Sustainability in Software Product Lines: Report on Discussion Panel at SPLIC 2014

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ABSTRACT
Sustainability (defined as “the capacity to keep up”) encompasses a wide set of aims: ranging from energy efficient software products (environmental sustainability), reduction of software development and maintenance costs (economic sustainability), to employee and end-user wellbeing (social sustainability). In this report we explore the role that sustainability plays in software product line engineering (SPL). The report is based on the “Sustainability in Software Product Lines” panel held at SPLIC 2014.

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D.2.8 [Software]: Metrics – performance measurement, process metrics, product metrics. D.2.9 [Software]: Management – productivity, software quality assurance. K.4.2 [Computing Milieux]: Social issues – employment. K.4.2 [Computing Milieux]: Organizational Impacts – automation, computer-supported collaborative work, employment, reengineering

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Management, Measurement, Documentation, Performance, Design, Economics, Human Factors.

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software product lines, sustainability, sustainability design.

1. INTRODUCTION
Sustainability (defined as “the capacity to keep up”) encompasses a wide set of aims: ranging from energy efficient software products (environmental sustainability), reduction of software development and maintenance costs (economic sustainability), to employee and end-user wellbeing (social sustainability). In this report we explore the role that sustainability plays in software product line engineering (SPL). This report is based on the “Sustainability in Software Product Lines” panel held at SPLIC 2014. The report brings together ideas discussed by the panelists as well as audience members.

Panelists (ordered by surnames):
- Dr. Danilo Beuche: CEO at the Pure Systems, Germany
- Dr. Paul Clements: Vice President of Customer Success at BigLever Software, USA
- Prof. Mark Harman: Professor of Software Engineering at the University College London, UK
- Prof. Linda Northrop: Chief Scientist and SEI Fellow at the Software Engineering Institute and a Professor at Carnegie Mellon University, USA
- Dr. Rick Rabiser: senior researcher at Johannes Kepler University Linz, Austria

This panel explored state, challenges, and directions in research and practice for Sustainability in Software Product Line Engineering. These are summarised in section 2 of the present report. The panel also discussed the relation and applicability of the principles and commitments of Sustainability Design, as stated in the Karlskrona Manifesto for Sustainability Design [1]. The relevance of these principles and commitments to Software Product Lines Engineering is discussed in section 3 of this report.

2. WHAT IS “SUSTAINABILITY” FOR SPL?

Economic Sustainability
For SPL sustainability has, first and foremost, economic implications. An SPL is a business model adapted by a company in order to succeed with its business objectives, or, in other words, achieve financial profit. Once a company succeeds, it wishes to continue to enjoy the level of its success. Thus, sustainability here is the ability to continue to enjoy financial benefit, that is the sustainability of the business, not the PL per se. Change, however, undermines economic sustainability of SPL. Change can have a number of origins, such as related to technology, governance, or people. SPL embraces change by maintaining commonality and managing variability.

To be sustainable an SPL must be:

1. resilient to change and threats, without much extra re-investment. This implies ability to manage the variability of the technical asset base, variability of context in which the business exists (i.e., its ecosystem and governance), and variability of people.

2. adaptive, i.e., able to support change which is not covered by SPL, but is disruptive.

Moreover, from the economic perspective, sustainability of an SPL-based business is also pre-supposes expected evolution of the business beyond a single PL. This is because a dramatic change often happens at a larger scope than a single PL. Such change (e.g., move to a completely new market or technological solutions) maybe force evolution of a given PL into a new “off-spring” PL, or even change of the business model from SPL to something else.

Thus, when considering economic sustainability with SPL, the goal is not to keep a product line going for as long as possible, as sustainability of a business is not always about sustaining an SPL.

Social Sustainability
The social sustainability perspective in SPL is particularly relevant for the processes that support SPL business model, and so, the SPL product.

From the process-focused perspective, in order to ensure sustainable SPL model, the respective SPL-focused culture must be established in the company. The main pressures on the SPL process come from:

1. people mobility, whereby departure of key people from the company leads to loss of knowledge and process disruption. To counter this, it is necessary to document the core PL process variability to help sustain PL beyond employment commitments of specific individuals. This point is also relevant to with respect to SPL champions. Often these are innovative individuals who invigorate the SPL practice in a
Involving multiple disciplines is always key (e.g., projects with SVAl required software engineers, hardware specialists, metallurgists, sales, marketing, management, etc.). Only when involving all relevant people, sustainability can be achieved, e.g., by changing organisational culture to SPL thinking.

However, it has to be noted that this principle is not unique for addressing sustainability concerns, but is inherent for any “big problem”.

**Principle 2: Sustainability requires long-term thinking**

*Commitment: Consider multiple timescales, including the long term. Include longer-term indicators in assessment and decisions*

Similar to principle 1, this principle also is not unique to addressing sustainability concerns, but is inherent for any “big problem”. Yet, this principle is applicable to all scopes of sustainability: relating to both environmental, economic, and social concerns.

The SPL business model supports a “longer-term” thinking than the traditional development models. In particular, through continuous monitoring and adjustment of the current situation, longer-term goals can be better managed. However, this “longer-term” horizon covers only a few months time ahead. This certainly is not sufficiently long-term for addressing the big issues related to environmental and social sustainability.

**Principle 3: It is possible to meet the needs of future generations without sacrificing the prosperity of the current generation.**

*Commitment: Innovation in sustainability can play out as decoupling present and future needs. By moving away from the language of conflict and the trade-off mind-set, we can identify and enact choices that benefit both present and future.*

Innovation is essential (however, re-invention of the wheel is a constant danger and innovation ideas should always be carefully checked with existing solutions). In ideal world each problem will have a solution where (innovation-based) decoupling could resolve trade offs. However, where such solutions are not found, we advocate adoption of the search-based software-engineering perspective, whereby this principle can be re-formulated as an optimization problem (e.g., finding optimal point between sustainability concerns and those of costs, delivery time, etc.) in a multi-objective trade-off space: “minimal sacrifice for maximal sustainability”. Such formulation leads to identification of the Pareto fronts, i.e., a set of (equally “good”) solutions whereby interchange increments in various objectives (e.g., sustainability vs. cost) is optimized.

**Principle 4: Sustainability is systemic**

*Commitment: Sustainability is never an isolated property. Systems thinking has to be the starting point for the trans disciplinary common ground of sustainability.*

Similar to principle 1, this principle also is not unique to addressing sustainability concerns, but is inherent for most “big problems”.

Yet, we agree that systems thinking is essential in establishing a sustainable SPL-lead business, though may not even be sufficient - as often systems of systems thinking is required. Since a number of systems influence each other (e.g., the payment/promotions system affects the way that people are assigned to roles/teams and so affects people mobility and, consequently, the SPL process and product) this has to be taken into account (which is accounted for in Principle 7).

**Principle 5: Sustainability requires action on multiple levels**

*Commitment: Seek interventions that have the most leverage on a system and consider the opportunity costs: Whenever you are taking...
action towards sustainability, consider whether this is the most effective way of intervening in comparison to alternative actions (leverage points).

This principle, again, is not unique to addressing sustainability concerns, but is inherent for most “big problems”.

With respect to SPL, we should point out the importance of monitoring and re-evaluation: having captured and compared different alternatives with each other, one is more prepared for selection of the most effective action. This, of course, re-iterates the need for good automation in support for SPL, both on product and context side. In PL we can set up monitoring environment not only to validate configurations, manage variability/commonality and other product or process related data, but also set up (e.g., a machine-learning) environment to collect and interpret economics and analytics-related data.

Another point relevant to leverage points is consideration of the role of the government in IT sector: it has to create a regulatory framework which motivates sustainability requirements. These requirements will, in turn, be propagated by customers to the SPL-based software providers.

**Principle 6: Sustainability applies to both a system and its wider context**

Commitment: There are at least two spheres to consider in system design:

- the sustainability of the system itself:
- how it affects overall sustainability of the wider system of which it will be part of

It is often useful to distinguish multiple systems during design, to consider the impact on each of them, such as the designed system vs. its production system and usage systems.

From the search-based software engineering perspective, this principle can be refined into 3 alternative formulations:

a) If the wider context is the other systems, we must co-evolve the given system and its environment. This can be formulated as a co-evolution problem for fitness function with two evolving populations whose fitness functions depend on each other

b) if the wider context means different “demanding contexts” (such as people), we need to test systems to check how robust/sustainable they are in the different demanding contexts. So will search for demanding contexts to test the evolving systems.

c) Finally, we can aim to adapt a system to its wider context. One applications of SBSE, can be by using it to search over history of patterns of power consumption and find optimization strategies for adapting the device setups such that power consumption is minimized (e.g., overnight use SBSE to search over the phone use patterns during the past day to optimize its settings for minimal battery power consumption).

**Principle 7: System visibility is a necessary precondition and enabler for sustainability design**

Commitment: Strive to make the status of the system and its context visible at different levels of abstraction and perspectives to enable participation and informed responsible choice.

Indeed, visibility is a necessary pre-condition of a good decision-making. Visibility is interpreted as measurability. To paraphrase Kelvin, we can’t control what we cannot measure, and we can’t affect or optimize what we can’t measure.

**Conclusion**

Sustainability is becoming and increasingly important subject in the field of software development and its relevance to and influence on Software Product Lines cannot be denied. It is clear that economic sustainability is a major driver for applying SPL within a company, but our study highlights that it is interwoven with all aspects of sustainability in a myriad of ways. For example the ability to scale up development without overstretching the workforce is a direct relation of SPL to social sustainability.

But while we have noted a strong relation between various aspects of sustainability and the benefits and drawbacks of Software Product Line based development, we also observe the limited and informal understanding of how these relations can be considered and exploited. The strongest understanding exists in the area of economic sustainability where metrics and links to business processes are being explored to inform the effectiveness and benefits of the SPL to the company. Far less of an understanding exists about the relation between Software Product Lines and for example environmental and social sustainability. These fall outside the traditional considerations for SPL and, as such, have received less attention from industry and the research community.

We call upon SPL community to explore in detail the relations between SPL and Sustainability to achieve a better understanding of its implications, benefits and drawbacks. From this panel it is clear that SPL can and does contribute to sustainability, and this positive conurbation must be further maximised.

4. REFERENCES

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