

Debugging

Module Code: ELEE1147

Module Name: Programming for Engineers

Credits: 15

Module Leader: Seb Blair BEng(H) PGCAP MIET MIHEEM FHEA

Introduction to Debugging

- Debugging is a crucial aspect of software development that involves identifying and fixing errors or defects (bugs) in computer programs.
- Regardless of programming language or development environment, all software developers encounter bugs during the development process.
- Debugging is the systematic process of locating and resolving these bugs to ensure that the software behaves as expected.



Origin of Debugging?

Name: Admiral Grace Hopper (USN)

When: 1947

How: Working on the Mark II computer in Harvard and discovered a moth stuck in one of the relays which was causing the errors in the computer... she remarked that she was "debugging" the computer.

*she created the first compiler and contributed to the programming language COBOL



Why Debugging Matters

- **Ensuring Software Quality:** Debugging helps improve the quality and reliability of software by identifying and fixing defects that could lead to unexpected behavior or system crashes.
- **Enhancing User Experience:** Software with fewer bugs provides a better user experience, leading to increased satisfaction and trust among users.
- **Reducing Development Costs:** Addressing bugs early in the development process helps reduce the time and resources required to fix them later, minimizing the overall cost of development.
- **Maintaining Developer Confidence:** Effective debugging techniques empower developers to tackle complex problems with confidence, enhancing their productivity and morale.

Common Types of Bugs

- **Syntax Errors:** These occur when the code violates the syntax rules of the programming language, leading to compilation errors.

```
#include <stdio.h>

int main() {
    int x = 5;
    printf("The value of x is: %d\n", x);
    return 0;
}
```

Common Types of Bugs

- **Logic Errors:** Logic errors occur when the program does not produce the expected output due to flaws in its logic or algorithm.

```
#include <stdio.h>

int main() {
    int x = 5;
    int y = 3;
    int sum = x - y; // Logic error: subtracting instead of adding
    printf("The sum of x and y is: %d\n", sum);
    return 0;
}
```

Common Types of Bugs

- **Runtime Errors:** Runtime errors occur during program execution and can result in crashes or unexpected behavior, often caused by issues such as null pointer dereferences or array out-of-bounds access.

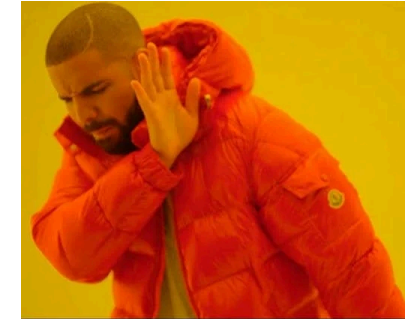
```
#include <stdio.h>

int main() {
    int x = 5;
    int y = 0;
    int result = x / y; // Runtime error: division by zero
    printf("The result is: %d\n", result);
    return 0;
}
```

Debugging Techniques

- **Print Statements:**

```
int main() {  
    int x = 5, y = 3;  
  
    printf("Program start\n"); // Print statement to indicate the start of the program  
  
    // Print statements to output variable values  
    printf("Value of x: %d\n", x);  
    printf("Value of y: %d\n", y);  
  
    printf("Checkpoint reached\n"); // Print statement to indicate a checkpoint  
  
    printf("Calculating sum\n"); // Print statement to perform a calculation  
  
    int sum = x + y;  
  
    printf("The sum of x and y is: %d\n", sum); // Print statement to output the result  
  
    printf("Program end\n"); // Print statement to indicate the end of the program  
  
    return 0;  
}
```



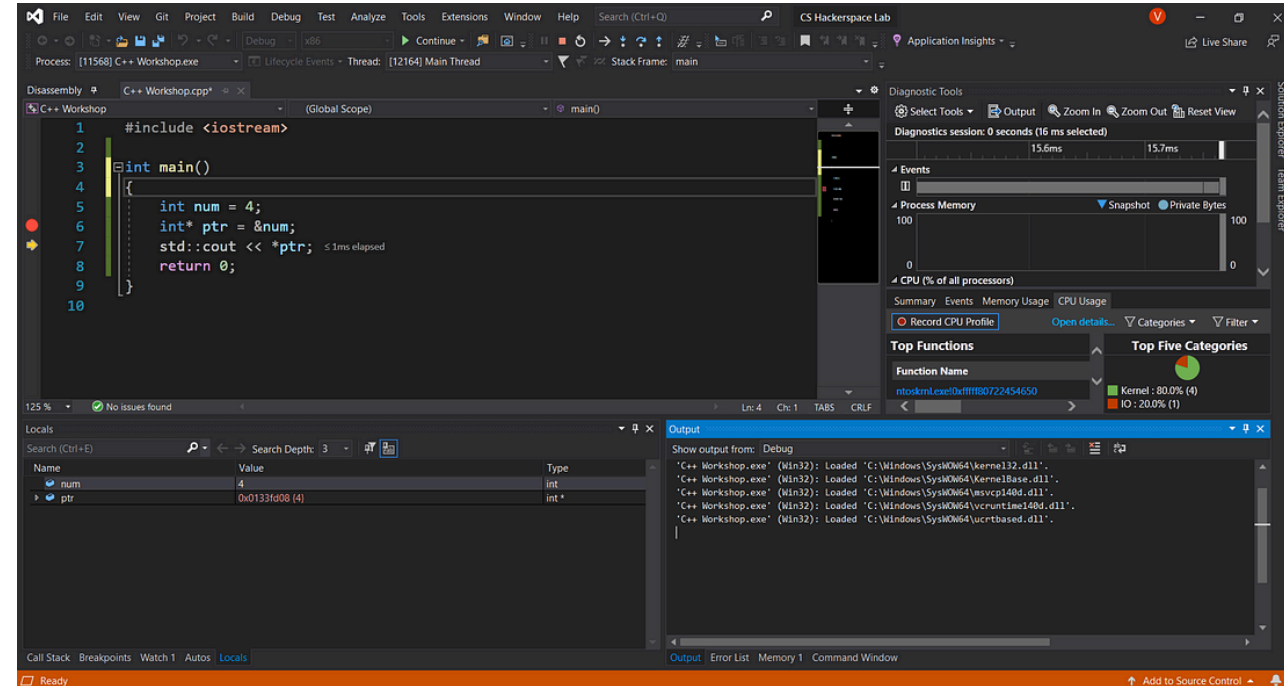
Using the
debugger to spot
logical errors



Using the print
function everywhere
in your program

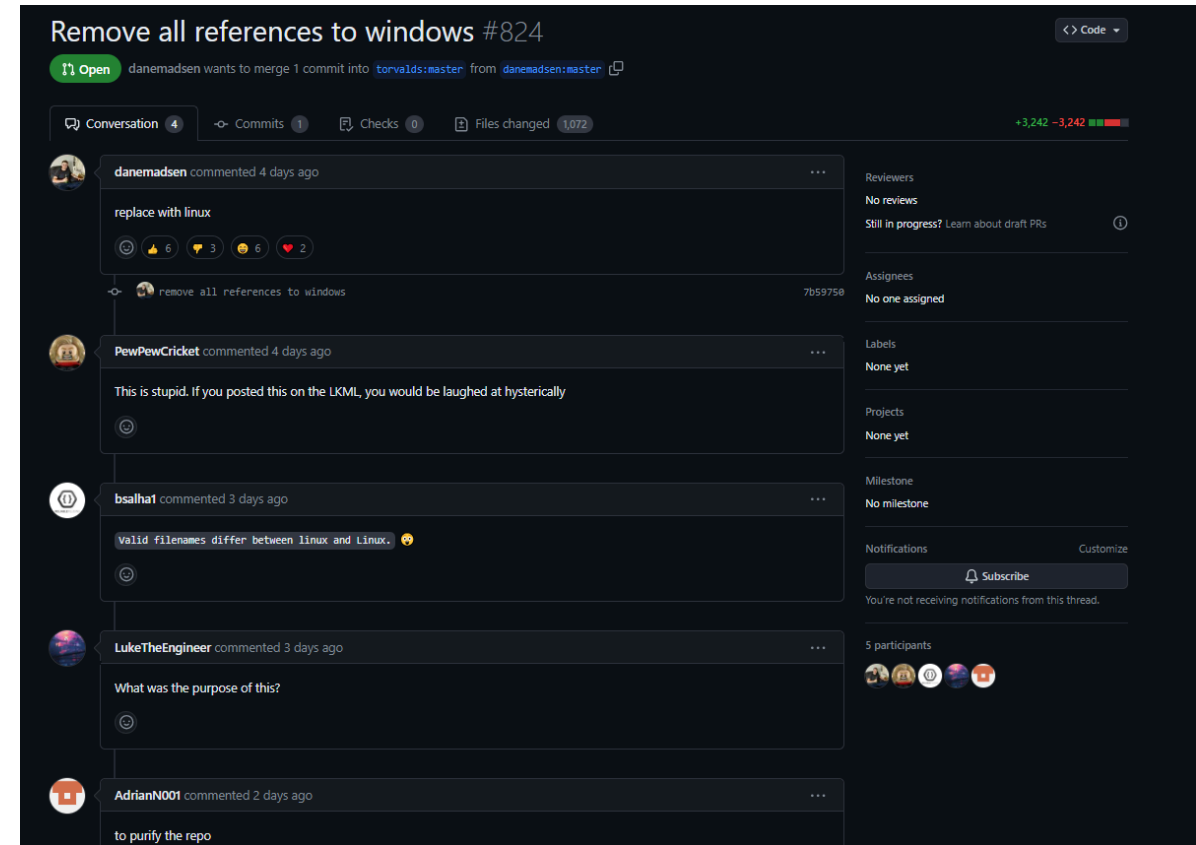
Debugging Techniques

- **Debugger Tools:** Integrated development environments (IDEs) and standalone debugger tools provide features such as breakpoints, stepping through code, and variable inspection, allowing developers to analyze program behavior in real-time.



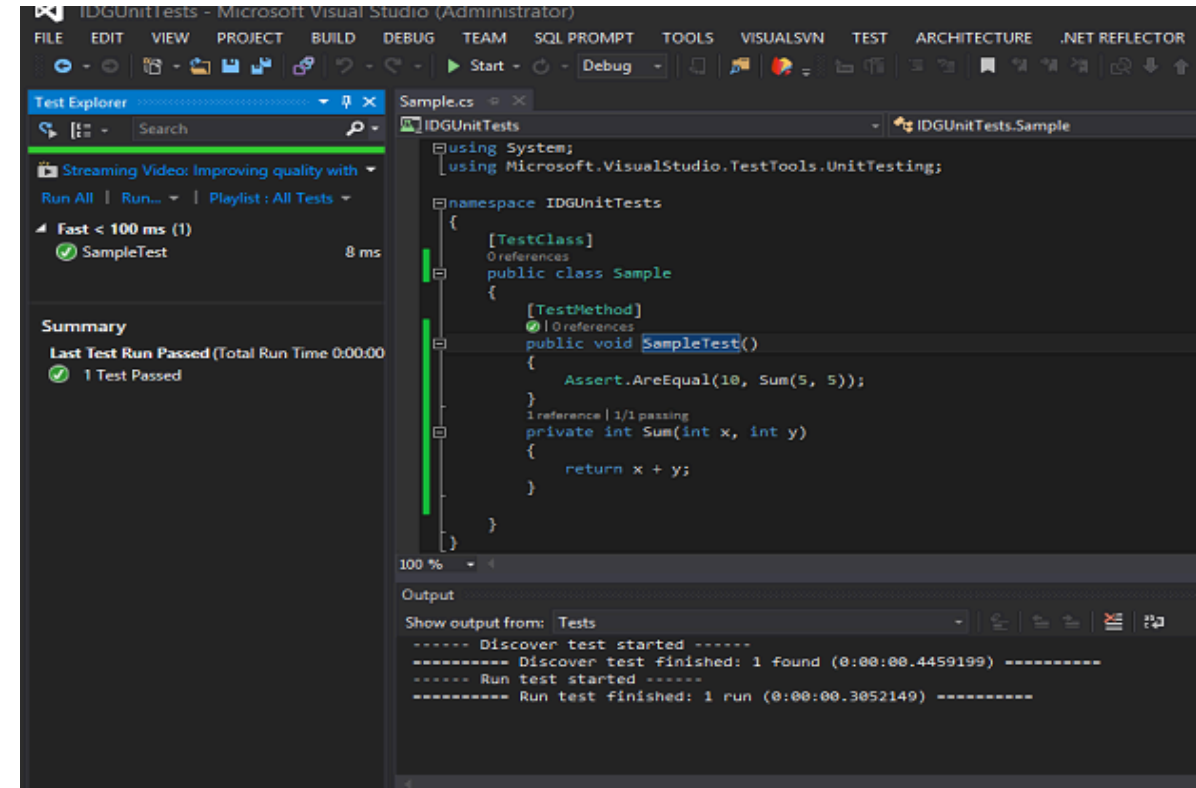
Debugging Techniques

- **Code Review:** Collaborating with peers to review code can help identify bugs and provide alternative perspectives on problem-solving.



Debugging Techniques

- **Unit Testing:** Writing and executing unit tests to validate individual components of the software can help catch bugs early in the development process.



Debugging Techniques

- **Logging:** Incorporating logging mechanisms into the software to record relevant events and errors can aid in post-mortem analysis and troubleshooting.

```
File Edit View Search Terminal Help
Oct 27 17:41:01 systemd[1]: Started ExpressVPN Daemon.
Oct 27 17:41:01 systemd[8053]: expressvpn.service: Failed to execute command: No such file or directory
Oct 27 17:41:01 systemd[8053]: expressvpn.service: Failed at step EXEC spawning /usr/sbin/expressvpnd: No such file or directory
Oct 27 17:41:01 systemd[1]: expressvpn.service: Main process exited, code=exited, status=203/EXEC
Oct 27 17:41:01 systemd[1]: expressvpn.service: Failed with result 'exit-code'.
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:01 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:02 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:03 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:03 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:04 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): Failed to get GBM bo for flip to new front.
Oct 27 17:41:05 /usr/lib/gdm3/gdm-x-session[983]: (EE) modeset(0): present flip failed
```

Best Practices for Effective Debugging

- **Reproduce the Issue:** Attempt to reproduce the bug consistently to understand its scope and conditions.
- **Isolate the Problem:** Narrow down the search for the bug by identifying the specific sections of code or inputs that trigger the unexpected behavior.
- **Stay Organized:** Keep track of debugging progress, including any changes made to the code or observations during the process, to maintain clarity and focus.
- **Document Findings:** Documenting the debugging process, including the steps taken and the solutions attempted, can provide valuable insights for future reference.
- **Continuous Learning:** Stay updated on debugging techniques and tools, and learn from past debugging experiences to improve problem-solving skills.