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Understanding Responsible Computing Via Project Management for Sustainability

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Abstract

Everyone acknowledges the importance of responsible computing but practical advice is hard to come by. Important Internet applications are ways to accomplish business processes. We investigate how they can be geared to support responsibility as illustrated via sustainability. Sustainability is not only urgent and essential but also challenging due to engagement with human and societal concerns, diverse success criteria, and extended temporal and spatial scope. This article introduces a new framework for developing responsible Internet applications that synthesizes the perspectives of Theory of Change, Participatory System Mapping, and Computational Sociotechnical Systems.

Keywords: Business processes, Internet ethics, Societal considerations

1 Introduction

How can we create responsible Internet applications? We address this question through a particular family of Internet applications, namely, process and project management, and through a particular illustration of responsibility, namely, sustainability. Our envisioned framework highlights the fact that responsibility, like the closely related concept of ethics, cannot be approached from the standpoint of pieces of software but must be viewed in terms of how they affect human outcomes and interactions in a social context [1]. Computer scientists use the term "system" almost exclusively to refer to an artifact, realized in software or hardware. Sustainability calls for a broader notion of a system that reflects two connotations: a system encompasses the entities of interest (so must include stakeholders) and a system is what we place in an environment (so must take into account its interactions with the surrounding socioeconomic world) [2].

Key challenges arise in incorporating sustainability into the business processes and practices of planning, scheduling, and executing projects [3]. We adopt the term *Project Management for Sustainability* or PMfS to include the desired capabilities and practices. Current management tools (e.g., Zoho Projects, JIRA, and Microsoft Project) emphasize considerations relating to cost, time, and quality, but offer weak support for the complex factors that underpin sustainability [4]. Moreover, achieving responsibility is not merely a matter of applying tools because conceptually prior to any tools is understanding the requirements for a project and ensuring that they reflect criteria such as ethics.

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This article identifies the key aspects for which project management needs to be expanded: optimization, stakeholders, causal models, and ethics. It offers an interdisciplinary framework for responsibility combining the Theory of Change and participatory system mapping from the social sciences with computational sociotechnical systems. It concludes with guidance on future research challenges and a call to arms for responsible Internet computing.

2 Sidebar: Sustainability

Emerging issues such as climate change, pollution, depletion of natural resources, and social inequality have made sustainability an existential concern for humanity, leading to an urgent need to accommodate sustainability in all business operations [5].

Von Carlowitz [6] formulated sustainability in the early 1700s in the context of forestry: how planned reforestation would mitigate the risks of timber shortage. Carson's book *Silent Spring* [7] inspired the study of sustainability in the modern era. *The Limits to Growth* [8] was a landmark report based on computer simulations arguing that the finite supply of natural resources is unlikely to support the-then current rates of economic and population growth much beyond 2100.

This report has led to international initiatives, including the Earth Summit and the United Nations Commission on Sustainable Development (CSD). Sustainable development is "development that meets the need of the present without compromising the ability of future generations to meet their own needs" [9].

The *Triple Bottom Line* [10] captures the three essential elements of sustainability:

- Social: culture, accessibility, and participation;
- Environmental: soil, water, atmosphere, biodiversity, and energy consumption;
- Economic: costs and bureaucracy.

These factors cannot be traded off directly and coming up with joint criteria is nontrivial. For each of these factors, we must balance short-term and long-term risks and payoffs, local and global scope, transparency, and accountability with privacy, individual freedom, and societal interests. Additionally, these factors interact in subtle ways and we must tackle the interdependencies [3].

Sustainability is reliant on the behaviors of stakeholders, with their beliefs and competencies. How well it is achieved depends on how we capture stakeholders' requirements, help them reconcile conflicts, and responsibly trade off current and future needs.

3 Challenges for Sustainability

To understand the challenges facing Project Management for Sustainability (PMfS), consider a typical construction project—a housing complex Sustainability is crucial across the three stages in the lifecycle of the complex.

Creating and commissioning Developers identify a need and find a site. To obtain approvals for converting that land from its current use, they prepare designs showing

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how the envisioned complex would fit into its environment in terms of ecology (wildlife habitats), construction (building materials and equipment), transit (road capacity, new metro stop), utilities (water, sewage, electricity, telecommunications), and services (schools, clinics). They build the complex.

Use Households move in, leading to ongoing operations and maintenance, with an environmental footprint.

Decommissioning Decades later the complex is taken out of use and possibly demolished. Concerns include reusability and recyclability of the materials, any pollution caused, and effects on the local socioeconomic system, such as nearby businesses.

Decisions can have long-term effects. An energy-efficient construction with space for trees lowers the carbon footprint during use. Damage to the environment during use may hinder reintroducing a bird sanctuary upon decommissioning. And, clean decommissioning facilitates commissioning another project in the same space.

The processes that go into realizing a complex's lifecycle are clearly based on information exchange and decision making. How those decisions are framed yields the requirements that determine whether information technologies are applied responsibly. Thus, PMfS must address the following challenges arising from the wide scope that sustainability induces.

Optimization. Whereas traditional project management has a short horizon, PMfS must consider the entire life cycle of a project. In our housing complex example, we should include the eventual reclamation of the site upon decommissioning. Since information about the future may be lacking, we may need to combine quantitative and qualitative methods for optimization.

Stakeholders. PMfS relies on stakeholder participation for defining problems, identifying solutions, realizing them, and tracking and assessing outcomes [11].

The stakeholders may change over the lifecycle of a project, e.g., for a housing complex: first the designers, then the building material suppliers, then residents, operators and the surrounding community members, and finally future generations who will decommission the complex. Such stakeholders are autonomous and don't follow a top-down hierarchy as traditional process management assumes.

Causal models. Capturing the interplay of causal relationships at multiple time scales and across organizational boundaries (accounting for autonomous stakeholders) is essential for PMfS. The causal models of interest involve not just physical phenomena (e.g., a garbage incinerator puts out smoke or big trees help reduce the need for cooling) but also social and cognitive phenomena (a lack of public transportation leads people to use personal vehicles or people may adjust their air conditioner settings depending on how their neighbors set theirs).

Ethics. PMfS must contend with competing demands by stakeholders and along different sustainability dimensions. The social norms and values that motivate human behavior are particularly relevant in achieving sustainability. Interesting considerations here involve intergenerational equity (trading of present prosperity with the future) and intragenerational equity (how welfare is distributed currently) under uncertainty.

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4 Elements of a Conceptual Framework for Responsibility

As the above challenges indicate, tackling responsibility requires a new, interdisciplinary framework, which we introduce below in terms of its three main elements.

4.1 Theory of Change

To bring about change, i.e., to identify or evaluate potential interventions, we need an understanding, or *theory*, about cause and effect. These theories help us tackle complex systems where outside influences and internal indeterminacy render hard predictions impossible.

The *Theory of Change* is a way to make the theories underlying an intervention explicit [12]. The Theory of Change is widely used for policy evaluation by governments and by Non-Government Organisations (NGOs). The approach begins with a project's long-term goals and then works back through intermediary stages until the current state is reached [13]. Laying out a Theory of Change forces us to articulate the causal links, thereby exposing unproven or problematic assumptions.

Typically, Theories of Change are developed by starting with the goal of the project and working backward through a causal chain to identify the outcomes that are expected to yield the expected impact. These outcomes map to project outputs (e.g., deliverables and products). Project activities that create the outputs require inputs such as people, money, and equipment. Thus, we obtain a causal chain that shows the requirements to achieve the goals. Using this chain, one can clarify the assumptions underlying the theory of change and justify these assumptions by reference to prior knowledge, experience, or intuition. It helps to arrange the causal chain along a timeline and specify what resources are needed when, as in conventional process management.

By making explicit the assumptions, contexts, and mechanisms that underlie a project plan, it reveals misunderstandings and conflicts and potential pathways to resolve them. A Theory of Change can help clarify the assumed scope of a project, including which factors and outcomes are integral to the desired change, and which are irrelevant or unchanging. Finally, a Theory of Change is a useful starting point for computational models of the project domain that incorporate the mechanisms posited in the Theory.

4.2 Participatory System Mapping

Despite its strengths in laying out the hypothesized causes of change, the Theory of Change approach may oversimplify complex systems as linear sequences of inputs, activities, outputs, outcomes, and impacts, and ignore feedback loops between outputs and inputs or activities. Moreover, the approach emphasizes direct causes and causes that are within a narrow project boundary, risking ignoring exogenous disruptive causes. One way of overcoming these limitations is to combine the Theory of Change with Participatory System Mapping.

Participatory Systems Mapping is a modeling methodology in which a group of stakeholders collaboratively develop a causal map of an issue. This map includes factors and links between them. A factor is anything expressed as a variable (i.e., can increase or decrease); a link is a causal relationship between factors. The map represents what stakeholders believe to be the causal structure of their system.

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Building a map is a valuable exercise in clarifying participants' understanding. The map is a useful resource, not only for documentation but also for further analysis. Participatory system maps such as the example in Figure 1 provide the thinking tools which can be used for discussion and exploration of complex issues, as well as sense-checking the implications of suggested causal links.

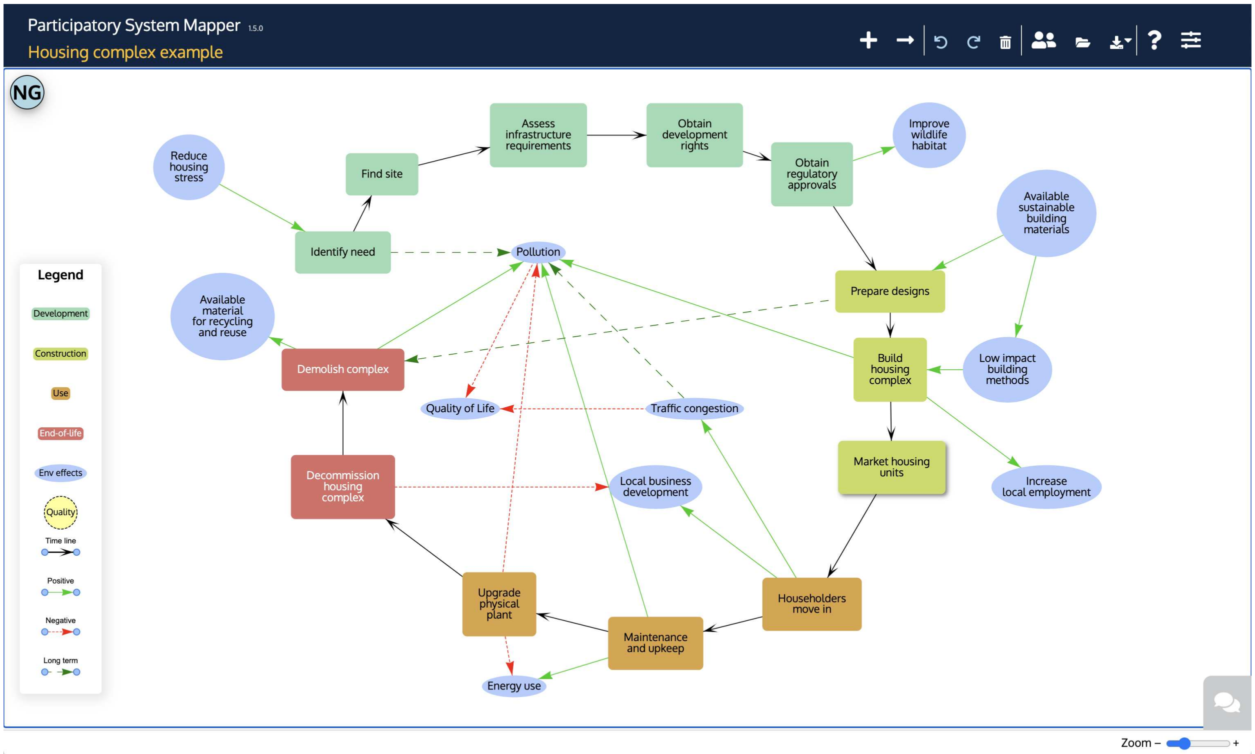

Figure 1: An example Participatory System Map. The rectangles mark the course of the project, color-coded by stage. Ovals represent sustainability factors and the arrows causal links. Green arrows are positive relationships, red dotted arrows are negative, and dashed arrows are long-term effects.

Figure 1 was created using the PRSM tool for participatory mapping [14]. The displayed map shows the theory of change geared to our example. The co-creation of such maps by stakeholders does take effort in that they must reflect on each other's perspectives but the exercise is facilitated by the structure of the map.

Participatory mapping is helpful in developing an understanding of a domain and identifying the project scope. The map may then be formalized as the basis for a Theory of Change, or by quantifying the links between factors to yield a system dynamics model, or by building an agent-based model that represents the causal analysis embodied in the map.

However, methods for formalizing system maps into more quantified models are still in their infancy. Further research is needed on methods for refining a system map into a Theory of Change and then into a computational model.

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4.3 Computational Sociotechnical Systems

We adopt a notion of a *sociotechnical system*, whose social tier includes stakeholders and whose technical tier includes computational artifacts or resources such as databases and sensors. The stakeholders have (preferences over) goals and values. They interact with each other to advance their goals and to promote their values; they form expectations of one another and track them. Being autonomous, the stakeholders may violate each other's expectations but concomitantly can hold others, and be held by others, to account [2]. The technical artifacts make their interactions possible and provide affordances that make some interactions easier and some harder [1].

This vision of a sociotechnical system is computational in that the specific computations by the stakeholders in the social tier are realized by the more detailed computations by the artifacts in the technical tier. Figure 2 illustrates our conception in schematic terms.

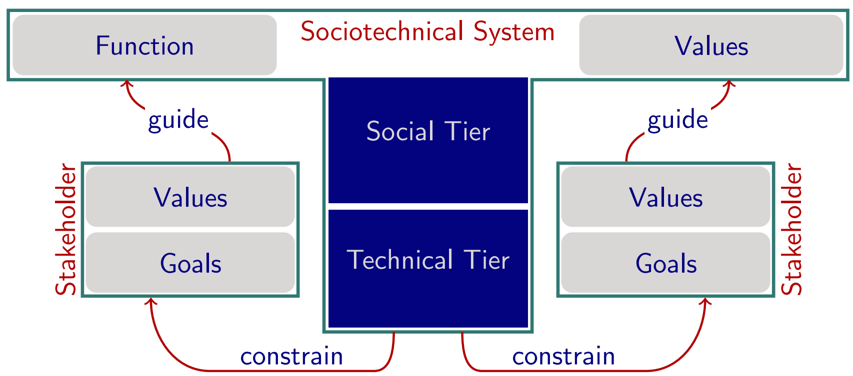

Figure 2: A sociotechnical system and its stakeholders schematically comprising a social and a technical tier. It exists for the benefit of its stakeholders and provides some function and promotes some values. The stakeholders act under the umbrella of the system, constrained by the social tier (e.g., norms) and the technical tier (e.g., affordances). The system itself is guided by and adapts to satisfy the stakeholders it serves, aligning its function with the stakeholders' goals and its values with their values.

We adopt sociotechnical systems as a basis for modeling sustainability. To be sustainable, a system must be open in that the stakeholders can come and go—the system must outlast its stakeholders' tenures in it. Moreover, even for the same stakeholders, their goals and values change over time because of their experiences, needs, and changing social mores. A hallmark of sustainability is the coherence over time of the values realized by the system.

Thinking about sustainability naturally leads to a social tier of norms that guide the behaviors of its members (the stakeholders), yet leaves them with the autonomy to contravene those norms, should that be appropriate. And, a technical tier remains essential because we need to design our devices and data to be able to respect the dictates of sustainability. As environmental conditions or stakeholder values change (in the extreme case because of a generational shift, but even otherwise), the currently established norms may no longer be appropriate for many of the stakeholders. When that happens, their behavior in alignment with their values would repeatedly lead to the norms being deviated from [15]. When the norms are deviated from sufficiently often by sufficiently many stakeholders, the social tier

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has changed in either interpretation of norms: (1) for nonlegislated norms, the deviations are evidence that new norms have emerged and (2) legislated norms, there would be ample grounds for revising them.

5 Vision and Directions

Putting the above together, our envisioned conceptual framework for responsible Internet computing involves (1) expanding our conception of a system for an Internet application to include the social structure in which it is (to be) deployed; (2) engaging the stakeholders in capturing their preferences over the functionality desired, their values, and what tradeoffs are acceptable; and (3) developing causal models of possible interventions.

To realize this vision requires advances along each of the above three themes. We outline some representative (i.e., not comprehensive, but promising) challenges for each theme below.

Causal modeling We need ways to achieve better causal modeling, which underpins the Theory of Change. One way to do so is through extensive use of agent-based modeling and simulation. In addition, these models should be used as inputs to further participatory mapping to provide empirical grounding to the deliberations being carried out and thus help identify misalignment in their assumptions. This process would be recursive in that producing a causal model of one aspect of the project may require additional participatory mapping and uncover additional misalignments.

Value alignment Ethics is fundamentally based on values. Responsibility requires that we respect stakeholders' values, which they may have figured out *a priori*. If the stakeholders support sustainability, they would find that at least some of their values align, suggesting the possibility of them being able to collaborate, though they may be at variance on other values. Even if they do not fully agree, they would need to understand where each other stands. And, being able to reconcile sufficiently the tradeoffs they are willing to make would lead to the creation of a social tier that prohibits or disincentivizes certain behaviors and outcomes

Renewal Sustainability by definition is not a one-shot problem and calls for constant care. A sustainable project must include the ability to monitor its functioning, e.g., to discover if the right goals are being (adequately) met and if the goals being met are the right ones. Based on such observations, if any misalignments arise, we would need a way to make course corrections by changing the process being enacted. Not all such misalignments need to be resolved in a project so a concomitant challenge is to resolve the project scope such that the participants can focus their efforts on the most germane aspects.

Such improvements can be seen in terms of optimization. Given the stakeholders' preferences, we expect the system to maximize an associated objective that reflects those preferences. When the outcomes are no longer optimal—either because new knowledge indicates better solutions or because the stakeholders' preferences have shifted—we would need to revise the operations in the technical tier as well as the applicable norms in the social tier. As explained above, mostly those revisions may be incremental but sometimes they may require extensive changes.

Putting it together, we can see that achieving responsible Internet computing requires more than an exhortation to be responsible or do the right thing. Computer scientists must engage stakeholders in ways that go beyond current approaches focused on surveys or interviews to (1) help stakeholders understand the causal models of the technical aspects, which they may not understand well, (2) obtain their help in jointly developing models of social interactions, where they would have experience, and (3) jointly elicit and formalize the values and tradeoffs to be embodied in the solution.

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