Lessons in Social Coding

Software Analytics in the Age of GitHub

Bogdan Vasilescu

ISR, School of Computer Science
Carnegie Mellon University

@b_vasilescu http://bvasiles.github.io
Social Web
+
Software Engineering
Social Software Engineering
Programming in a socially networked world: the evolution of the social programmer
C Treude, F Figueira Filho, B Cleary, MA Storey. 
*FutureCSD-CSCW 2012*

Social coding in GitHub: transparency and collaboration in an open software repository
L Dabbish, C Stuart, J Tsay, J Herbsleb. 
*CSCW 2012*

Social networking meets software development: Perspectives from GitHub, MSDN, Stack Exchange, and TopCoder
A Begel, J Bosch, MA Storey. 
*IEEE Software 2013*
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

GIT
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

GIT

GITHUB UI

Fork 11,965

Fork your own copy of rails/rails to your account

Create pull request

Discuss and review the changes in this
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

**GIT**

**GITHUB UI**

**THE “PULL REQUEST” MODEL**
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

**GIT**

**GITHUB UI**

Create a branch
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

THE “PULL REQUEST” MODEL

Add commits
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

**GIT**

**GITHUB UI**

- Fork your own copy of rails/rails to your account
- Create pull request

---

**THE “PULL REQUEST” MODEL**

1. Fork the repository
2. Create a new branch
3. Make changes
4. Open a pull request
5. Discuss and review the changes
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

THE “PULL REQUEST” MODEL

GIT

GITHUB UI

Discussion & code review
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

**GIT**

**GITHUB UI**

**THE “PULL REQUEST” MODEL**

Pull request updates
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

THE "PULL REQUEST" MODEL

Merge
“SOCIAL CODING”: CODE IS MEANT TO BE SHARED

**GIT**

Unified development, testing, code review, integration → DEVOPS

**GITHUB UI**

Lowest ever barrier to entry for newcomers

Democratic, open, social process

THE “PULL REQUEST” MODEL
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

BlackDuck 2015 survey [https://goo.gl/Ltaqqs](https://goo.gl/Ltaqqs)
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

12 million people
31 million repositories

Source: BlackDuck 2015 survey
https://goo.gl/Ltaqqs

GitHub stats from: https://github.com/about
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

12 million people
31 million repositories
18.5 million software dev's

GitHub stats from: https://github.com/about
World estimates from: http://goo.gl/Htnni9
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

- 12 million people
- 31 million repositories
- 18.5 million software dev’s
- 15,000+ people

BlackDuck 2015 survey
https://goo.gl/Ltaqqs

GitHub stats from: https://github.com/about
World estimates from: http://goo.gl/Htnni9
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

12 million people
31 million repositories
18.5 million software dev's
15,000+ people

CULTURE CHANGE

"it's just so uncool not sharing the code in the age of social coding"

GitHub stats from: https://github.com/about
World estimates from: http://goo.gl/Htnni9
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

- 18.5 million software dev’s
- 15,000+ people
- 31 million repositories
- 12 million people

CULTURE CHANGE

"it’s just so uncool not sharing the code in the age of social coding”

HIRING

- $100+ /hour:
  - owns popular OSS products;
  - stackoverflow score > 20K; ...
- $50+ /hour:
  - active OSS contributor;
  - stackoverflow score > 5K; ...

- How Much Do You Cost? Yegor Bugayenko http://goo.gl/N0mL3F
- Activity traces and signals in software developer recruitment and hiring J Marlow, L Dabbish. CSCW 2013

GitHub stats from: https://github.com/about
World estimates from: http://goo.gl/Htnni9
BlackDuck 2015 survey https://goo.gl/Ltaqqs
https://news.ycombinator.com/item?id=2982987
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING

Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING

- 12 million people
- 31 million repositories
- 18.5 million software dev's
- 15,000+ people

CULTURE CHANGE

"it’s just so uncool not sharing the code in the age of social coding"

HIRING

- $100+ /hour:
  - owns popular OSS products;
  - stackoverflow score > 20K; ...
- $50+ /hour:
  - active OSS contributor;
  - stackoverflow score > 5K; ...

INDUSTRIAL INVOLVEMENT & ADOPTION

- Microsoft
- Google
- Facebook

- GitHub stats from: https://github.com/about
- World estimates from: http://goo.gl/Htnni9
- Open source-style collaborative development practices in commercial projects using GitHub
- E Kalliamvakou, D Damian, K Blincoe, L Singer, DM German. /ICSE 2015
- How Much Do You Cost? Yegor Bugayenko http://goo.gl/N0mL3F
- Activity traces and signals in software developer recruitment and hiring
- J Marlow, L Dabbish. CSCW 2013
LARGE, DIVERSE, COMPLEX ECOSYSTEM
LARGE, DIVERSE, COMPLEX ECOSYSTEM
LARGE, DIVERSE, COMPLEX ECOSYSTEM
LARGE, DIVERSE, COMPLEX ECOSYSTEM
WE DON'T YET UNDERSTAND THE EFFECTS
WE DON’T YET UNDERSTAND THE EFFECTS

INDIVIDUAL PRODUCTIVITY?

- Signaling
- Distraction
- Audience pressure
WE DON’T YET UNDERSTAND THE EFFECTS

INDIVIDUAL PRODUCTIVITY?
• Signaling
• Distraction
• Audience pressure

TEAM EFFECTIVENESS?
• Teams: large, distributed, diverse
• New technology for process automation
WE DON'T YET UNDERSTAND THE EFFECTS

INDIVIDUAL PRODUCTIVITY?
- Signaling
- Distraction
- Audience pressure

TEAM EFFECTIVENESS?
- Teams: large, distributed, diverse
- New technology for process automation

SOFTWARE QUALITY?
- More contributors
- Faster pace
- DEVOPS
EMPIRICAL STUDIES

EXPERIMENTS

- Small sample size
- Threats to ecological validity
- Relatively expensive

Best way to control for confounds

QUASI-EXPERIMENTS

- Large samples
- “Real” data
- More generalizable
- Relatively cheap

Everything is archived and can be mined
QUASI-EXPERIMENTS

DATA ANALYSIS (STATISTICS) → TRENDS
QUASI-EXPERIMENTS

DATA ANALYSIS (STATISTICS) → TRENDS

DATA-DRIVEN vs. INTUITION-BASED decision making

DATA SCIENTIST: standard on software teams

- Analyze This! 145 Questions for Data Scientists in Software Engineering
  A. Begel, T. Zimmermann. ICSE 2014

- The Emerging Role of Data Scientists on Software Development Teams
  M. Kim, T. Zimmermann, R. DeLine, A. Begel. ICSE 2016
EXAMPLE: PULL REQUEST EVALUATION TIME
Hypothesis:
Only technical attributes matter:
• Size
• Complexity
• Tests
Hypothesis:
Only technical attributes matter:
• Size
• Complexity
• Tests

SOCIAL CODING!
•Submitter is core developer
•Number of followers
•Strength of social connection

... all stronger predictors than including tests

• Influence of social and technical factors for evaluating contribution in GitHub
  J. Tsay, L. Dabbish, J. Herbsleb. ICSE 2014
• Wait for it: Determinants of pull request evaluation latency on GitHub
  Y Yu, H Wang, V Filkov, P Devanbu, B Vasilescu. MSR 2015
EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

12 million people
31 million repos
## Experimental Risk: Big Data to the Rescue

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**Null Hyp. TRUE**
**EXPERIMENTAL RISK: BIG DATA TO THE RESCUE**

<table>
<thead>
<tr>
<th>1</th>
<th>FALSE POSITIVES</th>
<th>2</th>
<th>FALSE NEGATIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Null Hyp. TRUE</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Null Hyp. FALSE</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

- 12 million people
- 31 million repos

FALSE POSITIVES
- Null Hyp. TRUE: 1
- Null Hyp. FALSE: 2

FALSE NEGATIVES
- Null Hyp. TRUE: 0
- Null Hyp. FALSE: 0
## EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

<table>
<thead>
<tr>
<th>1. FALSE POSITIVES</th>
<th>2. FALSE NEGATIVES</th>
<th>3. CONFOUNDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject Null Hyp.</td>
<td>Accept Null Hyp.</td>
</tr>
<tr>
<td>Null Hyp. TRUE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Null Hyp. FALSE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **FALSE POSITIVES**
  - Null Hyp. TRUE
  - Null Hyp. FALSE

- **FALSE NEGATIVES**
  - Null Hyp. TRUE
  - Null Hyp. FALSE

- **CONFOUNDERS**
  - 12 million people
  - 31 million repos
### EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

#### FALSE POSITIVES
1. **Reject Null Hyp.**
2. **Accept Null Hyp.**

#### FALSE NEGATIVES
- Null Hyp. TRUE
- Null Hyp. FALSE

#### CONFOUNDS

### HUGE SAMPLE SIZES:
- More stringent a priori about significance level
  → reduce False Positives

#### Statistics
- 12 million people
- 31 million repos
## EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>False Negatives</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Confounds</td>
<td>Null Hyp. TRUE</td>
<td>Null Hyp. FALSE</td>
</tr>
</tbody>
</table>

**Huge Sample Sizes:**

- More stringent a priori about significance level → reduce False Positives
- Detect even small effects → reduce False Negatives

12 million people
31 million repos
### EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

#### FALSE POSITIVES
- Reject Null Hyp.
- Accept Null Hyp.

#### FALSE NEGATIVES
- Null Hyp. TRUE: 1
- Null Hyp. FALSE: 2

#### CONFOUNDS

#### HUGE SAMPLE SIZES:
- More stringent a priori about significance level → reduce **False Positives**
- Detect even small effects → reduce **False Negatives**
- Handle more degrees of freedom → control for **Confounds**

- 12 million people
- 31 million repos
**EXPERIMENTAL RISK: BIG DATA TO THE RESCUE**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FALSE POSITIVES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FALSE NEGATIVES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CONFOUNDS</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HUGE SAMPLE SIZES:**

- More stringent a priori about significance level → reduce **False Positives**
- Detect even small effects → reduce **False Negatives**
- Handle more degrees of freedom → control for **Confounds**

**SEPARATE SIGNAL FROM NOISE:**

- Quantify **effect size**

---

12 million people

31 million repos
# EXPERIMENTAL RISK: BIG DATA TO THE RESCUE

<table>
<thead>
<tr>
<th>1</th>
<th>FALSE POSITIVES</th>
<th>Reject Null Hyp.</th>
<th>Accept Null Hyp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>FALSE NEGATIVES</td>
<td>Null Hyp. TRUE</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>CONFOUNDS</td>
<td>Null Hyp. FALSE</td>
<td>2</td>
</tr>
</tbody>
</table>

## HUGE SAMPLE SIZES:
- More stringent a priori about significance level → reduce **False Positives**
- Detect even small effects → reduce **False Negatives**
- Handle more degrees of freedom → control for **Confound**s

## SEPARATE SIGNAL FROM NOISE:
- Quantify **effect size**
- Mix research methods
  - **Quantitative**: stats, data mining, ...
  - **Qualitative**: case studies, user surveys, grounded theory, ...

12 million people
31 million repos
**EXPERIMENTAL RISK: BIG DATA TO THE RESCUE**

1. **FALSE POSITIVES**
   - Reject Null Hyp.
   - Accept Null Hyp.

2. **FALSE NEGATIVES**
   - Null Hyp. TRUE
   - 1
   - Null Hyp. FALSE
   - 2

3. **CONFOUNDS**

**HUGE SAMPLE SIZES:**
- More stringent a priori about significance level → reduce False Positives
- Detect even small effects → reduce False Negatives
- Handle more degrees of freedom → control for Confounds

**SEPARATE SIGNAL FROM NOISE:**
- Quantify effect size
- Mix research methods
  - Quantitative: stats, data mining, ...
  - Qualitative: case studies, user surveys, grounded theory, ...

**VALIDATE DATA FIRST!**
- Spot-checking

12 million people
31 million repos
1. TEAM DIVERSITY
   [CHI 2015]

2. MULTITASKING ACROSS PROJECTS
   [ICSE 2016]

3. CONTINUOUS INTEGRATION
   [ESEC/FSE 2015]
DIVERSITY IS RECOGNIZED AS VALUABLE
DIVERSITY IS RECOGNIZED AS VALUABLE

“Driver of internal innovation and business growth” [Forbes]
DIVERSITY IS RECOGNIZED AS VALUABLE

“Driver of internal innovation and business growth” [Forbes]

Companies with diverse executive boards have higher earnings and returns on equity [McKinsey]
DIVERSITY IS RECOGNIZED AS VALUABLE

“Driver of internal innovation and business growth” [Forbes]

Companies with diverse executive boards have higher earnings and returns on equity [McKinsey]

POLL: WHY WOULD WE WANT DIVERSITY?
DIVERSITY IS RECOGNIZED AS VALUABLE

“Driver of internal innovation and business growth” [Forbes]

Companies with diverse executive boards have higher earnings and returns on equity [McKinsey]

BENEFITS:

• access to different networks
• broader views
• creativity
• adaptability
• problem solving

→ INFORMATION PROCESSING THEORY

DIVERSITY IN SOFTWARE TEAMS?

1. HIGHER RISK OF:
   - communication breakdown
   - conflict
   - confusion
   - stress
   - discrimination
   ...

vs.
DIVERSITY IN SOFTWARE TEAMS?

1. HIGHER RISK OF:
   - communication breakdown
   - conflict
   - confusion
   - stress
   - discrimination
   ...

→ SIMILARITY ATTRACTION THEORY

→ SOCIAL IDENTITY, SOCIAL CATEGORIZATION THEORY

DIVERSITY IN SOFTWARE TEAMS?

2. OPEN SOURCE / GITHUB ARE MERITOCRACIES

[CHASE 2015]
DIVERSITY IN SOFTWARE TEAMS?

2. OPEN SOURCE / GITHUB ARE MERITOCRACIES

“More about the contributions to the code than the `characteristics’ of the person”

“Any demographic identity is irrelevant”

“Code sees no color or gender”

[CHASE 2015]
3. PERCEPTION: OPEN-SOURCE IS UNFRIENDLY TO NEWCOMERS & WOMEN

“I have used a fake GitHub handle (my normal GitHub handle is my first name, which is a distinctly female name) so that people would assume I was male” [CHASE 2015]
3. PERCEPTION: OPEN-SOURCE IS UNFRIENDLY TO NEWCOMERS & WOMEN

“I have used a fake GitHub handle (my normal GitHub handle is my first name, which is a distinctly female name) so that people would assume I was male”  
[CHASE 2015]

GENDER REPRESENTATION

<table>
<thead>
<tr>
<th>Platform</th>
<th>Female (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack Overflow</td>
<td>5.8%</td>
</tr>
<tr>
<td>GitHub</td>
<td>~5%</td>
</tr>
<tr>
<td>Google</td>
<td>10.9%</td>
</tr>
<tr>
<td>Open Source</td>
<td>18%</td>
</tr>
<tr>
<td>Inside Microsoft</td>
<td>16.6%</td>
</tr>
</tbody>
</table>

3. PERCEPTION: OPEN-SOURCE IS UNFRIENDLY TO NEWCOMERS & WOMEN

“I have used a fake GitHub handle (my normal GitHub handle is my first name, which is a distinctly female name) so that people would assume I was male” [CHASE 2015]

Does diversity create added value in GitHub teams?
1. Mine data from many collaborative projects
1. Mine data from many collaborative projects

2. Compare outputs produced per unit time in more/less diverse teams

[CHI 2015]
1. Mine data from many collaborative projects

2. Compare outputs produced per unit time in more/less diverse teams

[CHI 2015]
Team boundaries?

Demographics not salient?

- Demographic diversity and employee attitudes: An empirical examination of relational demography within work units. Riordan, C. M., and Shore, L. M. J. Appl. Psychol. 82, 3 (1997),
User survey
4,500 invitations, 816 responses
CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

User survey
4,500 invitations, 816 responses

What constitutes a team?

Which differences do people recognize among team members?

Does diversity matter?

- Demographic diversity and employee attitudes: An empirical examination of relational demography within work units. Riordan, C. M., and Shore, L. M.. J. Appl. Psychol. 82, 3 (1997),
Open card sorting

CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

Team boundaries?

Demographics not salient?

[CHASE 2015]
User survey
4,500 invitations, 816 responses

What constitutes a team?
- The team is everyone

Which differences do people recognize among team members?
- Gender is surprisingly salient

Does diversity matter?
- Split opinions

[CHASE 2015]
CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

Gender not explicit

Multiple aliases
Gender tool

Gender not explicit

Multiple aliases

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

GENDER TOOL

Gender not explicit

Multiple aliases

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

Gender, representation and online participation: A quantitative study.

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

GENDER TOOL

Gender not explicit

Multiple aliases

CHALLENGES

1. EXP. DESIGN

2. DATA MINING

3. STATISTICAL ANALYSIS

Bing Maps + Heuristics

USA
GENDER TOOL

Gender not explicit

Multiple aliases

CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

GENDER TOOL

Gender, representation and online participation: A quantitative study.

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

Bing Maps + Heuristics

Bogdan + USA

Male

Name frequency tables for 30 countries
Gender tool

- Gender not explicit
- Multiple aliases

Bing Maps + Heuristics

Name frequency tables for 30 countries

Location matters!
- Andrea (Italy) → male
- Andrea (USA) → female

http://github.com/tue-mdse/genderComputer
http://github.com/tue-mdse/countryNameManager

DEALIASING TOOL

Gender not explicit
Multiple aliases

INTUITION:

Laurent Gautier - laurent@cbs.dtu.dk
Laurent Gautier - s010592@student.dtu.dk
Laurent - lgautier@gmail.com
- lgautier@altern.org

CHALLENGES
1. EXP. DESIGN  2. DATA MINING  3. STATISTICAL ANALYSIS

DEALIASING TOOL

INTUITION:

Laurent Gautier - laurent@cbs.dtu.dk
Laurent Gautier - s010592@student.dtu.dk
Laurent - lgautier@gmail.com
- lgautier@altern.org

DEALIASING TOOL

INTUITION:
• first name

Laurent Gautier - laurent@cbs.dtu.dk
Laurent Gautier - s010592@student.dtu.dk
Laurent - lgautier@gmail.com
- lgautier@altern.org
DEALIASING TOOL

INTUITION:
• first name
• email prefix

Laurent Gautier - laurent@cbs.dtu.dk
Laurent Gautier - s010592@student.dtu.dk
Laurent - lgautier@gmail.com
- lgautier@altern.org

DEALIASING TOOL

Gender not explicit

Multiple aliases

INTUITION:

- first name
- email prefix
- first initial + last name
...

Laurent Gautier - laurent@cbs.dtu.dk
Laurent Gautier - s010592@student.dtu.dk
Laurent - lgautier@gmail.com
- lgautier@altern.org

CHALLENGES
1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

CHALLENGES

1. EXP. DESIGN  2. DATA MINING  3. STATISTICAL ANALYSIS

REGRESSION

Outputs produced / unit time
(#Commits/quarter)

response
Team productivity.

Outputs produced / unit time
(#Commits/quarter)

response

Gender diversity (Blau)
Tenure diversity (CV)

main predictors
CHALLENGES

1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

REGRESSION

Outputs produced / unit time (#Commits/quarter)  response

Gender diversity (Blau)  Tenure diversity (CV) main predictors

Total commits

Project size

controls
Outputs produced / unit time (#Commits/quarter) 

Gender diversity (Blau) 

Tenure diversity (CV) 

Team size 

Experience 

Total commits 

Project size 

Human resources 

main predictors

controls

CHALLENGES
1. EXP. DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

REGRESSION
REGRESSION

Outputs produced / unit time (#Commits/quarter)

response

Gender diversity (Blau)
Tenure diversity (CV)

main predictors

Total commits
Team size
Experience
Project age
Time

Project size
Human resources
Evolution of GitHub & time passing

controls
**Outputs produced / unit time**
(#Commits/quarter)

**main predictors**
- Gender diversity (Blau)
- Tenure diversity (CV)

**response**

**controls**
- Project size
- Human resources
- Team size
- Experience
- Evolution of GitHub & time passing
- Project age
- Time
- Popularity
- Distributed development
- Comments
- Forks
<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Project age</th>
<th>Total #commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.00</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.08</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>
### Different projects...

<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Age</th>
<th>Total #commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>0.00</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Q6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>0.25</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Q7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56</td>
<td>53</td>
<td>20</td>
<td>0.00</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>116</td>
<td>219</td>
<td>93</td>
<td>0.05</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Q6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>186</td>
<td>367</td>
<td>119</td>
<td>0.06</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Q7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>129</td>
<td>453</td>
<td>114</td>
<td>0.08</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>
### CHALLENGES

1. EXP. DESIGN  
2. DATA MINING  
3. STATISTICAL ANALYSIS

Different projects ...  
... observed over time

<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Project age</th>
<th>Total commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>0.00</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>0.25</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>56</td>
<td>53</td>
<td>20</td>
<td>0.00</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>116</td>
<td>219</td>
<td>93</td>
<td>0.05</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>186</td>
<td>367</td>
<td>119</td>
<td>0.06</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>129</td>
<td>453</td>
<td>114</td>
<td>0.08</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>
### Challenges

1. **Exp. Design**
2. **Data Mining**
3. **Statistical Analysis**

Different projects...  
... observed over time  
Outputs produced

<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Project age</th>
<th>Total commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>0.00</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>0.25</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>56</td>
<td>53</td>
<td>20</td>
<td>0.00</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>116</td>
<td>219</td>
<td>93</td>
<td>0.05</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>186</td>
<td>367</td>
<td>119</td>
<td>0.06</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>129</td>
<td>453</td>
<td>114</td>
<td>0.08</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>
### Different projects ...

... observed over time   Outputs produced

<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Project age</th>
<th>Total #commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>0.00</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Q6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>0.25</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Q7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>56</td>
<td>53</td>
<td>20</td>
<td>0.00</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Q5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>116</td>
<td>219</td>
<td>93</td>
<td>0.05</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Q6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>186</td>
<td>367</td>
<td>119</td>
<td>0.06</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Q7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>129</td>
<td>453</td>
<td>114</td>
<td>0.08</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>
### LINEAR MIXED-EFFECTS REGRESSION

**Longitudinal data**

**Random effects:** project, time

**Nesting:** projects

**Random slope:** team size | project

---

<table>
<thead>
<tr>
<th>Project</th>
<th>Created on</th>
<th>Project age</th>
<th>Total #commits</th>
<th>#Forks</th>
<th>Time</th>
<th>#Commits</th>
<th>#Comments</th>
<th>Team size</th>
<th>Gender diversity</th>
<th>Commit tenure diversity</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2011-02-15</td>
<td>12</td>
<td>557</td>
<td>51</td>
<td>Q2</td>
<td>47</td>
<td>26</td>
<td>9</td>
<td>0.25</td>
<td>0.47</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>0.54</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>56</td>
<td>53</td>
<td>20</td>
<td>0.56</td>
<td>0.87</td>
</tr>
<tr>
<td>B</td>
<td>2010-09-21</td>
<td>11</td>
<td>2075</td>
<td>578</td>
<td>Q4</td>
<td>71</td>
<td>169</td>
<td>83</td>
<td>0.03</td>
<td>0.66</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q5</td>
<td>116</td>
<td>219</td>
<td>93</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q6</td>
<td>186</td>
<td>367</td>
<td>119</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q7</td>
<td>129</td>
<td>453</td>
<td>114</td>
<td>0.85</td>
<td>0.82</td>
</tr>
</tbody>
</table>

**CHALLENGES**

1. EXPERIMENTAL DESIGN
2. DATA MINING
3. STATISTICAL ANALYSIS

**Different projects ...**

... observed over time

**Outputs produced**

**Diversity measures**

**Nesting:** projects
RESULTS

Higher productivity
RESULTS

Other confounds held fixed, higher team diversity (gender & tenure) is associated with increased code production (commits per quarter).

But small effects!
RESULTS

Other confounds held fixed, higher team diversity (gender & tenure) is associated with increased code production (commits per quarter).

But small effects!

ONGOING / FUTURE WORK:

- Diversity effects beyond code production (e.g., team cohesiveness & code quality)
- Why are social coding platforms so exclusive? Gamification?
1. Team Diversity [CHI 2015]
2. Multitasking Across Projects [ICSE 2016]
3. Continuous Integration [ESEC/FSE 2015]
WORKING ON MULTIPLE PROJECTS IN PARALLEL

REASONS:

- Dependencies
- Downtime
- Being “stuck” in one project
- Request from other dev’s
- Personal interest
- Signaling
- …

• Working for free? Motivations of participating in open source projects
  A. Hars and S. Ou. HiCSSI, 2001

• The open source software development phenomenon: An analysis based on social network theory
  G. Madey, V. Freeh, and R. Tynan. AMCIS, 2002

• Activity traces and signals in software developer recruitment and hiring
  J. Marlow, L. Dabbish. CSCW 2013
WORKING ON MULTIPLE PROJECTS IN PARALLEL

PROS:
- Fill downtime
- Cross-fertilisation

CONS:
- Distraction
- Cognitive switching cost - storing state

REASONS:
- Dependencies
- Downtime
- Being “stuck” in one project
- Request from other dev’s
- Personal interest
- Signaling
- ...

- Memory for goals: An activation-based model
  E. M. Altmann and J. G. Trafton.

- What makes interruptions disruptive? A process-model account of the
  effects of the problem state bottleneck on task interruption and resumption
  J. P. Borst, N. A. Taatgen, and H. van Rijn. CHI 2015
SWITCHING PROJECTS IS EXPENSIVE

ANECDOtal RULE OF THUMB  [G. Weinberg, 1992-7]

From: http://blog.codinghorror.com/the-multi-tasking-myth/

- Quality Software Management, 1: Systems Thinking.
EXAMPLE BEHAVIOR:

**EXAMPLE BEHAVIOR:**

- Feel more productive
- Believe they contribute more code

**PEOPLE WHO MULTITASK:**

- **User survey** (128 responses)

[ICSE 2016]
GITHUB DEV’S MULTITASK ACROSS PROJECTS OFTEN

EXAMPLE BEHAVIOR:


PEOPLE WHO MULTITASK:

- Feel more productive
- Believe they contribute more code

User survey (128 responses)

Is there a limit to multitasking?

[ICSE 2016]
1. Mine data on ~1200 prolific developers

[ICSE 2016]
**NATURAL EXPERIMENT**

1. Mine data on ~1200 **prolific developers**

2. Compare **outputs produced per unit time** (LOC added / week) in different multitasking & project switching conditions

[ICSE 2016]
**MULTITASKING DIMENSIONS**

1. **PROJECTS PER DAY**

Working sequentially vs. Within-day multitasking

---

- **xmirror_piwigo**
- **plone_***
- ***_zope**
- **gotcha_***

---

- **rubinius_rubinius**
- **rvm_rvm-site**
- **wayneeseguin_***
- **sm_***
**Multitasking Dimensions**

1. **Projects per Day**

- **Working sequentially** vs. **Within-day multitasking**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>xmirror_piwigo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plone_*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*_zope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gotcha_*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AvgProjectsPerDay = 1

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>rubinius_rubinius</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rvm_rvm-site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wayneeseguin_*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sm_*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AvgProjectsPerDay = 2.2
MULTITASKING DIMENSIONS

2. WEEKLY FOCUS

Working mostly on one project  vs.  Contributing evenly to all projects

High focus

Low focus
MULTITASKING DIMENSIONS

2. WEEKLY FOCUS

Working mostly on one project vs. Contributing evenly to all projects

High focus

$S_{\text{Focus}} = 0.25$

Low focus

$S_{\text{Focus}} = 1.85$

Shannon entropy:

$$S_{\text{Focus}} = - \sum_{i=1}^{N} p_i \log_2 p_i$$

Projects this week

Fraction commits in project $i$
Repetitive day-to-day working style vs. Changing focus one day to next

AvgProjectsPerDay = 1
$S_{Focus} = 1$

AvgProjectsPerDay = 1
$S_{Focus} = 1$
Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

clear-code_*
mroonga_*
test-unit_*
groonga_*

1 2 3 4 5 6
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

clear-code_*
mroonga_*
test-unit_*
groonga_*

nodes
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

clear-code_*
mroonga_*
test-unit_*
groonga_*

1 2 3 4 5 6
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

- clear-code_*
- mroonga_*
- test-unit_*
- groonga_*

1 2 3 4 5 6

- groonga_*
- clear-code_*
- mroonga_*
- test-unit_*
### 3. Day-to-Day Focus

#### Repetitive Day-to-Day Working Style vs. Changing Focus One Day to Next

**Focus Shifting Networks**

<table>
<thead>
<tr>
<th>clear-code_*</th>
<th>mroonga_*</th>
<th>test-unit_*</th>
<th>groonga_*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **groonga_***
- **clear-code_***
- **mroonga_***
- **test-unit_***
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs.
Changing focus one day to next

Focus shifting networks

clear-code_*
mroonga_*
test-unit_*
groonga_*

1 2 3 4 5 6
Multitasking Dimensions

3. Day-to-Day Focus

Repetitive day-to-day working style

vs.

Changing focus one day to next

Focus shifting networks

- clear-code_*
- mroonga_*
- test-unit_*
- groonga_*

1 2 3 4 5 6

groonga_*

1 1

clear-code_*
mroonga_*
test-unit_*
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

clear-code*
mroonga*
test-unit*
groonga*

5/7
1
1/7
1/2
Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

\[ S_{\text{Switch}} = - \sum_{i=1}^{N} \left( p_i \sum_{j \in \pi_i} p(j|i) \log_2 p(j|i) \right) \]

Markov entropy
3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

\[ S_{\text{Switch}} = - \sum_{i=1}^{N} p_i \sum_{j \in \pi_i} p(j|i) \log_2 p(j|i) \]

How predictable is my behavior tomorrow if today I work on project X?
Repetitive day-to-day working style vs. Changing focus one day to next

Focus shifting networks

\[ S_{Switch} = - \sum_{i=1}^{N} \left( p_i \sum_{j \in \pi_i} p(j|i) \log_2 p(j|i) \right) \]

How important is project X relative to my other projects?
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

\[ S_{Switch} = 0 \]  
Less repetitive day-to-day

\[ S_{Switch} = 0.325 \]  
More repetitive day-to-day
MULTITASKING DIMENSIONS

3. DAY-TO-DAY FOCUS

Repetitive day-to-day working style vs. Changing focus one day to next

\[ S_{\text{Switch}} = 0 \]  
Less repetitive day-to-day

\[ S_{\text{Switch}} = 0.325 \]  
More repetitive day-to-day

\[ S_{\text{Switch}} = 2 \]
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Higher productivity
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Higher productivity
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Weekly focus
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Weekly focus

Higher productivity
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Weekly focus

Day-to-day focus (repeatability)

Higher productivity
RESULTS – LINEAR MIXED EFFECTS REGRESSION

Projects per day

Weekly focus

Day-to-day focus (repeatability)

Higher productivity
Interaction effects: No scheduling is productive beyond 5 projects/week

Day-to-day focus (repeatability)
TODAY

1. TEAM DIVERSITY
   [CHI 2015]

2. MULTITASKING ACROSS PROJECTS
   [ICSE 2016]

3. CONTINUOUS INTEGRATION
   [ESEC/FSE 2015]
Ruby on Rails

Pull requests require review

- **Open PR**
- **Merge PR**

Issues

<table>
<thead>
<tr>
<th>Pull requests</th>
<th>Labels</th>
<th>Milestones</th>
</tr>
</thead>
</table>

- **467 Open**
- **12,551 Closed**

- **Move Integer#positive? and Integer#negative? query**
  - #20143 opened an hour ago by meinac

- **Deprecate `assert_template`**
  - #20138 opened 9 hours ago by tgxworld
Ruby on Rails

Large GitHub sample

# Pull Requests

- **467 Open**  
  12,551 Closed

- **Move Integer#positive? and Integer#negative? query methods to Numeric**  
  #20143 opened an hour ago by meinac

- **Deprecate `assert_template`**  
  #20138 opened 9 hours ago by t gxworld

- **Add Enumerable#map_with to ActiveSupport**  
  #20134 opened 13 hours ago by mlarraz

- **Allow creating a save callback for same name with parent association**  
  #20127 opened 23 hours ago by meinac

- **ActiveSupport::HashWithIndifferentAccess select and reject should return enumerator if called without block**  
  #20125 opened a day ago by imanel

- **Don't ignore false values for `include_blank` passed to `Tags::Base#select_content_tag`**  
  #20124 opened a day ago by greysteil

- **Fix for irregular inflection inconsistency**  
  #20123 opened a day ago by yoongkang

- **Add openssl_verify_mode and sync other smtp_settings with API docs**  
  #20117 opened 2 days ago by jfine

- **ActiveJob - log enqueued message only after the job was successfully enqueued**  
  #20116 opened 2 days ago by activejob

- **[ci skip] Remove comments about Rails 3.1**  
  #20113 opened 2 days ago by claudiob

- **Remove overridden root method and move it's implementation in original method**  
  #20109 opened 2 days ago by prathamesh-sonpatki

- **Add missing spec and documentation for button_tag helper**  
  #20108 opened 3 days ago by akshay-vishnoi

- **Removed not needed includes, As record_tag_helper is moved to a gem we..**  
  #20107 opened 3 days ago by ankit8898

- **Add ability to translate rails guides documents.yaml**  
  #20098 opened 3 days ago by hanachin

- **adds ArgumentError for render partial with invalid collection**  
  #20083 opened 5 days ago by farukaydin

- **docs for updating nested attributes while creating parent record**  
  #20082 opened 5 days ago by sh6khan

- **put dynamic matchers on GeneratedAssociationMethods instead of model**  
  #20080 opened 5 days ago by robertjlooby

[MSR 2015]
PROCESS AUTOMATION

Is it good? Should I merge? ✗ / ✓

Ruby on Rails

Large GitHub sample

# Pull Requests

1 hour 1 day 1 week 1 month 6 months

0 1000 2000 3000

[MSR 2015]

rails / rails

<table>
<thead>
<tr>
<th>Issues</th>
<th>Pull requests</th>
<th>Labels</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>467 Open</td>
<td>✓ 12,551 Closed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Move Integer#positive? and Integer#negative? query
#20143 opened an hour ago by meinac

Deprecate `assert_template`. ✓
#20138 opened 9 hours ago by tgxworld

Remove overridden root method and move it's implementation in original method
#20109 opened 2 days ago by prathamesh-sonpatki

Add missing spec and documentation for button_tag helper
#20108 opened 3 days ago by akshay-vishnoi

Removed not needed includes, As record_tag_helper is moved to a gem we..
#20107 opened 3 days ago by ankit8898

Add ability to translate rails guides documents.yaml
#20098 opened 3 days ago by hanachin

Adds ArgumentError for render partial with invalid collection
#20083 opened 5 days ago by farukaydin

Docs for updating nested attributes while creating parent record
#20082 opened 5 days ago by sh6khan

Put dynamic matchers on GeneratedAssociationMethods instead of model
#20080 opened 5 days ago by robertjlooby

Ruby on Rails

Large GitHub sample
CI PULL REQUEST PROCESS

PR auto merged into testing branch
CI PULL REQUEST PROCESS

TRAVIS-CI

Broken build

CI “Build”: Compile, unit test, integration test, quality analysis, etc.

[ICSME 2014]
PR is updated in response to failure
CI PULL REQUEST PROCESS

TRAVIS-CI

More updates

[ICSME 2014]
TRAVIS-CI

Tests finally pass

Clean build

CI PULL REQUEST PROCESS
CI PULL REQUEST PROCESS

CI AS GATEKEEPER:

- Integrated in PR process
- Tighter feedback loop
- Find integration errors & regression failures early
CI PULL REQUEST PROCESS

CI AS GATEKEEPER:
- Integrated in PR process
- Tighter feedback loop
- Find integration errors & regression failures early

CI AS VALET:
- Automate more of the process
- More time to focus on other things

TRAVIS-CI

http://goo.gl/ermLno
CI PULL REQUEST PROCESS

How well does it work?

CI AS GATEKEEPER:
• Integrated in PR process
• Tighter feedback loop
• Find integration errors & regression failures early

CI AS VALET:
• Automate more of the process
• More time to focus on other things
1. Mine data from projects that adopted Travis-CI
1. Mine data from projects that adopted Travis-CI

2. Compare before vs. after

- How many pull requests are closed per month?
- How many bugs are reported per month?
CHALLENGES

1. DATA MINING

2. STATISTICAL ANALYSIS

NOT ALL BUGS CREATED EQUAL

Bugs vs. feature requests

STM32L1 get_cpuid() hard faults when using a Cat. 1 or Cat. 2 STM32L1 #3692

DipSwitch opened this issue 12 days ago · 2 comments

DipSwitch commented 12 days ago

From the STM32L1 Reference Manual (31.2 Unique device ID registers (96 bits)):

Base address: 0x1FF80050 for Cat.1 and Cat.2 devices and 0x1FF80000 for Cat.3, Cat.4, Cat.5 and Cat.6

Three solutions possible for this problem:

- Compile time: Via the linkerscript for the device (this I would prefer since this is the cleanest solution in my opinion)

```
MEMORY
{
    rom (rx) : ORIGIN = 0x08000000, LENGTH = 128K
    ram (rw) : ORIGIN = 0x20000000, LENGTH = 32K
    cpuid (r) : ORIGIN = 0x1FF80050, LENGTH = 12
}

_cpuuid_address = ORIGIN(cpuid);
```

INCLUDE cortexm_base.ld
CHALLENGES

1. DATA MINING

2. STATISTICAL ANALYSIS

NOT ALL BUGS CREATED EQUAL

Bugs vs. feature requests

STM32L1 get_cpruid() hard faults when using a Cat. 1 or Cat. 2 STM32L1 #3692

DipSwitch opened this issue 12 days ago · 2 comments

DipSwitch commented 12 days ago

From the STM32L1 Reference Manual (31.2 Unique device ID registers (96 bits)):

Base address: 0x1FF80050 for Cat.1 and Cat.2 devices and 0x1FF80000 for Cat.3, Cat.4, Cat.5 and Cat.

Three solutions possible for this problem:

- Compile time: Via the linkerscript for the device (this I would prefer since this is the cleanest solution in my opinion)

```
MEMORY
{
    rom (rx) : ORIGIN = 0x00000000, LENGTH = 128K
    ram (rw) : ORIGIN = 0x20000000, LENGTH = 32K
    cpuid (r) : ORIGIN = 0x1FF80050, LENGTH = 12
}

_cpruid_address = ORIGIN(cpuid);

INCLUDE cortexm_base.ld
```
CHALLENGES

1. DATA MINING

2. STATISTICAL ANALYSIS

SOCIO-TECHNICAL PROCESS!

Bug reporter matters
Early vs. late discovery

Core developers (early)  Users (late)
CHALLENGES

1. DATA MINING

2. STATISTICAL ANALYSIS

SOCIO-TECHNICAL PROCESS!

Bug reporter matters

Early vs. late discovery

Core developers (early)
Users (late)

Other confounds

Project size
Team size
Project test suite size

Issue tracker activity
Project age
Defect rate (#Bugs/month) ~ Travis-CI (T/F) + Project age + Issue tracker activity + Project source code size + Project test code size + Project popularity

controls
Defect rate (Bugs/month) ~ Travis-CI (T/F) + Project age + Issue tracker activity + Project source code size + Project test code size + Project popularity

CHALLENGES

1. DATA MINING
2. STATISTICAL ANALYSIS

ZERO-INFLATED NEGATIVE BINOMIAL REGRESSION

NEGATIVE BINOMIAL
Over-dispersed count data (variance > mean)

ZERO INFLATED
Excess zeros. No bugs reported:
• because high quality?
• because nobody reporting?

RESULTS

WITH TRAVIS-CI:

• Code grows faster
• Dev’s find more defects
• Users don’t experience quality changes

PR throughput (#PRs/month) + 20..40%

Defect rate (#Bugs/month) + 48% (core dev’s)
None (users)
Where and why do CI failures occur? Many can be foreseen and prevented

Do CI failures “predict” eventual defects? Yes - focus code review / testing

How do people learn to program? Failures and fixes both logged

How does the onboarding process change? Machine vs. human response
Fear of losing face? Enforce project norms
SUMMARY: PERCEPTION → EVIDENCE

- **PERCEPTION:** CI REQUIRES BIG INVESTMENT
PERCEPTION: CI REQUIRES BIG INVESTMENT

Teams using CI handle more PRs & find more defects.

SUMMARY: PERCEPTION → EVIDENCE
SUMMARY: PERCEPTION → EVIDENCE

- **PERCEPTION: CI REQUIRES BIG INVESTMENT**
  
  Teams using CI handle more PRs & find more defects.

  *FSE ’15a*

- **PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN**

  More diverse teams are more productive.

  *CHI ’15*
SUMMARY: PERCEPTION → EVIDENCE

- **PERCEPTION: CI REQUIRES BIG INVESTMENT**
  Teams using CI handle more PRs & find more defects.
  FSE '15a

- **PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN**
  More diverse teams are more productive.
  CHI '15

- **PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP**
  > 5 projects/week
  ICSE '16
  always counterproductive
PERCEPTION: CI REQUIRES BIG INVESTMENT
Teams using CI handle more PRs & find more defects.

PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN
More diverse teams are more productive.

PERCEPTION: EXPERIENCE MATTERS THE MOST
Not in first 6 months: social environment more important

PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP
> 5 projects/week always counterproductive
SUMMARY: PERCEPTION → EVIDENCE

- PERCEPTION: CI REQUIRES BIG INVESTMENT
  Teams using CI handle more PRs & find more defects.  
  FSE '15a

- PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN
  More diverse teams are more productive.  
  CHI '15

- PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP
  > 5 projects/week always counterproductive  
  ICSE '16

- PERCEPTION: EXPERIENCE MATTERS THE MOST
  Not in first 6 months: social environment more important  
  FSE '15b

- PERCEPTION: GAMIFICATION IS A GOOD IDEA
  Incentivize participation  
  But, quicker disengagement  
  CSCW '14
  IWC '14
ANALYTICS: NEXT STEPS

CI BUILD FAILURES
Why do they happen? Can we automatically prevent them?

DIVERSITY
Which aspects of team diversity are most important for:
› productivity?  › code quality?
› cohesiveness?  › architecture?

DESIGN
Why are social coding platforms so seemingly exclusive?

MULTITASKING
Are there “risky” habits that lead to buggier code?
All the code that will ever be written has already been written.
SOFTWARE DEVELOPMENT BECOMES A SEARCH PROBLEM

- Code snippets
- CI scripts
- Refactoring
- Porting
- Documentation
- Q&A
Soon: All the code that will ever be written has already been written.

Software development becomes a search problem

- Code snippets
- CI scripts
- Refactoring
- Porting
- Documentation
- Q&A

Bing Code Search: http://codesnippet.research.microsoft.com
All the code that will ever be written has already been written.

Software development becomes a search problem:

- Code snippets
- CI scripts
- Refactoring
- Porting
- Documentation
- Q&A

I noticed you use iterators a lot. Here's how you can do it with iterators:

```java
k = [[1, 2], [4], [5, 6, 2], [1, 2], [3], [4]]

///How to remove duplicates from a list of lists?
```

The iterator-based solution is faster, but pull request reviewers tend to prefer this set-based version:

Don't forget the NULL check! It's a common bug.
SOFTWARE DEVELOPMENT BECOMES A SEARCH PROBLEM

- Code snippets
- CI scripts
- Refactoring
- Porting
- Documentation
- Q&A

DON'T FORGET TO TEST AGAINST PYTHON 2.6. **SIMILAR CODE BREAKS PYTHON 2.6 BUILDS OFTEN.**

S.O.O.N.: All the code that will ever be written has already been written.
MICHELANGELO:

“Every block of stone has a statue inside it; it is the task of the sculptor to discover it.”
MICHELANGELO: “Every block of stone has a statue inside it; it is the task of the sculptor to discover it.”

Almost any software engineering question has an answer inside a big code archive. It is the task of the data scientist to discover it.
Baishakhi Ray · Alexander Serebrenik · Vladimir Filkov · Prem Devanbu · Cindy Rubio Gonzalez · Casey Casalnuovo · Daryl Posnett · Yue Yu · Qi Xuan · Mark van den Brand · Kelly Blincoe · Daniela Damian
SOFTWARE DEVELOPMENT IS CHANGING

OPEN-SOURCE IS GROWING
Companies:
- 78% run OSS
- 66% build on top of OSS

SOCIAL CODING IS GROWING
12 million people 31 million repositories
18.5 million software dev's 15,000+ people

CULTURE CHANGE
"It’s just so uncool not sharing the code in the age of social coding"

HIRING
- $100+/hour:
  - owns popular OSS products;
  - stackoverflow score > 20K;
  - ...
- $50+/hour:
  - active OSS contributor;
  - stackoverflow score > 5K;
  - ...

INDUSTRIAL INVOLVEMENT & ADOPTION
Microsoft
Google
Facebook

- GitHub stats from: https://github.com/about
- World estimates from: http://goo.gl/Htnni9
- How Much Do You Care? Yegor Bugayenko http://goo.gl/IltnL3F
- Activity traces and signals in software developer recruitment and hiring
  J. Marlow, L. Dabbish. CSCW 2013

CULTURAL CHANGE
"it's just so uncool not sharing the code in the age of social coding"

OPEN-SOURCE IS GROWING
12 million people 31 million repositories
18.5 million software dev's 15,000+ people

EVERYTHING IS ARCHIVED!
Source code
People involved
Bug reports
Communication
...

DATA ANALYSIS (STATISTICS)
→ TRENDS

EXPERIMENTAL RISK: BIG DATA TO THE RESCUE
FALSE POSITIVES
FALSE NEGATIVES
CONFOUNDS

HUGE SAMPLE SIZES:
- More stringent a priori about significance level → reduce False Positives
- Detect even small effects → reduce False Negatives
- Handle more degrees of freedom → control for Confound

SEPARATE SIGNAL FROM NOISE:
- Quantify effect size
- Mix research methods
  - Quantitative: stats, data mining
  - Qualitative: case studies, user surveys, grounded theory

VALIDATE DATA FIRST!
- Spot-checking

SUMMARY: PERCEPTION → EVIDENCE

PERCEPTION: CI REQUIRES BIG INVESTMENT
Teams using CI handle more PRs & find more defects.

FSE '15a

PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP
>4-5 projects/week is always counterproductive

ICSE '16

PERCEPTION: EXPERIENCE MATTERS THE MOST
Not in first 6 months: social environment more important

FSE '15b

PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN
More diverse teams are more productive.

CHI '15

PERCEPTION: GAMIFICATION IS A GOOD IDEA
Incentivize participation

CHI '14

PERCEPTION: EXPERIENCE MATTERS THE MOST
But, quicker disengagement

IWC '14

DATA-DRIVEN vs. INTUITION-BASED decision making

DATA SCIENTIST: standard on software teams

>4-5 projects/week is always counterproductive

ICSE '16

ACCESS TO BIG DATA TO THE RESCUE

FALSE POSITIVES
1
FALSE NEGATIVES
2
CONFOUNDS
3

MICROSOFT
OPEN SOURCE
FACEBOOK
GOOGLE

PROJECT MAINTAINERS
INDIVIDUAL DEVELOPERS
COMMUNITY DESIGNERS

PERCEPTION: EXPERIENCE MATTERS THE MOST
Not in first 6 months: social environment more important

FSE '15b

PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN
More diverse teams are more productive.

CHI '15

PERCEPTION: GAMIFICATION IS A GOOD IDEA
Incentivize participation

CHI '14

PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP
>4-5 projects/week is always counterproductive

ICSE '16

SUMMARY: PERCEPTION → EVIDENCE

PERCEPTION: CI REQUIRES BIG INVESTMENT
Teams using CI handle more PRs & find more defects.

FSE '15a

PERCEPTION: EXPERIENCE MATTERS THE MOST
Not in first 6 months: social environment more important

FSE '15b

PERCEPTION: OPEN-SOURCE IS HOSTILE TO WOMEN
More diverse teams are more productive.

CHI '15

PERCEPTION: GAMIFICATION IS A GOOD IDEA
Incentivize participation

CHI '14

PERCEPTION: MULTITASKING IS EXPENSIVE BUT NOBODY KNOWS WHEN TO STOP
>4-5 projects/week is always counterproductive

ICSE '16