Getting It Right

COMS W4115

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Getting It Right

Your compiler is a large software system developed by four people.

How do you get it right?

Subjects

- Team-oriented development
- Interface-oriented design
- Version control systems
- assert()
- Regression test suites
- Writing tests
- Code coverage
- Makefiles

Team-oriented Development

Basic challenge: Remove as many inter-person dependencies as possible.

One group asked if the lexer/parser person should finish before the tree walker person started.

Divide and conquer: try to make it so that each person can work at his/her own rate and not depend on others.

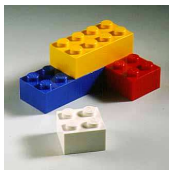
Tricky: each pass depends on the previous one.

Solution: careful design and modularity

Interface-oriented Development

Divide your compiler into a series of modules, e.g.,

1. Lexer/Parser
2. Static semantics
3. Code generation
4. Assembler



Clearly define the interface between each module.

You'll want to write this in your project report, anyway.

Make the interfaces the "contracts" between the team members.

Interface-oriented design

Write the interfaces first.

Document them well.

Write the public class definition, the method declarations, and the comments first.

Later, fill in code for each method, private fields, etc.

Use javadoc to extract documentation from your Java code and share with other group members

Version Control Systems

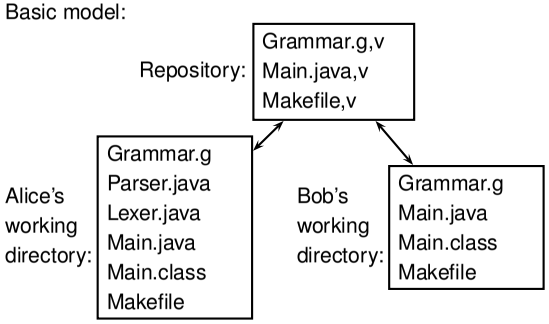
Four people working on a single program is not as easy as just one.

Need some way to make sure everybody's working on the same program.

Version control systems a good solution.

The CVS Version Control System

Basic model:



Using the CVS Version Control System

1. Prepare a repository
2. Add an empty sudirectory to the repository
3. Create a working directory
4. Add files, update directory, commit changes

One group member does 1,2 once.

Each group member does 3 once.

Each group member does 4 repeatedly.

Using CVS

Creating a working directory:

```
% mkdir mydir
% cd mydir
% cvs checkout ourproj
```

Editing, adding, and updating

```
% cd ourproj
```

edit files, compile, etc.

```
% cvs add Grammar.g
% cvs commit Grammar.g
% cvs update
```

Assert

```
class Foo {
    public static void main(String[] args) {
       assert false;
    }
}
```

```
% javac -source 1.4 foo.java
% java -ea Foo
Exception in thread "main"
    java.lang.AssertionError
        at Foo.main(foo.java:3)
```

Assert Philosophy

- Catch errors early and often
- Check function arguments are acceptable
  E.g., `assert n != null;`
- Check function return value is consistent
- Check constructor has filled in every field
- Check object state is consistent
- Check loop invariants
- For the really ambitious, write methods that check consistency of a whole data structure.

Regression test suites

How to avoid introducing new bugs when adding features?

Partial answer: build something that tells you whether you've broken the program.

Regression suite:

- collection of tests
- exercises as much of your program as possible
- results are compared with "golden" references

Regression tests

Easiest is when program takes a text file as input and produces text as output.

Fortunately, compilers behave like this.

Regression test inputs: short programs

Regression test golden references: assembly language

Example tests

```
module test_emit1:
type a;
type b;
input a;
input b : integer;
output c : integer;

emit a;
emit b;
emit c

end module
```

```
module test_emit2:
output a;
output b : integer;
output c : float;

emit a;
emit b(10);
emit c(5.0f)

end module
```

Writing Tests

Try to cover as much of your language as possible.

Try to write one test for each feature mentioned in the language reference manual.

Build sequences of tests that start with simple versions of a feature and build into the most complex.

Keep tests focused: easier to track down fault if one fails.

Running Tests

Easiest is to use a scripting language that

- invokes the test,
- compares the outputs, and
- logs results and any errors

For CEC, I wrote a shell script to do this.

Shell Script

Carefully runs two programs.

Compares output to reference file.

Stores results when it differs.

```
#!/bin/sh

STRLXML=./strlxml
XMLSTRL=./xmlstrl

globallog=teststrlxml.log
rm -f $globallog
error=0
```

Shell Script

```
Check() {
  basename=`echo $1 | sed 's/.*\\///
                           s/.strl//'`
  reffile=`echo $1 | sed 's/.strl$/.out/'`
  xmlfile=${basename}.xml
  outfile=${basename}.out
  difffile=${basename}.diff
  echo -n "Parsing $basename..."
  echo "Parsing $basename" 1>&2
  $STRLXML < $1 > $xmlfile 2>&1 || {
    echo "FAILED: strlxml terminated"
    error=1 ; return 1
  }
  $XMLSTRL < $xmlfile > $outfile 2>&1 || {
    echo "FAILED: xmlstrl terminated"
    error=1 ; return 1
  }
```

Shell Script

```
  diff -b $reffile $outfile > $difffile 2>&1 || {
    echo "FAILED: output mismatch"
    error=1 ; return 1
  }
  rm $xmlfile $outfile $difffile
  echo OK
}

for file in tests/test*.strl
do
  Check $file 2>> $globallog
done

exit $error
```

Code coverage

Basic idea: your test suite should at least send the program counter over every part of your code.

To measure coverage, need some sort of tool that can tell when each line of code is executed.

I found a couple of them:

- gcov: works with gcc to report for C (C++?)
- clover: Commercial tool for Java, but free for students and open-source developers

There are many more.

Example of gcov

```
$ gcc -fprofile-arcs -ftest-coverage tmp.c
$ a.out
$ gcov tmp.c
87.50% of 8 source lines executed in file tmp.c
Creating tmp.c.gcov.
```

```
        main() {
     1      int i, total;
     1      total = 0;
    11      for (i = 0; i < 10; i++)
    10        total += i;
     1      if (total != 45)
######        printf ("Failure\n");
            else
     1        printf ("Success\n");
     1    }
```

Makefiles

How do you make it easy to compile your compiler?

Need to run ANTLR to generate files, then run javac on the results.

How do you make sure everything gets compiled when needed?

A Basic Makefile

```
% cat Makefile
Simp.class : Simp.java
        javac Simp.java
% make Simp.class
javac Simp.java
% make Simp.class
make: `Simp.class' is up to date.
%
```

A More Complicated Makefile

```
JAVASRC = SimpParser.java SimpWalker.java \
          SimpLexer.java SimpParserTokenTypes.java

SimpParser.class : $(JAVASRC)
        javac $(JAVASRC)

SimpParser.java SimpLexer.java : Simp.g
        java antlr.Tool Simp.g

clean :
        rm -f *.class SimpParserTokenTypes.txt \
        SimpParser.java SimpWalker.java \
        SimpLexer.java \
        SimpParserTokenTypes.java
```

A More Complicated Makefile

```
% make
java antlr.Tool Simp.g
ANTLR Parser Generator   Version 2.7.1   1989-2000 jGuru
javac SimpParser.java SimpWalker.java SimpLexer.java Sim
% rm SimpParser.class
% make
javac SimpParser.java SimpWalker.java
  SimpLexer.java SimpParserTokenTypes.java
% make clean
rm -f *.class SimpParserTokenTypes.txt \
SimpParser.java SimpWalker.java \
SimpLexer.java \
SimpParserTokenTypes.java
```

Writing Makefiles

Rules take the form:

target : *source source ...*
commands

tab

Variable definition and use:

variable = value

$(*variable*)