ON IMPACT IN SOFTWARE ENGINEERING RESEARCH

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ANDREAS ZELLER: KEY FACTS

- PhD in 1997 on Configuration Management with Feature Logic
- Since 2001 professor at Saarland Informatics Campus (Saarland University / CISPA)
- Four 10-year impact awards 2009–2017 (for papers 1999–2007)
- ACM Fellow in 2010
- ERC Advanced Grant in 2011
- SIGSOFT Outstanding Research Award on Friday

WHAT IS IMPACT?

WHAT IS IMPACT?

- *How do your actions change the world?*
- Often measured in citations, publications, funding, people, …
- All these are indicators of impact, *but not goals in themselves*
- We want to make the world a better place
- Gives meaning and purpose to our (professional) life

WHAT MAKES IMPACTFUL RESEARCH?

- *Intellectual challenge* – was it hard, or could anyone have done this?
- *Elegance* – is your research specific to a context, or can it be reused again and again?
- *Usefulness* – can someone make money with it?
- Innovation is the *delta* in any of these metrics

VARYING PERSPECTIVES

- *Programming Languages* folks miss the intellectual challenge
- *Formal Methods* folks miss elegance *and* challenge
- *Industry* folks miss usefulness and applicability

WHAT MAKES IMPACTFUL RESEARCH?

- *How did your work make the world a better place?*

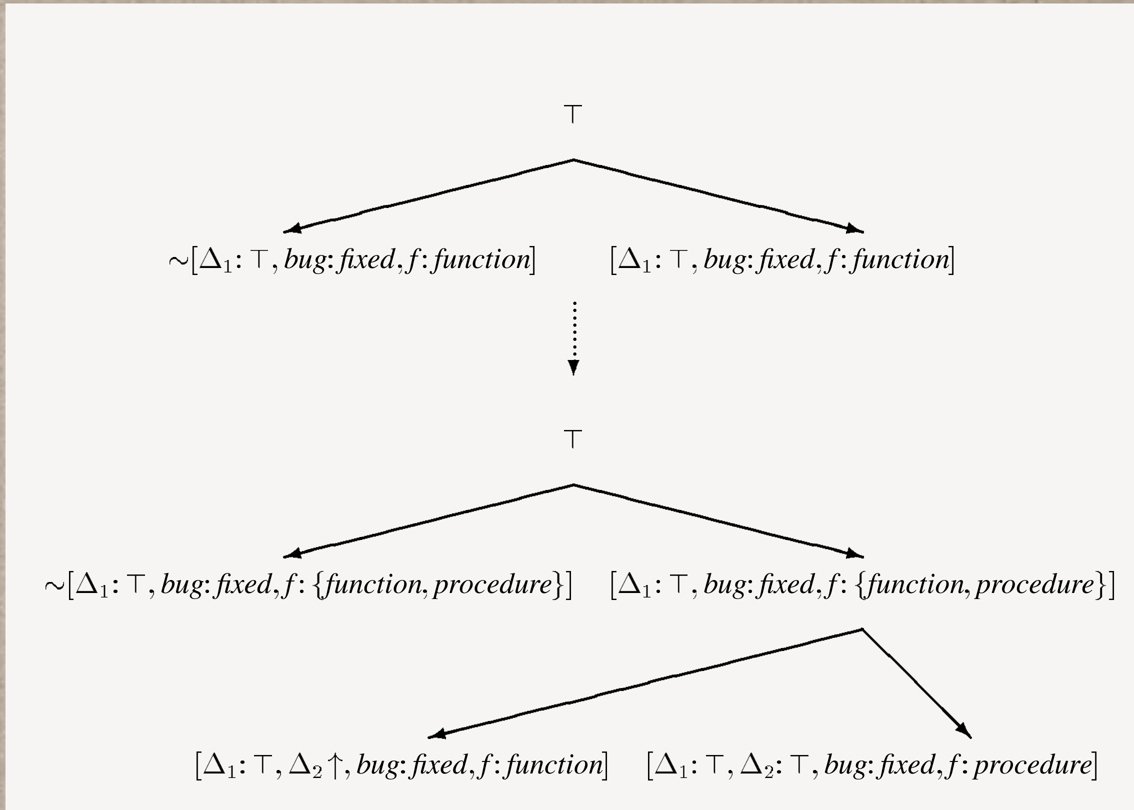
MY PATH TO IMPACT

MY PATH TO IMPACT

- Life can only be understood backwards;
  but it must be lived forwards
  (Søren Kierkegaard)

CONFIGURATION MANAGEMENT WITH FEATURE LOGIC (1991–1997)

- Topic defined by my PhD advisor Gregor Snelting
- Idea: Formally describe variants and revisions with *feature logic*
- "A unified model for configuration management"



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$[\Delta_1\colon \top, \Delta_2\colon \top, \mathit{bug}\colon \mathit{fixed}, f\colon \mathit{procedure}]$

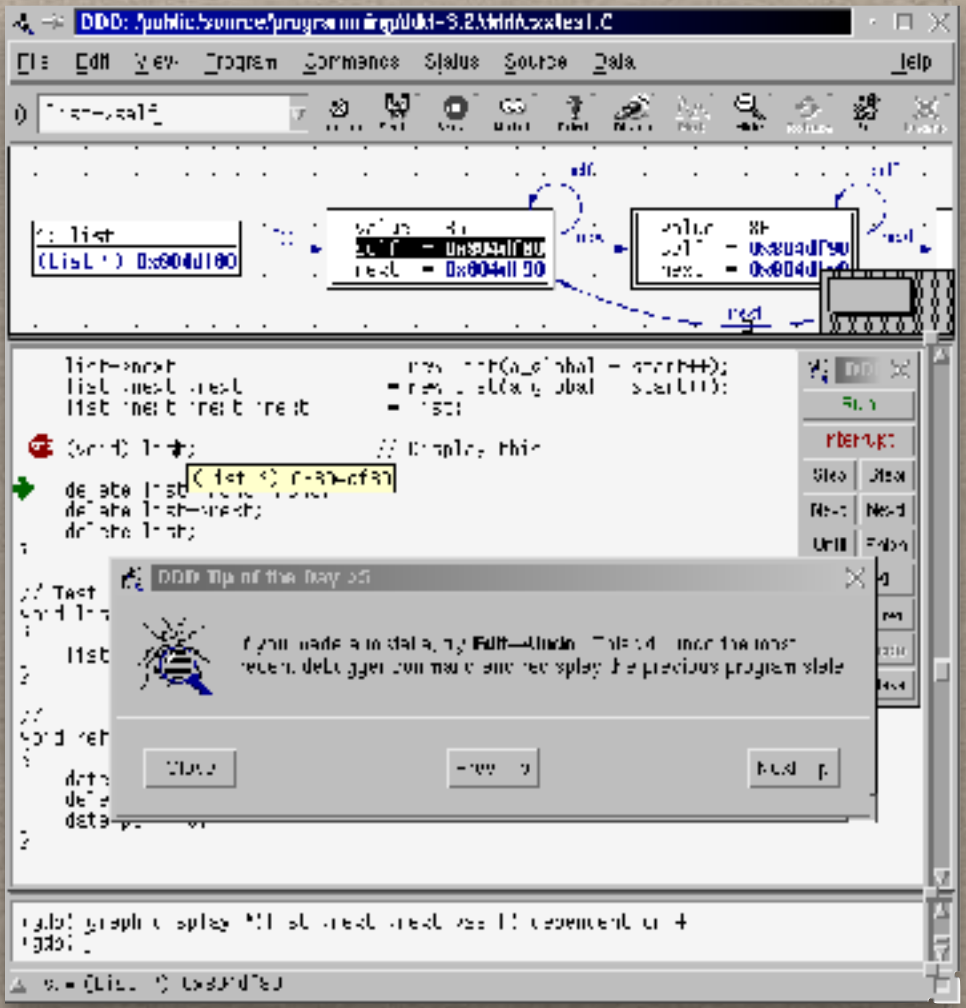
Figure 8: Delta features and other features

FEATURE LOGIC: LESSONS LEARNED

- You can get plenty of papers accepted
  - even if you miss the problem
  - even if you do not evaluate
- “Modeling for the sake of modeling”
- Enabled much of my later work, though

DDD (1994–1999)

- During PhD, programmed a lot
- Debugging was hard!
- Built the DDD debugger GUI with my student Dorothea Lütkehaus
- Welcome change from formal work



If you made a mistake, try Edit→Undo. This will undo the most recent debugger command and redisplay the previous program state.

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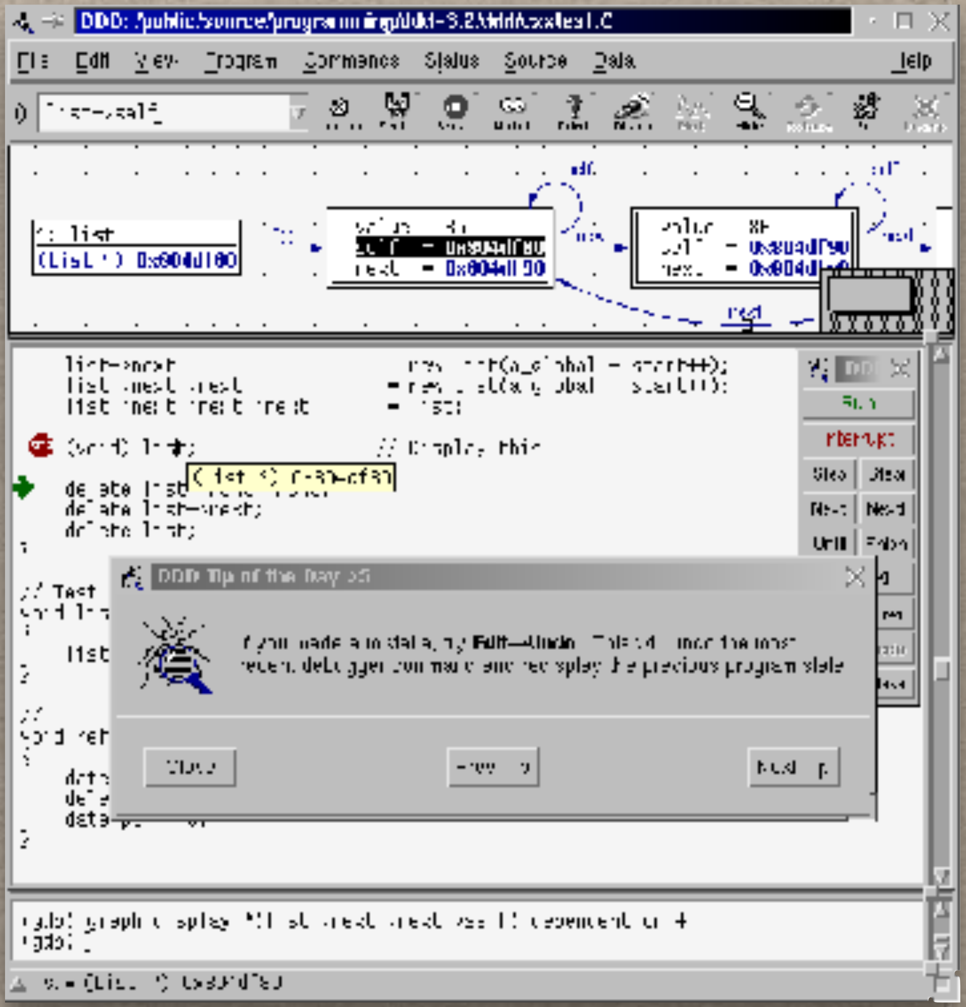
DDD (1994–1999)

- DDD was among the first dev tools with a "professional" GUI
- Downloaded by the tens of thousands
- Adopted as a GNU project: Street credibility with developers
- Impact through *usefulness*

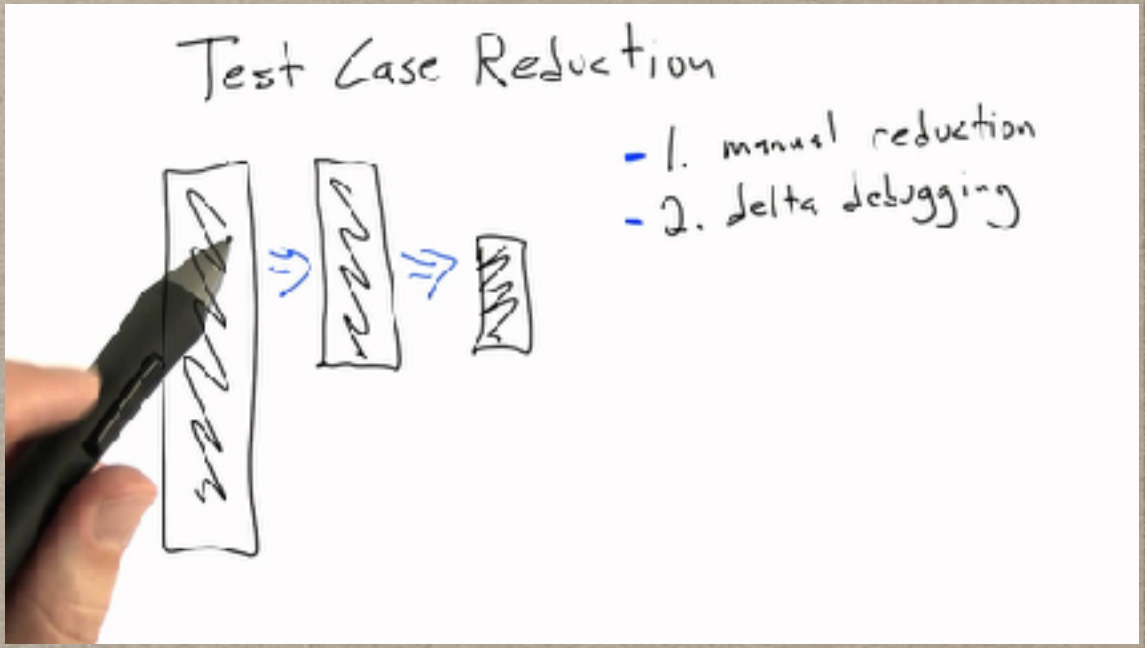


DDD: LESSONS LEARNED

- **Work on a real problem**
  - *"real" as in "real world", not "real papers"*
- **Assume as little as possible**
  - *make things fit into real processes*
- **Keep things simple**
  - *complexity impresses, but prevents impact*

DELTA DEBUGGING (1999–2003)

- After PhD, looking for new topic
- Delta Debugging brought together debugging and version control
- Isolate failure causes through repeated experiments



DELTA DEBUGGING (1999–2003)

- Delta debugging was a bomb
- Easy to teach + understand
- 7 lines of algorithm (and 25 lines of Python)
- Spent two years on these

$$dd(c_{\checkmark}, c_{\times}) = dd'(c_{\checkmark}, c_{\times}, 2)$$

$$dd'(c'_{\checkmark}, c'_{\times}, n) =$$

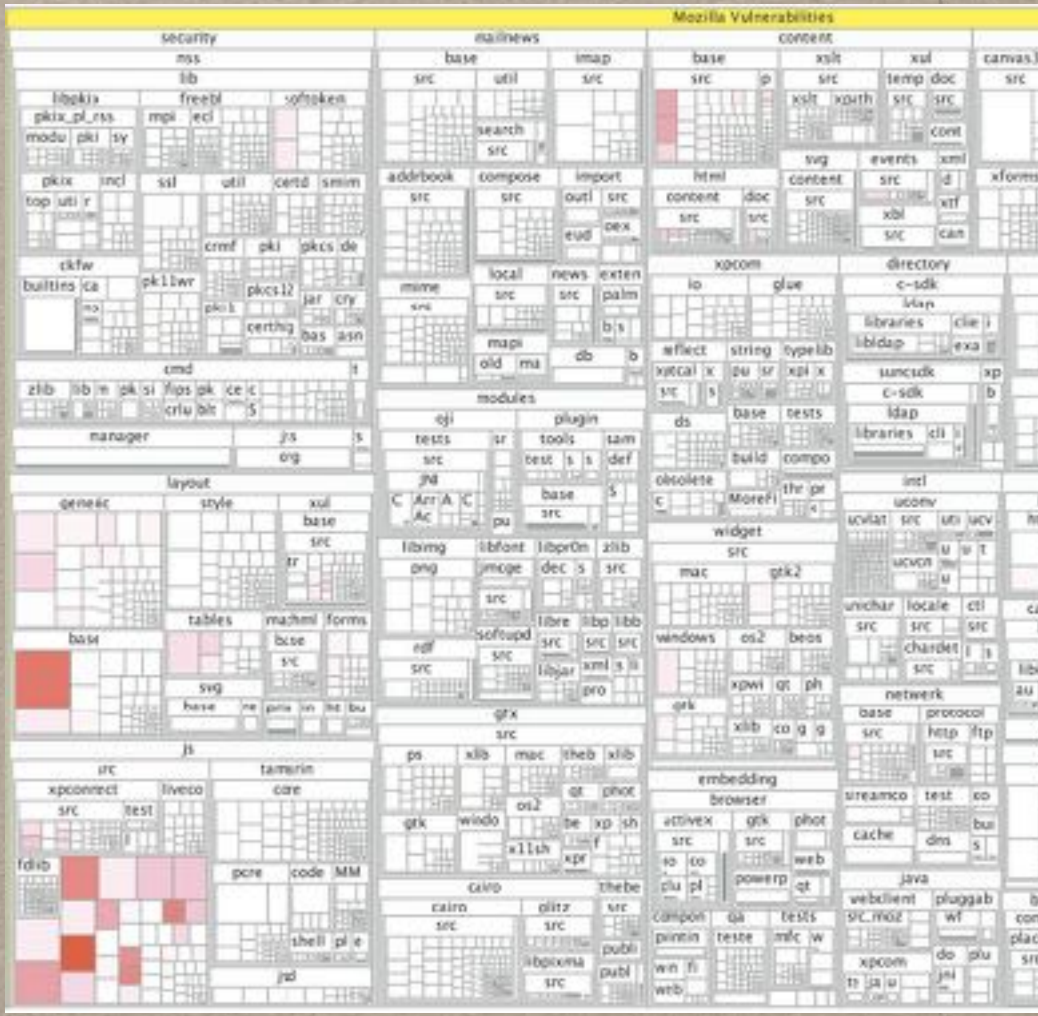
$$\begin{cases} (c'_{\checkmark}, c'_{\times}) & \text{if } |\Delta| = 1 \\ dd'(c'_{\times} \setminus \Delta_i, c'_{\times}, 2) & \text{if } \exists i \in \{1..n\} \cdot \mathit{test}(c'_{\times} \setminus \Delta_i) = \checkmark \\ dd'(c'_{\checkmark}, c'_{\checkmark} \cup \Delta_i, 2) & \text{if } \exists i \in \{1..n\} \cdot \mathit{test}(c'_{\checkmark} \cup \Delta_i) = \times \\ dd'(c'_{\checkmark} \cup \Delta_i, c'_{\times}, \max(n-1, 2)) & \text{else if } \exists i \in \{1..n\} \cdot \mathit{test}(c'_{\checkmark} \cup \Delta_i) = \checkmark \\ dd'(c'_{\checkmark}, c'_{\times} \setminus \Delta_i, \max(n-1, 2)) & \text{else if } \exists i \in \{1..n\} \cdot \mathit{test}(c'_{\times} \setminus \Delta_i) = \times \\ dd'(c'_{\checkmark}, c'_{\times}, \min(2n, |\Delta|)) & \text{else if } n < |\Delta| \text{ (“increase granularity”)} \\ (c'_{\checkmark}, c'_{\times}) & \text{otherwise} \end{cases}$$

DELTA DEBUGGING: LESSONS LEARNED

- Work on a real problem
  - *Why debug? We build correct software*
- Assume as little as possible
  - *Version control? tests? Never heard of it*
- Keep things simple
  - *25 lines of Python is probably excessive*
- **Have a sound model**
  - *DD was my version model reborn*

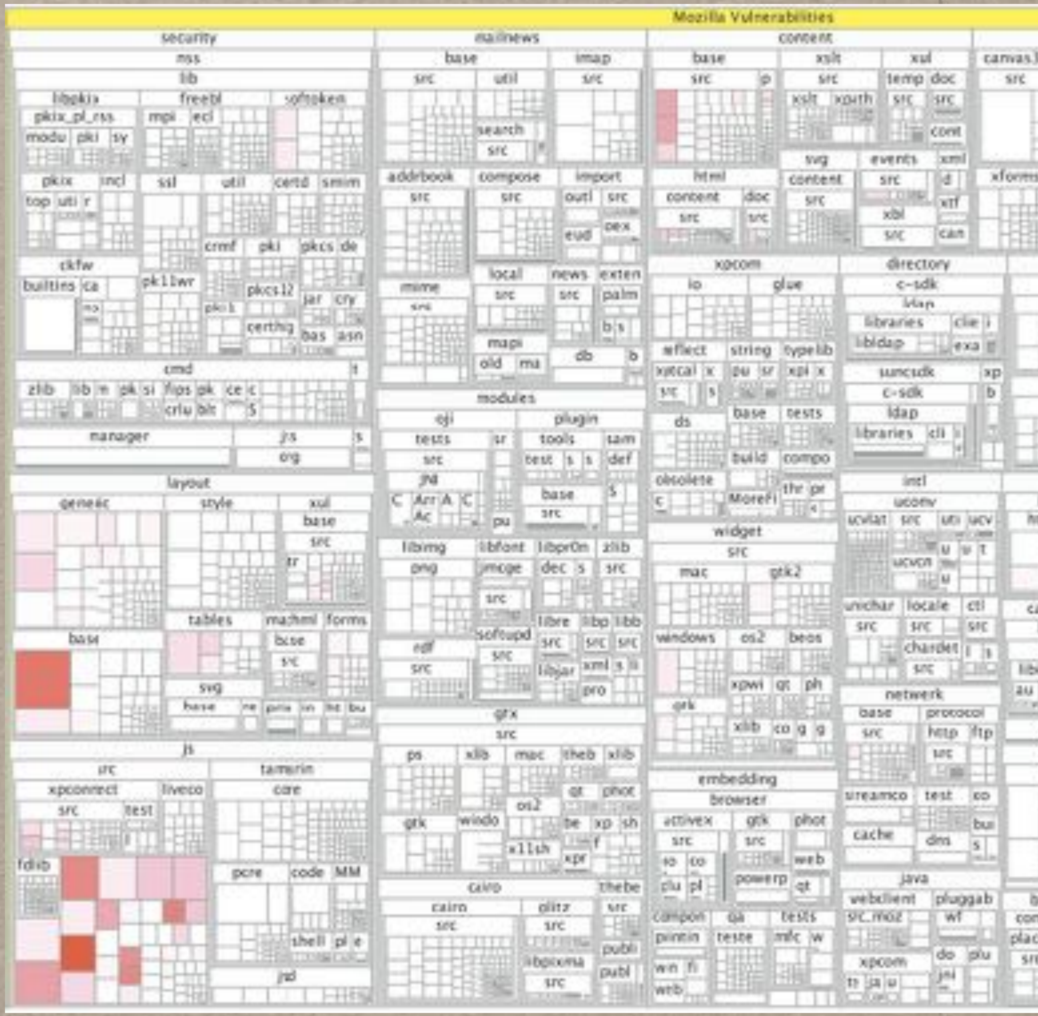
MINING SOFTWARE ARCHIVES (2003–2010)

- In the early 2000s, open-source version repositories became available
- Stephan Diehl saw an opportunity for visualization and approached me
- Quickly expanded into data mining
- Tom Zimmermann: our MSc student
- Work of a research team



MINING SOFTWARE ARCHIVES (2003–2010)

- Our 2004 paper was the first ICSE paper on mining software archives
- Handful of competing groups; instant hit
- MSR now a conference on its own
- Paper has 1200+ citations so far
- Impact at Microsoft, Google, SAP…



MINING SOFTWARE ARCHIVES (2003–2010)

- We are now after the gold rush
- Data still exciting (if you have some)
- Few new insights on old data
- Get out of a field when too crowded

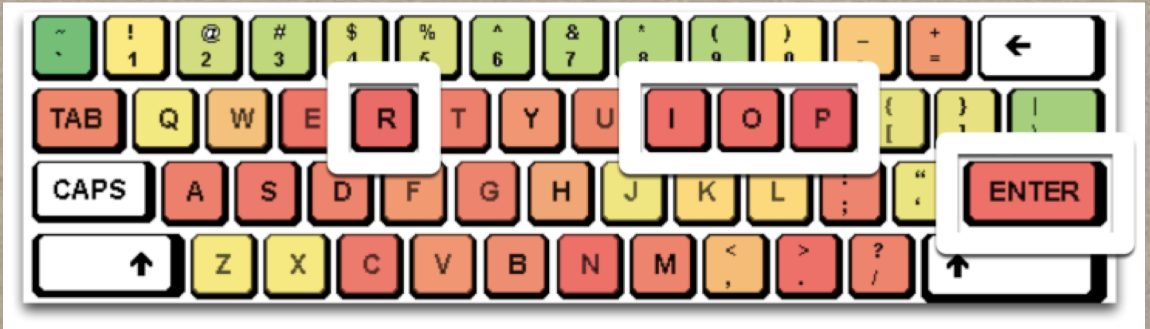


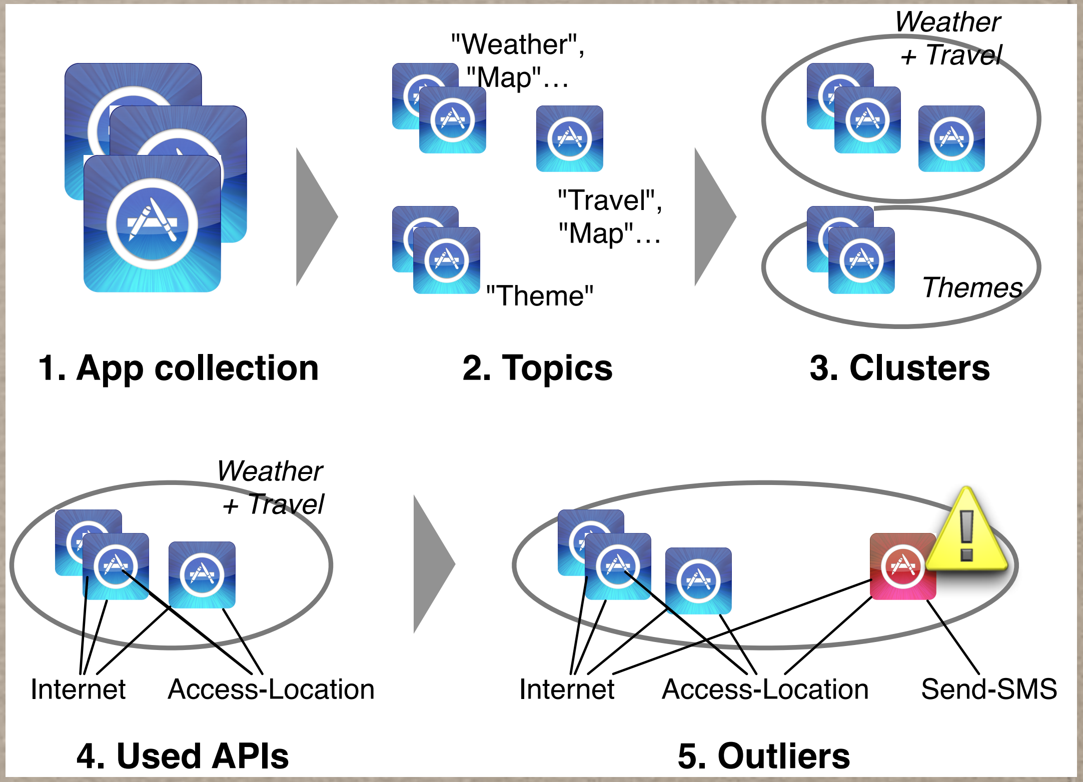
Figure 2: Color-coding keys by their defect correlation; (red = strong). The five strongest correlations are highlighted.

MINING SOFTWARE REPOSITORIES: LESSONS LEARNED

- Work on a real problem
  - *Empirical research is core field of SE*
- Assume as little as possible
  - *simple parsers for multiple languages*
- Keep things simple
  - *essence of 2004 paper is one line of SQL*
- Have a sound model
  - *retrieval, precision, recall, etc, etc*
- **Keep on learning**
  - *statistics, data mining, machine learning*

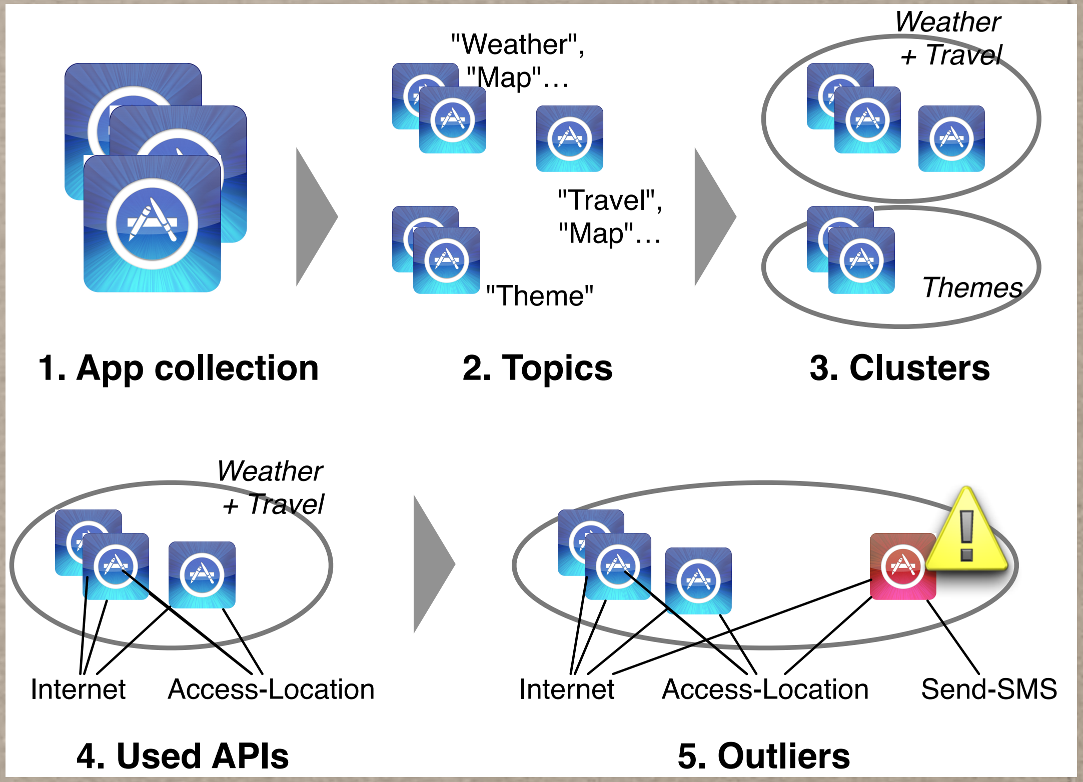
MINING APP ARCHIVES (2014-)

- How do we know an app does what it should do?
- CHABADA checks for mismatches between *description* and *behavior*
- Novel usage of NLP; novel app store mining



MINING APP ARCHIVES (2014-)

- The ICSE paper of 2014 is among most cited
- CHABADA techniques now adopted by Google and Microsoft
- Most of your mobile apps have gone through such an analysis :-)



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MINING APPS: LESSONS LEARNED

- Work on a real problem – *Yes, there is malware*
- Assume as little as possible – *Descriptions and APIs*
- Keep things simple – *Standard NLP techniques*
- Have a sound model – *Standard NLP methods*
- Keep on learning – *NLP, machine learning, recommendation…*
- **Keep on moving** – *Security starts with SE*

MORE THINGS I DID

- **Automatic repair**
  - Wesley Weimer beat us to it
- **Automatic parallelization**
  - Struggled with complexity
- **Automatic website testing**
  - Built a company for that
- **Structured fuzzing**
  - Langfuzz found 2000+ browser bugs
- **Automatic sandboxing**
  - lots of potential in here

THINGS I STAYED AWAY FROM

- **Symbolic techniques**
- **Formal methods**
- **Modeling**
- **Architecture**

- Work on a real problem
- Assume as little as possible
- Keep things simple
- Have a sound model
- Keep on learning
- Keep on moving

YOUR WAYS TO HAVE IMPACT

IMPACT AS A RESEARCHER

- Society funds research
  to take *risks that no one else does*
- Research is *risky by construction* –
  you should expect to fail, and fail again
- Tenure is meant to allow you to take arbitrarily
  grand challenges – so work on the grand stuff
- If you lack resources, try smarter and harder

IMPACT AS A TEACHER

- Teaching can be a great way to multiply your message
- Not only focus on teaching the standards, *but also your research*
- Teaching your research helps to propagate it and make it accessible
- Engage students on topics dear to you

IMPACT WITH INDUSTRY

- *Do* work with industry
  to find problems and frame your work
- Do *not* work with industry
  to solve (their) concrete problems
- Your role as researcher is more
  than a cheap consulting tool
- Many “research” funding schemes
  are there to *subsidize* industry

IMPACT THROUGH TOOLS

- Getting your technique out as a tool is a great way to have impact!
- Also allows to check *what actual users need* (and if they exist)
- A tool can have far more impact than a paper
- Funding agencies and hiring committees begin to realize this

IMPACT AS FOUNDER

- Creating a company out of your research can be great fun!
- Push your research and ideas into practice
- Again, shows you what the market wants (and what not)
- Plenty of support available (money, consultancy)

IMPACT AS MENTOR

- Working with advanced students can be the most satisfying part of your job
- The variety of SE research needs *universal problem solving skills*
- Find such skills besides good grades

A GREAT ENVIRONMENT

- My institution (Saarland University) hired me although I was the candidate with the *fewest publications*
- But they liked the papers, so they hired me
- No pressure or incentives on papers, citations, funding, etc.
- One single expectation: *long-term impact*

SURVIVOR BIAS

- Researchers with great impact are the selected few who *survived* academic selection
- What worked for me will not work for most
- Most of us have to struggle with plenty of bad, misguided, short-term career incentives
- Follow incentives until tenured, *then set better ones*
- Get lucky!

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LESSONS LEARNED: ON IMPACT IN SE RESEARCH

- **Work on a real problem**
  – possibly bursting your bubble
- **Assume as little as possible**
  – immediate impact on adoption
- **Keep things simple**
  – complexity inhibits impact
- **Have a sound model**
  – tools may fade away, concepts persist
- **Keep on learning**
  – learn new stuff and leverage it
- **Keep on moving**
  – do not stay in your cozy SE corner