31st Annual INCOSE international symposium
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Challenges in Detecting Emergent Behavior in System Testing

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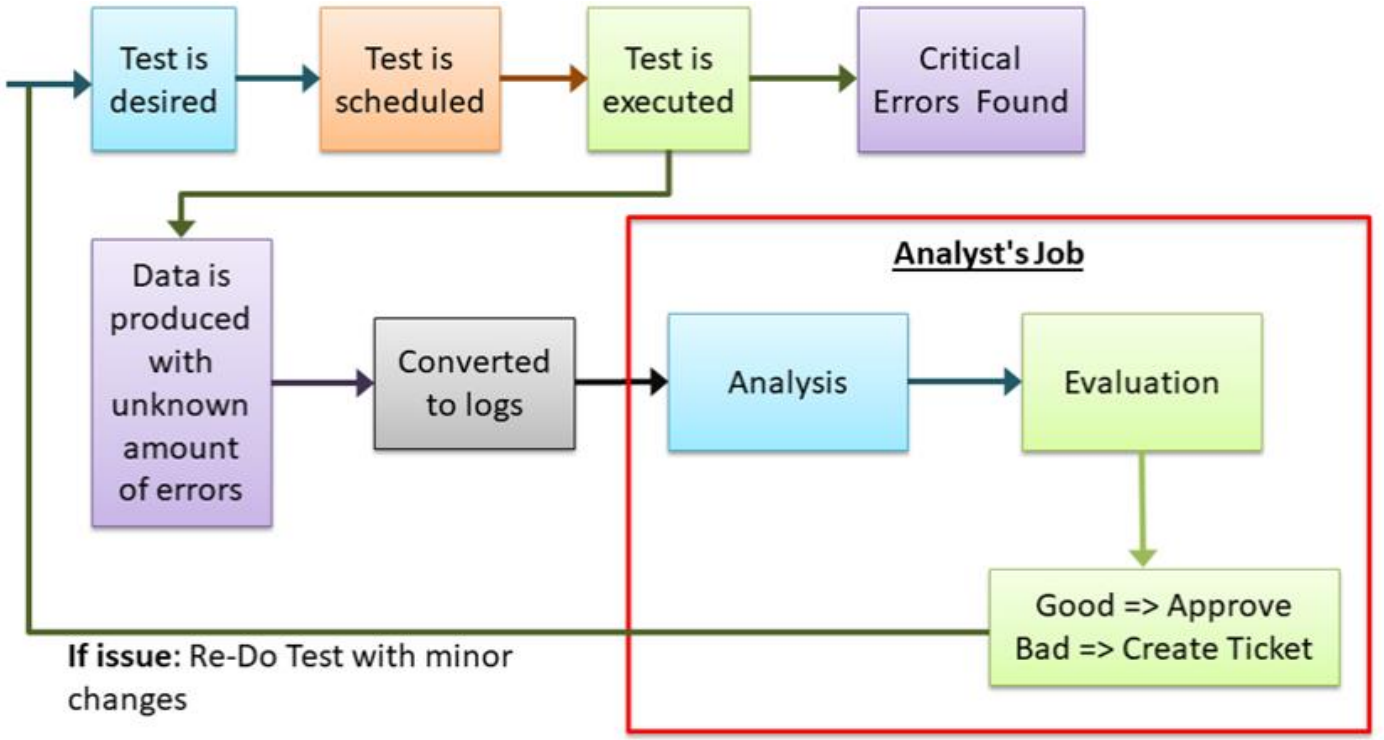
Agenda

- Problem statement
- Research questions
- State of practice
- Emergent behavior
- Challenges in detecting emergent behavior
- Anomaly detection approaches
- Research questions with answers
- Conclusion
- Further work
- Q & A

Problem statement

- Undetected unwanted behavior in system integration testing
- Dependency on system experts for manual analysis of test data

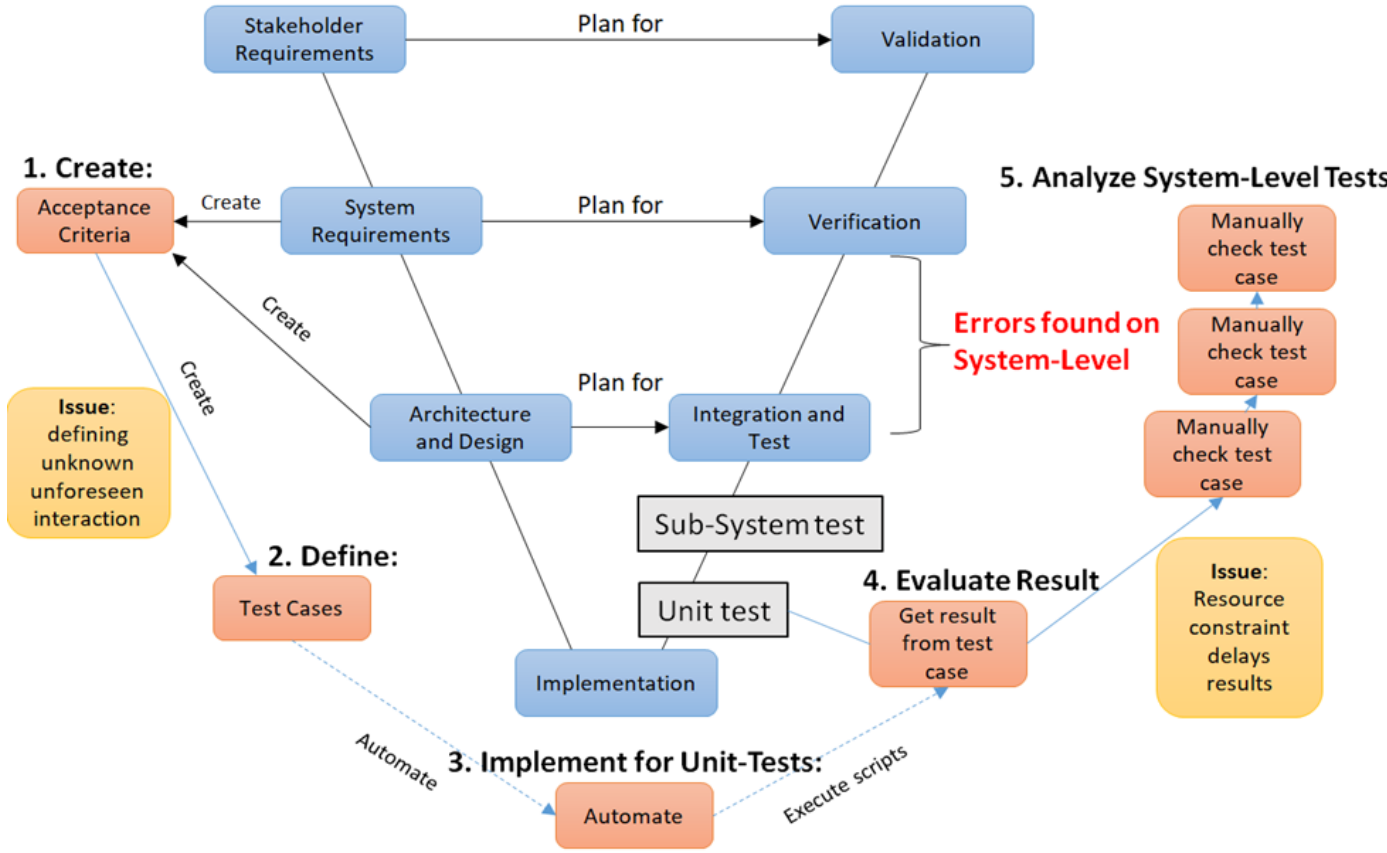


Research questions

- What are the current challenges in detecting emergent system behavior?
- How are cost and resource constraints affecting the detection of emergent system behavior?
- How can the Company improve detection of emergent system behavior during the system integration phase?

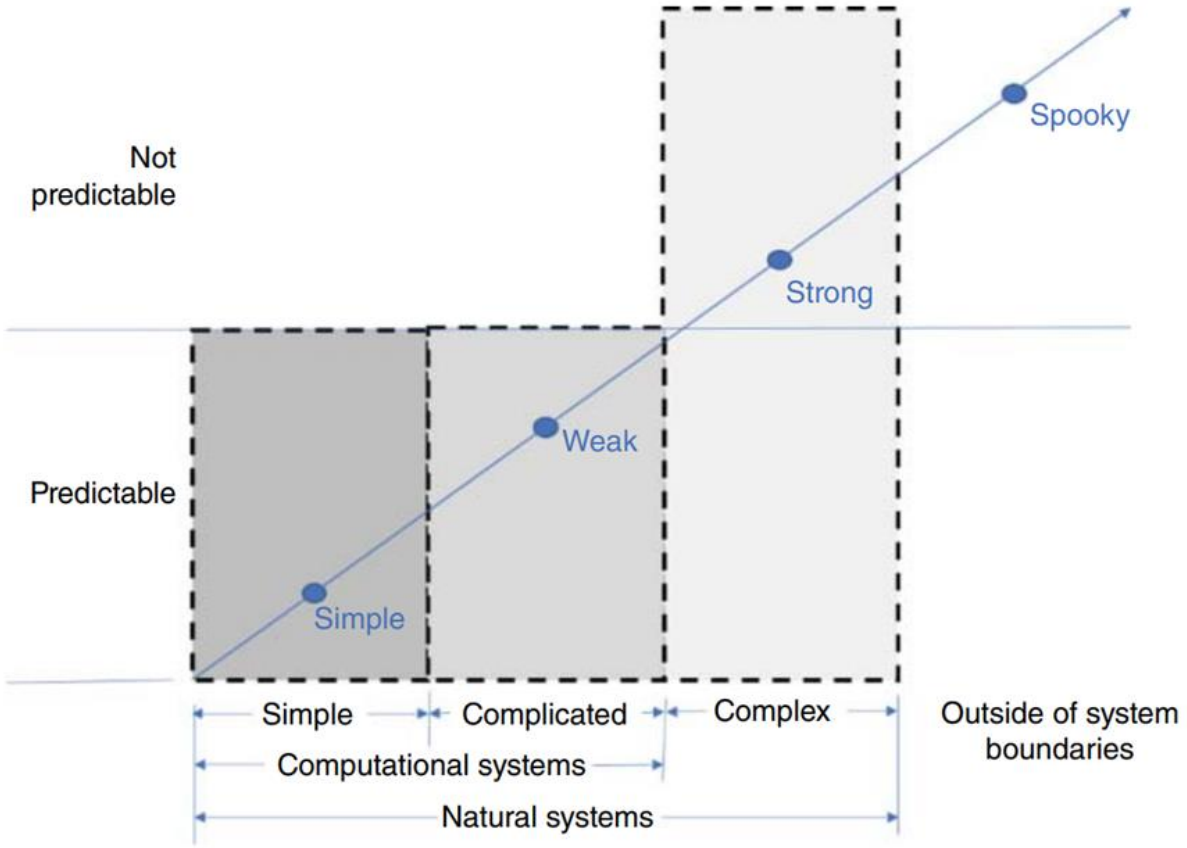
State of practice

- Test Cases with defined acceptance criteria – partly automated
- Manual analysis on both test cases and general, dependent on domain experts tacit knowledge



Emergent behavior

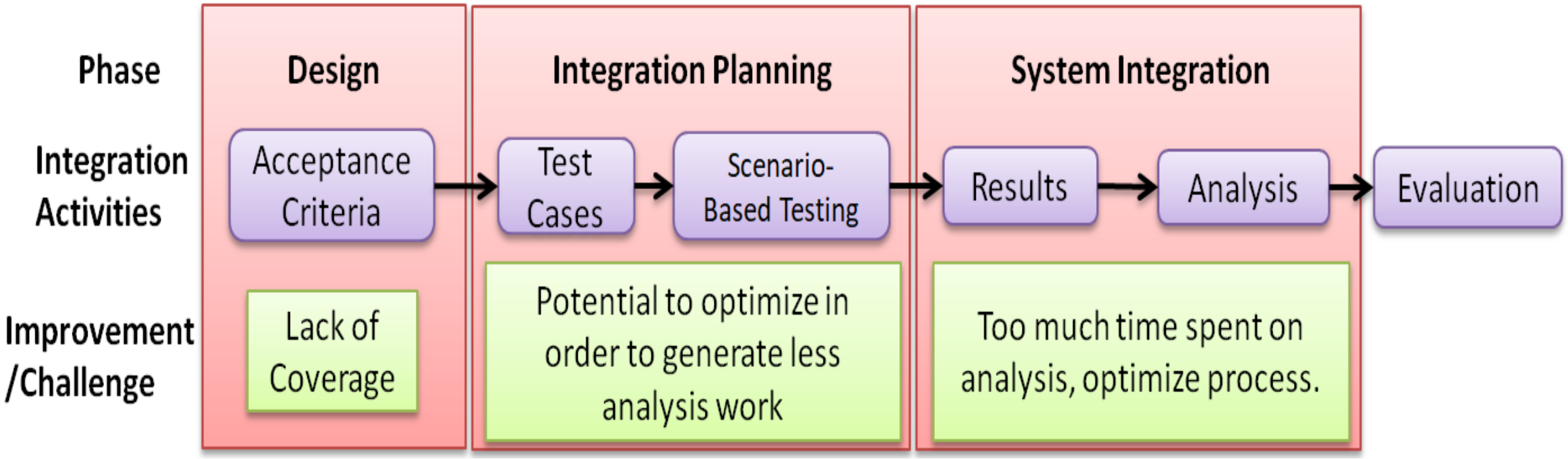
- «The whole being more than the sum of its parts »
- System categories
  - Simple, complicated, complex
- Emergence categories
  - Simple, weak, strong, spooky



Challenges in detecting emergent behavior

- Investigation into the problem domain
  - Interviews
- Bottleneck
  - Analysis coverage
- Scheduling and communication
  - Asyncronous process
  - Lack of information
- Process improvements

Anomaly detection approaches



Anomaly detection approaches

- Design Phase
  - Low detectability due to low knowledge
- Integration Phase
  - Macro-level
  - Micro-level

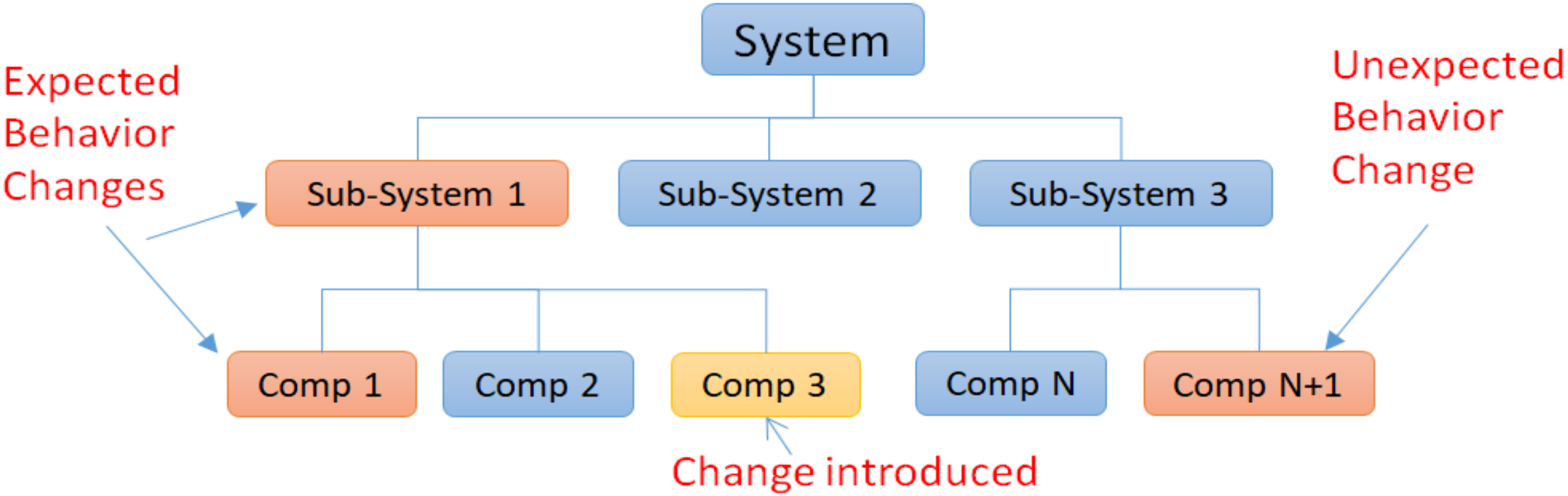
Anomaly detection approaches

- Macro-level
  - Use of selected system parameters
  - Accumulated values indicate quality (behavior integrity)
  - Specific values indicate performance in certain conditions
- Pros:
  - Less resource intensive
- Cons:
  - Little information on which system part that causes the emergent behavior

Anomaly detection approaches

- Micro-level
  - Check of each component for each new development increment
  - Analysis (only) on detected system parts
- Pros:
  - Ability to identify components causing emergent behavior
- Cons:
  - Costly

Anomaly detection approaches



Research questions with answers

- What are the current challenges in detecting emergent system behavior?
  - Unpredictability
    - Unstated expectations to the product
    - Undiscovered behavior due to interactions
  - Scheduling
    - Analysts not allocated to do analysis
  - Communication
    - Information flow (availability and purpose)

Research questions with answers

- How are cost and resource constraints affecting the detection of emergent system behavior?
  - Manual analysis is resource demanding and prioritized only in specific project phases
  - Non-continuous testing, poor test coverage, slow feedback, late detection of emergent behavior
  - Domain experts are needed both in development and analysis
  - Automation techniques are the best way to improve

Research questions with answers

- How can the Company improve detection of emergent system behavior during the system integration phase?
  - Macro approach
    - Similar to manual analysis and capable of detecting emergent behavior
    - Should be automated to speed up the detection process
  - Micro approach
    - Updated training data for detection algorithm to fit the development
    - Tuning of threshold values (not too wide and not too sensitive)
    - Should be automated to speed up the detection process

Conclusion

- Unfit process
  - Acceptance criteria testing does not detect emergent behavior
  - Manual analysis detects emergent behavior, but is resource demanding
  - Automation is necessary, but manual analysis is still needed
- Scheduling and communication issues
  - Lack of information about test purpose
  - Poor presentation of test data and lack of analysis tools
  - Manual distribution of test data
  - Conflicts with other tasks

Conclusion

- Approaches
  - An automated test framework can control behavior changes, localize faults, and ensure continuous testing
  - A macro approach has low cost, is scalable, and fits best the company case
  - A micro approach is more costly, less scalable, but aids with localization of root causes

Further work

- The company should investigate other approaches for detection of emergent behavior not part of the current processes
  - Design phase: Model-based-testing
  - Integration phase: Machine learning
  - Life cycle: Digital twin

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