15-410

"...Goals: Time Travel, Parallel Universes..."

Version Control
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Dave Eckhardt

Nathaniel Filardo

Zach Anderson (S '03)

Disclaimer

This lecture will mention one SCMS

- **git**

You don't need to use git

- **Not even if “all the TA's do”**

Outline

Motivation

Repository vs. Working Directory

Conflicts and Merging

Branching

A Brief Introduction to git

Goals

Working together should be easy

Time travel

- Useful for challenging patents
- *Very* useful for reverting from a sleepless hack session

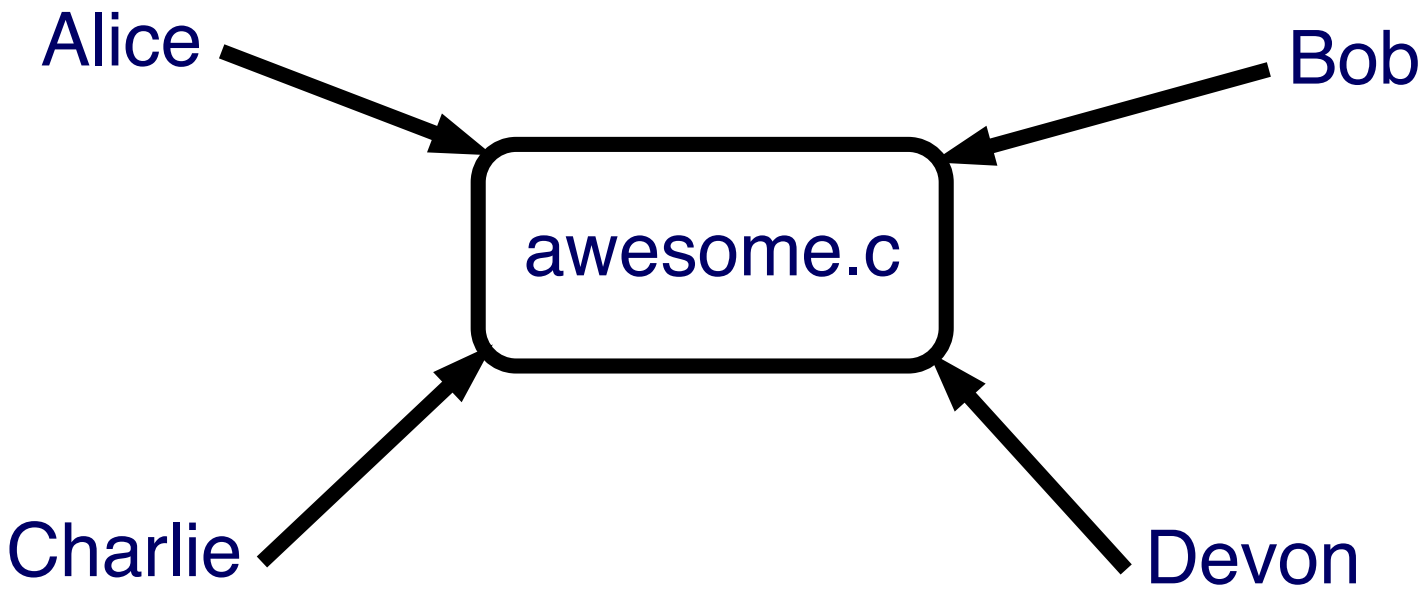
Parallel universes

- Experimental universes
- Product-support universes

Goal: Shared Workspace

Reduce development latency via parallelism

- **[But: Brooks, Mythical Man-Month]**



Goal: Time Travel

Retrieving old versions should be easy.

Once Upon A Time…

Alice: What happened to the code? It doesn't work.

Charlie: Oh, I made some changes. My code is 1337!

Alice: Rawr! I want the code from last Tuesday!

Goal: Parallel Universes

Safe process for implementing new features.

- Develop bell in one universe
- Develop whistle in another
- Don't inflict B's core dumps on W
- Eventually produce bell-and-whistle release

How?

Keep a global repository for the project.

Definitions

Version / Revision / Configuration

- Contents of some files at a particular point in time
- aka “Snapshot”

Project

- A “sequence” of versions
  - (not really)

Repository

- Directory where projects are stored

The Repository

Stored in group-accessible location

- Old way: file system
- Modern way: "repository server"

Versions *in repository* visible group-wide

- Whoever has read access
- "Commit access" often separate

How?

Keep a global repository for the project.

Each user keeps a working directory.

The Working Directory

Many names (“sandbox”)

Where revisions happen

Typically belongs to *one* user

Versions are *checked out* to here

New versions are *checked in* from here

How?

Keep a global repository for the project.

Each user keeps a working directory.

Concepts of checking out, and checking in

Checking Out. Checking In.

Checking out

- A version is copied from the repository
  - Typically “Check out the latest”
  - Or: “Revision 3.1.4”, “Yesterday noon”

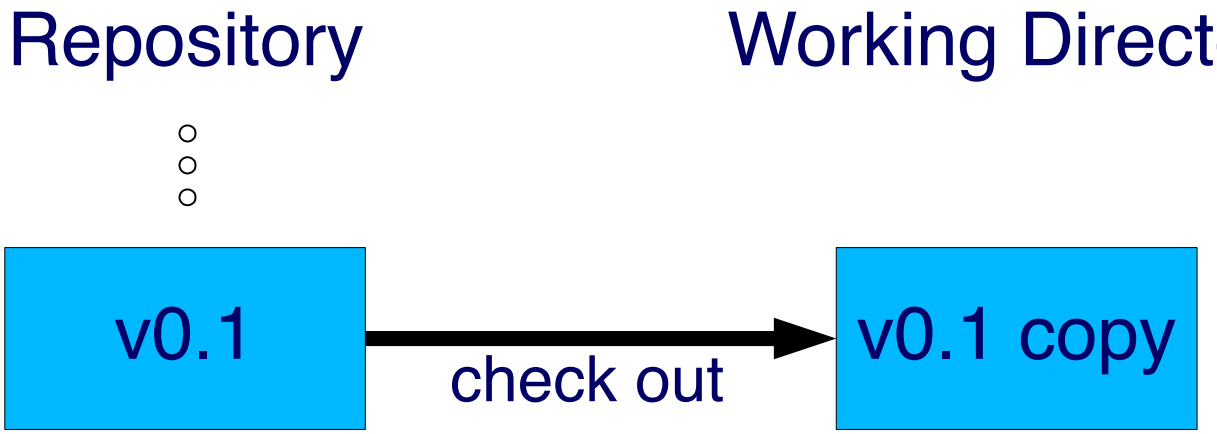
Work

- Edit, add, remove, rename files

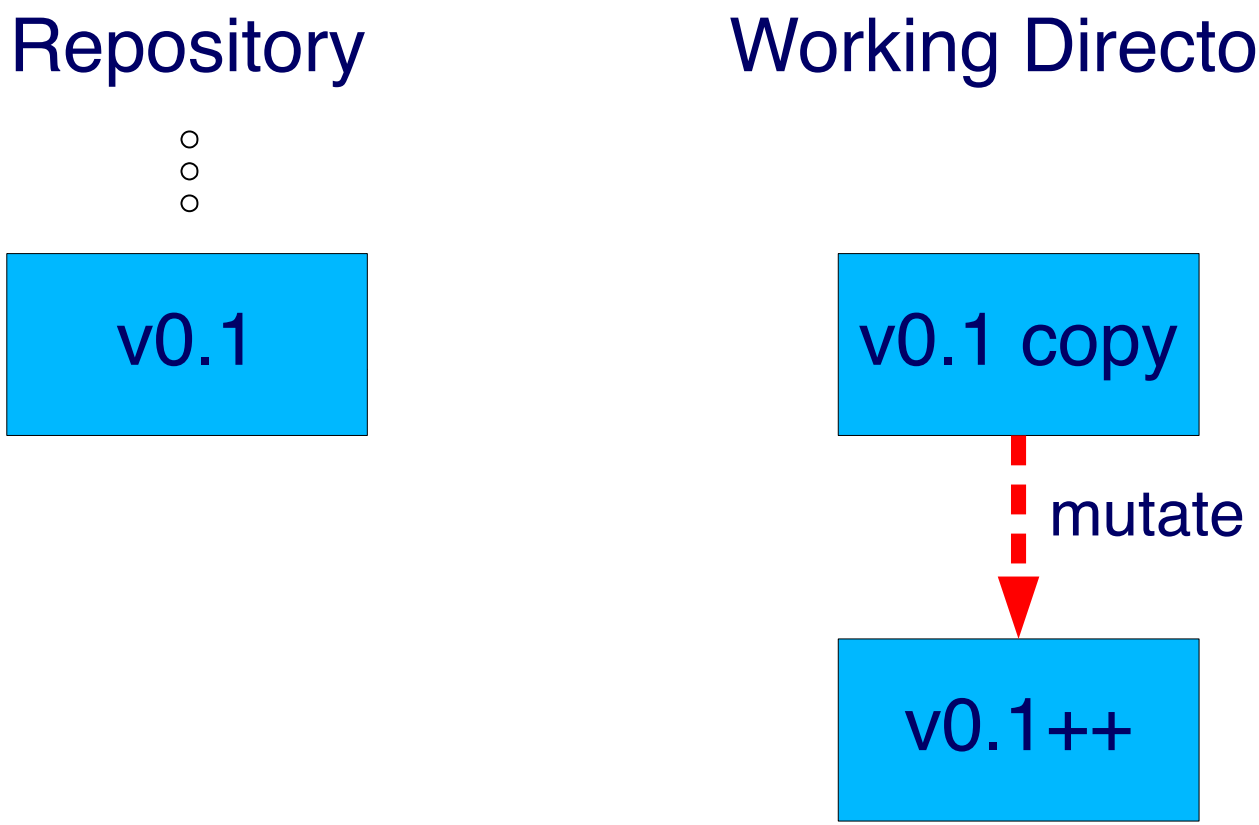
Checking in

- Working directory ⇒ repository *atomically*
- Result: new version

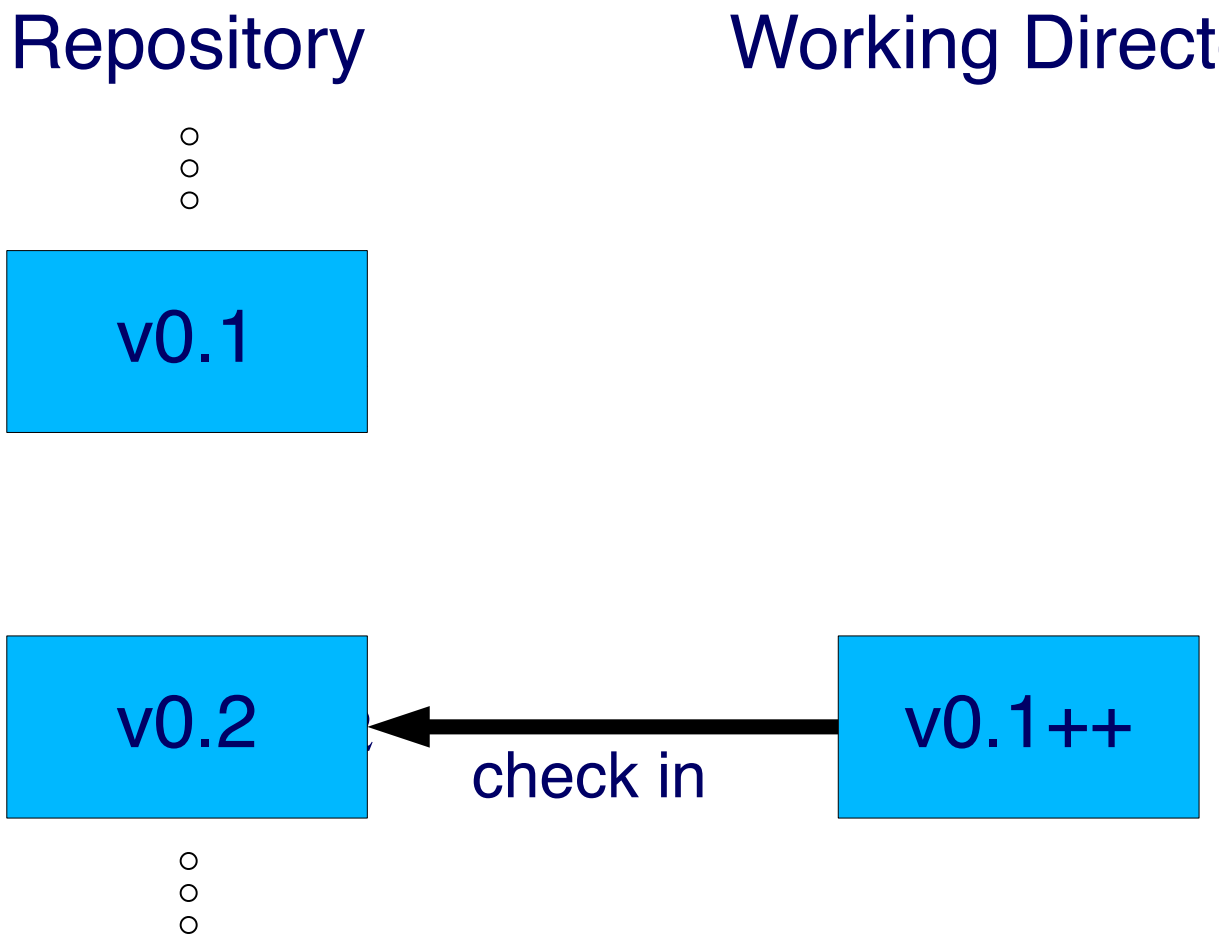
Checking Out. Checking In.



Checking Out. Checking In.



Checking Out. Checking In.



How?

Keep a global repository for the project.

Each user keeps a working directory.

Concepts of *checking out*, and *checking in*

Mechanisms for merging

Conflicts and Merging

Two people check out.

- Both modify foo.c

Each wants to check in a new version.

- Whose is the *correct* new version?

Conflicts and Merging

Conflict

- Independent changes which "overlap"
- *Textual* overlap detected by revision control
- *Semantic* conflict cannot be

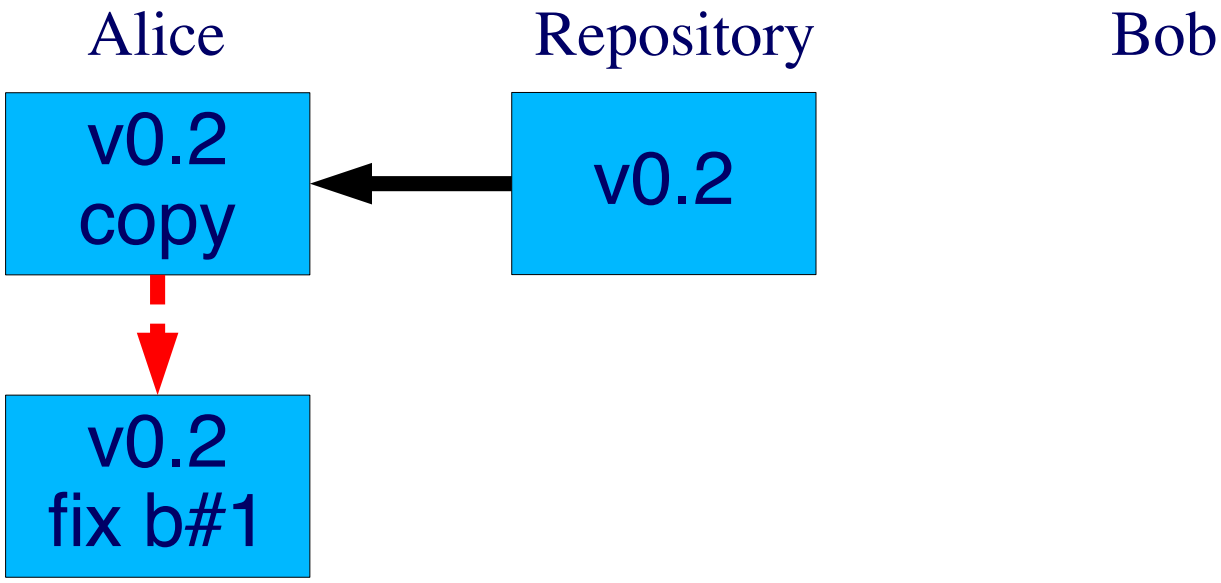
Merge displays conflicting updates per file

Pick which code goes into the new version

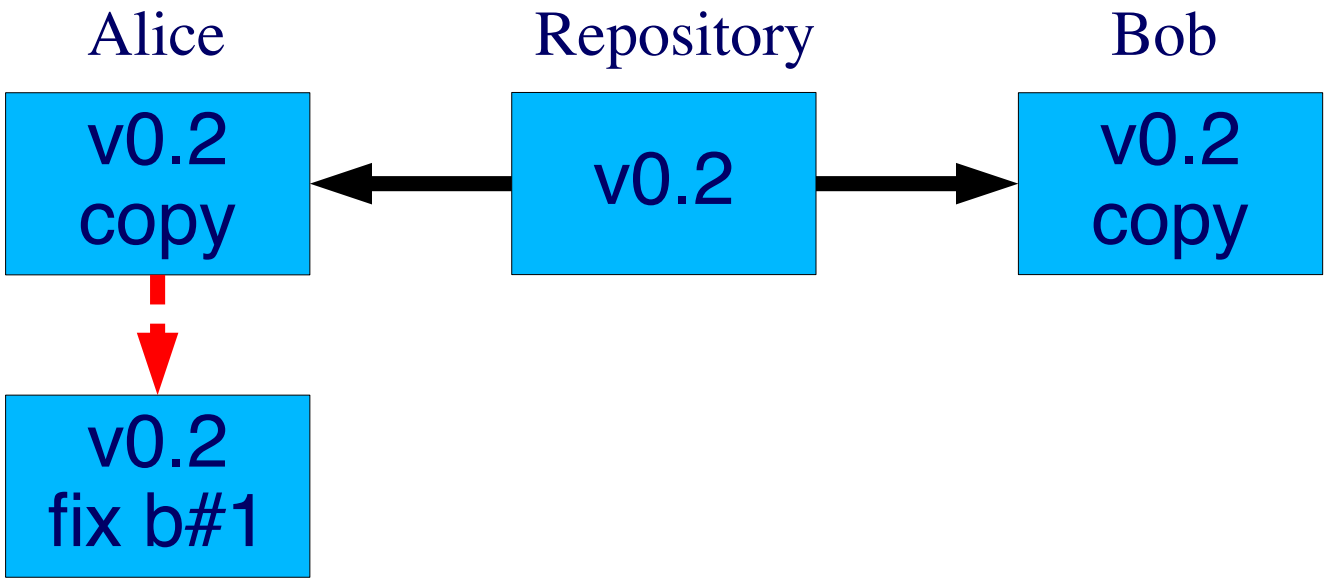
- A, B, NOTA

Story now, real-life example later

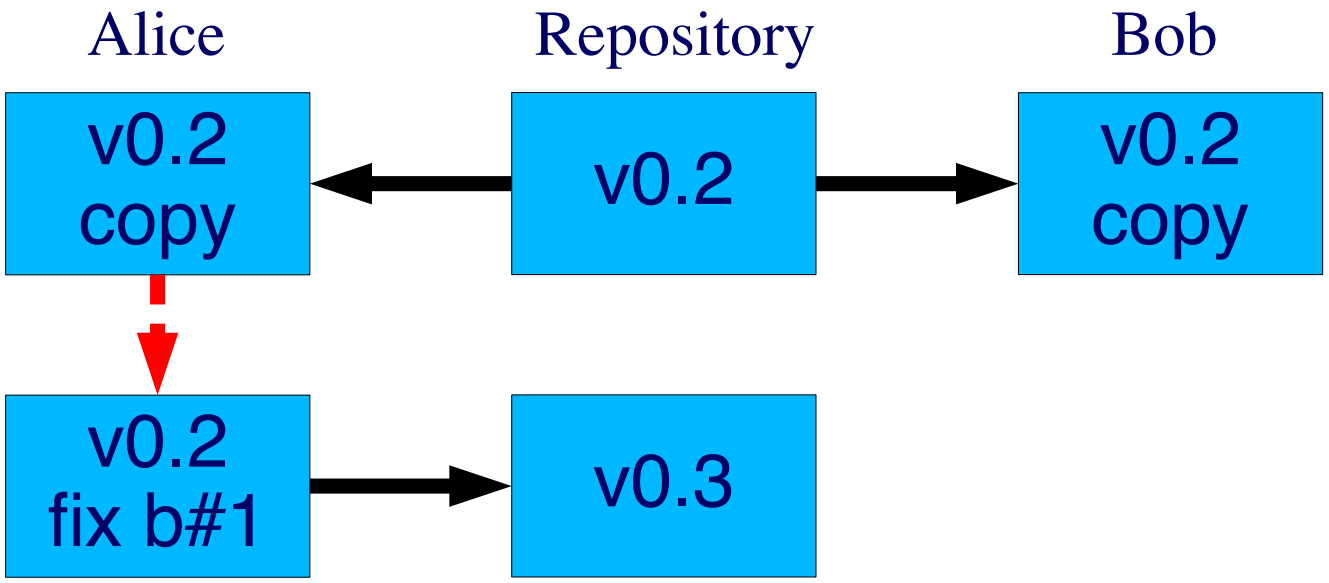
Alice Begins Work



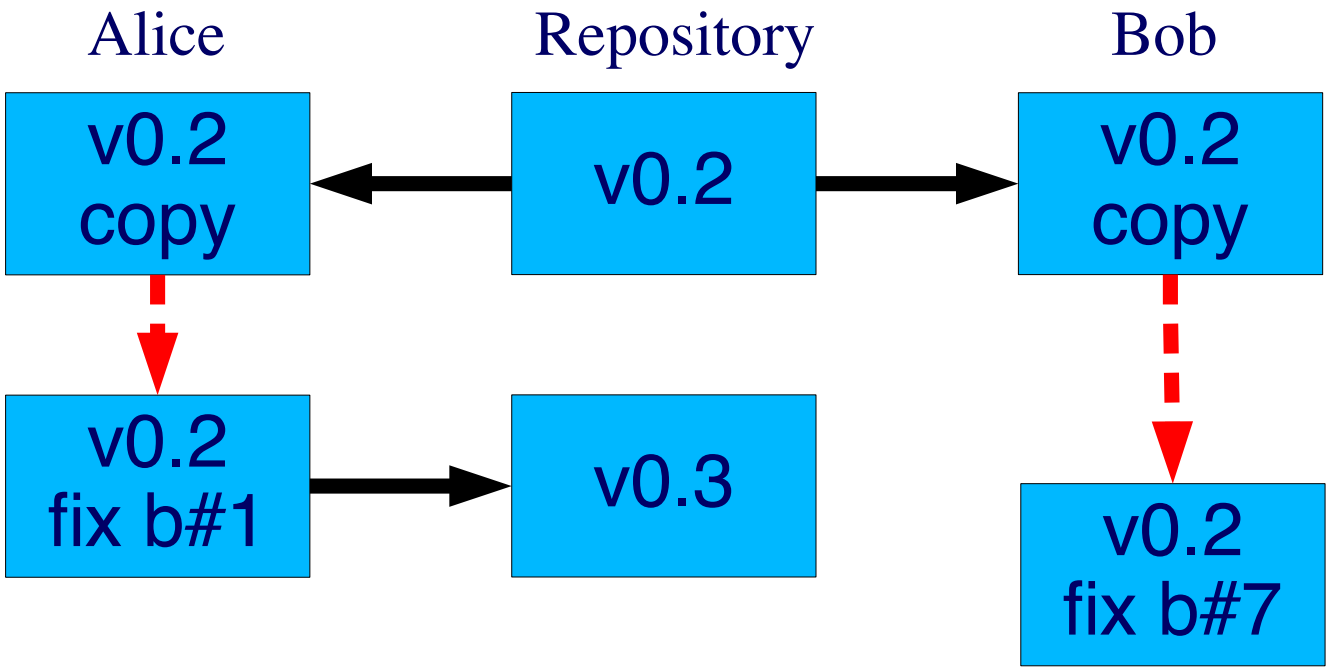
Bob Arrives, Checks Out



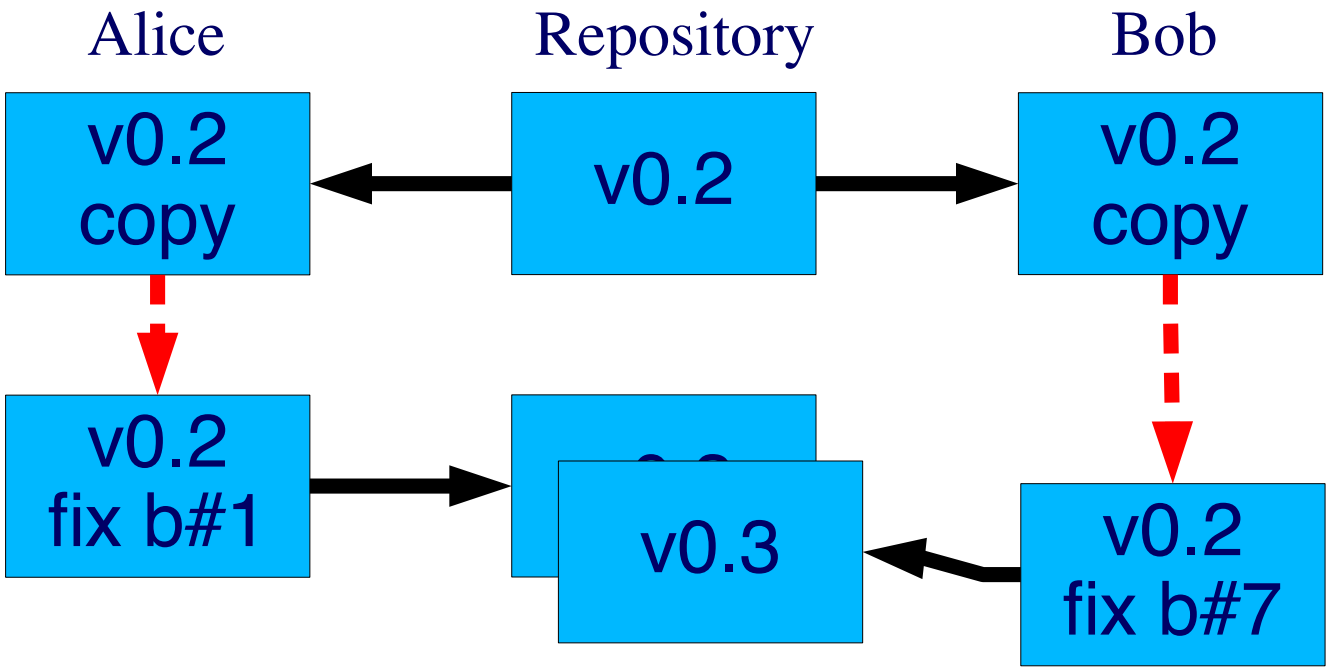
Alice Commits, Bob Has Coffee



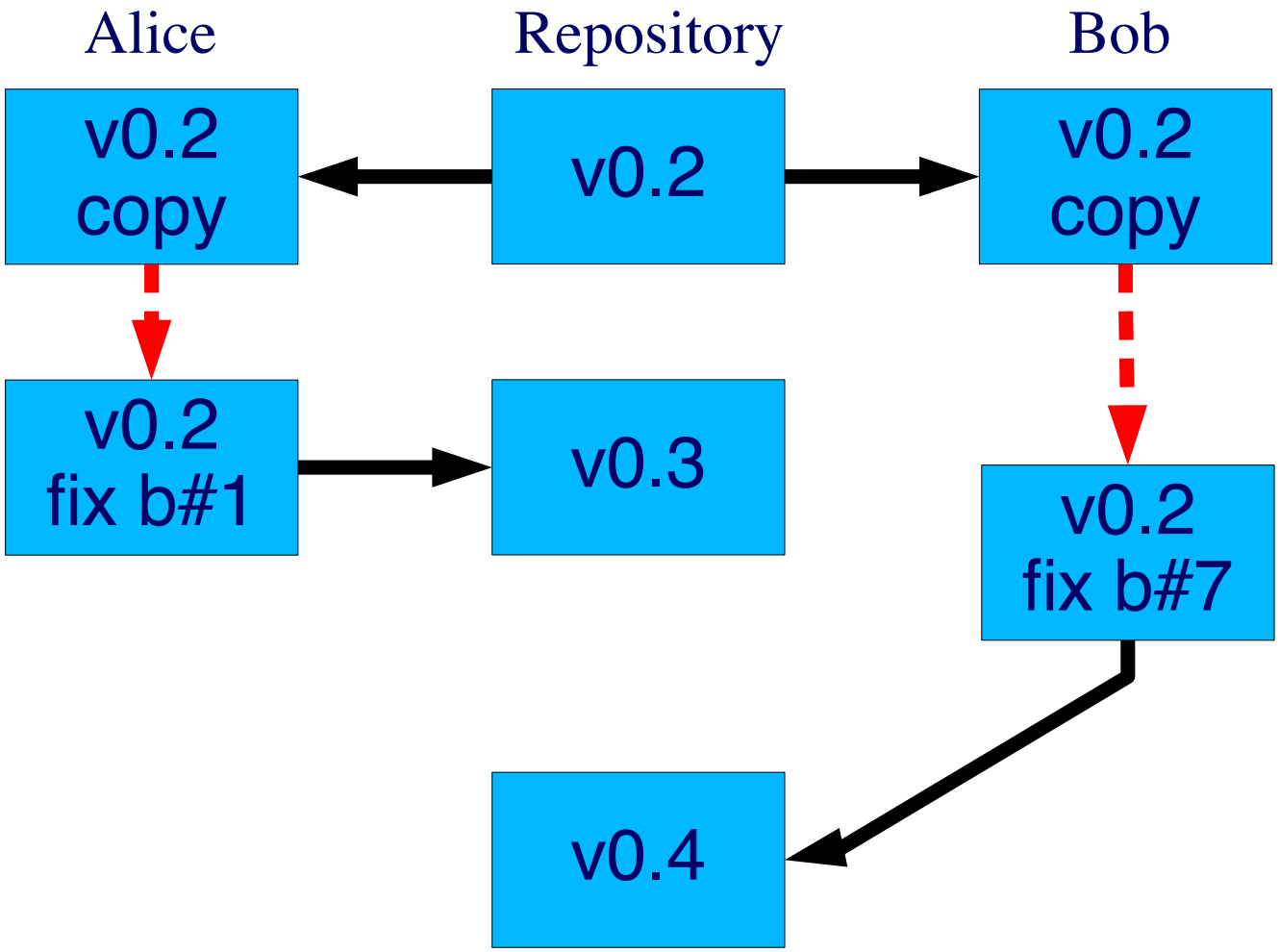
Bob Fixes Something Too



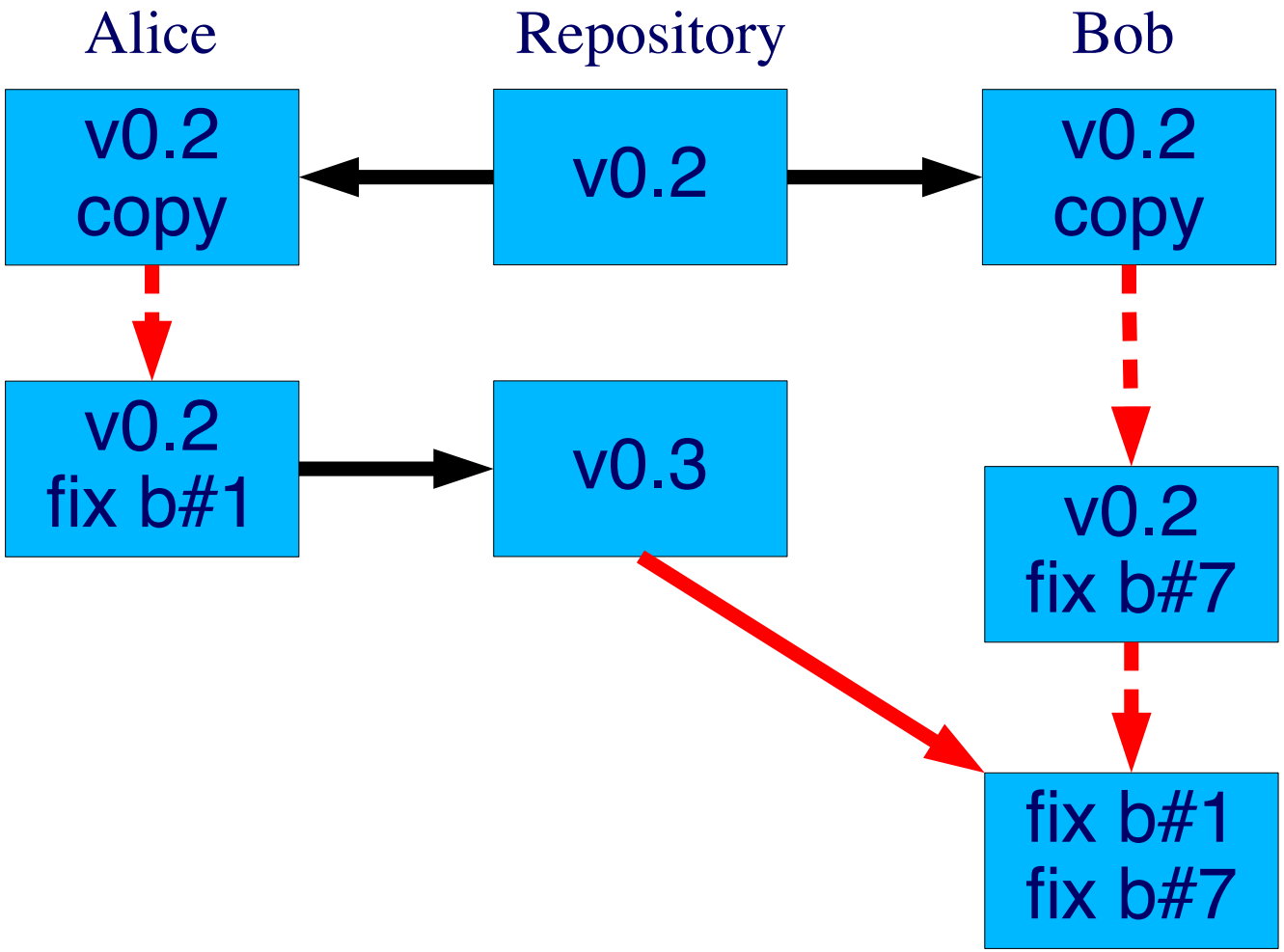
Wrong Outcome



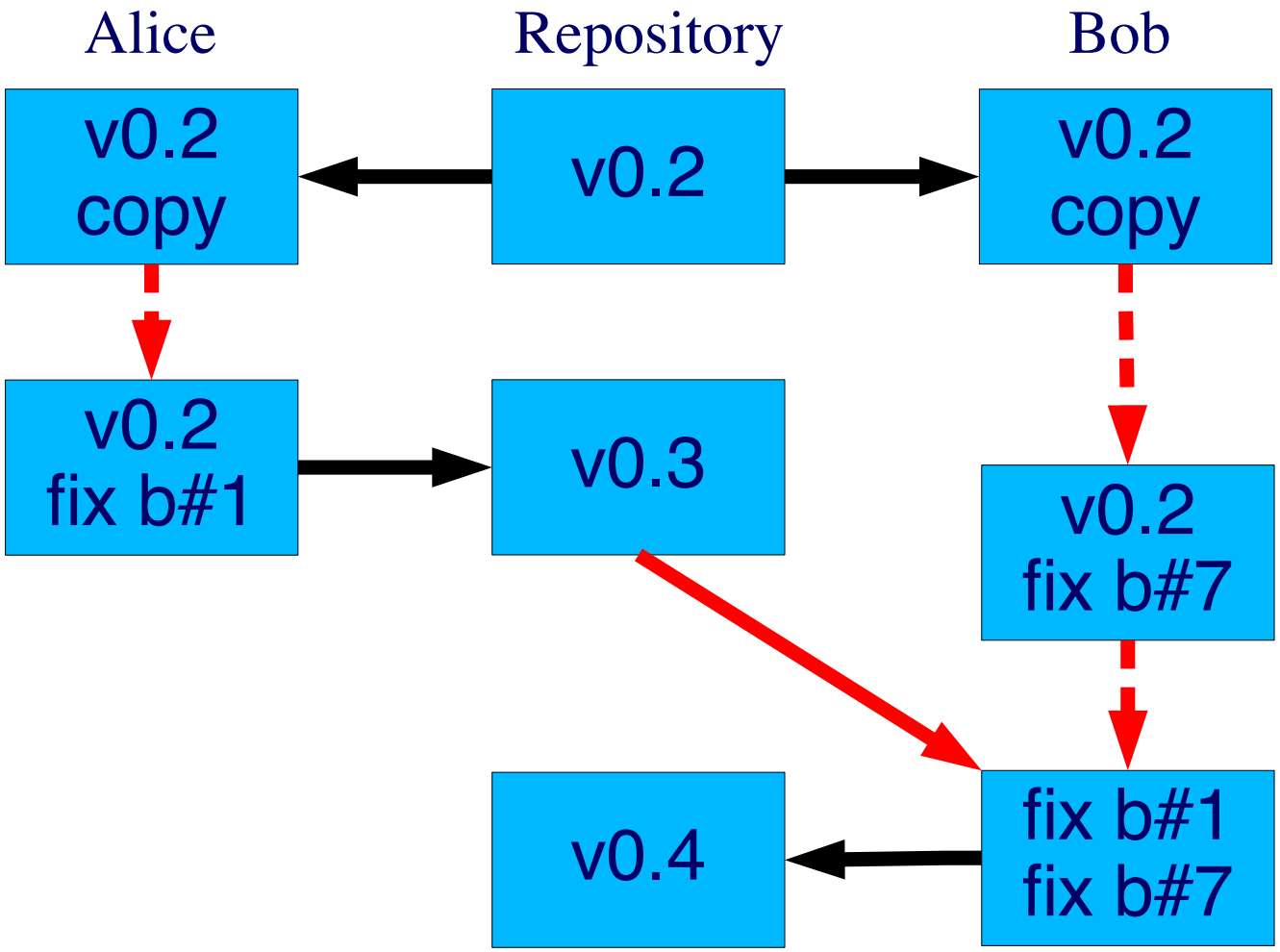
“Arguably Less Wrong”



Merge, Bob, Merge!



Committing Genuine Progress



How?

Keep a global repository for the project.

Each user keeps a working directory.

Concepts of *checking out*, and *checking in*

Mechanisms for *merging*

Mechanisms for branching

Branching

A branch is a *sequence of versions*

- **(not really...)**

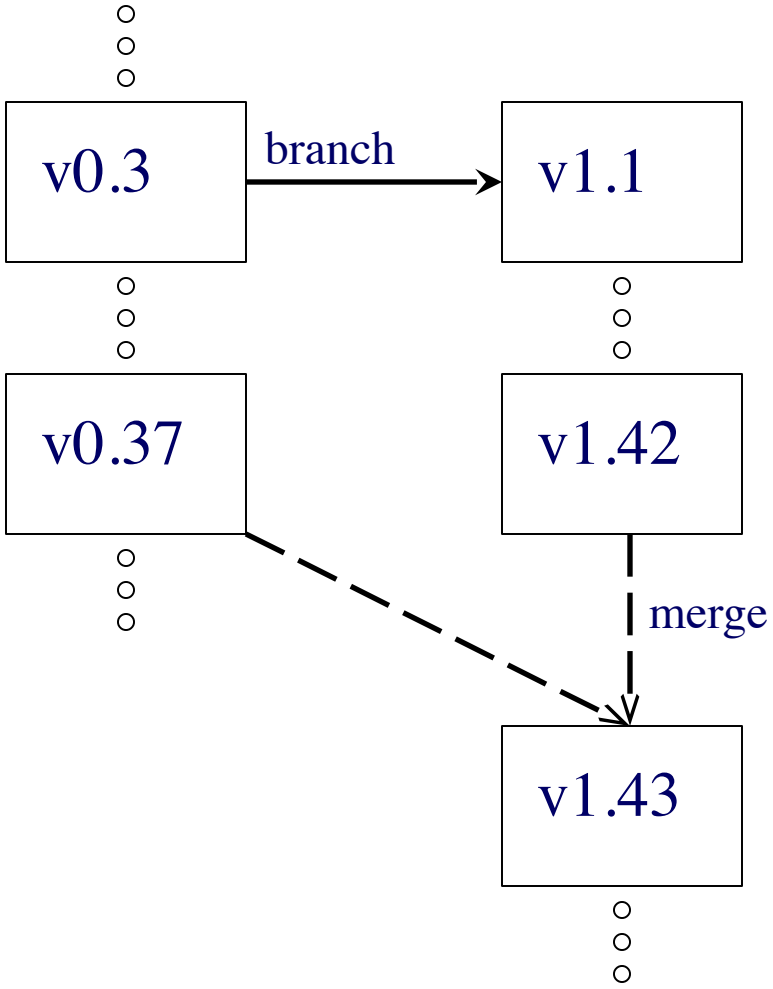
Changes on one branch don't affect others

Project may contain many branches

Why branch?

- **Implement a new "major" feature**
- **Begin a temporary independent sequence of development**

Branching



The actual branching and merging take place in a particular user's working directory, but this is what such a sequence would look like to the repository.

Branch Life Cycle

"The Trunk"

- **"Release 1.0", "Release 2.0", ...**

Release 1.0 *maintenance* branch

- **After 1.0: 1.0.1, 1.0.2, ...**
- **Bug-fix updates as long as 1.0 has users**

Internal *development* branches

- **1.1.1, 1.1.2, ...**
- **Probably 1.1.1.client, 1.1.1.server**

Branch Life Cycle

"Development excursion" branch model

- **Create branch to fix bug #99 in v1.1**
- **One or more people make 7 changes**
- **Branch "collapses" back to trunk**
  - **Merge 1.1.bug99.7 against 1.1.12**
  - **Result: 1.1.13**
  - **There will be no 1.1.bug99.8**
    - In some systems, there *can't* be

Branch Life Cycle

"Controlled isolation" branch model

- Server people work on 1.3.server
  - Fix server code
  - Run stable client test suite vs. new server
- Client people work on 1.3.client
  - Fix client code
  - Run new client test suite vs. stable server
- Note
  - Branches do *not* collapse after one merge!

Branch Life Cycle

"Controlled isolation" branch model

- **Periodic merges - example**
  - **1.3.server.45, 1.3.12 ⇒ 1.3.13**
  - **1.3.client.112, 1.3.13 ⇒ 1.3.14**
  - **Each group can keep working while one person "pushes up" a version to the parent**
- **When should server team "pull down" 1.3.14 changes?**
  - **1.3.server.47, 1.3.14 ⇒ 1.3.server.48?**
  - **1.3.server.99, 1.3.14 ⇒ 1.3.server.100?**

Branch Life Cycle

Successful development branch

- Merged back to parent
- No further versions

Unsuccessful development branch

- Some changes pulled out?
- No further versions

Maintenance branch

- "End of Life": No further versions

Are Branches *Deleted?*

Consider the repository "data structure"

- Revisions of each file (coded as deltas)
- Revisions of the directory tree

Branch delete

- *Complicated* data structure update
  - [Not a well-tested code path]
- Generally a bad idea
  - History could *always* be useful later...

Source Control Opinions

CVS

- still somewhat used
- mature, lots of features
- default behavior often wrong

SubVersion (svn)

- SVN > CVS (design)
- SVN > CVS (size)
- Doesn't work in AFS
- Yes, it does
- No, it doesn't?
- Google was an SVN champion... still?

Perforce

- commercial
- reasonable design
- works well (big server)

BitKeeper

- ~~Favored by Linus Torvalds~~
- "Special" license restrictions

git

- Favored by Linus Torvalds

Source Control Opinions

Others

- Mercurial ("hg")
  - Mostly-merge-once branches
  - Design is similar to git (mutual feature cloning)
    - More Python, less C, smaller user community
- Bazaar ("bzr")
- Monotone
- arch/tla
- darcs ("patch algebra")

Generally

- Promising plans
- Some rough edges
- *Many* use cases covered
- Ready yet?

Recommendation for 15-410

You can use SVN if you're used to it

- Or hg

Current TA favorite: git

- It can do what you need
  - (plus a vast array of things you don't need)
- It's unlikely to suddenly vanish
- It's "very likely" (25%?) to be chosen by your next boss

Be careful about online git/hg providers

- Your work will probably be *public and searchable* – see syllabus!

Getting Started

Already installed on Andrew Linux systems!

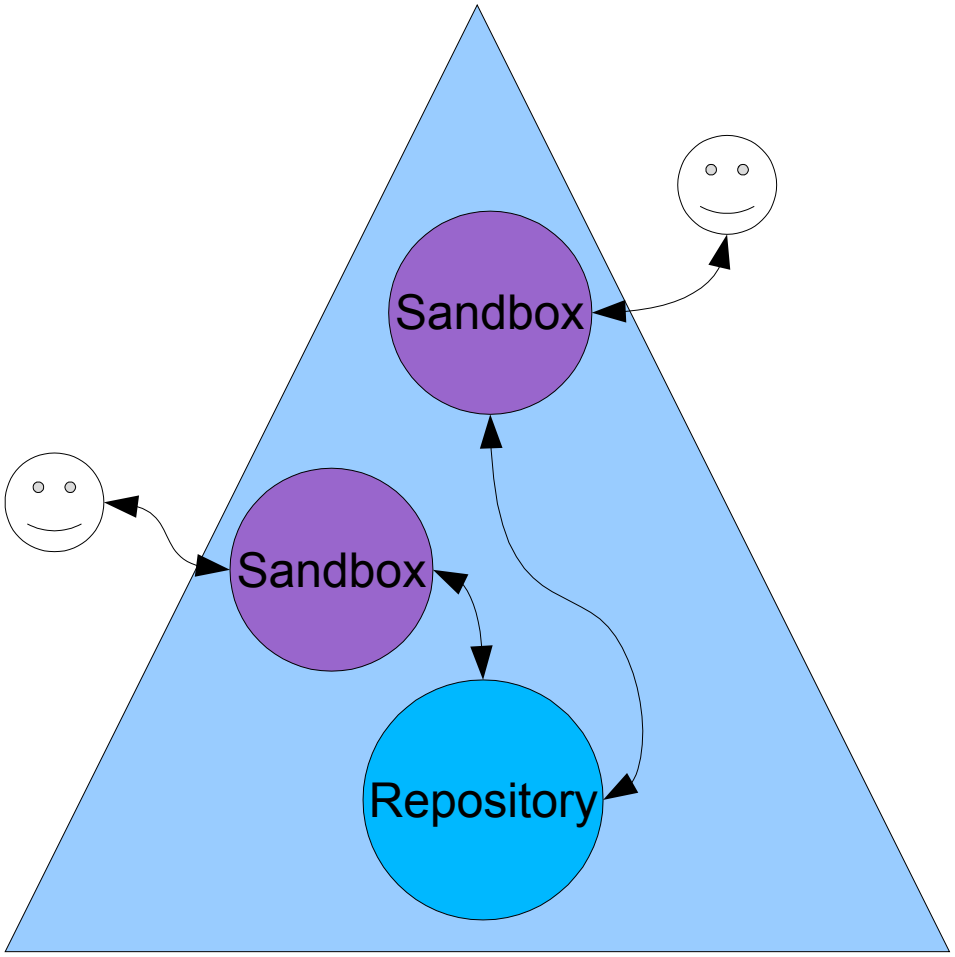
Or you can install it yourself on your own.

- **("Some assembly required")**

Git is a "distributed" source-control system

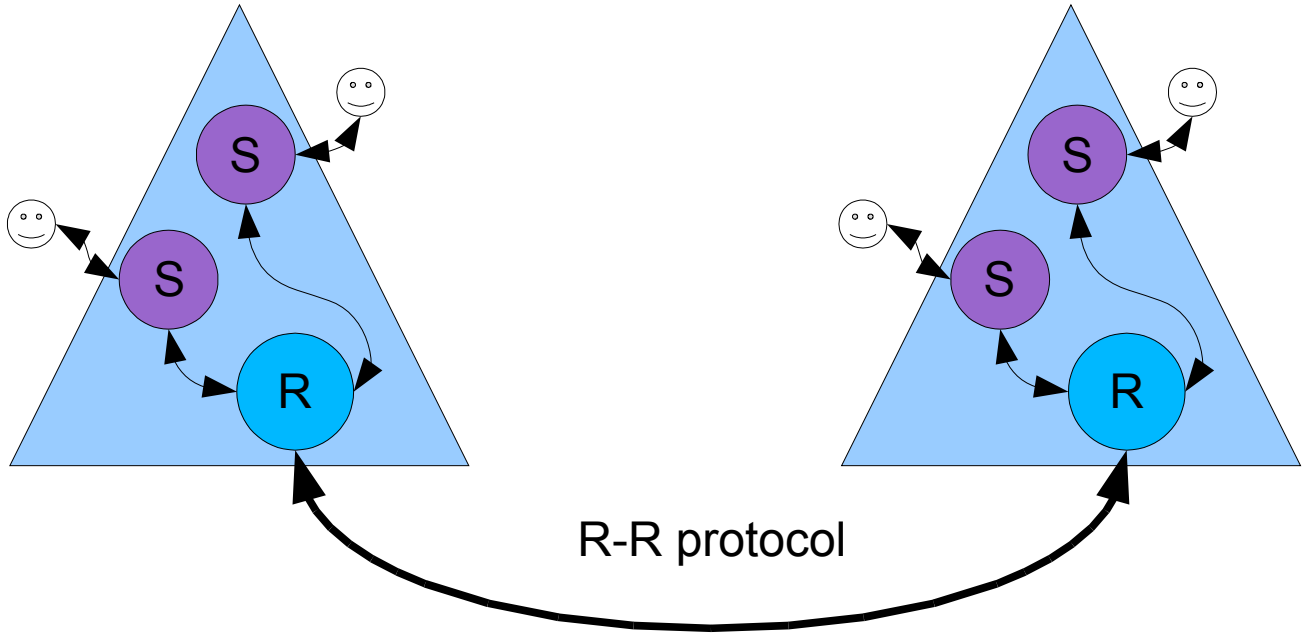
- **???**

Traditional “File System” Model



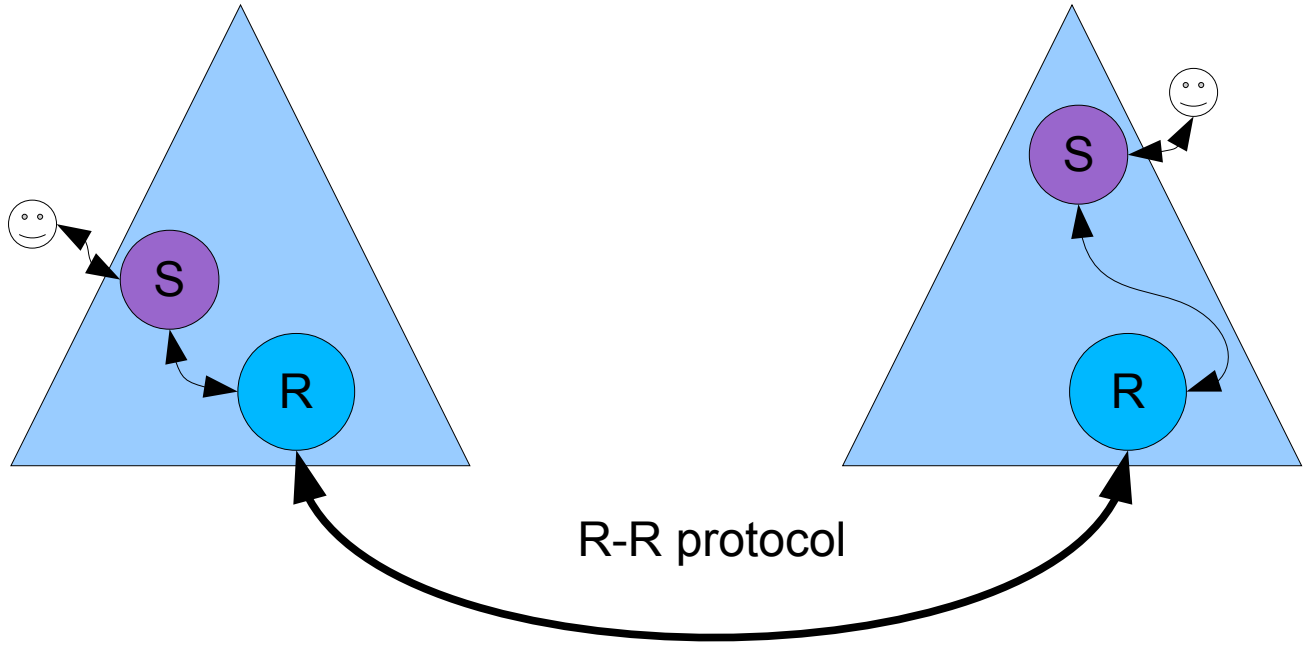
SCCS
CVS
SVN

“East-Coast / West-Coast” Model



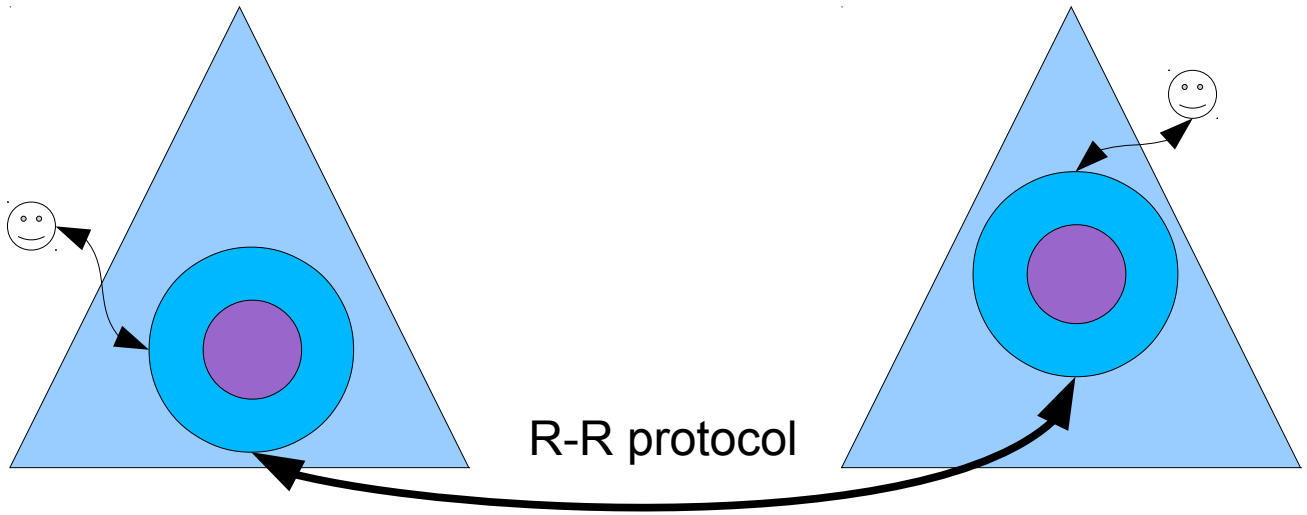
Inter-repository protocol runs “sometimes”.
Conflicts are tricky.
Perforce does this.

Laptop Model!



∀ laptop
  Sandbox-repository protocol.
  Also, inter-repository protocol.
  More protocols == more fun?

“Distributed Version Control”



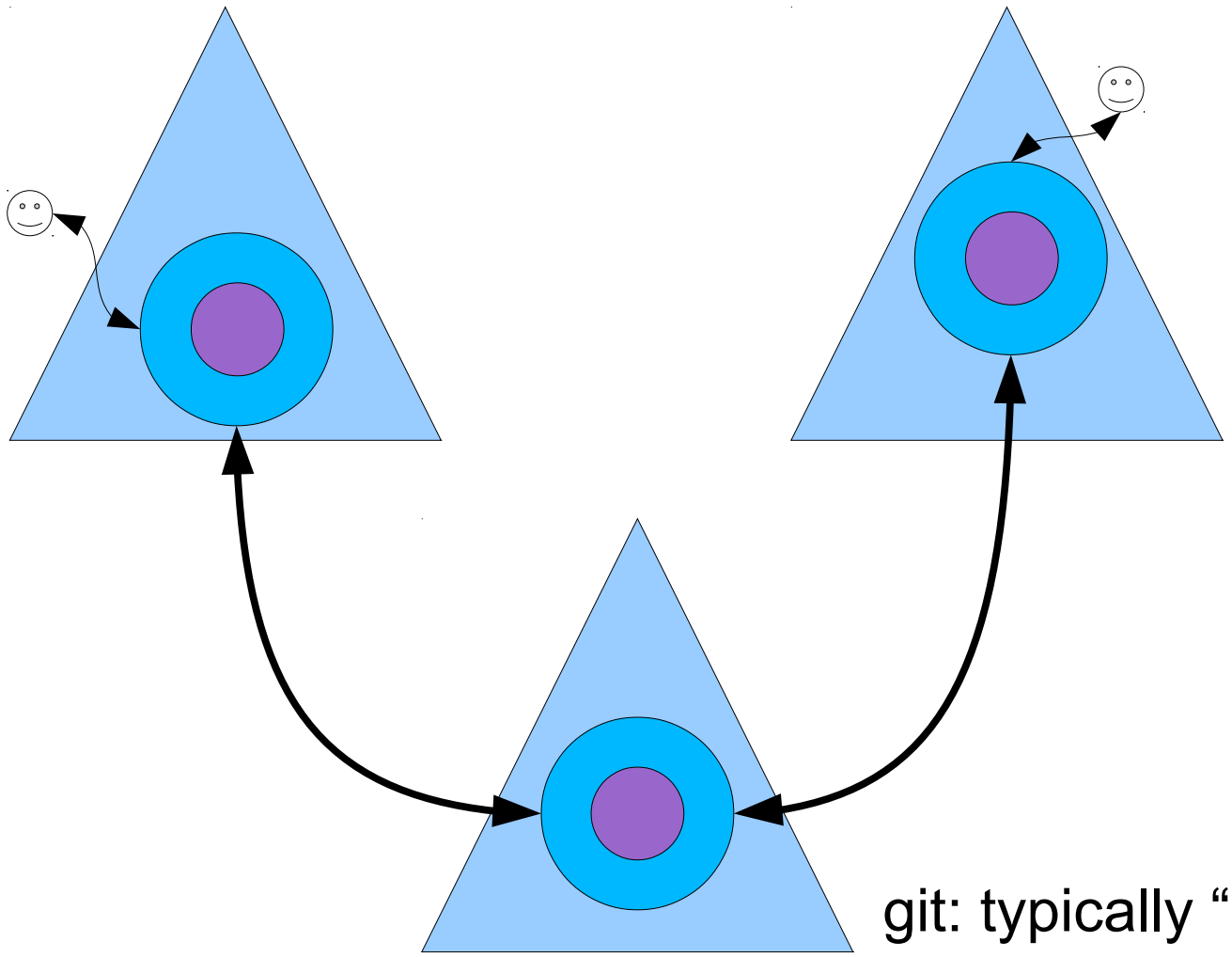
Repository holds current files *and* metadata.

Inter-repository protocol is tricky (no “before”).

Whose laptop do we release to customers from??

hg, git
darcs

“The Repository”



git: typically “bare”

Creating A New Project

Anywhere, but safest in a blank directory:

```
$ git init
```

Creates a ".git" subdirectory

- **Contains a hash-tree of all entities ever seen by the version control system.**
- **Also contains things like config, heads, remotes, and other goodies.**

Populating the world

Adding Files

```
$ git add file1 file2 ...
```

- To add *every* file in a directory

```
$ git add dir/
```

  - Rarely what you want!!!

These are "staged" operations...

- "Add" requires a commit just like "edit" does.

Checking In

Commit Yourself!

```
$ git commit -a
```

- Fires up your $EDITOR and asks you for commentary.
- Can restrict which files on the command line, or even use --interactive.
- Adds a new snapshot to *LOCAL* repository's history
  - Your partner has *no idea that this has happened.*

Sharing Your Work

How do changes become non-local?

Pull

```
$ git pull [remote-path/URL]
```

- Pulls changes from a remote repository.
- Git has a notion of "default remote"

Push

```
$ git push [remote-path/URL]
```

- Pushes changes from the local repo into the remote.

Checking Out A Project

Making a new checkout:

```
$ git clone remote-path/URL [local-name]
```

- Clones the remote repository
- All set for you to work in.
- The default push/pull target is the remote you copied.

You can use this mechanism to "branch".

- Git also supports named branches in a repo.
- See "man git-branch" or any of the other docs.

Conflicts and Merging

Suppose this hello.c is in the repository:

```
#include <stdlib.h>
#include <stdio.h>

int main(void)
{
        printf("Hello World!\n");
        return 0;
}
```

Conflicts and Merging

Suppose Alice and Charlie each check out this version, and make changes:

Alice's Version

```
#include <stdlib.h>
#include <stdio.h>

#define SUPER 0

int main(void)
{
        /* prints "Hello World"
           to stdout */
        printf("Hello World!\n");
        return SUPER;
}
```

Charlie's Version

```
#include <stdlib.h>
#include <stdio.h>

int main(void)
{
        /* this, like, says
           hello, and stuff */
        printf("Hello Hercules!\n");
        return 42;
}
```

Conflicts and Merging

Suppose Alice "checks in" first

```
$ git commit -a ⇒ ok
$ git push      ⇒ ok
```

Now Charlie...

```
$ git commit -a ⇒ ok, but invisible to Alice
$ git push      ⇒ fail!
$ git pull      ⇒ Alice's changes "appear"
$ ...edit...
$ git commit -a && git push
```

Merge Mutilation

There wasn't a conflict “here”
Conflicts are entirely textual!

commit:file name

Division between conflicting commits

```
#include <stdlib.h>
#include <stdio.h>

#define SUPER 0

int main(void)
{
<<<<<<<< HEAD:hello.c
        /* this, like, says hello, and stuff */
        printf("Hello Hercules!");
        return 42;
========
        /* prints "Hello World" to stdout */
        printf("Hello World!");
        return SUPER;
>>>>>>>> 12341234abcd5656efef78789090012345678 9ab:hello.c
}
```

Information

To get a summary of changes:

```
$ git status
```

To ask about changes in the past:

```
$ git log
```

Suggestions

"Commit early and often"

- So you can locally track history, roll back...

"Push good news"

- Build, test, push to shared space

"Pull often"

- Big merges are painful merges

Develop a convention for commit entries

- Type of revision (bug-fix, commenting, etc.)
- Meaningful, short descriptions

Suggestions

"Backups"

- "push" and "pull" do a lot
- Snapshotting your central repository every now and then may be smart

When to branch?

- Bug fixing?
  - Check out, fix, check in to same branch
- Trying COW fork since regular fork works?
  - Branching probably a good idea.
- For "backed up but not released to partner"

Summary

We can now:

- Create projects
- Check source in/out
- Merge, and
- Branch

See GIT documentation

- 15-410 “git intro” web page – specific help
- Lots of documentation online (*many* features)
- Search for “git tutorial”

Further Reading

“Git for Computer Scientists”

“Git from the Bottom Up”

“Git Magic”

“How to use git to lose data”