Role of change history in empirical studies of software

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Outline

- Motivation and goals
- Why changes are made?
  - how to obtain the purpose
- Why changes are hard?
  - how to obtain change effort
- Implications

Motivation

- Example
  - Real, 20 year old, huge switching product
  - large proportion of changes are enhancements
- Advantages of change history data
  - ubiquitous - most products have it
  - massive - far larger than any survey
  - complete - all parts of software are recorded
  - unbiased - no Hawthorne effect
  - uniform over time

Goal

- Design tools and methods that do not compromise advantages of change history data, i.e.,
  1. Are uniformly applicable
  2. Minimize human involvement
  3. Use existing data
  4. Complete - characterize all parts of software

Great, but can it be done?

- Change history contains
  - who changed, when and what was changed
- But is it possible to obtain:
  - **why?**
  - **how difficult?**
- Two studies on
  - purpose (with L. Votta)
  - effort (with T. Graves)

How Code Evolves

- By adding and deleting line blocks

before: after:

```
// initialize
int i=0;     int i=0;
while (i++)  while (i++ < N)
  read (x);  read(x);
```

- one line deleted
  - two lines added
  - two lines unchanged

Any VCS Records:

- Change - added and deleted lines
- Who - login, organization
- When - date and time
- Description - line of text
- Available data:
  - ~100M lines, ~4M changes, ~5K logins, 30Gb
  - ~30 products (select one)

Why code is changed?

- Primary reasons for maintenance activities
  - corrective: fix faults
  - adaptive: add features
- How those reasons relate to:
  - interval, effort, quality
  - developer, size
  - location, time

How to obtain the purpose?

- Look for bug/new field
  - may not be there, unreliable, only two values
- Ask developers
  - too much overhead - small coverage
- Read change abstracts
  - great idea - but 2M abstracts
- Let computer read abstracts
  - but how?

Algorithm

- Use change description line
  - extract frequent keywords
  - classify keywords (fix, new, add, etc.)
    - discover new types
      - perfective - code cleanup
      - inspection - code inspection suggestions
    - verify on sample abstracts
  - keyword -> purpose of the change
  - iterate

Example keywords

Adaptive: add, new, create, initial coding, modify, update	**Corrective:** fix, bug, error, problem, incorrect, must, needs
Perfective: cleanup, remove, clear, unneeded, flex name	**Inspection:** code review, inspection, rework, walkthrough

Proportions

- Why:
  - add new functionality - 45%
  - fix faults (bug) - 34%
  - cleanup/restructure - 4%
  - code inspection - 5%
  - unclassified - 12%

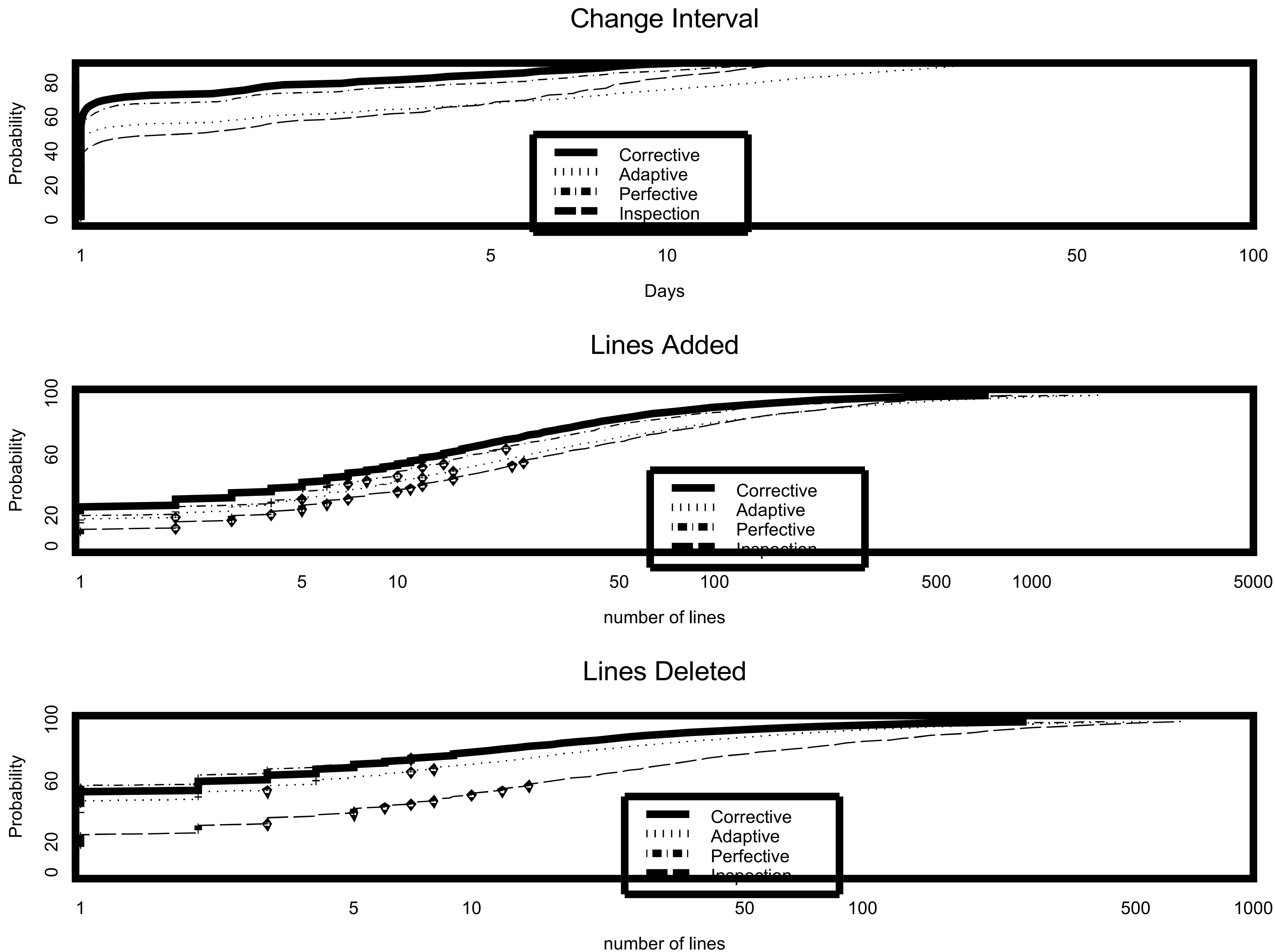
Is it right?

- Survey:
  - 2+5 developers (>9 years experience)
  - 20+150 changes (< 2 years old)
    - ~ equal numbers for different types
    - small percent of all changes developers did
- Questions
  - Type: bug, new, cleanup, inspection
  - Difficulty: Easy, Medium, Hard

Results

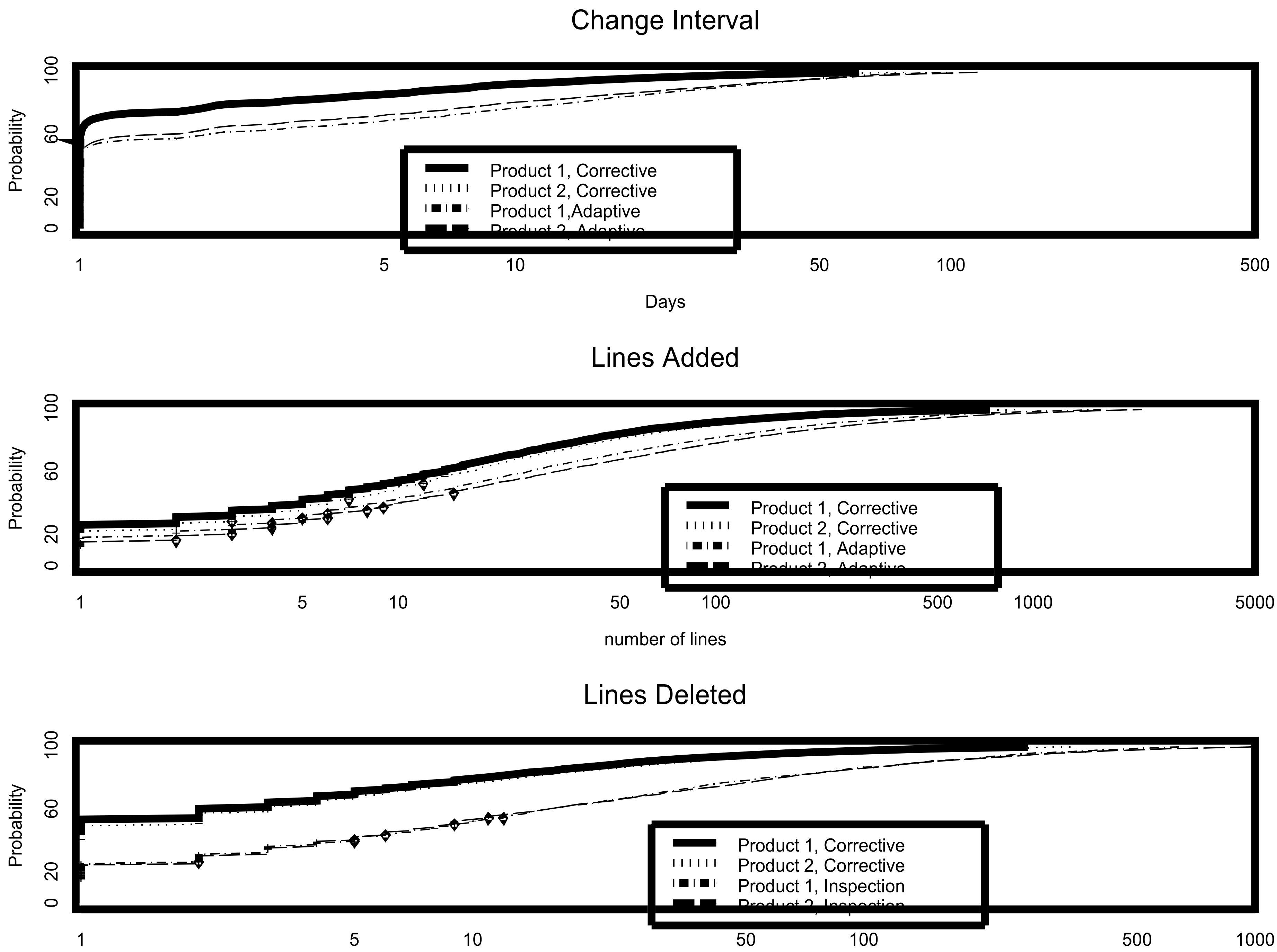
- Unclassified changes are mostly bug fixes
  - Almost perfect match
    - Inspection changes are easiest to detect

Dev.\Auto	Corrective	Adaptive	Perfective	Inspection
Corrective	**35**	**10**	**5**	**1**
Adaptive	**11**	**23**	**3**	**4**
Perfective	**10**	**8**	**27**	**9**
Inspection	**1**	**0**	**0**	**21**


Change Interval
Probability
0 20 40 60 80
Corrective
Adaptive
Perfective
Inspection
1 5 10 50 100
Days
Lines Added
Probability
0 20 60 100
Corrective
Adaptive
Perfective
Inspection
1 5 10 50 100 500 1000 5000
number of lines
Lines Deleted
Probability
0 20 60 100
Corrective
Adaptive
Perfective
Inspection
1 5 10 50 100 500 1000
number of lines

Will it work elsewhere?

- Other Product
  - 2 X size and five years older
  - different functionality
  - different organization
- Tool
  - the same classification (no manual input)
- Results
  - very similar purpose profiles



Change Interval
Probability
0
20
60
100
Product 1, Corrective
Product 2, Corrective
Product 1,Adaptive
1
5
10
50
100
500
Days
Lines Added
Probability
0
20
60
100
Product 1, Corrective
Product 2, Corrective
Product 1, Adaptive
1
5
10
50
100
500
1000
5000
number of lines
Lines Deleted
Probability
0
20
60
100
Product 1, Corrective
Product 2, Corrective
Product 1, Inspection
1
5
10
50
100
500
1000

Effort Estimation

How difficult a change was?

What makes changes difficult?

Where difficult changes are?

Why change effort

- detect key factors that affect effort
  - in a larger project change type, size, and developer are aggregated over many changes and their effects can not be detected

How to get effort?

- ask developers
  - small coverage, large effort
- use developer reported monthly effort
  - divide among changes made that month
- simplification
  - developers report similar effort every month
  - hence reported effort can be replaced by 1

Algorithm

- Specify factors that might contribute to effort
- Use reported effort (unit monthly effort if reported effort unavailable) to estimate contributions from each factor
- Use cross-validation to determine significance of each factor

Example

$$ChangeEffort \sim Purpose + Size + Login$$
$$+ Decay + FileType + otherFactors$$

- Choose factors that may affect effort
  - base factors: purpose, size, developer
  - test factors: e.g., complexity, decay, ...
- Result
  - the value and significance of each factor
  - e.g. effort for a similar change ⇧ 20%/year

Example Factor Estimates

11 developers from 5ESS OA

Factor	Effect	Significant
purpose	bug change takes twice more effort than new change	**yes**
size	effort is proportional to: #delta, #files, #lines	**yes**
login	effort to make a similar change can vary 3 times across logins	**no**
decay	making a similar change takes **5-25%** more effort each year	**yes**
sdl versus c	no effect	**no**

Applications

- SoftChange system - prototype tool
- Other applications
  - monitoring (where/when code decays)
  - expertise locator (who is the best match)
  - process/tool evaluation (is there any effect)
    - Version Editor and process capability studies
  - benchmarking - 4 projects

More results

- Assessing code decay
- Predicting fault potential
- Complexity of parallel changes
- How legacy organizations cope with changing business environment

Summary

- **Change history is invaluable**
- automatically it can be enhanced with
  - purpose
  - effort
- Cost drivers can then be determined

Summary

- **Change history is invaluable**
- automatically it can be enhanced with
  - purpose
  - effort
- Cost drivers can then be determined
- ***Don’t forget change history in your next study!***

SoftChange: highlights

- ECMS/SABLIME + SCCS interface
  - Summarization (5ESS ~ 30Gb data)
    - developer, size, time, interval, #files, #delta
  - Financial Support System (FSS) interface
    - person, monthly effort
  - Reliable automatic MR classification
    - bug, new, code improvement
  - Change effort estimation

Architecture