

Understanding and Mastering Debugging Techniques in Software Development

Module Code: ELEE1147

Module Name: Programming for Engineers

Credits: 15

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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 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.

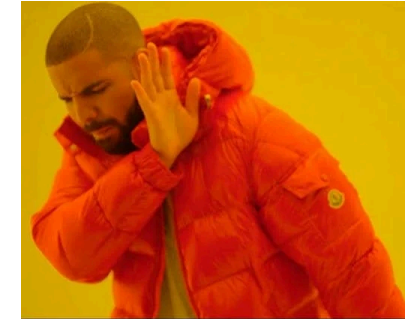
```
#include <stdio.h>

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;  
}
```



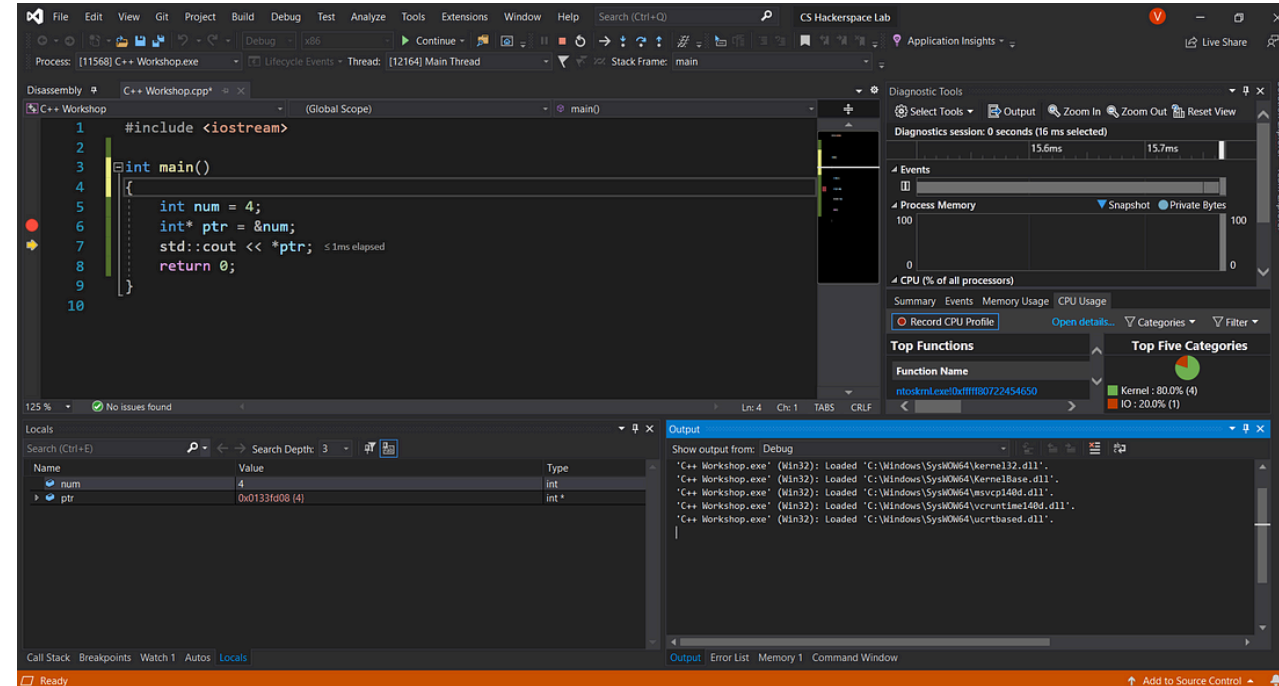
Using the
debugger to spot
logical errors



Using the print
function everywhere
in your program

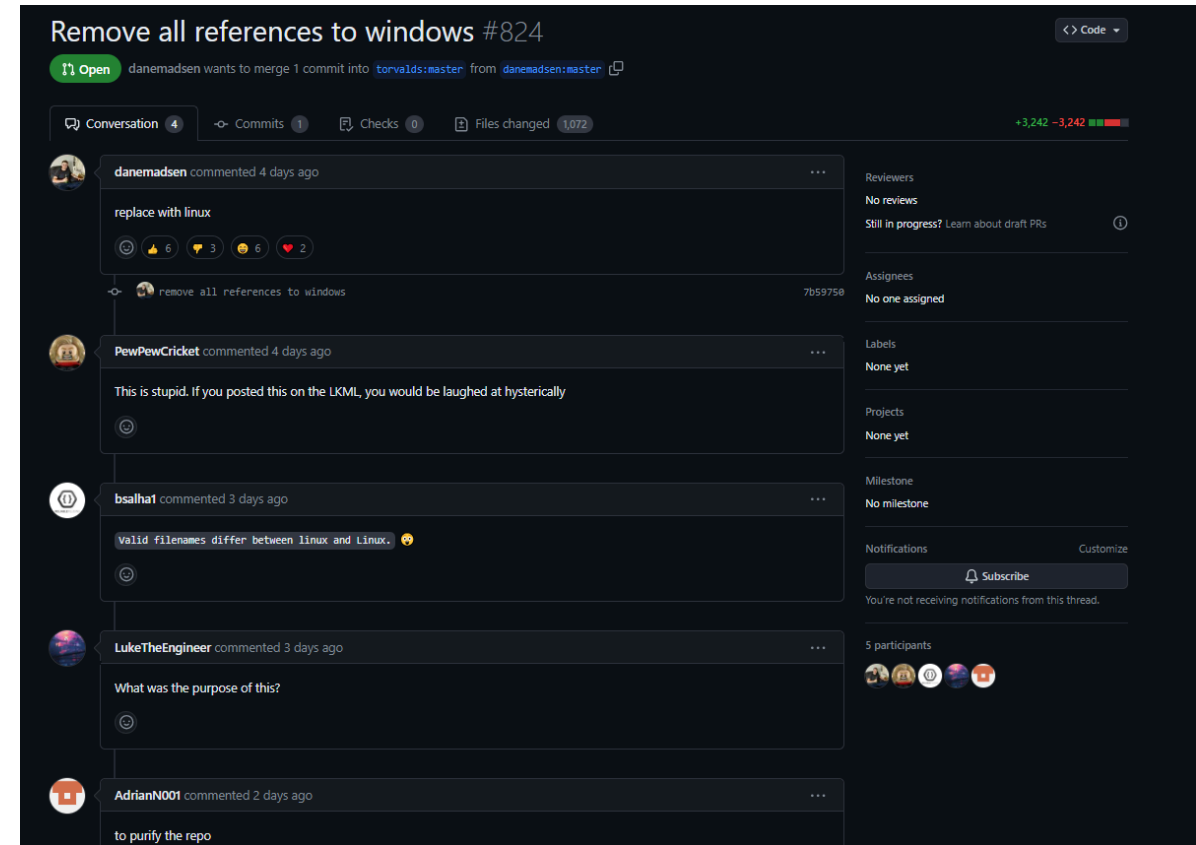
Debugging Techniques

- **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.



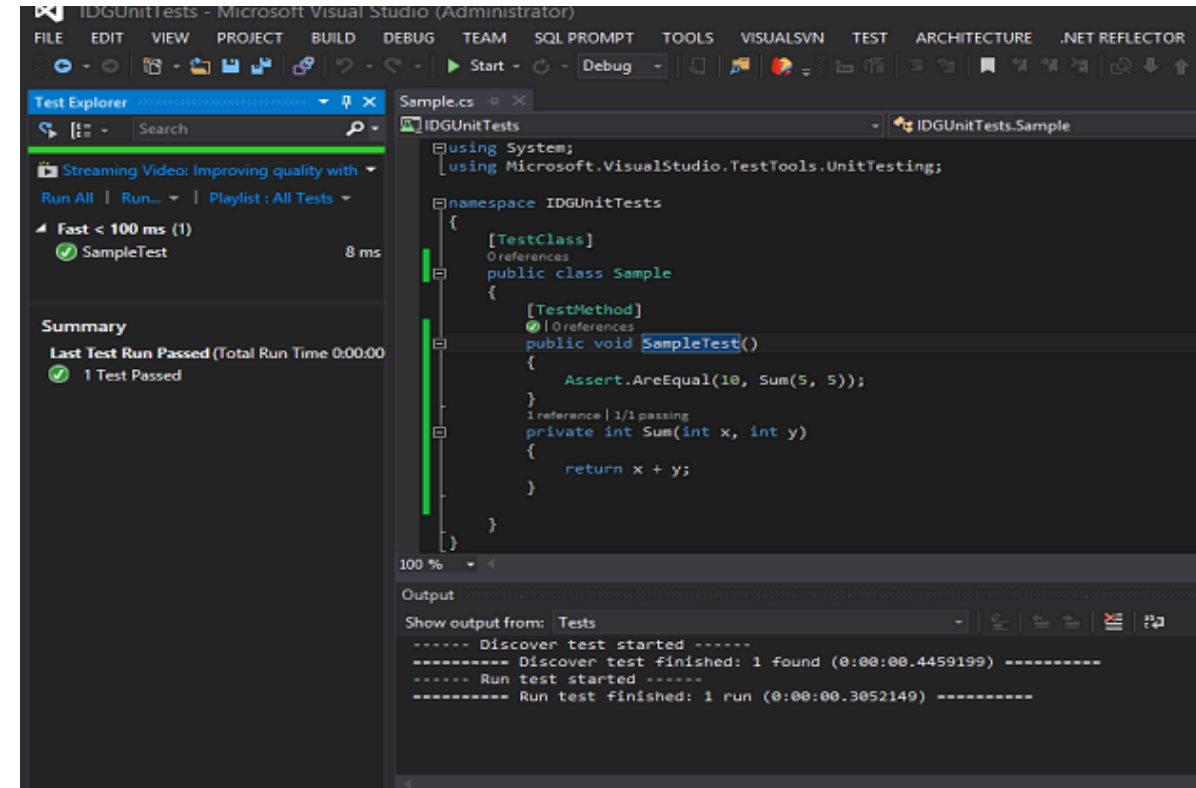
Debugging Techniques

- **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.



The screenshot shows the Microsoft Visual Studio (Administrator) interface. The 'Test Explorer' on the left displays a test named 'SampleTest' with a green checkmark, indicating it passed. The 'Summary' section shows 'Last Test Run Passed (Total Run Time 0:00:00)' and '1 Test Passed'. The main editor shows the code for 'Sample.cs' with the following content:

```
using System;
using Microsoft.VisualStudio.TestTools.UnitTesting;

namespace IDGUnitTests
{
    [TestClass]
    public class Sample
    {
        [TestMethod]
        public void SampleTest()
        {
            Assert.AreEqual(10, Sum(5, 5));
        }

        private int Sum(int x, int y)
        {
            return x + y;
        }
    }
}
```

The 'Output' window at the bottom shows the test execution details:

```
----- Discover test started -----
----- Discover test finished: 1 found (0:00:00.4459199) -----
----- Run test started -----
----- Run test finished: 1 run (0:00:00.3052149) -----
```

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
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```

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.