to market yielding less time to develop and test products before commercial market launch. The third driver is *profitability*. It is managed through organizational decisions made to level out the influx of technology and the market demands in a way that will allow the manufacturer to profit the most (i.e. by ignoring less profitable improvement scenarios) from individual projects in the short term and for brand reputation in the long term. Consequently, the conflict between these three drivers is a difficult one to optimally manage and often leads to quality and reliability issues (e.g. failures) that should be analyzed methodically.

Failure mechanisms are of interest to both researchers and practitioners in many domains, as they provide means to better understand the limitations of current systems, to indicate the relevant directions for improvement, and ultimately to enhance the overall quality through taking corrective or preventive measures. For the outlined domain of this work, a first step is to devise an abstraction of a failure mechanism that is able to address also the user-centered failures, or so-called soft failures. In view of this, we adopted and augmented the software failure mechanism presented in (British Standard 5760-8: 1998). The resulting framework is depicted in Figure 1, and is traced in what follows.

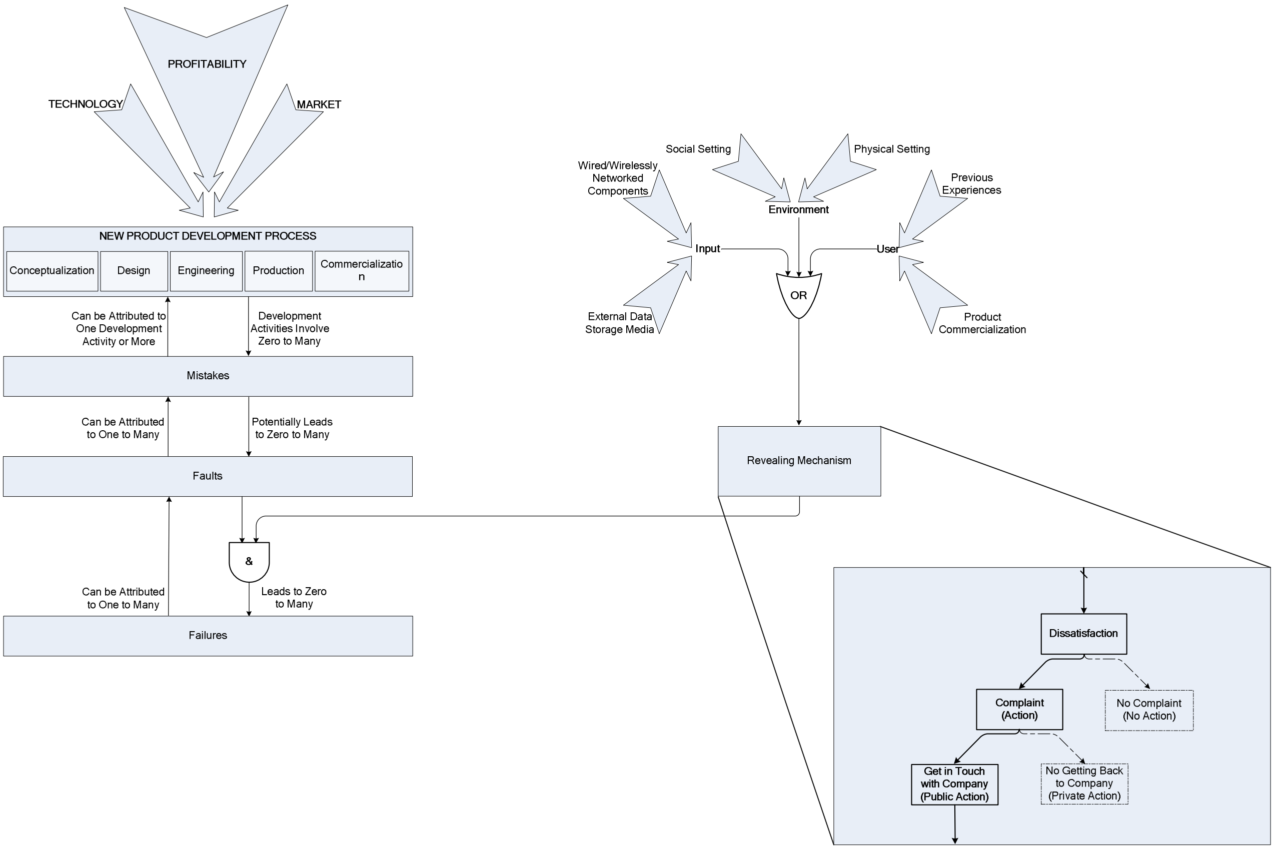

***Figure 1** Failure mechanism framework in NPD*

Commonly, NPD projects comprise the following main (relatively overlapping) activities: Conceptualization, design, engineering, and commercialization. Due to the conflict of the three aforementioned drivers (cf. top left side of Figure 1), these activities are highly prone to introducing mistakes in the development of new products. From the soft reliability viewpoint, a *mistake* could be, for example, failing to take into account the regional/cultural characteristics of a particular user group by missing out tests with real users from that region (where the product is also marketed) due to the time-to-market pressure. This could potentially lead to some product design *faults*: E.g., as a safeguard against fluctuating voltage, some users turn the power off when a product is not in use, which requires them to go through tedious set-up operations on every power on, because designers assumed that the device would customarily be left on stand-by mode when not in use by neglecting the fact that voltage is not stable in all countries. Such faults, dissatisfying for a certain population of users, get revealed in the field in the form of *failures* and, depending on the consumer complaint behavior (CCB), may get reported back to the manufacturer. All cases that are reported back to the manufacturer are referred to as *failure*s, regardless of whether or not the field-call leads to a product return. This is the natural 'downstream' flow of a failure occurrence. Note that the history that leads to its occurrence is typically latent at the time it is reported to the manufacturer. Figure 1 also shows the more forced 'upstream' flow of information from the failure back to its origin within the NPD activities. In order to maximize the benefits of getting insights from field failures of strongly innovative products, this upstream flow needs to comprise timely and meaningful information. This information should ultimately be linked with the corresponding activities that initially introduced the underlying mistakes, in order to efficiently make the necessary improvements. Making the upstream part of the loop systematic requires zooming in on the 'failures', 'faults' and 'mistakes' boxes in Figure 1 to discern the explicit types (i.e. finding out about the history of a failure that led to its occurrence), and hence to develop a classification model that encompasses these types in a way that is generic, unambiguous and practicable. This is the topic of the next section, 'failure classification model'.

It should be noted that the failure mechanism framework presented in Figure 1 is applicable not only to *field* feedback situations, but also to *test* feedback situations prior to market launch of a product. Consequently, the generic nature of this framework supports both *corrective* and *preventive* actions, respectively, that can be taken against failures. This paper, which focuses explicitly on soft failures, undertakes the analysis of the corrective approach. This is believed to be the initial stepping stone, because it provides more opportunity to reveal the coverage and contents (as experienced in reality) of this relatively new class of failures through the analysis of abundant field data. Conversely, test data is typically not as abundant, but it also has great potential to contribute valuable information to soft reliability research due to its richer context information (i.e. failure mode information involving the user, the product, and the environment).

The failure *revealing mechanism* consists of any combination of triggering factors (cf. top right side of Figure 1) together with the individual complaining behavior of users (cf. bottom right side of Figure 1). Depending on whether the product is a derivative of an existing product or a really new product, the *user* already has or newly forms a mental model of it. In the former case, the user forms this mental model based on previous experiences with similar products. In the latter case, since there are no previous experiences to refer to, the user is predictably influenced by the way the product is positioned and commercialized in the market. Either way, any discrepancies between the actual product and the user's mental model of it are potential sources of soft failures. The *environment* is another triggering factor. The physical setting involves all kinds of physical conditions of the place the product is being operated in. The possible effects range from the long since recognized effects of temperature, humidity, etc. on the performance of a product, to the specific physical location with respect to other products that may interfere with the product's full performance. The effects of the social setting come into play mainly in the context of multi-user systems. Accordingly, a product designed for use in a small office environment may generate dissatisfaction in responding to the demands of a more crowded workplace. Likewise, a heavily-used copier by an experienced operator at a copier shop will probably generate fewer problems than a heavily-used copier by many different inexperienced operators at a public library. The last triggering factor, *input*, implies possible incompatibility issues with other systems that are (wired/wirelessly) networked to the product, or with external data storage media (e.g. CD, DVD, USB memory stick). When such an incompatibility is due to a specifications violation, it is a typical instance of a hard failure case. Otherwise, it is a specifications omission, and hence a soft failure case.

The customized abstraction presented in Figure 1 serves as a blueprint for the resulting user-centered failure classification model that is discussed hereafter.

FAILURE CLASSIFICATION MODEL

The forced 'upstream' flow of failure information to the related NPD activities has been introduced in the failure mechanism framework. This flow, triggered by the *revealing mechanism*, first points to the *failures*, each of which can then be attributed to the underlying *faults*. In order to identify the kinds of failures and their respective underlying faults for the purposes delineated earlier, we developed a failure classification model based on real case studies (e.g. Koca *et al.*, 2007) and supporting literature. The resulting model from this iterative development process, depicted in Figure 2, takes the failure mechanism framework as a basis, and further specifies the contents of the *failures* and *faults* components of it. Moreover, to provide a more complete user-centric view, it also covers the link to the *consumer complaint/appraisal behavior*. It should be noted that the dashed lines in the model indicate the parts that lie outside the scope of this work. The reasons for these exclusions are explained in the descriptions of the relevant parts.

Consumer complaint/appraisal behavior

The consumer complaint/appraisal behavior part of our model starts with the *acquisition* of a product (or intention to do so), for which the initial "phases of use" described by (Bouwmeester and Bosma, 2006) is of high importance. The successful communication of a product to its (potential) users is quite influential in forming a mental model of it: E.g., commercial product exposure, creating user awareness for the (many) features and functions the product has, and making these functions appealing and intuitive for the user in order to motivate use. Based on the success of this communication, the users will either be satisfied or not. If *satisfaction* is to an extent of only meeting customary user expectations, then the user is likely to take no action. However, if the satisfaction is to the extreme of creating a 'wow-factor' as in the three-arrow model of (Kano *et al.*, 1994), the user may like to share this privately among friends and family, or publicly by getting in touch with the company to express his/her contentment. *Dissatisfaction*, which is often a sum of various negative experiences, can be viewed in a similar way. If the sum of negative experiences is below the 'action level', the user is likely to take no action. However, if it exceeds that level, the user is likely to undertake action to make his/her discontent known to others. Such action is private if it is in the form of spreading bad word of mouth, warning friends and family, deciding to stop buying the product or boycotting the product, and is public if it is in the form of getting in touch with the company to remedy the discontentment. The part of this model stemming from dissatisfaction complies with the work of (Day and Landon, 1977), which is widely accepted in the CCB literature. The dashed lines in the consumer complaint/appraisal behavior part of our model indicate where it is typically difficult to collect reliable data (i.e. concerning *private action*s or *no action*s taken in cases of both satisfaction and dissatisfaction) from the field. A possible source to extract such information is user tests.

Our model identifies four cases when a (potential) user gets in touch with the company. In these cases, users contact either one of the manufacturer's call centers, repair centers, dealers, or World Wide Web customer support sites, (i) to express appreciation, (ii) to remedy a product failure, (iii) to remedy marketing, sales, services related failures, (iv) to return a product that has not been used. Although the fourth case contributes to the number of 'product returns', the model highlights that such cases are not due to any failures on behalf of the manufacturer, but that they are rather due to wrongly purchased products. The coverage of our model is intended to demarcate and to emphasize the scope of our work regarding soft failures, with respect to the general picture.

Product failures & marketing, sales, services failures

A CE company offers products and related services to its customers. Therefore, failures happen along these two main lines. *Product failure*s consist of hard and soft failures. *Hard failure*s (i.e.

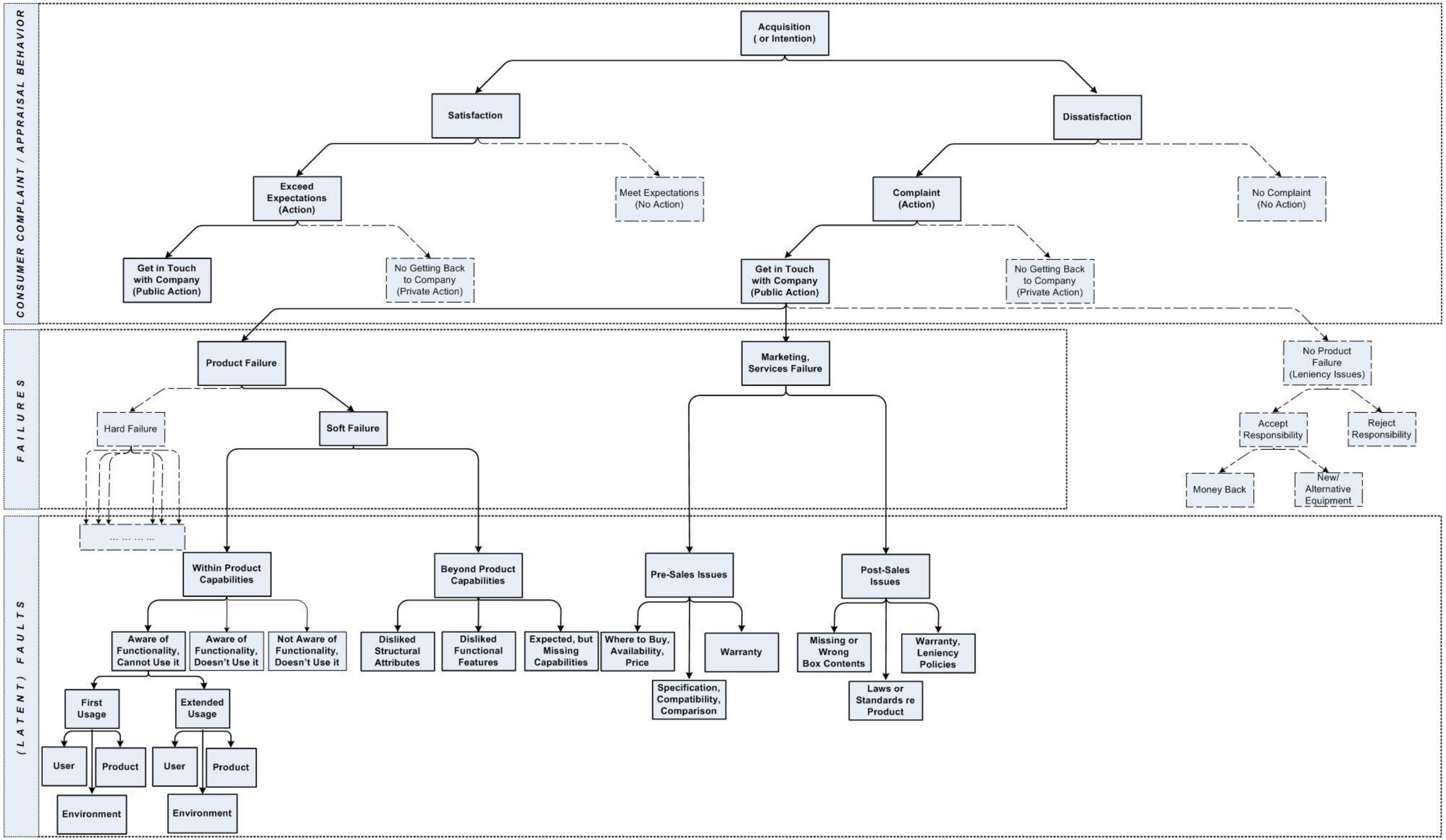

Figure 2 *User-centered failure classification model*

failures that require the intervention of authorized technical support for recovery by means of repair or replacement of parts) are generally classified in accordance with the existing IRIS (a.k.a. International Repair Information System) coding system or a similar coding scheme, which lie outside the scope of this work (IRIS, 2007). Therefore, our model does not go deeper into the classes of hard failures, hence the dashed lines. We propose a deeper classification of *soft failure*s (i.e. failures that necessitate professional intervention for recovery -but not repair- by means of information or instructions), as an attempt to fill in the gap for a means of identifying the various reasons for their occurrence. *Marketing, sales, services failure*s consist of pre- and post-sales issues. *Pre-sales issues* are commonly encountered at call centers, where potential buyers contact to find out about product availability, price, specifications, compatibility, and warranty related issues. These queries generally indicate weaknesses of information broadcast channels, such as Internet, television, radio, printed media advertisement, shop-floor guidance, and packaging (e.g. product-box graphics). *Post-sales issues* are generally observed to fall into three categories. Firstly, it may be that the product's box turns out to have the wrong or missing contents, which could be caused by the dealer (e.g. mix up of accessories on the shop floor) or the manufacturer (e.g. production line error). Secondly, it may be that the user runs into an unexpected state of interaction, only later to find out that the product is subject to (unchangeable) laws or standards that the user was not made aware of at the time of purchase (e.g. copyright issues for recording digital content, region codes for playing digital content). Thirdly, it may be that the warranty schemas, related company policies and services are not transparent for the users. Therefore, they put extra effort in trying to find out about the missing information by getting in touch with the company. Also, services related discontentment cases fall under this category, since they relate to the weakness of leniency policies.

Soft failures

Soft failures are first classified at the product-level, and then at the user-level, in order to ensure the objectivity of our approach. The product-level classification makes a distinction between two main types of soft reliability problems: The problems that can be resolved *within* the capabilities of the product by providing supporting guidance and instructions; versus the problems due to users' expectations that are *beyond* what the product is capable of, and hence can only be addressed by providing (the missing) information to the user in order to compensate for the discrepancy. This distinction corresponds to errors of omission and errors of commission as referred to by (Krippendorff, 1989), in that order. Problems that are resolvable *within product capabilities* are due to three user-level reasons: (i) the user is aware of a (potential) functionality, but does not know how to correctly operate it (e.g. usability or learnability issues), (ii) the user is aware of a functionality, but does not prefer to use it (i.e. due to lack of motivation), (iii) the user is not aware of the existence of a functionality, and therefore does not use it (e.g. the pull or exposure of the functionality is failing). The latter two classes are lightly bordered in the model, to indicate that they are not readily retrievable from the field, but more from user tests. Problems that are *beyond product capabilities* are also due to three user-level reasons: (i) the user is displeased with the quality of a (static) structural attribute of the product (e.g. fan noise level, response speed, luminosity level, ergonomics design), (ii) the user is displeased with having to go through a procedure anew every time, in order to reach a 'goal' (e.g. having to go through tedious set-up operations every time the product is turned on, just because the product was not designed to be switched off overnight), (iii) the user expects to achieve a 'goal', which is not possible within the capabilities of the product (i.e. specifications omissions: a functionality expected by the user is completely missing in the product). Both sets of user-level reasons are derived from phases of use (Bouwmeester and Bosma, 2006), and supported by related literature (Han *et al.* 2001; Blandford *et al.*, 2003).

During the iterative development of our model, we observed that the case where a user is aware of a (potential) functionality, but does not know how to correctly operate it, is quite common.

Therefore, we further specified this class into *first-* and *extended usage* of a functionality. This distinction deliberately does not take the lifetime of the product as basis, but instead, the lifetime of the functionality (i.e. whether the functionality has ever worked fine before or not). This is motivated by the fact that the various functionalities of strongly innovative products are typically progressively used along the lifetime of the product, and hence some functionality may never have been used until after several months. Finally, both first- and extended usage classes are further grouped into those soft failures that require a change in either one of the following for recovery: (i) the *user*, i.e., by remedying the learnability or usability overhead, (ii) the *environment*, i.e. by adjusting the physical place of the product or the devices it connects to, (iii) the *product*, e.g., by doing a software upgrade, resetting, or restarting. All these subclasses have been formulated based on knowledge from usability design related literature (Bloch, 1995; Bly, *et al.*, 2006; Palen and Salzman, 2002; Venkatesh *et al.*, 2003).

THE EXPERIMENT: FAILURES REPORTED TO CALL CENTERS

We conducted an exploratory failure classification experiment on field data collected by call centers of a multinational high-volume CE company. With the main objective of evaluating the applicability of our failure classification model on call center data, we also compared soft reliability of more innovative CE products versus less innovative ones. The comparison aims to demonstrate the correlation between the innovativeness levels of CE products, and the distribution of the types of soft failures over them.

Data sets

Two data sets were analyzed. Both sets consist of calls from the Netherlands, collected over the same three-month period. The first data set consists of 1683 calls about four strongly innovative product families that, on the whole, are highly networked to their environment, allow for wireless streaming of digital content, and are multifunctional. The second data set consists of 2006 calls about three relatively less innovative product families that are more stand-alone, that do not allow for wireless connectivity, and that are comparatively less multi-functional. All product families were selected based on their observed and expected tendency to generate soft failures in the field.

Classification results and discussion

The classification was done manually, based on the free-text summaries of calls logged by the call center agents. Since not all calls had consistent information about ‘repeated’ failure cases, it was not always possible to discern between first- and extended usage classes. Therefore, to preserve consistency in our analysis, we excluded these classes from this experiment, and used a simpler version of our model as shown in the below figures. The results of our preliminary classifications are depicted in Figure 3 and Figure 4.

As seen from Figure 3 and Figure 4, in both data sets the majority of failures fell under the category of soft failure. All soft failure cases classified have been observed to be temporarily resolved by the user with guidance or information from the call center agent. However, such instance-based remedial (i.e. *corrective*) actions are not helpful in essence to *prevent* soft failures from happening. Therefore, the soft failures classification proposed here is expected to identify the weaker soft reliability aspects of products that need attention from the product development team while improving future generation products.

The comparison of the classification results of the two data sets reveals that the amount of soft failures in strongly innovative CE products is significantly (i.e. 18%) more than in less innovative CE products. Specifically, users of strongly innovative products calling call centers generally experience product and user related usability problems, whereas users of less innovative products call mostly due to product-repair related issues.

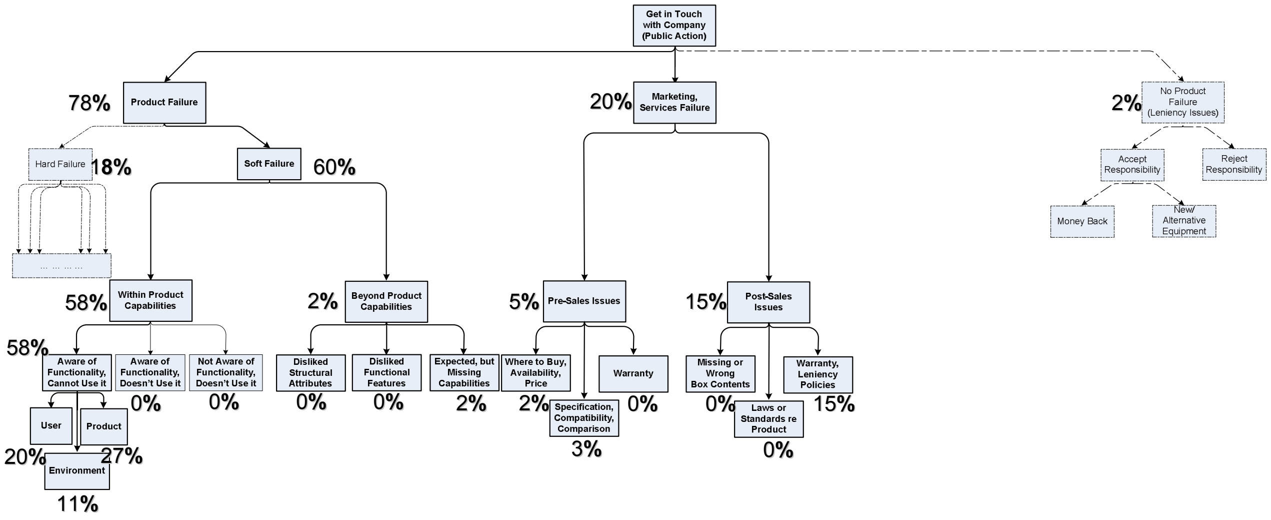

Figure 3 Failure distributions of strongly innovative CE products

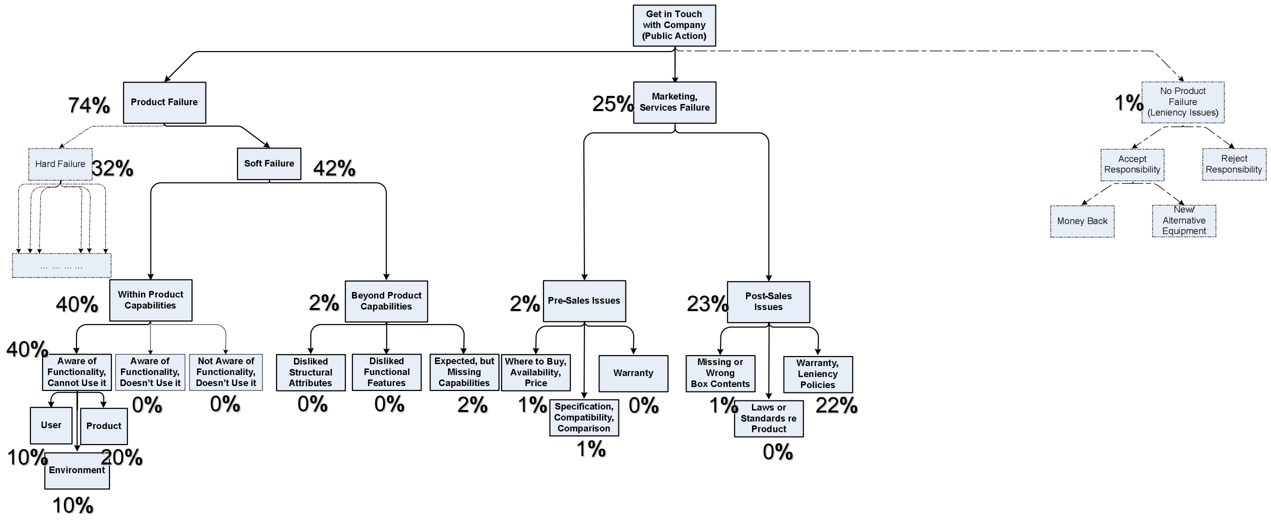

Figure 4 Failure distributions of less innovative CE products

This preliminary experiment is a pioneer of a series of our model validation activities. Currently, we are in the process of conducting large-scale and long-term structured experiments to internally and externally validate our classification model. Initial internal validation activities involve, on the one hand, the face validity assessment in collaboration with the experienced industrial partners of our research and, on the other hand, involve inter-rater agreement calculations to assess the model's interpretive reliability. Moreover, the precision and recall rate of the model will be assessed, based on the results of the ongoing experiments, and any redundant classes will thereby be identified. External validation activities involve classification experiments with real data from various sources (e.g. call center, repair center, test, Internet forums), on products with different degrees of innovativeness, from various countries, over a fixed time period (i.e. for longitudinal study purposes). Future experiments include testing our model across a selection of (strongly innovative digital electronics) industries, and across companies in the same industry. These experiments are expected to ensure the generalizability of our failure classification framework.

CONCLUSION

In this study we first discussed the recent changes in today's CE world, which surfaced the urgent need for an expanded view of quality and reliability to also explicitly and methodically cover soft reliability. Then we presented a failure mechanism framework in NPD. This framework served as a basis for delineating the scope of this research about user-centric failure classification. The main contribution of our research is the outcome of an iterative development process of a user-centered failure classification model. With this model, we proposed a new approach to identify specifically soft failures, based on case studies and supporting literature. We then tested the applicability of this classification model through an experiment with real field data, which produced encouraging results. Our preliminary findings from this field data analysis also include a comparison of failure distributions of strongly innovative versus less innovative CE products. Finally we briefly reported on our various ongoing activities for model validation.

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REFERENCES

Blandford, A., Thimbleby, H. and Bryan-Kinns, N. (2003), "Understanding Interaction Traps". In *Proceedings of 17th Annual Human-Computer Interaction Conference,* Bath, UK, Vol.2, pp. 57-60.

Bloch, P.H. (1995) "Seeking the Ideal Form: Product Design and Consumer Response". *Journal of Marketing*, Vol.59, No.3, pp. 16-29.

Bly, S., Schilit, B., McDonald, D.W., Rosario, B. and Saint-Hilarie, Y. (2006), "Broken Expectations in the Digital Home". In *Proceedings of CHI 2006 Extended Abstracts on Human Factors in Computing Systems*, Quebec, Canada, pp. 568-573.

Bouwmeester, K. den and Bosma, E. (2006), "Phases of Use: A Means to Identify Factors that Influence Product Utilization". In *Proceedings of CHI 2006 Extended Abstracts on Human Factors in Computing Systems*, Quebec, Canada, pp. 117-122.

British Standard 5760-8: 1998 (1998), "Reliability of Systems, Equipment and Components. Guide to Assessment of Reliability of Systems Containing Software". BSI London, UK, pp. 5.

Brombacher, A.C., Sander, P.C., Sonnemans, P.J.M. and Rouvroye, J.L. (2005), "Managing Product Reliability in Business Processes 'Under Pressure'". *Reliability Engineering & System Safety*, Vol.88, No.2, pp. 137-146.

Day, R.L. and Landon, E.L. Jr. (1977), "Toward a Theory of Consumer Complaining Behavior". In Woodside, A. G., Sheth, J. and Bennett, P. (Eds.), *Consumer and Industrial Buying Behavior,* Elsevier North-Holland Inc., Amsterdam, pp. 425-437.

Han, S.H., Yun, M.H., Kwahk, J. and Hong, S.W. (2001), "Usability of Consumer Electronic Products". *International Journal of Industrial Ergonomics,* Vol.28, No.3-4, pp. 143-151.

IRIS coding, URL: http://www.eicta.org/index.php?id=37. Latest access: April 2007.

Kano, N., Seraku, N., Takashi, F. and Tsuji, S. (1994), "Attractive Quality and Must-Be Quality". *The Journal of Japanese Society for Quality Control*, Vol.14, No.2, pp. 39-48.

Koca, A., Schouwenaar, A.J.M. and Brombacher, A.C. (2007), "Field-Feedback in Innovative Product Development: A Comparison of Two Industrial Approaches". In *Proceedings of 14th International Product Development Management Conference*, Porto, Portugal, [*to appear*].

Krippendorff, K. (1989), "On the Essential Contexts of Artifacts or on the Proposition That 'Design is Making Sense (Of Things)'". *Design Issues*, Vol.5, No.2, pp. 9-39.

Ouden, E. den, Lu, Y. and Brombacher, A.C. (2006), "Consumer Oriented Product Quality: Why Available Approaches are No Longer Sufficient". *Journal of Product Innovation Management*, [*accepted*].

Palen, L. and Salzman, M. (2002), "Beyond the Handset: Designing for Wireless Communication Usability". *ACM Transactions on Computer-Human Interaction*, Vol.9, No.2, pp. 125-151.

Venkatesh, V., Morris, M.G., Davis, G.B. and Davis, F.D. (2003), "User Acceptance of Information Technology: Toward a Unified View". *MIS Quarterly*, Vol.27, No.3, pp. 425-478.