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STEVENS INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY

A Hybrid Simulation Approach for Competitive Open Software Development Process

Sponsor: DASD(SE)

By
Razieh Saremi

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8th Floor
Washington, DC 20009

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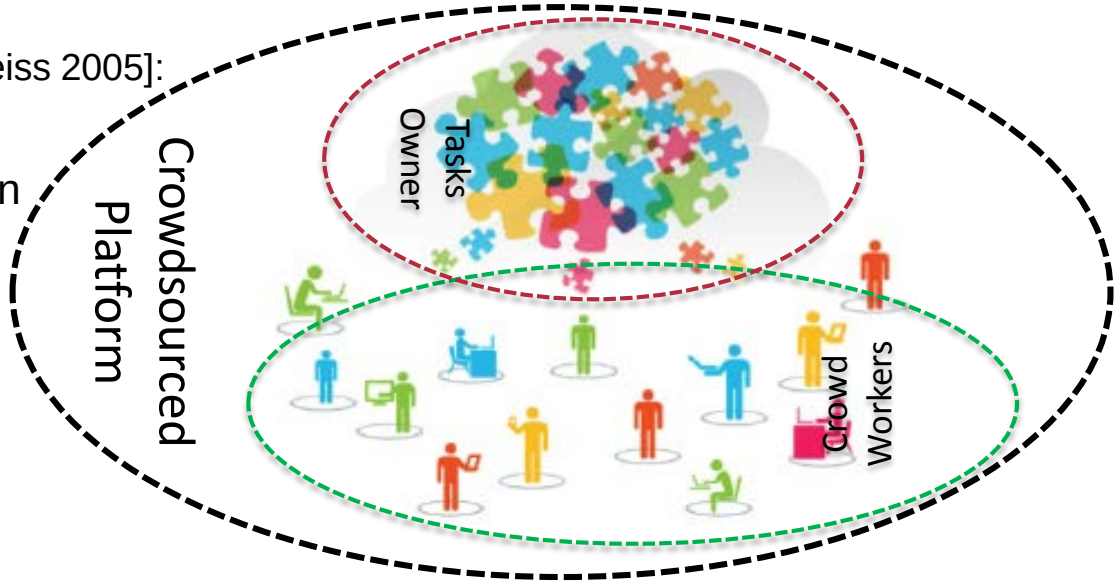
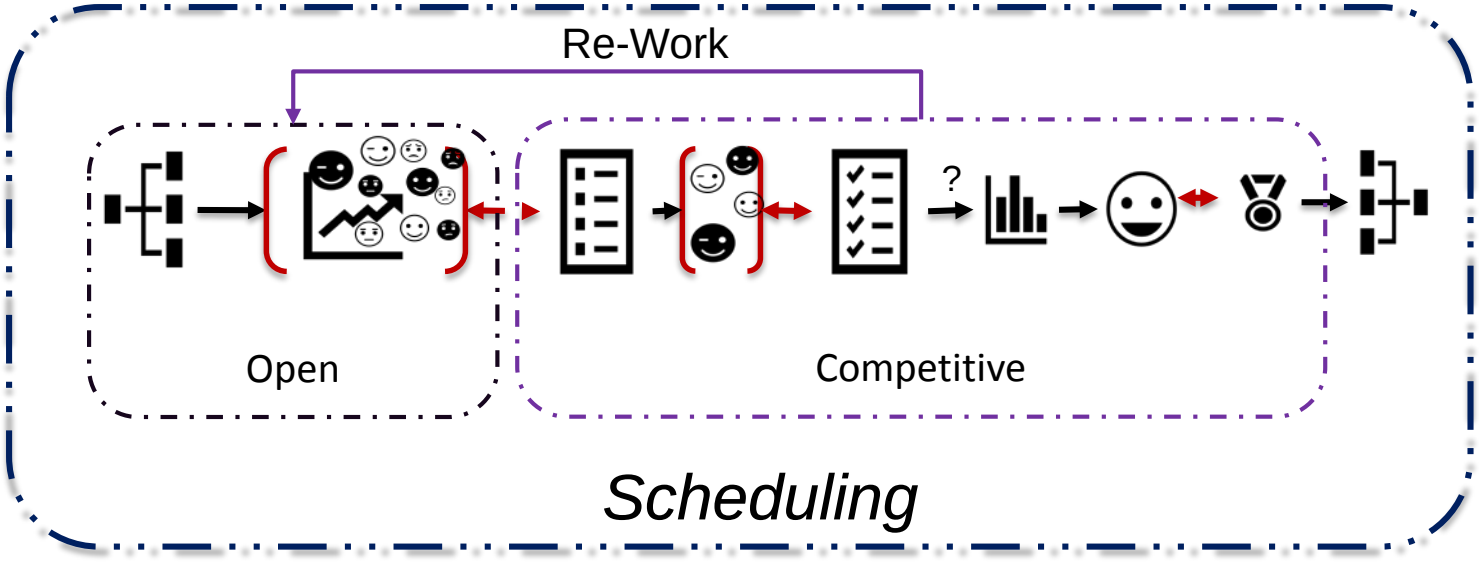
Open Competitive Software Workflow

Open Market Software Development [Weiss 2005]:

- Potentially large number of unknown workers
- Have access to the internet
- Collaborate and coordinate on the tasks
- Workers take the work they choose





Task Scheduling in Software Engineering

✓Scheduling a software project:

- ➢Setting sequence of time dependent tasks that make a project [Mingozi et al 1998]
- ➢Assign tasks to workers to be done in specific time frame [Alba et al 2007]

✓ Complex tasks require higher cooperation amongst co-workers [Malon 1994].

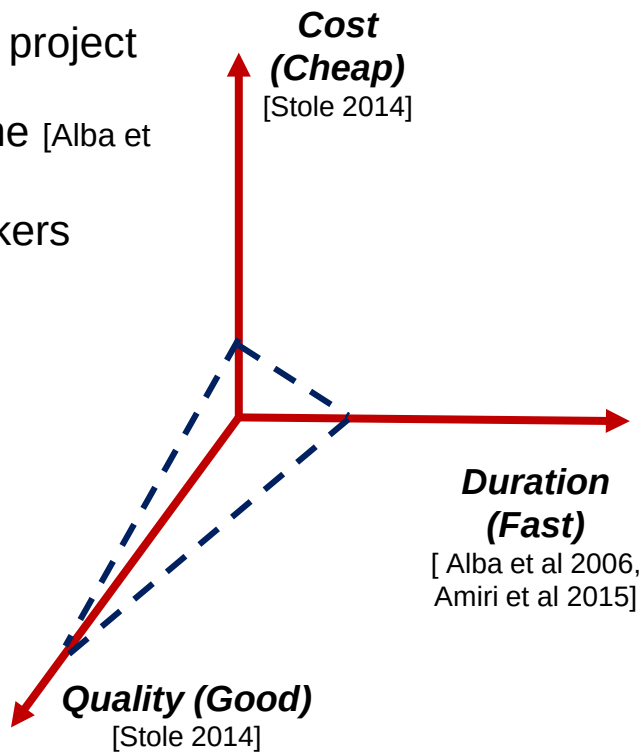
➢*Challenges in OSD Scheduling: [Gao et al 2015, Barreto et al 2008]*

- Not knowing workers in person,
- Working from different time zone,
- Workers interest in other tasks among pool of open tasks

❑ Understanding the crowd workers' sensitivity and performance to the arrival task [Difallah 2016]

- Zero registration,
- Zero submission and
- Not qualified submission.

❖ *Improper scheduling would result in **task failure*** [Faradiani et al 2011]



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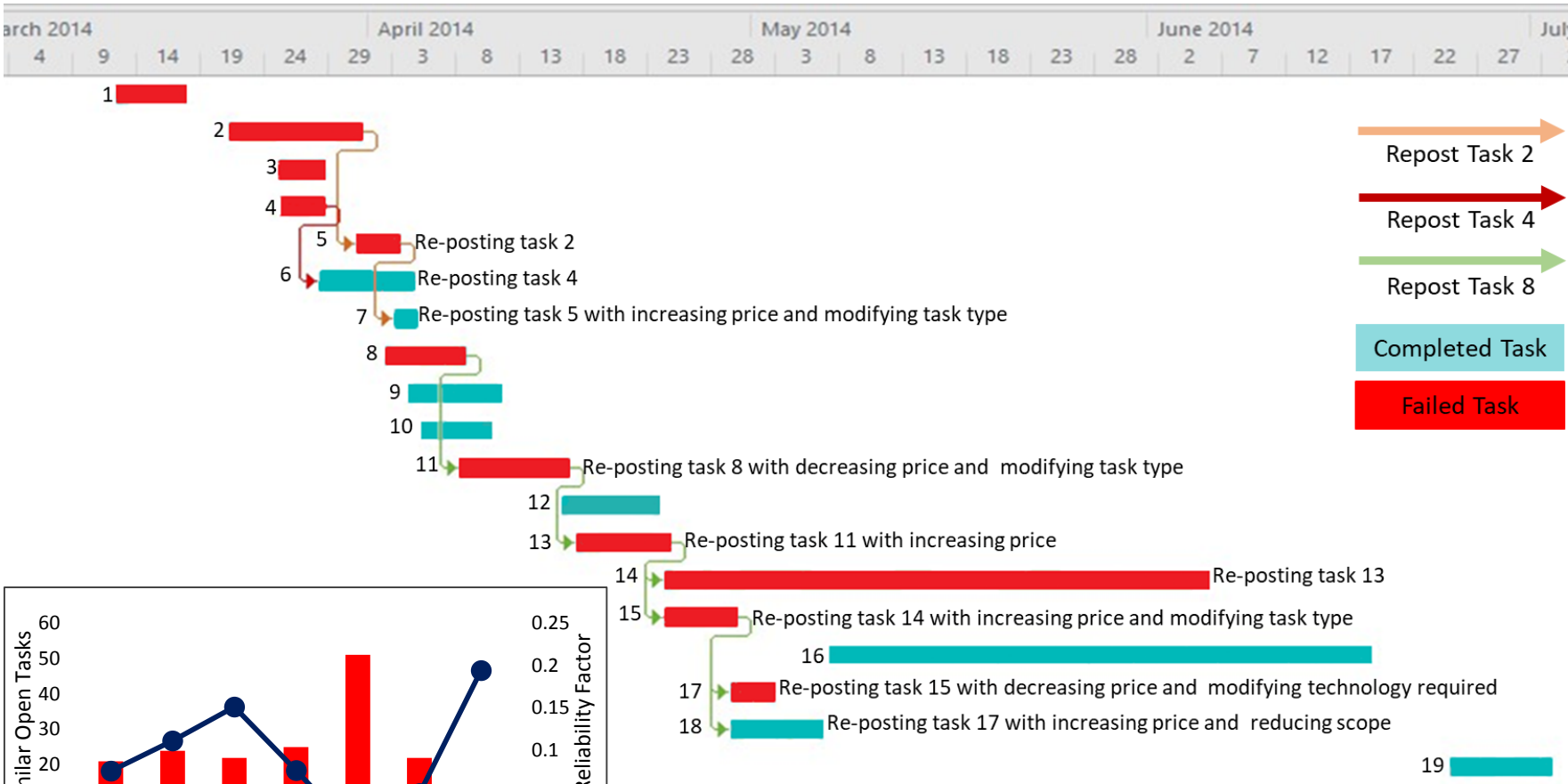
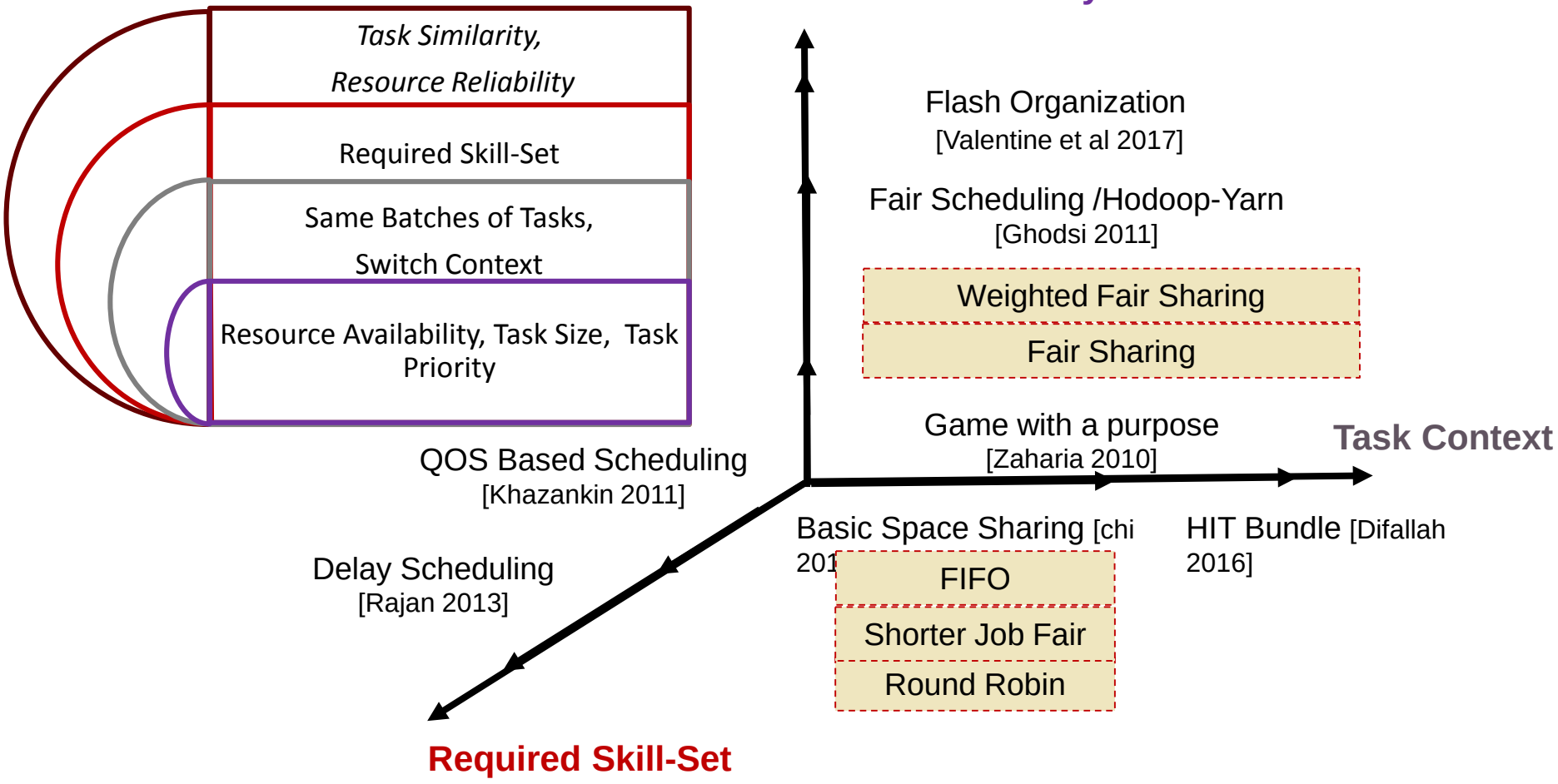
Motivation Example



Project Duration: 110 Days
Project Failure Ratio: 57%

Limitations of Existing Methods



Research Question

Is it feasible to provide a more effective automated task scheduling framework in competitive open software development environments in order to reduce task failure ratio?

Research Approach:

Trained Data Set:

- CSD data from Jan 2014 to Feb 2015
- extracted from TopCoder website
- 403 individual projects
- 4907 component development tasks
- 8108 workers, 5062 active workers
- 60433 worker-task participation records

Presented Model:

Hybrid simulation model:

- ✓ Systems Dynamic
- ✓ Discrete Event
- ✓ Agent Based Model

AnyLogic®

CSD Market Place

Cd
TCO
Quartz Energy - Offset Operator Frac Schedule AngularJS REST API Integration Code Challenge
Ends May 29 API Angular 2+ SQL Server +1
$1,500
Purse
Submission
11 0
5d 20h to go
2d 20h
to register

CSD Market

Demand:

CSD Mini-Tasks per week

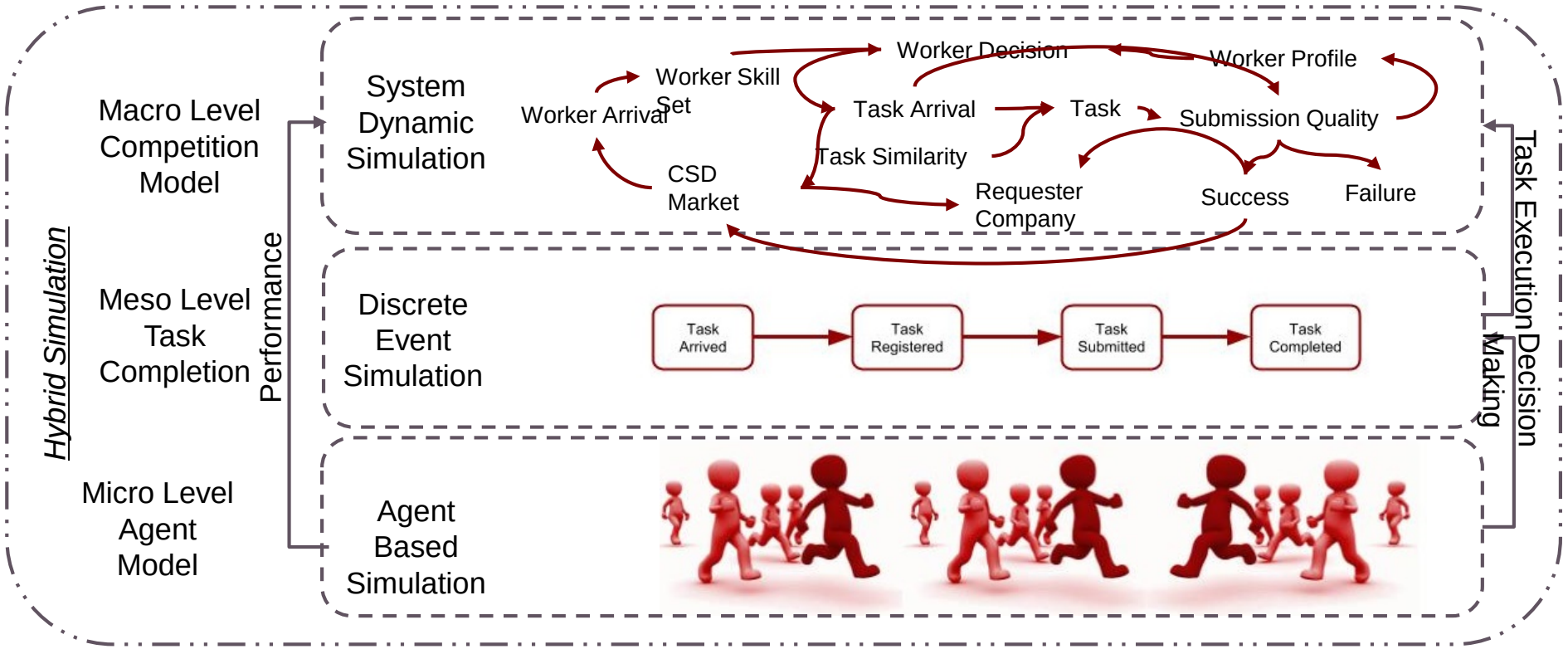
76 New Arrival
2 Cancel
1 Starve
8 Fail

Supply:

CSD Workers per week

Belt	Rating Range (X)	# Workers	% Workers
Gray	X<900	4557	90.02%
Green	900<X<1200	146	2.88%
Blue	1200<X<1500	273	5.39%
Yellow	1500<X<2200	78	1.54%
Red	X>2200	8	0.16%

Study Design



Overall View of Hybrid Simulation Model

Relaxed Assumptions:

- Workers' trust factor is constant
  - Tasks will not be cancelled by client requests
    - Tasks will not face zero registration scenario

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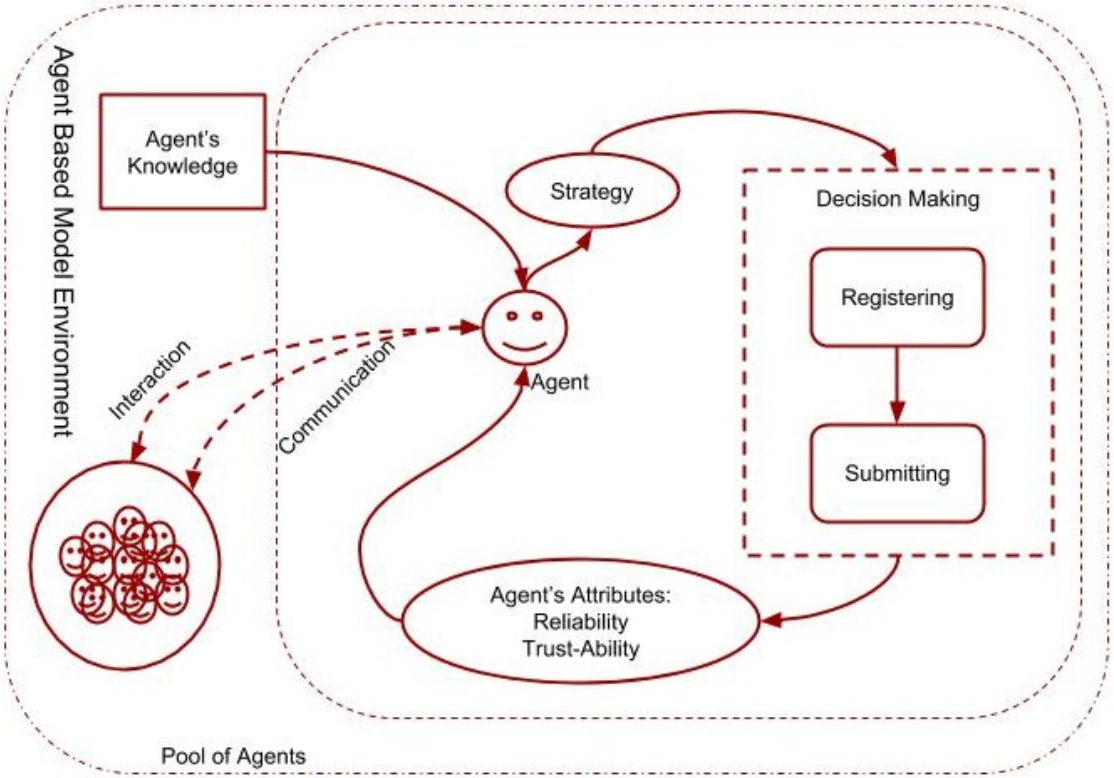
Micro level: Agent Model



Agent's Decision Making:

✓ *Registering* : 1

$$P(R_j)=\begin{cases}1 & Regs \leq 18\\ Bernoulli(0.3) & Regs > 18\end{cases}$$

✓ *Submitting* : 0.51

$$P(S_j)=\begin{cases}0.6 & j\epsilon\ Red\\ 0.6 & j\ \epsilon\ Yellow\\ 0.39 & j\ \epsilon\ Blue\\ 0.45 & j\ \epsilon\ Green\\ 0.25 & j\ \epsilon\ Gray\end{cases}$$

Knowledge:

✓59% of workers respond to a task call

✓24% of the workers will make submissions

Workers' Reliability (Re): Pert(0, 1, 0.19)

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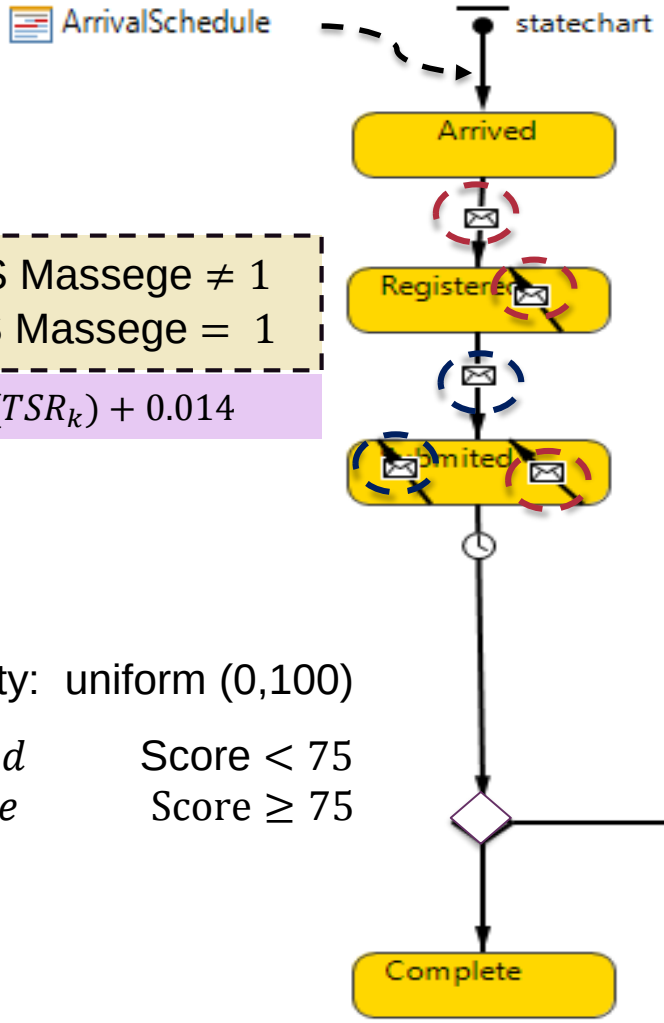
Meso level: Task Completion Model



$$P(TS_i)=\begin{cases}0 & \text{AS Massege} \neq 1\\ 1 & \text{AS Massege} = 1\end{cases}$$

$$FPS_k = 0.0473(TSR_k) + 0.014$$

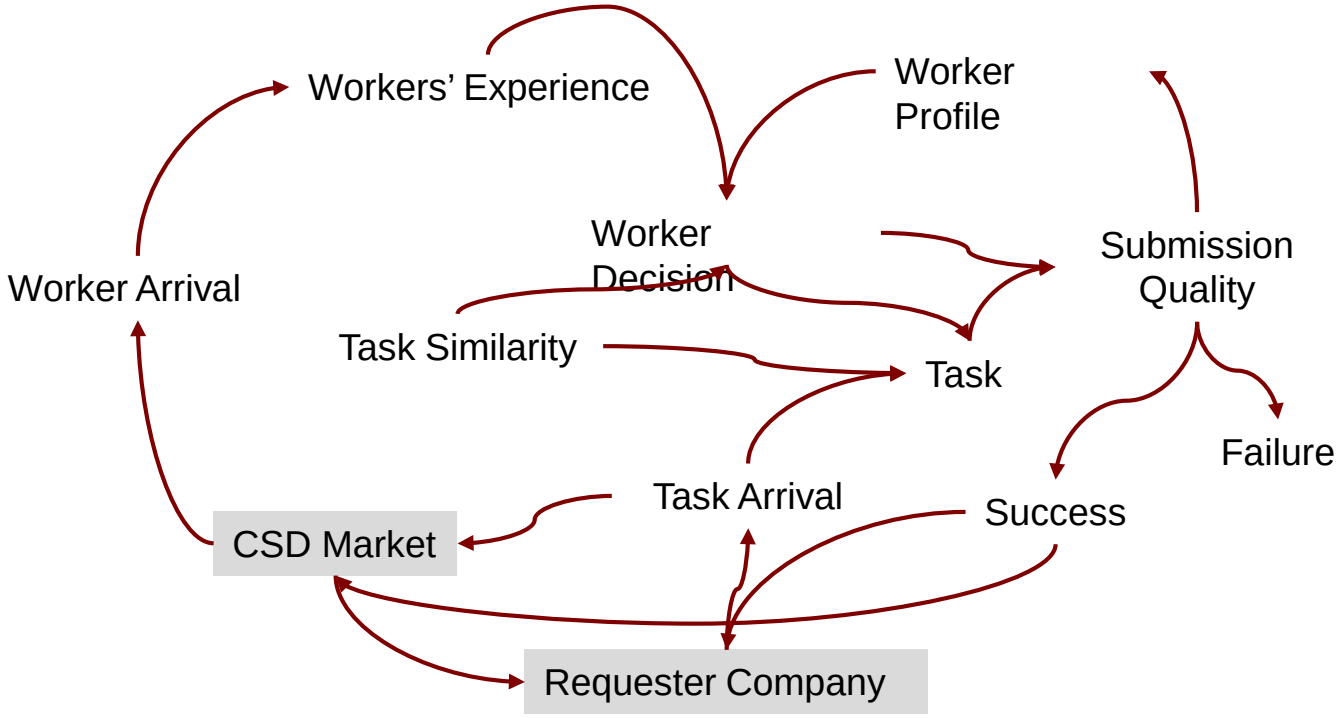
$$P(TR_i)=\begin{cases}0 & \text{AR Massege} \neq 1\\ 1 & \text{AR Massege} = 1\end{cases}$$

$$FPR_k=\begin{cases}\frac{\sum_i^n Re_j * P_j}{3} & \sum_i^n Re_j > 2\\ \frac{\sum_i^n Re_j * P_j}{2} & 1 < \sum_i^n Re_j < 2\\ \frac{\sum_i^n Re_j * P_j}{1} & \sum_i^n Re_j < 1\end{cases}$$

Task Score/ Quality: uniform (0,100)

$$P(TW_i)=\begin{cases}Cancelled & \text{Score} < 75\\ Complete & \text{Score} \geq 75\end{cases}$$

Macro Level: Competition Mode



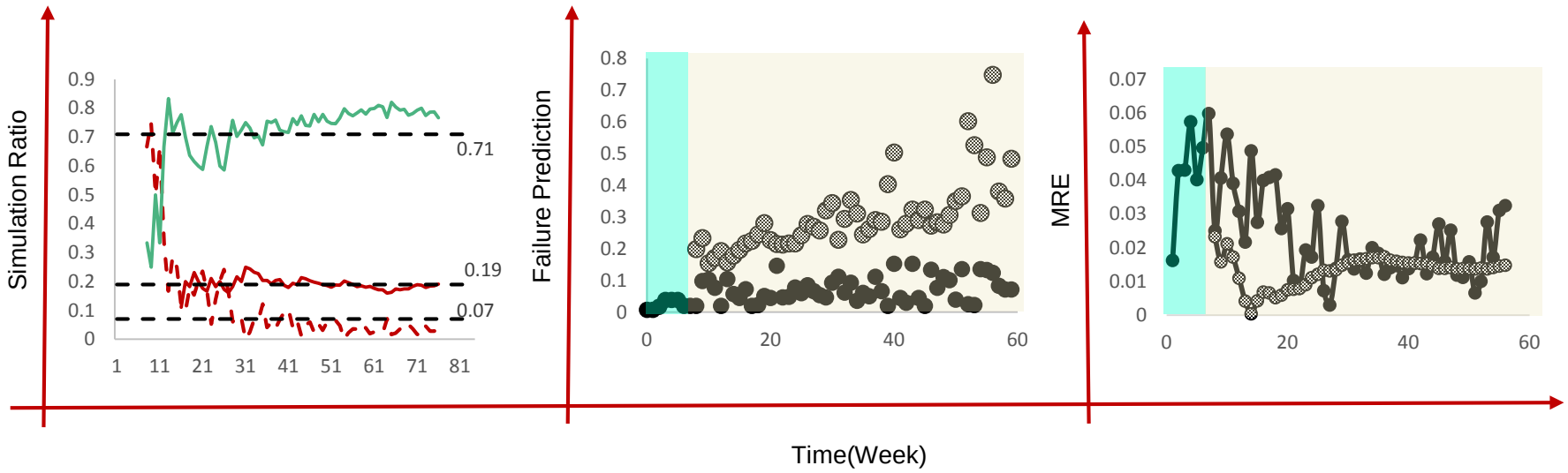
Workers' Arrival: Poisson(18, 800, 20, 0, 1)

Workers' Experience: Beta (1 , 5 , 0 , 3000)

Tasks' Arrival: Task Model Schedule

Task Similarity: uniform (0.33,0.98)

Model Accuracy



Success Ratio ~ 71%
Failure ratio ~ 13%

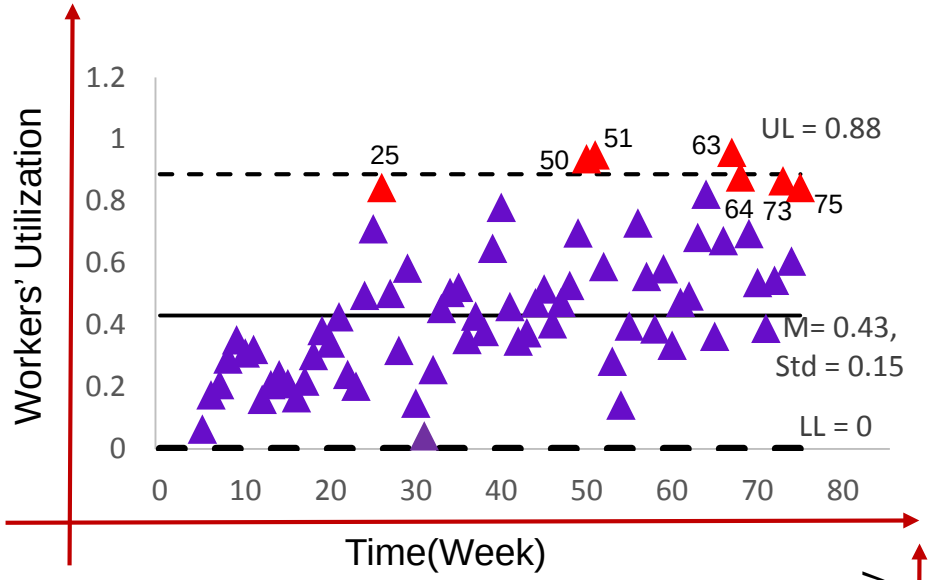
V.S.

Actual Failure Ratio ~ 14%

Failure prediction i Submissions(SFP) ~ 15%
Failure Prediction in Registration (RFP) ~ 6.5%

MRE(SFP) = 2%
MRE (RFP) = 1.1%

Model Insights

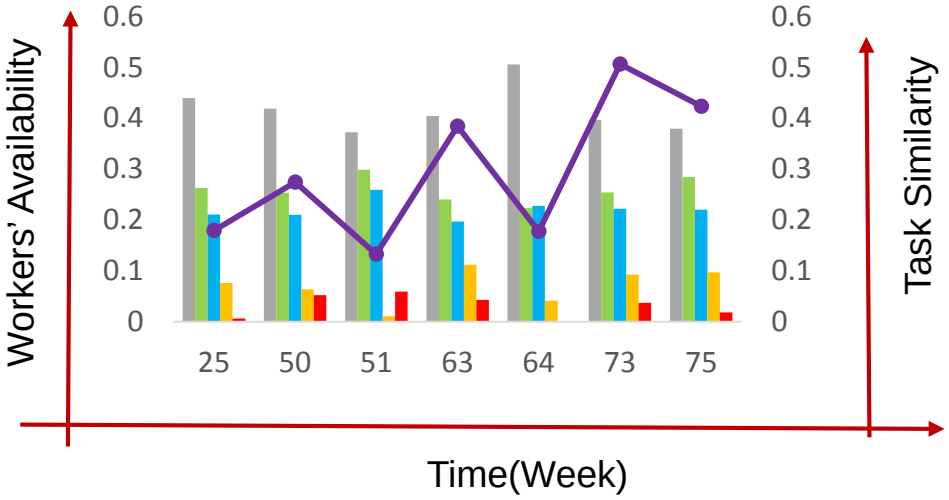


Task Similarity level < 60%

Close availability of midlevel experienced worker

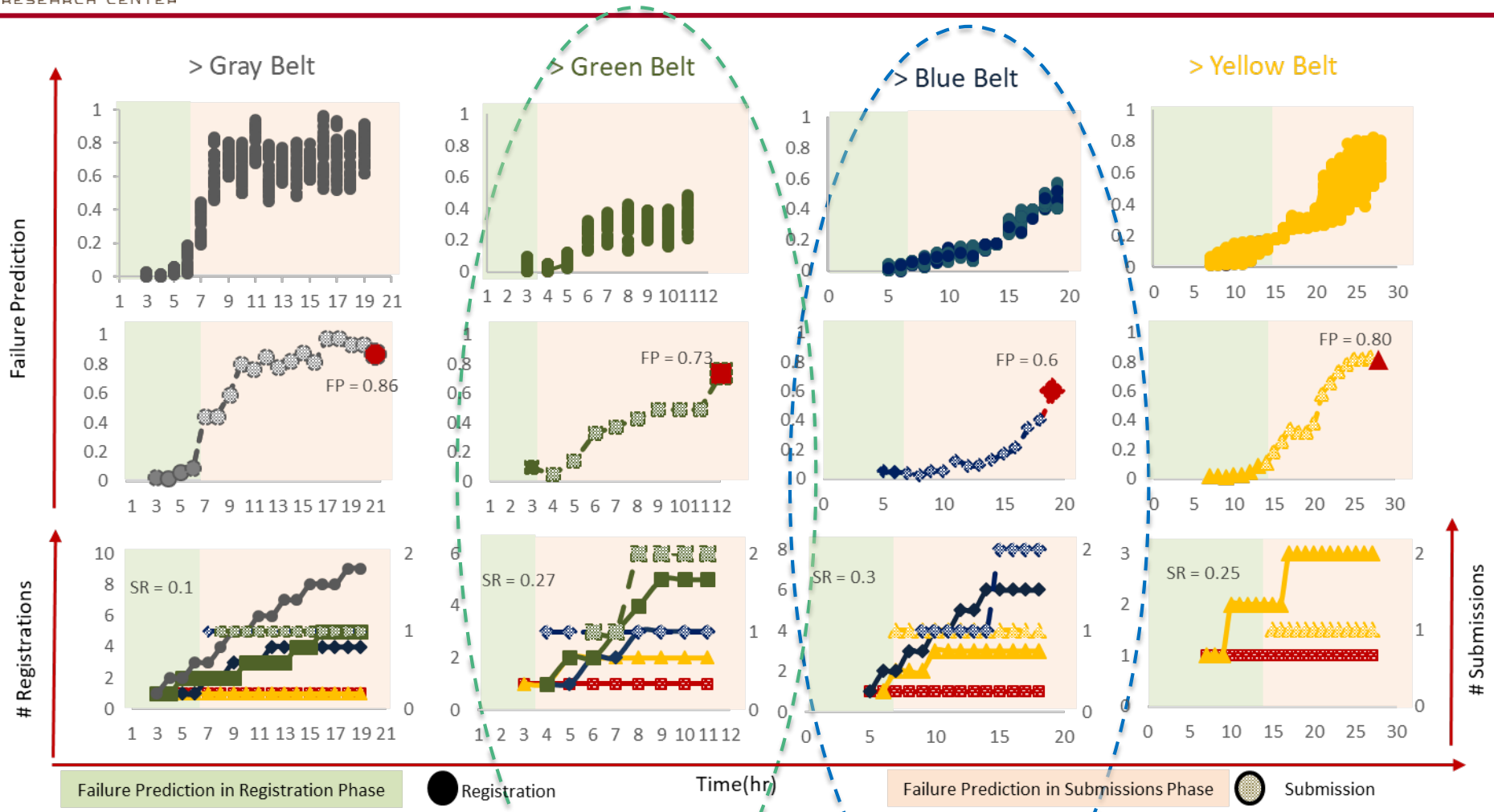
Scenario 1: How diverse?

Scenario 2: How open?



Gray Category | Green Category | Blue Category | Yellow Category | Red Category | Task Similarity Level | Worker Utilization

Scenario 1: Agents' Diversity

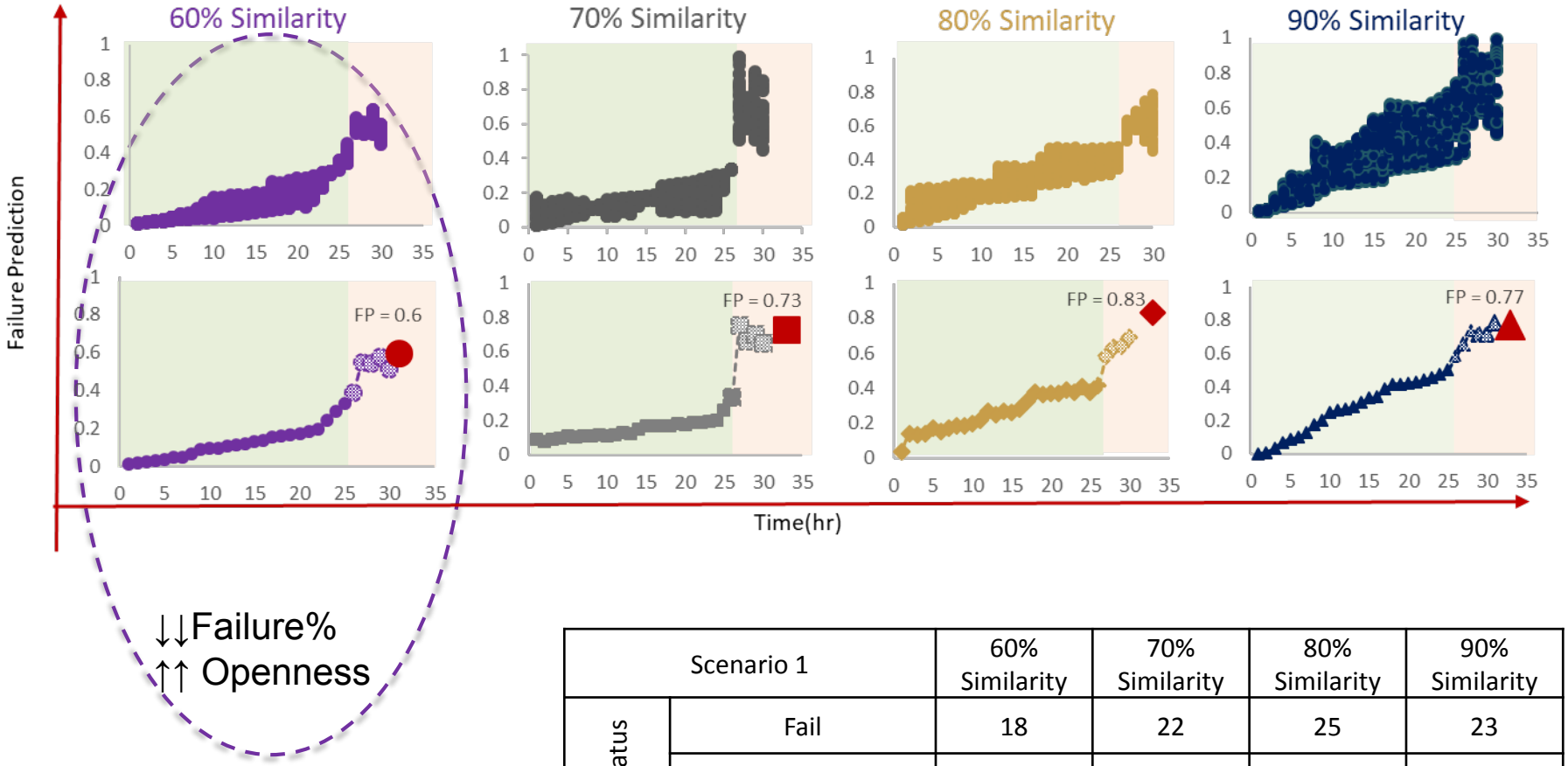


↓ Failure%
↑Submissions%

↓ Failure%
↑Submissions%

- ✓ Scenario ran 30 times
- ✓ PM only can manage the diversity of registrants' experience

Scenario 2: Task Openness



↓↓Failure%
↑↑ Openness

Failure Prediction in Registration Phase

Failure Prediction in Submissions Phase

Simulation Failure Prediction

Scenario 1		60% Similarity	70% Similarity	80% Similarity	90% Similarity
Task Status	Fail	18	22	25	23
	Success	12	8	5	7
	Failure Prediction	60%	73%	83%	77%

- ✓ Scenario ran 30 times
- ✓ PM can manage openness of the pool of tasks only

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Conclusion and Future Work

Conclusion:

This study provides a hybrid simulation model to help providing more insights in order to have a more efficient task scheduling in OSD.

- ✓ Attracting higher number of middle ranked agents to compete on the task, would provide lower chance of task failure in general.
- ✓ Similarity level of 60% and lower in the pool of available tasks, provides lower chance of task failure.

Future Work:

- ✓ Updating the model with schedule available projects form the entire data set and report the recommendation metrics

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Limitation

- ✓ Presented model created based on competitive crowdsourcing only
- ✓ No access to the management dataset and overheads
- ✓ No access to the actual task sequential per project
- ✓ Assuming that monitory prize and task duration represents task complexity
- ✓ Different factors that may influence workers' decision-making process

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Q&A

Thank you!