Preliminary Thoughts on a Taxonomy of Value for Sustainable Computing

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ABSTRACT

In recognition of the various and imminent limits to global consumption-based growth, some quarters of the technology industry have begun to consider the novel use of computing to prevent, postpone, alleviate, or recover from a crisis in what could be called "sustainable computing." There is, however, a great danger that certain inclinations of the technology sector will undermine the very goals of sustainability and resilience that such efforts claim to seek.

This paper outlines a preliminary taxonomy of value for sustainable computing projects. The taxonomy suggests a three-dimensional classification of projects in terms of their impact on, intention toward, and effort required for sustainability. By making explicit an evaluative framework by which computing might and might not contribute to sustainability goals, the hope is that future work will tend toward projects that are genuinely helpful.

Categories and Subject Descriptors

K.4 [**Computers and Society**]

Keywords

Sustainability, sustainable computing, green computing, computing within limits.

1. INTRODUCTION

The fact of a finite planet combined with increasing population and growing per-capita consumption inevitably raises a neo-Malthusian challenge to global society [4]. We appear to be facing an imminent "collapse" scenario. Though the proximal cause and the exact nature of outcomes is uncertain, it seems safe to say that should some form of civilizational collapse occur, it will be dramatic and, at least for a time, extremely painful [6][8].

In recognition of this possible scenario, some quarters of the technology industry have begun to consider the novel use of computing to prevent, postpone, alleviate, or recover from a crisis in what could be called "green" or "sustainable computing" [5]. There is, however, a real danger that these phrases become mere buzzwords that play up empty actions [7]. In fact, some inclinations of the technology industry – its faddishness, its consumption orientation, its hunger for electrical power and rare natural resources, its rapid innovation-obsolescence cycle – might not only fail to lead to sustainability, but only accelerate collapse.

This paper seeks to bring attention to this possibility through a multidimensional taxonomy of sustainable computing efforts. The hope is that, by debating, incorporating, and applying a taxonomy of this nature, the sustainability computing community will remain conscious of the possibility that glib sustainability efforts may not genuinely contribute to sustainability.

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2. FOUNDATIONAL CONCEPTS

2.1 Sustainability as Resource Equilibrium

Throughout this paper, sustainability will be discussed of in terms of resource consumption and replenishment. Doing so provides a convenient way to discuss a wide range of sustainability issues using the same vocabulary. Resources can, of course, be physically concrete natural resources such as fossil fuels, rare metals, or wood. However, there are other types of resources. By casting clean water or clean air as a resource, pollution can be considered a depletion of resources. Similarly, by thinking of regions with inhabitable climate as a resource, inhospitable climate change could be considered a depletion of that resource.

Sustainability then can be thought of as the point of equilibrium where the amount of resources being replenished is equal to the amount of resources being depleted, as suggested by some ecological economists [2].

2.2 Multiple Resources

Most technologies and human activities involve multiple resources. A mobile phone, for example is made of a variety of raw materials and its manufacture contributes to a degree of air and water pollution. It's thus possible for a given project to contribute to sustainability with respect to one resource while taking away from sustainability with respect to another. For example, a smartphone app that helps users conserve water may do so at the expense of greater fossil fuel consumption.

This paper does not address this issue in particular, and instead proposes a taxonomy that applies generically with respect to a single resource. This should not lead to a loss of generality because the taxonomy can be applied on a per-resource basis, or with regard to a pre-defined package of resources, or on the basis of a resource currency whereby one resource could be theoretically exchanged for another.

3. PRELIMINARY TAXONOMY

The proposed taxonomy suggests three dimensions by which a project can be classified. These are intended to be conceptually orthogonal – that is to say, classification according to one dimension is *conceptually* independent of the other dimensions, in the same way that one can choose a model of car independent of the color in which it is painted (and vice versa). However, there may be empirical correlations in the dimensions – to continue the analogy, automobiles leave the factory with a limited set of colors, so as a practical matter, knowing the model limits the colors a car could be.

The taxonomy presented below is not meant to be comprehensive or final. In fact, before any such taxonomy gains wide acceptance, it would need to be discussed, debated, and vetted with a larger community. What is presented should be considered a first draft straw man to elicit comments, criticism, and alternate suggestions.

3.1 Impact

Arguably, what matters most to sustainability is whether a project, technology, policy, or system in fact moves things toward or away from sustainability. The first dimension of the taxonomy therefore focuses on the nature of actual sustainability impact:

Level -3 – Adversely affects sustainability. Increases the rate of net resource depletion.

Level -2 – Maintains status quo without affecting movement toward or away from sustainability. The net rate of resource depletion is unaffected.

Level -1 – Decreases the rate of net resource depletion, but does not take things toward a sustainable equilibrium. The rate of resource depletion is still positive.

Level 0 – Achieves a sustainability equilibrium in and of itself, but does not move things toward increased sustainability. Net resource depletion is zero.

Level 1 – Contributes to movement toward a globally sustainable equilibrium. Actively moves things toward net resource replenishment.

The numbering system requires some explanation. The idea is that with respect to sustainability, Level 0 represents the steady-state sustainable equilibrium. This state is akin to what Herman Daly calls stead-state economics [2], but with a narrow focus on a single project and the resource the project is concerned with. If all human activities were suddenly to achieve Level 0 tomorrow, our sustainability concerns would cease, because all systems would be at a sustainable equilibrium.

Levels -3 through -1 take away from sustainability, because they reflect a net consumption of resources. However, there are different gradations. Level -3 takes us further away from sustainability and at a faster rate. Level -2 maintains the status quo. Level -1 decreases the *rate* at which we are moving away from sustainability, but it does not flip the sign. It is not enough to move us closer to sustainability. The only level at which there is a net positive contribution to sustainability is Level 1.

One caveat is that level ratings are meaningless unless associated with specific systems whose boundaries are clearly demarcated for the sake of analysis. Flying an airplane on a periodic basis, for example, is generally unsustainable because of carbon emissions and consumption of fossil fuels, so it would be Level -2. Yet, it's conceivable that some future airline company dutifully cancels the effect of its emissions through carbon offsets and invents engines that use renewable plant-based diesel fuel. The company's flights and offsets taken as a whole might then be Level 0. (For the sake of simplifying discussion, second-order effects such as soil depletion, non-carbon air pollution, etc. are not considered here, but that isn't to say that they shouldn't be.)

Impact generally requires proactive verification, especially for Level -1 and higher levels.

3.2 Intention

The next dimension of classification is whether there is any intention among the people responsible for a project, technology, policy, or system to address sustainability. Intention is important to consider in the context of sustainability projects, because ultimately, sustainability can only be reached by a global shift in intention. At the same time, intention and impact are not always aligned. There are well-known cases where good intentions lead to adverse outcomes (e.g., Jevons' paradox [1]), as well as cases where indifferent intentions lead to positive outcomes. Having a vocabulary for discussing such instances is helpful.

There are three basic levels of intention:

Class A: Genuine intention to move things toward increasing sustainability.

Class B: Neutral, indifferent, or half-hearted intention to move things toward sustainability, yet also without negligence or active intention to be adverse to sustainability.

Class C: Intention to move things in a direction that runs counter to sustainability, or negligence toward an incidental effect that runs counter to sustainability.

Class C requires additional explanation. It certainly includes cases where an entity is intentionally and primarily working against sustainability. Those cases, however, are extremely rare, possibly limited to fictional evil villains. Even oil companies would deny that they are intentionally trying to destroy the planet, or that they are primarily acting to hurt sustainability – even at their most venal, their goal is profit through serving customers, not unsustainability for its own sake. They could argue that resource depletion is an unintended consequence of their otherwise prosocial work.

Yet, it seems intuitively clear that entities whose main activity is in fact to deplete natural resources have a different kind of intention than, say, user interface designers who might not realize that by making a social media more user friendly, they would be increasing power consumption. This difference between Class B and Class C intention can be captured by borrowing from the legal concept of *negligence*. In law, whether an entity is negligent depends on the risks that a hypothetical, reasonable person could foresee given knowledge available to the entity [3]. Therefore, Class C intention includes situations in which whether or not an activity is "intended" to be unsustainable, it is one that a hypothetical, reasonable person can nevertheless see to run counter to sustainability.

As this point about negligence highlights, intention is dependent on human judgment, and therefore on historical context. For example, though it is increasingly recognized that consumption of electronic gadgets contributes to resource depletion of various minerals, it is not yet widely understood. The hypothetical, reasonable person may not believe it to have any impact on sustainability. Thus, consumer hardware could currently be categorized as Class B. As societal understanding of sustainability increases, however, it could flip over into Class C.

3.3 Effort Requirements for Impact

The final dimension looks at what is required for a given project to have its impact (whether positive or negative), with a focus on the amount of human effort – either individual or societal – is required.

Unlikely: Requires significant or sustained effortful activity that people are unlikely to take up without a considerable external impetus.

Effortful: Requires moderate or medium-term effortful activity that some people or some societies might be able to muster.

Effortless: Requires almost no significant change in behavior among people or societies.

Of course, effort may be required in different amounts at different phases of implementation. Many projects have a high start-up cost but need little ongoing effort; others can be started relatively easily but require continual attention. It's possible that this dimension will benefit from additional granularity.

4. EXAMPLES

As an illustration of the taxonomy, below are two examples:

Smartphone: Today's smartphones require material and energy resources to manufacture and ship, as well as ongoing energy consumption to operate. Few manufacturers aggressively attempt to recover old devices for recycling (and in any case, consumers rarely use them), and there is little attempt to move to renewable energy sources or to offset carbon emissions from ongoing fuel use. Thus, on an individual unit basis, and considered against a history in which people have been using mobile devices for over a decade, their impact rating would be a Level -2. Considered as an industry, however, smartphones would be at Level -3 since their use is only growing.

As to intention, it's not widely acknowledged yet that a smartphone consumes much of anything, or that their use is fundamentally unsustainable. Yet, manufacturers certainly know that they are depleting resources to mass produce them. It's a little hard to say whether a Class B or Class C intention rating is appropriate, but as societal understanding of the devices' impact on the environment increases, Class C seems inevitable.

As to effort, smartphones are already in use, follow on an existing base of mobile phones and distribution channels, and are desired by consumers, so implementation is Effortless.

Intelligent thermostat: Consider a thermostat that applies machine learning to determine a household's power usage habits as they go about their regular lives and automatically regulates appliances in order to reduce total energy usage. Such a project might be classified as a Level -1, Class A, Effortless project (shorthand: -1/A/Effortless) since the intention is clearly toward greater sustainability; the use of the device decreases the rate of resource consumption but does not replenish it; and relatively little effort is required of the user (other than to purchase and install the device).

It should be clear from these examples that all other things being equal, a project that could be categorized as 1/A/Effortless is superior to any project that is -3/C. The polarity of the effort dimension flips, however, with respect to intention and impact. That is, while a 1/A/Effortless project is superior to a 1/A/Unlikely project with respect to sustainability, a -3/C/Unlikely project is more desirable than one that is -3/C/Effortless, because the fact that the negative impact is harder to cause is better for sustainability than for it to come effortlessly.

5. CONCLUSION

This paper proposes a three-dimensional taxonomy of sustainability computing that classifies projects according to their (1) impact on sustainability, (2) intention with respect to sustainability, and (3) required human effort to achieve impact. It is hoped that the proposal will provoke discussion and debate, and ultimately lead to a taxonomy that used to discuss sustainability projects.

Future work should consider whether and how an eventual taxonomy can be operationalized. The current proposal, for example, includes a couple points where subjective judgment is required. For practical application, a process and a clear protocol are necessary – not to eliminate the requirement for judgment, but to allow for a consistent application of the ratings.

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