Recursion

- A recursive function is a function that, directly or indirectly, calls itself
- Each function call has its own copy of parameters and local variables
- Internally, function calls are maintained using a stack
- Make sure that recursion will end!
Example: Factorial

```c
int factorial(int n)
{
    if (n==0)
        return 1;
    return n*factorial(n-1);
}
```

- This will compute $n!$ for any nonnegative integer $n$
- What is wrong with this function?

Applications of Recursion

- The factorial example is a simple illustration of recursion, but it can easily be implemented non-recursively
- Recursion useful whenever an algorithm solves a problem by applying itself to “smaller” instances of the problem
- Often, algorithms are more rapidly designed recursively, which encourages rapid application development
Mergesort

- Simplistic algorithms for sorting an array of $n$ elements take $O(n^2)$ comparisons
- In mergesort, the array is divided in half, and each half is sorted individually
- The two sorted halves are then merged in $O(n)$ comparisons, for $O(n \log_2 n)$ comparisons overall
- Limiting case of recursion: an array with one element is already sorted!

Fast Fourier Transform

- The Fast Fourier Transform (FFT) computes the discrete Fourier transform of a vector of functions values
- It recursively transforms odd-numbered and even-numbered points, and then merges the results
- $O(n^2)$ work reduced to $O(n \log_2 n)$
- For efficiency, should use pointers that take larger and larger steps to access elements!
Debuggers

- A debugger is a tool that performs step-by-step execution of a program, allowing the programmer to study its behavior and find bugs.
- IDEs, like MDS and Microsoft Visual Studio, typically include debuggers.
- A debugger runs your program, stopping execution at user-specified breakpoints to allow inspection.

The MDS Debugger

- Before debugging, use F9 to set breakpoints in your program.
- F5 begins execution within the debugger, or resumes after breakpoint.
- When stopped, F10 steps through next line.
- F11 steps into function call.
- Shift-F11 steps out of function.
- Hover over variables to see values.
The **gdb** Debugger

- **gdb** is the GNU debugger
- Run from UNIX prompt with executable filename as argument
- **break** command sets breakpoint, can specify function name or line number
- **run** command begins execution
- **step** command advances one line, steps into functions automatically
- **cont** resumes execution
- **print** shows value of given expression

Next Time

- Testing strategies
- Debugging strategies
- Designing software with testing and debugging in mind!