Pricing Crowdsourcing-based Software Development Tasks (ICSE'13-NIER)



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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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Background

Crowdsourcing: Micro task VS. Complex task

The TopCoder Platform

A Recent News...

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Typical work day of one star developer:

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
 - Suprising 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.

Micro Task VS. Complex Task

crowdsourcing.org **Crowdsourcing Industry Landscape** Kuke Catarse Aunited TenPagestonn* Hum Court trampoline Oneeds Chengeutorus Same STARDUST GALAXY ZOO ChaCha A watching wegellhere 🔶 REVENUE TRADES trustDuddy 🖅 peerform 🤣 isePankur 🛨 CROWDFUNDER \$ \$ <u>\$</u> RU ARRIGAND MC4 CocketHub () Funding Circle (2007) akvo.org Startup 40Billion.com WENCORPS HSXO Brownbooknet \$ 00000 GreenNote Crowdfunding Alla crowdcube 🗳 MicroVentures KICKSTARTER Injøinel 🔗 cashare" SELLŵBAND 🗽 kachingle **Collective Knowledge** Sammlung von Wissen und Informationen aus Finanzielle Beiträge von Online-Investoren TOMTOM Crowdcast ROOT Metrics CONSENSUS POINT & beansight 🧶 CMINABANNE TV 🔁 appback 🔞 crowdrise Inneuatrs SEEDUPS Spot.us einem Pool von Mitwirkenden. Sponsoren oder Spendern für Non-Profit Initiativen oder Unternehmer 类 🔌 ScalableWorkforce.com AD TOURNAMENT jade maenet ADHACK Stockphoto AudioDraft weeehii threadless ZOOPPA brand potion Tattoo minted. Mypitch 👎 Ideavibes 🎢 CrowdWorx IQ Engines 죾 CapAngel BY THE CITY FOR THE CITY VICTORS BRICHTIDEA: BIGDOOR V smartsheet appowell giveo 99 designs HYDRA **GENERO**IN SootB **O** DESIGN 🗾 spigit evly 🕑 📮 kapost 💥 🙀 A TUNCE on jovoto elle MASS ANIMATION PROVA ryzł \sim TUNEDIT **Collective Creativity** Tools GLOBALLIVESproject Creative Talent-Pools, in denen Kunst- oder Anwendungen, Plattformen und Tools, die 🛄 🐨 🐨 🖓 Ushahidi 💡 IdeaScale 🦛 crowdtwist 🖬 grow vc creativeallies 🔊 Logo DesignTeam? () crowdbands &**liser**eterm die Zusammenarbeit. Kommunikation und Medien-Inhalte erschaffen werden denAustausch zwischen Gruppen von Menschen förder Test Elance Coudcrowd GRABCAD liveops Desk gengo Treelancer Fin Gg 🙍 Crowd Together SuggestionBox.com Servio Boost Priper CAPTED Samasource Samasource SpeakerText Truvell THEBLOGTV fashionstake Kindling 👷 😌 🖉 GURUR MICTOTASK task 🖞 🔥 Do Nanza **Lingotek Sex*pertplanet Monanau **Cloud Collaboration Community Building** Satisfaction DAILY GROMMET Nutzung eines dispersen, virtuellen Pools von BZZADAO Aufbau von Communities durch aktives agasauris mediapiston Engagement von Einzelpersonen, die gemeinsame Leidenschaften, Überzeugungen Arbeitskraft, der auf Anfrage zur Verfügung steht, um Aufgaben verschieden Komplexität zu erfüllen. und Interessen teilen. yet 2 com mutopo Schaordix one sculture METAL 2.1 (LM) our Fing 🗱 E-Democracy oro **O**ecycler nosco NETFLIX е^үека Nokia Beta Labs INNOCENTIVE changemakers engage4change phillytreemap nigo caree in crisis § idea ideaken atizo Jpen CHALLENGE **Civic Engagement Open Innovation** ideaconnection innovaro AZRedistricting.com change.org DOO IDEAnet Kollektive Aktionen im öffentlichem Interesse. Nutzung von Ressourcen außerhalb des Unternehmens um gemeinsam Ideen zu generieren, zu entwickeln und umzusetzen

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Micro Task VS. Complex Task

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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 425,993 strong

Membership
 China
 India
 U.S.

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What is TopCoder ?

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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
- □...

How Does It Work?



Credit: www.topcoder.com, © 2007, TopCoder, Inc

Overview

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Motivation
New Phenomenon
The Pricing Issue



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

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□ New Phenomenon In SE activity

2 examples that challenge traditional law

Parkinson's Law

COCOMO Model

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

Basic COCOMO Model

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(EFFORT = a * SIZE)



Fig.3 The effort estimated by COCOMO model, compared to the actual effort.

Motivation - The Pricing Issue

Active Component Development Contests									
Catalog	Component		Register by	Submit by	Payment*	Reliability Bonus	D3	Registrants Rated/ Unrated	Submissions
.NET 🚸	PXV2 Integration Service Part 1 Version 1.0	TC013	02.02.2013 10:25 EST	02.05.2013 10:30 EST	\$700.00	\$140.00	315	5/3	0
JAVA CINC	Media Conversion Engine Front End 2 Version 1.0	TC013	02.02.2013 09:18 EST	02.04.2013 09:23 EST	\$600.00	\$120.00	270	10/5	0
	Benchmarking and Reporting Tool Rewrite Release 1 Core DAO Version 1.0	TC013	01.30.2013 23:18 EST	02.01.2013 23:23 EST	\$400.00	\$80.00	180	17/8	0
	Benchmarking and Reporting Tool Rewrite DAO Base Service Version 1.0	TC013	01.30.2013 08:00 EST	02.01.2013 08:05 EST	\$500.00	\$100.00	225	14/12	1

Fig.4 Active Component Development Contests on TopCoder.com

- Inappropriate price often lead to low capital efficiency and task starvation
- How to build empirical pricing models?

Overview

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Methodology

Methodology

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Price Drivers

			\sim							
Variable	Mandag	Input Complexity			<mark>y s</mark> tatis	stics		Regression Coefficients		
variable	Meaning	~		max	Mean	Medn	S.Dev	β	t	р
TECH	number of technologies which will be used		1.0	7.0	2.1	2.0	1.3	-6.265	-0.569	0.570
DEPE	number of component dependencies				.9	2.0	3.0	2.555	0.606	0.545
REQU	number of pages of requirement specification	Qual	itv ot	f Input	.7	3.0	1.8	-9.422	-1.332	0.183
COMP*	number of pages of component specification			mpac	.3	10.0	5.7	8.480	3.414	0.001
SEOU [*]	number of sequence diagrams of the des	vious	Pha	se De	cision	3.0	5.5	7.666	2.922	0.004
SCOR	score of winner's submission of design phase	viouo	-70.2	22.7	20.4	92.0	6.5	-3.032	-1.360	0.175
A WRD*	winner's award of design phase, measured in doll		0.0	4200.0	920.1	900.0	457.6	0.503	17.912	0.000
EFRT	winner's effort in design phase, measured in days		0.0	468.0	29.0	5.0	77.2	0.273	1.607	0.109
SUML	size of UML design file, measured in KB					142.0	85.5	-0.293	-1.386	0.166
WRAT	rating of the winner in design phase	Ποιγο	lonm	ont T	vne l	1632.0	629.3	-0.021	-0.994	0.321
REGI	number of registrants in design phase	Development iy		ypc –	8.0	5.2	2.692	0.914	0.361	
SUBM	number of submissions in design phase	~	1.0	26.0	2.8	2.0	2.4	-10.416	-1.601	0.110
ISUP*	indicating if the task aim at component update		0.0	1.0	0.2	0.0	0.4	-71.352	-1.998	0.046
ISJA	indicating if the development language is Java		0.0	1.0	0.5	1.0	0.5	-	-	-
ISCS	indicating if the development language is C#		0.0	1.0	0.5	0.0	0.5	23.986	0.808	0.419
SIZE	estimated size of the component, measured in KS	LOC	0.4	21.9	3.0	2.3	2.3	29.772	4.189	0.000
const*	the constant term.		-	-	-	-		463.194	2.437	0.015

TABLE I. DESCRIPTIVE STATISTICS AND REGRESSION COEFFICIENTS OF PROPOSED FACTORS

Methodology

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Predictive Models

Multiple Linear Regression Model:

 $PRICE = \beta_{1}TECH + \beta_{2}DEPE + \beta_{3}REQU + \beta_{4}COMP + \beta_{5}SEQU + \beta_{6}SCOR$ $+ \beta_{7}AWRD + \beta_{8}EFRT + \beta_{9}SUML + \beta_{10}WRAT + \beta_{11}REGI + \beta_{12}SUBM$ $+ \beta_{13}ISUP + \beta_{14}ISJA + \beta_{15}ISCS + \beta_{16}SIZE + \beta_{0} + \varepsilon$ (1)

8 other Machine Learning & Statistical models

3 Decision Tree based learners	2 Instance based learners	ers 1 Neural Net 7]	1 Support	1 Logistic
C5.0, CART, QUEST	KNN-1, KNN-k∈[3, 7]		Vector Machine	Regression

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Experiments & Insights

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

^D Sep 29th 2003 to Sep 2nd 2012

- 2,895 design and 3,015 development tasks
- 490 successful sw dev projects from TopCoder

Validation method



Experiments

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Performance Measures:

 $MRE_{i} = | actual_{i} - estimated_{i} | / actual_{i}$ $MMRE = \sum_{i} MRE_{i} / T$ $MdMRE = median(MRE_{1}, MRE_{2}, ..., MRE_{i}, ..., MRE_{T})$ $StdMRE = \frac{1}{T-1} \sqrt{\sum_{i} (MRE_{i} - MMRE)^{2}}$ $Pred(N) = \frac{1}{T} \sum_{i} \begin{cases} 1 & if MRE_{i} \leq N / 100 \\ 0 & otherwise \end{cases}$ (where $i \in \{1...,T\}$)

Experimental Results



Answer to RQ1:

Outperformed by all 9 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
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Fig.5 Performance of pricing models learned by each approach

Insights

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\Box Answer to RQ3:

Significance Anlysis

Variable	Maaring		Descrip	ptive Statis	Regression Coefficients				
variable	Meaning	Min	Max	Mean	Medn	S.Dev	β	t	р
TECH	number of technologies which will be used	1.0	7.0	2.1	2.0	1.3	-6.265	-0.569	0.570
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SUML	size of UML design file, measured in KB	24.0	644.0	158.1	142.0	85.5	-0.293	-1.386	0.166
WRAT	rating of the winner in design phase	481.0	3251.0	1688.2	1632.0	629.3	-0.021	-0.994	0.321
REGI	number of registrants in design phase	1.0	38.0	9.3	8.0	5.2	2.692	0.914	0.361
SUBM	number of submissions in design phase	1.0	26.0	2.8	2.0	2.4	-10.416	-1.601	0.110
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TABLE I. DESCRIPTIVE STATISTICS AND REGRESSION COEFFICIENTS OF PROPOSED FACTORS

Insights

Answer to RQ3:
 Rules of Thumb
 ISUP => \$70↓
 COMP(4 pages) => \$30↑
 SEQU(4 diagrams) => \$30↑
 SIZE(1 KSLOC) => \$30↑

May not alway be right
 But "Why am I bucking the trend?"

Overview

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Conclusion

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Analyzed 5,910 sw dev tasks on TopCoder

Proposed 16 price drivers

- Assessed 12 empirical pricing models
- Useful prediction quality is achievable (Pred(30)>0.8)
- Actionable advice can be extracted from our models to assist the developers on TopCoder

Future Work

Quality & Risk Factors

Price / Quality Trade off
 Assessing task complexity via UML design

Muti-objective Optimization
 Price / Quality / Risk

