Formalizing Process Assessment and Capability Determination: An Ontology Approach

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Problem Background

- Software Process Assessment boosts a wide range of Process Assessment Models (PAMs) such as;
  - ISO/IEC 15504-5 (ISO/IEC 33061)
  - CMMI
  - Automotive SPICE
- These models rely on conventional methods of evidence collection to rate process attributes and determine the capability level of the assessed process.
- Conventional methods are however, subjective, time consuming and prone to errors.

Some Solutions

- Use of ontologies – Proena & Borbinha (2017)
- Virtualising Process assessments – Shrestha et al. (2015)
- Use of safety-oriented process line engineering with defeasible logic- Ardila & Gallina (2017)
- Challenges
  - Formalizing PA rating is not addressed in the current approaches,
  - PA rating is a knowledge intensive process that it is manual, subjective and tedious process

Our earlier Work

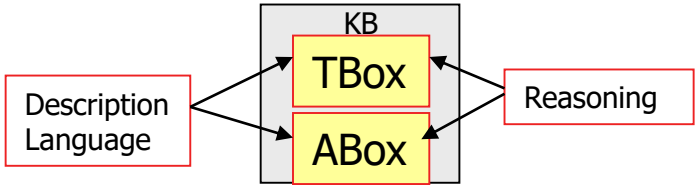
- Axiom based Metamodel for Software Process Formalization. SPICE (2017);
  - Provision of uniform concepts for software process formalization
- Ensuring Conformance to Process Standards through Formal Verification. SPICE(2018);
  - Considered only the process dimension of PAM – Capability Level I (Process outcomes characterizations)

Proposed Approach

- We build on the Capability Level I formalization (SPICE 2018);
  - To develop a three-step Capability Level determination Formalization Approach;
    1. PA Outcome characterizations - Use of DL axioms.
    2. We leverage the PA Outcomes achieved to derive the PA rating automatically.
    3. The PA ratings are used to automatically derive the Capability Level of the assessed process instance.
  - We demonstrate the feasibility of our approach using PA2.1 of Capability Level II for software requirements analysis process

Ontologies as formal models

- Ontology approaches are an application of formal methods into the semantic web where web resources are formally specified
- Description Logics (DLs) based ontologies are accepted as an important means for representing and formalizing knowledge
- DLs are a rich and flexible modeling language that underpins the web ontology language (OWL); a W3C standard for developing ontologies in the semantic web.
- DLs come with an unambiguous, standardized semantics and a wide range of tools such as *Protege* that are used to develop, visualize and store formal models
- OWL DL ontologies are composed of the TBox (class level) & ABox (instance level)
    - Standard Process is coded as TBox
    - Process instance is coded as ABox
- DLs are supported by a variety of optimized inference engines such as *Pellet* that can be utilized to support both process compliance and deriving capability levels



PAM Capability Dimension

- The capability dimension relates to assessment indicators (ISO/IEC 15504-5) & measurement framework (ISO/IEC 33020)
- PA ratings are grouped under capability levels

PA2.1 Performance management attribute

No	Process attribute outcome
PA2.1a	Objectives for the performance of the process are identified
PA2.1b	Performance of the process is planned and monitored
PA2.1c	Performance of the process is adjusted to meet the plans
PA2.1d	Responsibilities and authorities for performing the process are defined, assigned and communicated
PA2.1e	Resources and information necessary for performing the process are identified, made available, allocated and used
PA2.1f	Interfaces between the involved parties are managed to ensure both effective communication and also clear assignment of responsibility

PA Outcomes Characterization - DL Axioms (TBox)

- ISO/IEC 15504-5 specifies GP, GR and availability of GWP to achieve the PA outcomes
- However, there is no guarantee that individual PA outcomes are being achieved. To overcome this situation,
  - We extract the process requirements from the standard documents in form of if…then statements made up of 4 major components; GP, GR, GWP and process outcomes that are translated into DL axioms.
  - If a GR and GP are implemented and evidenced by a GWP then a related PA outcome is achieved.
  - These are illustrated with a set of PA 2.1 outcomes

PA Outcomes Characterization - DL Axioms (TBox) Cont

1. If the objectives for the performance of the process are identified and assigned to human resources (HR) and recorded in a plan, then process attribute outcome (PA 2.1a) is achieved.

$$PA2.1 \sqcap \forall hasProcessPerformance.\forall hasObjectives.(Identified \sqcap \exists recordedIn.Plan \sqcap \exists assignedTo.HR) \sqsubseteq \exists achieve.\{PA2.1a\}$$

2. If the performance of the process is planned and monitored, assigned to project planning management and control tools (PPMCT) and recorded in a plan, then process attribute outcome (PA2.1b) is achieved.

$$PA2.1 \sqcap \forall hasProcessPerformance.(Planned \sqcap Monitored \sqcap \exists recordedIn.Plan \sqcap \exists assignedTo.PPMCT) \sqsubseteq \exists achieve.\{PA2.1b\}$$

Achievement of Process Outcomes – PA2.1

PA2.1 has six outcomes, the rating scheme can be defined as:

$$\frac{PAOutcomesAchieved}{PAOutcomes} * 100\%$$

PA2.1 Performance Management Attribute Rating Scheme

PA outcomes achieved	PA outcomes achieved %	ISO/IEC 33020	Rate
0	0	$0- \leqslant 15\%$	N
1	16.7%	$> 15\%- \leqslant 50\%$	P
2	33.3%	$> 15\%- \leqslant 50\%$	P
3	50%	$> 15\%- \leqslant 50\%$	P
4	66.7%	$> 50\%- \leqslant 85\%$	L
5	83.3%	$> 50\%- \leqslant 85\%$	L
6	100%	$> 85\%- \leqslant 100\%$	F

Formalizing Capability Level Determination

- ISO/IEC 15504-2 General Rule.
  - *A Process instance is defined to be at a Capability Level k satisfy the rating 'F' and the level k attributes are rated as 'F' or 'L'. If a process instance achieves a rating 'F' and its attributes are rated as 'F' or 'L', then it achieves capability level k.*

$$CapabilityLevelOne \equiv SRAProcess \sqcap (LargellyAchieved \sqcup FullyAchieved)$$

$$\begin{aligned} CapabilityLevelTwo \equiv SRAProcess \sqcap FullyAchieved \\ \sqcap \exists hasProcessAttribute \cdot (PA2.1 \sqcap (PA21\_LargellyAchieved \\ \sqcup PA21\_FullyAchieved)) \sqcap \exists hasProcessAttribute \cdot (PA2.2 \\ \sqcap (PA22\_LargellyAchieved \sqcup PA22\_FullyAchieved)) \end{aligned}$$

Case Study - SwiftCom

- The case study is about ISO/IEC 29110 compliant website development and adapted from Laporte et al 2014.
- We specifically look at the software requirements analysis process.
- This case study provides the software requirements analysis process instance that we code as the DL ABox
- We evaluate the case study evidence to rate the PA2.1 to derive the capability level for the case study.

Summary of SwiftCom SRA process terminology

SwiftCom concepts	ABox concepts
Software requirements analysis process	SRA001
Software requirements	SR001
Software requirements specification	SRS001
Requirements examples	req001 and req002
Testing criteria	CT001
Testing report	TR001
Swift clients	clients001
Project progress report	PPR001
Change requests	CR001
Meeting record	MR001
PA2.1	PA2.1s
RMM	Apache subversion SVN
Project plan	PP001
Process performance	PPerformance

Summary of SwiftCom SRA process evidence for PA2.1

Outcomes	SwiftCom SRA process evidence
PA2.1a	Objectives were identified and recorded in a project plan
PA2.1b	The process was planned and monitored on a monthly basis with progress reports
PA2.1c	Several requirements were adjusted after the analysis phase to meet the plan
PA2.1d	Roles were assigned to the stakeholders and documented in the project plan
PA2.1e	Various open sources tools were used such as SVN
PA2.1f	Assignment of roles was done and documented in the project plan, progress reports were also discussed in the monthly progress meetings

Case Study Evaluation

- This case study was implemented using Protege and evaluated using a set of competency questions in the table below.

No	Competency questions
Q1	What are the PA2.1 outcomes achieved by PA2.1s (SRA001)?
Q2	What is the rating of PA2.1s?
Q3	Does SRA001 achieve capability level Two?

PA2.1s outcomes achieved, rating and capability level for SRA001