What if „business process“ is the wrong metaphor? Exploring the potential of Value Based Requirements Engineering for clinical software

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Abstract

Enduring low satisfaction of clinical users with their software systems suggests to challenge the basic assumptions of clinical software. A novel approach from Software Engineering is introduced which focuses on values rather than on processes. It is argued that value inventories of clinical users can and should be tried as a valuable asset from which to derive software requirements and designs. The article presents the basic findings from the social sciences which justify the approach and a road map for an empirical exploration.

Keywords: *clinical software; value based requirements enginering*

Introduction

Medical informatics is as informatics ([1] for a seminal early report). Software for clinical purposes has existed as long as software for banking, travel and transport, etc. After years of straightforward programming principles software engineering emerged and modeling languages and development methods came into use that guided a more principled industrial production of software. The Unified Modeling Language[1] collects the most typical software system models while business process modeling languages such as EPC [2] or BPMN[2] are used to describe how an organization or individual actors perform their software-supported work. These models assume that an organization enacts processes and assigns roles to employees. They take the physician captive of an overwhelming machinery to whose functioning he/she has no choice but to contribute a transaction here and there.

Major software vendors for the medical industry have enacted an equal role for physicians. SAP e.g. has created a medical variant of their R2/3 general purpose business process software, assuming that curing patients is a business process like transfering money or allocating cargo. GE merged various providers with some hospital background (such as IDX), most of it, however, in imaging or billing/revenue cycle.

While this has been the reality on a large scale of hospitals being equipped with software a community on Organisational and Social Aspects emerged within Medical Informatics (IMIA WG). It has enhanced Medical Informatics in aspects such as human computer interface, change management, expectation management, safety etc. In a programmatic paper Berg also identifies the risks of “attempt(s) to structure this work through the formal, standardized and 'rational' nature of IT systems” but does not offer an alternative. The WG itself still focuses on “Workflow - The Grand, and Grander, Challenge” [3]. And still, physicians are not satisfied with their software. Rigorous investigations are scarce. Research may be blurred through convenience samples of physicians ([3]), or presentation of results may be blurred through satisfaction ratings based on physicians’ convenience selections of software functions they like ([4]). Therefore, it seems to be timely to challenge the basic “business process” metaphor of clinical software and to search for alternatives.

Also within the software engineering community it has been emphasized that software project failures are often due to value-orientation shortfalls and that value-neutral approaches are an insufficient bases for an engineering discipline [5]. Therefore the term “value-based software engineering” has been coined [5] [6] and an agenda was put forward to explicate and utilize business and stakeholder values throught software engineering. This includes methods for value elicitation during requirements engineering, as well as the methods for the alignment of architecture, design, verification and validation, project, people and risk management with these values.

First investigations in the area of value-based requirements engineering have been made [7]. However, they have focussed mainly on the business value, which means that top down implemented values of the organization reign; or external shareholder values. Thus, currently there are no approaches for value-based software engineering focusing on the values of the individuals. And if the top down installed values don’t assign curing patients a central role the physician is almost inevitably at odds with these values. Therefore, we are advo-

[1] http://www.uml.org/
[2] http://www.bpmn.org/

[3] http://imia.org/, Working and Special Interest Group "Organisational and Social Issues”

cating a bottom up approach starting from physicians' personal values.

Approach

This is not an article about having applied value based requirements engineering. It rather wants to make the case that it is possible to try and that is worth trying. Because if it succeeds it suggests to deliver longer lasting results than traditionally manufactured software.

"Value" in Common and Specialty Language

In common language the word "value" has a variety of meanings which share the property of being positive about the entity whose value we speak about.

Several specialty languages have assigned more precise meanings to the term "value" a few of which will be introduced subsequently to substantiate the claim that "value" is a sufficiently specified entity to build a software theory upon, like "business process" has been taken for granted for two decades to be a sufficiently specified entity. Among the disciplines that contribute to the concept we concentrate on the empirical social sciences and on organizational psychology.

In a survey that tries to bridge these two perspectives Meligno and Ravlin introduce needs, personality types, motivations, goals, utilities, attitudes, interests, and nonexistent mental entities as possible meanings of the term value [8]. Some of these are more internal to the individual while others relate to the individual's environment of living.

Abstraction Levels of "Value"

According to our orientation towards individual or personal value inventories we will present conceptualizations of value in an inside out manner, starting with those that are most deeply rooted with the personality and ending with those that mutually relate the individual and his/her (work) environment.

Research on "fundamental values" by [9] reveals an astounding international consistency in terms of very basic orientations that individuals from very diverse cultural and educational backgrounds have in common. Schwartz comes up with a small catalog of fundamental values (power, achievement, hedonism, stimulation, self direction, universalism, benevolence, tradition, conformity, security). His empirical research in 200 population samples in over 60 nations demonstrates that an individual is highly likely to answer questionnaire items in such a way that one of the above directions – or two neighboring ones – clearly outweigh all other direction. If imagining the above directions as segments of a circle individuals will find themselves in one or at most two neighbouring segments.

This has been established over the years of fine-tuning respective questionnaires by starting with a key sentence that characterizes a direction and a set of questions or assertions for each of these directions. For the example of "benevolence" the key sentence is "preservation and the enhancement of the welfare of people with whom one is in frequent personal contact". An assertion that a benevolent individual is likely to acclaim to reads "He always wants to help the people who are close to him. It's very important to him to care for the people he knows and likes". In contrast, the respective assertion for universalism reads "He thinks it is important that every person in the word should be treated equally. He wants justice for everybody, even for people he doesn't know."

Benevolence and universalism share what Schwartz has called "self transcendence". They are in opposition to fundamental values such as "achievement" or "power" which Schwartz has comprised under "self enhancement". A large volume of evidence supports the naturally emerging assumption that an individual cannot be both self transcendent and self enhancing.

For practical purposes this conceptualization and related questionnaires can be used to "diagnose" individuals as to their prevailing value dimensions. A limitation of this practical approach for the context of value based requirements engineering is that both, names of dimensions and questionnaire items, are virtually unrelated to professional behaviors and software utilization. Nevertheless they may form a backbone against which more concrete probings for behavior and work related value manifestations can be validated.

Meglino contrasts fundamental values – terminal values in his terminology – with "instrumental values" or modes of behavior such as honesty, helpfulness. Terminal and instrumental values have in common that they reside in the individual under investigation and that they can be probed for without contexts. Of course, values inherent in the individual give rise to behaviors and attitudes towards objects and situations in a work environment; this aspect will be treated below. But as was the case with fundamental values as a kind of calibration backbone for instrumental values, instrumental values can be probed to achieve a calibration background which allows to consistently interpret behavioral or emotional reactions to work situations, among them software utilization situations. Concretely, an individual that is diagnosed as benevolent in the fundamental values questionnaires is likely to affirm behavior patterns of the helpfulness segment and will react positively to work or other situations where he/she can support individuals in need and to software features that support him to provide help. In contrast, if seeking power is an individual's prevailing fundamental value, he/she will affirm behavior patterns that add to his/her power and like situations and software that can contribute to that fundamental orientation.

Evidence that values are a stable part of a person's mental inventory comes from different sides. With twins reared apart Keller showed about the extent of variation concerning workplace behavior that 40% of the variation could be attributed to genetic factors [10]. Rokeach reports that in large communities values remain stable over long periods of time [11]. This is not really a surprise for two reasons: 1. societies teach their values to new generations in an absolute all or nothing manner which deeply roots them in personality [12]. 2. for values to be modified rational arguments may be insufficient; rather is emotional self dissatisfaction required [11].

"Attitudes": When values hit reality

While "value" means an internal trait of its holder "attitude" handles the relation of an internal trait to an external entity ([13]). This relation is conceptualized as a past judgment that is recalled from memory, triggered through a new similar encounter. New observations are compared with memorized information. In case of mismatch a modified judgment may be stored as the new attitude. In such a model different aspects can be experimentally modified and measured: the objects presented for encounter, the degree of mismatch between memorized and new, the trust into the judgment of mismatch etc.

The objects about which judgments are maintained are virtually unlimited. They can be physical objects, places, persons, conjectures, but also work tools and specifically software tools. Albarracin's [13] research goes into the detail of having, maintaining, and modifying attitudes. They take a values background as granted. Therefore, the question remains how and to what extent values and attitudes can be linked.

Consistent Personality – The Cognitive Dissonance Theory

Arguments and experimental results to this end come from a different branch in the social sciences. A theory has been developed and supported through numerous experiments that an individual cannot maintain a highly controversial inventory of "propositions" over an extended period of time. Feininger's theory of cognitive dissonance implies that an individual will sort out controversial propositions and keep maintaining a set within which the degree of controversy is small ([14]).

It can be assumed that a conjecture of "cognitive consonance" applies to fundamental values, instrumental values, and attitudes. In our approach it is used as a justification for the calibration mentioned above: it allows us to hypothesize that questionnaire results of one individual in the domains of fundamental values, instrumental values, and attitudes towards situations and software tools are somewhat in accordance. A person with fundamental value *benevolence* is likely to have *helpfulness* as a highly ranging instrumental values and positive attitudes towards situations where help is needed. An individual with fundamental value *power* and instrumental value *implementation* will have negative attitudes towards situations where help is needed. For the purpose of our project the presumably high correlation between different aspects or levels of abstraction of "value" has to be verified first. If it is supported experimentally it gives us the opportunity to choose from a variety of ways to probe our individuals. Value questionnaires on every level of abstraction will deliver the basic direction of values an individual adheres to.

Personal Values and Organisational Culture

When studying the feasibility of value based requirements engineering for software intended for the clinical workplace the question of interaction of individuals' values with organizational culture seems to be an important aspect. Many investigations address that interaction, also because rational goal directed handling of individuals' values for the purpose of better organizational performance seems to be a management opportunity. [8] surveys research where both influence of individuals' values on organizational culture and influence of organizational culture on individuals' values have been studied. The results are as divers as the investigations. A few examples from this and other investigations will demonstrate that high variability. Judge finds that for job applicants it is more likely to accept a job if they sense fit between their and the organization's values [15]. O'Reilly finds that fit of individual and organizational values positively predicts satisfaction and commitment and negatively predicts turnover [16]. Sheridan develops this into the questionable position to establish such an organizational culture where highly performing employees feel compelled to stay and badly performing employees feel compelled to leave [17].

All these findings mark a somewhat defensive position: rather than really believing and being able to modify individuals' values, organizations may believe that they are able to staff themselves with individuals whose existing value inventory fits their organization's existing value inventory. Other investigations show that not even this may guarantee improved performance. Polzer finds that identification with the organization – presumably a performance enhancing value – may be adverse when employees have to cooperate beyond the limits of an organization [18]. Wetter ([19]) and Shortell ([20]) find in different clinical settings that quality oriented employees' personal value systems do not correlate with enterprise outcomes.

Diversity within teams has also been analyzed as a factor for team cohesion and performance. A survey by Webber does not succeed with identifying widely valid influences of diversity on cohesion and performance [22]. The somewhat more detailed look taken by a Harrison finds that surface level diversity (age, sex, race) diminishes group performance and cohesion in the beginning [23]. However, these effects fade and deep level diversity factors such as job satisfaction, general satisfaction and other more fundamental determinants gain effect. Precisely, groups that differ in such deep level factors have reduced cohesion and performance. Jackson adds a medium level of diversity which may be important for the clinical workplace with its different professional groups having to cooperate closely. He finds that when groups differ in education and function (median level) and also in demographic variables (surface level) cohesion is at risk [24].

Value Inventories Found in Clinicians

Some research tries to unveil typical value inventories of clinicians. One well documented example has it that a majority of anaesthetists follow the professional stereotypes of either professional artist or good Samatarian. The former will typically find it most important to optimally control patients' vital signs. The latter will find it most important to give the patient a feeling of being taken good care of. It appears plausible but has to be checked that the professional stereotype of *professional artist* coincides with the fundamental value of *achievement*, and likewise for the *good Samatarian* with *benevolence*.

Investigations about nurses' value inventories deliver different but equally circumscribed results. [31] e.g. finds that operating theater nurses subscribe to a role of emotional hostess. They like to moderate and to make the operating theater an agreeable workplace for the surgeons. They explicitly state that managing emotions is labor and a factor of productivity in stressful work places. A similar attitude of holding oneself available upon need has also been found with some anaesthetists ([27]), but with a more organizational and less emotional perspective.

These and other investigations demonstrate a certain amount of variation between different clinicians. Nevertheless, there are prevailing directions in both fundamental values and more concrete levels such as instrumental values or role stereotypes. When probing a wider more representative collection of clinicians this variation is likely to increase. Of course, variation poses a challenge for the subsequent steps of formulating software requirements that fit this variety. But this challenge must be faced and possibly software may have to come in different variants for users with different value inventories.

This challenge is smaller than the one of using organizational culture and its relation to individual values, because knowledge about this is preliminary, controversial and hard to interpret. If we know the personal values of users or user subgroups we can assume them to be rather stable ([10]). Their consistency and longevity make them form a fixed target for software development and a valid anchor point for a new software paradigm in medicine. In contrast, processes are subject to permanent changes driven through changes within an organization and changes imposed from outside (billing, legal etc.).

Finding out about Personal Value Inventories

So far, we have taken the stance that individuals' values on different levels of abstraction and can be determined somehow. Indeed, a variety of methods has been developed in parallel to the theory. To assess whether they can be used as is or need modifications – or whether new methods need to be a developed – existing methods will be tested in our setting.

Methods range from genuinely qualitative ethnographic or phenomenonographic assumption free interpretations of open interviews to fully standardized questionnaires. In the phase of establishing and mutually calibrating our levels of abstraction of "value" we ought to be prepared to "reach the parts other methods cannot reach" ([25]). In series of articles in the BMJ the case has been made for the virtues of exploratory qualitative research as valid complement of quantitative affirmative research. Value based requirements engineering with values denoting individual values rather than organizational values such as mission or shareholder value is new in many respects. Therefore, we should aim at "discovering the meanings seen by those who are being researched and with understanding that view of the world rather than that of the researcher" ([26]). Such qualitative methods have e.g. been applied by [27] with anaesthetists and [28] with general practitioners.

While open qualitative explorations are intended to make sure that we don't miss aspects of clinicians' value systems, highly standardized methods such as standardized questionnaires play a different role later in the project: They can be applied somewhat mechanically by staff without specific qualifications in the humanities. For our approach to become a method we have to deliver "recipes" that can be "cooked" by software engineers. Standardized questionnaires or card sort techniques have been used in general populations ([9]), general and medical organizations ([16],[20]) and with clinicians ([29]).

In order to bridge between initial exploratory qualitative and final affirmative standardized methods and to substantiate the calibration and the consistent personality assumption intermediaries will also be used. By intermediary we mean partially standardized interviews as for instance in ([21],[30].[31]) which have been applied with medical students, nurses, and in a comparative study between different hospitals.

Utilizing Personal Values for Requirements Engineering

Value inventories are not genuinely linked to software requirements. However, cues about such links can be found through the following experimental setting. At the time when users inform about their value inventories they are also observed as they use software in fulfillment of their clinical tasks. Patterns of apparently satisfied, apparently unsatisfied, apparently dysfunctional etc. utilization, as well as patterns of denial and utterances or other expressions of dissatisfaction are recorded. A common interpretation is being sought for to link user reactions, user values, and software properties.

While the above is a systematic and empirical data collection and tagging activity which among others delivers existing but unsatisfactory software properties a creative act is required to come up with complementary software properties that are likely to satisfy the user, given his/her value inventory.

Making use of inappropriate behaviors to improve software is not completely new. MOQARE ([32]) observes or anticipates inappropriate patterns of utilization, relates them to plausible reasons and takes countermeasures intended to prevent the inappropriate patterns. MOQARE has been applied to different settings, including a preliminary investigation in the medical field ([33]). Like in the value based approach mismatches between expectations and software properties deliver the cues for improvement. But while the MOQARE approach handles individual patterns of misuse in response to accidental software properties in an ad hoc manner, the value based approach aims at a common theory intended to coherently explain all misuses as violations of a coherent value system and to deliver countermeasures in the form of improved software properties which are in agreement with the value system.

Project Status and Outlook

For VaReMed = **Va**lue Based **Re**quirements Engineering in **Med**icine the above roadmap has been agreed upon and has received funding from DFG. Experiments start in December 2009 and the first set of results about clinician value invento-

ries, situations of inappropriate use or signs of dissatisfaction, and how they presumably relate to each other will be presented at the conference.

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