Erlang Training and Consulting Ltd

Early fault detection with model-based testing

ACM SIGPLAN Erlang Workshop 2008

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Victoria, British Columbia, Canada, September 27, 2008

Agenda

- Model-based testing
- Research approach
- Results
- Challenges and recommendations
- Conclusions

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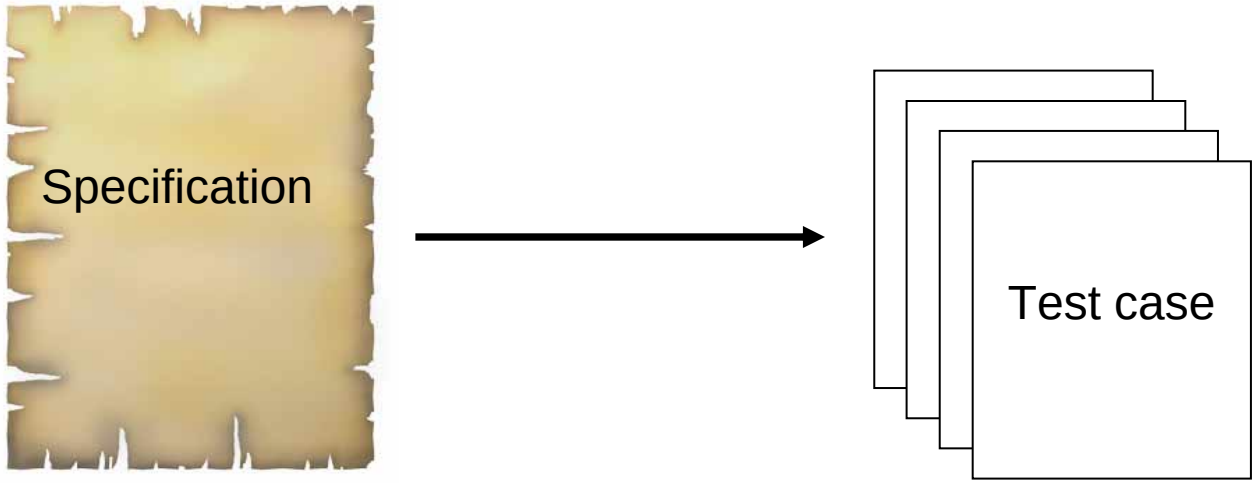
Model-based testing

The whats and whys

“Traditional” test case design



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Trend: increasing complexity

Increasingly complex requirements on interaction between systems

Difficult to achieve high coverage with hand-crafted test cases

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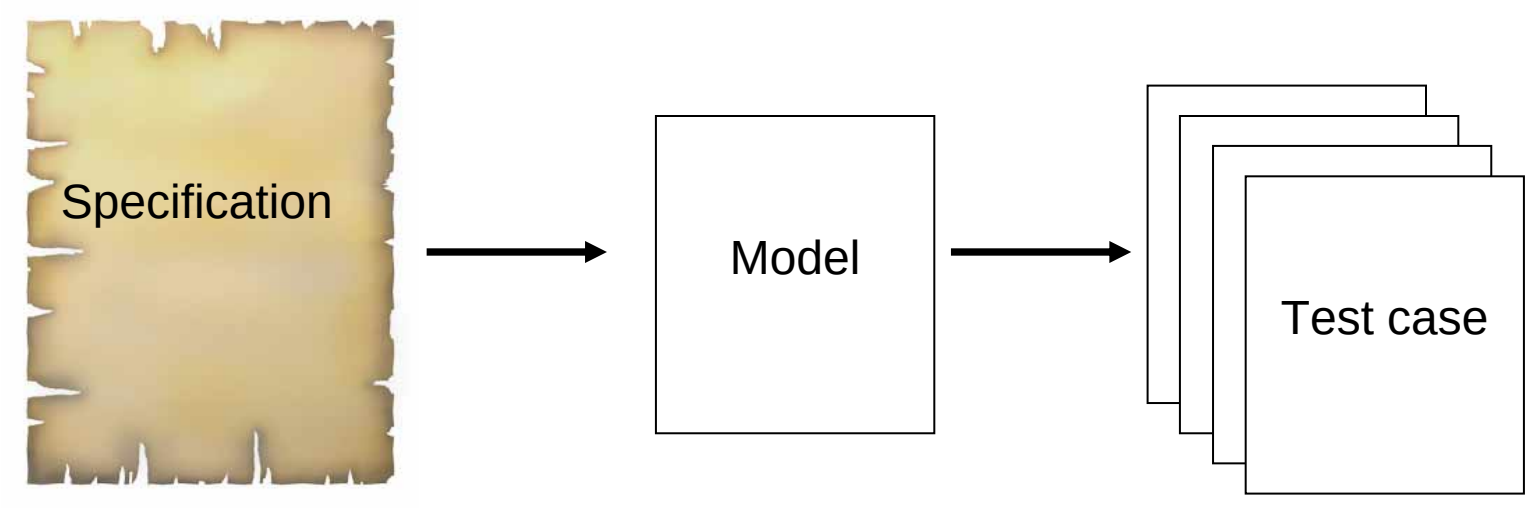
Model-based testing (MBT)



+ “Informal requirements”

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Steps of model-based testing

- Build an abstract model of system
- Validate the model
- Generate and execute test cases
- Assigning pass/fail verdict
- Analyzing the execution result.

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Steps of model-based testing - automation

Can be automated?

- [x] Build an abstract model of system
- [x] Validate the model
- [ ] Generate and execute test cases
- [ ] Assigning pass/fail verdict
- [x] Analyzing the execution result.

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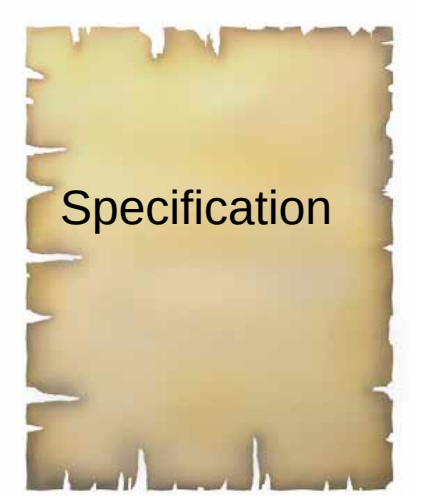
Model-based testing – with QuickCheck




```
-module(imap_eqc).
-behaviour(eqc_statem).

command(S) ->
   ...

precondition(State, {call, _, select, [CPid,_]}) ->
    min_state(client(CPid,State), ?AUTH)

postcondition(State, {call, _, select, [CPid,_]}, Result) ->
    is_status(Result, ?OK_RESP);
```

eqc:sample(...)

eqc:quickcheck(...)

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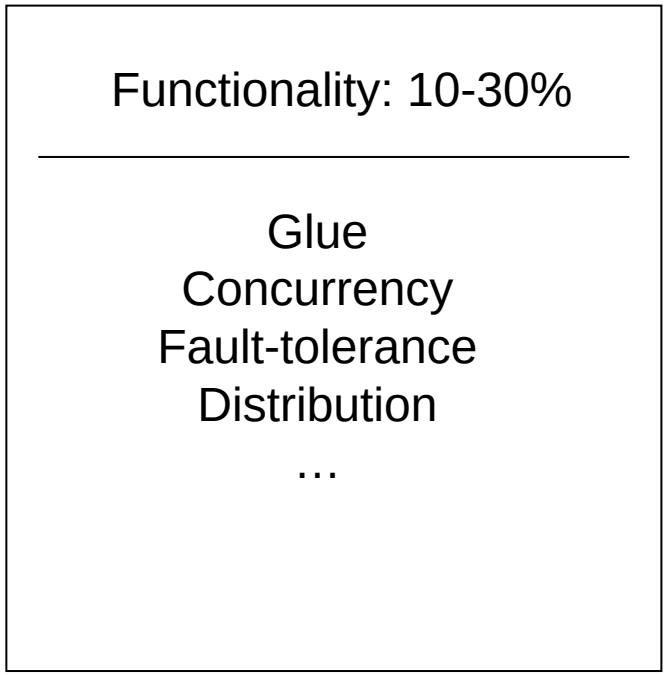
Why is MBT feasible?

Only small part of system-code typically concerned with functionality



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Why is MBT feasible?

You don’t model the full system

Abstractions are applied when modeling

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Model-based testing advantages

- Fault prevention
- Reduced cost of updating test cases

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Model-based testing in industry

AGEDIS Case Studies (France Telecom, Intrasoft and IBM)

Dalal et al.

Identifies **organizational obstacles** to practice introduction

Model-basted testing must be well **integrated in the test process**

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Model-based testing in industry

Pretschner et al

"Model-based test cases does not detect more faults than hand-crafted test cases"

"Tests were executed after the system was completely implemented"

Artho et al.

component level testing of NASAs K9 planetary rover

"the testing was conducted **after the implementation of the system** was finished"

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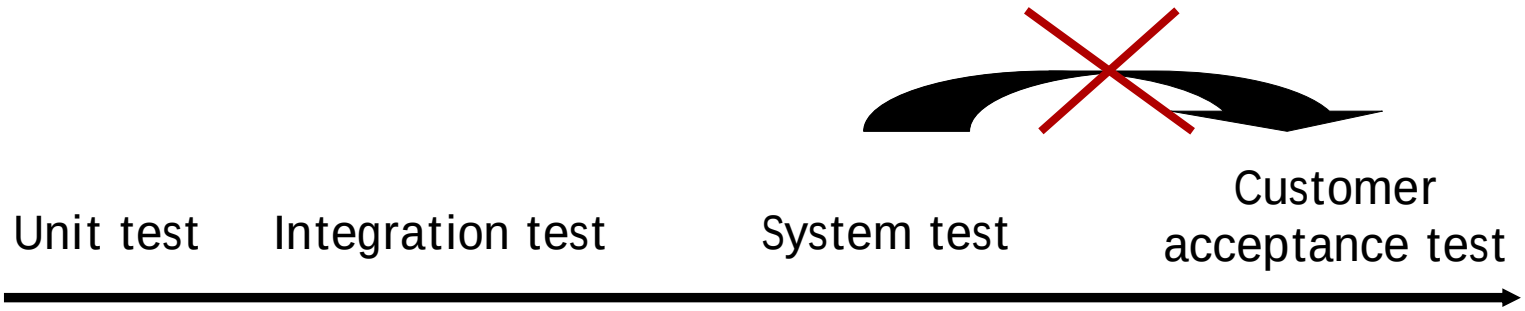
Research approach

How we applied model-based system testing to a large scale Erlang system

Project: Messaging Gateway

Study executed as a process improvement initiative

Goal: reduce fault-slip-through to acceptance testing



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Costs of faults-slip-through

-> Higher cost of tracking and fixing faults

-> Reduced confidence in system

-> Build and deploy additional release candidates

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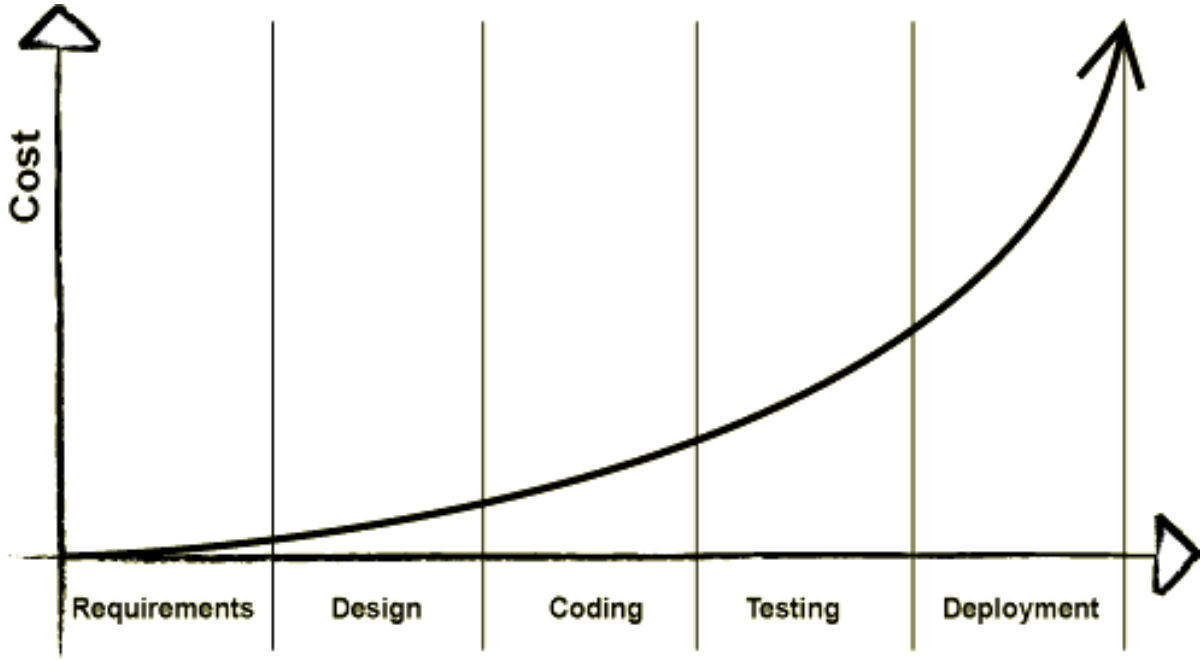
Boehm curve



* Boehm, Software Engineering Economics,Prentice Hall PTR, 1981

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Central question

How can model-based testing be applied at the system-level, to enable early fault-detection and increased confidence in the system?

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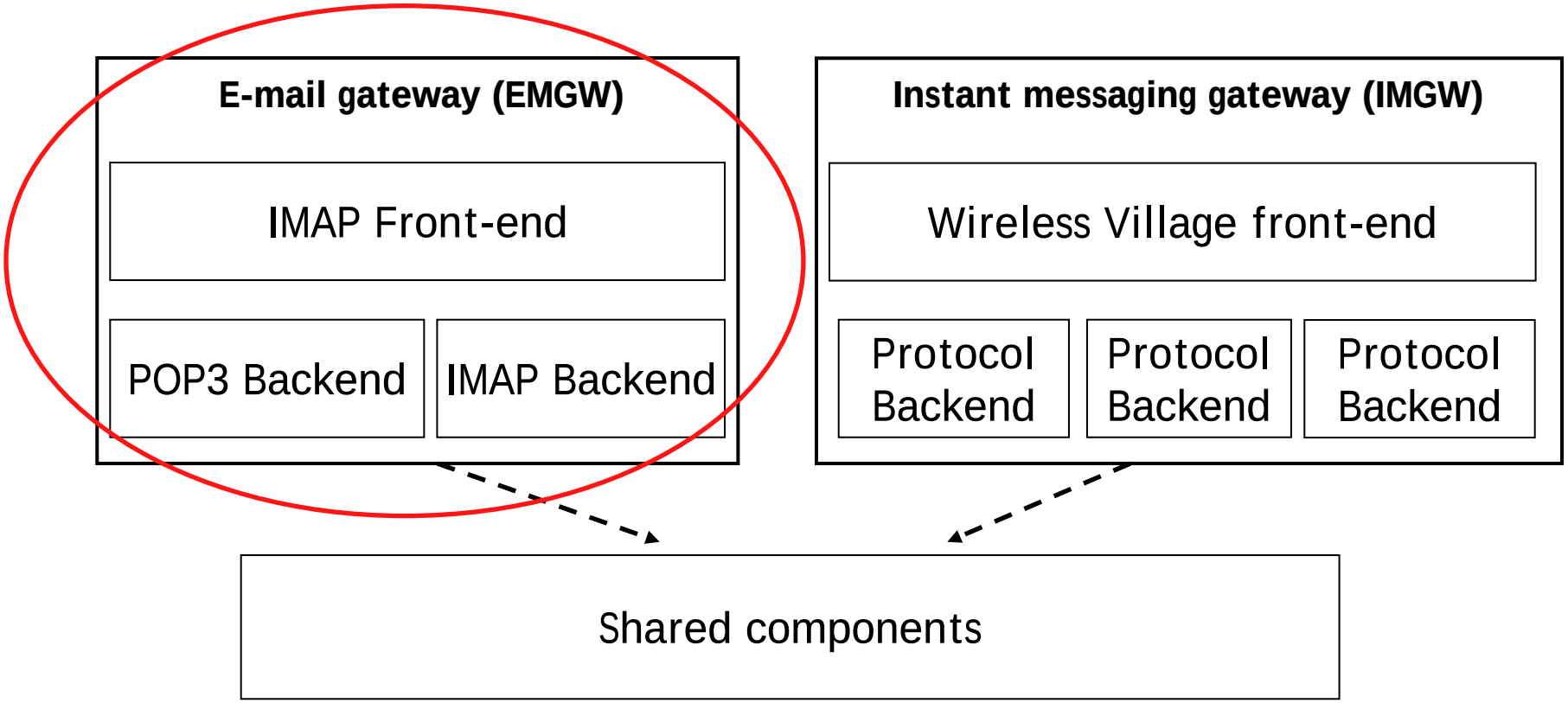
Messaging gateway system



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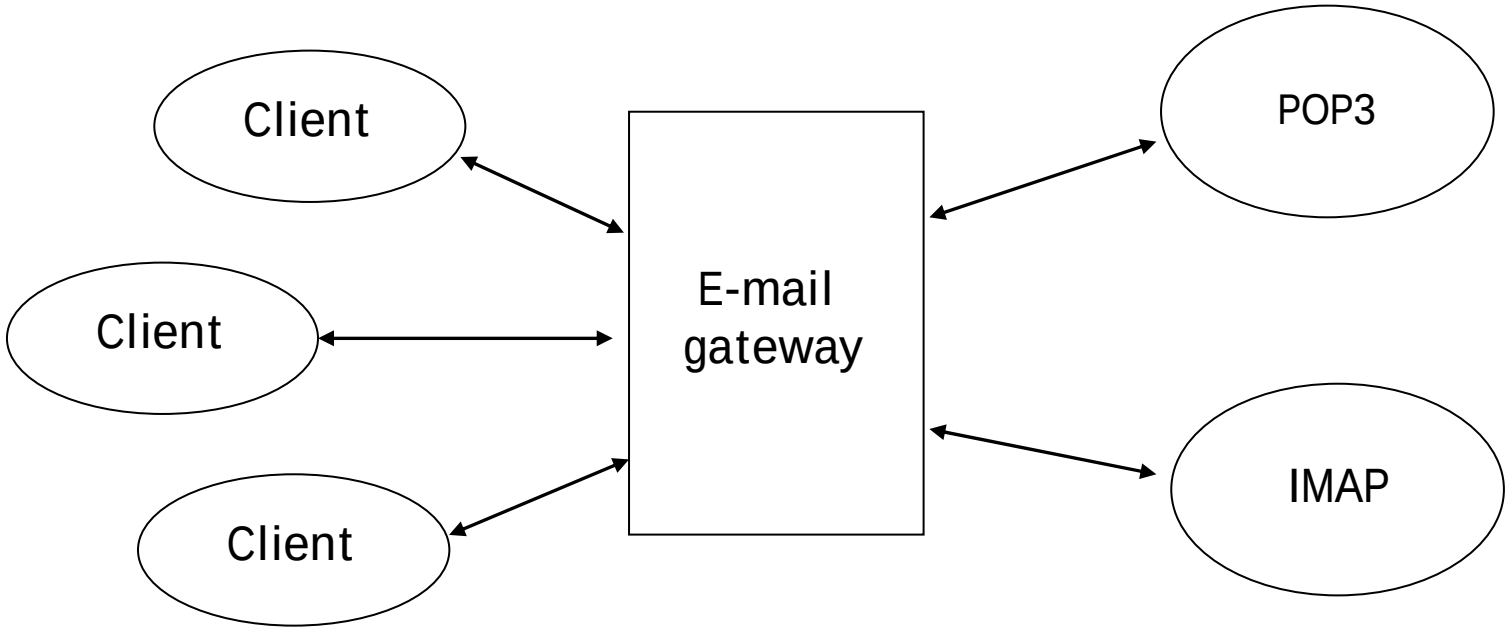
Test approach



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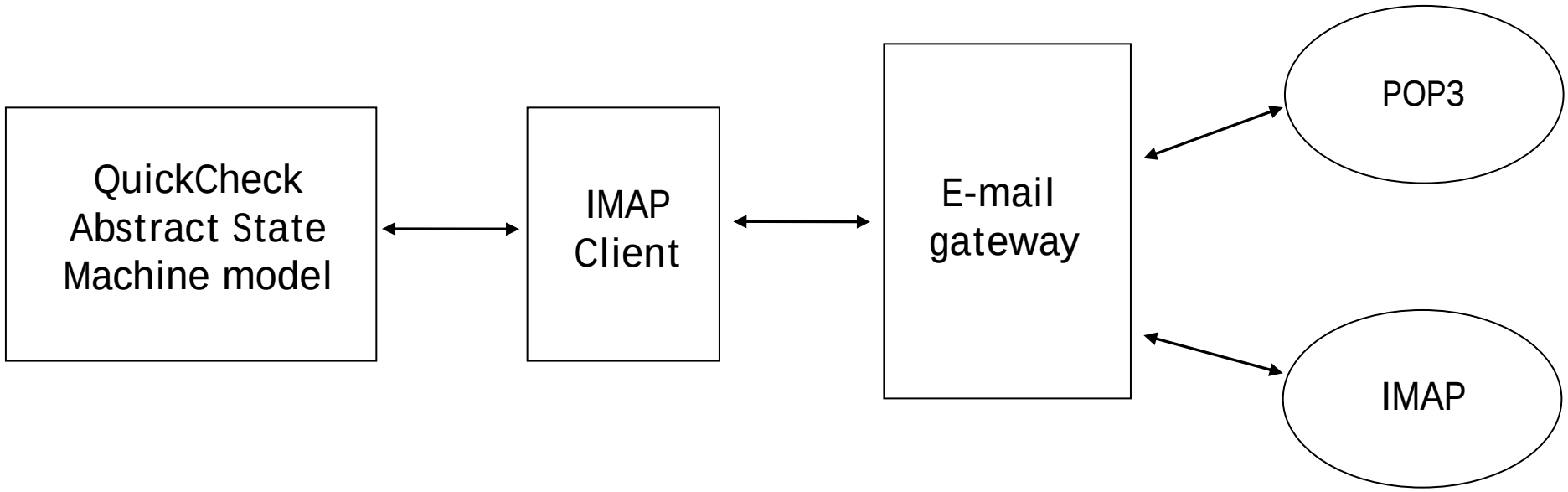
Test approach



Hypothesis: Model-based will result in lower fault-slip through from system testing to customer acceptance testing

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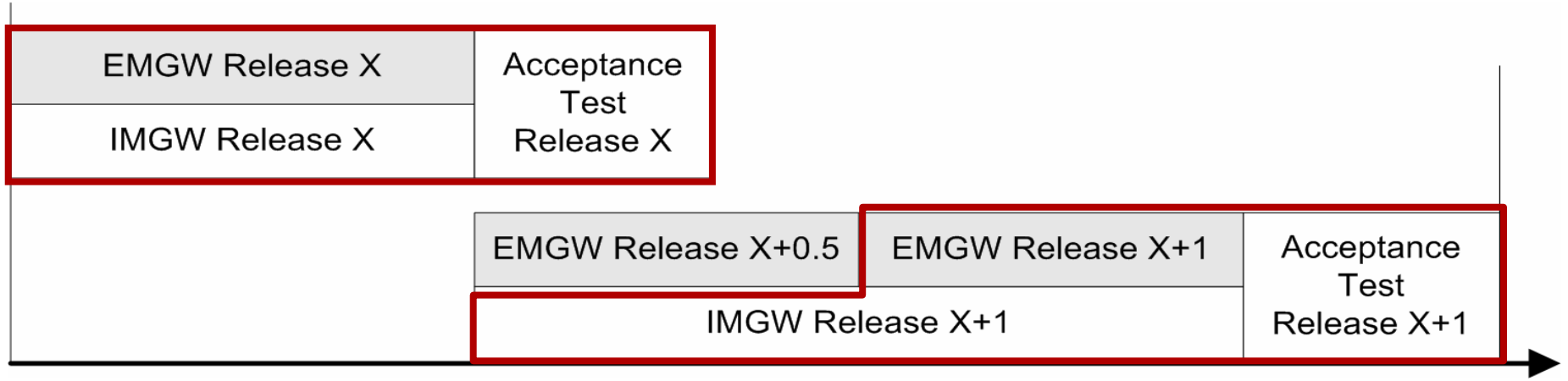
Study timeline

Three studied releases:

- Release X
- Release X+0.5
- Release X+1



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Model-based testing in iterative development

For each iteration:

- Select requirements
- Model requirements
- Validate and execute

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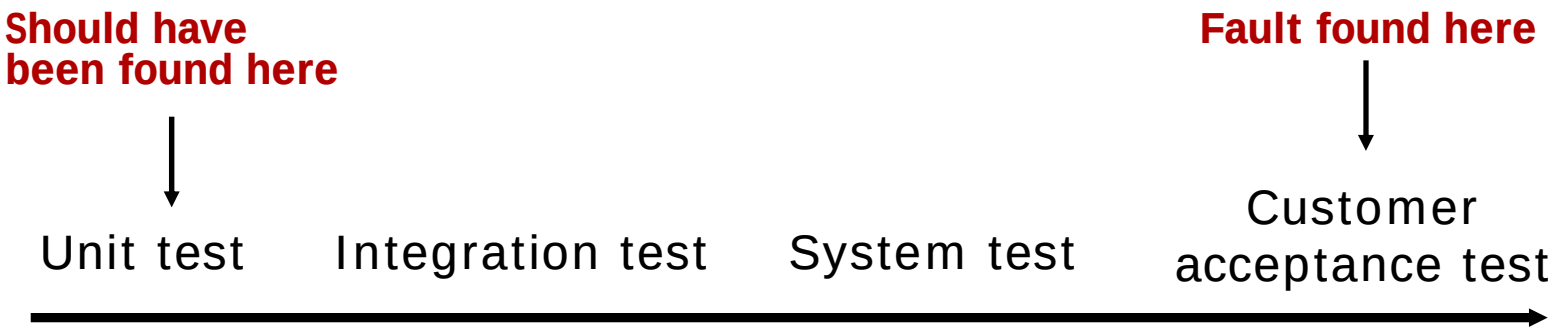
Fault-slip-through measurement



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Results

Model-based testing

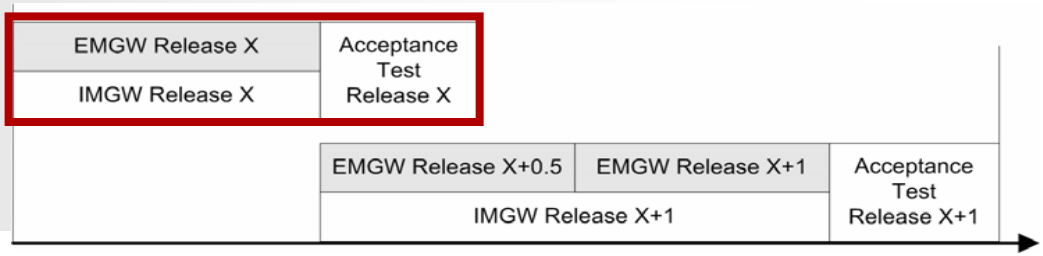
Research approach

Results

Challenges and recommendations

Conclusions

Results – Release X



EMGW

Found/Belonging	System Test	Acceptance test
Unit Test	1 (0)	1
Integration Test	1 (1)	0
External Integration Test	0 (0)	0
System Test	9 (6)	3
~~Acceptance Test~~	~~0 (0)~~	~~2~~
Total found/test level	**11** (7)	**4**

IMGW

Found/Belonging	System Test	Acceptance test
Unit Test	6	4
Integration Test	0	0
External Integration Test	0	0
System Test	8	10
~~Acceptance Test~~	~~0~~	~~4~~
Total found/test level	**14**	**14**

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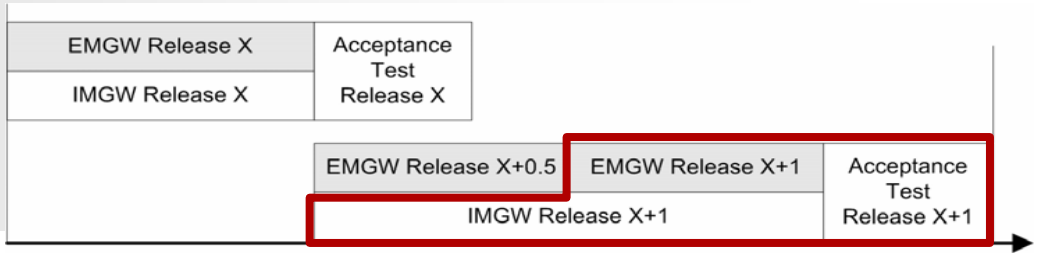
Results – Release X+1



EMGW

Found/Belonging	System Test	Acceptance test
Unit Test	24 (21)	3
Integration Test	1 (1)	0
External Integration Test	0 (0)	0
System Test	39 (26)	4
~~Acceptance Test~~	~~0 (0)~~	~~10~~
Total found/test level	**64** (48)	**7**

IMGW

Found/Belonging	System Test	Acceptance test
Unit Test	1	4
Integration Test	1	0
External Integration Test	0	1
System Test	12	7
~~Acceptance Test~~	~~0~~	~~2~~
Total found/test level	**14**	**12**

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Phase Input Quality

Phase Input Quality (PIQ) =

$$\frac{\text{Should have been found on earlier level}}{\text{Total found on level}}$$

Release/FST	X	X+0.5	X+1
EMGW FST to ST	18%	24%	39 %
EMGW FST to AT	67%	–	41%
IMGW FST to ST	43%	–	14%
IMGW FST to AT	78%	–	86%

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Challenges and recommendations

(As usual,) there is no silver bullet

Challenges

Finding suitable abstractions is difficult

We cannot execute partial tests

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Recommendations

Iterative model development crucial

Test techniques are complementary

Challenges and recommendations

A substantial initial investment is required to integrate the model-based testing into the test process

Visibility of results crucial to success

- both internal and external

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Conclusions

Model-based testing

Research approach

Results

Challenges and recommendations

Conclusions

Conclusions

Significantly more faults found by model-based testing

Results supports our hypothesis - model-based testing decreased the fault-slip-through

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Questions?

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