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Incremental Process Modeling through Stakeholder-based Hybrid Process Simulation

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Contributions

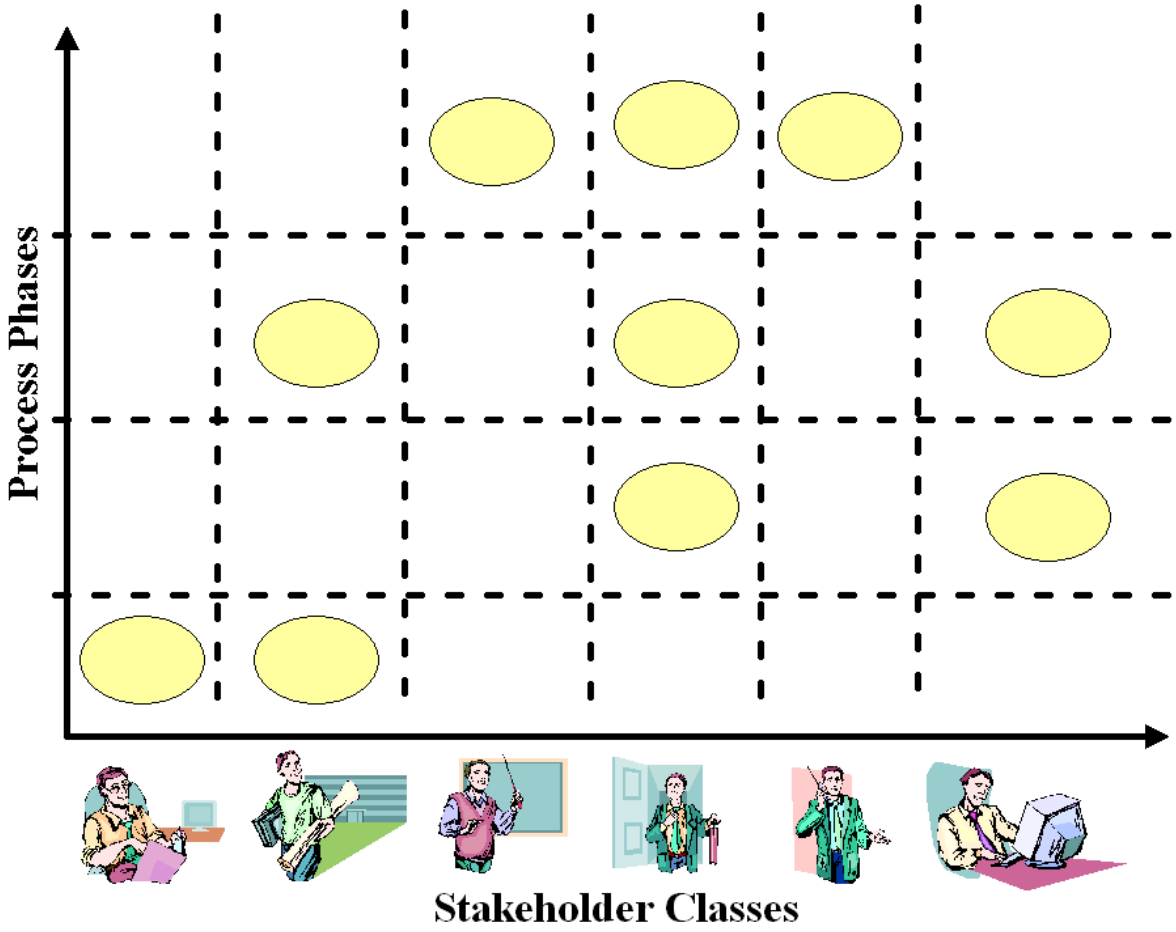
- **Modeling Process Based on Stakeholders' Concerns**
  - Stakeholders have different concerns
  - One stakeholder class may have different concerns at different phases
- **Incrementally Integrate Stakeholders' Concerns via Hybrid Simulation**
  - Indentify information flow between Models
  - Feedback at different level of abstraction
  - Adjusting process attributes to satisfy stakeholders' requirements

Process Modeling/Simulation Trends

- **Process Modeling as a Programming Language**
  - Process Modeling Language
  - Supports process simulation
  - Enhances process automation
- **Hybrid Process Simulation**
  - Capable of capturing both process static and dynamic attributes
  - Tool support

Two Dimensions of Stakeholders' Concerns

- **Stakeholder Classes**
- **Process Phases**



Classification of PMLs Based on Modeling Perspectives

- **Discrete PML: Event/Step/State Based**
  - ***Modeling the discrete steps/activities and their interrelations, configurations***
  - ***Little-JIL, Object Petri-Nets, etc.***
- **Continuous PML: "Perspective" Based**
  - ***Modeling the dynamics of the process based on certain perspective***
  - ***System Dynamics***

Hybrid Process Simulations

- **Vertical integration:**
  - ***Discrete model was first built at a lower level, and then continuously calculates the process factors and incorporates the feedback loop at the system level***
- **Horizontal integration:**
  - ***Integrating discrete and continuous process simulations at different phases of software development***

Hybrid Process Simulations

- **Stakeholder-based Integration**
  - ***Build discrete process model and build multiple continuous models based on different stakeholders' perspectives (concerns)***
  - ***Select one discrete model and one continuous model for simulation***
  - ***Feedback hybrid simulation results to both models, and adjust process attributes if necessary***
  - ***Incrementally integrating multiple continuous models from different stakeholders***

Stakeholders and Their Dependencies on PML Classes*

Stakeholder Classes	Discrete PMLs	Continuous PMLs
Process Performer (PP)	High	Low
Process Engineer (PE)	High	High
Process Manager (PM)	High	High
Customer (CU)	Medium	High
End User (EU)	High	High
Educator (ED)	High	High
Tool Provider (TP)	High	High
Researcher (RS)	High	High
Union Representative (UR)	Medium	Medium
Regulator (RG)	Low	Low
Standardizer (SD)	High	High
Domain Specific stakeholder (DS)	High	High

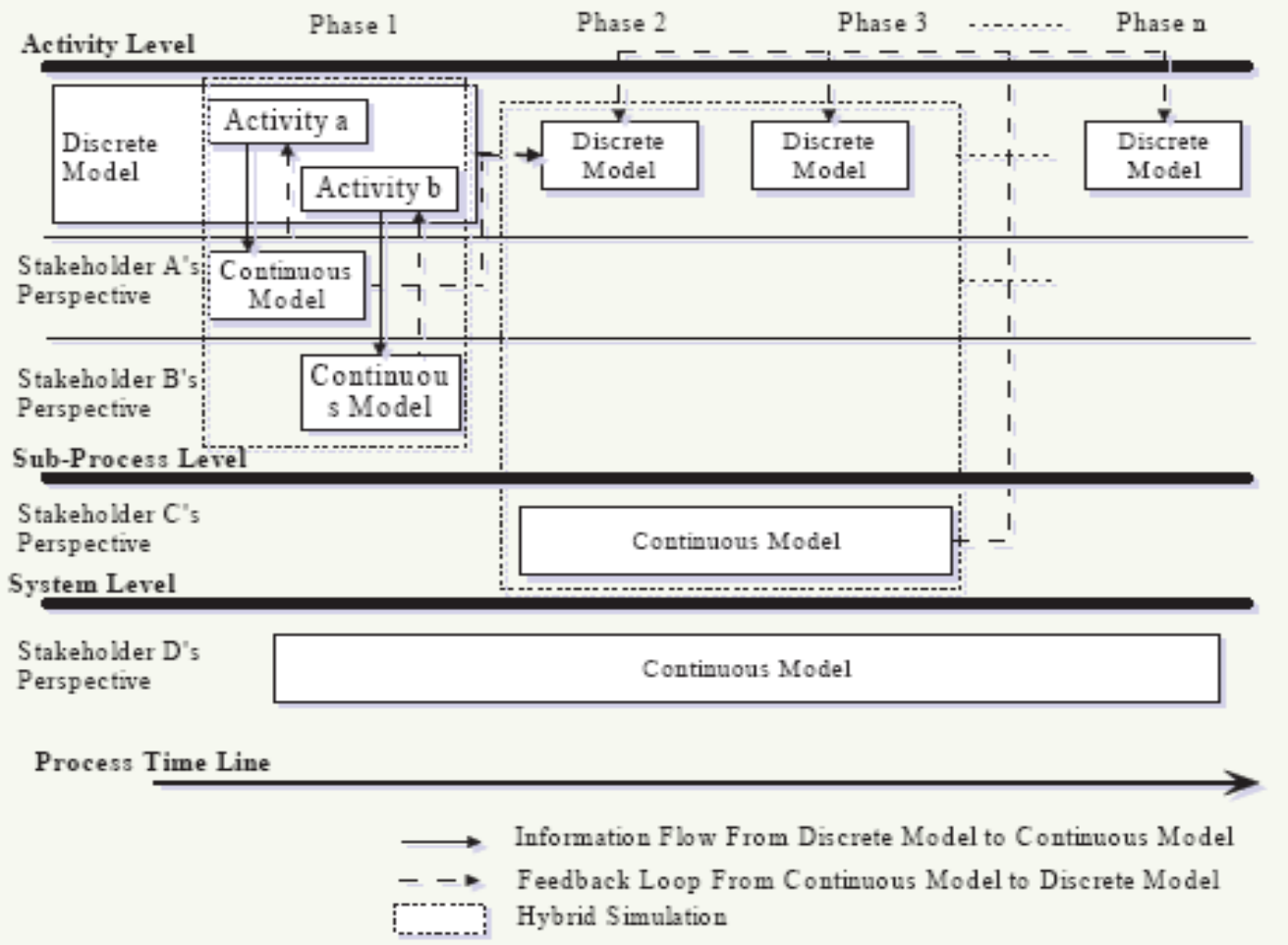
***Based on activity analysis of different stakeholders in process modeling and simulation**

Continuous Process Modeling Perspectives and Their Associated Stakeholder Classes**

Continuous Process Modeling Perspectives		Associated Stakeholder Classes							
		PP	PE	PM	CU	EU	ED	TP	RS
People	Workforce Modeling		X	X	X	X	X	X	X
	Exhaustion and Burnout	X	X	X	X	X	X	X	X
	Learning		X	X	X	X	X	X	X
	Team Composition	X	X	X	X	X	X		X
Process/Product	Inspection		X	X	X	X	X		X
	Software Evolution		X		X		X		X
	Software Reuse		X	X	X	X	X		X
	COTS		X	X	X	X	X	X	X
	Software Architecting		X	X	X	X	X	X	X
	Quality and Defect		X	X	X	X	X	X	X
	Requirement Volatility		X	X		X	X	X	X
	Process Improvement		X	X	X	X	X	X	X
Project	Integrated Project Modeling		X	X		X	X	X	X
	Business Case Analysis	X	X	X		X	X	X	X
	Personnel Resource Allocation		X	X		X	X	X	X
	Staffing	X	X	X		X	X	X	X
	Earned Value		X	X		X	X	X	X

**Based on activity analysis of different stakeholders in process modeling and simulation and application categories in [Madachy, R.J.: Software Process Dynamics. Wiley-IEEE Press (2008)].

Overview of Stakeholder-based Hybrid Simulation



Case Study: Scenario

- ***Project data (Tvedt, J.D.: An extensible model for evaluating the impact of process improvements on software development cycle time. PhD thesis, Tempe, AZ, USA (1996))***

Attributes	Value
Project Size	90,667 LOC
Increment 1	22,667 LOC
Increment 2	32,000 LOC
Increment 3	32,000 LOC
Schedule	250 Days
Team Size	15 Engineers
Estimated Budget	3750 Man-Days
Nominal Development Productivity	40 LOC/Man-Day
Nominal Defect Generation Rate	33 errors/KLOC
Nominal Defect Regeneration Rate	4:1
Nominal Defect Detection Rate	0.84
Nominal Review Productivity	220 - 1100 LOC/Man-Day
Nominal Test Productivity	40 LOC/Man-Day

- ***A moderate change occurred late in the development phase due to the requirement volatility, an additional 5000 LOC workload need to be modeled to verify the schedule and quality constraints.***

Case Study: Scenario (cont.)

- ***Planed 30-day schedule***

Activity	Man Power	Days
Schedule and Assign Tasks	1 Project Manager	1
Modify Design	6 Design Engineers	8
Review Design	4(1 DE, 1 QA, 2 Other)	1
Modify Code	6 Design Engineers	10
Modify Test Plans	4 QA Engineers	3
Modify Unit Test Package	4 QA Engineers	8
Test Unit	10 (6 DE, 4 QA)	10

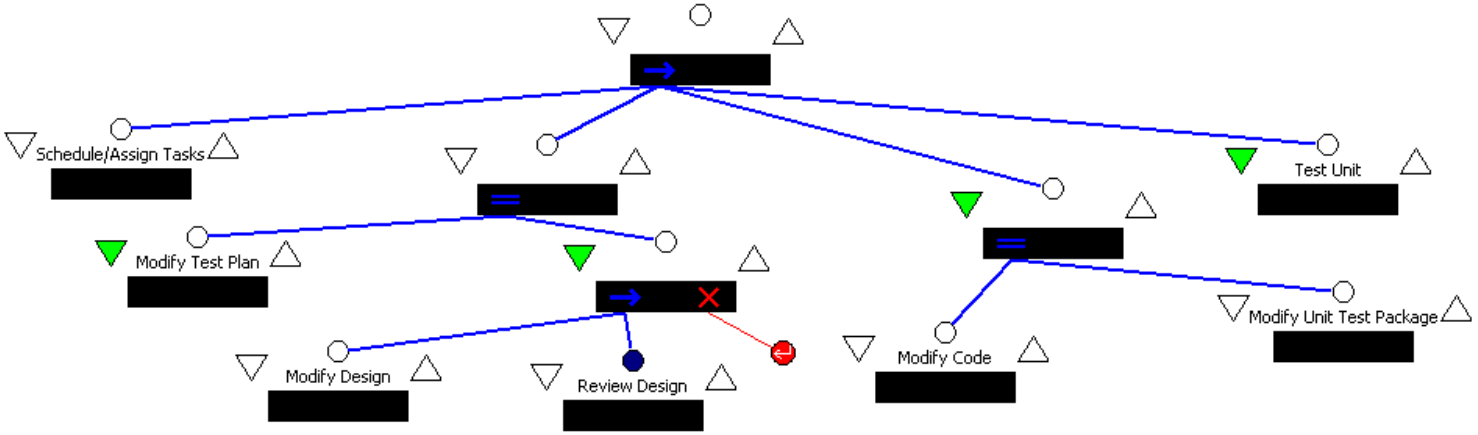
- ***Problem 1: The process manager intends to verify if each activity and the entire process can meet the planned deadline.***
  - **Stakeholder: process manager**
  - **Perspective: earned value of each step (verify if earned value is equal to or greater than planned)**

Case Study: Scenario (cont.)

- ***Problem 2: The process engineer investigates the quality factors of the ISPW-6 process to help process manager verify whether the residual defect density is within the acceptable range, while the original deadline is maintained.***
  - **Stakeholder: process engineer, process manager**
  - **Perspective: defect dynamics across several phases**

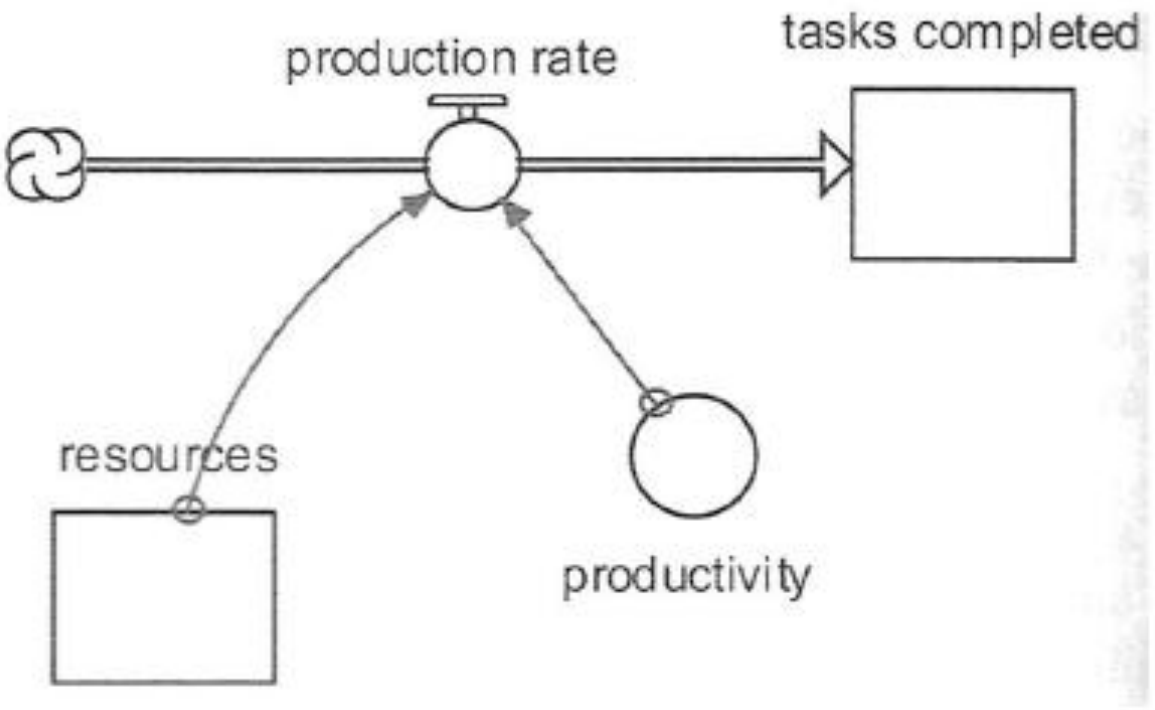
- ***We try to address these problems by hybrid process simulation***
  - **In order to adjust process attributes in both model when necessary**
  - **In order to improve process quality**
  - **Incrementally integrate stakeholders' concerns**

Map this process into ISPW-6 Process using Little-JIL

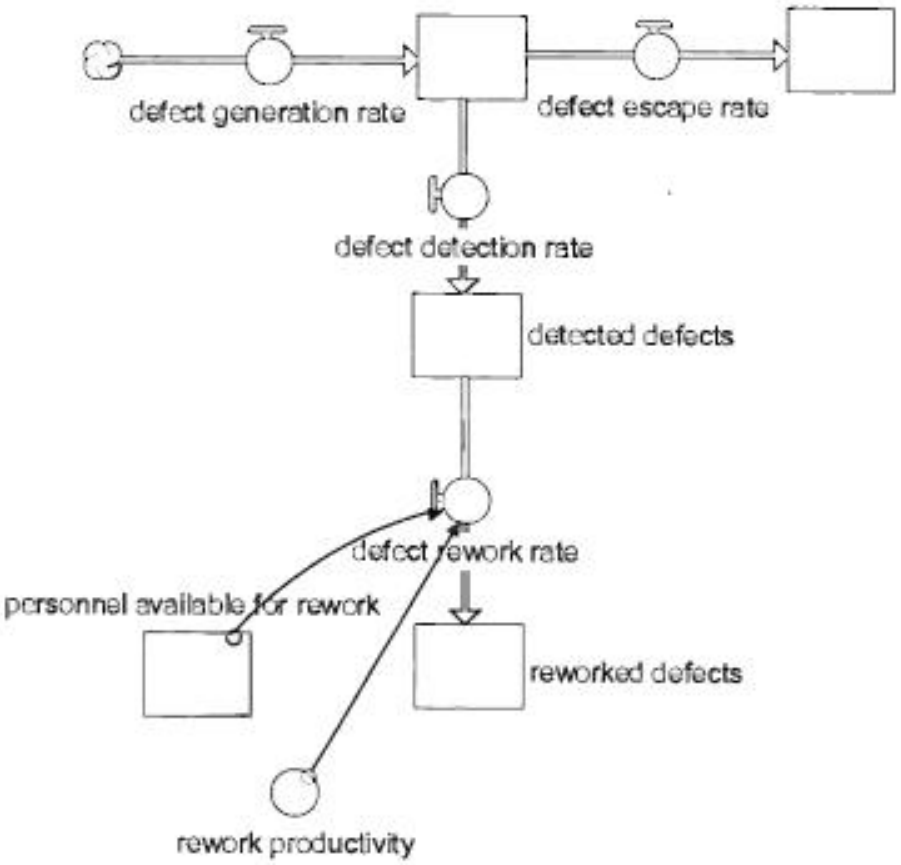


- a relatively confined portion of the software change process
- focuses on the designing, coding, unit testing, and management of a rather localized change to a software system
- a change in requirements occurring either late in the development phase

ISPW-6 Process in System Dynamics: Earned Value

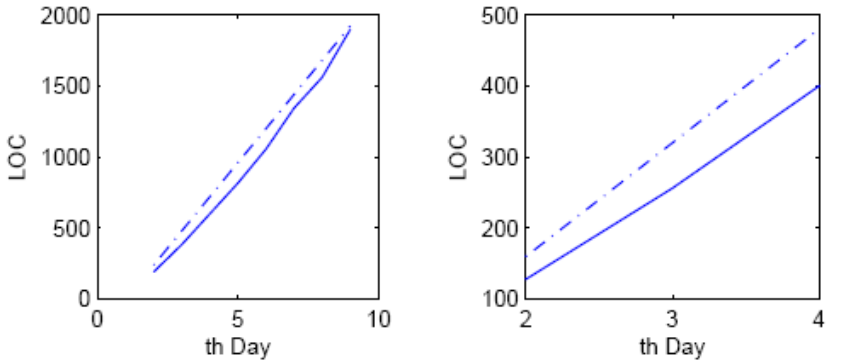


ISPW-6 Process in System Dynamics: Defect Dynamics



Problem 1: Earned Value Perspective

- **Simulation Results for each steps**

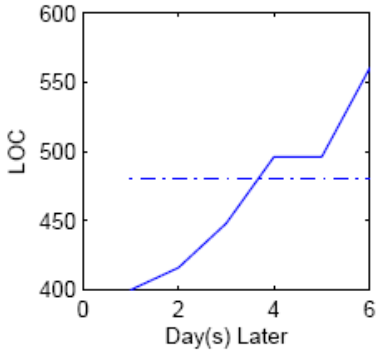


(b) Modify Design Simulation (c) Modify Test Plan Simulation

- **Adjustment strategy**
  - **Increase productivity (critical path)**
  - **Change plan (critical path)**
  - **Concurrent tasks rescheduling (non-critical path)**

Problem 1: Earned Value Perspective

- Concurrent task scheduling is the solution.
- Re-simulate to verify if the adjustments can satisfy original deadline.

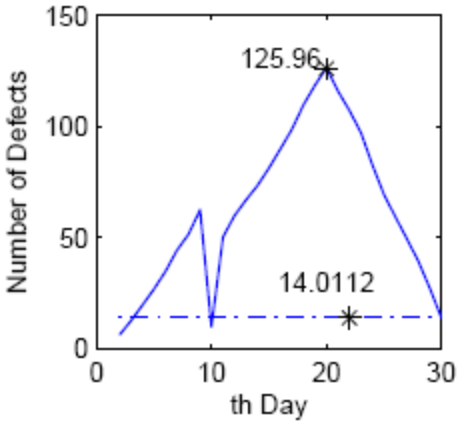


(d) Modify Test Plan Resched-ule Simulation

- Done.

Problem 2: Defect Dynamics Perspective

- **Simulation results for involved steps (who generate/detect/fix defects)**



(e) Residual Defect Number over Time

- **Defect density = 2.8 defects/KLOC**

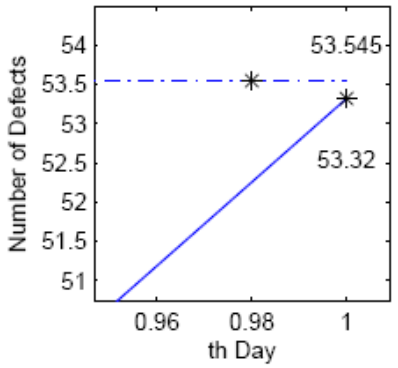
Problem 2: Defect Dynamics Perspective

- If acceptable defect density = 3 defect/KLOC
  - Pass

- How about 2.5 defect/KLOC?
  - Adjustment have to be made at certain steps (review steps)
  - Increase detection rate by reallocate manpower in review steps

Problem 2: Defect Dynamics Perspective

- Using simulation again to find how much we should improve
  - Additional 1.5 defects at deadline
  - Equal to additional 0.325 defects at design review
  - Defect Regeneration Rate = 4:1
  - Current defect detection rate = 0.84



(f) Detected Defects via Design Review

- Re-simulation result
  - Defect detection rate should be increased to 0.845

Challenges

- **Integration of discrete process model and continuous process model**
  - **Inconsistent data representations between models**
  - **Lack of tool support for hybrid process simulation**
- **Solutions for Process Optimization**
  - **Hard for full automation due to process complexity**

Conclusions

- **Develop a stakeholder-based hybrid process modeling approach.**
- **Incrementally integrate stakeholders' concerns into process model at different abstraction level.**
- **Case studies show possible application in practice.**

Future Work

- **Improve the hybrid modeling scheme by investigating other applications, such as software evolution and reuse.**

- **Enhance the automation of the hybrid simulation method.**