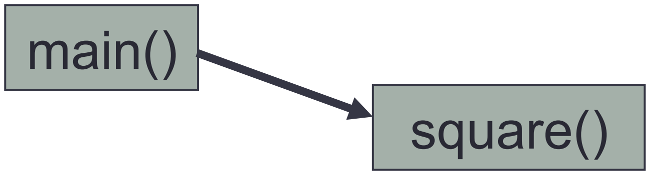
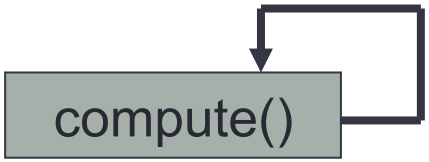
RECURSION

Recursive Functions

- All function calls that we have seen so far have been made by other functions



- A recursive function is a function that calls itself



Recursion

- Some problems are more easily solved using recursion
- Tree functionality is more easily solved by recursion than by iteration

First Recursive Problem

```
void count (int index)
{
  printf ("%d", index);
  if (index < 2)
  {
    count (index + 1);
  }
}

int main ()
{
  count (0);
  return 0;
}
```

What is the output?

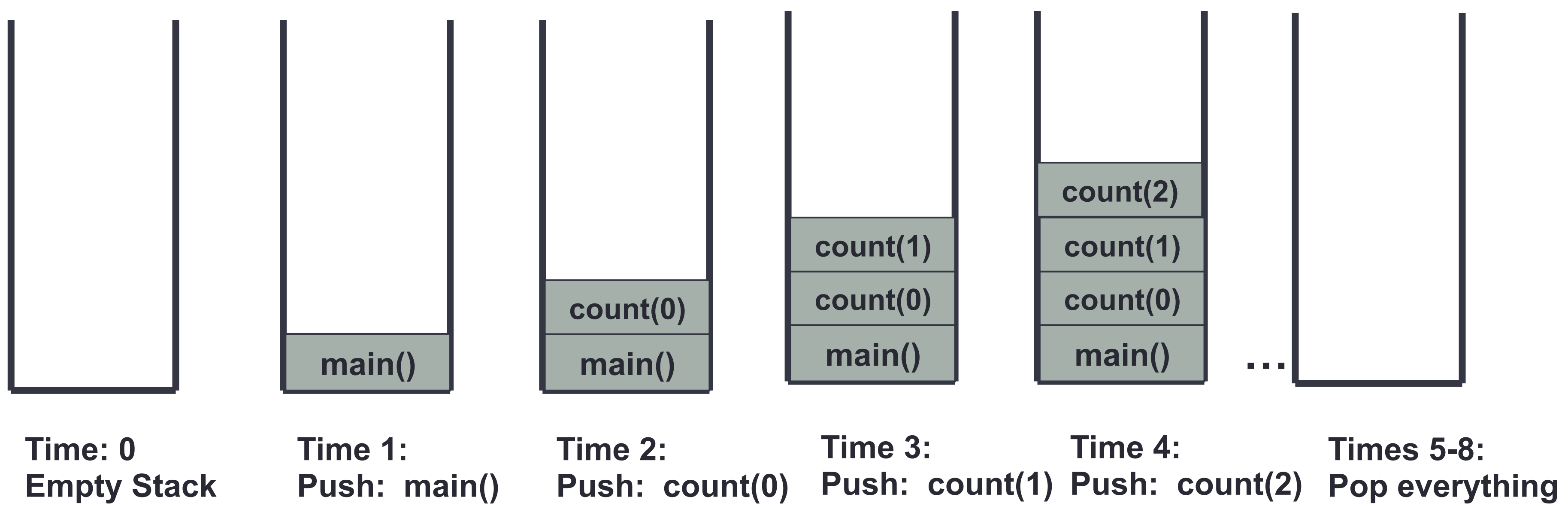
Visualizing Recursion

- To understand how recursion works, it helps to visualize what is going on
- We will do this using *Activation Records (stack frames)* and the *Call Stack*
- Each time a function is called, an activation record is created and pushed on to the top of the stack
- When the function returns, the activation record is popped off the stack

Recursion and the Call Stack

- When a method calls itself recursively, you just push another copy of the function on to the top of the stack

Recursion and Call Stacks



What is the Output?

```
void count (int index)
{
  printf ("%d", index);
  if (index < 2)
  {
     count (index + 1);
  }
}

int main ()
{
  count (3);
  return 0;
}
```

What is the Output?

```
void count (int index)
{
  if (index < 2)
  {
     count (index + 1);
  }
  printf ("%d", index);
}

int main ()
{
  count (0);
  return 0;
}
```

What is the Output?

```
void upAndDown (int index)
{
  printf ("Pushing level: %d\n", index);
  if (index < 4)
  {
     upAndDown (index + 1);
  }
  printf ("Popping level: %d\n", index);
}
int main ()
{
  upAndDown (1);
  return 0;
}
```

Recursion and Factorials

- Computing factorials are a classic problem for examining recursion.

- A factorial is defined as follows:

```
n!  = n * (n-1) * (n-2) …. * 1;
```

- For example:

```
1! = 1 (Base Case)
2! = 2 * 1 = 2
3! = 3 * 2 * 1 = 6
4! = 4 * 3 * 2 * 1 = 24
5! = 5 * 4 * 3 * 2 * 1 = 120
```

Recursion and Factorials

- First step is to frame the problem in terms of itself. You do this by finding a pattern
- Once you see the pattern, you can apply this pattern to create a recursive solution to the problem
- Divide a problem up into:
  - What it can do (usually a base case)
  - What it cannot do
    - What it cannot do resembles original problem
    - The function launches a new copy of itself (recursion step) to solve what it cannot do

Recursive Factorial Solution

```
int main ()
{
  int i;

  for (i = 1; i <= 10; ++i)
  {
    printf ("%d!: %d\n", i, factorial (i));
  }
  return 0;
}
```

Recursive Fibonacci

- Write a recursive function to calculate the Fibonacci value at a particular index

- Fibonacci: Each number in the series is the sum of the two previous numbers:
  - 0, 1, 1, 2, 3, 5, 8, 13, 21 …
  - Fib (0) = 0
  - Fib (1) = 1
  - Fib (2) = 1
  - Fib (3) = 2
  - Fib (4) = 3