# The Game Development Process: Debugging

## Introduction

- Debugging is methodical process for removing mistakes in program
- So important, whole set of tools to help. Called "debuggers"
  - Trace code, print values, profile
  - New Integrated Development Environments (IDEs) (such as Game Maker) have it built in
- But debugging still frustrating
  - Beginners not know how to proceed
  - Even advanced can get "stuck"
- Don't know how long takes to find
  - Variance can be high
- What are some tips? What method can be applied?

## Outline

- 5-step debugging process
- Prevention
- Game Maker specifics
- Debugging tips

## Step 1: Reproduce the Problem Consistently

- Find case where always occurs
  - "Sometimes game crashes after kill boss" doesn't help much
- Identify steps to get to bug
  - Ex: start single player, room 2, jump to top platform, attack left, …
  - Produce systematic way to reproduce

## Step 2: Collect Clues

- Collect clues as to bug
  - Clues suggest where problem might be
  - Ex: if crash using projectile, what about that code that handles projectile creation and shooting?
- And beware that some clues are false
  - Ex: if bug follows explosion may think they are related, but may be from something else
- Don't spend too long - get in and observe
  - Ex: see reference pointer from arrow to unit that shot arrow should get experience points, but it is NULL
  - That's the bug, but why is it NULL?

## Step 3: Pinpoint Error

1) *Propose a hypothesis* and prove or disprove
  - Ex: suppose arrow pointer corrupted during flight. Add code to print out values of arrow in air. But equals same value that crashes. *Hypothesis is wrong*. But now have new clue.
  - Ex: suppose unit deleted before experience points added. Print out values of all in camp before fire and all deleted. *Yep, that's it.*

Or, 2) *divide-and-conquer* method (note, can use with hypothesis test above, too)
  - Sherlock Holmes: "when you have eliminated the impossible, whatever remains, however improbably, must be the truth"
  - Setting breakpoints, look at all values, until discover bug
  - The "divide" part means break it into smaller sections
    - Ex: if crash, put breakpoint ½ way. Is it before or after?
  - Repeat.
  - Look for anomalies, NULL or NAN values

## Step 4: Repair the Problem

- Propose solution. Exact solution depends upon stage of problem.
  - Ex: late in code cannot change data structures. Too many other parts use.
  - Worry about "ripple" effects.
- Ideally, want original coder to fix
  - If not possible, at least try to talk with original coder for insights.
- Consider other similar cases, even if not yet reported
  - Ex: other projectiles may cause same problem as arrows did

## Step 5: Test Solution

- Obvious, but can be overlooked if programmer is sure they have fix (but programmer can be wrong!)
- So, test that solution repairs bug
  - Best by independent tester
- Test if other bugs introduced (beware "ripple" effect)

## Outline

- 5-step debugging process (done)
- Prevention (next)
- Game Maker specifics
- Debugging tips

## Debugging Prevention

- Add infrastructure, tools to assist
  - Alter game variables on fly (speed up debugging)
  - Visual diagnostics (maybe on avatars)
  - Log data (events, units, code, time stamps)
- Indent code, use comments (in Game Maker)
- Use consistent style, variable names
  - Ex: spr_boss, obj_boss
- Avoid duplicating code – hard to fix if bug
  - Use a script
- Avoid hard-coded values – makes brittle
- Always initialize variables when declared
- Verify coverage (test all code) when testing

## Outline

- 5-step debugging process (done)
- Prevention (done)
- Game Maker specifics (next)
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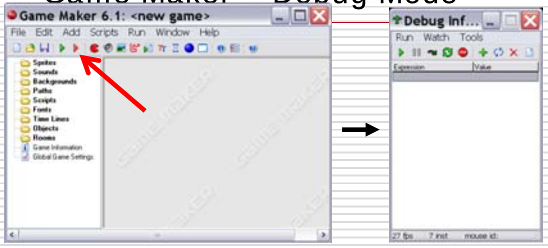
## Game Maker – Print Messages

- Display a Message
  - object → main2 → info
- Or, in code (control → code)
  - `show_message("Executed this code")`
  - `show_message("num:" + string(num_here))`
- Beware if done every step!
  - Save code ahead of time
  - Use task manager to kill
    - Ctrl-Alt-Delete → Task Manager
    - Process is name of game file, not GameMaker.exe

## Game Maker – Debug Mode

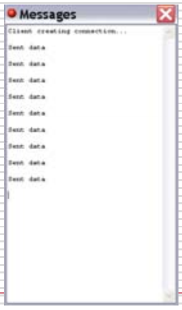


- Ex: easy
  - obj_hero.y
  - obj_hero.can_shoot

- Save/load
- Look at instances, global variables, local variables
- Execute code
- Set speed

## Game Maker – Print Debug Messages

- Like show_message() but in debug mode only
  - Note, doesn't pause
- In code
  - show_debug_message ("Executed this code")
- Need to run in debug mode
- Debug information → Tools → Show messages

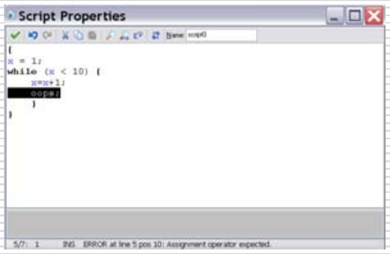


```
Client creating connection...
Sent data
Sent data
Sent data
Sent data
Sent data
Sent data
Sent data
Sent data
Sent data
```

## Game Maker – Log Messages

- Write messages to file
- Example:
  - At beginning (maybe create log object)
    - `global.log_name = "logfile"; global.fid = file_text_open_write(global.log_name);`
  - Then, where needed:
    - `file_text_write_string(global.fid,"Debug message here") ;`
  - Close when done (object → event other → game end):
    - `file_text_close(global.fid)`
- More file operations (look online) possible
  - Note: files also useful for save/load game, etc.

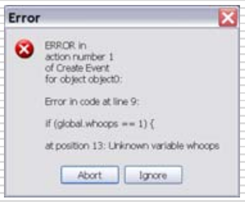
## Game Maker – Script/Code Syntax



```
{
x = 1;
while (x < 10) {
    x=x+1;
    oops;
    }
}
```

```
5/7:   1      INS   ERROR at line 5 pos 10: Assignment operator expected.
```

## Game Maker – Error Messages (1 of 2)

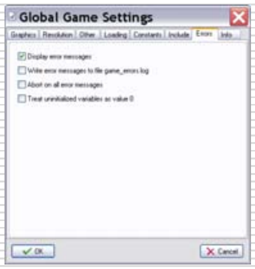


```
ERROR in
action number 1
of Create Event
for object object0:

Error in code at line 9:

if (global.whoops == 1) {

at position 13: Unknown variable whoops
```

Pay attention!
Refers to:
-Object
-Event
-Line number
-Variable name

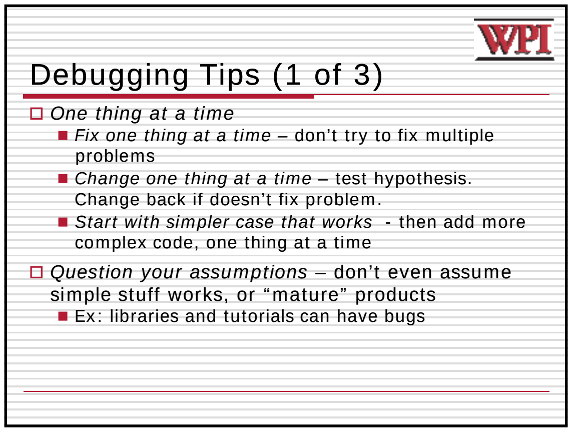
- Help pinpoint problem
  - Refer to object and method and offending code

## Game Maker – Error Messages (2 of 2)



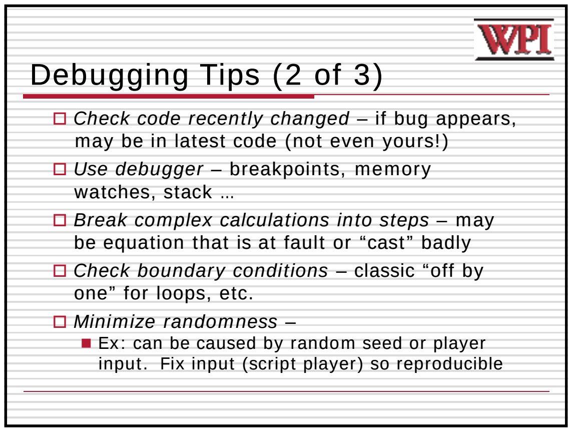
- [✓] Display error messages
- [ ] Write error messages to file game_errors.log
- [ ] Abort on all error messages
- [ ] Treat uninitialized variables as value 0

- Can write messages to log file
- Can ignore messages
  - Use "error_last" and "error_occurred" for custom handling
  - Typically, use only in release



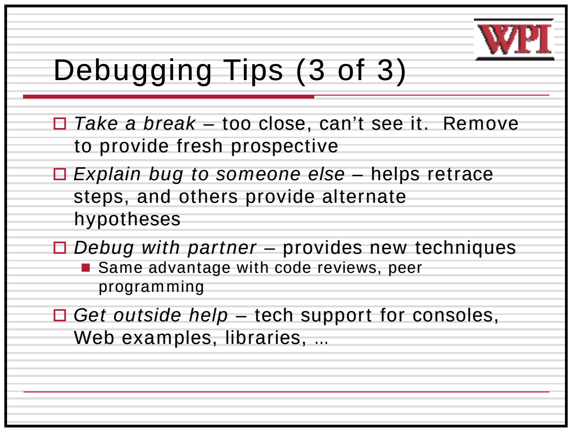
## Debugging Tips (1 of 3)

- *One thing at a time*
  - *Fix one thing at a time* – don't try to fix multiple problems
  - *Change one thing at a time* – test hypothesis. Change back if doesn't fix problem.
  - *Start with simpler case that works* - then add more complex code, one thing at a time
- *Question your assumptions* – don't even assume simple stuff works, or "mature" products
  - Ex: libraries and tutorials can have bugs



## Debugging Tips (2 of 3)

- *Check code recently changed* – if bug appears, may be in latest code (not even yours!)
- *Use debugger* – breakpoints, memory watches, stack …
- *Break complex calculations into steps* – may be equation that is at fault or "cast" badly
- *Check boundary conditions* – classic "off by one" for loops, etc.
- *Minimize randomness* –
  - Ex: can be caused by random seed or player input. Fix input (script player) so reproducible



## Debugging Tips (3 of 3)

- *Take a break* – too close, can't see it. Remove to provide fresh prospective
- *Explain bug to someone else* – helps retrace steps, and others provide alternate hypotheses
- *Debug with partner* – provides new techniques
  - Same advantage with code reviews, peer programming
- *Get outside help* – tech support for consoles, Web examples, libraries, …