

## Finding the Error

- Unit tests cannot find the source of an error
- Idea: "Visualize" the program with print statements

```
def last_name_first(n):
    """Returns: copy of <n> in form <last>, <first>"""
    end_first = n.find(' ')
    print end_first
    first = n[:end_first]
    print 'first is '+str(first)
    last = n[end_first+1:]
    print 'last is '+str(last)
    return last+', '+first
```

Print variable after each assignment

Optional: Annotate value to make it easier to identify

## Structure vs. Flow

### Program Structure

### Program Flow

- Way statements are presented
  - Order statements are listed
  - Inside/outside of a function
  - Will see other ways...
- Order statements are executed
  - Not the same as structure
  - Some statements duplicated
  - Some statements are skipped
- Indicate possibilities over **multiple executions**
- Indicates what really happens in a **single execution**

Have already seen this difference with functions

## Structure vs. Flow: Example

### Program Structure

### Program Flow

```
def foo():
    print 'Hello'
# Application code
if __name__ == 'main':
    foo()
    foo()
    foo()
```

Statement listed once

>>> python foo.py  
'Hello'  
'Hello'  
'Hello'

Statement executed 3x

Bugs can occur when we get a flow other than one that we were expecting

## Conditionals: If-Statements

### Format

### Example

```
if <boolean-expression>:
    <statement>
    ...
    <statement>
```

# Put x in z if it is positive  
if x > 0:  
| z = x

### Execution:

if <boolean-expression> is true, then execute all of the statements indented directly underneath (until first non-indented statement)

## Conditionals: If-Else-Statements

### Format

### Example

```
if <boolean-expression>:
    <statement>
    ...
else:
    <statement>
    ...
```

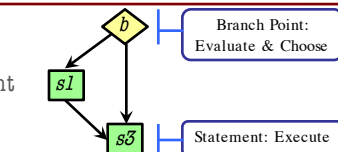
# Put max of x, y in z  
if x > y:  
| z = x  
else:  
| z = y

### Execution:

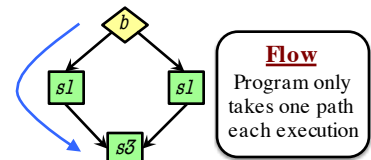
if <boolean-expression> is true, then execute statements indented under if; otherwise execute the statements indented under else

## Conditionals: "Control Flow" Statements

```
if b:
    s1 # statement
s3
```



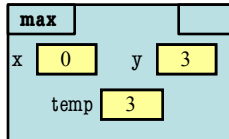
```
if b:
    s1
else:
    s2
s3
```



## Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x,y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp
    return y
```

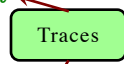
- temp is needed for swap
  - x = y loses value of x
  - “Scratch computation”
  - Primary role of local vars
- max(3,0):



## Program Flow and Testing

- Must understand which flow caused the error
  - Unit test produces error
  - Visualization tools show the current flow for error
- Visualization tools?
  - print statements
  - Advanced tools in IDEs (Integrated Dev. Environ)

```
# Put max of x, y in z
print 'before if'
if x > y:
    print 'if x>y'
    z = x
else:
    print 'else x<=y'
    z = y
print 'after if'
```



## Watches vs. Traces

### Watch

- Visualization tool (e.g. print statement)
- Looks at **variable value**
- Often after an assignment
- What you did in lab

### Trace

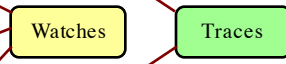
- Visualization tool (e.g. print statement)
- Looks at **program flow**
- Before/after any point where flow can change

## Traces and Functions

```
def shift(p):
```

```
    print 'Start shift()'
    p.x = p.y
    print p.x
    p.y = p.z
    print p.y
    p.z = p.x
    print p.z
    print 'End shift()'
```

Example: flow.py



## Local Variables Revisited

- Never refer to a variable that might not exist
- Variable “**scope**”
  - Block (indented group) where it was first assigned
  - Way to think of variables; not actually part of Python
- Rule of Thumb:** Limit variable usage to its scope

```
def max(x,y):
    """Returns: max of x,y"""
    # swap x, y
    # put larger in temp
    temp = y
    if x > y:
        temp = x
    return temp
```

First assigned

Inside scope

## Conditionals: If-Elif-Else-Statements

### Format

```
if <boolean-expression>:
    <statement>
...
elif <boolean-expression>:
    <statement>
...
else:
    <statement>
...
```

### Example

```
# Put max of x, y, z in w
if x > y and x > z:
    w = x
elif y > z:
    w = y
else:
    w = z
```