Model-Based Testing
in the Cloud

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CTO

Conformiq Inc.

Conformiq in Nutshell
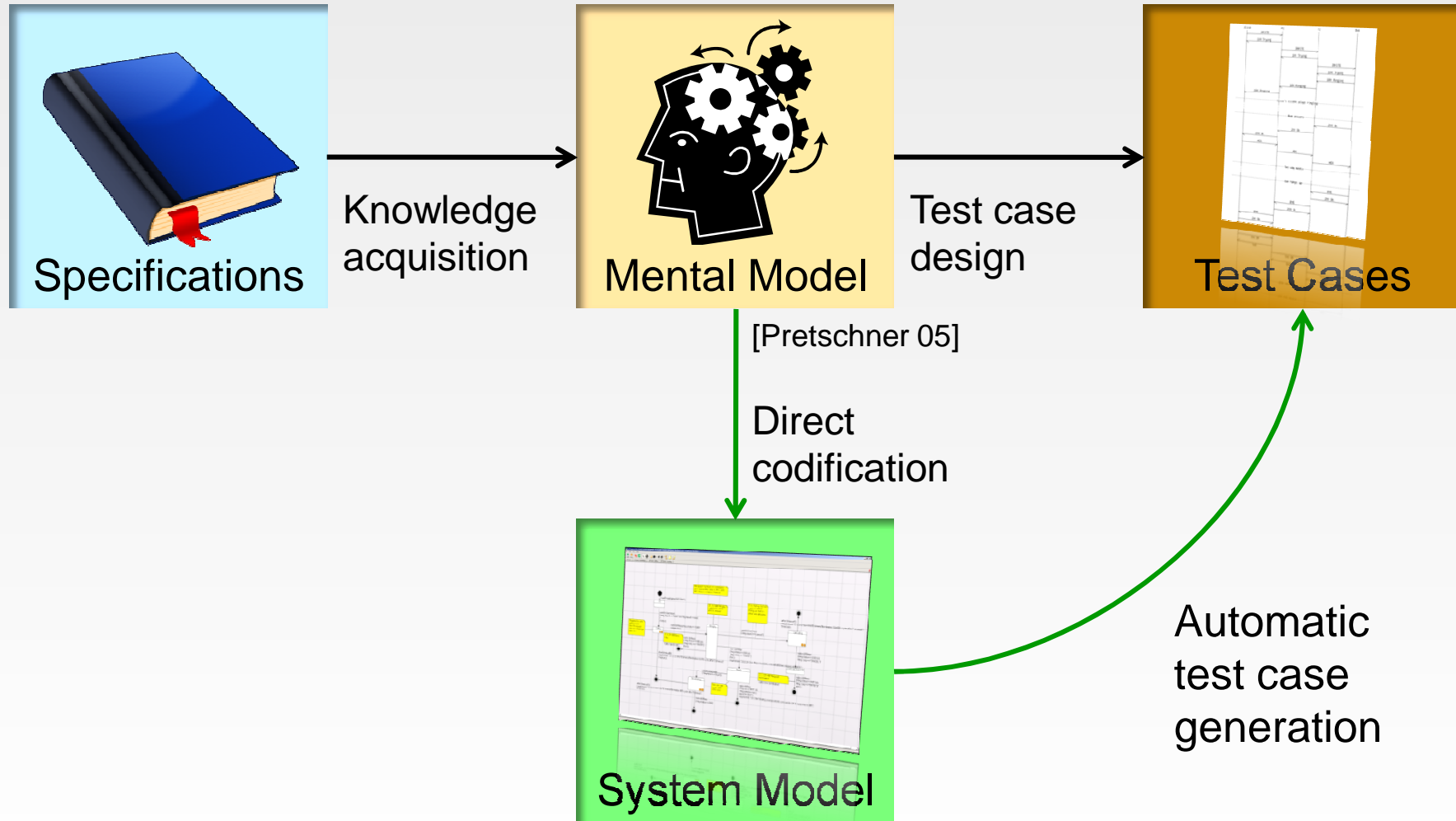
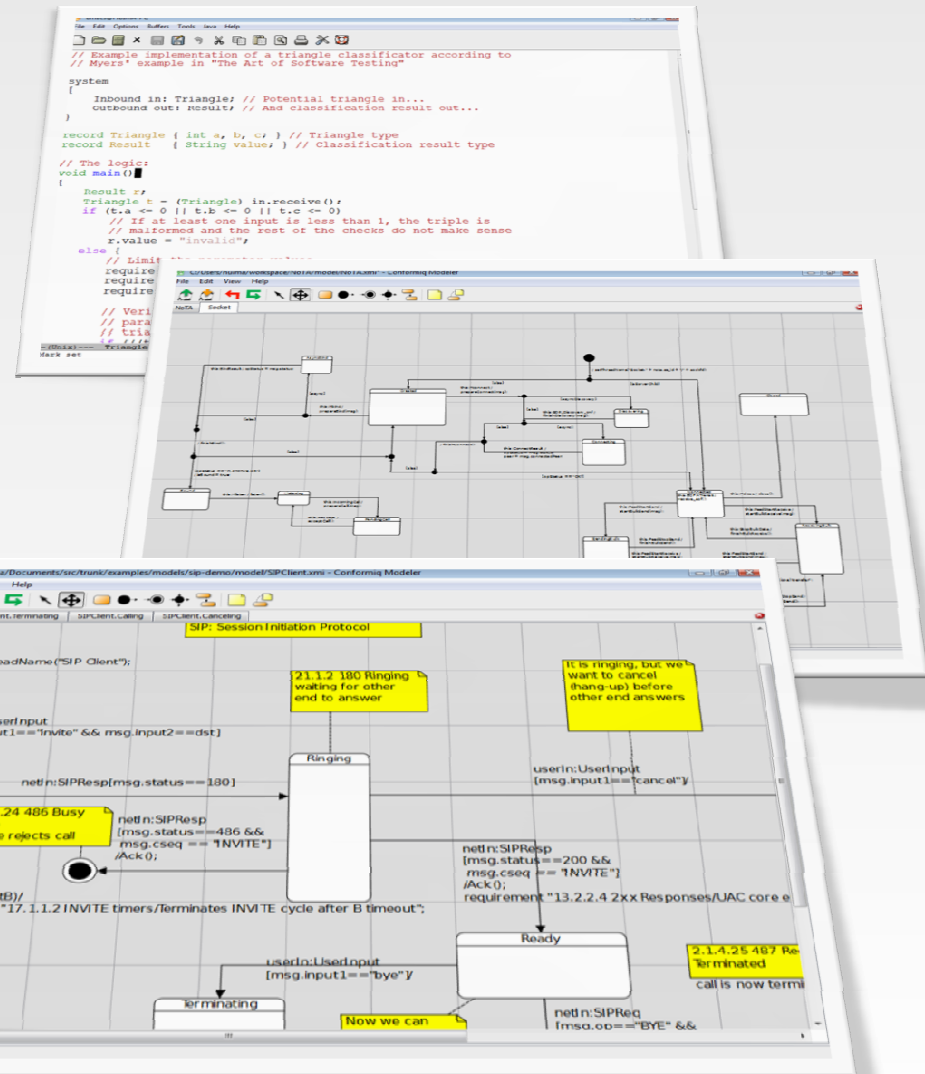| **Who We Are**	**What We Deliver**
• Privately held high-technology company • Offices in US, Sweden, Finland and Germany; partner presence in India	• Software for **Automated Test Design™** • 5X to 20X productivity gain in **test design** with improved test coverage and quality • Focus on black-box functional and feature testing

System Model Driven Test Generation

Specifications → Knowledge acquisition → Mental Model → Test case design → Test Cases

[Pretschner 05]

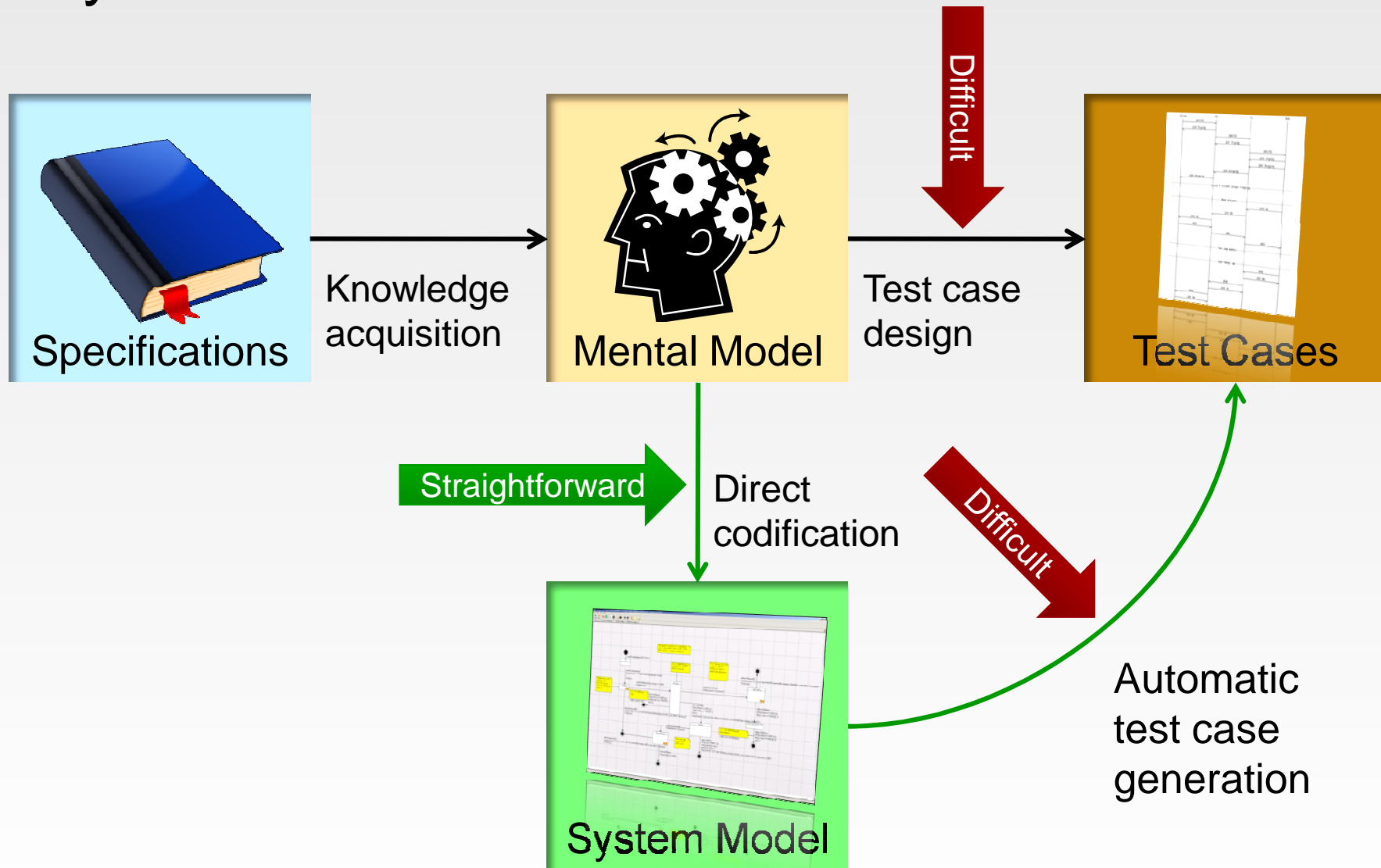Mental Model → Direct codification → System Model → Automatic test case generation → Test Cases

System Model…

- Computer-readable

- Describes the correct operation of the system

- Small and high-level

- Easy to modify

- Has same level of abstraction as the test harness

- An object-oriented computer program

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System Model Driven Test Generation

Specifications

Knowledge acquisition

Mental Model

Difficult

Test case design

Test Cases

Straightforward

Direct codification

Difficult

System Model

Automatic test case generation

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Test Generation from System Models

| Benefits	Difficulty

• Productivity improvement (we have measured consistently five-fold productivity improvement in test case design in industrial projects)
 	
• Direct correspondence between specifications and system models
	• Algorithmic complexity (depending on assumptions) is
	  – NP-hard
	  – PSPACE-hard
	  – Non-elementary
	  – Undecidable
	
	→ Performance is a general bottleneck and hindrance for adoption

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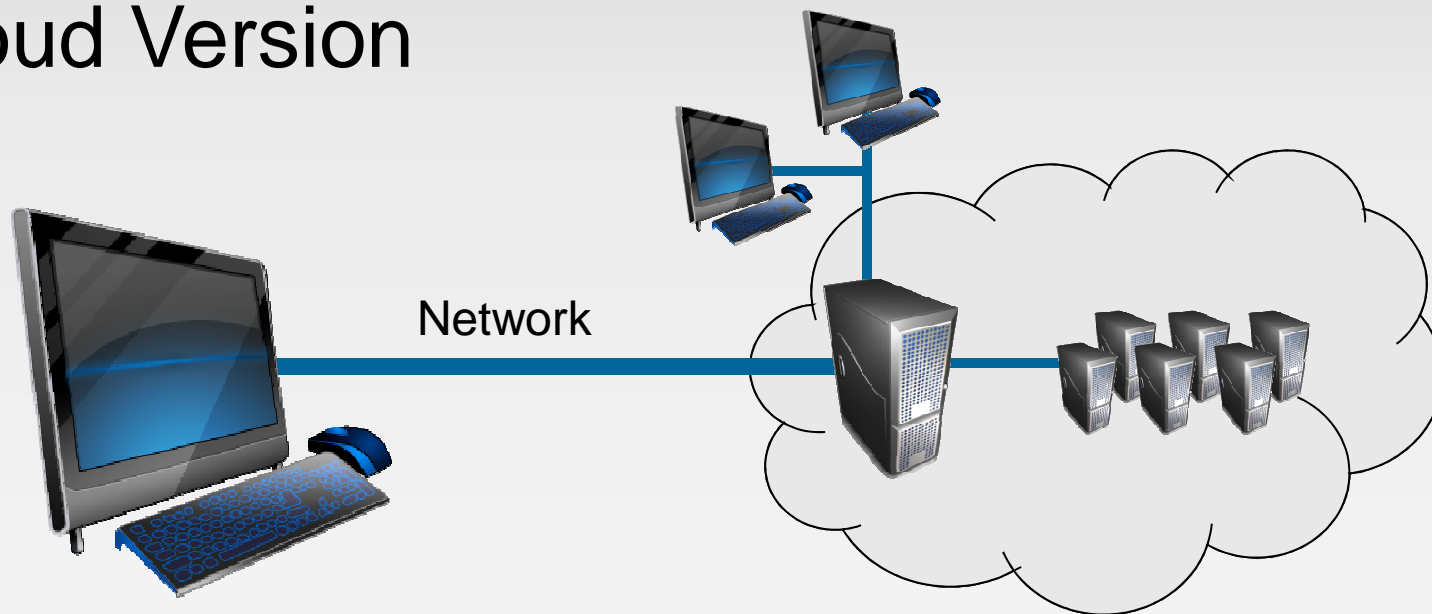# Conformiq's Test Generation Solution

Network
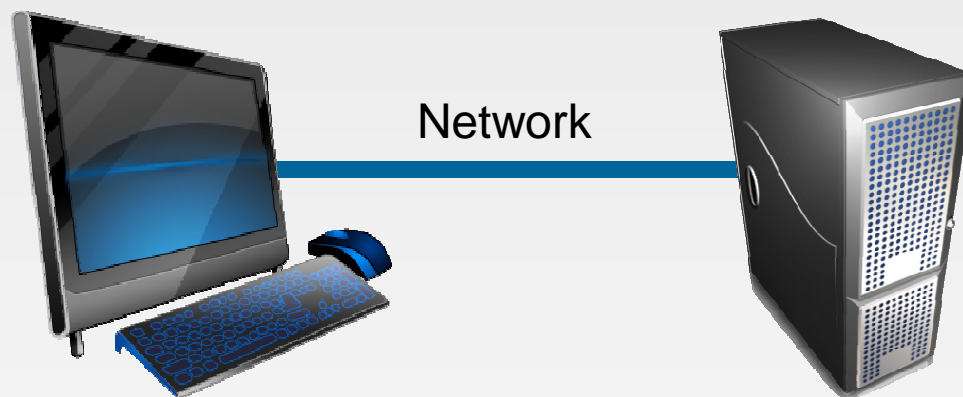
IDE for automatic
test design

Eclipse® based
desktop application

Server component
for test generation
mathematics

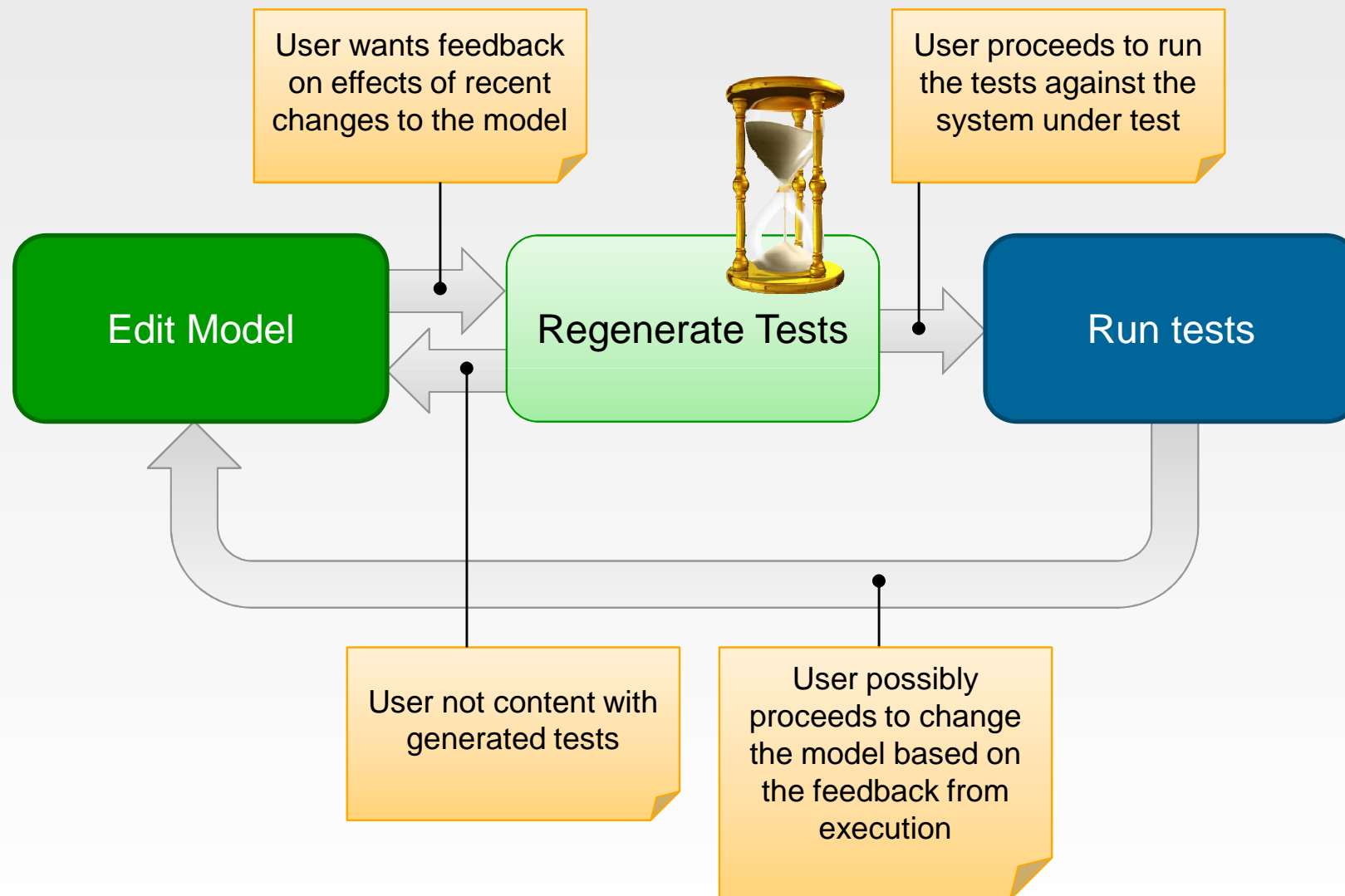Multicore-enabled
service

The Cloud Version

Network

IDE for automatic
test design

Eclipse® based
desktop application

Distributed,
parallel
computation
architecture for
test generation

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Typical Use During Test Development

User wants feedback on effects of recent changes to the model

User proceeds to run the tests against the system under test

Edit Model

Regenerate Tests

Run tests

User not content with generated tests

User possibly proceeds to change the model based on the feedback from execution
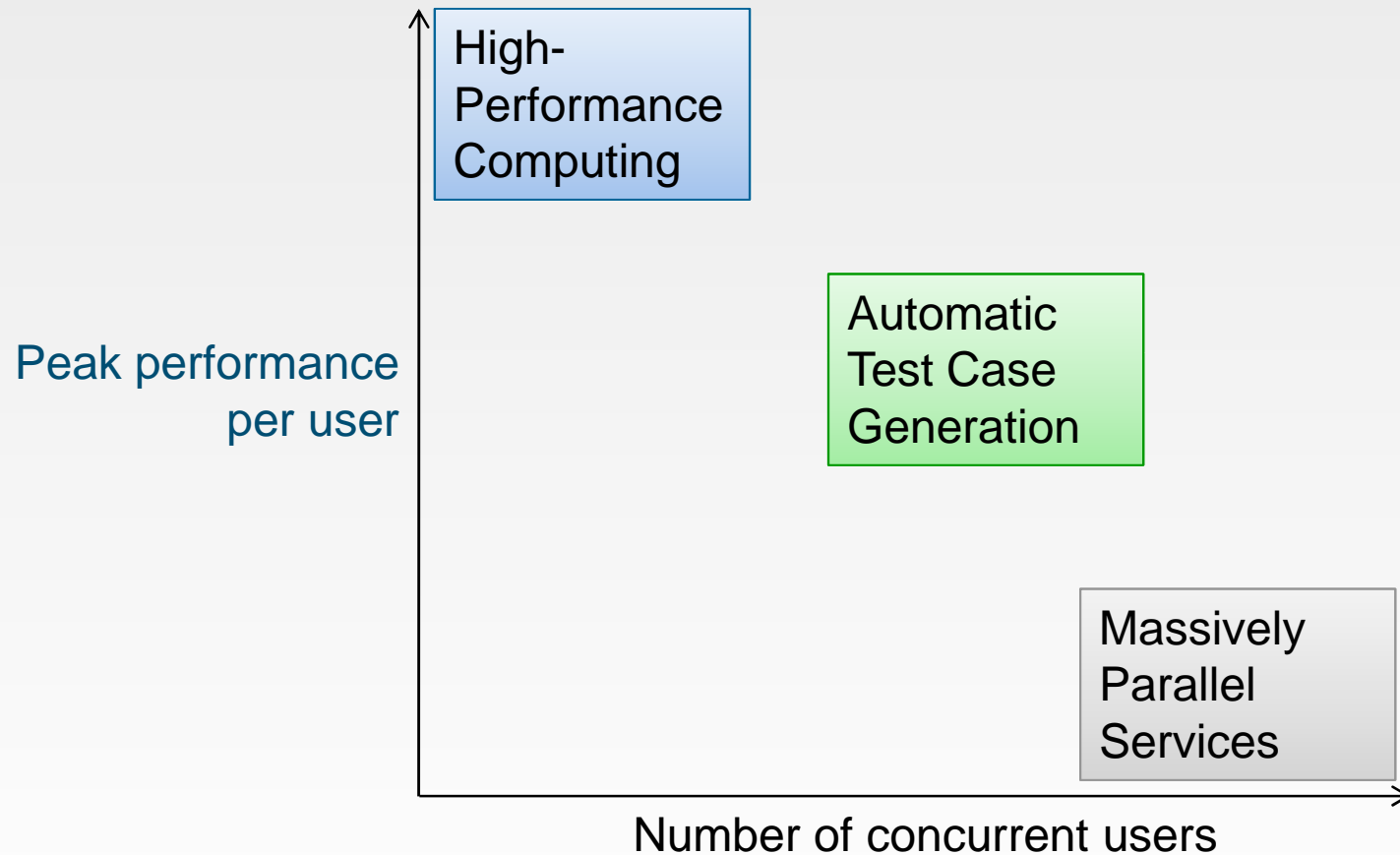
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Problem Characteristics

- Test generation with the current approach scales algorithmically well to 20 – 100 CPUs based on the system model's complexity

- Typical test generation times on single workstation range from 10 minutes to 6 hours

- In a mature deployment, it seems that roughly ¼ of test engineers are primary users of the technology, with another ¼ having a supportive role

- Quick turn-around time in test generation is important for the general efficiency of the team

- Usage is somewhat sporadic, i.e. test generation activity can be high or low depending on the current project's stage

Benefits of the Cloud Approach

- Enables high peak performance and fast test generation turn-around time, making automated test design teams more productive

- When deployed in a flexible, elastic cloud, reduces capital expenditure as the peak use can be tolerated without reserving the computational power permanently

Scalability via Cloud Computing

Peak performance per user (y-axis) vs Number of concurrent users (x-axis): High-Performance Computing; Automatic Test Case Generation; Massively Parallel Services

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Standardization Perspective

- We use currently CORBA (an OMG standard) as the middleware, and the standards-driven interoperability between the Java ORB and ACE/TAO (a C++ ORB) is crucial for us

  – WSDL/SOA/XML is the key to many of the present grid/cloud computing technologies, but CORBA is faster and has less overhead than the web services stack, making it suitable not only for configuration but also for runtime data exchange

  – At the same time, traditional HPC-standards for distributed computing such as MPI have proven to be of only little value to us, especially because they seem to handle dynamic configurations poorly (number of CPUs changes during a single run)

- We do <u>not</u> use tree reduction frameworks or huge databases (cf. the Google approach)

Summary

- Automatic test generation from system model is computationally intensive but delivers measurable and significant benefits

- Automatic test generation activity in teams is sporadic and depends on project stage

- For this problem, the cloud approach provides scalability both in terms of peak performance (test generation time) as well as in the number of (concurrent) users

- It is an interesting, new HPC application with direct applications in the everyday operations of software companies

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