

Chapter 15 Debugging

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Debugging with High Level Languages

- ◆ **Same goals as low-level debugging**
 - Examine and set values in memory
 - Execute portions of program
 - Stop execution when (and where) desired
- ◆ **Want debugging tools to operate on high-level language constructs**
 - Examine and set variables, not memory locations
 - Trace and set breakpoints on statements and function calls, not instructions
 - ... but also want access to low-level tools when needed

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Types of Errors

- ◆ **Syntactic Errors**
 - Input code is not legal
 - Caught by compiler (or other translation mechanism)
- ◆ **Semantic Errors**
 - Legal code, but not what programmer intended
 - Not caught by compiler, because syntax is correct
- ◆ **Algorithmic Errors**
 - Problem with the logic of the program
 - Program does what programmer intended, but it doesn't solve the right problem

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Syntactic Errors

- ◆ Common errors:
 - missing semicolon or brace
 - mis-spelled type in declaration
- ◆ One mistake can cause an avalanche of errors
 - because compiler can't recover and gets confused

```

int main () {
  int i ← missing semicolon
  int j;
  for (i = 0; i <= 10; i++) {
    j = i * 7;
    printf("%d x 7 = %d\n", i, j);
  }
}

```

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Semantic Errors

Common Errors

- Missing braces to group statements together
- Confusing assignment with equality
- Wrong assumptions about precedence/associativity
- Wrong limits on for-loop counter
- Uninitialized variables

```
int main () {  
    int i  
    int j;  
    for (i = 0; i <= 10; i++)  
        j = i * 7;  
    printf("%d x 7 = %d\n", i, j);  
}
```

missing braces, so printf
not part of for loop

Algorithmic Errors

- Design is wrong, so program does not solve the correct problem
- Difficult to find
 - Program does what we intended
 - Problem might not show up until after many runs
- Maybe difficult to fix
 - May have to redesign
 - May have large impact on program code
- Classic example: Y2K bug
 - only allow 2 digits for year, assuming 19__

Debugging Techniques

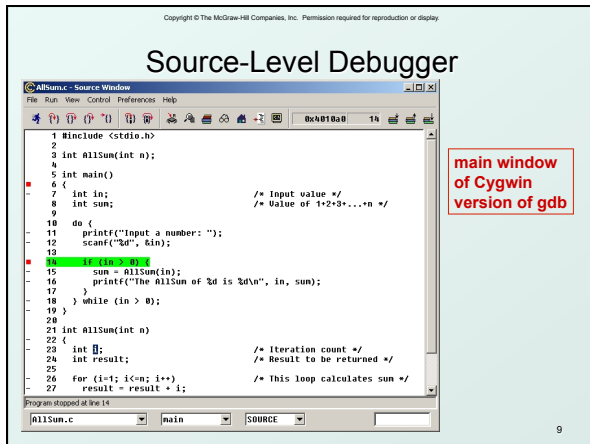
Ad-Hoc

- Insert printf statements to track control flow and display values
- Add code to explicitly check for values out of expected range, incorrect branches, etc.
- Advantage:
 - No special debugging tools needed
- Disadvantages:
 - Frequent recompile and execute cycles makes this method time-consuming
 - Requires intimate knowledge of code
 - Inserted code can be buggy

Debugging Techniques

Source-Level Debugger

- Examine and set variable values
- Tracing, breakpoints, single-stepping on source-code statements



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Source-Level Debugging Techniques

- ◆ **Breakpoints**
 - Stop when a particular statement is reached
 - Stop at entry or exit of a function
 - **Conditional breakpoints:**
Stop if a variable is equal to a specific value, etc.
 - **Watchpoints:**
Stop when a variable is set to a specific value
- ◆ **Single-Stepping**
 - Execute one statement at a time
 - Step “into” or step “over” function calls
 - ◆ **Step into:** next statement is first inside function call
 - ◆ **Step over:** execute function without stopping
 - ◆ **Step out:** finish executing function, stop on exit

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Source-Level Debugging Techniques

- ◆ **Displaying Values**
 - Show value consistent with declared type of variable
 - Dereference pointers (variables that hold addresses)
 - See Chapter 16
 - Inspect parts of a data structure
 - See Chapters 19

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