# Sustainable Software Systems Engineering

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# Motivation

- Why is it important?
  - Sustainability is a major challenge for our society
  - Software systems are everywhere
- How to define sustainability?
  - The capacity to endure [1]
- What does this mean? [2]
  - Take the dimensions and effects into account
  - Dimensions: individual, social, economic, technical, environmental
  - Effects: direct impact, indirect impact, socio-economic impact
  - Interdependencies exist between these dimensions including tradeoffs that may have to be negotiated for a system under analysis

→How to design sustainable software systems?

→Requirements are the key [2]

[1]
The Oxford Dictionary of English. Oxford University Press, 2010, sustainability.
[2] C. Becker *et al*., "Requirements: The Key to Sustainability," in *IEEE Software*, vol. 33, no. 1, pp. 56-65, Jan.-Feb. 2016.
doi: 10.1109/MS.2015.158

# Sustainable Software Systems Engineering – Sustainability Debt

## Sustainability in Software Systems

- Requirements Engineering
  - Goal Modelling
  - Elicitation Techniques
- Leverage Points
  - Decision Making
- IT-Alignment
  - From Goals to Architecture

## Sustainability by Software Systems

- Business Process Management
  - Modelling
  - Analyse
- S-LCA
  - Modelling
  - Visualising
- Privacy
  - Souverignity

# Research Areas

# Crowd-Focused Semi-Automated Requirements Engineering for Evolution Towards Sustainability

- Prof. Dr. Norbert Seyff
  - Professor of Requirements Engineering (RE) at the FHNW University of Applied Sciences and Arts Northwestern Switzerland and Senior Research Associate at the University of Zurich
- Assoz. Prof. Dr. Iris Groher
  - Associate Professor at the Department of Business Informatics – Software Engineering at the Johannes Kepler University Linz
- Seyff, Betz, Groher et al. : *Crowd-Focused Semi-Automated Requirements Engineering for Evolution Towards Sustainability*, RENext!, International Requirements Engineering Conference (RE) 2018, Banff, Canada, *to appear*

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# Introduction

- For software to endure, it needs to be both useful and adaptable as stakeholders requirements, technology and environments evolve and change over time
- Sustainability requires
  - To consider multiple levels and dimensions of (long-term) effects and affected stakeholders
- Current requirements engineering approaches do not explicitly address sustainability in the evolution of systems

Reasons:

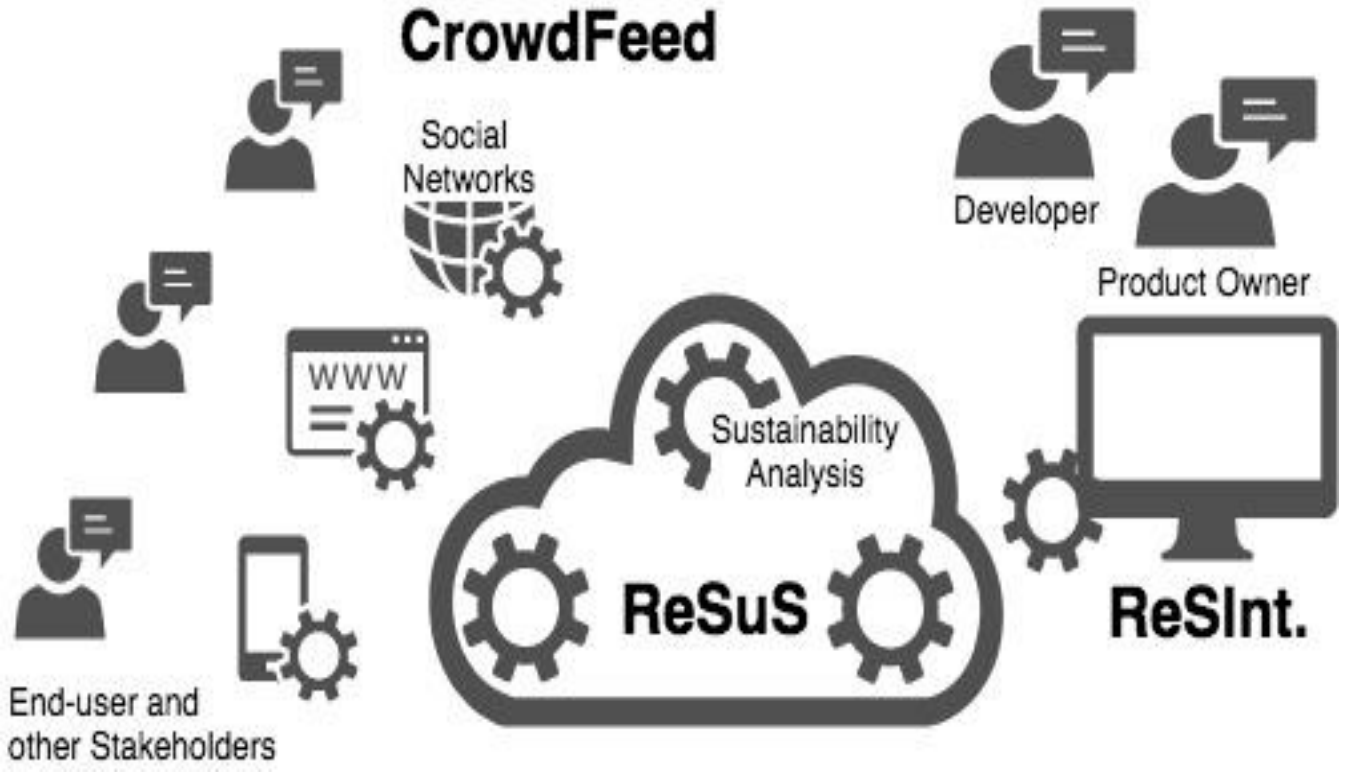
- Lack of awareness
- Lack of shared understanding of the concept of sustainability
- Identifying and analysing the effects of requirements regarding sustainability is challenging

# Idea

- A crowd-focused requirements elicitation, analysis and negotiation approach
- Application of machine learning techniques to derive an understanding of what the sustainability impact of a given requirement is perceived to be
- Vision: The city of Lappeenranta has finished building another smart city quarter…

→ We foresee that this platform will lead to a better understanding of what sustainability is for a given domain and community

# Conceptual Solution



# Crowd Feed

- Stakeholder can provide ideas, problems, and experiences on software systems
  - feedback can include concerns about sustainability
  - Directly and indirect
- Different kind of devices and software can be used
  - App stores
  - Social networks
  - Dedicated feedback tools
- Feedback can be provided
  - Linguistic
  - Non-linguistic
- Feedback can be initiated by
  - The sender (push)
  - The asker (pull)
- The crowd is  actively involved in the prioritisation of a requirement and the discussion about its sustainability impact
- Problems:
  - users may lack motivation
  - feedback acquisition approaches might not consider users' preferences

# Ongoing work

- Investigating end-users' stakeholders'
  - needs (e.g., privacy)
  - preferences (e.g., feedback formats)
  - motives (e.g., social recognition, altruism, power)
- A preliminary survey of 17 participants (end-users)
- Aspects that could increase end-users' willingness to provide feedback
  - a clear statement from the feedback receiver that she is indeed interested in receiving feedback
  - being informed about the feedback status (e.g., under discussion, implemented)
  - collecting points that can be exchanged for other incentives.
- Aspects that could decrease it
  - Collecting points for a competition with other end-users
  - Missing setting to send the feedback "private"
- Currently we are running a more in depth study with 8 participants
- Based on this we plan to
  - Design GUI variants of the *CrowdFeed* component

→ A Solution that addresses the individual preferences and motives of different stakeholders increases the chance to get feedback

# ReSuS

- Feedback is stored  in a Database
  - Together with metadata and context information
- Categorises and analyses feedback
  - Categorisation (e.g., feature request, bug report)
  - Analyses: To identify whether a feedback cluster (i.e., associated feedback that belongs together) potentially has an influence  on sustainability
- Based on:
  - Machine learning
    - Topic modelling will be applied to categorise and cluster the feedback
- Problem:
  - Currently no machine learning approach available analysing the possible impact on sustainability

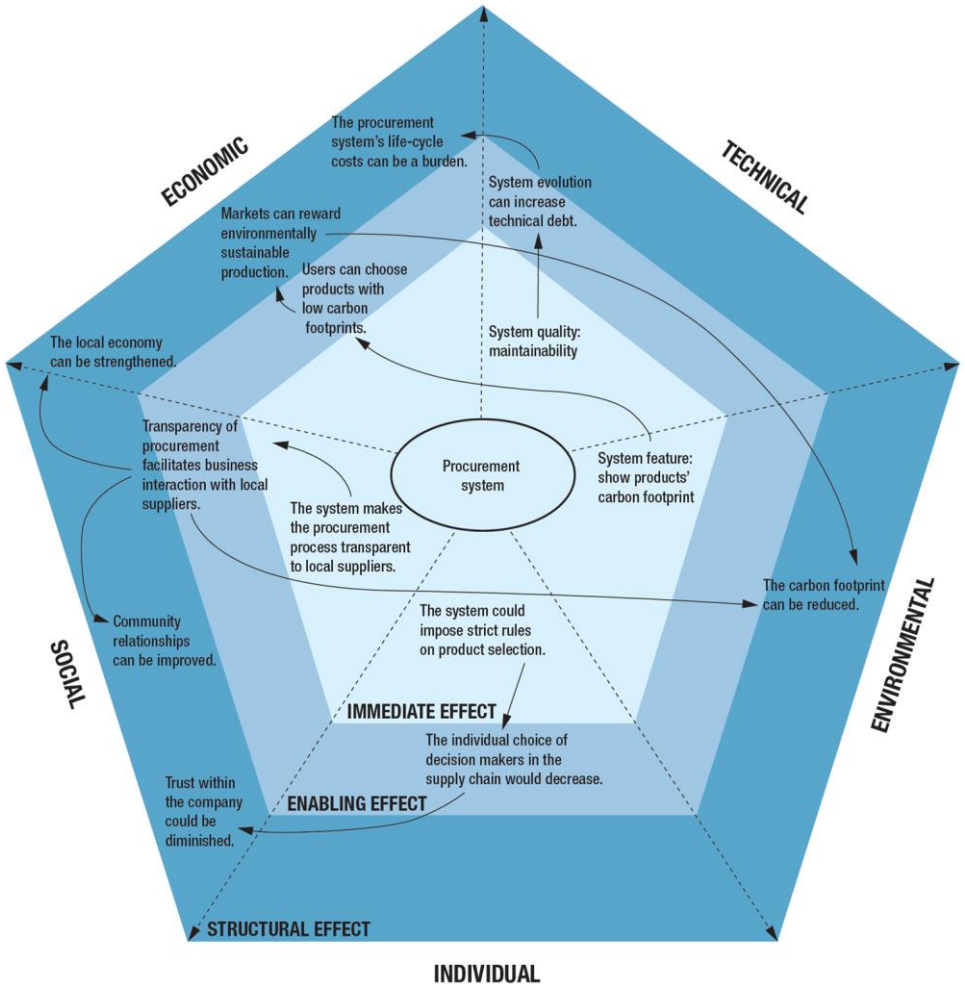
# Ongoing work

- Implemented a web-based prototype for the automatic analysis of natural language requirements sustainability dimensions
- The tool uses multi-label classification
- Sustainability experts can review the suggested classification and either approve it or perform adaptations
  - The algorithm constantly learns
- Initial experiments indicate that the automatic classification as compared to a manual classification was correct in about 75% of all cases

# ReSIntegator

- Combine different views
  - Sustainability dimensions
  - Levels of effect
  - Life cycle
- Decision makers will have the opportunity to
  - Enrich the sustainability analysis
  - Manually assess the possible sustainability effects
  - Calculate the prioritization of the requirements building
- Supports the communication between the crowd and the decision makers
  - Provides information regarding the analyzed input
  - Enables the companies to communicate their prioritizing and their final decisions
  - Decision makers can formulate questions to the crowd
- Problems:
  - Enhance understanding
  - Reduce complexity
  - Quality of analyses results
  - Transparency

# Ongoing work




Becker, C., Betz, S., Chitchyan, R., Duboc, L., Easterbrook, S. M., Penzenstadler, B., ... & Venters, C. C. (2016). Requirements: The key to sustainability. *IEEE Software*, *33*(1), 56-65.

# Social Value Icons

| Icon | Referent | Icon | Referent |
|---|---|---|---|
|  | Freedom of Assoc. |  | Child Labour |
|  | Forced Labour |  | Equal Opport. |
|  | Working Hours |  | Fair Salary |
|  | Health and Safety |  | Social Security |

Betz, Stefanie, Andreas Fritsch, and Andreas Oberweis. "TracyML-A Modeling Language for Social Impacts of Product Life Cycles."

# Social Value Icons

## Test of Assoziativness

| Icon | Referent | HR | FA | Icon | Referent | HR | FA |
|---|---|---|---|---|---|---|---|
|  | Freedom of Assoc. | 91% | 17 |  | Child Labour | 83% | 4 |
|  | Forced Labour | 83% | 1 |  | Equal Opport. | 74% | 0 |
|  | Working Hours | 83% | 1 |  | Fair Salary | 100% | 2 |
|  | Health and Safety | 96% | 1 |  | Social Security | 61% | 5 |

Fritsch, Andreas, and Stefanie Betz. "Evaluation of Social Value Icons for a Domain-Specific Modeling Language." *INFORMATIK 2017* (2017).

# Summary and Outlook

With our approach we want to:

1. Support stakeholders  in iteratively uncovering, evaluating and validating their subtle and maybe hidden concerns regarding the impact of the software product and its requirements on all five sustainability dimensions and levels of effects
2. Allow evaluating and validating these perceptions using an iterative process
3. Learn from the crowd what sustainability is for them
4. Lead to a better understanding and awareness of sustainability

**It is a serious challenge, but let us get started**

# Thank you

- I am very interested in your feedback, always!

- Please contact:

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