Who Can Help Me with this Change Request?

Huzefa Kagdi, Missouri University of Science & Tech Denys Poshyvanyk, William and Mary







Motivation

- Given a new developer with a maintenance task who should they ask for assistance?
- Who is the expert for a given piece of code?
- Open source environment:
 - Distributed with no central management
 - Possibly hundreds of volunteers/developers
 - Developers/managers change over time

Overview of the Approach

(DE Bug Trackin			BCTuoded DGT: insert(HopType key, ValueType value) >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	<pre>BDTLoods DTT ::scort/SeyType key, TuloType value) // lookspipe, remain keyrulus if not present // return pointer to mode with key DETLoods + a option(+) </pre>	<pre>BOTunded ETT::Luces(ExpType kay, ValueType value) >> lookup twy, create kayrwile if not present >> return pointer to node with kay (ESTrouck a = getMod(rey)) s_ites.excles.exclest = value; return n;</pre>
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	Alias: Version: 2.0 Beta 2 Product: koffice Priority: NOR		<pre>if (result second) { result first): } </pre>	<pre>if (result second) { return *(result first); } // true, node emists }</pre>	if (result.second) // true. no { return *(result.first):
orts	Component: general Severity: normal Status: RESOLVED		<pre>else // false.create node { DTDode* parent * result_first; DTDode* parent * result_first; DTDode* see DTDhode(0. 0. parent. item); if parent * parent * parent * parent; improve ().de: improve ().de:</pre>	<pre>elime {</pre>	else // false.c 20Thoode* parent = rewalt.irmt: // false.c 20Thoode* saw_mode = saw 20Thoode(0. 0. parent. item 11 parent = left = saw_mode. else
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eports	Target: <u>V</u> otes: 0		BDTmodeL DDT::issee:(DeyType key, ValueType value) >> booksp key, orease keyratike if not present >> return pointer to node with key	BCTwode6 BCT::inser(ZeyType key, TalosType value) >> lookup key, commits key:value if and present >> return pointer to mode with key	BSTmodeś BST:::secot(NeyType key, ValueType value) >> lookap key, czeste keyruslae il mot present >> return poister to node with key
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reported in the last 3	Version: 2.0 beta-2 (using 4.1.2 (KDE 4.1.2), Kubuntu pack		<pre>BSTsode& BST::getFicdelDerType key} // lookap key, create key-sale if not present // return polate to node with key (pairtKeyType. ValueType) item(Key. 1): // create item to be inserted</pre>	<pre>BUTsode& BUT: getHode(HerType ker) // lookup ker, create ker/value (! not present // return pointer to node with key (pair/KeyType. ValueType) item(key. 0); // create item to be inserted</pre>	<pre>BSTsodeL BST: getRodelBoyType key) // lookup key, create key/walse if not present // return pointer to node with key (pair(NeyType, ValueType) item(Key, E): // create item</pre>
s reports with patches	Compiler: gcc		<pre>if (_root ** 0)</pre>	<pre>if (_root == 0) { BSTmode= new_mode = new BSTmode(0, 0, 0 item); root = new_mode; root = new_mode; root = new_mode; root = new_mode;</pre>	<pre>if (_root ** 0) BiTmode* new_node * new BiTmode(0, 0, 0, 1tem); root * new_node; veture = root; veture = root; </pre>
ekly Bug statistics	OS: Linux (i686) release 2.6.24-21-generic		pair(BTmode+, hool) result = find(key); // search for key // Docation found	pair(BSTaode*, bool) result * find(key); // search for key	pair(BFInder, hon); result = find(key); // search fo
t hated bugs t severe bugs	when you split views, you get another tool options docker even if th	ere's	<pre>// return *(result first); // true, node emists // else</pre>	if (year's second) // Loastin found { return +(result.(inst)) plue // false, create ande	<pre>i return +(result.first); // true, not) clim</pre>
t often reported bugs	already one, this new docker has all options grayed out so it doesn' Splitting again creates another docker.	work.	<pre>B0Tmode* percent = reemit (irst: B0Tmode* new_node = new D0Tmode(0, 0, percent, item); if (key (percent-yetNev()) percentlat(= new_node;</pre>	<pre>BTInode* perent - result (ire): BTInode* perent (BTInode(0, 0, perent, item): if (hey (parest-spetMey()) parentleft = new_mode:</pre>	BTmode* perent = result first: DTmode* new_mode = new DTmode(0. 0. perent. item) if (key (perent-wptKey()) perent-i_left = new_mode:
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ort ownership counts and	Comment #1 From Jan Hambrecht 2008-11-02 20:35:14		// return pointer to node with key (Notices - estimation (her); Notices second - voice; notices = (Notice - voice; notices = (Notice - voice; notices = (Notice - voice; notices = (Notices - voices - voice; notices = (Notices - voices - voices - voice; notices = (Notices - voices - voic	BOTunded. BGT: innert(KeyType key, TalosType value) // lookup key, create key-value if not present // return pointer to node with key	RGTmodeL RGT::insect(KeyType key, ValueType value) // lookup key, Greate key-value if not present // return pointer to node with key
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y Account			<pre>pair(KeyType, ValueType) iten(key, 0): // create item to be inserted</pre>	<pre>BUTmode& BUT: getHode(HerType ker) // lookup ker, create ker/value (f not present // return pointer to mode with key (pair/KeyType. ValueType) item(key. 0); // create item to be inserted</pre>	BSTmodel BST: getRodelBerType key) // Docksp key. create key/value if not present // return pointer to node with key (pair(KeyType, ValueType item(key, E): // create item
Account	fix duplication of tool options dockers when working in split view m	ode	<pre>if (_root += 0)</pre>	<pre>if (_root == 0)</pre>	
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	M +1 -2 KoDockerManager.cpp M +18 -4 KoToolDockerFactory.cpp			else parent-)_rtyht = new_mode: return *new node:	elee parent-)_right = new_node: return =new node:
			-		
			82 8		

Overview of the Approach

First Last Prev Next No search results available Bug 173891: splitting views duplicates the tool options docker Alias: Version: 2.0 Beta 2 Product: koffice Prjority: NOR component: general Severity: normal status: RESOLVED Resolution: FIXED	Binding and a second seco	<pre>C Bitchest + : periods(r)(p)) interval Simple Control (Control (Contro) (Contro</pre>	<pre>[BSTmodel x + getHode(Leg)); x_item.shoodd + value; return n; } BSTmodel BST()getRode(ReyType key) >> looksp key, investe keytwiste if not present >> return positer to node with key</pre>
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<pre>s reported in the tast 3 Version: 2.0 beta-2 (using 4.1.2 (KDE 4.1.2), Kubuntu packages) (compiler: gcc</pre>	<pre>####################################</pre>	<pre>influence lease reads - final f</pre>	<pre>status to the second seco</pre>

Our Approach

- Recommend a ranked list of developers to assist in performing changes to a given source code file
- Based on textual analysis of bug reports and similar source code files
 - LSI-based concept location [Marcus'04]
- Based on mining past change records in software repositories (i.e., commits)
 - xFinder [Kagdi'08]

Related Work

- McDonald & Ackerman use most recent modification date along with user profile information collected separately
- Anvik & Murphy mine the source and bug repositories
- Minto & Murphy compute coordination between developers and how files have changed together
- Mockus & Herbsleb use experience atoms to measure expertise.
- German studied MR of CVS logs
- Canfora & Cerulo mine previous change requests
 for impact analysis

Parsing Source Code Snapshot and Extracting Documents with LSI

 Corpus is a collection of documents (e.g., methods, classes, *files*)

```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
            InterruptedException{
  if (m iFlag == 0)
     processCorpus(monitor,checkUpdate());
  else if ( m iFlag == 2 )
     processCorpus (monitor, UD UPDATECORPUS);
 else
      processQueryString(monitor);
 if (monitor.isCanceled())
      throw new InterruptedException("The long running
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Removing non-literals

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public void run(IProgressMonitor monitor)
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}
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public void run IProgressMonitor monitor throws InvocationTargetException InterruptedException if m_iFlag processCorpus monitor checkUpdate else if m_iFlag processCorpus monitor UD_UPDATECORPUS else processQueryString monitor if monitor isCancelled throw new InterruptedException the long running

Removing Stop Words

• Common words in English, programming language keywords

public void run IProgressMonitor monitor throws InvocationTargetException InterruptedException if m_iFlag the processCorpus monitor checkUpdate else if m_iFlag processCorpus monitor UD_UPDATECORPUS else a processQueryString monitor if monitor isCancelled throw new InterruptedException the long running

Splitting Identifiers

public void run IProgressMonitor monitor throws InvocationTargetException InterruptedException if m_iFlag the processCorpus monitor checkUpdate else if m_iFlag processCorpus monitor UD_UPDATECORPUS else a processQueryString monitor if monitor isCancelled throw new InterruptedException the long running

- IProgressMonitor = i progress monitor
- InvocationTargetException = invocation target exception
- m_IFlag = m i flag
- UD_UPDATECORPUS = ud updatecorpus

Indexing Current Snapshot of the Software with Latent Semantic Indexing



Identifying Similar Files to Change Requests with LSI

Bug 173881 - spliting views duplicates	s the tool op	Home Report New Wish or Bug	IRiSS		
Actions A Prod Reports Compon Requests Resolut	Prev Next No search results available Bug J23051 : splitting views duplicate the tool options docke Viets: Koffice Projenty: NOR ent: general Sevenity: normal tuse: RESOLVED ion: FUXED get: Votes: 0		Find What: set screen view	M	<u>S</u> earch <u>O</u> ptions
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xFinder

- Basic premise:
 - Developers who contributed substantial changes to a specific part of source code in the past are likely to best assist in future changes
- Levels of expertise:
 - *File expert:* highest contribution to a specific file
 - *Package expert*: updated the largest number of unique files to a specific package
 - System expert: updated the largest number of unique files to the project

xFinder Internals

- Each change is archived via a commit
- These commits are examined to infer the expertise
- Examined data:
 - Committer's ID
 - Date of the commit
 - Files' names and their full paths

xFinder: Contribution Measures

- Number of commits
- Number of workdays
- Most recent workday
- Number of changed files

Determining Expertise using xFinder

- The commit contribution, activity and most recent workday are used to derive a developer-to-code mapping
- Developers are ranked according to this mapping
- If this mapping can't be derived, the number of changed files is used

Example: determining experts for KOffice bug# 173881

• "splitting views duplicates the tool options docker"

Concept Location in Source code with Information Retrieval

Rank	Class Names	Similarity
1	KoDockerManager	0.66
2	ViewCategoryDelegate	0.54
3	ViewListDocker	0.51
4	KisRulerAssistantToolFactory	0.49
5	KWStatisticsDocker	0.46

xFinder

Rank	File Experts	Package Experts
1	jaham	mpfeiffer
2	boemann	jaham
3		zander

Preliminary Evaluation

- KOffice
 - 911 KLOC
 - 4,756 classes
 - 19,900 unique words
- Sampled 22 bugs out of 128 total between soft-freeze and Beta 04.

Evaluation Methodology

- 1 Select a "fixed" change request
- 2 Select a snapshot of software on or before a day on which change request was reported, but not fixed
- 3 Apply concept location to identify similar files to the change request
- 4 Use xFinder to collect a ranked list of developers
- 5 The developers, who contributed patches are "ground truth"
- 6 Compare 4 and 5
- 7 Repeat above steps for N change requests

Measuring Accuracy of Recommendation for bug# 167009

• "Kword crashes after deleting non existing page"

Files with Relevant Classes	Recommendation Coverage					
Files with Kelevant Classes	File	Pack	Sys	Ovl		
KWFrameDialog.cpp	1	1	0	1		
KWShapeConfigFactory.cpp	1	1	0	1		
FrameViewTester.cpp	0	1	0	1		
KWDocument.cpp	1	1	0	1		
KWTextFrameSet.cpp	1	1	1	1		
KWFrameSet.cpp	1	1	1	1		
FrameSet.h	1	1	0	1		
KWFrameConnectSelector.cpp	1	1	0	1		
KWGeneralFrameProperties.cpp	1	1	0	1		
Accuracy (%)	90	100	20	100		

Results for KOffice Bugs

Bug #	ug # Bug description excerpt		Accuracy (%)			Ranking Effectiveness			
Dug #	bug description excerpt	File	Pkg	Sys	Ovl	R _f	R _p	R _s	Ro
124527	Displaying calculation results	20	20	0	20	5	5		5
125306	Can't undo 'Insert Calendar' tool	0	30	70	100	-	2	1	1
130922	Import from xls treats borders wrong	0	0	90	90		—	1	1
137639	Inverted radial gradient colors	20	60	0	60	1	1		1
140603	!= in cell formula is buggy	0	10	50	60	1	4	1	1
141536	Crash when pasting a new layer	0	70	20	80	-	1	1	1
156754	Can't rotate image by less than 0.5°	0	50	0	50		2	—	2
162872	Transparent pixels with paintop	10	50	90	100	2	1	1	1
164688	Cut/copy/paste in the selection tool	0	60	20	70	Ι	1	2	1
166966	Crash: closing unsaved doc	10	10	0	20	8	10	-	8
167009	Crash: deleting non-existing page	90	100	20	100	1	1	5	1
167247	Broken tooltip for resource choosers	60	70	0	90	1	1	_	1
169696	Loaded shapes at wrong place	40	90	40	100	2	1	4	1
171969	Decoration not in sync with shape	50	90	40	100	1	1	3	1
172861	Kspread crashes on find	0	0	0	0	_	_	—	—
173282	Crash on double click into cell	0	0	0	0	_	_	-	-
173354	Sstart presentation from first page	20	50	50	100	1	1	2	1
173630	Format -> Page Layout does nothing	10	70	30	100	10	2	1	1
173732	OpenCalc file importer broken	0	0	0	0	_	—	—	—
173882	Can't set splitter orientation	50	70	30	90	1	1	1	1
175373	Can't edit formulas in tool options	0	0	0	0		—	_	_
176278	Crash on loading image	20	40	30	60	6	3	5	3
	Average	18.2	42.7	26.4	63.2	3.3	2.1	2.2	1.8

Conclusions

- Proposed and implemented novel combination of MSR and IR techniques for identifying expert programmers to incoming change requests
- The proposed approach can recommend relevant developers with relatively high accuracy