SCALABLE HUMAN-COMPETITIVE SOFTWARE REPAIR

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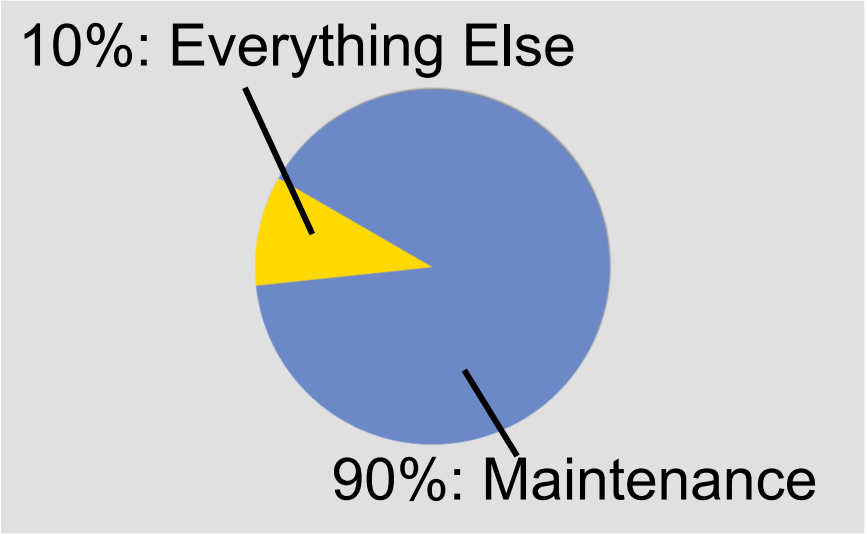
"Everyday, almost 300 bugs appear […] far too many for only the Mozilla programmers to handle."

– *Mozilla Developer, 2005*

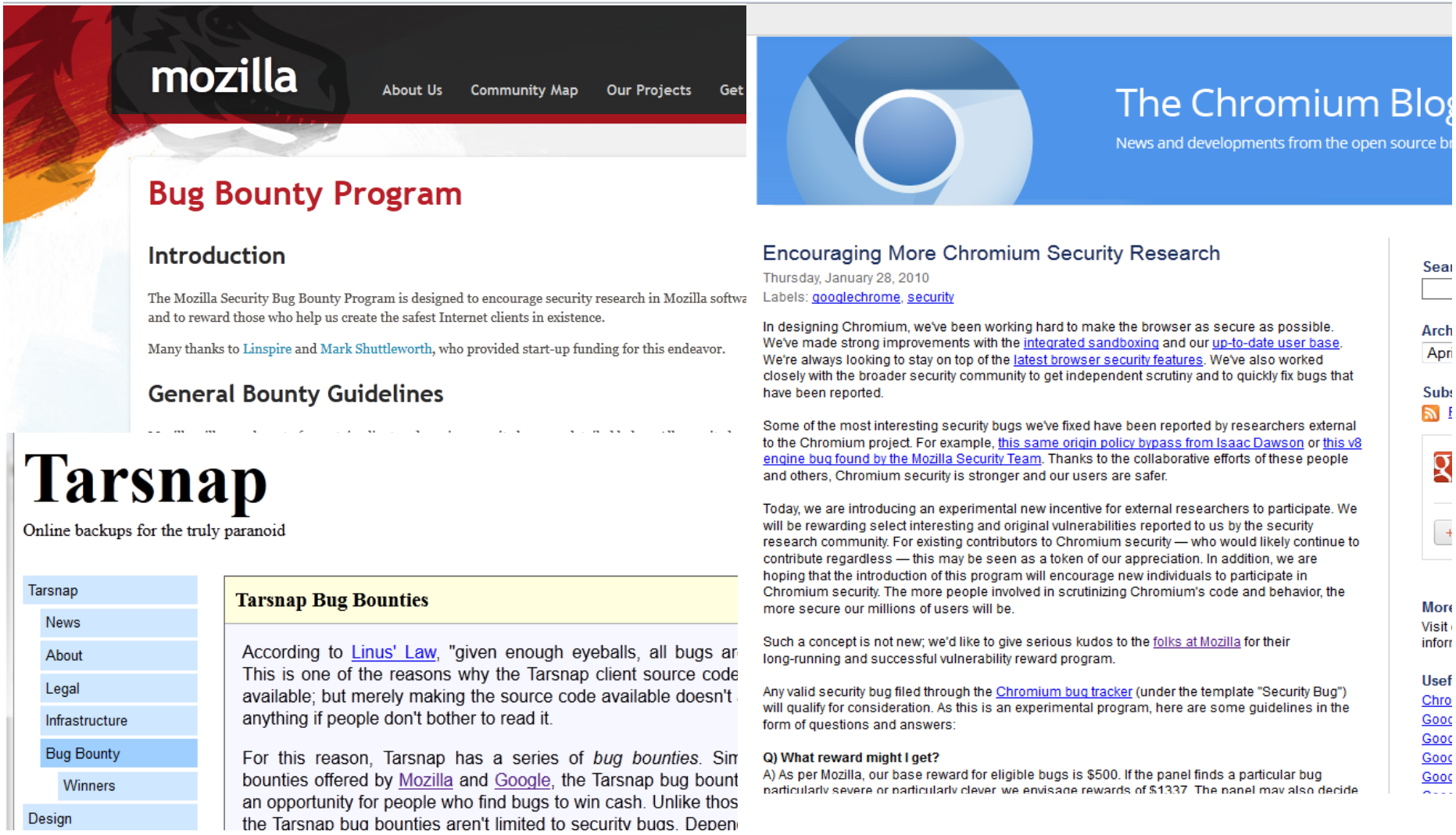
Annual cost of software errors in the US: $59.5 billion (0.6% of GDP).

PROBLEM: BUGGY SOFTWARE

Average time to fix a security-critical error: 28 days.



BUG BOUNTIES: $20-$3000+ PER PATCH



E.G., GOOGLE PAID $11,500 IN BOUNTIES BETWEEN MAY 23, 2012 AND JUN 26, 2012

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News

Google calls, raises Mozilla's bug bounty for Chrome flaws

Boosts cash-for-bugs maximum payment to $3,133, makes researchers mostly happy

By Gregg Keizer

July 22, 2010 11:59 AM ET 2 Comments + Briefcase What's this?

Computerworld - Google on Tuesday hiked bounty payments for Chrome bugs to a maximum of $3,133, up almost $2,000 from the previous top dollar payout of $1,337.

The move came less than a week after rival browser maker Mozilla increased Firefox bug bounties to $3,000.

In an entry to the Chromium project's blog, Chris Evans, who works on the Chrome security team, announced the new maximum bounty of $3.133.70 and said Google would "most likely" award that amount for all vulnerabilities rated "critical" in the company's four-step scoring system.

"The increased reward reflects the fact that the sandbox makes it harder to find bugs of this severity," said Evans, referring to the technology baked into Chrome that isolates processes from one another and the rest of the machine, preventing or at least hindering malicious code from escaping an application to wreak havoc or infect the computer.

Tarsnap:

125 spelling/style
63 harmless
11 minor
+ 1 major

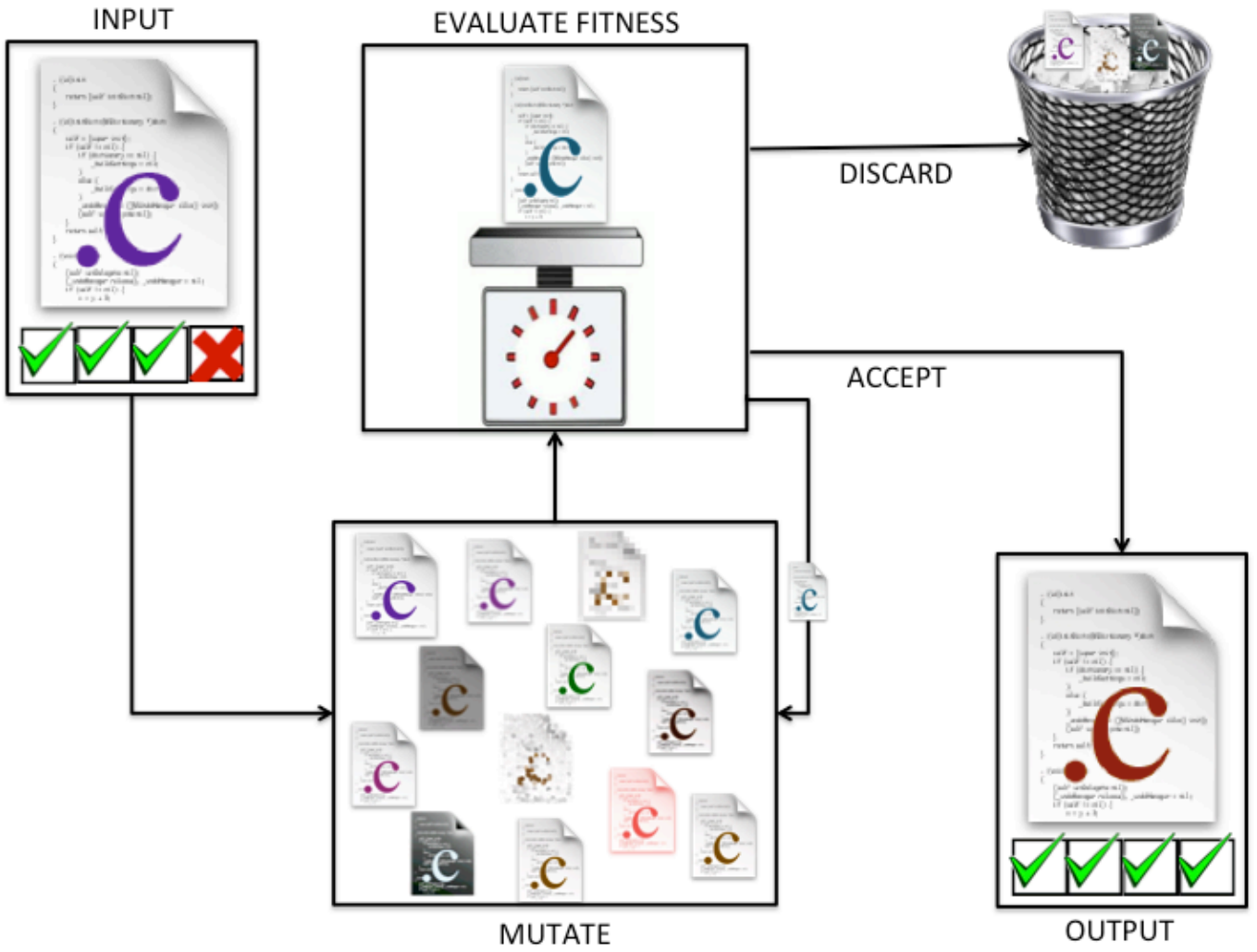
75/200 = 38% TP rate

$17 + 40 hours per TP

which were wrong yet didn't actually affect the compiled code.

But most importantly, $1265 of bugs gives me the peace of mind of knowing that I'm not the only person who has looked at the Tarsnap code, and if there are more critical bugs like the [redacted] I fixed in January, they've escaped more than just my eyeballs. Worth the money? Every penny.

GENPROG: EVOLVING SOFTWARE REPAIRS



WHY WE ARE HUMAN COMPETITIVE

Effective:

- **Tested on 105 human-repaired bugs in over 5 million LOC**
- **GenProg automatically repaired 60 (57%)**
- **Tarsnap CEO found 38% rate "worth every penny"**
- **Security repairs tested using Microsoft's fuzz-testing std**

Cheap: $7.32 per TP (successful bug fix)

- **Tarsnap paid $17 per TP, IBM pays $25**

Fast: 96 minutes (wall clock)

- **Compared to 40 hours for Tarsnap**

Quality (ISSTA to appear):

- **GenProg-patched code + machine-generated documentation is more maintainable than Human-generated patches + commit message**

SYSTEMATIC EVALUATION

Question: "If I were to use your technique on the next 100 bugs that were filed against my project, how many would it fix, how much would that cost, and how long would it take?"

Goal: a large set of important, reproducible bugs in non-trivial programs.

Approach: use historical data of important, reproducible bugs in non-trivial programs

- Consider popular programs from SourceForge, Google Code, Fedora SRPM, etc
- Bugs merited a developer-written test case and a bug report "severity" of 3/5 or more
- Use all pairs of viable versions from source control repositories.
- "Lock in" our algorithm first, then gather up all bugs.
- Evaluate in Amazon EC2 cloud

BENCHMARKS

Program	Description	LOC	Tests	Bugs	
				Fixed	Total
fbc	Language (legacy)	97K	773	1	3
gmp	Multiple precision math	145K	146	1	2
gzip	Data compression	491K	12	1	5
libtiff	Image manipulation	77K	78	17	24
lighttpd	Web server	62K	295	5	9
php	Language (web)	1,046K	8,471	31	44
python	Language (general)	407K	355	1	11
wireshark	Network packet analyzer	2,814K	63	3	7
Total		**5,14M**	**10,193**	**60**	**105**

SCALABILITY

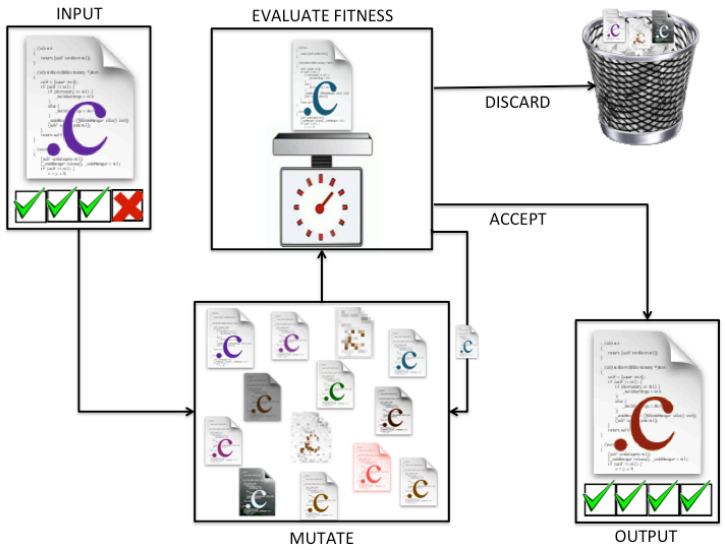
In 2009, we demonstrated that it was possible to repair bugs using GP

- Evaluated on small/toy programs with small test suites, no direct cost comparisons, no systematic quality comparisons

2012: human-competitive scalable repairs for off-the-shelf, real-world bugs

- ~100x more code, ~200x more tests, ~10x more bugs (and bugs that matter!), systematic study, direct time measurements (e.g., 96 minutes vs. 40 hours), direct cost measurements (e.g., $8 vs. $17), direct maintainability measurements

CONCLUSION



GenProg addresses a critical and challenging problem (0.6% US GDP)

Better than humans on quantitative metrics used in software industry.

Systematic selection of benchmark programs and bugs

Scalability achieved through algorithmic innovations