



Reversible Debugging Software

“Quantify the time and cost saved using reversible debuggers”

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Abstract and Introduction

Abstract

Reversible debuggers (RDBs) allow software developers to run code backwards as well as forwards, making it easier for them to find the root cause of bugs. However, most software companies continue to use forward only debugging techniques to review their codes. This research will use interviews and a survey to quantify the time saved by software developers writing compiled code on Linux when RDBs are used to find and fix software bugs. The results, expressed in percentage of time spent, found that developers spend half their programming time debugging, which equates to an estimated \$312billion per year. RDBs were found to reduce this debugging time by 26%, equalling a saving of \$81.1bn per year to the global software industry.

Introduction

Reversible debugging has been an application researched for years. Reversible debuggers (RDBs) allow software developers to run code backwards as well as forwards. This makes it easier for them to find the root cause of bugs.

Although a limited number of reversible debugging software products are available in the market, few are commercially viable, particularly for complex codes. Such codes typically have a higher probability of difficult intrinsic bugs that require significant amounts of time to find. GDB in particular struggles with poor performance caused by low speed and high memory consumption.

Hence, most software companies continue to use forward debugging techniques to review their codes because of the scarcity of suitable reversible debugging tools, and a general lack of awareness within the market regarding the existence of reversible debugging options. Quantifying the time saved by RDBs will support marketing efforts of these products to the software development industry.

Research Questions, Methodology, Constraints and Exclusions

Research Questions:

What is the time saved by software developers writing compiled code in the Linux environment when RDBs are used to fix software bugs?

In particular, the project will:

1. Quantify the time typically taken by software developers to rectify errors in their code without using RDBs; and
2. Quantify the time typically taken by software developers to rectify errors in their code using RDBs.

Methodology:

1. The research phase will predominantly comprise of short interviews with approximately 10 to 12 organisations that compile code on the LINUX operating environment. These organisations will also fill in the Cambridge Venture Project (CVP) survey to help quantify how much time they spend debugging with and without RDBs.
2. Broader research in the form of the CVP survey with potential users of reversible debuggers will be conducted to gain insights on how much time is currently spent debugging.
3. The results will be quantified in terms of percentage of time spent.

Constraints:

It is anticipated that the project will be subjected to the following constraints:

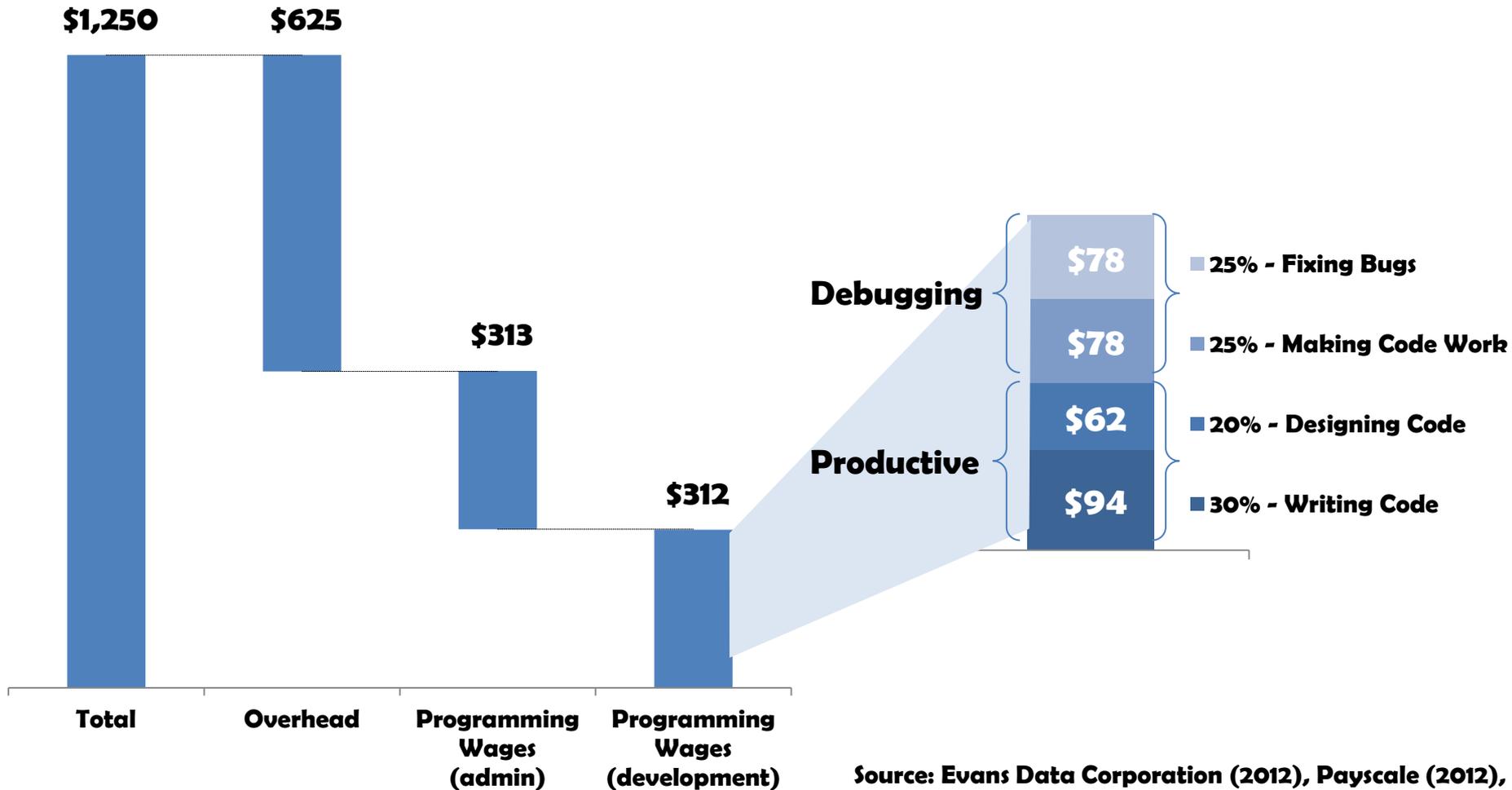
1. Time available will limit the project scope.
2. Product limitations will require the researchers to target people who compile code on Linux.

Due to the above constraints, this project will exclude:

1. Interviewing software developers who do not programme compiled code on Linux;
2. Quantifying the opportunity costs and other related costs of bugs.

RESULTS: The global cost of software development is US\$1.25 trillion

Software development cost structure (US\$ billion)



Source: Evans Data Corporation (2012), Payscale (2012), RTI (2002), CVP Surveys (2012)

**The global cost of software development is
US\$1.25 trillion**

50.1%

Programmers total work time spent doing admin*

49.9%

Programming time spent debugging**

***According to 54 questionnaire responses to the CVP survey and 11 interviews, based on the question 'what percentage of your time is spent programming (e.g. designing, writing, testing, debugging etc.) compared with other tasks (e.g. admin, meetings, sales, etc)?' Other tasks were then grouped as 'admin'.**

****According to 54 questionnaire responses to the CVP survey and 11 interviews, based on the question 'Of the time spent programming, what percentage of your time is spent on the following: (1)fixing bugs (2)making code work (3)designing code (4) writing code.' (1) and (2) then were grouped as debugging.**

**The global cost of software development is
US\$1.25 trillion**

US\$156 Billion per year

Wages-only estimated cost of debugging*

US\$312 Billion per year

**TOTAL estimated cost of debugging including wages
and overheads****

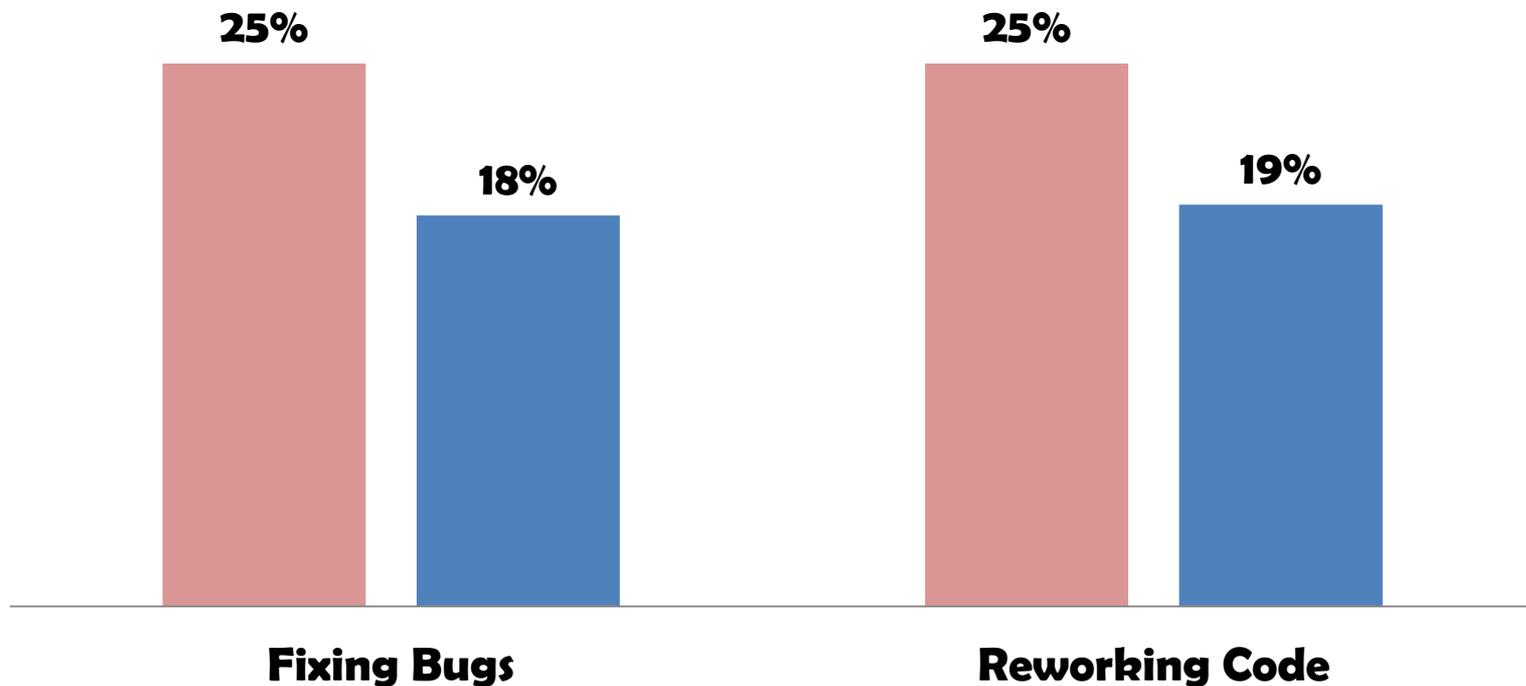
***Developers spend 50% of their time debugging, which equals half programming wages (development): $312/2=\$156\text{bn}$**

****Total cost of debugging to software development equals $1/4$ total software development costs = $1250*0.25=\$312\text{bn}$**

The global cost of software development is US\$1.25 trillion

% of programming time spent debugging

■ Before RDBs ■ After RDBs



Total saved with RDBs = 13 percentage point drop in total programming time

Total saved with RDBs = 26% decrease in debugging time

Reversible debuggers have the potential to significantly improve programming productivity

\$81.1 Billion

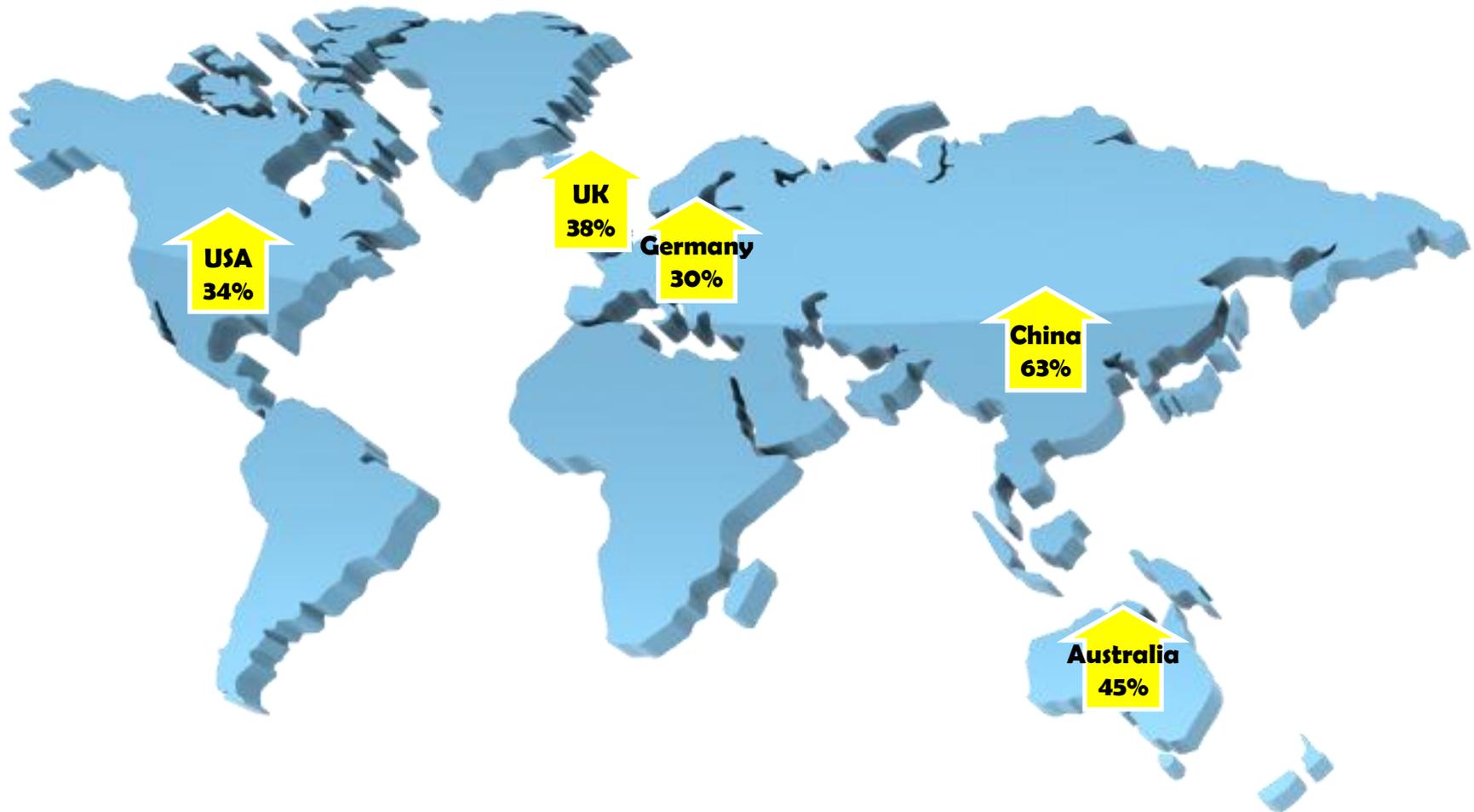
TOTAL software development costs saved per year*

Potential value of efficiencies gained by using RDBs

***Programming time (development) costs \$312bn per year. RDBs can save 26% of this cost: $312 \times 0.26 = \$81.1\text{bn}$**

China and Australia are leading growth in the software industry

2007-2011 Industry Growth Rates by Country



Summary

- Programmers spend 50.1% of their work time not programming. Half of their time spent programming is spent debugging.
- Total estimated cost of debugging is \$312bn per year.
- RDBs reduce time spent debugging by 26%.
- 26% reduction in time spent debugging is estimated to equal \$81.1bn in total software development costs saved per year.
- The software industry has been growing across the world, which is likely to put upward pressure on the cost of debugging.

Further Research

This research used only wages and overhead costs to calculate the cost of bugs to the software industry. These figures were also used to estimate the dollar amount saved by using RDBs. No attempt was made to quantify the auxiliary costs of bugs, such as remedying issues that occur in the field, opportunity costs of software products that are delayed and/or cancelled due to bugs, consequential damage to software companies' reputations due to bugs in released software and delays and cancellations of software projects. Extending this research to investigate the auxiliary costs of bugs once software has been released would more accurately represent the real cost of bugs to the software industry.

If RDBs reduce debugging time by 26%, a further extension to this research could involve more accurately quantifying the dollar savings that can be created by using RDBs when auxiliary costs are taken into account. It would also be interesting to discover whether/which auxiliary costs are substantially reduced by RDBs.



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Appendix Section Listing

1. Average software developer wages
2. Total software development costs
3. Global software revenues
4. References

A1. Average software developer wages

| Salary | |
|-----------------------|-----------------|
| US | \$76,000 |
| India | \$6,353 |
| Finland | \$45,979 |
| Australia | \$62,700 |
| China | \$18,640 |
| Mexico | \$17,277 |
| UK | \$46,736 |
| Average Salary | \$39,098 |

A2. Total software development costs

| | | 2012 | 2013 | 2014 | 2015 |
|---|---|----------------------------|----------------------------|----------------------------|----------------------------|
| a | Number of software developers | 16,000,000 | 17,300,000 | 18,600,000 | 20,000,000 |
| b | Average software developer salary | \$39,098 | \$39,098 | \$39,098 | \$39,098 |
| c | Salary & Overhead* (b x 2) | \$78,196 | \$78,196 | \$78,196 | \$78,196 |
| d | Total cost of software development (a x c) | \$1,251,134,537,143 | \$1,352,789,218,286 | \$1,454,443,899,429 | \$1,563,918,171,429 |
| e | Total software developer salary (a x b) | \$625,567,268,571 | \$676,394,609,143 | \$727,221,949,714 | \$781,959,085,714 |
| f | cost of programming (e x 50%) | \$312,783,634,286 | \$338,197,304,571 | \$363,610,974,857 | \$390,979,542,857 |
| g | Cost of debugging (f x 50%) | \$156,391,817,143 | \$169,098,652,286 | \$181,805,487,429 | \$195,489,771,429 |
| h | Potential value of Undo (f x 13%) | \$40,661,872,457 | \$50,729,595,686 | \$54,541,646,229 | \$58,646,931,429 |

* Ratio of salary to overheads is 1:1 based on RTI research

A3. Global software revenues

| Description | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 |
|--|---------|---------|---------|---------|---------|---------|
| Total Global Software Revenues (\$ in mn): | | | | | | |
| By Country (Top 10) | | | | | | |
| United States | 152,982 | 141,515 | 132,169 | 133,718 | 127,801 | 114,252 |
| Japan | 28,027 | 28,739 | 27,702 | 30,945 | 29,981 | 27,994 |
| Germany | 22,817 | 21,757 | 19,936 | 20,105 | 19,053 | 17,511 |
| United Kingdom | 19,094 | 18,450 | 17,222 | 17,043 | 15,303 | 13,827 |
| France | 14,244 | 13,541 | 12,548 | 12,656 | 12,141 | 11,193 |
| Canada | 10,020 | 9,453 | 8,916 | 8,926 | 8,406 | 7,736 |
| Italy | 7,236 | 7,152 | 6,725 | 6,852 | 6,212 | 5,817 |
| Australia | 7,398 | 6,897 | 6,642 | 6,378 | 5,839 | 5,105 |
| China | 7,077 | 6,475 | 5,995 | 5,665 | 5,182 | 4,349 |
| Netherlands | 5,997 | 5,709 | 5,246 | 5,346 | 5,163 | 4,693 |

A4. References

| Author | Year | Title | Source |
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