# Software Tools
# Version Control

Part II - Lecture 6

# Today's Outline

- Introduction to Version Control
- Managing Concurrency
- Decentralized Version Control

# Introduction to Version Control

*The only constant is change.*
*(Heraclitus)*

# Version Control

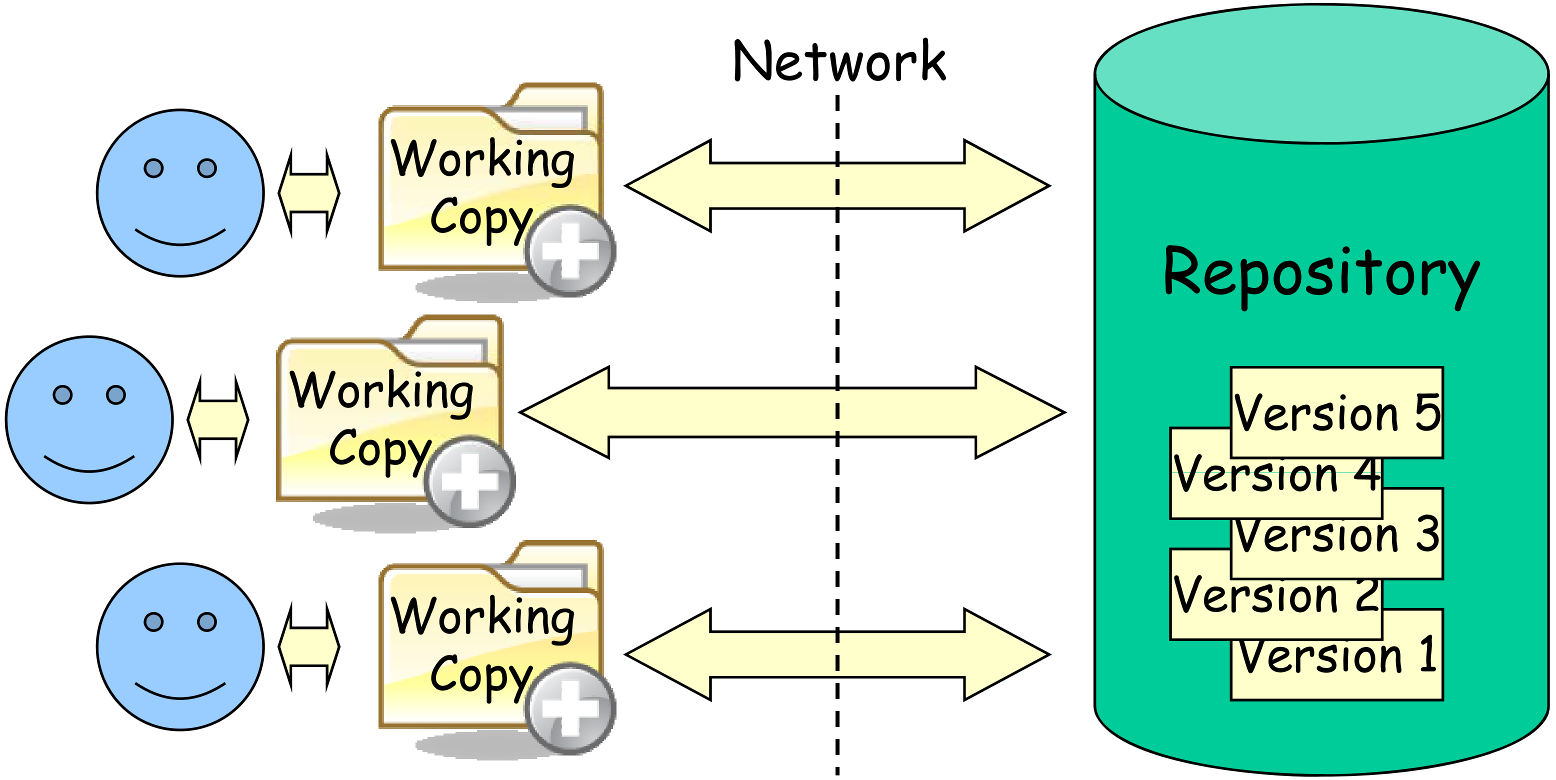
Common problems in a software project:

- A change needs to be undone
- Old code that was overwritten would be useful again
- Several developers work on the same program part simultaneously
- How do I get the latest version of the code?

The solution: a Version Control System (VCS)

- Manages a common repository for all artefacts
- Controls concurrent access
- Creates new version for each change (redo/undo possible)
- Helps to merge several contributions to same part

# Version Control System



- Developers work on their local working copies
- Developers synchronize their working copy with the repository
- Repository usually uses delta encoding for the versions
- Two ways to avoid conflicts: reserved vs. unreserved checkouts

# Product Space and Version Space

**Product space**: What is versioned? How is the data organized?

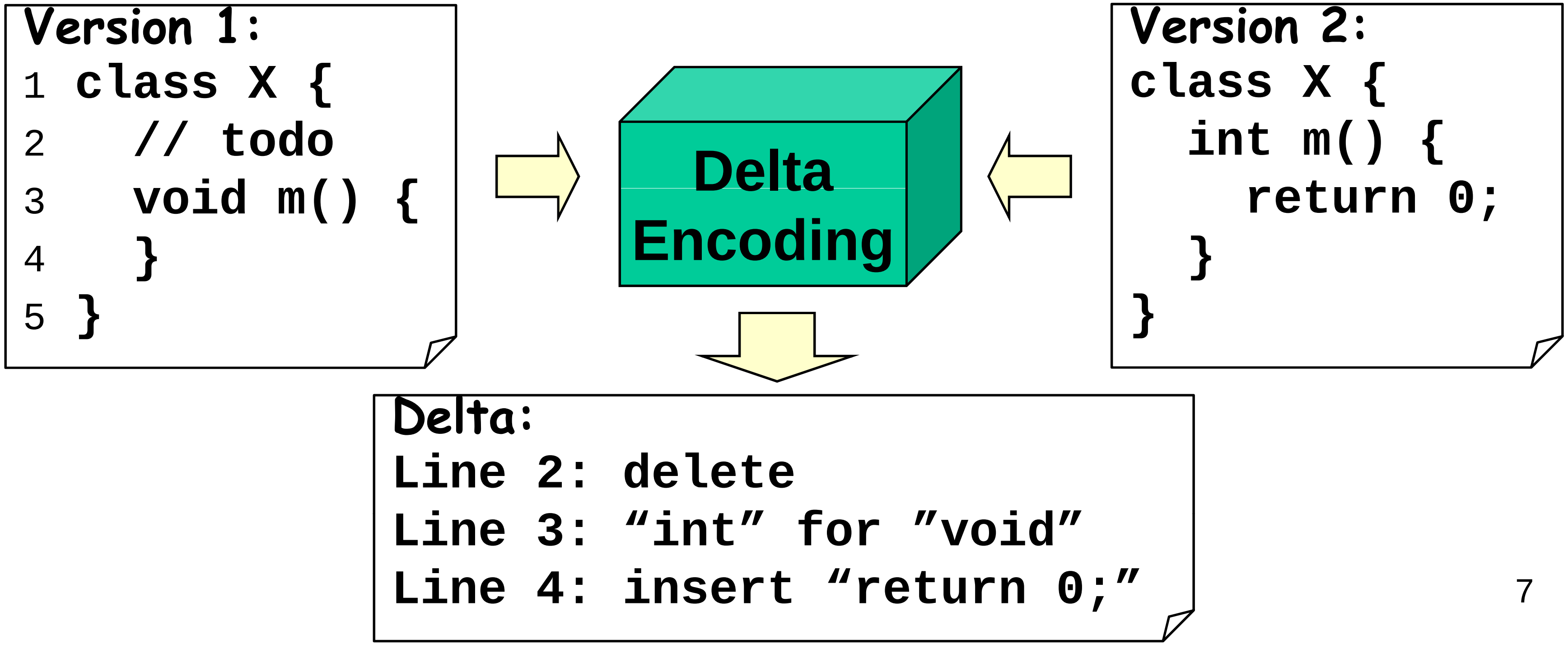
- Just files: each file has a version number which is increased when the file is changed (e.g. CVS)
- Files and folders: the whole file-folder structure has a single version number which is increased for any change done to any file/folder (e.g. SVN)

**Version Space**: How is the data versioned? How are versions organized?

- Serial number (1, 2, 3, …), build date (e.g. 20060901), …
- X.Y.Z (major version . minor version . build)
  - Sometimes odd Y signifies development branch (e.g. Linux)
  - Usually:
    - Change of X: breaks compatibility, adds substantial new features
    - Change of Y: compatible, new features added
    - Change of Z: maintenance/bugfix release
- Special versions: alpha, beta, RC (Release Candidate)

# Delta Encoding

- Storing every version of a file takes up a lot space
- Idea: just store differences between versions
- Differences ("deltas" / "diffs") can be calculated automatically with various algorithms
- Deltas can be recorded in a separate file and used to update files (e.g. for "patches")



**Version 1:**

```
1 class X {
2   // todo
3   void m() {
4   }
5 }
```

**Version 2:**

```
class X {
  int m() {
    return 0;
  }
}
```

**Delta:**

```
Line 2: delete
Line 3: "int" for "void"
Line 4: insert "return 0;"
```

# Branches & Tags

Branches: different copies of a project which are developed simultaneously; “self-maintained lines of development” (**/branches**)

- One main branch (**/trunk**)
- Maintenance branches: used for maintaining old versions which are still widely used (e.g. commercial OS)
- Experimental branches: used for trying out new features before merging them into the trunk
- Personal developer branches: for people trying out their own ideas

Tags: particular marked versions of the project (**/tags**)

- Can be used to refer to and recreate an old version
- Actually also like a copy of the project at a particluar point in time
- Difference to branches: usually not changed any more

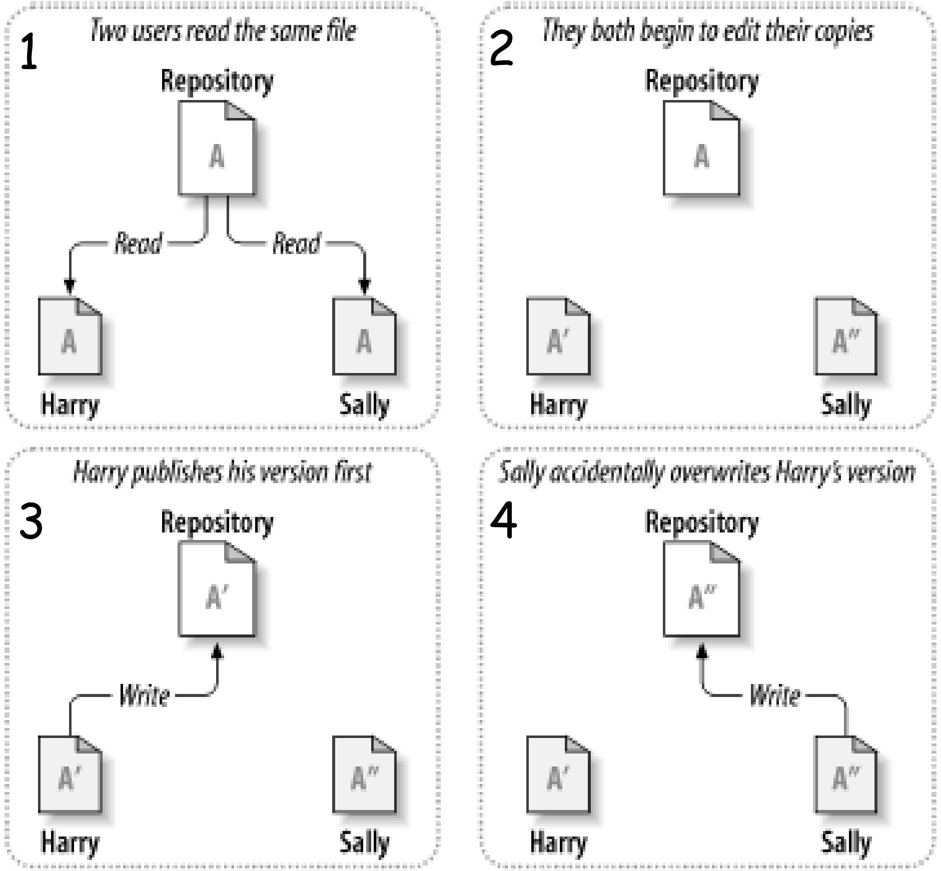
# Version Control Best Practices

1. Complete one change at a time and commit it
   - If you committing several changes together you cannot undo/redo them individually
   - If you don't commit and your hard disk crashes…
2. Only commit changes that preserve system integrity
   - No "breaking changes" that make compilation or tests fail
3. Commit only source files (e.g. not `.class` files)
4. Write a log entry for each change
   - What has been changed and why
5. Communicate with the other developers
   - See who else is working on a part before changing it
   - Discuss and agree on a design
   - Follow the project guidelines & specifications

# Managing Concurrency

# Concurrent File Access: "Lost Update" Problem

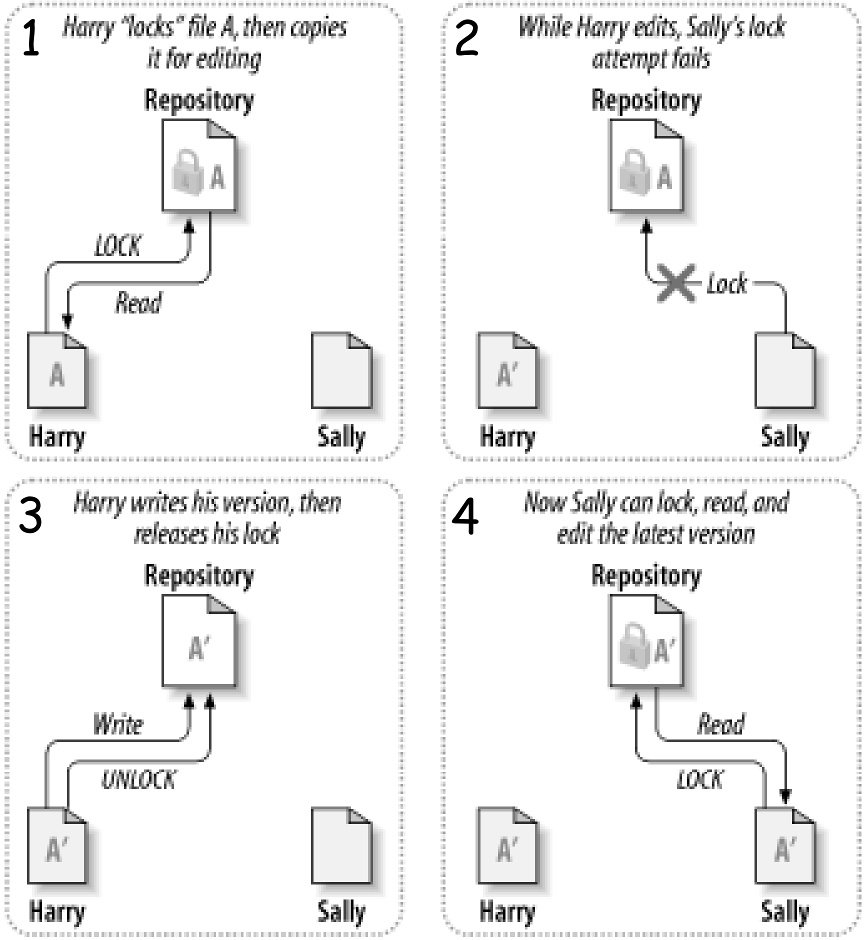
- When sharing files developers can accidentally overwrite each others changes
- Consider two developers working on the same file
- Two approaches for solving this:
  - Reserved checkouts ("locking")
  - Unreserverd checkouts ("merging")
- Many old version control systems support only locking (e.g. RCS, SCCS)
- Newer systems offer merging
- Both approaches have disadvantages


1
Two users read the same file
Repository
A
Read
Read
A
A
Harry
Sally
2
They both begin to edit their copies
Repository
A
A′
A″
Harry
Sally
3
Harry publishes his version first
Repository
A′
Write
A′
A″
Harry
Sally
4
Sally accidentally overwrites Harry's version
Repository
A″
Write
A′
A″
Harry
Sally

Images taken from the SVN Book (see resources page)

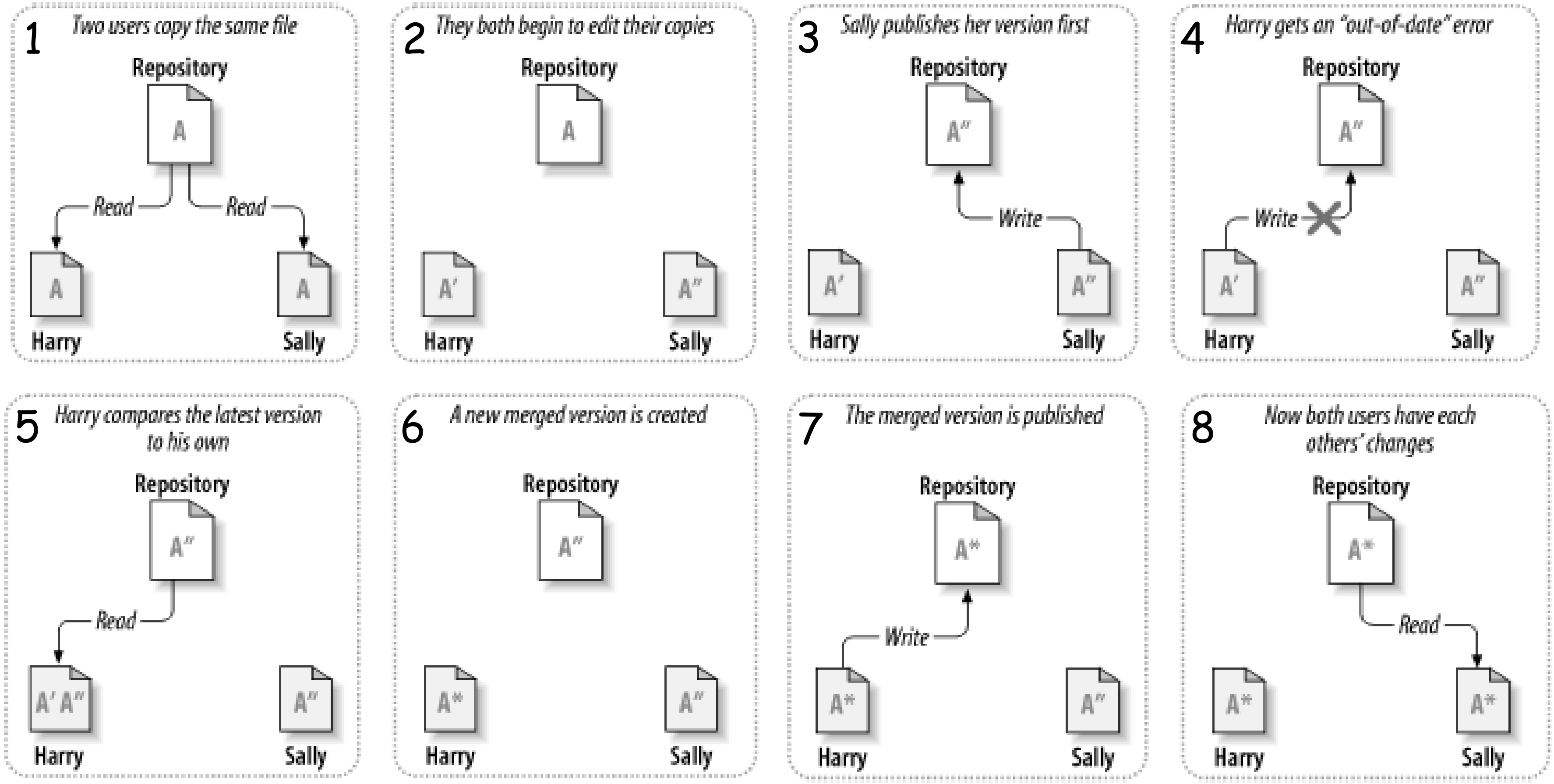
# Reserved Checkouts (Locking)

- Only one person can edit a file at a time
- Before getting write access developer has to acquire the lock of the file
- Attempts to get lock while someone else has it fail
- Sally has to wait for Harry to release the lock
- Access to files is serialized
- Workflow: lock-modify-unlock

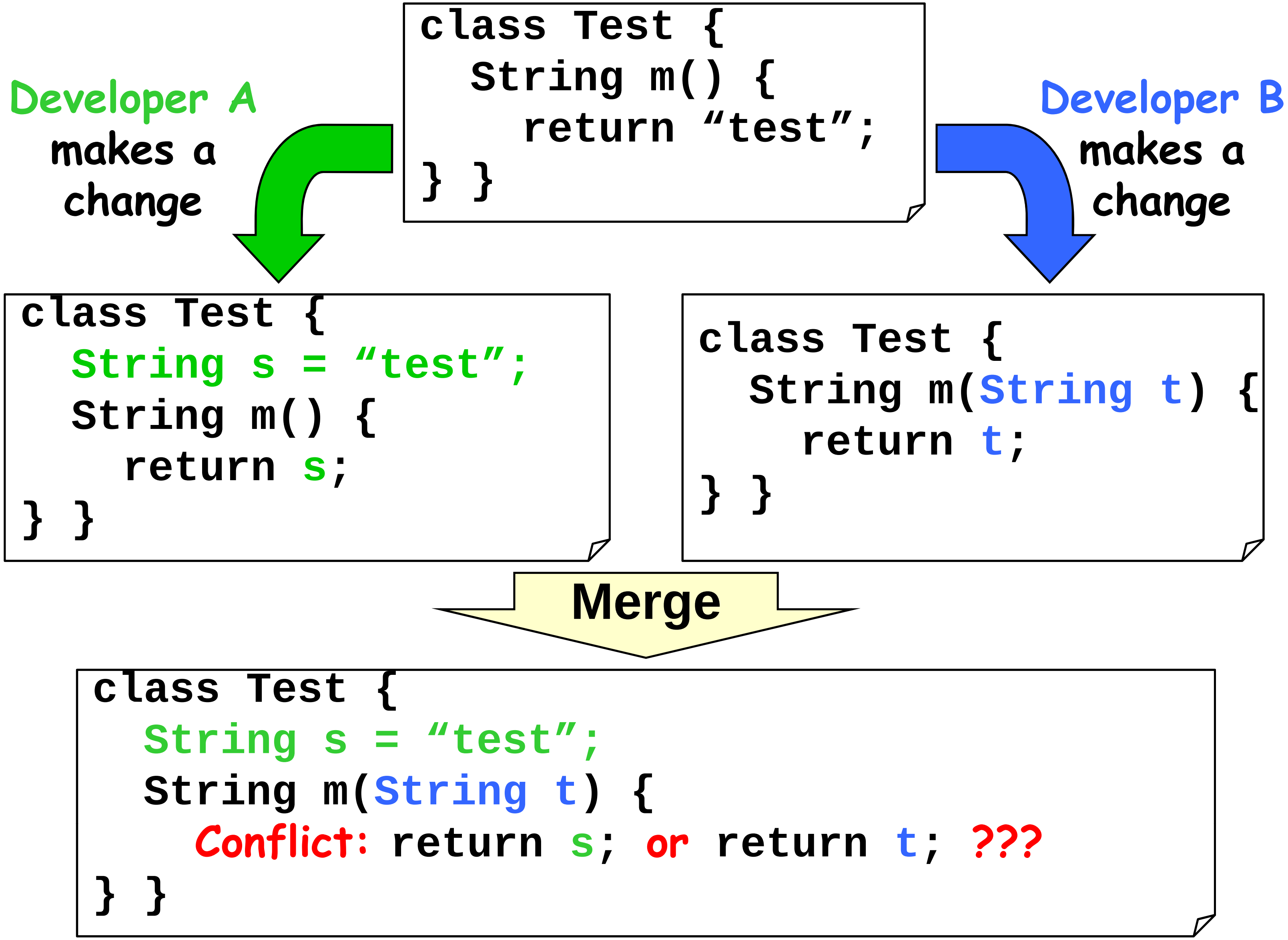

1 Harry "locks" file A, then copies it for editing
Repository
A
LOCK
Read
A
Harry
Sally
2 While Harry edits, Sally's lock attempt fails
Repository
A
Lock
A'
Harry
Sally
3 Harry writes his version, then releases his lock
Repository
A'
Write
UNLOCK
A'
Harry
Sally
4 Now Sally can lock, read, and edit the latest version
Repository
A'
Read
LOCK
A'
Harry
A'
Sally

# Unreserved Checkouts (Merging)

- Everybody can modify their working copy whenever they want
- But own changes have to be merged with changes of others before they can be written to repository (copy-modify-merge)


1 Two users copy the same file
Repository
A
Read
Read
A
A
Harry
Sally
2 They both begin to edit their copies
Repository
A
A′
A″
Harry
Sally
3 Sally publishes her version first
Repository
A″
Write
A′
A″
Harry
Sally
4 Harry gets an "out-of-date" error
Repository
A″
Write
A′
A″
Harry
Sally
5 Harry compares the latest version to his own
Repository
A″
Read
A′ A″
A″
Harry
Sally
6 A new merged version is created
Repository
A″
A*
A″
Harry
Sally
7 The merged version is published
Repository
A*
Write
A*
A″
Harry
Sally
8 Now both users have each others' changes
Repository
A*
Read
A*
A*
Harry
Sally

# Merging Example



```
class Test {
  String m() {
    return “test”;
} }
```

Developer A makes a change

```
class Test {
  String s = “test”;
  String m() {
    return s;
} }
```

Developer B makes a change

```
class Test {
  String m(String t) {
    return t;
} }
```

Merge

```
class Test {
  String s = “test”;
  String m(String t) {
    Conflict: return s; or return t; ???
} }
```

# Merging: Textual and Semantic Conflicts

- Textual conflicts
  - Changes of different developers are very close or overlapping each other ("overlap")
  - Merge tool cannot automatically combine them
  - Merge tool detects such conflicts & reports them to the user
  - Version control system will refuse to write a file with unresolved textual conflicts to the repository
- Semantic conflicts (logical conflicts)
  - Changes are semantically incompatible, but may not be overlapping (e.g. in different files)
  - E.g. developer A changes method signature of method `m`, developer B inserts method calls to `m` using the old signature
  - Non-overlapping semantic conflicts are not detected by a generic merge algorithm!!!
  - Can be avoided by following specifications and communicating with others
- Both textual and semantic conflicts have to be resolved by the user

# Locking vs. Merging

Arguments against locking and for merging

1. Administrative problems: people forget releasing their locks; frequently administrators have to do it
2. Unnecessary serialization: very counter-productive
   - Locking prevents people from editing different parts of the same file
   - In reality conflicts occur rarely and can be resolved without problems
   - Conflicts usually indicate lack of communication
     - Developers have not agreed on a proper design
     - With mutual agreement on design conflicts are usually straightforward to merge
3. False sense of security: locking does not prevent semantic conflicts of distributed changes (i.e. in different files)

# Locking vs. Merging

Arguments for locking and against merging

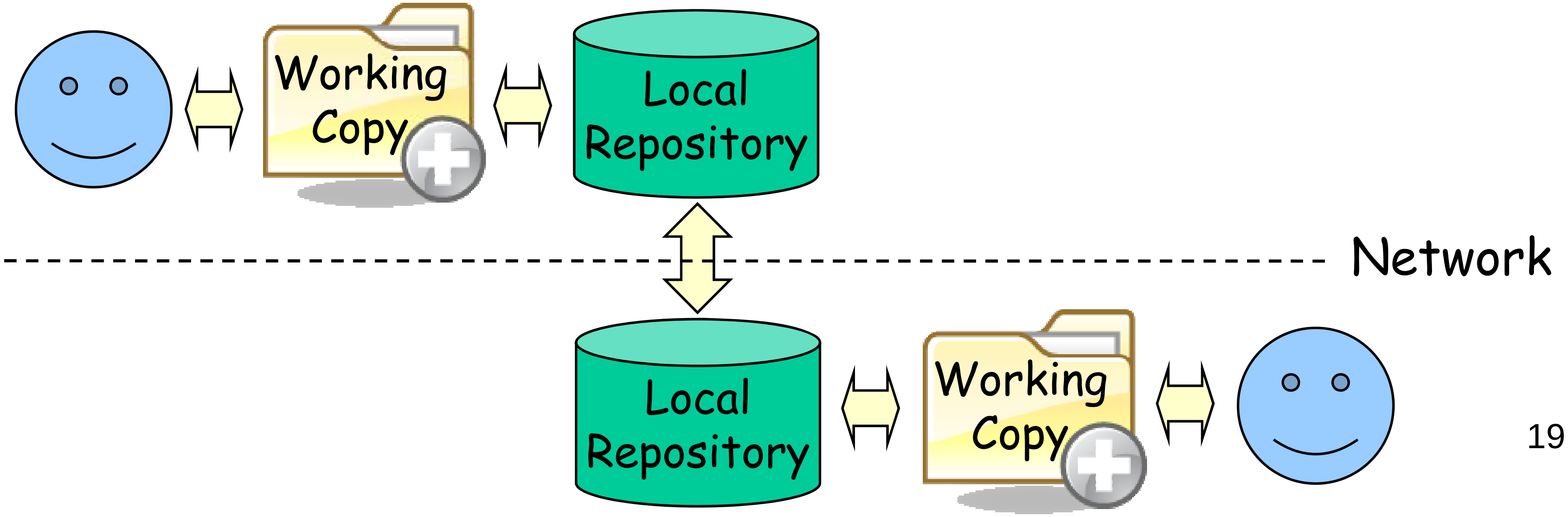
1. "Unmergeable" files: a generic merging tool does not work for all file types
   - For some formats (e.g. for graphics) generic merging leads to many conflicts
   - Conflicts can be very hard to resolve (e.g. for binary formats)
   - One of two conflicting changes get lost (because they cannot be merged)
2. Tradition: an organization might have always used a locking VCS

# Decentralized Version Control

# Decentralized Version Control

Every developer has their own local repository (a.k.a. “distributed version control”)

1. Developers work on their working copy
2. Developers commit changes of the working copy to their own local repository first
3. Changes can be exchanged between repositories (“pushed” and “pulled”)



# Branches, Push and Pull

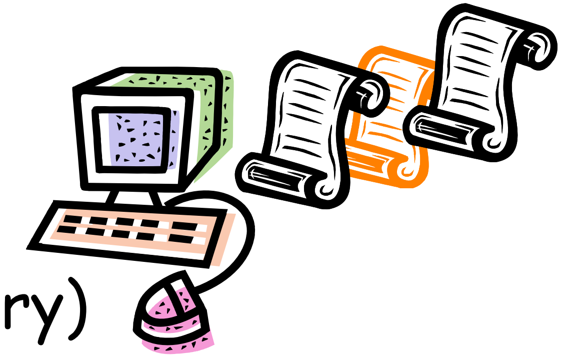
**Branches**

- Create a branch of a repository by cloning it
- I.e. get the content and the change history
- The branch and the original repository share a common ancestor version and can be merged later
- Main branch of a project called “trunk”

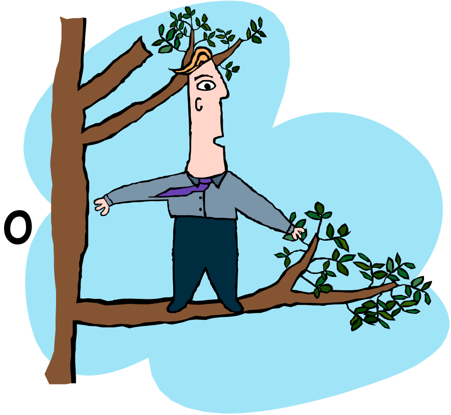
- Changes can be **pushed** from one branch to another (like committing changes from a working copy)
  - E.g. optimizations from an experimental branch to the trunk

- Changes can be **pulled** from one branch to another (like updating a working copy)

# Decentralized Version Control Advantages



- Versioning can be done locally (does not depend on central repository)
  1. Good if you don't have Internet connectivity
  2. Good if you don't have access to the main repo
  3. Good for bigger changes that involve many steps
- Easier to branch a repository (i.e. create a clone) keeping all its history (its previous versions)
  1. You can develop your own branch
  2. Because history of a branch is kept, changes can be easier merged back into the original repository
  3. Changes can also be merged into any other branch



# Summary

# Today's Summary

- A Version Control System manages the different versions of all artefacts in a project
- Many local working copies and one shared repository, compressed with delta encoding
- Prevents lost updates through reserved (locking) or unreserved (merging) checkouts
- Supports automatic merging and detects textual conflicts, but cannot detect non-textual sematic conflicts
- Conflicts always have to be resolved manually
- In decentralized version control systems every user has a full repository with several versions (not just a working copy)

# Quiz

1. What is delta encoding? Give an example.

2. What is the difference between locking and merging? When should each of it be used?

3. What is a semantic conflict? Why can it be a problem?

4. What is the main difference between centralized and decentralized version control?