Improving Effectiveness of Automated Software Testing in the Absence of Specifications

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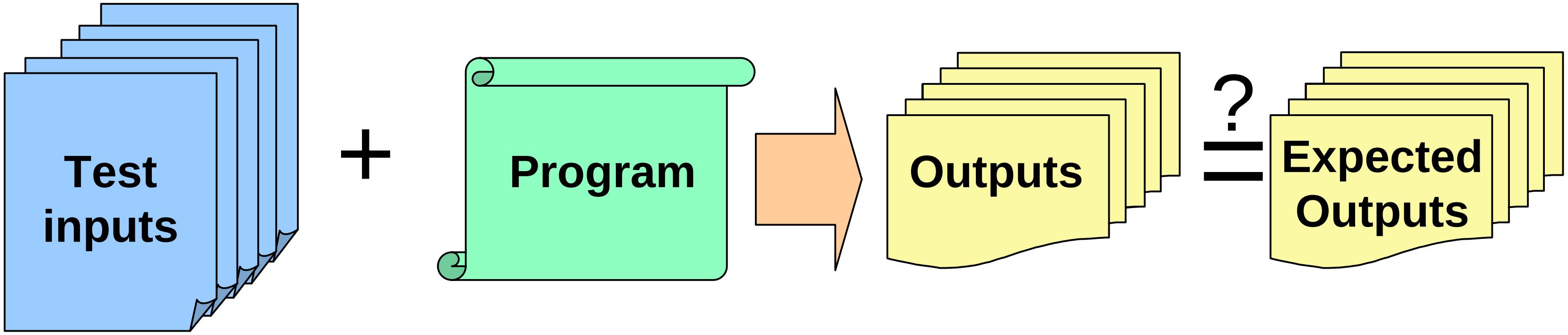
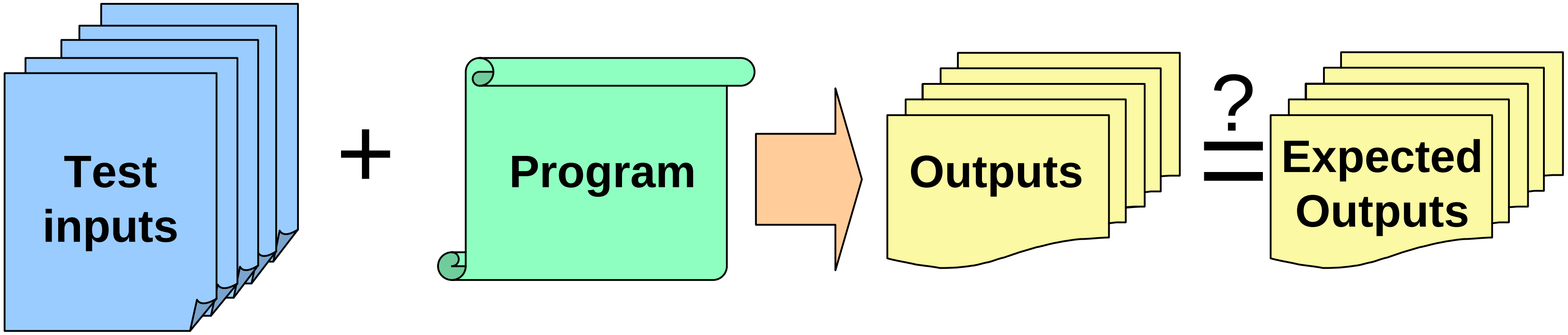
Testing Setup

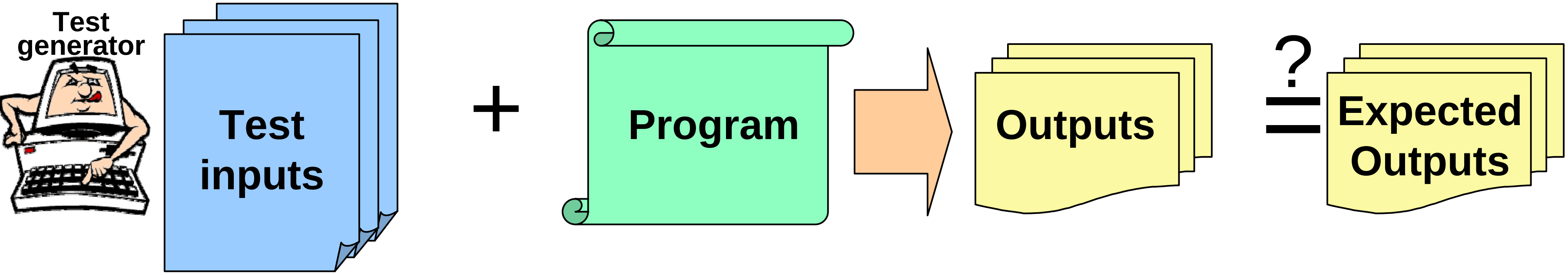


Problems



- **Are some of those generated tests redundant?** [Xie et al. ASE’04]

Problems



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- **How can we generate non-redundant tests?** [Xie et al. TACAS’05]

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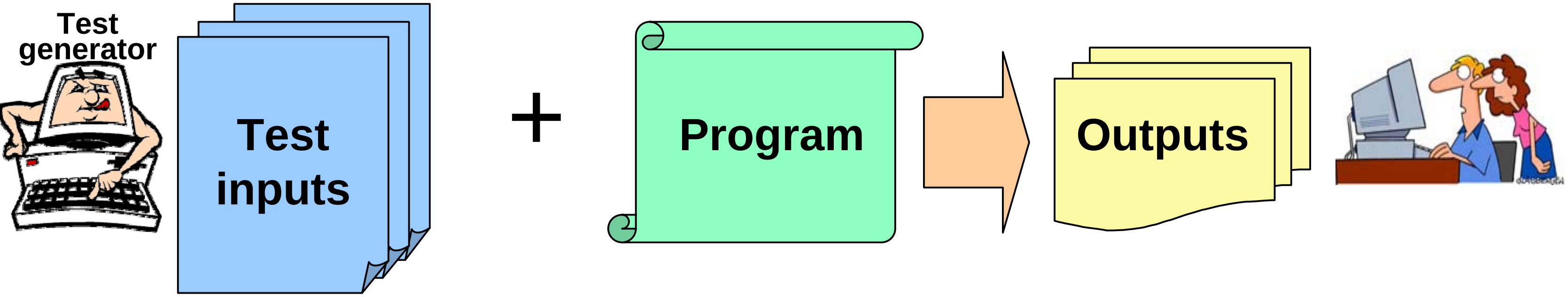

- **Are some of those generated tests redundant?** [Xie et al. ASE’04]
- **How can we generate non-redundant tests?** [Xie et al. TACAS’05]
- **What if we don’t know expected outputs?** [Xie&Notkin ASE’03, Xie&Notkin ICFEM’04]

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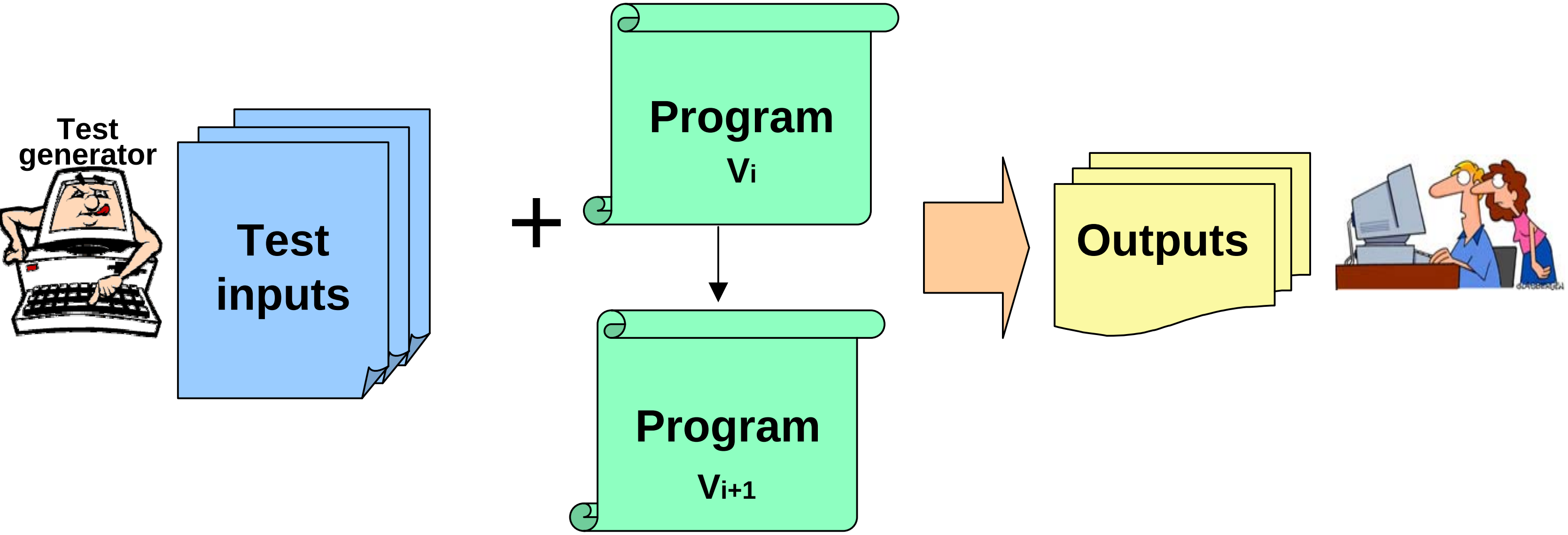

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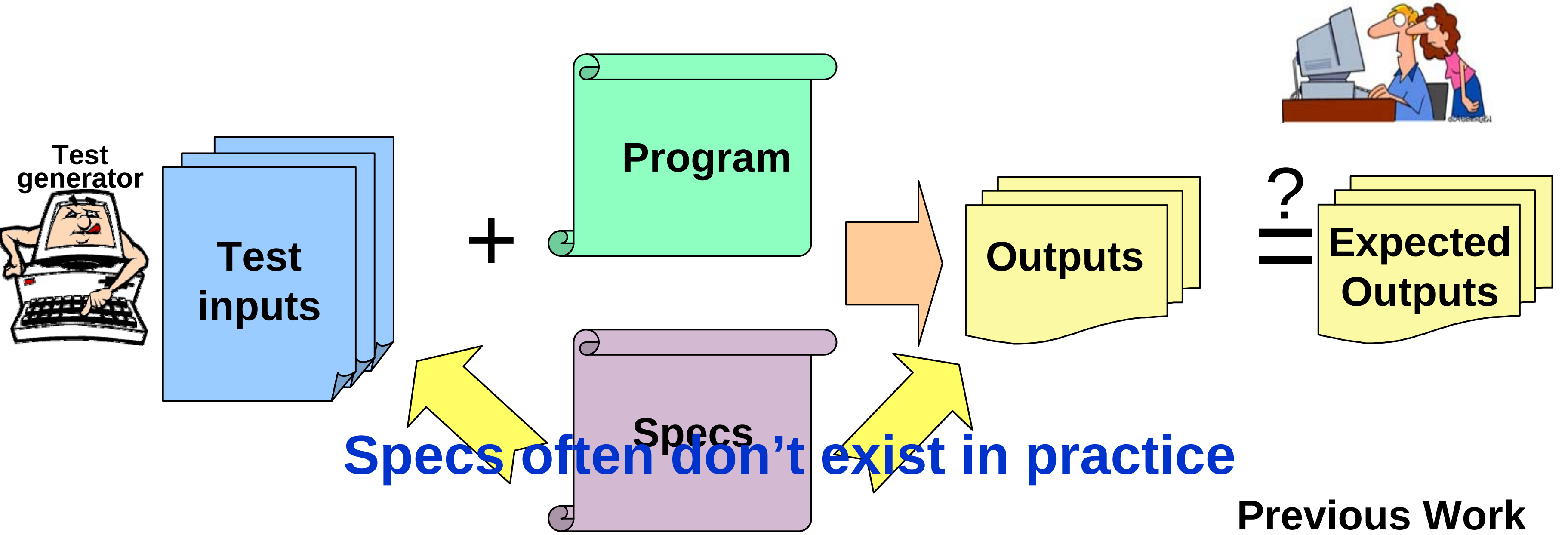
- **How can we know changes don’t introduce error?** [Xie&Notkin ICSM’04]

Specification-Based Testing



Specs often don't exist in practice

- Are some of those generated tests redundant?
- How can we generate non-redundant tests?
- What if we don't know expected outputs?
- How can we know changes don't introduce error?

Previous Work

TestEra [Marinov et al. 01],

Korat [Boyapati et al. 02],

AsmlT [Grieskamp et al. 02],

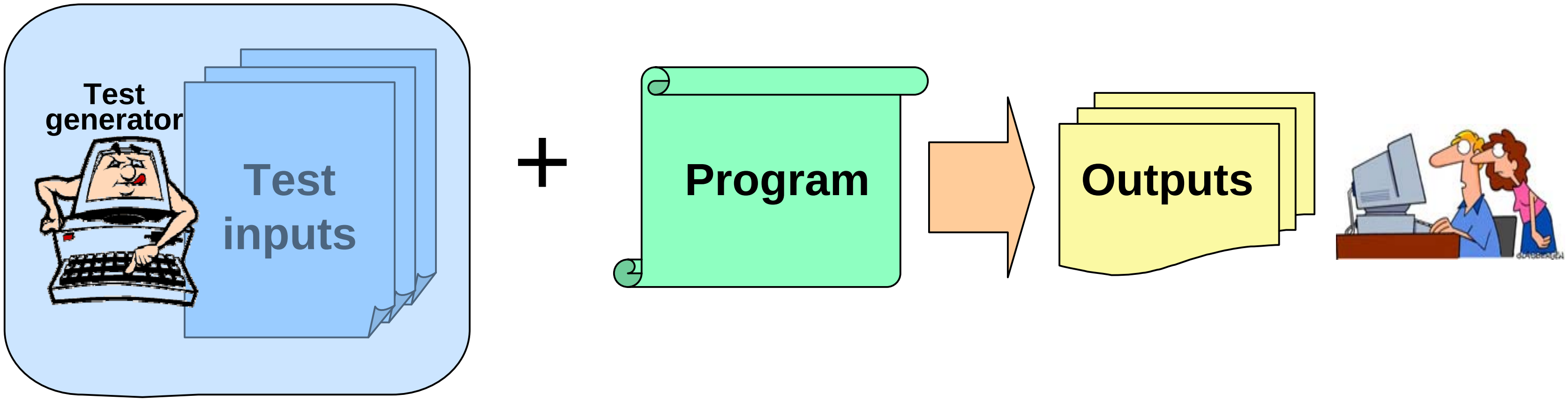
JPF [Visser et al. 04],

ASTOOT [Doong et al. 94],

JML [Cheon et al. 02],

etc.

Contributions



Test generator

Test inputs

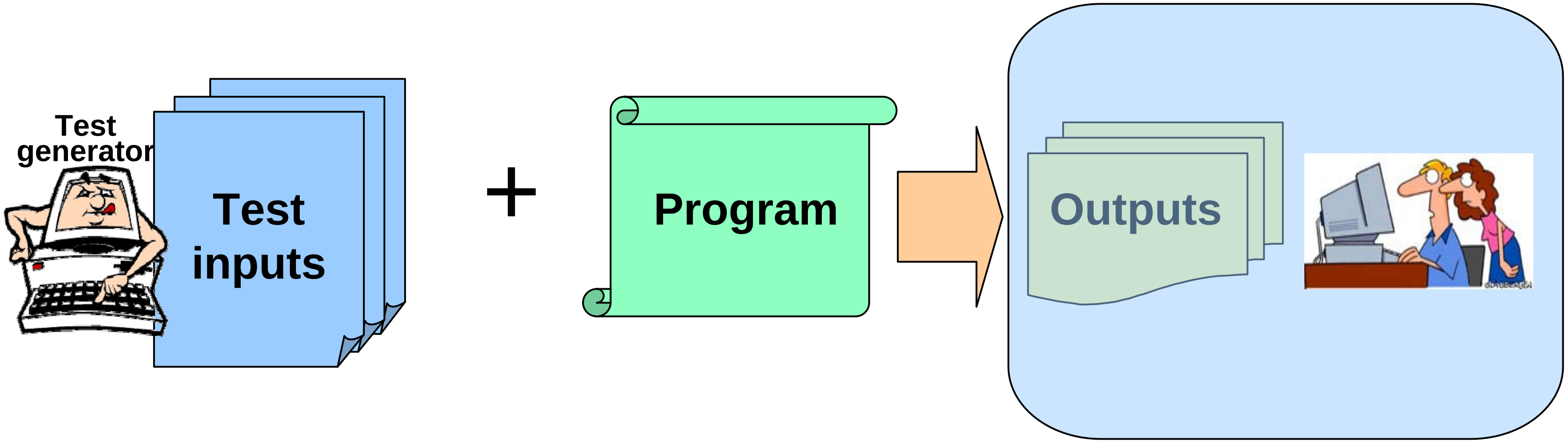
+

Program

Outputs

- Effectively invest machine resources
  - detect redundant tests [Xie et al. ASE’04]
  - generate non-redundant tests [Xie et al. TACAS’05]

Contributions



Test generator

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Program

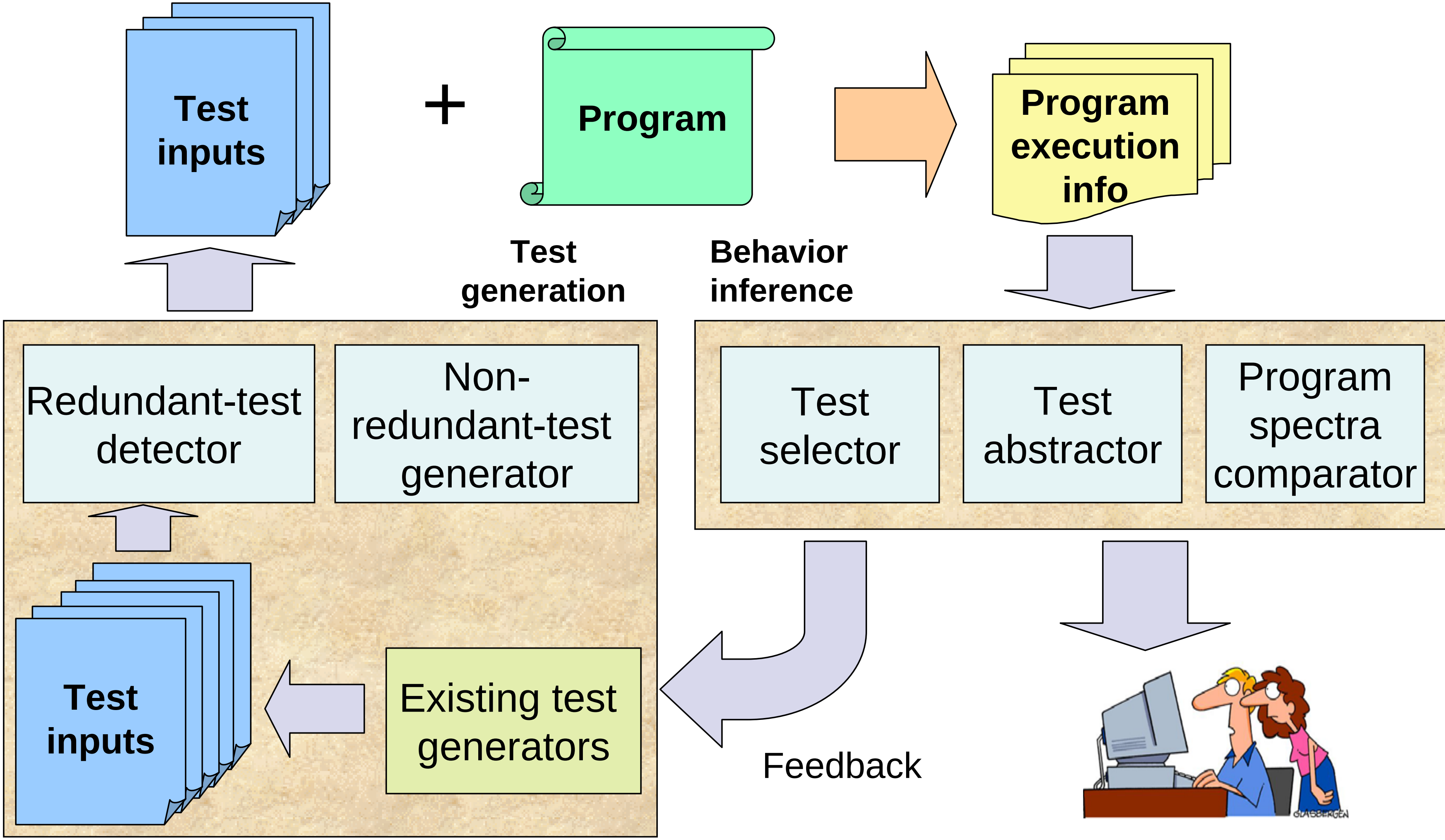
Outputs

- Effectively invest machine resources
  - detect redundant tests [Xie et al. ASE’04]
  - generate non-redundant tests [Xie et al. TACAS’05]
- Effectively invest human resources
  - select tests for inspection [Xie&Notkin ASE'03/ASEJ’06]
  - summarize tests for inspection [Xie&Notkin ICFEM’04]
  - expose regression faults [Xie&Notkin ICSM’04/TSE’05]

Contributions

Framework for Improving Effectiveness of Automated Testing

in the Absence of Specifications



Test inputs

+

Program

Program execution info

Test generation

Behavior inference

Redundant-test detector

Non-redundant-test generator

Test selector

Test abstractor

Program spectra comparator

Test inputs

Existing test generators

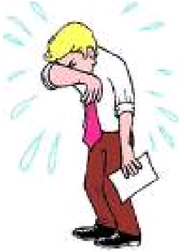
Feedback

Relationships to Industry

- ASE 03 paper on Jov: test generation/selection based on operational violations (integration of Daikon and Jtest)
  - 12/06/03: Highlighted in testdriver.com newsletter #1
  - 07/23/04: Visited Agitar upon their invitation
  - 07/17/06: Compared in an ISSTA 06 paper by Agitar people
- ASE 04 paper on Rostra (redundant-test detection): Parasoft Jtest 4.5 generates 90% redundant tests
  - 09/16/04: Received an email from Parasoft VP
  - 11/05/04: Visited Parasoft upon their invitation
- TACAS 05 paper on test generation using symbolic execution
  - Techniques reimplemented upon JPF by NASA Research people
  - Techniques reimplemented for C# by Microsoft Research people

Story Behind – Struggling (2000-2002)

09/2000



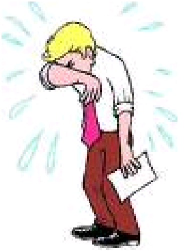
Reading, Thinking, Proposing, Exploring, …

Dynamic call graph extractors, code Instrumentation, etc.

2001
SE Research
Links

Summer 2001 intern

Avaya Labs Research supervised by Dave Weiss on SPL, processes, workflows



Regression test prioritization w/ Daikon invs
Fault localization with value spectra

2001 Nov
SE Genealogy

Regression testing with spectra comparison

later developed as
[ICSM 04/TSE 05]

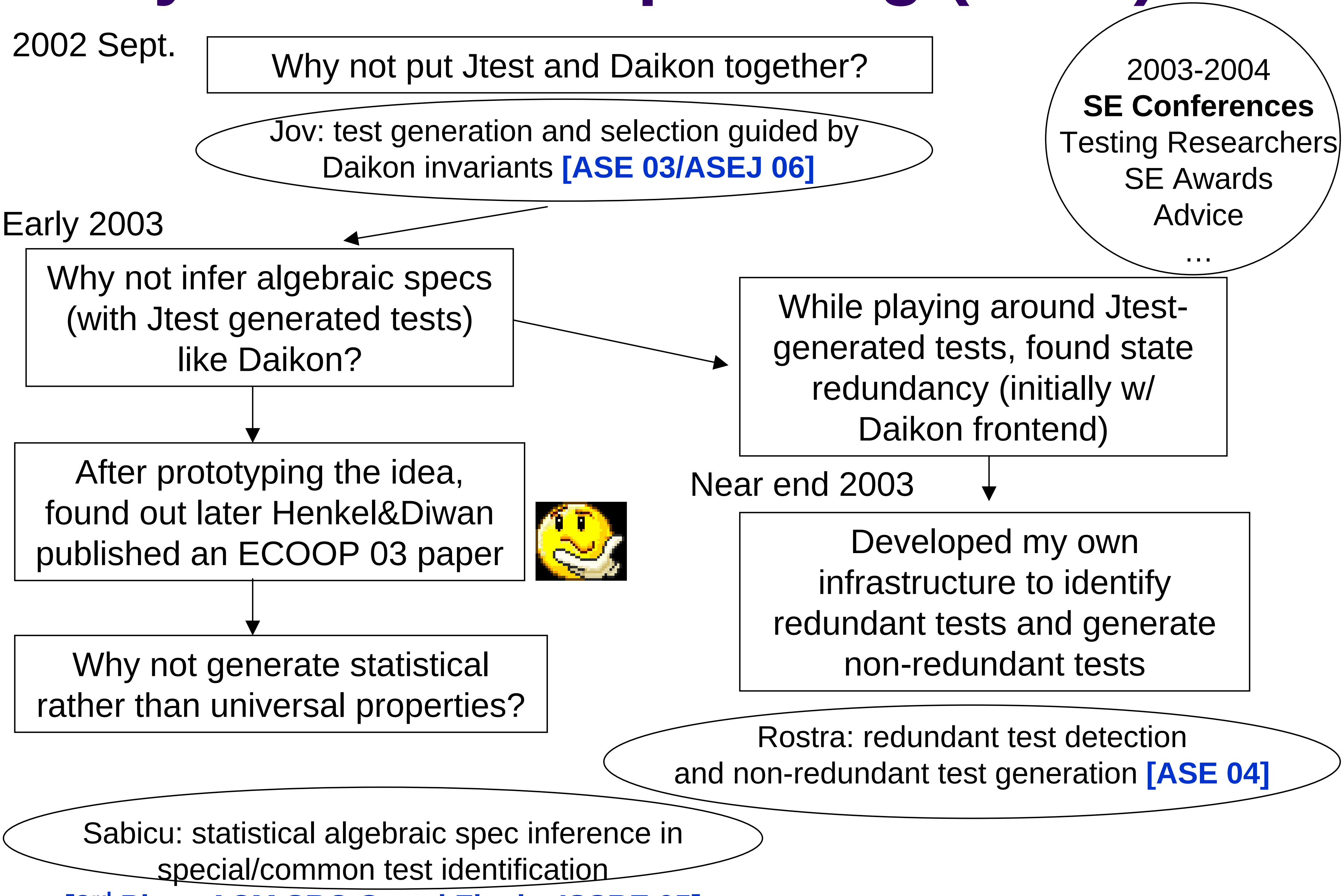
Summer 2002 intern

IBM Research supervised by Gary Sevitsky on SoftViz, perf analysis, dyn analysis

Knew about Parasoft Jtest
Attended a talk by Susan Horwitz

Why not put Jtest and Daikon together?

Story Behind – Expanding (2003)



2002 Sept.

Why not put Jtest and Daikon together?

Jov: test generation and selection guided by Daikon invariants **[ASE 03/ASEJ 06]**

2003-2004
SE Conferences
Testing Researchers
SE Awards
Advice
…

Early 2003

Why not infer algebraic specs (with Jtest generated tests) like Daikon?

After prototyping the idea, found out later Henkel&Diwan published an ECOOP 03 paper

Why not generate statistical rather than universal properties?

While playing around Jtest-generated tests, found state redundancy (initially w/ Daikon frontend)

Near end 2003

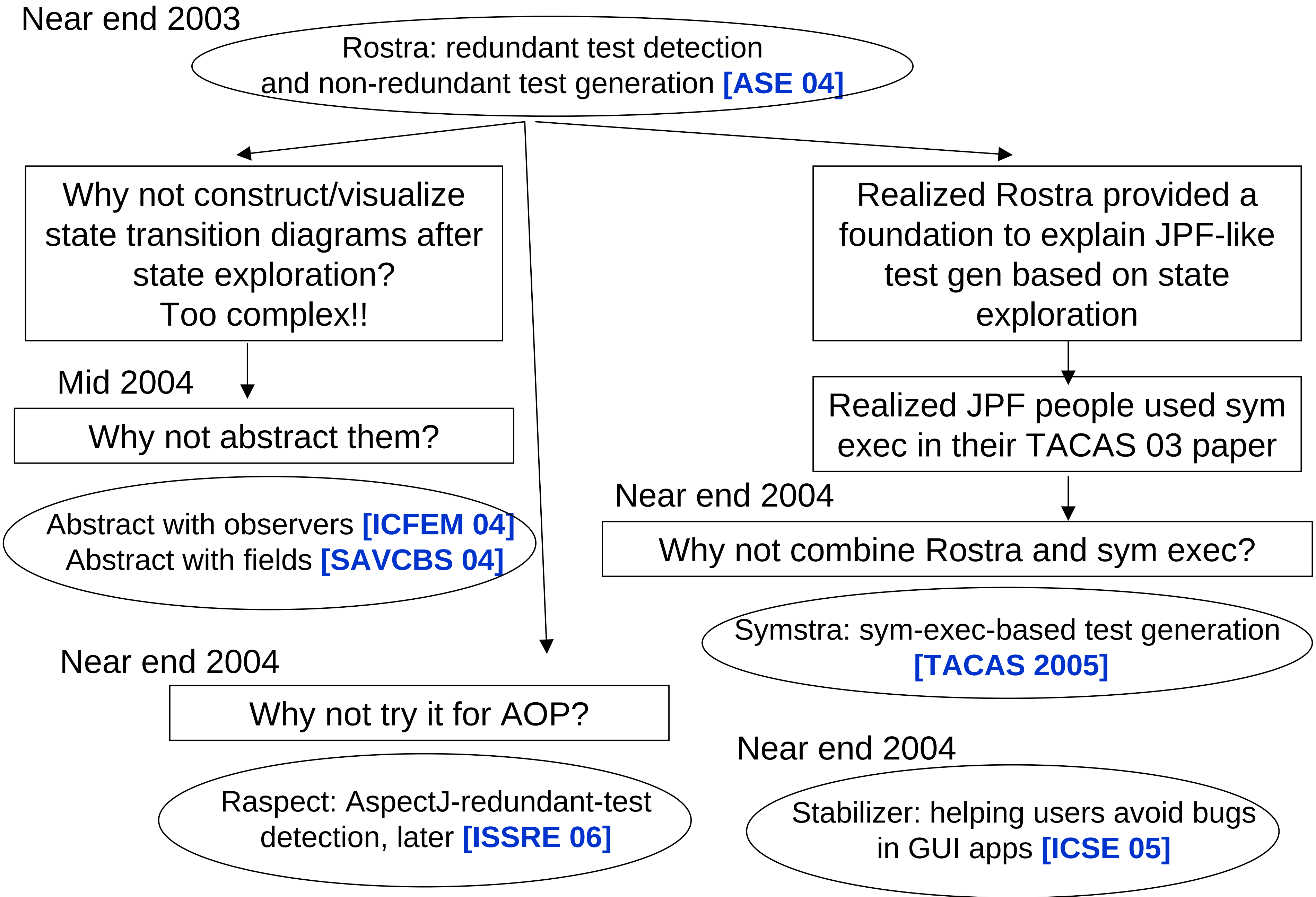
Developed my own infrastructure to identify redundant tests and generate non-redundant tests

Rostra: redundant test detection and non-redundant test generation **[ASE 04]**

Sabicu: statistical algebraic spec inference in special/common test identification

[3rd Place ACM SRC Grand Finals, ISSRE 05]

Story Behind–Expanding More (2004)



Near end 2003

Rostra: redundant test detection
and non-redundant test generation **[ASE 04]**

Why not construct/visualize state transition diagrams after state exploration?
Too complex!!

Mid 2004

Why not abstract them?

Abstract with observers **[ICFEM 04]**
Abstract with fields **[SAVCBS 04]**

Near end 2004

Why not try it for AOP?

Raspect: AspectJ-redundant-test detection, later **[ISSRE 06]**

Realized Rostra provided a foundation to explain JPF-like test gen based on state exploration

Realized JPF people used sym exec in their TACAS 03 paper

Near end 2004

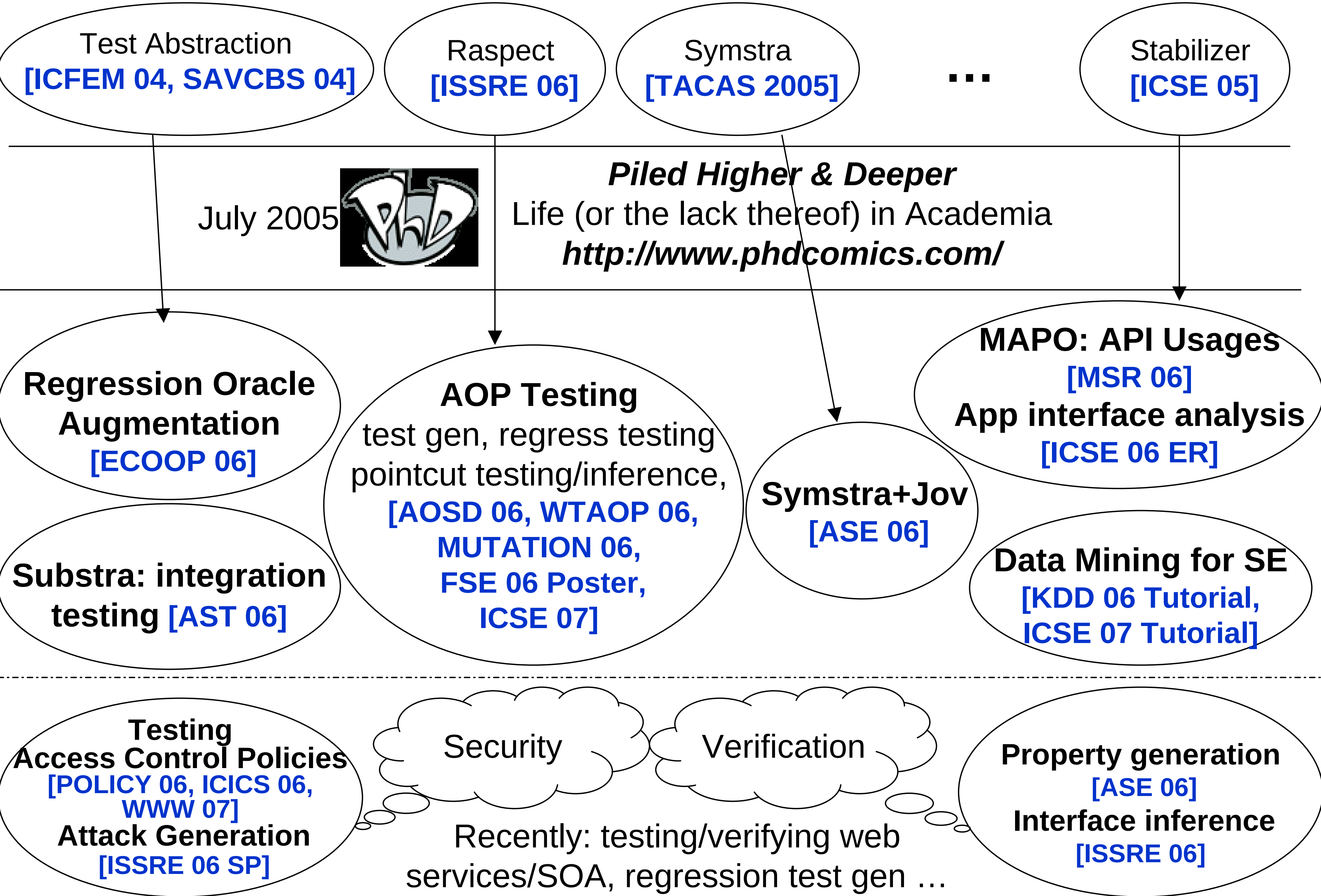
Why not combine Rostra and sym exec?

Symstra: sym-exec-based test generation
[TACAS 2005]

Near end 2004

Stabilizer: helping users avoid bugs in GUI apps **[ICSE 05]**

Story Behind being Dr. XIE (Aug 2005-)



Test Abstraction [ICFEM 04, SAVCBS 04]

Raspect [ISSRE 06]

Symstra [TACAS 2005]

…

Stabilizer [ICSE 05]

July 2005

Piled Higher & Deeper
Life (or the lack thereof) in Academia
http://www.phdcomics.com/

Regression Oracle Augmentation [ECOOP 06]

AOP Testing
test gen, regress testing
pointcut testing/inference,
[AOSD 06, WTAOP 06, MUTATION 06, FSE 06 Poster, ICSE 07]

Symstra+Jov [ASE 06]

MAPO: API Usages [MSR 06]
App interface analysis [ICSE 06 ER]

Substra: integration testing [AST 06]

Data Mining for SE [KDD 06 Tutorial, ICSE 07 Tutorial]

Testing Access Control Policies [POLICY 06, ICICS 06, WWW 07]
Attack Generation [ISSRE 06 SP]

Security

Verification

Recently: testing/verifying web services/SOA, regression test gen …

Property generation [ASE 06]
Interface inference [ISSRE 06]

Conclusion

- Framework for improving testing effectiveness
  - effectively invest machine resources
    - redundant-test detection [ASE 04]
    - non-redundant test generation [TACAS 05]
  - effectively invest human resources
    - test selection [ASE 03/ASEJ 06]
    - test abstraction [ICFEM 04]
    - program-spectra comparison [ICSM 04/TSE 05]
- Lessons learned
  - Working around industrial/existing tools helps
  - Talking to researchers helps (collaboration also helps)
  - One research idea leads to another (from hands-on experience)
  - A mixture of holding hammers + nails
  - Big picture (don’t get lost when too excited about low-level solution details)

Questions?

Lessons Learned

- Working around industrial tools helps
- Dynamic analysis tools can be integrated too
- Both measuring and managing redundancy are important
- Breaking into pieces helps
- Grouping pieces helps
- Looking inside helps
- Exploit the most out of artifacts that already exist
- unavoidable for tools to ask help from developers (wisely)
- Automatically generating complex arguments is more difficult than expected
- Practical lightweight specifications may help
- Model-based testing may be a good way to go when doing integration or system testing