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Software Sustainability Assessment (SoSA) exercise report

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Abstract. This document reports on an exercise carried out within the CAiSE 2016 tutorial. The participants were asked to apply the SoSA method on a case, divided into three distinct groups. Then they were asked to provide feedback on the method. Herein, we analyse the results of their models, their feedback and we discuss benefits and drawbacks of the method.

Keywords: Sustainability, green software, information systems, socio-environmental impact, SoSA method, experience report.

1   Facts about the tutorial and the SoSA exercise

The tutorial took place on June 15th, during the 28th International Conference on Advanced Information Systems Engineering (CAiSE 2016), held in Ljubljana, Slovenia [1]. The tutorial aimed at raising awareness on the role that Information Systems research and engineering can have in creating a more sustainable world. We first explained the basics of sustainability from the economic, social and environment points of view, discussed the role played by information systems research and engineering in technical sustainability, presented relevant toolset of methods and technologies applicable to this research domain, presented some open research challenges and debated the future of the discipline. The tutorial had 21 attendees, mainly being academics but also a few researchers from industry.

One of the methods we presented is Software Sustainability Assessment (SoSA) [17], which enables software developers to specifically consider environmental and social dimensions of an existing or envisioned software system, relative to technical and economic dimensions [2]. In the following, we describe an exercise of applying SoSA to a smart mobility case.

2   Exercise on applying SoSA

First, we introduced the SoSA method, after which we presented an example of its application to a smart city streetlight project. Then we described a smart mobility case and invited the participants to split into three groups (7, 5 and 2 subjects) in order to apply the method. The symbols of the notation are shown in Fig. 1 and the instructions are shown in Fig. 2.
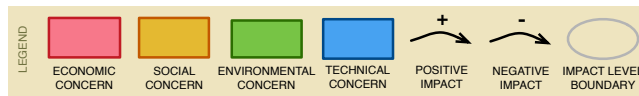

Fig. 1. Notation of the SoSA method

Fig. 2. Exercise slide

The participants used post-its coloured according to the colour scheme proposed by the method. They labelled the post-its with quality concerns and stuck them in a whiteboard. Then they drew the relationships among concerns with markers. The results are shown in Fig. 3.
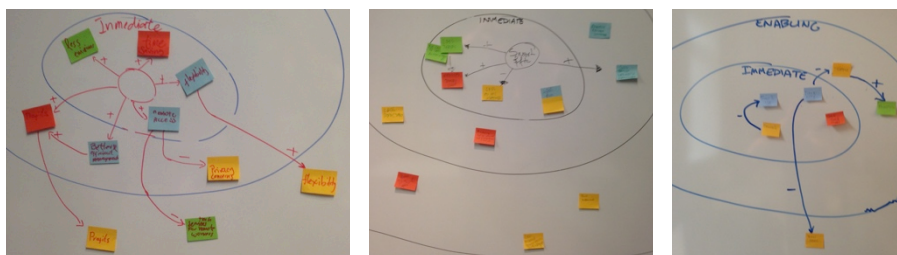

Fig. 3. SoSA diagrams of groups A, B and C

We have modelled the diagrams with OmniGraffle, a general-purpose diagramming tool (see Fig. 4, Fig. 5 and Fig. 6).
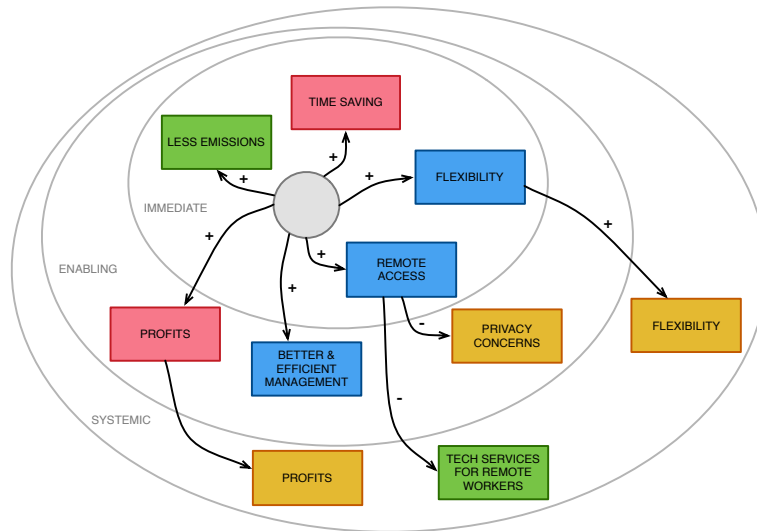

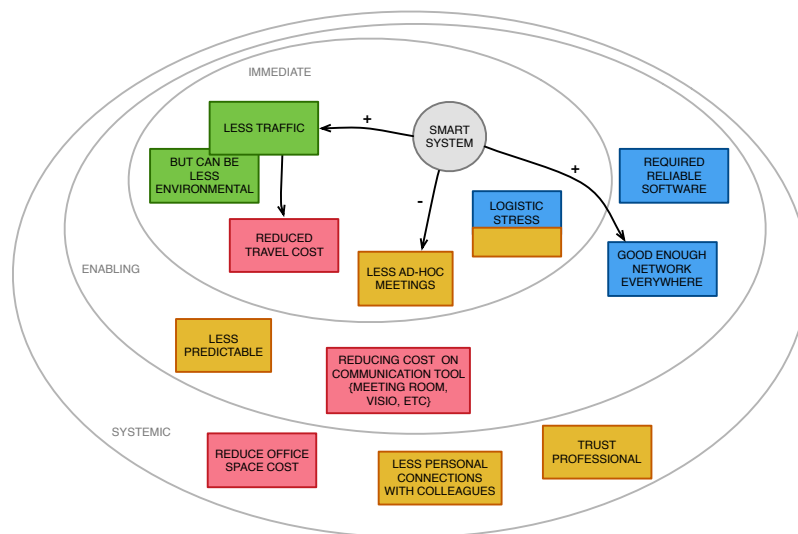**Fig. 4.** SoSA diagrams of group A (neat version)

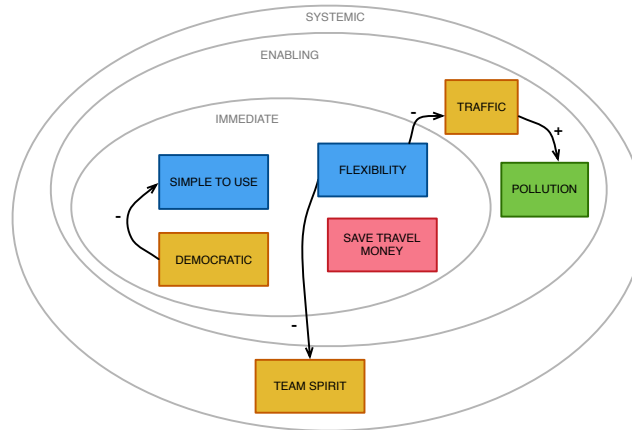**Fig. 5.** SoSA diagrams of group B (neat version)

Fig. 6. SoSA diagrams of group C (neat version)

In the following, we collect some observations the subjects provided as feedback. We mark each observation a possible SoSA revision suggestion (in RED).

O1. The starting point of the method was unclear for some subjects. "We needed more guidelines on how to start, how to draw the lines and the connections, whether they all start from the Smart Office centre and they go from there or how they can be interrelated." Revision suggestion: add guidelines on (1a) starting the model, (1b) dependency semantics between <software system> and <concern>.

O2. Some participants expressed that they would rather use the element that represents the software system being built as a source of links, so as to express in an explicit manner the system's effect on sustainability concerns (see Fig. 4 and Fig. 5). Revision suggestion: same as point (1a) above.

O3. Some participants expressed the need for guidelines on deciding to which impact level a concern should be ascribed. Also, they were hesitant to link elements at the immediate impact level with elements at the systemic impact level. Some participants even expressed that skipping a level is a sign of a missing explanatory mechanism and it should trigger the alarms of the analyst. Revision suggestion: add guidelines on (3.a) classifying impact level; add (3.b) dependency semantics of direct impact vs. indirect impact (e.g. in Fig. 4, is it correct that the system as a direct impact on concern Remote Access and an indirect impact on concern Privacy?); add (3.c) semantics of skipping an impact level (is that a bad smell?).

O4. Some subjects were unsure on how to link concerns together. Revision suggestion: add (4) semantics of dependency between concerns.

O5. We need to clarify that we need to involve all relevant stakeholders. The result is an inter-subjective agreement. Revision suggestion: add (5) guidelines to define (and iteratively refine) the list of "relevant" stakeholders.

O6. A subject pointed out that she would like to have SoSA integrated with goal-oriented methods (e.g. i* [3], Goal-oriented Requirements Language [4]) in order

to facilitate automatic reasoning on the trade-offs. Revision suggestion: none. Study i* and possible implications for the SoSA method (related work?).

O7. One team was unsure on how to categorise a concern. They had doubts on what to do "when you have impact that falls on two or more dimensions". See, for instance, how they classified Logistic stress both as a social and as a technical concern, in Fig. 5. Revision suggestion: add (7.a) definition of quality concern; (7.b) definition of multi-dimensional concern and (7.c) related guidelines (how to specialize the concern for each relevant dimension?).

3   Suggestions for potential improvements to SoSA

Based on the feedback by the workshop participants and our own observation of the current limitations of the method, we consider the following observations and suggestions for potential improvements.

S1. Provide some guidelines to start the modelling.
- Allow for modelling software system features (to be identified) besides quality concerns.
- Provide guidelines on exploring the direct system's effect on sustainability concerns (see Fig. 4 and Fig. 5).

S2. The mechanisms to specify the directionality of the links could be more expressive. It may be convenient to express these different situations:
- In some cases there are evidences of a causal relationship between two concerns; such evidences can come from scientific papers or previous experiences of the development team or the client organisation.
- In other cases, there exist evidences of a correlation between two variables, but not of a causal relationship.
- Finally, sometimes a causal relationship is expected but there are no evidences of it yet.

S3. The mechanisms to specify the influence among variables (the links) could be more expressive. It may be convenient to indicate the expected or measured influence with different levels of granularity, depending on the situation (i.e. whether evidence exists concerning the strength of the influence, whether we just need to make a simple trade-off analysis, etc.). Some examples are:
- Simply indicate positive (+) or negative (-) influences.
- A finer-grained qualitative range (e.g. --, - , +, ++, ?).
- Numeric factors of influence or correlation. Such numbers can be correlation coefficients based on existing empirical research or estimated weights.

S4. The metamodel could be extended with attributes to store data that can be used for analysis.

S5. The SoSA method has some features in common with exiting methods. It may be convenient to make a deeper comparison with the purpose of (i) understanding their similarities and differences, (ii) consider incorporating into SoSA some additional features existent in other methods, (iii) provide guidelines to shift

from one method to the other when it is deemed convenient. The following methods have some common features with SoSA:

- Causal loop diagrams (a.k.a. word-and-arrow diagrams, influence diagrams, cognitive maps) are graphs constructed by linking together key variables and indicating the causal relationships between them [5]; they often include reinforcing and balancing loops. It should be taken into account that, unless the links characterisation mechanisms are designed with care, they might be subject to ambiguity and other problems [6].
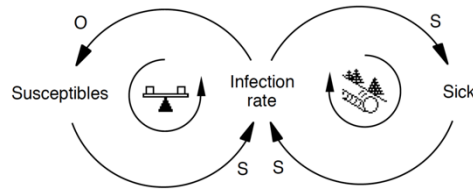

Fig. 7. Causal loop diagram in "S" and "O" notation, capturing the balancing and self-reinforcing loops inherent in the spread of a disease (from [6])
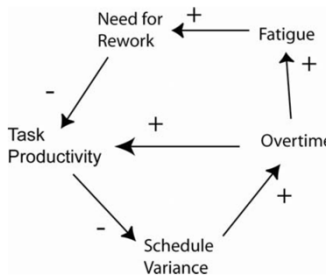

Fig. 8. An inconvenient feedback loop that can occur in project management (from [7])

S6. The theories of change (a.k.a. impact map, logic model) are theories about the impact of a project or programme, identifying all the assumptions and specifying them with detail [8]. In the context of social and environmental intervention projects, a subsequent step is data collection and analysis to track the unfolding of the assumptions, gather evidences on whether they hold or not, aiming at evaluating whether the project is successful or not. This is an important part of impact assessment methods, whose purpose is to identify and predict the potential impact of a project both on the living and on the non-living environment and also on human health, for the purpose of recommending appropriate legislative measures, programs, and operational procedures to minimize the impact [9]. Impact assessment methods are used to ensure that the environmental implications of decisions are taken into account before the decisions are made [10]. Theories of change are also a major component in the calculation of the social return of investment (SROI) [11]. SROI is a variant of impact assessment methods in which socio-environmental value is monetised in

order to calculate the ratio between that value and the costs of a project [12]. SROI is frequently used by philanthropic funds.
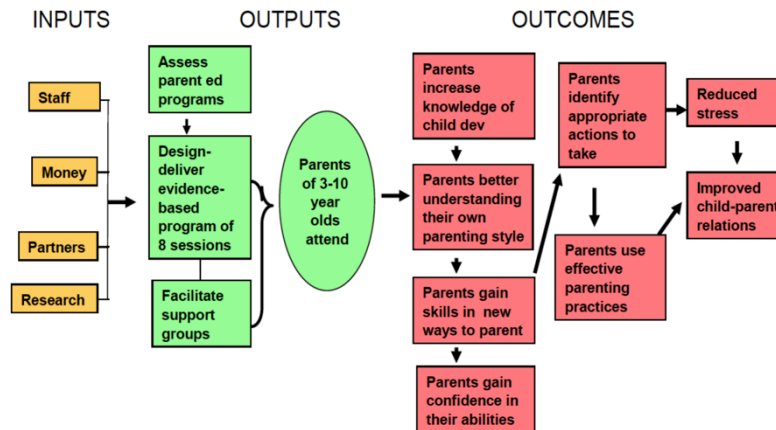

Fig. 9. Theory of change underlying a parent education program intended to reduce the stress of parenting in a municipality (from [13])

S7. There should be a clear methodological path from the SoSA analysis to the design of indicators. That way, the stakeholders can later develop a dashboard that monitors the real impact of the system, once it is in operation.

S8. The relationships between the software system and the immediate impacts are not specified explicitly. They are implicit if we consider that the software system will contribute to the technical requirements or that the technical requirements act as surrogates of the system. In any case, such relationship is indeed important to reconcile the method with theories of change (which are necessary to assess socio-environmental impact).

S9. It is important to acknowledge that each stakeholder (either an interest group as a unit or an individual person) can have their own perspective in defining and interpreting a problem situation [14]. In the case of SoSA, this means that defining the influences of the software system in the environment entails subjectivity and requires discussion and agreement. In this sense, it is relevant the influence of soft systems methodologies [15]. This also has been acknowledged in similar methods; for instance, Jafari et al. elaborate on how the soft systems stance affects the application of Causal Loop Diagrams [16].

4 Conclusions

The increasing commitment of enterprises and software developers on having a good social and environmental impact contrasts with the lack of methods to assess the sustainability of software systems. The SoSA method intends to cover this gap by facilitating the brainstorming and analysis of sustainability concerns related to a given

software under development. We have reported on an exercise carried out during a tutorial run within the CAiSE 2016 conference, in which subjects used SoSA to model the impacts of a smart mobility software. We collect their models and comments. We also enumerate suggestions for improving SoSA, based on the reported exercise and our own experience with the method.

Future research should include releasing an improved version of the method and investigating additional applications both in controlled experimental settings and within real software development projects.

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