ECONOMIC APPROACHES TO SOFTWARE CORRECTNESS

DAVID F. BACON * YILING CHEN IAN KASH DAVID PARKES MANU SRIDHARAN * MALVIKA RAO

HARVARD UNIVERSITY

* IBM RESEARCH

THIS MAKES ME MAD

The application Safari quit unexpectedly.

Mac OS X and other applications are not affected.

Click Reopen to open the application again. Click Report to see more details or send a report to Apple.



ENGINEERING-BASED CORRECTNESS

SOFTWARE ENGINEERING

- Methodology
- Process
- # Fatal Flaws:
 - Not Quantitative
 - Degenerates to Religion



MATHEMATICS-BASED CORRECTNESS

FORMAL METHODS

- Specs & Proofs
- Model Checking
- # Fatal Flaws:
 - Rely on Spec
 - Don't Scale



"SOFTWARE CRISIS" -SOLVED!

"well before the seventies have run to completion, we shall be able to design and implement ... systems virtually free of bugs."

-- Edsger Dijkstra, 1972 Turing Award Lecture

BUGS HAVE A LONG TAIL



USERS AND DEVELOPERS ÅRE ISOLATED FROM EACH OTHER



...deliberately because feedback can't be accumulated automatically

CAN A MARKET HELP SOLVE THIS PROBLEM?

Large supply of work
Large supply of capable workers
Real value for performing the work

IMAGINE...

The application Safari quit unexpectedly.

Mac OS X and other applications are not affected.

Click Reopen to open the application again. Click Report to see details or send a report. Click Offer Bounty to contribute to a bounty for fixing this bug.



Select an amount to offer as a bounty for fixing this bug.



Your bounty will be held in escrow until the bug is fixed or the time limit expires. The default time limit is 6 months.

Currently, 875 users have offered a total of \$2298.45 for fixing this bug. You have been affected by this bug 7 times.



MARKET DEMAND

₩U users

R_{uj} reward by user *u* for job *j*

₩J jobs

₩ W workers

Demand for job $j = R_j = \sum_{u \in U} R_{uj}$

Correctness Demand = $R = \sum_{j \in J} R_j$

MARKET SUPPLY

U users

*J jobs

 $R_{uj} \text{ reward by user } u \text{ for job } j$ $C_{wj} \text{ cost to worker } w \text{ for job } j$

* W workers

Potential Value for job $j = P_j = \max_{w \in W} (R_j - C_{wj}, 0)$

Correctness Potential = $P = \sum_{j \in J} P_j$

CORRECTNESS EQUILIBRIUM

₩U users

*J jobs

 $R_{uj} \text{ reward by user } u \text{ for job } j$ $C_{wj} \text{ cost to worker } w \text{ for job } j$

* W workers

Potential Value for job $j = P_j = \max_{w \in W} (R_j - C_{wj}, 0)$

Correctness Potential = $P = \sum_{j \in J} P_j = 0$

DYNAMIC EQUILIBRIUM

Market is in *correctness equilibrium* when correctness potential = 0
In "living" software that never happens:
new bugs are found
bug bids change
workers come and go

Goal: design a system that tends towards *Jynamic equilibrium*

BUG ~ LACK OF FEATURE



BUG ~ LACK OF APPLICATION



RE-IMAGING SOFTWARE DEVELOPMENT

Come up with an idea # Fund development via crowdsourcing Implement via open market of programmers Deploy to a wide market of users Were report bugs and missing features User bid on work items Programmers fix bugs and improve software Users test fixes/improvements

FUND DEVELOPMENT What is Discover Start KICKSTARTER Q Help Sign up Log in Kickstarter? great projects a project Macaw: The Code-Savvy Web Design Tool by Macaw Comments 36 Washington, DC Updates 1 Backers 940 Technology Home 10 about 940 640 H INSPECTOR LIBRARY ROCK CREEK AVIARY backers DONATE \$88,138 EXHIBITS EDUCATION ABOUT POSITION & SIZE ** Y 222 pledged of \$75,000 goal AUTO TYPOGRAPH 28 - 400 Open Sans FX 1.38 T 86 days to go PLAY rgb(0, 0, 0) TTTI AW O **Back This Project** PX 🔚 1 \$1 minimum pledge - E Σ S ¥ S/line NEW EXHIBIT This project will be funded on Friday Nov 1, 10:11am EDT. MVCAW

Funding period Oct 2, 2013 - Nov 1, 2013 (30 days)

IMPLEMENT WITH OPEN MARKET



Algorithm	High School	Conceptu	alization		Architecture	Design	Development	Assembly	Application Testing	Marathon Matches		
Development Competitions			Submission Details									
Pating					Java		.NET		Total			
Rating.		Inquiries		58		0		58				
	1/15 21/15		Submiss	ions		33		r	v/a	33		
[competition histo			Submission Rate			56.90%		r	i/a	56.90%		
[current contests]			Passed S	Screening		33		r	i/a	33		
[rendenity detail]		87.5 12 of 96 1 of 2 322 <u>58</u> <u>66.67%</u> 1864 1050	Screenin	g Success Rate		100.00%		r	i/a	100.00%		
Percentile:			Passed R	Review		33		r	i/a	33		
Rank: Country Rank: Volatility:			Review S	uccess Rate		100.00%		r	i/a	100.00%		
			Appeals*			241		r	i/a	241		
Competitions: Reliability:			Appeal S	uccess Rate*		47.72%		r	i/a	47.72%		
Maximum Rating: Minimum Rating:			Maximun	n Score		99.43		r	i/a	99.43		
			Minimum	Score		78.46		r	i/a	78.46		
			Average	Score		94.06		r	i/a	94.06		
			Average	Placement		1.85		r	i/a	1.85		
			Wins			19		r	i/a	19		
			Win Perc	entage		57.58%		r	v/a	57.58%		
			to a build a second from a scientistic second data and the March 40, 2020 (To De des did estimated and the science data)									

only includes appeals from projects posted on or after March 16, 2006 (TopCoder did not previously collect the relevant data)

DEPLOY TO A WIDE MARKET





USERS REPORT BUGS

GitHu	This repository - Search or type a command	Explore	Features	Enterprise	Blog	Sign u	Sig	ın in
kan	igax / fabric.js				*	Star 2,319	រ្វិ Fork	370
Browse	Issues Milestones					New	Issue #731	•
	Kienz opened this issue 3 months ago Global canvas zooming					Op 4 com	en nents	11
	No one is assigned No milestone Labels Posibility to zoom canvas (+/-) and all it's objects. bounty feature Here are some ideas from @kangax: feature feature							*
	 Programmatic canvas zooming One zoom level property (1 by default = normal zoom) UI for canvas zooming UI is a secondary thing; we can do it <i>after</i> implementing printroduce another canvas mode, similar to free drawing m 	rogrammatic zoomin lode. When in that m	ng. For this, node, canva	we'll probably s would zoom	need to on click or			ų
	dblclick or whatever. You wouldn't be able to select objects I like how zoom works in google docs. I think we should base of Other ideas:	s (similar to free dra	wing mode)).				

USERS BID ON WORK ITEMS

Bountysource Q Issi	ue URL, Project, Language, etc.
	Went to come cook? Dougt rouwork
	want to earn some cash? Bountysource's
Home » Projects » Fab	ric.js » Global canvas zooming [\$1,070]
Fabric JS Open	anvas zooming [\$1,070]
Overview Bounties	4 Place Bounty
Payment Method:	 Google Wallet PayPal
Bounty Amount:	\$ 200
Bountysource Fee:	\$20.00
Total:	\$ 220
	Post anonymously
	Create \$200 Bounty

PROGRAMMERS FIX BUGS

Bountysource

Blog Teams Enterprise

🕜 dfbacon 🔻

Fabric.js

Javascript Canvas Library, SVG-to-Canvas (& canvas-to-SVG) Parser

Fabric		Javascript Canvas Library, SVG-to-Canvas (& canvas-to-SVG) Parser								
		Search issues Bounty Range: \$ 50	- Infinity							
	.)3	□ Has active bounties □ Hide open issues □ Hide closed issues □ Only show paid out issues								
		Title	\$	Ю	Ŧ	O				
		Global canvas zooming [\$1,070]	\$ 1,070	心 1	13	3 mo				
 ☆ Follow this project (●) View on GitHub 		Add support for skewing [\$125]	\$ 125		12	3 mo				
		Site redesign [\$110]	\$ 110	1分1	17	4 mo				
		Curve Text Feature [\$100]	\$ 100		19	3 mo				
		Background refactor suggestion [\$55]	\$ 55	1 分1	15	1 yr				
\$1,645	\$210	Support events for objects in group [\$35]	\$ 35		16	6 mo				
in bounties	claimed	fabric.Rect clone() and toSVG() not working if rect is part of fabric.PathGroup [\$35]	\$ 35		12	7 mo				
	2 218	Optimize methods for activate/deactivate object(s) [\$35]	\$ 35			5 mo				
forks	watchers	Using pre-rendering techniques [\$25]	\$ 25		15	10 mo				
101110	Hatoholo	Bounding rectangle of a group is displayed incorrectly when scaled [\$20]	\$ 20			6 mo				
		Add support for static width/height of fabric.Text (text wrap)		1 分 2	10	1 yr				
		Add crossOrigin to images loaded by fabric.Image.fromURL to prevent canvas tainting			15	1 yr				
		Allow exporting self-contained SVG files			12	6 mo				
		Failure to render nvd3 charts			13	4 mo				
		Implement strokeDashArray for Path, Text, Circle, Ellipse (when no native)			13	4 mo				
		Support touch and mouse events simultaneously		心 1	13	4 mo				

DRIVE OUT INEFFICIENCIES

dfb@watson.ibm.com

A Music

sic Movies

TV Shows App Store

Books Podcasts

Showing results for "flashlight"

iPhone Apps



Flashlight @ Utilities

Free



Flashlight. Utilities

🛡 Update 💌



Flashlight for iPhone, iPod a... Utilities

Free 🔹



Flashlight ® Utilities

\$0.99 -



Flashlight * Productivity

Free -



Flashlight e Utilities

Free 🔻



Flashlight ∞ Utilities





Flashlight O Utilities

Free



Best Flash Light! - Torch... Utilities



Magnifying Glass With Light -... Utilities

Free 🔻



myLite LED Flashlight &... Utilities





iLlumination US -Universal... Productivity

HOW DO WE DESIGN SUCH A MARKET?

GUIDING PRINCIPLES:

Autonomy: all actions are market-driven Inclusiveness: all contributors are rewarded * Transparency: "financial disclosure" Reliability: robustness to manipulation * Apply both market pressure and software tools

WHAT ARE THE COMPONENTS?

Funding

Workflow Process

Reputation System

FUNDING

Cash or scrip or votes?

Sources of real cash:
direct user bids
escrow from sale (closed source)
escrow from contribution (shareware)
escrow from registration (open source)

Time limit on bids - money reverts to source

WORKFLOW: BUG

Everyone Shares Reward

Humans vs Tools?

Report ℬ Bid **Categorize** Reproduce **∦** Fix **Test Commit** Distribute

LOTS OF UNCERTAINTY

- When are two crashes the "same bug"?
 - % Line number? Data set?
- When does a change "fix" a bug?
 - Partial fixes & incorrect fixes are not uncommon
 - One fix may improve or worsen another bug
- If multiple fixes submitted, which is best?
 - Band-aids versus Deep fixes

* Program analysis can belp reduce uncertainty, but will never eliminate it

DEMAND TRAJECTORY



MECHANISM DESIGN PROBLEMS

- Avoiding Freeloading
- Preventing Fraudulent "Fixed" Claims by Providers
- Preventing Fraudulent "Not Fixed" Claims by Consumers
- Lag in fix verification by Consumers

REPUTATION SYSTEM

- Ratings based on past performance
- Control certain activities (e.g. commits) May also affect reward distribution # Adjusted with information about software lifetime Can be seeded by central organization # useful when project is small * occasional escape hatch

MARKET-BASED SOFTWARE

ONLY SCALABLE SOLUTION

EMPOWERS USERS AND PROGRAMMERS

MAKES PROBLEM QUANTITATIVE

THANKS.

QUESTIONS?