3rd International Workshop on Measurement and Metrics for Green and Sustainable Software Systems (MeGSuS'16)
Celebrated within ESEIW 2016
September 7, 2016 - Ciudad Real, Spain

How sustainable are model software artifacts in the context of Model Driven Software Engineering

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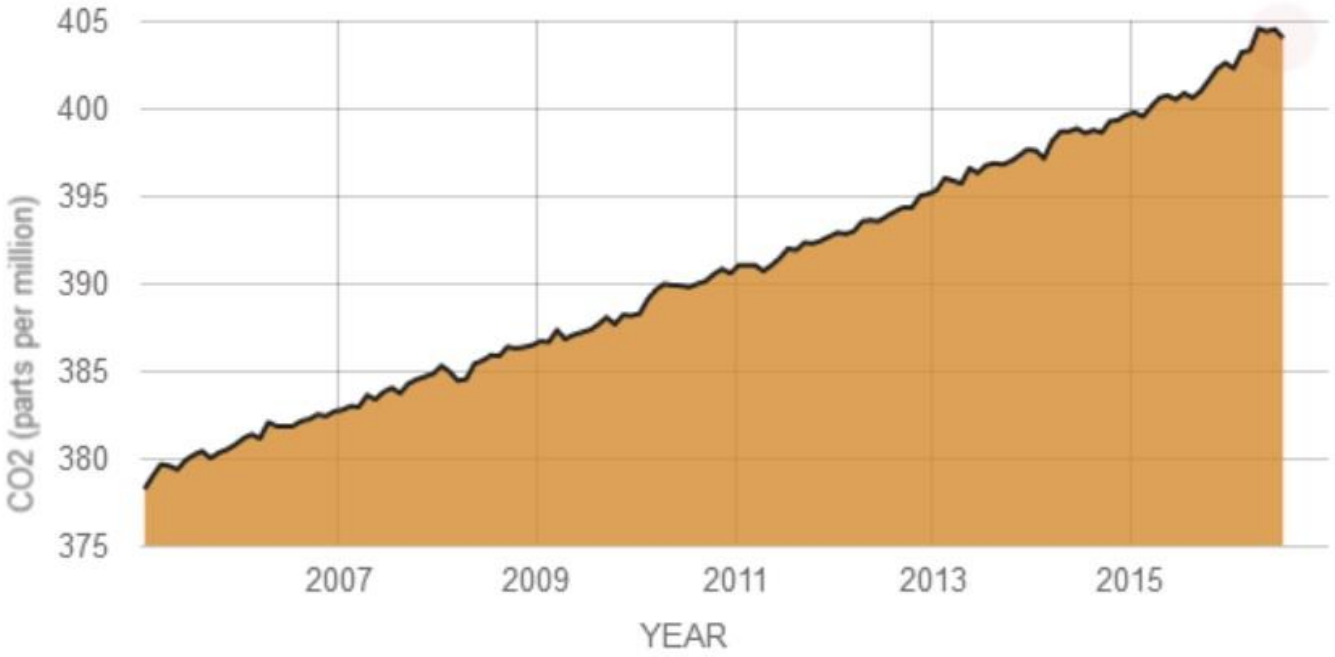
1. Introduction: Why we are here

CO^2 in the atmosphere: 404.48 (06/16) → 403.99 (07/16) ppm



Direct Measurements: 2005-Present. Credit: NOAA

1. Introduction: Software Sustainability

Two categories of Software Sustainability

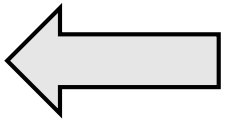
Green BY Software

Software that helps tackle environmental issues (using video conferences, software for car sharing, etc.).

Green IN Software

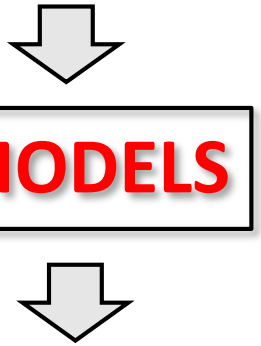
Software itself that is responsible for major environmental degradation (amounts of energy consumed by software engineering processes used to develop the software)

GREEN IN MODELS



1. Introduction: Model Driven Software Engineering (MDSE)

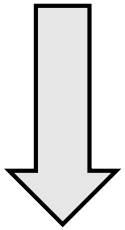
- Software is becoming **increasingly complex** .
- It is **difficult/impossible to test every aspect of system software.**



MDSE: a methodology for applying the advantages of modeling to software engineering activities that includes various model-driven approaches to software development, including **model-driven development** and **model-driven architecture** (MDA).

1. Introduction: Research Goal

The literature on Software Sustainability **proves to be rather chaotic and sometimes inconsistent**



improving the epistemology in the area of MDSE sustainability:

1. by **reshaping existing dimensions** for software sustainability in terms of MDSE;
2. by identifying **8 quality aspects in the context of MDSE.**

2. Related Work

- **Not aware of any proposal dedicated to Green IN models**.

- The workshop entitled **"1st Modelling For Sustainability Workshop" (2016)**. This workshop focused on **Green By Models.** It considered works such as:
    a) a smart city project related to transportation;
    b) an electric vehicles project;
    c) a project related to sustainable agriculture.

3. Reshaping Sustainability Dimensions

UN definition (1987): "**meet the needs of the present without compromising the ability of future generations to satisfy their own needs**". Three dimensions identified:

a. Environmental

a1. Green IN

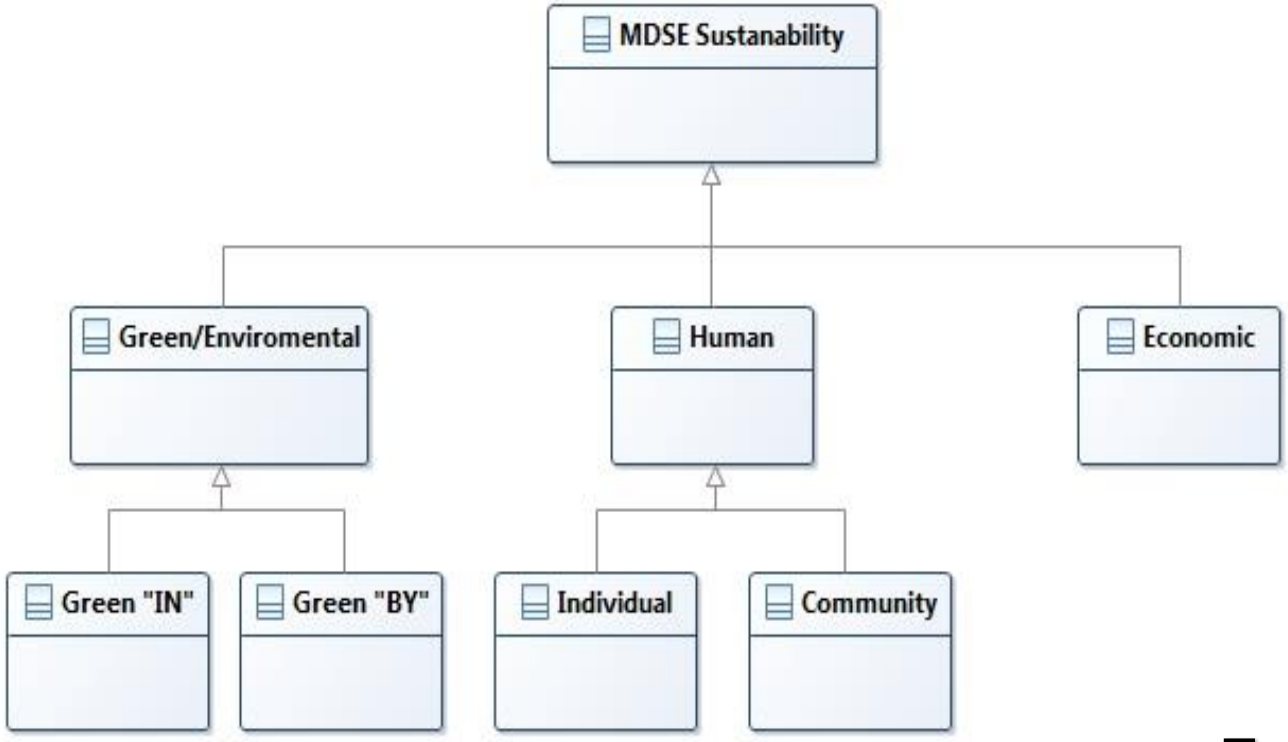
a2. Green BY

b. Society

b1. Individual

b2. Community

c. Economy

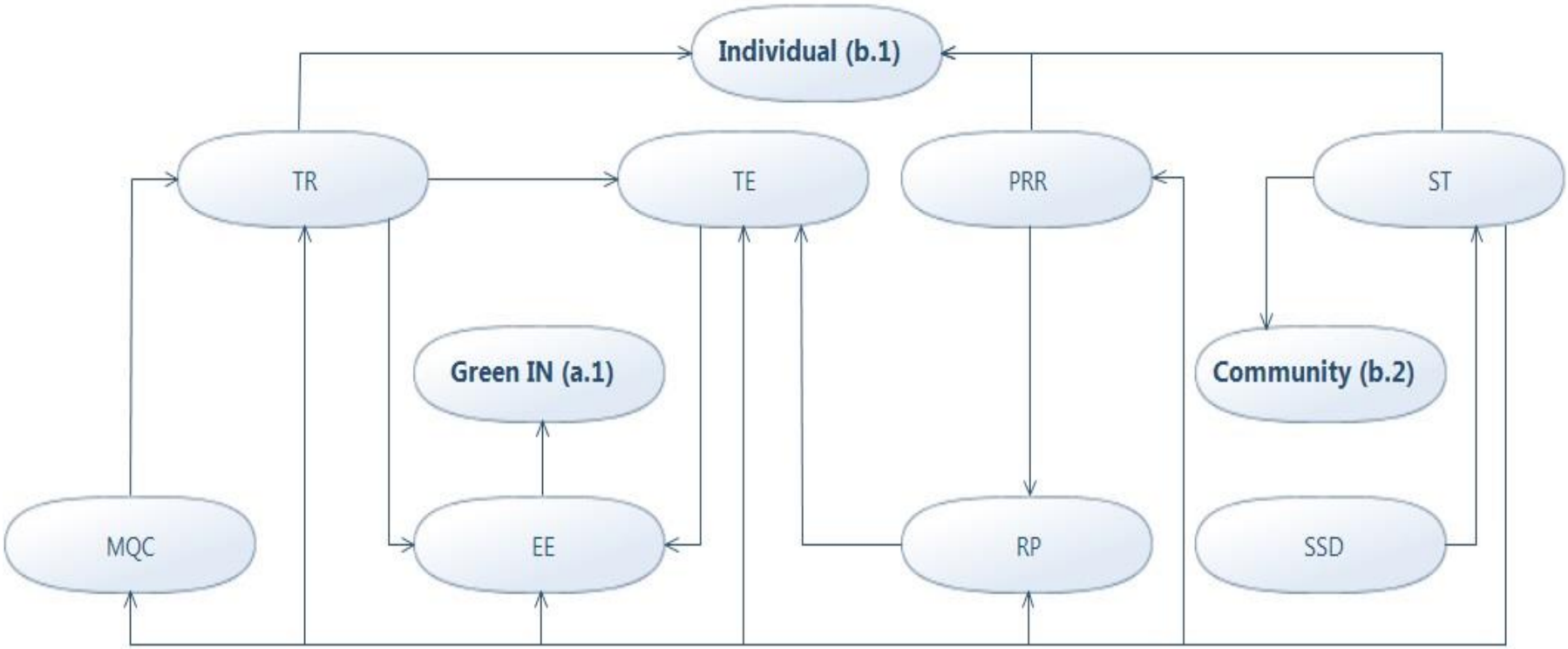


3. Quality Aspects for MDSE Sustainability

Acronym	Quality Aspects
EE	Energy efficiency
TE	Time effectiveness
PRR	Portability and Reuse-Recycling
ST	Standardability
MQC	Model Quality Checkability
RP	Reliability and Perdurability
TR	Transformability
SSD	Software System Dimension

3. Quality Aspects for MDSE Sustainability

Interconnectivity and affect relationships of the quality aspects



3. Quality Aspects for MDSE Sustainability

#	GREEN IN (a.1)
1	SSD→ST→EE→(a.1)
2	SSD→ST→MQC→TR→EE→(a.1)
3	SSD→ST→MQC→TR→TE→EE→(a.1)
4	SSD→ST→TR→EE→(a.1)
5	SSD→ST→TR→TE→EE→(a.1)
6	SSD→ST→TE→EE→(a.1)
7	SSD→ST→RP→TE→EE→(a.1)
8	SSD→ST→PRR→RP→TE→EE→(a.1)

#	INDIVIDUAL (b.1)
9	SSD→ST→MQC→TR→(b.1)
10	SSD→ST→TR→(b.1)
11	SSD→ST→PRR →(b.1)
12	SSD→ST→ (b.1)

#	COMMUNITY (b.2)
13	SSD→ST→ (b.2)

4. Guidelines for MDSE Sustainability

(qa)	Relationships between quality aspects
EE	EE can be identified by considering (not only) the degree of the TE, from how easy is to TR a model software artifact, and by the fact of using or not a model standard (ST).
TE	TE can be identified by considering (not only) the degree of the RP, from how easy is to TR a model software artifact, a and by the fact of using or not a model standard (ST).
TR	The degree of TR can be identified by considering (not only) how easy it is to check the MQC of a model software artifact, and by the fact of using or not a model standard (ST).
PRR	The degree of PRR can be identified by considering (not only) the fact of using or not a model standard (ST).
MQC	The degree of how easy it is to check the MQC can be identified by considering (not only) the fact of using or not a model standard (ST).
RP	The degree of RP can be identified by considering (not only) the fact of using or not a model standard (ST)., and the degree of the PRR.
ST	The fact of using or not a model standard can be decided by considering (not only) the SDD.
SSD	We did not find quality aspects that could affect the SSD.

5. Example

We intend to develop a software system using a MDSE methodology where we want to **design a view of the software describing 100 classes and their relationships (SSD)**. We consider two hypothetical case solutions:

Case 1) It is used MDA as standard of MDSE methodology. UML will be used as modeling language, and the 100 classes and their relationships will be designed with UML class diagrams.

Case 2) It is not used a standard, the 100 classes and their relationships will be designed manually (sketches by hand).

5. Example: Measurement

#	GREEN IN (a.1)
1	SSD→ST→EE→(a.1)
2	SSD→ST→MQC→TR→EE→(a.1)
3	SSD→ST→MQC→TR→TE→EE→(a.1)

#	Case 1	Case 2
1	The fact that we use UML (ST), will require more energy for the process of model software artifacts development (EE) (than in the Case 2).	The fact that we represent manually (not using any specific ST) the 100 classes (SSD), will require no electrical energy for the design of the models (made by hand) (EE).
2	The fact that we use UML (ST), it could help the process of checking (e.g. by OCL in UML) the quality (MQC) of the 100 classes (SSD). The improvement of the quality of	The fact that we represent manually (not using any specific ST) the 100 classes (SSD), it could affect negatively the process of checking the quality (MQC) of the software model artifact under development. The possible decrease
3	models could also help the process of the transformation (TR) of the models to the code (that could be done automatically or semi-automatically). All these factors could result in reducing the time spent modeling and coding (TE) which could require less energy for the process of model software artifacts development (EE). This could finally lead to reduce the depletion of electrical energy (a.1).	of the quality of models could also negatively affect the process of the transformation (TR) of the models to the code (that has to be done manually). All these factors could result in increasing the time spent modeling and coding (TE), which, on one hand, will require no electrical energy for the design of the models (made by hand); on the other hand, due to the missing of the benefits related to using a ST, the MQC, and the TR, will probably require more electrical energy (than in the Case 1) for the coding phase (EE and then a.1).

5. Example: Results

- If we know that the system under development will not need to be implemented in an actual software, **we would not be interested in considering quality aspects such as PRR, MQC, RP and TR**; in this context, the Case 2 solution may be considered more sustainable than Case 1.

- If we focus on all the quality aspects presented earlier, the Case 1 solution may be considered more sustainable than the Case 2 solution.

6. Conclusion and Future Work

Presented in this work:

- **reshaping of existing dimensions** for software sustainability and MDSE, **in terms of MDSE sustainability**;
- **8 quality aspects, the graph with the affect relationships,** and the paths to measure the sustainability of model artifacts in the context of MDSE;
- **set of guidelines to obtain the 8 quality aspects**;

6. Conclusion and Future Work

- Developing a **survey in the MDSE community** to see **how models are seen according to the sustainability dimensions and quality aspects** identified in this paper.

- Developing a consolidated and valid **set of guidelines in the context of MDSE sustainability**.

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