Improving software team collaboration with Synchronized Software Development

Stanislav Levin  
The Blavatnik School of Computer Science  
Tel Aviv University  
Tel-Aviv, Israel  
stanisl@post.tau.ac.il

Amiram Yehudai  
The Blavatnik School of Computer Science  
Tel Aviv University  
Tel-Aviv, Israel  
amiramy@tau.ac.il

Abstract—Effective collaboration is a key factor in the success of a software project developed by a team. In this work, we suggest the approach of Synchronized Software Development (SSD), which promotes a new mechanism of collaboration in general, and for code synchronization in particular. In SSD, code changes made by one developer are automatically propagated to others as long as they keep the code free of compilation errors. Changes that introduce compilation errors are not propagated until the errors are fixed. Moreover, other developers are restricted from concurrently editing the entities involved in these changes. While in this state, developers are, however, free to modify the rest of the entities.

The novelty of our approach is that it actively synchronizes developers with the latest error free version of the source code, preventing possible conflicts and merges that may arise due to concurrent changes made by fellow team members. SSD also allows for a more transparent and practically near real time awareness of new code that is being introduced by multiple developers. We built CSI (Code Synchronizing Intelligence), a prototype demonstrating key features of SSD.

Index Terms—collaboration; change; awareness; conflicts; merge;

I. INTRODUCTION

Modern software projects involve multiple developers collaboratively working on the same codebase. In fact, parallel development has become the norm rather than an exception [1]. The task of sharing a codebase repository is usually carried out by a Software Configuration Management system (SCM) [2], [3], [4], [5]. The SCM system maintains all files that comprise the software project, and serves as the only version controlling mechanism through which developers share code [6]. The SCM tools employ a common checkin / checkout model according to which a change will become visible to others, only after the developer who made it checks in his code to the shared repository. A direct implication of this model is that code conflicts will only be discovered post factum, when a developer tries to checkin the already conflicting code. Once aware of the conflict the developer is forced to resolve it by means of merging his version with the repository’s one. Such manual merges are considered both time consuming and error prone [7], [8]. This is a definite limitation of the current checkin / checkout model. Inspired by Google Docs [9], we envision a development environment that provides similar real time collaborative editing capabilities for code development.

II. RELATED WORK

A number of tools have been suggested so as to address the code conflicts issue, and have mostly concentrated on increasing developers’ awareness of the activities performed by fellow team members. Such tools usually come either as a plug-in integrated into the Integrated Development Environment (IDE) (Syde [10], Lighthouse [11]) or as a standalone application (Palantir [12], FASTDash [13]). CollabVS [14] extends the standard Visual Studio user interface with collaboration oriented features such as chat, video, and audio streams on top of its conflict detection mechanisms. CloudStudio [15] suggests a concept of “cloud-based development”, and replaces the explicit checkin / checkout model with interactive editing and real-time conflict tracking and management. One of the main goals of these tools is to provide developers with relevant information so as to assist them in avoiding code conflicts. The described tools share a common principle, they collect relevant information and present it to the developer. It is up to the developer to utilize this information and perform (or refrain from performing) a particular set of actions in order to prevent conflicts and promote collaboration. The developer is only shown the path, yet he is the one who has to walk it.

Our work addresses the difference between knowing the path and walking the path [16]. The suggested approach, Synchronized Software Development (SSD), forcibly turns concurrent changes into sequential ones, by allowing only one developer to edit any given entity (e.g. method) at any given time. Other developers are blocked from concurrently editing that particular entity. While blocked they may, however, edit other entities in the code. In addition to the trivial case of concurrently editing the same entity, SSD also aims to detect indirectly conflicting (concurrent) changes that may affect one another, resulting in a conflict. For instance, changing a method’s name at one site, while using the old method’s name at another. SSD strives to enforce conflict prevention by means of fine grained restrictions on entity editing, and thus prevent the conflicts (and manual merges) originating from the...
checkin / checkout synchronization model typically employed by current SCM systems.

III. MOTIVATING USE CASE

We call the state in which the code fails to compile "unbuildable" state, and the state in which the code successfully compiles a "buildable" state.

We shall now analyze a use case demonstrating SSD in a real life scenario, accompanied with some screenshots from CSI, our SSD prototype.

1) Two developers, Alice and Bob, begin in the same file state. See figure 1, section 2.

2) Bob intends to add a new parameter, "newParam", of type int to the method "Foo". Bob begins typing in his change, but mistakenly types "in newParam", missing the "t" at the end of "int".

3) Not being aware of his mistyping, Bob also changes the name of the method from "Foo" to "Foo1". At this stage Bob has a new name for the method "Foo" (i.e. "Foo1") and an additional, incorrect parameter definition. These changes render the file state unbuildable. Since the code state is currently unbuildable, none of the changes Bob has made are propagated to Alice. See figure 1, section 2.

4) Meanwhile, Alice intends to change the method "Foo" to "Foo2". She is currently unaware that Bob has already changed this method’s name to "Foo1", and in the file version she currently has, the method’s name is still "Foo". Alice begins changing the name of "Foo" to "Foo2", say by typing an additional "2" at the end of the "Foo" string in the method definition, and is immediately warned that the current method is locked for editing by another developer (Bob).

5) Alice is now made aware that the method is undergoing changes by some other developer (Bob), and is forced to wait till these changes are complete, avoiding the conflict that would have otherwise been introduced due to fact they both had changed the method’s name. See figure 2, section 3.

6) Once Bob adds the "t" to the mistyped "in", his code becomes buildable, and is instantly propagated to Alice, which gets the new method name, with the additional parameter added by Bob. Alice may now commence the change she has intended. See figure 2, section 4.

It is worth noting that SSD works on the fly, as developers type in code. Neither Alice nor Bob has to actively save their file in order for SSD to perform. This may be witnessed by the asterisk symbol near the file name at the top of the editing tab in the Eclipse IDE, which indicates that the file at hand has not been saved yet and all changes are currently buffered in memory, see figures 1-2.

In a typical SCM system, such a conflict would only be discovered post factum, when a developer would try to check in an already conflicting code version. In an SSD system the conflict is discovered at the time of producing conflicting code, while in current SCM systems it is only discovered after it has been checked in to the SCM.

The key concept of an SSD system is that it is aware of all changes currently carried by all team members. Thus, once the (chronologically) first developer begins changing the method’s name, the SSD system locks the method element for editing by other developers. When another developer tries to change the same method, the SSD system will notify him that the element he’s trying to edit is already being edited. He should then wait until the undergoing change is complete, and only then introduce his own changes. By means of locking we aim at preventing concurrent, conflicting changes, that otherwise might have resulted in a conflict. However, the locking is so fine grained that we expect it to be practically transparent to developers, and they will only be aware of it in case it intervenes to prevent a highly probable conflict.

The concept demonstrated in the use case we described applies to a wide variety of changes: introducing new methods, changing existing method’s name, changing existing method’s body, and so on. An SSD system should support all code editing operations available in a standard IDE.

IV. DEPENDENCY DETECTION TO THE AID OF CONFLICTS PREVENTION

We believe it is highly undesirable for developers to make design related decisions based on stale code. Our fundamental assumption is that while coding, a developer would rather wait (obviously, within reason), than engage in a manual merge process incurred by possible code conflicts. Our efforts are proactive, directed at preventing conflicts before they actually occur.

We establish the notion of element (i.e., Abstract Syntax Tree nodes (AST)) dependency. Elements $E_1$, $E_2$ are dependent if one of the following holds:

1) $E_1 = E_2$.
2) $E_1$, $E_2$ have a common ancestor of type method or statement in the AST.
3) $E_1$ references $E_2$’s binding or vice versa (e.g., $E_1 = \mathit{aMemberField} + 1$; $E_2 = \mathit{int} \ aMemberField$).

We argue that in order to prevent conflicts, no dependent elements should be subject to concurrent editing.

The first case implies that no single element may be concurrently edited.

The second case deals with concurrent editing of elements such as statements inside methods, or parameters in method invocations taking place inside the body block of another method. Theoretically, an SSD system could allow concurrent editing of statements in the same method, however, we believe this is not a good practice since it may lead to inconsistencies in the method’s logic.

We demonstrate the third case with an example. Suppose we have a variable:

```java
int someVar;
```

denoted by $E_1$, and a statement:

```java
int otherVar = someVar;
```
Fig. 1.
(1) Alice and Bob begin in the same state.
(2) Bob introduces some changes. Method’s name is changed, and the new parameter has an invalid type.

Fig. 2.
(3) Alice’s trial to edit the method’s name prompts the system to block her change, and display an alert.
(4) Bob fixes the errors and turns the file state buildable, his code is then propagated to Alice.

denoted by $E_2$. Let $E_{id_j}$ denote $E_i$ element’s copy at developer $j$’s site (i.e., $E_{id_2}$ is $E_1$’s copy at developer2’s site).

Suppose now, that developer1 renames $E_{id_1}$ to:

\[
\text{int newSomeVar;}
\]

while at the same time, developer2 changes $E_{id_2}$ to:

\[
\text{int otherVar = someVar + 1;}
\]

(before either change is propagated to the other site). Note that developer1’s renaming of $E_{id_1}$ results in a cascading change to $E_{id_2}$ in order to make the code buildable. $E_{id_2}$ is now:

\[
\text{int otherVar = newSomeVar;}
\]

and it is in conflict with $E_{id_2}$, which is:

\[
\text{int otherVar = someVar + 1;}
\]

Once such a state is reached, no matter what order the changes are propagated in, a conflict is inevitable, $E_{id_2} \neq E_{id_1}$. The third element dependency condition above aims to prevent such cases.

V. CSI - AN SSD PROTOTYPE

We’ve begun implementing CSI (Code Synchronizing Intelligence), an SSD prototype plug in for the Eclipse IDE. CSI uses the Java Model [17] offered by the Eclipse JDT (Java Development tools) in order to be notified of changes (introduction, deletion and modification of Java elements, which in turn may be classes, methods, member variables and so on) made to the model representing the program structure.

The Java Model plays an important role in tracking changes on a semantical level, rather than observing textual changes, which is a key principle of SSD.

VI. DISCUSSION & LIMITATIONS

It is crucial to determine the dependent elements as soon as possible in order to enforce locking in near real time. Any delay in doing so may result in a conflict due to unrestricted concurrent editing. We’re investigating ways to employ AST resolution on the fly (as code is written) in order to detect complex element dependency, while incurring minimal performance cost.

Developer’s privacy should also be taken into account. A developer may want to go "off the record" whenever he wishes to delay the propagation of his changes, despite the fact that technically, they can be propagated immediately. Local testing is great motivation for going off record. However, this increases the chance of introducing a conflict once going back "on record", since during the off record period the developer is unsupervised by the locking mechanism.

VII. IMPACT AND FUTURE WORK

SSD combined with cloud computing in general, and cloud-based development [15] in particular, will result in a powerful, collaboration oriented IDE, provided in a form of Software as a Service (SaaS) [18]. This, in turn, may change the current perception of an IDE, and present opportunities for new paradigms in the field of software development.
An example of such a paradigm is near real time automated unit testing. Near real time code propagation presents the opportunity for running automated unit test suites on code that has just been written (long before it is checked-in to the SCM). To reduce running times, regression test selection algorithms and techniques [19] can be employed. Near real time regression testing will assist in a considerably earlier regression bug detection, than in a traditional checkin / checkout model. This in turn, will lead to a cost reduction in software development projects [20].

SSD can change the rules of known practices like Pair Programming, challenging the traditional separation between the driver-navigator roles.

The nature of SSD blurs the boundaries between distributed and non distributed software development, enabling close collaboration even between geographically separated developers. We intend to elaborate our research and extend our vision of software development environments in the presence of SSD. Our future efforts will be dedicated to conducting further user studies and experiments in order to devise SSD best practices.

REFERENCES

[1] A. Sarma, G. Bortis, and A. Van Der Hoek, “Towards supporting awareness of indirect conflicts across software configuration management workspaces,” in Proceedings of the twenty-second IEEE/ACM international conference on Automated software engineering. ACM, 2007, pp. 94–103.

[2] “Apache Subversion.” [Online; accessed 11-April-2011].

[3] “Rational ClearCase.” [Online; accessed 11-April-2011].

[4] “GIT, a free, open source, distributed version control system.” [Online; accessed 11-April-2011].

[5] “Mercurial is a free, distributed source control management tool.” [http://mercurial.selenic.com/], [Online; accessed 02-April-2011].

[6] L. Hattori and M. Lanza, “An environment for synchronous software development,” in Software Engineering-Companion Volume, 2009. ICSEC-Companion 2009. 31st International Conference on. IEEE, 2009, pp. 223–226.

[7] C. A. Ellis and S. J. Gibbs, “Concurrency control in groupware systems.” SIGMOD Rec., vol. 18, no. 2, pp. 399–407, 1989.

[8] Y. Brun, R. Holmes, M. D. Ernst, and D. Notkin, “Proactive detection of collaboration conflicts,” in Proceedings of the 8th Joint Meeting of the European Software Engineering Conference and ACM SIGSOFT Symposium on the Foundations of Software Engineering (ESEC/FSE11), 2011, pp. 168–178.

[9] “Google docs - online documents with real-time collaboration.” [http://www.google.com/apps/intl/en/business/docs.html], [Online; accessed 24-November-2011].

[10] L. Hattori and M. Lanza, “Syde: a tool for collaborative software development,” in Proceedings of the 32nd ACM/IEEE International Conference on Software Engineering-Volume 2. ACM, 2010, pp. 235–238.

[11] I. A. Da Silva, P. H. Chen, C. Van der Westhuizen, R. M. Ripley, and A. Van Der Hoek, “Lighthouse: coordination through emerging design,” in Proceedings of the 2006 OOPSLA workshop on eclipse technology exchange. ACM, 2006, pp. 11–15.

[12] A. Sarma, Z. Noroozi, and A. V. D. Hoek, “Palantr: Raising awareness among configuration management workspaces,” 2003, pp. 444–454.

[13] J. T. Biehl, M. Czerwinski, G. Smith, and G. G. Robertson, “Fastdash: A visual dashboard for fostering awareness,” in in Software Teams. SIGCHI conference on Human Factors in computing systems, 2007, pp. 1313–1322.

[14] P. Dewan and R. Hegde, “Semi-synchronous conflict detection and resolution in asynchronous software development,” ECSWC 2007, pp. 159–178, 2007. [Online]. Available: [http://dx.doi.org/10.1007/978-1-84800-031-5_9]

[15] M. Nordio, B. Meyer, and H.-C. Estler, “Collaborative software development on the web,” Computing Research Repository, vol. abs/1105.0768, 2011.

[16] “The Matrix.” [http://www.imdb.com/title/tt0133093/] [Online; accessed 11-November-2011].

[17] “Java model.” [http://help.eclipse.org/helios/index.jsp?topic=org.eclipse.jdt.doc.isv/guide/jdt_int_model.html] [Online; accessed 05-March-2011].

[18] H. Erdogmus, “Cloud computing: Does nirvana hide behind the nebula?” IEEE Software, vol. 26, pp. 4–6, 2009.

[19] T. L. Graves, M. J. Harrold, J.-M. Kim, A. Porter, and G. Rothermel, “An empirical study of regression test selection techniques,” ACM Trans. Softw. Eng. Methodol., vol. 10, pp. 184–208, April 2001. [Online]. Available: [http://doi.acm.org/10.1145/567006.567020]

[20] J. Link and P. Frolich, Unit Testing in Java: How Tests Drive the Code. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2003, pp. 305–306.