Pricing Crowdsourcing-based Software Development Tasks

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Overview

- Background
  - Crowdsourcing: Micro task VS. Complex task
  - The TopCoder Platform

- Motivation
  - New Phenomenon
  - The Pricing Issue

- Methodology

- Experiments & Insights

- Conclusion
Overview

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- **Methodology**

- **Experiments & Insights**

- **Conclusion**
Typical work day of one star developer in Verizon:

- 09:00 a.m. – Arrive and surf Reddit, watch cat videos
- 11:30 a.m. – Take lunch
- 01:00 p.m. – Ebay time
- 02:00 p.m. – Facebook updates – LinkedIn
- 04:30 p.m. – End of day update e-mail to management
- 05:00 p.m. – Go home
Introduction to Crowdsourcing

- A proper way...
  - Labor of the Internet
  - Low cost
  - Surprising deliverable

- Wisdom of the Crowd
What is Crowdsourcing?

- "Crowdsourcing" defined by Jeff Howe:
  - “The act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call.”

- Crowdsourcing VS. Outsourcing:
  - The crucial prerequisite is the use of the open call format and the large network of potential laborers.
Finanzielle Beiträge von Online-Investoren, Sponsoren oder Spendern für Non-Profit Initiativen oder Unternehmen.

Tools

Anwendungen, Plattformen und Tools, die die Zusammenarbeit, Kommunikation und den Austausch zwischen Gruppen von Menschen fördern.

Cloud Collaboration

Nutzung eines dispersen, virtualen Pools von Arbeitskraft, der auf Anfrage zur Verfügung steht, um Aufgaben verschiedener Komplexität zu erfüllen.

Civic Engagement

Kollektive Aktionen im öffentlichen Interesse.
Micro Task VS. Complex Task

Growth of workers by category

Workers doubled in number 2010-2011

In 2011, number of workers based on 26 CSPs

Credit: http://sandfishdesign.co.uk, © 2012, Crowdsourcing, LLC
What is TopCoder?

- The world's largest competitive community for crowdsourced software development
- The TopCoder Community is 600,000 strong

Membership:
- China
- India
- U.S.

Credit: www.topcoder.com, © 2007, TopCoder, Inc
What is TopCoder?

What kinds of projects can I do with TopCoder?

- Mobile Applications
- Analytics and Optimization
- Scientific Algorithm Development
- Online Communities
- Open Platforms
- Digital Media
- Business Systems
- ...
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Motivation - New Phenomenon

- New Paradigm
  - Crowdsourced development
    - 1. Open call format
    - 2. Large networked potential labor

Fig. 1 Illustration of crowdsourcing-based software development process.

1. Competition
2. Global Labor
Motivation - New Phenomenon

- New Phenomenon In SE activity
  - 2 examples that *challenge* traditional law
    - Parkinson's Law
    - COCOMO Model
Motivation - New Phenomenon

- Parkinson's Law

("Work expands so as to fill the time available for its completion."")

Fig. 2 Correlation between the time allocated and the actual time consumed
Motivation - New Phenomenon

- Basic COCOMO Model

\[ \text{EFFORT} = a \times \text{SIZE}^b \]

Fig. 3 The effort estimated by COCOMO model, compared to the actual effort.
Motivation - The Pricing Issue

- Inappropriate price often lead to low capital efficiency and task starvation

- How to build empirical pricing models?

Fig. 4 Active Component Development Contests on TopCoder.com
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## Methodology

### Price Drivers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meaning</th>
<th>Statistics</th>
<th>Regression Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECH</td>
<td>number of technologies which will be used</td>
<td>Min: 1.0</td>
<td>Max: 7.0</td>
</tr>
<tr>
<td>DEPE</td>
<td>number of component dependencies</td>
<td>Mean: 2.1</td>
<td>Median: 2.0</td>
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<tr>
<td>REQU</td>
<td>number of pages of requirement specification</td>
<td>S. Dev: 1.3</td>
<td>-2.65</td>
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<tr>
<td>COMP</td>
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<td>-1.332</td>
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<td>winner’s award of design phase, measured in dollars</td>
<td>0.503</td>
<td>17.912</td>
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<tr>
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<td>winner’s effort in design phase, measured in days</td>
<td>0.273</td>
<td>1.607</td>
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<td>142.0</td>
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<td>-0.994</td>
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<td>number of registrants in design phase</td>
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<td>5.2</td>
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<td>SUBM</td>
<td>number of submissions in design phase</td>
<td>92.0</td>
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<td>indicating if the task aim at component update</td>
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</tr>
<tr>
<td>ISJA</td>
<td>indicating if the development language is Java</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>ISCS</td>
<td>indicating if the development language is C#</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>SIZE</td>
<td>estimated size of the component, measured in KSLOC</td>
<td>0.4</td>
<td>21.9</td>
</tr>
<tr>
<td>const</td>
<td>the constant term.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**TABLE I. DESCRIPTIVE STATISTICS AND REGRESSION COEFFICIENTS OF PROPOSED FACTORS**
Methodology

- Predictive Models
  - **Multiple Linear Regression Model:**

  \[
  PRICE = \beta_1 TECH + \beta_2 DEPE + \beta_3 REQU + \beta_4 COMP + \beta_5 SEQU + \beta_6 SCOR \\
  + \beta_7 AWRD + \beta_8 EFRT + \beta_9 SUML + \beta_{10} WRAT + \beta_{11} REGI + \beta_{12} SUBM \\
  + \beta_{13} ISUP + \beta_{14} ISJA + \beta_{15} ISCS + \beta_{16} SIZE + \beta_0 + \epsilon
  \]  
  (1)

- 9 other Machine Learning models

<table>
<thead>
<tr>
<th>4 Decision Tree based learners</th>
<th>2 Instance based learners</th>
<th>1 Neural Net</th>
<th>1 Support Vector Machine</th>
<th>1 Logistic Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5.0, CART, QUEST, CHAID</td>
<td>KNN-1, KNN-k∈[3, 7]</td>
<td></td>
<td></td>
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Experiments

- **Aim:**
  - To answer the following RQs.

- **RQs:**
  - **Baseline Comparison**
    - How much better?
  - **Performance Assessment**
    - Which is the best?
  - **Actionable Insights**
    - What guidance can we offer?
Experiments

- Dataset
  - Sep 29th 2003 to Sep 2nd 2012
  - 2,895 design and 3,015 development tasks
  - 490 successful sw dev projects from TopCoder

- Validation method
  - LOOCV
Experiments

- **Performance Measures:**

\[ MRE_i = \frac{|\text{actual}_i - \text{estimated}_i|}{\text{actual}_i} \]
\[ MMRE = \frac{\sum_i MRE_i}{T} \]
\[ MdMRE = \text{median}(MRE_1, MRE_2, ..., MRE_i, ..., MRE_T) \]
\[ StdMRE = \frac{1}{T-1} \sqrt{\sum_i (MRE_i - MMRE)^2} \]
\[ Pred(N) = \frac{1}{T} \sum_i \begin{cases} 1 & \text{if } MRE_i \leq N / 100 \\ 0 & \text{otherwise} \end{cases} \]

(\text{where } i \in \{1\ldots T\} )
Answer to RQ1:
Outperformed by all 10 predictive models, according to Pred(30) measure

Fig. 5 Performance of pricing models learned by each approach
Experimental Results

☐ Answer to RQ2:

☐ Decision tree based learners

☐ C5.0, QUEST, CART

Fig. 5 Performance of pricing models learned by each approach
Answer to RQ3:

Significance Analysis

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<td>0.0</td>
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<tr>
<td>REQU</td>
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<td>COMP</td>
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<td>4200.0</td>
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<tr>
<td>EFRT</td>
<td>winner’s effort in design phase, measured in days</td>
<td>0.0</td>
<td>468.0</td>
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<td>REGI</td>
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<td>SUBM</td>
<td>number of submissions in design phase</td>
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<td>26.0</td>
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<td>0.0</td>
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 Insights

- **Answer to RQ3:**
  - **Rules of Thumb**
    - ISUP ⇒ $70↓
    - COMP(4 pages) ⇒ $30↑
    - SEQU(4 diagrams) ⇒ $30↑
    - SIZE(1 KSLOC) ⇒ $30↑

- **May not always be right**
  - But "Why am I bucking the trend?"
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Conclusion

- Analyzed 5,910 sw dev tasks on TopCoder
- Proposed 16 price drivers
- Assessed 10 empirical pricing models
- Useful prediction quality is achievable (Pred(30)>0.8)
- Actionable advice can be extracted from our models to assist the managers and developers on TopCoder
Thanks !