SOFTEAM Think Object Research Team

A Learning based approach for Green Software Measurements

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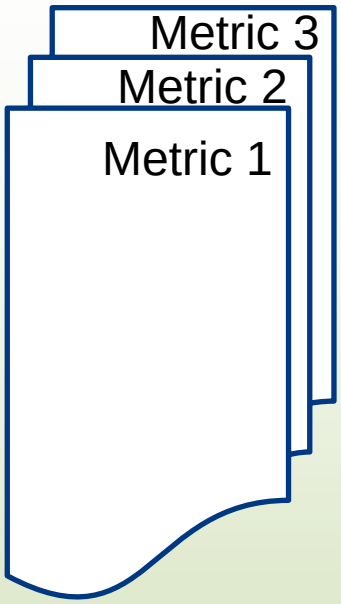
Plan

- Context
- State of art
- Problematics
- Motivations
- Our approach
- Framework & Experiments
- Conclusion & Perspectives

Context

- **Software measurement**
  - Greater marketing of software
  - More complex systems
  - High demand for adapted measurement
  - Current metrics are no longer adapted
  - Sequential measurement
  - Lots of data to analyze

Context - Current measurement processes

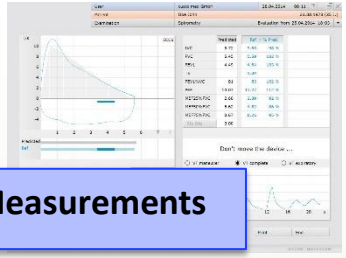


Measures 1

Measures 2

Measures 3

Software Measurand



Measurements

State of art

- **Standardized metric (ISO/IEC9126)** [ISO/IEC 9126-1, 2001]
- **Green metric**
  - Method to measure energy consumption of Java-based SW [J. Rocheteau et al,2014]
  - Conceptual framework for estimating SW energy consumption [L. Ardito, G. Procaccianti, et al., 2015]
  - Greenability extension to a standardized quality model [C.Calero, M.A.Moraga, M.F.Bertoa and L.Duboc, 2014]
  - Green software metric survey [P.Bozzelli, Q.Gu And P.Lago, 2013]

➔Not modeled and are only method for estimating

- **Machine Learning approach for SW defect prediction** [I.H. Laradji et al. 2015, - M. Monperrus, et al., 2011]

➔Not on green measurement

Problematics

- **Constraint analysis ➔ depends on experts**
- **Sequential measurements**
  - Determined at the beginning
  - Post-measurement process analysis
  - Difficulties to find out the failure causes
- **Process heavy and expensive for effective and quality measurement**
  - So high ressources necessary for effective and quality measurement (Experts, time)

Motivations

- **To formally specify metrics**
  - Using common standards
- **An advanced analysis**
  - Machine learning – results classifications
- **A relevant suspicious failure detection**
  - Metric recommendation
  - @Runtime

Metrics designing and modeling

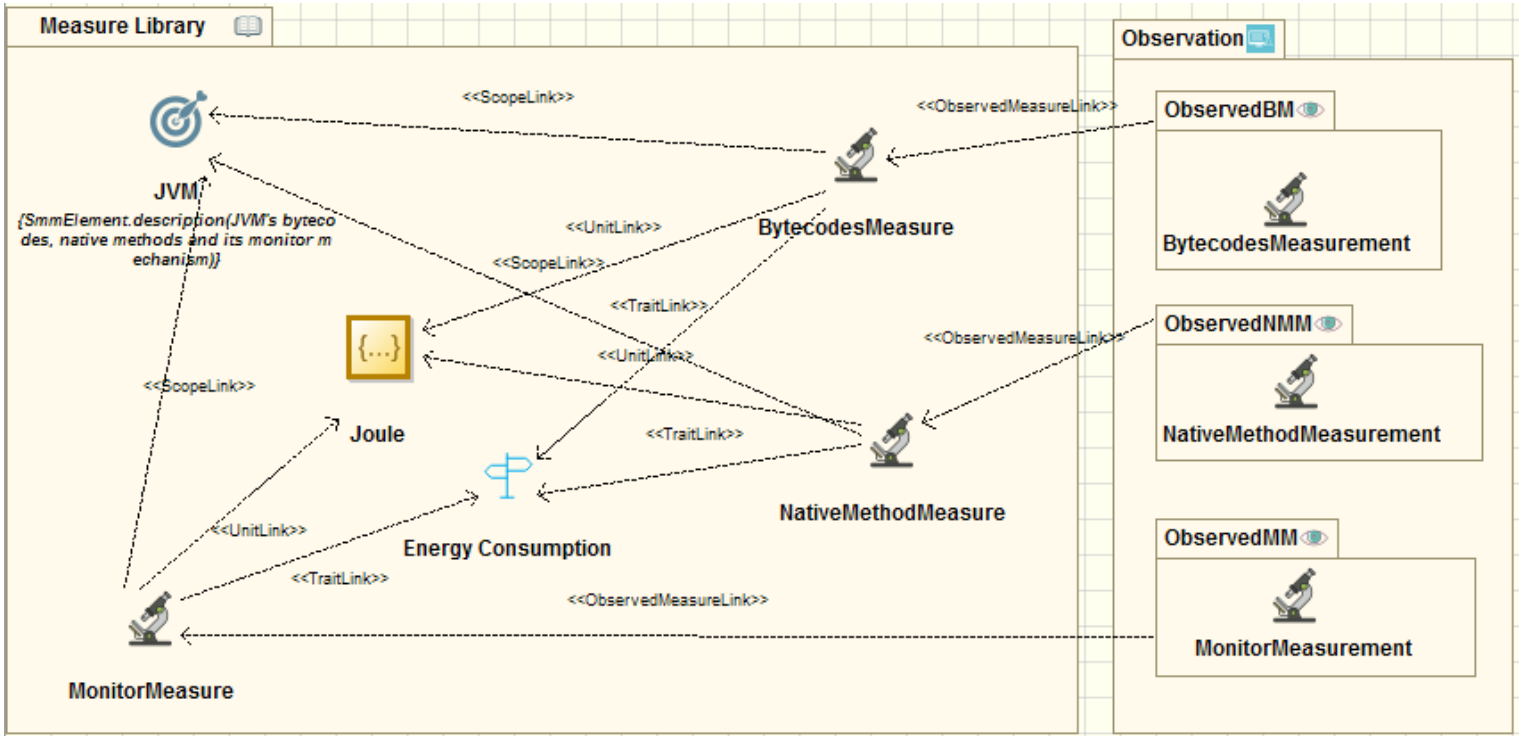
- **Structured Metric Meta-model (SMM)** [1]
  - OMG standard 

  - Meta-model to specify a metric
  - ➔ Formal metric, interchange format, interoperability
- **Modelio** [2] MODELIOSOFT
  - Open source modeling tool
  - Based on UML
  - Supports several OMG's standard : SysML, MARTE …
  - Extendable through module as SMM

[1] http://www.omg.org/spec/SMM/1.1/
[2] https://www.modelio.org/

Example - Green Metric Modeling

The Computational Energy Cost Metric modeled in SMM with Modelio [1]



[1] C. Seo, S. Malek, and N.Medvidovic. Estimating the Energy the Energy Consumption in Pervasive Java-based Systems. In Proc. of the IEEE International Conference on Pervasive Computing and Communications, PERCOM'08, USA, 2008

A Learning approach

- **Advanced analysis**
  - Based on Machine Learning
- **Relevant analysis interpretation**
  - Adjustable measurement cycle
- **In continuous**
  - During the measurement process

Advanced analysis

- **Support Vector Machine (SVM)** [1]
  - Supervised learning technique
  - Classify a data sample
  - From a learning data set
  - Through a linear hyperplan
  - Supports big data

➔ **Still requires (too) many resources (experts, time, datasets …)**

[1] CHAPELLE, Olivier. Training a support vector machine in the primal. *Neural computation*, 2007, vol. 19, no 5, p. 1155-1178.

Advanced analysis

- **Semi Supervised Learning algorithm**
  - Learning on set of data labeled
  - Training on set of data unlabeled
  - Smart analysis during measurement process

➔ **Effective and independent measurements sorting**

- **Existing algorithms**
  - Self-training, Co-training, S3VM …[1]
- **S3VM** [2]
  - Based on SVM
  - Add two constraints to each point of working set
  - To minimize the misclassification error

[1] Zhu, X. (2007). Semi-Supervised Learning Literature Survey. *Sciences-New York*, 1–59. http://doi.org/10.1.1.146.2352

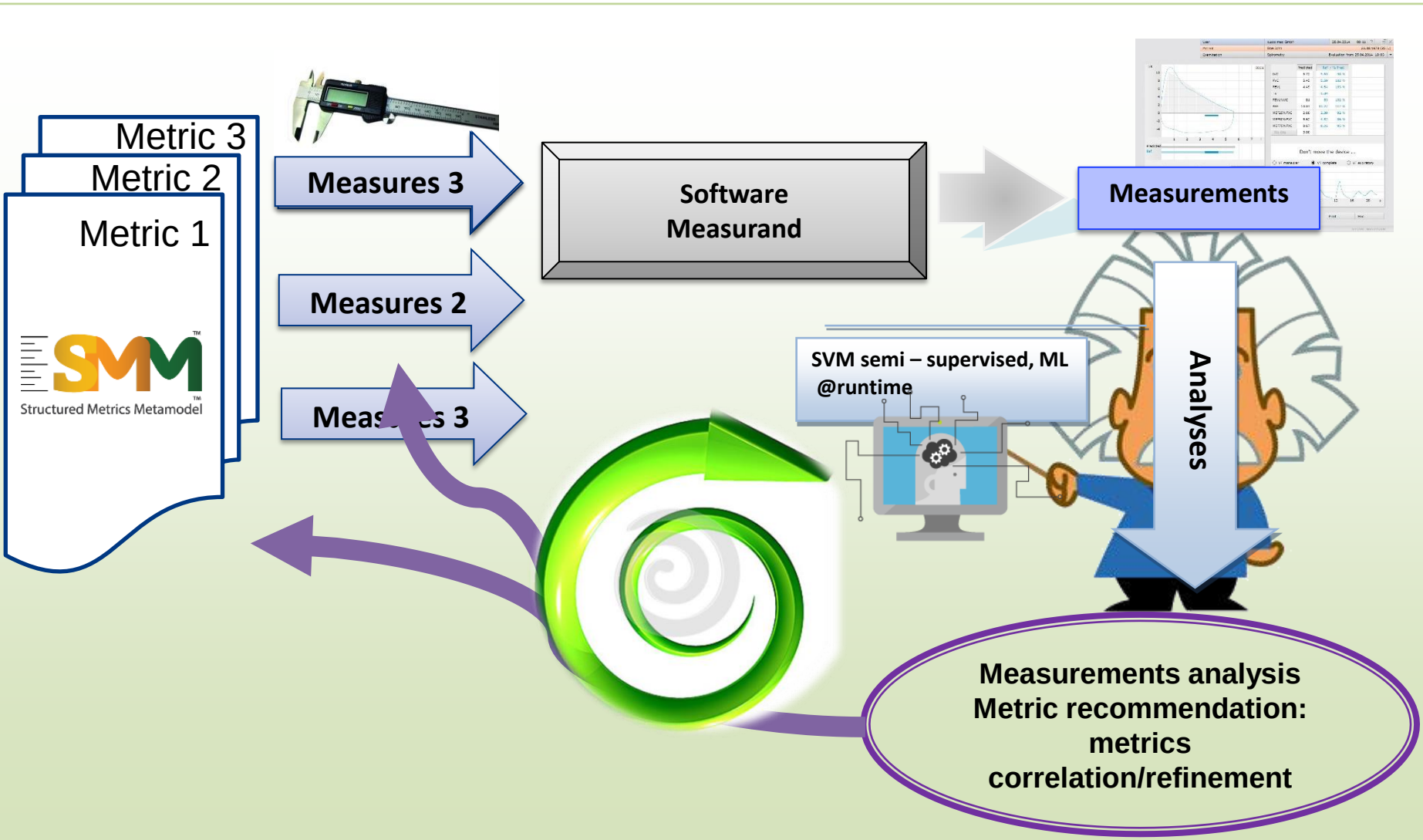
[2] K. Bennett, A. Demiriz et al., Semi-supervised support vector machines. Advances in Neural Inf. processing systems, 1999

An efficient failure detection process

- **Measurement interpretation**
  - Determinates the suspicious trait to an analysis
  - Related to determined measures pivots
- **Efficient metric recommendation**
  - Associates a measure to an existing metric(s)
  - Or a new metric from metrics correlation

  ➔ model of metric correlation
- **Readjustment of the measurement cycle**
  - The recommended metric(s) becomes the next metric

Our framework



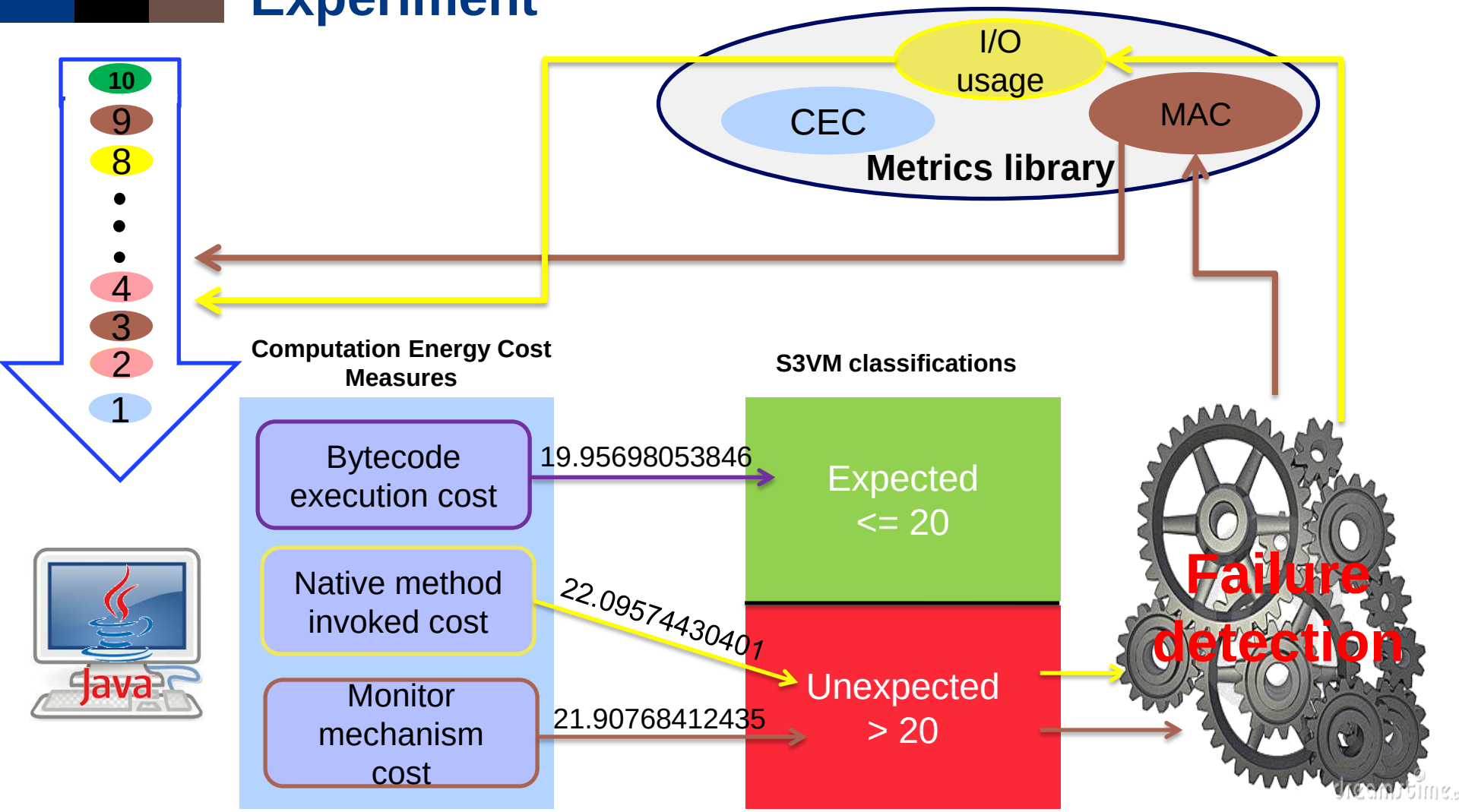
Experiment - context

- **Executed metric context**
  - Computational Energy Cost (CEC) metric
  - Java-based software

- **Computes :**
  - JVM bytecode execution cost
  - JVM native method invoked cost (NM)
    - depends on I/O usage cost
  - JVM monitor mechanism cost (MM)
    - depends on data memory access cost

- **I/O usage metric is associated to NM measure**
- **Memory Access Count is associated to MM measure**

Experiment


10
9
8
4
3
2
1
I/O usage
CEC
MAC
Metrics library
Computation Energy Cost Measures
S3VM classifications
Bytecode execution cost
19.95698053846
Native method invoked cost
22.09574430401
Monitor mechanism cost
21.90768412435
Expected <= 20
Unexpected > 20
Failure detection
Java

ITEA3

- **European project**  **MEASURE**
  - Measuring Software Engineering
    - Increase the quality and efficiency
    - reduce the costs and time-to-market

Conclusion & Perspective

- **Easier usage metrics**
  - Model metrics in OMG SMM format
- **Independent measurement process**
  - Learning measurement analysis
- **Adjustable measurement process**
  - Efficient failure detection
  - @runtime in continuous way

➔**Two green contributions : green metrics & the measurement process**

- **Learning analysis**
  - To define the datasets
- **Metrics recommendation algorithm**
  - To define measure pivots
  - To define the link between metrics and measures

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- OMG, Structured Metrics Meta-model (SMM), version 1.1.1, http://www.omg.org/spec/SMM/1.1.1/, April 2016
- ITEA3 MEASURE project, http://measure.softeam-rd.eu/, 2015

Thank you for your attention

Questions ??