



Modeling Kanban Scheduling in Systems of Systems



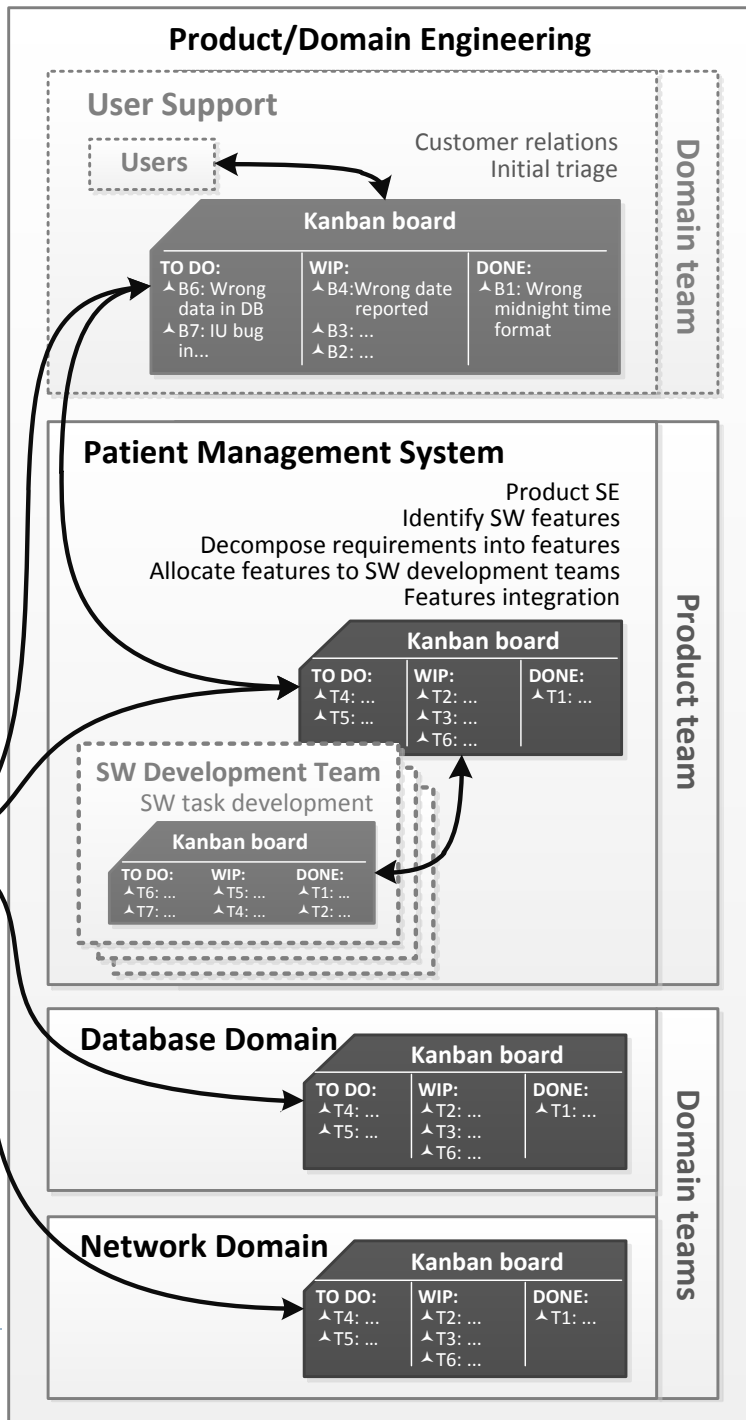
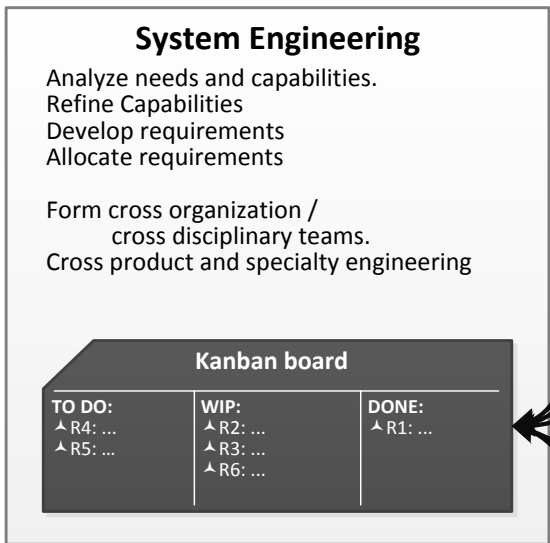
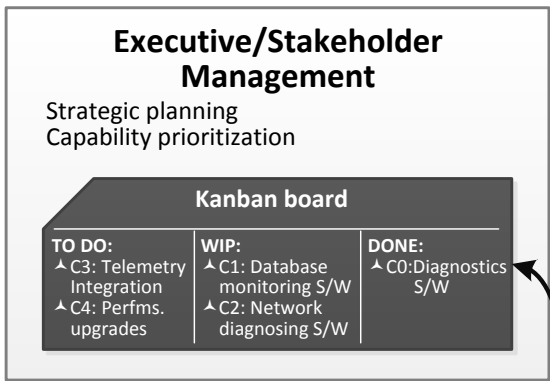
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Outline

- ▶ Kanban scheduling in SoS
 - ▶ Example of SoS / SoS structure
 - ▶ Typical obstacles in SoS
 - ▶ Kanban scheduling in SoS
- ▶ Simulation model
- ▶ Results & future work

SoS structure

- ▶ Acknowledge and directed SoS
- ▶ Three main levels:
 - ▶ Executive/Stakeholder management
 - ▶ System Engineering team
 - ▶ Product/Domain teams
- ▶ Example: Health case SoS (next slide)



↔ Work Flow

Obstacles

- ▶ Lack of visibility
- ▶ Efficient use of resources
- ▶ Time waste on context switching
- ▶ Increase value delivered earlier

Key aspects of Kanban scheduling

- ▶ **Eliminate waste**
 - ▶ Minimize context switching
 - ▶ Limit work in progress
- ▶ **Make process more visible and transparent**
 - ▶ Kanban boards
- ▶ **Increased value delivered earlier**
 - ▶ Value-based work prioritization
- ▶ **Reduce governance overhead**

Discrete event simulation model

▶ Inputs:

- ▶ Event scenario: a sequence of events that describes how network evolves over course of their execution
- ▶ Simulation configuration: structure of teams, resource/specialties allocation, prioritization algorithm

▶ Outputs:

- ▶ Sequence of network states
- ▶ Analysis: various indicators of effectiveness

Scenario generator

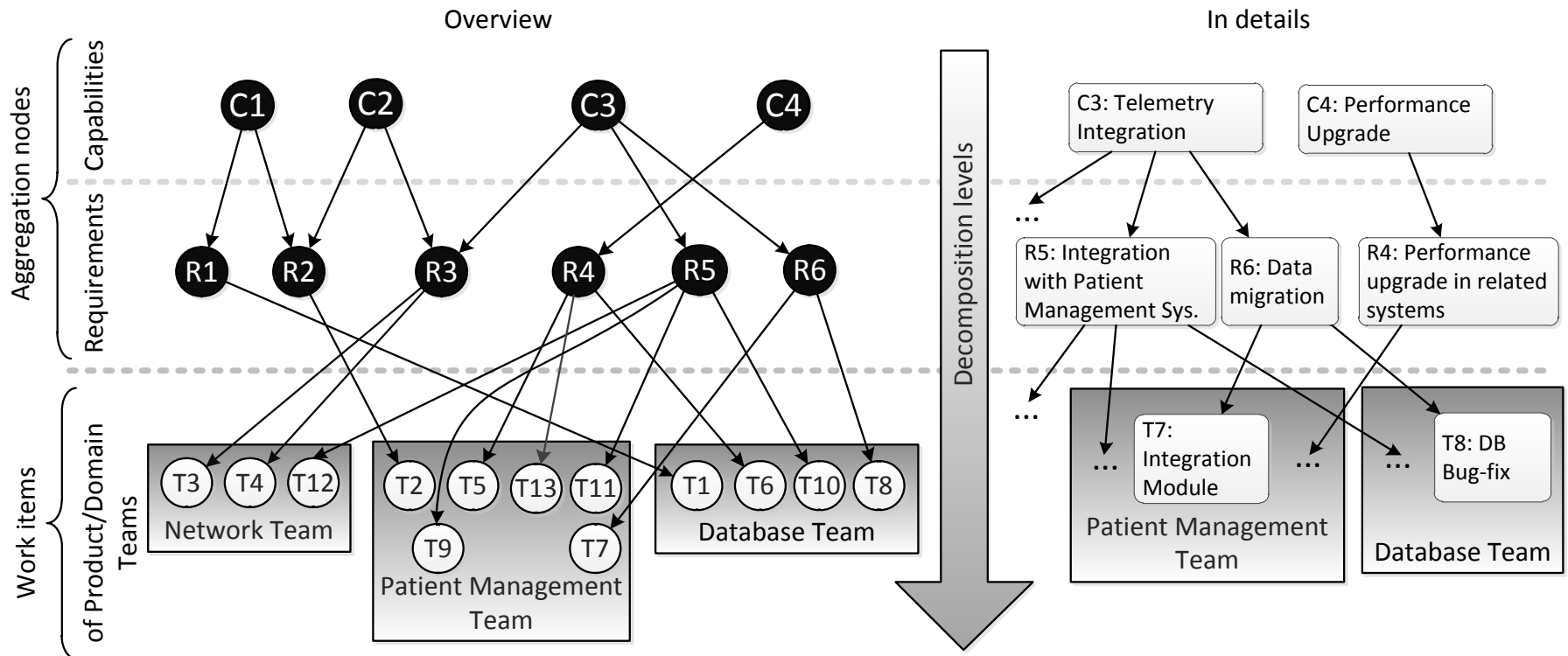
- ▶ **Inputs:**

- ▶ General team structure
- ▶ Amount of work (capabilities, requirements, WIs)
- ▶ Decomposition rules (requirements per capability)
- ▶ Special cases

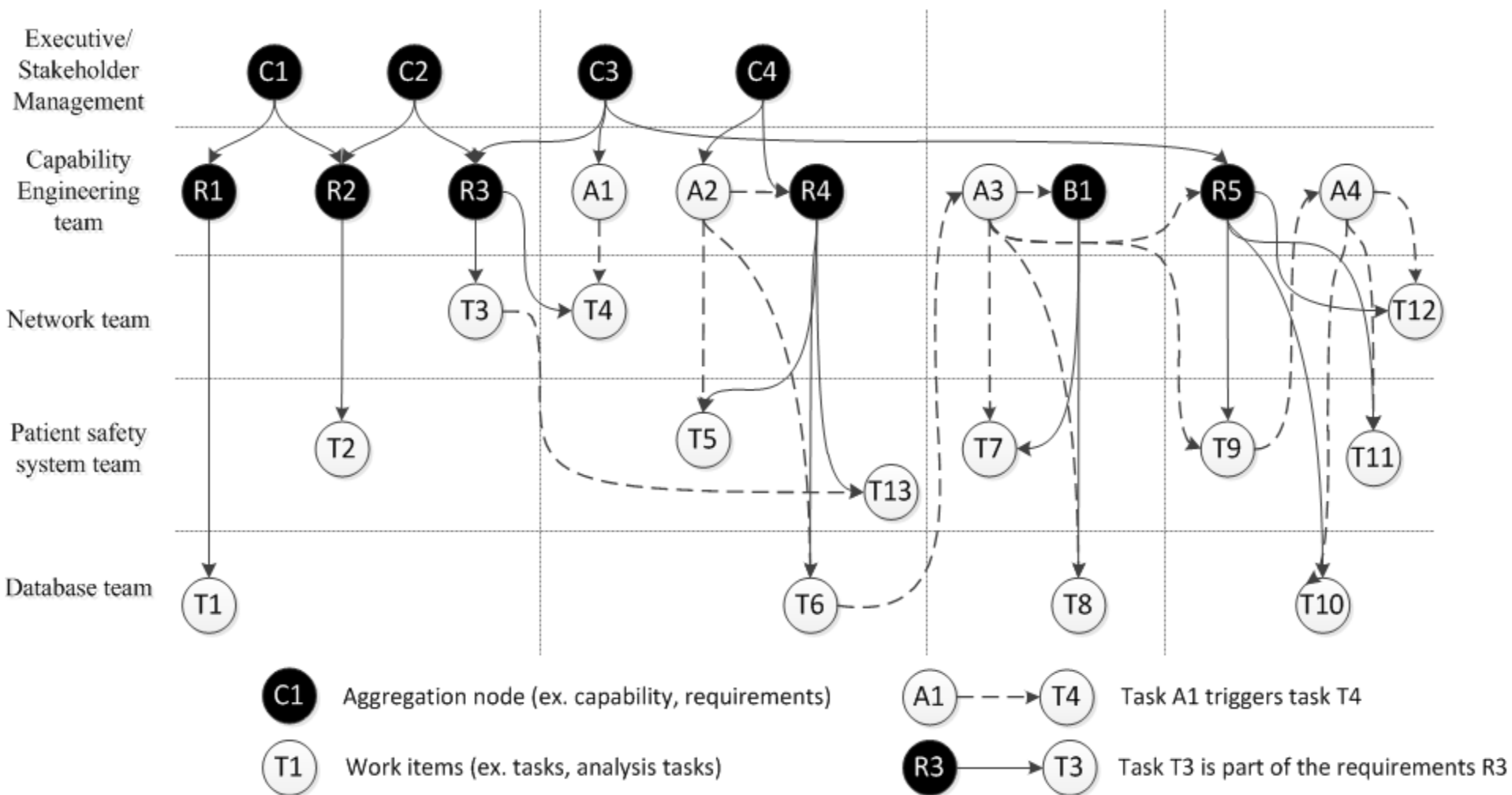
- ▶ **Outputs:**

- ▶ Event scenario

Scenario: capabilities to requirements to products



Scenario: network structure & relationships



Implementation: scenario generator

The screenshot shows a web browser window with the title "Scenario Generator" and the URL "localhost:9000/SG". The page content is titled "KSS Simulator" and features a "Scenario Generator" section with several adjustable sliders and a "Generate" button. A sidebar on the left contains navigation links: "Simulator", "Configuration Files", "Scenario Files", "Scenario Generator", and "Help".

| Parameter | Value |
|---|-------|
| Number of product/domain teams | 5 |
| Number of capabilities on start | 10 |
| Number of capabilities on the go | 5 |
| Requirements per one capability | 5 |
| Work items per one requirement | 5 |
| Capabilities overlap (# of common requirements) | 5 |
| Number of critical tasks that cause blocked WIs | 5 |

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Implementation: resource configuration

Simulator

Configuration Files

Scenario Files

Scenario Generator

Help

New Simulation Configuration for Scenario from_generator

Step 2

| Teams\Specialties | Resources | | | | | | | | | | | | | | | |
|-------------------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| | sp0 | sp1 | sp2 | sp3 | sp4 | sp5 | sp6 | sp7 | sp8 | sp9 | sp10 | sp11 | sp12 | sp13 | sp14 | sp15 |
| SysEng | 12 | | | | | | | | | | | | | | | |
| DevTeamt2 | | 12 | | | | | | | | | | | | | | |
| DevTeamt3 | | | 12 | | | | | | | | | | | | | |
| DevTeamt4 | | | | 12 | | | | | | | | | | | | |
| DevTeamt5 | | | | | 12 | | | | | | | | | | | |
| DevTeamt6 | | | | | | 12 | | | | | | | | | | |
| DevTeamt7 | | | | | | | 12 | | | | | | | | | |
| DevTeamt8 | | | | | | | | 12 | | | | | | | | |
| DevTeamt9 | | | | | | | | | 12 | | | | | | | |
| DevTeamt10 | | | | | | | | | | 12 | | | | | | |
| DevTeamt11 | | | | | | | | | | | 12 | | | | | |
| DevTeamt12 | | | | | | | | | | | | 12 | | | | |
| DevTeamt13 | | | | | | | | | | | | | 12 | | | |
| DevTeamt14 | | | | | | | | | | | | | | 12 | | |
| DevTeamt15 | | | | | | | | | | | | | | | 12 | |
| DevTeamt16 | | | | | | | | | | | | | | | | 12 |

Stop Condition Time: days

Work Completeness:

Prioritization Algorithm: KSS Scheduling

Random Work Selection

LIFO Work Selection

FIFO Work Selection

Context Switching Delay:

Name of the configuration: (.xml)

Please wait. Processing ...



Implementation: results

Welcome to Ka... x Welcome to Ka... x Results x Results x Results x Results x Results

localhost:9000/result

KSS Simulator

Scenario: **Paper_example**
Configuration: **paper_example**

KSS Prioritization
[data file](#)
Time spent: 24.0
Average Time to Start Expedited Work: 0.0
Total value: 1030.0

| Indicator \ Capability | C1 | C2 | C3 | C4 |
|------------------------|--------|--------|--------|--------|
| Actual effort Required | 16.0 | 31.0 | 44.0 | 23.0 |
| Effort spent | 17.0 | 33.0 | 46.0 | 24.0 |
| Work Completeness | 100.0% | 100.0% | 100.0% | 100.0% |

LIFO work selection
[data file](#)
Time spent: 28.0
Average Time to Start Expedited Work: 0.0
Total value: 1030.0

| Indicator \ Capability | C1 | C2 | C3 | C4 |
|------------------------|--------|--------|--------|--------|
| Actual effort Required | 16.0 | 31.0 | 44.0 | 23.0 |
| Effort spent | 16.0 | 33.0 | 47.0 | 24.0 |
| Work Completeness | 100.0% | 100.0% | 100.0% | 100.0% |

Random work selection
[data file](#)
Time spent: 26.0
Average Time to Start Expedited Work: 0.0
Total value: 1030.0

| Indicator \ Capability | C1 | C2 | C3 | C4 |
|------------------------|--------|--------|--------|--------|
| Actual effort Required | 16.0 | 31.0 | 44.0 | 23.0 |
| Effort spent | 16.0 | 32.0 | 46.0 | 25.0 |
| Work Completeness | 100.0% | 100.0% | 100.0% | 100.0% |

Delivered Value

1,200
900
600
300
0

1 3 5 7 9 11 13 15 17 19 21 23
2 4 6 8 10 12 14 16 18 20 22 24

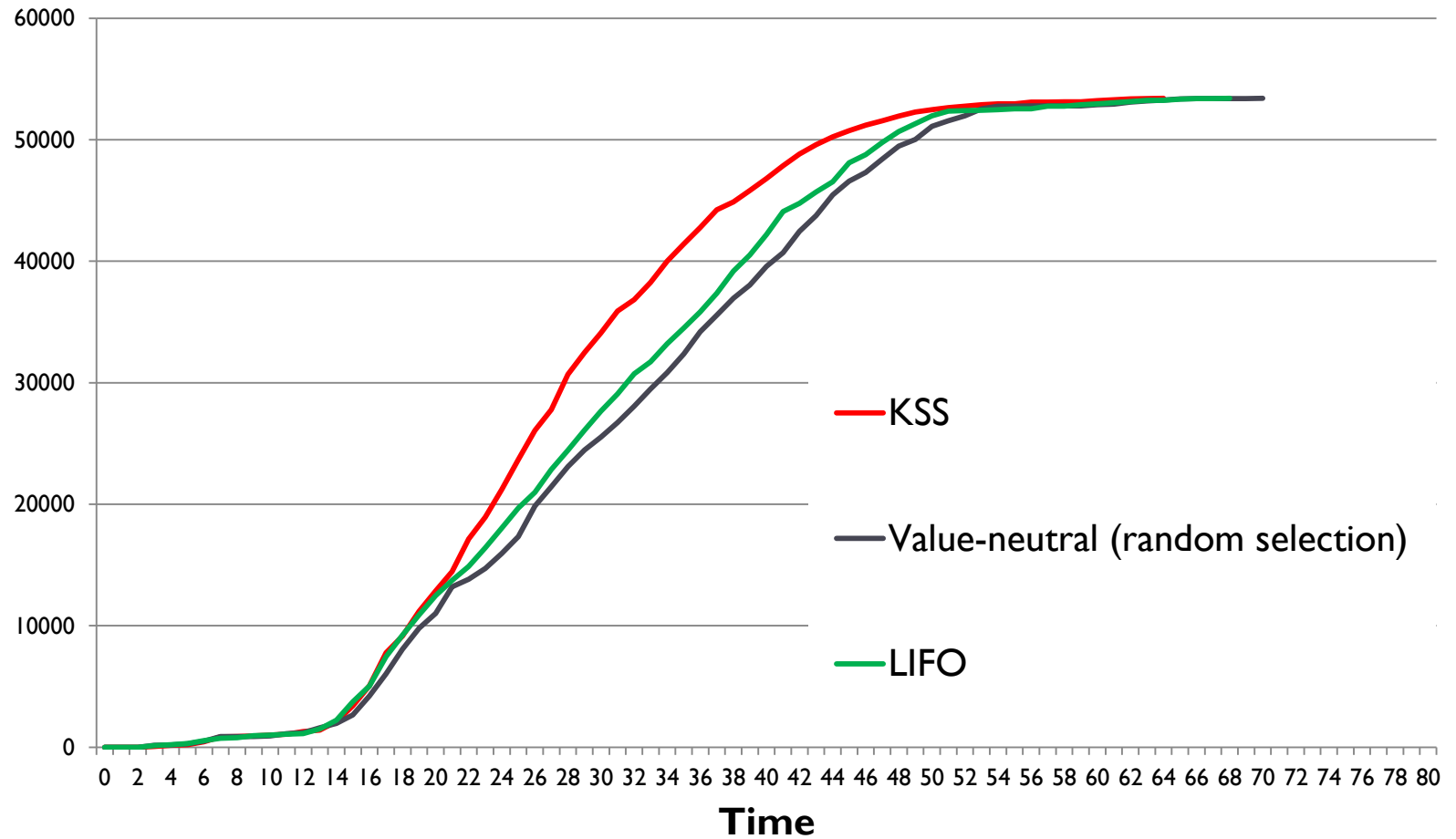
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Results: complex scenario

- ▶ 10 teams (20 members each) + system engineering team.
- ▶ 20 new capabilities at start.
- ▶ Each capability unfolds into 30 requirements on average
- ▶ Each requirement unfolds into 9 tasks on average.
- ▶ Each tasks takes 3-15 days.
- ▶ There are 5 expedite tasks that cause blocked work (blocked tasks)
- ▶ Simulation time-frame: 1 day.

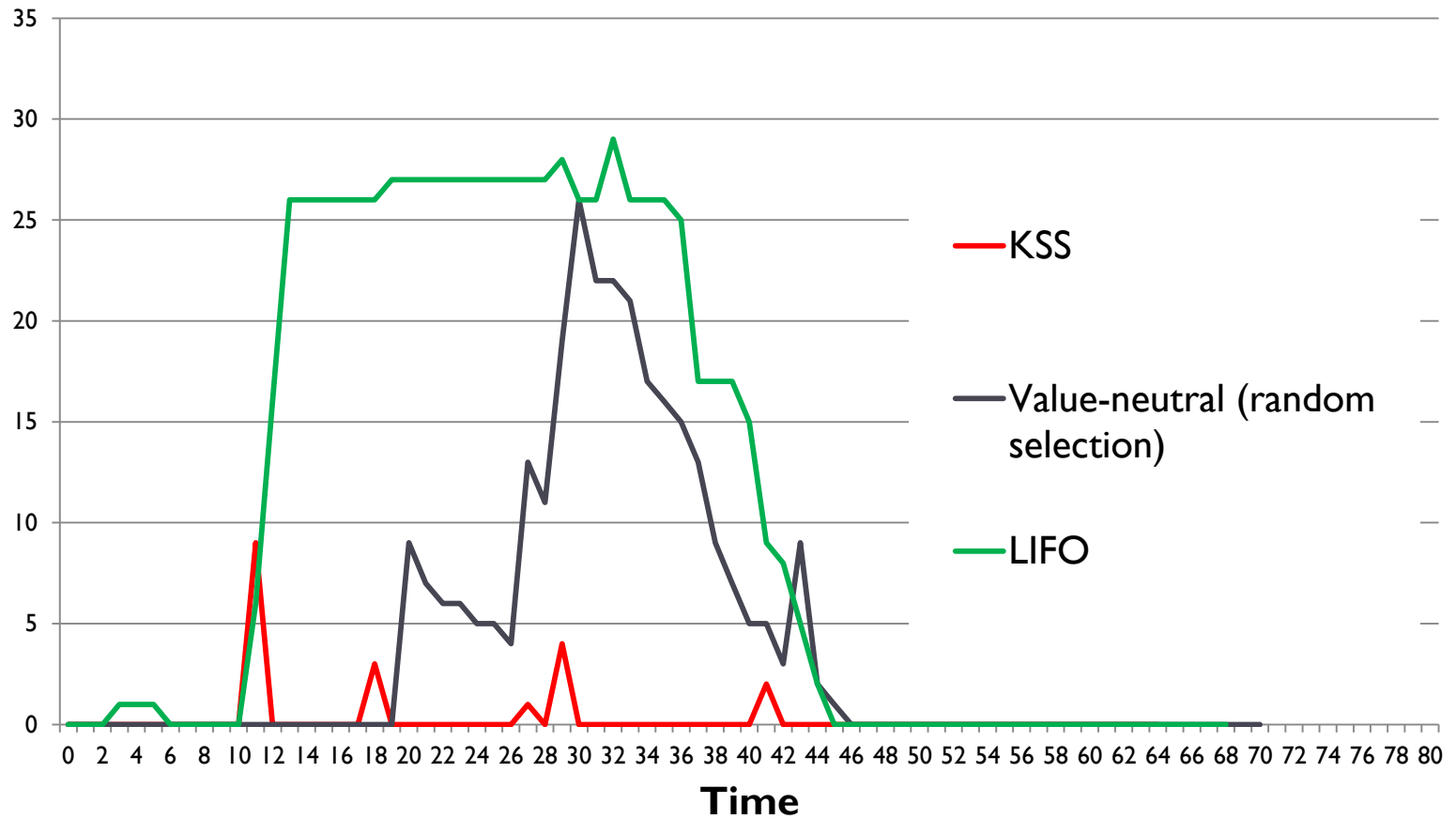
Results: complex scenario

Value



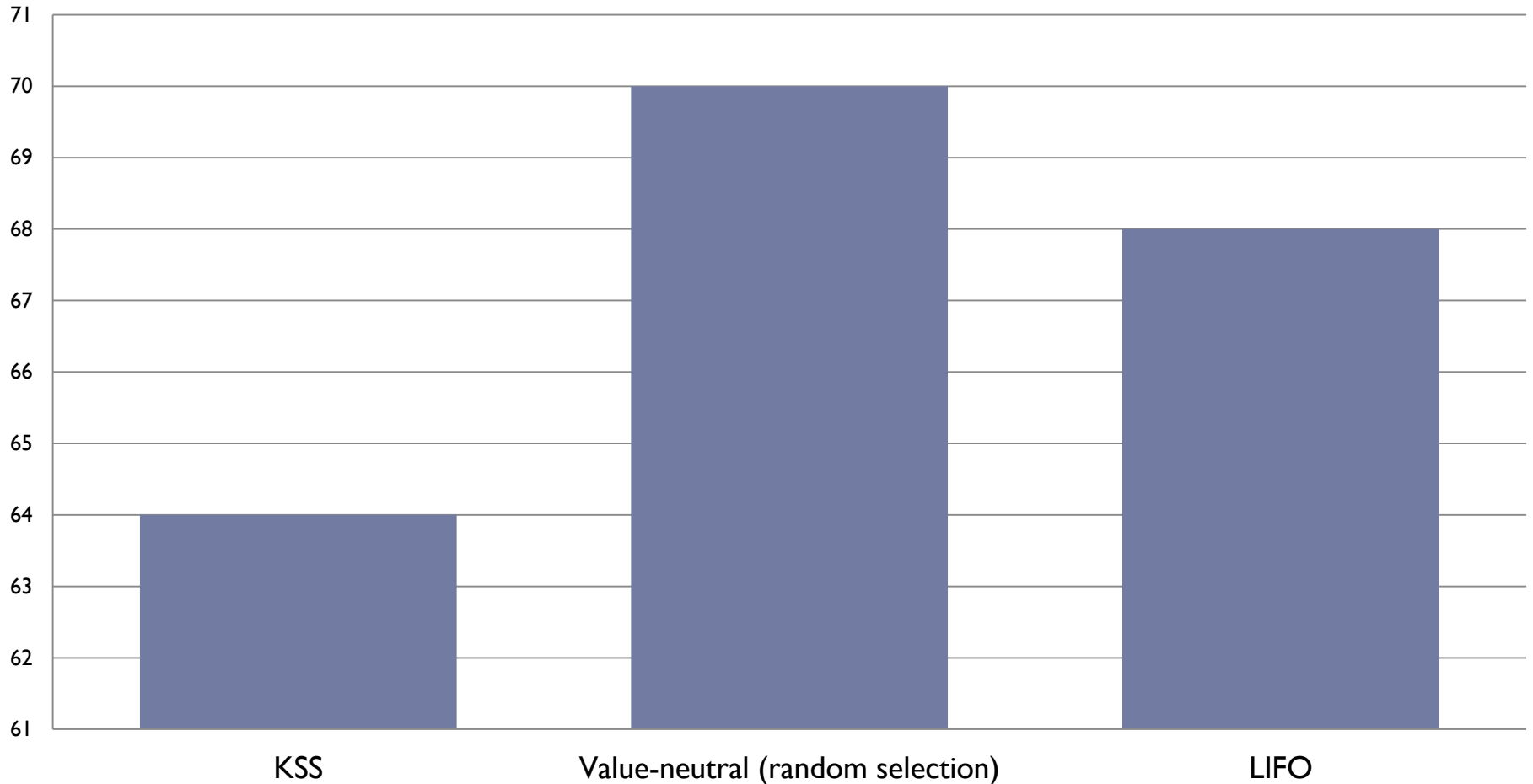
Results: complex scenario

Number of Suspended Tasks



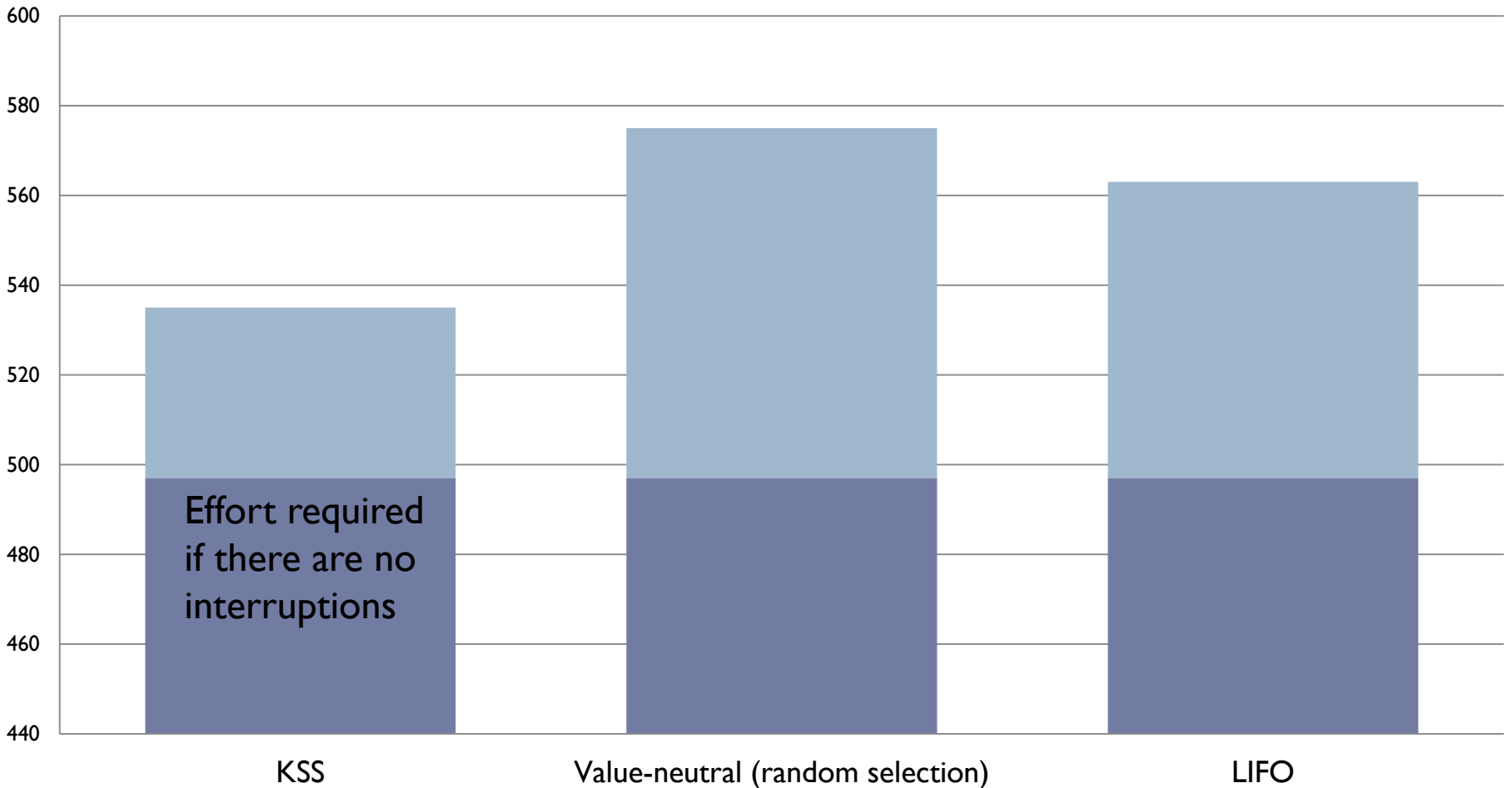
Results: complex scenario - total time spent

Total schedule (calendar days)



Results: complex scenario - total effort

Total effort (person-days)

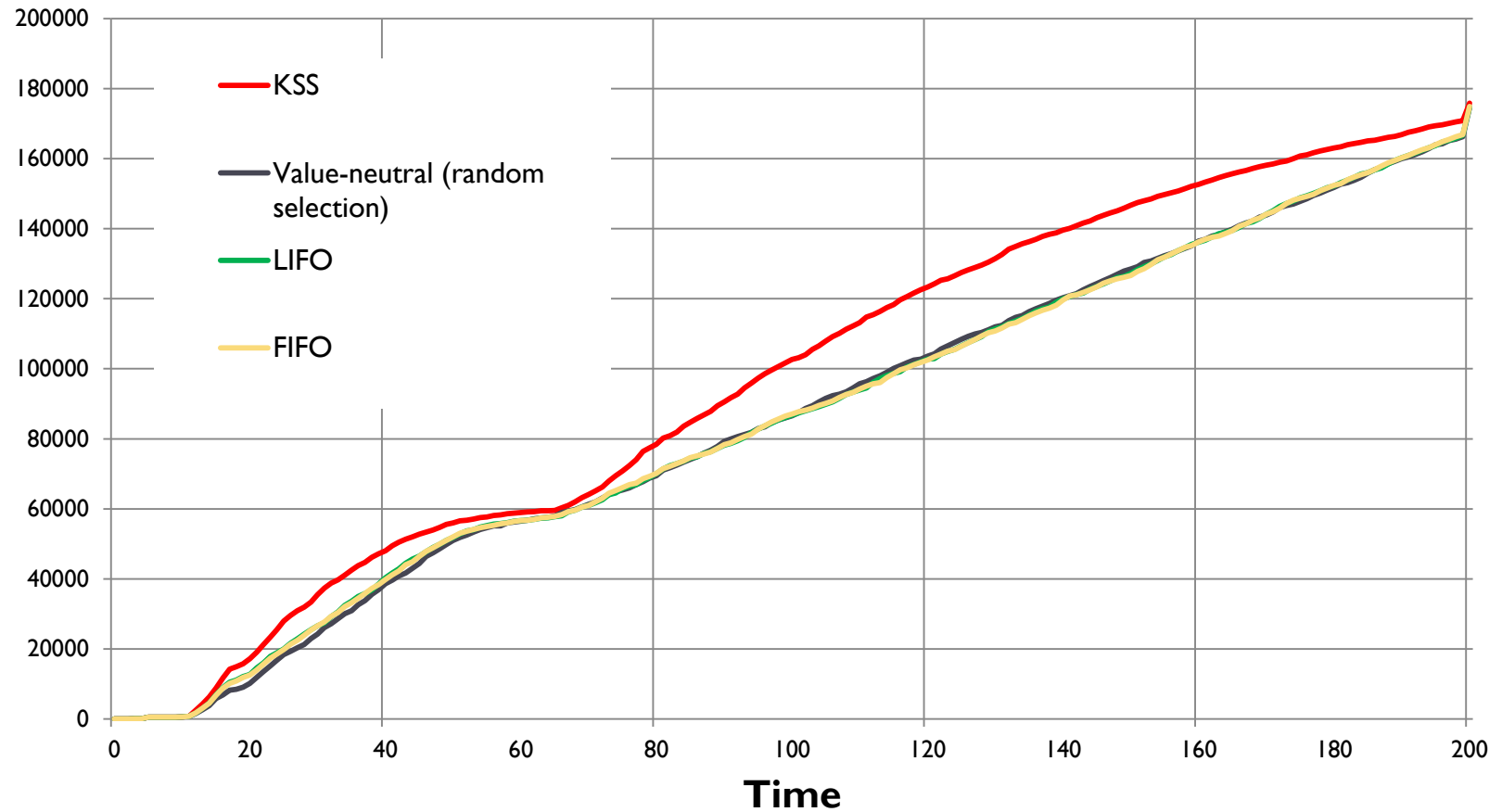


Results: even more complex scenario

- ▶ 15 teams (12 members each) + system engineering team.
- ▶ 10 new capabilities at start
- ▶ 20 more capabilities added during the simulation
- ▶ Each capability unfolds into 30 requirements on average
- ▶ Each requirement unfolds into 10 tasks on average.
- ▶ Each tasks takes 3-15 days.
- ▶ There are 10 expedite tasks that cause blocked work (blocked tasks)
- ▶ Simulation time-frame: 1 hour
- ▶ Simulation length (fixed time simulation): 200 days/1600 hours.

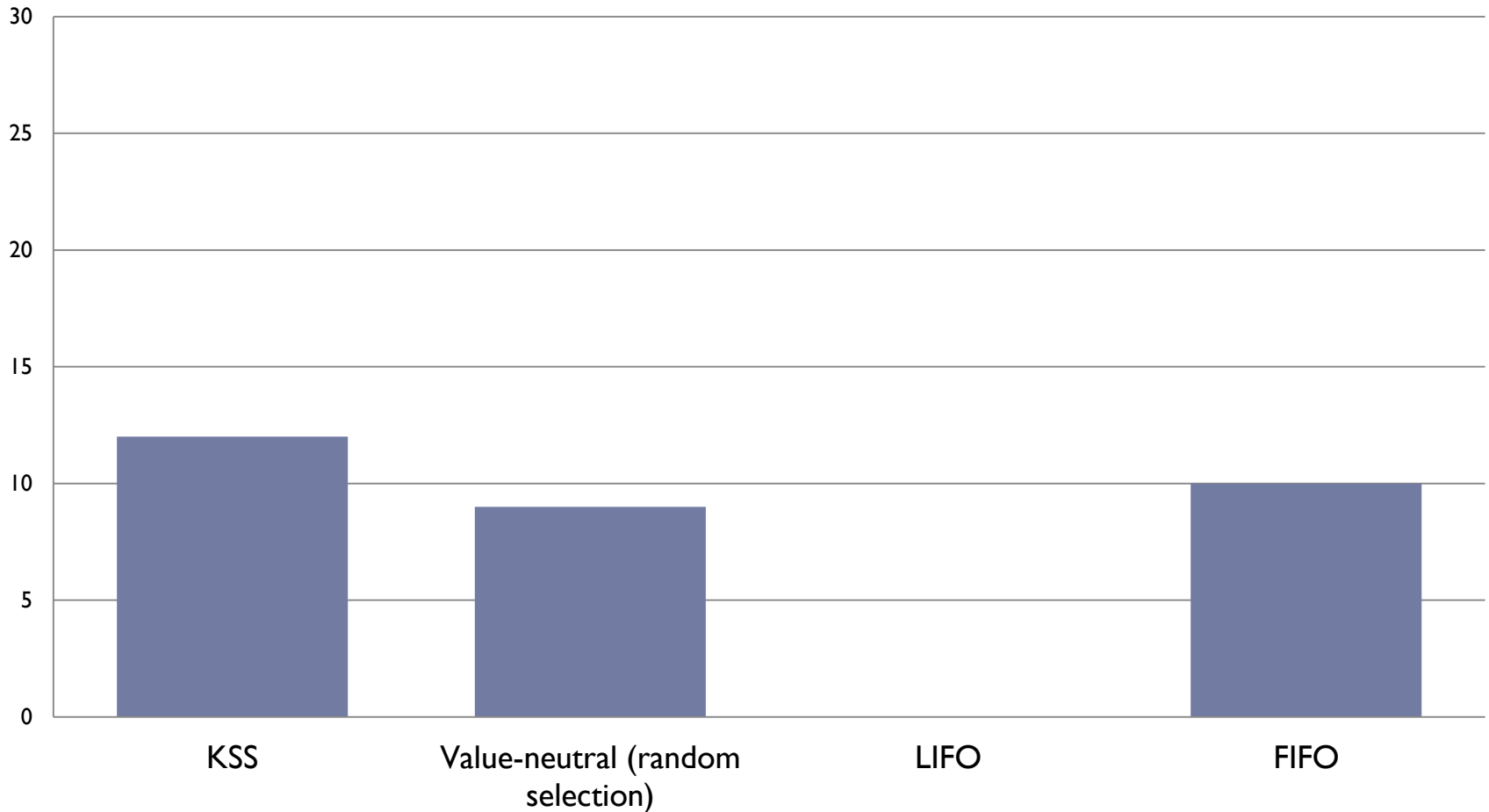
Results: even more complex scenario

Value



Results: capability completeness

Number of 100% complete capabilities



What can we do with the simulator?

- ▶ Hypothesis testing
- ▶ Process improvement
- ▶ Business decision support
- ▶ Cost and effort estimation

Conclusion: future work

- ▶ Pilot the Kanban scheduling with several organizations
- ▶ Fine-tune the simulator using empirical data and organizations' feedback
- ▶ Scale up the cases we run through the simulator
- ▶ Refine and calibrate cost models

Questions & answers
