Collective Intelligence-Based Quality Assurance: Combining Inspection and Risk Assessment to Support Process Improvement in Multi-Disciplinary Engineering

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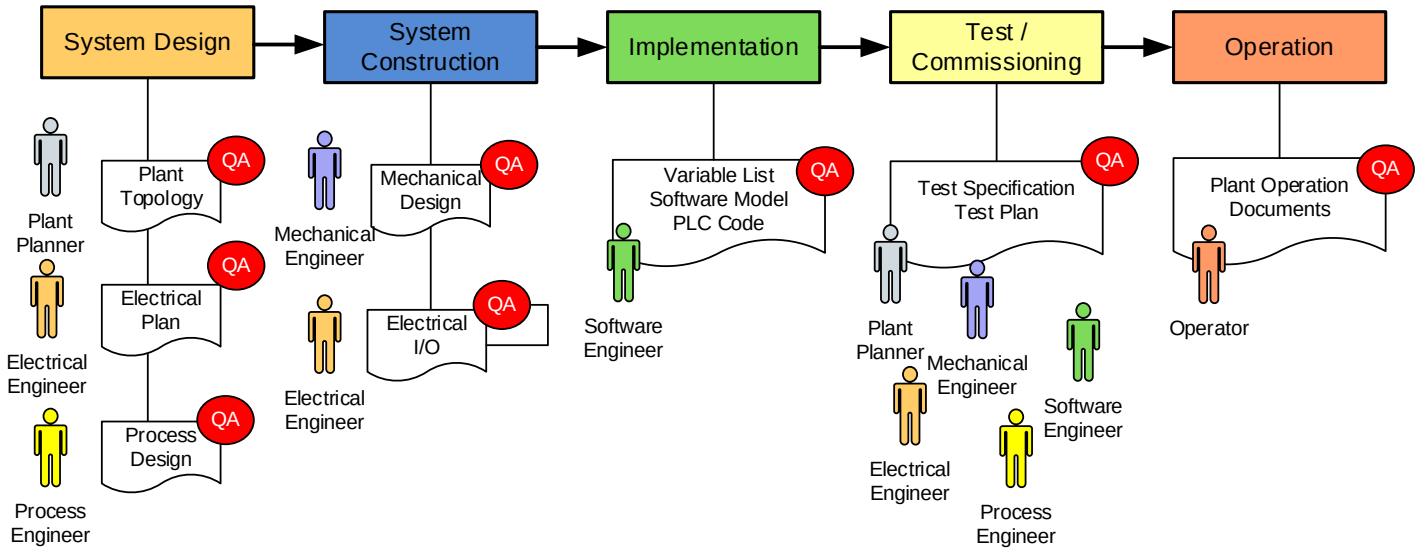
Motivation & Goals

Context:

- Multi-Disciplinary Engineering, such as steel mills or manufacturing facilities.
- Isolated Quality Assurance Method applications (e.g., Inspection, FMEA).
- Isolated and limited explicit and reusable engineering knowledge across methods and engineering phases (implicit knowledge is embodied by human experts).

Goals:

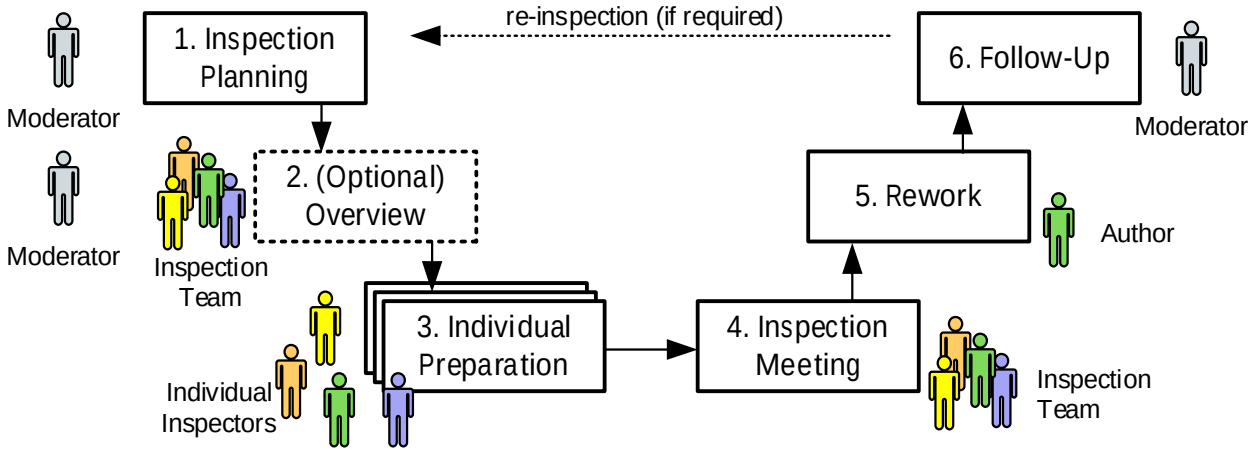
- Process for making implicit available knowledge usable for reuse.
- Concept for combining inspection and the FMEA with collective intelligence support.



Related Work

Software Reviews / Inspection

- Focus on Software Engineering.
- Formal and structured process approach to identify defect early and efficient in Software Engineering artefacts.



- Guidelines and reading techniques, e.g., perspectives or scenarios.
- Implicit Engineering Knowledge is available (human experts).
- Limited tool support for inspection, e.g., Paper-Based, Gerrit Code Review or DefectRadar, but no tool support for organizing / reusing engineering knowledge.

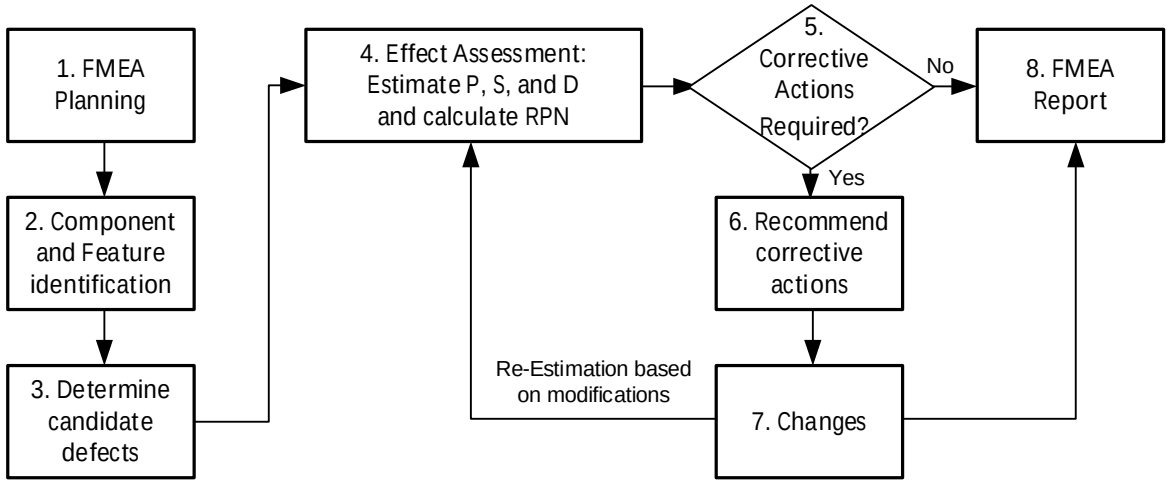
gerrit
Gerrit Code Review

DefectRadar

Related Work

Failure Mode and Effect Analysis (FMEA)

- Focus mainly on Systems Engineering.
- Early Risk Assessment and Risk Avoidance (risk-priority-numbers and corrective actions).
- Implicit Engineering Knowledge is available (human experts).



- Individual Tools are available that follow the FMEA process in a specific domain.
- However, very limited support of engineering knowledge across tools and disciplines.

Challenge: How to capture and reuse engineering knowledge based on available implicit expert knowledge or isolated tool data?

Research Issues

Goal

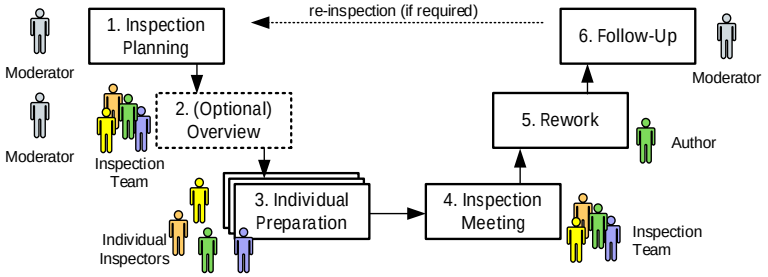
§ Process approach to bridge the gap between methods and tools to reuse engineering knowledge: Knowledge collection, aggregation, and reuse.

Research Issues

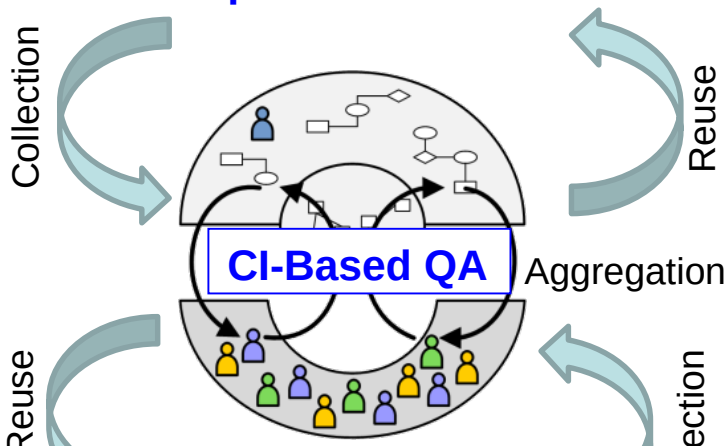
§ RI-1. How can a collective intelligence-based quality assurance *(CI-based QA)* approach support process improvement in MDE from a process perspective?

§ RI-2. What capabilities are required to enable CI-based QA for Inspection and the FMEA?

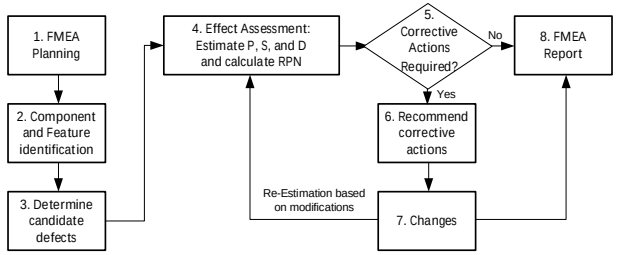
- Process and tool capabilities.
- Requirements for tool development and evaluation.



Inspection Process



FMEA Process



Examples for prominent Collective Intelligence Systems:

Needs and required Tool Capabilities

Core goal of Isolated Methods under Investigation:

- Inspection: early, effective, and efficient defect detection.
- FMEA: early risk assessment.

Needs and required tool capabilities for *CI-based QA*
(derived from research & industry experts)

- **Defect Detection Performance**
  - Support for effective and efficient defect detection early in the engineering process.
  - Immediate improvements of artifacts and engineering plans already after application of isolated methods.
- **Risk Assessment**
  - Systematic and traceable risk assessment and quality assurance processes.
  - Defined responsibilities and roles for method application.
  - Guidance of less-experienced team members during method application.
- **Reuse of Experience and Tool Support**
  - Reuse of experiences and knowledge from method application for engineering process improvement.
  - Inspection/FMEA tool support.

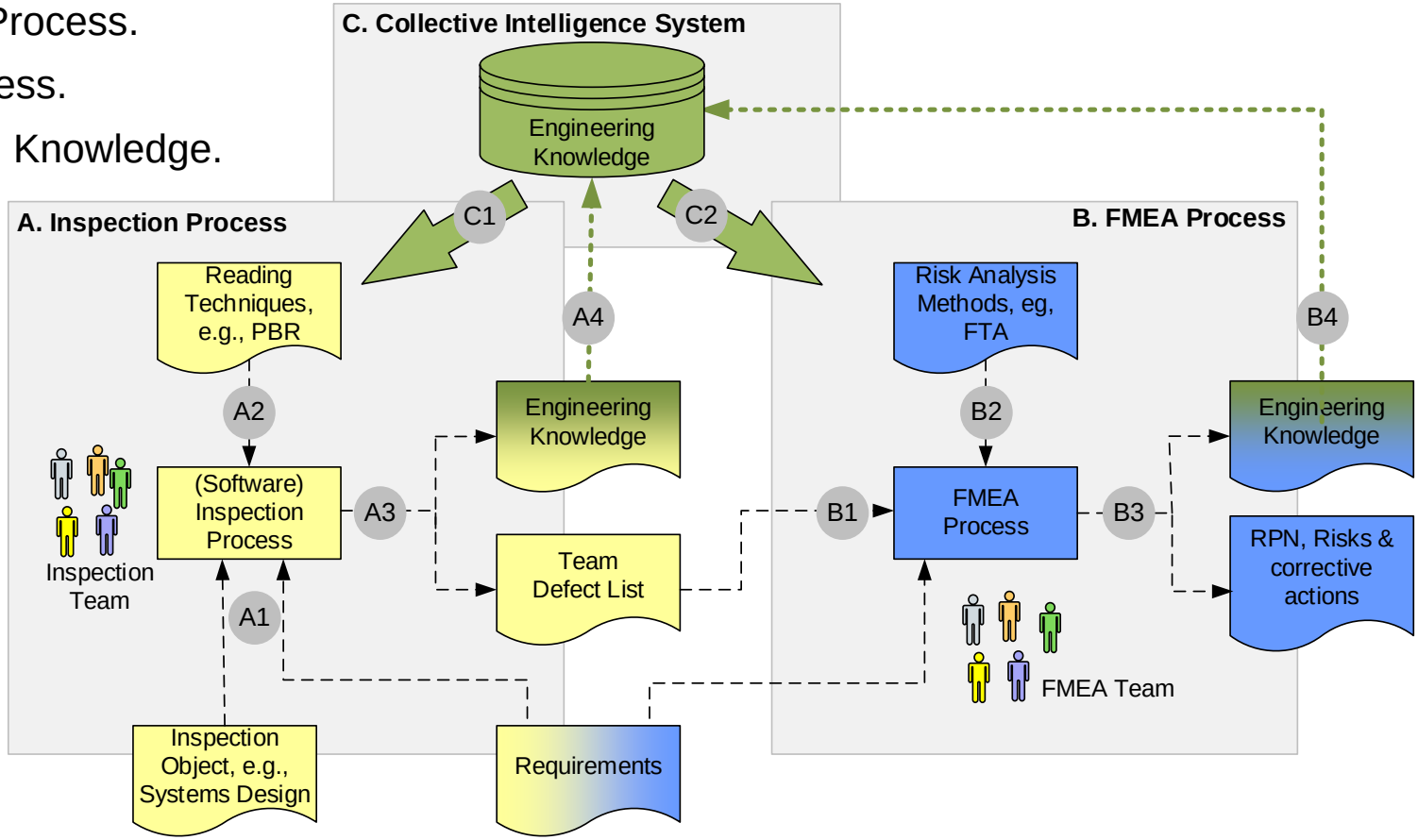
Combining Inspection & FMEA from Process Perspective

§ Combined Inspection and FMEA process bridged with a Collective Intelligence System (CI-based QA) with input/output artefacts.

(A) Inspection Process.

(B) FMEA Process.

(C) Engineering Knowledge.

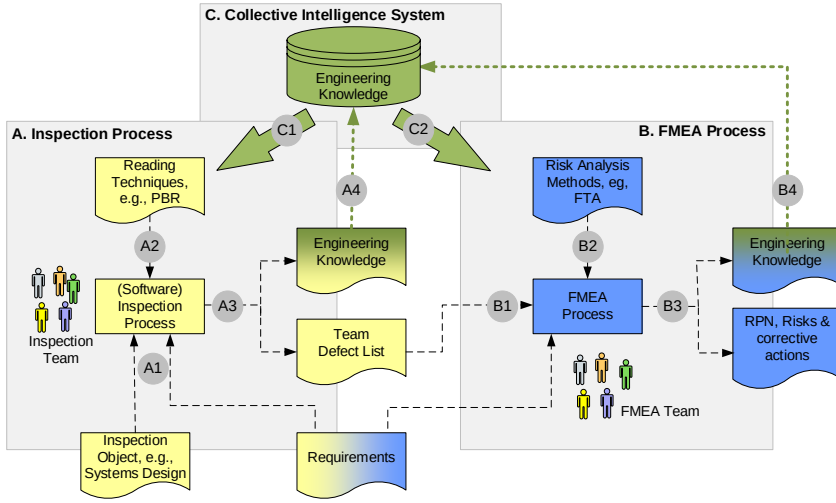


7 A*, B*, and C* represent inputs and outputs to / from individual and important process steps

Improvement Capabilities

Isolated Artefact Improvements (as it is)

- Defect Detection with traditional inspection process steps (Ax).
- Risk assessment with the traditional FMEA approach (Bx).



Artefact Improvement of Method Combinations

- Team defect lists (output of inspection) can improve the risk assessment based on real-world defects (Ax and Bx).

Improvement of Inspection / FMEA Methodology

- Inspection improvement based on lessons learned from Inspection Application (Ax, C1).
- FMEA improvement based on lessons learned from FMEA Application (Bx, C2).
- Combined and cross-method benefits arise from reusing and generalizing engineering knowledge as a foundation for method improvement (A4/B4 à C1/C2)

Conceptual Evaluation

- Derived from discussions with research and industry experts.
- Traditional inspection and FMEA processes and the CI-based QA process approach.

Needs and Capabilities	Inspection	FMEA	CI-Based QA
Defect Detection Performance			
+ Effective and efficient **defect detection**	++	--	++
+ Effective and efficient **risk assessment**	o	++	++
Risk Assessment			
+ Systematic quality assurance	o	o	++
+ Traceable results	o	o	++
+ Defined **roles and responsibilities**	o	o	o
+ Guidelines for method application (methodological support)	o	o	++
Reuse of Experience and Tool Support for Engineering Process Improvement			
+ Reuse of Experiences and Knowledge	--	--	++
+ Immediate **artifact improvements**	o	o	++
+ Tool support*	o	o	--
+ Implementation/Application Effort	o	o	o

Legend: ++ strong support, o neutral support, weak support

* Tool support & prototype solution of the CI-based QA approach is currently under development.

Summary and Future Work

Summary

- On process level, the goal was to bridge the gap between isolated and limited explicit engineering knowledge that hinder efficient reuse.
- *A CI-based QA* process approach is reasonable to bundle benefits of different (isolated) QA methods, such as Inspection and the FMEA (RI-1).
- Based on expert discussion we elicited key capabilities and fundamental requirements for *CI-based QA* (RI-2) and initially evaluated these key capabilities with the conceptual process prototype.

Limitations

- Initial conceptual evaluation on process level for two selected QA approaches.
- Collective intelligence systems have been considered as black-box with expected key capabilities.
- Currently no fully-featured CI System available (currently under development).

Future Work

- Definition of a collective intelligence system that is capable of supporting key capabilities.
- Implementation and evaluation of the *CI-based QA* approach.
- Empirical evaluations also in larger industry context.

Thank you ...

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