Recursion

Lecture 2
Sections 20.1 - 20.4

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Outline

Recursion

Definition (Recursive Function)

A recursive function is a function that calls on itself.

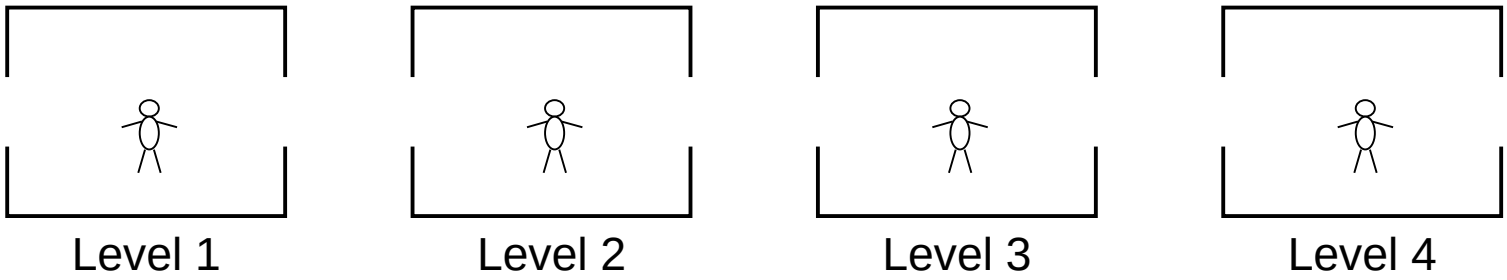
- A recursive function must contain a decision structure that divides the code into two cases.
  - The recursive (general) case.
  - The nonrecursive (base) case.
- The code must guarantee that eventually the nonrecursive case is called.

1st-Order Recursion

Example (The Factorial Function)

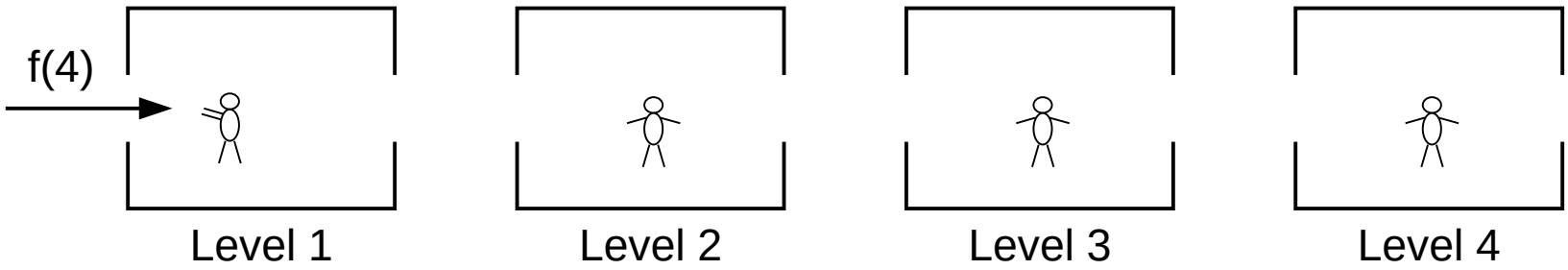
```
int factorial(int n)
{
    if (n == 0 || n == 1)
        return 1;
    else
        return n*factorial(n - 1);
}
```

An Analogy



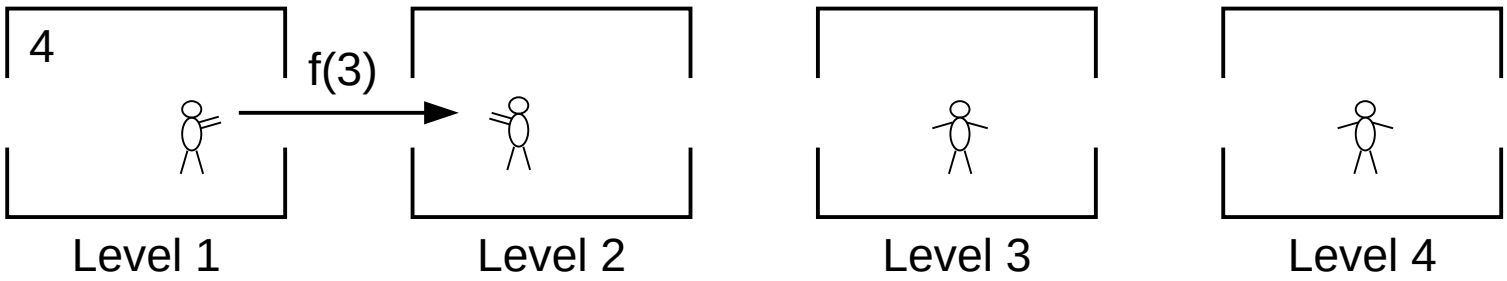
Each “little man” has exactly the same instructions.

An Analogy



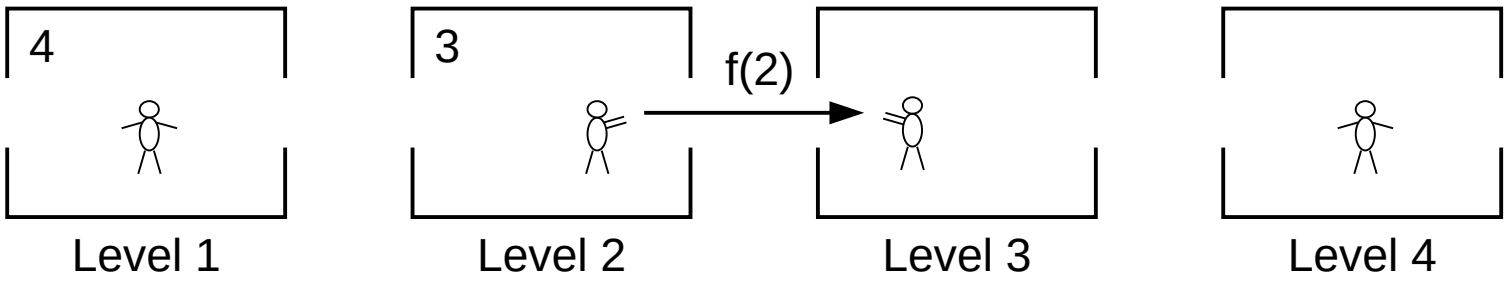
The first man is given the number 4.

An Analogy



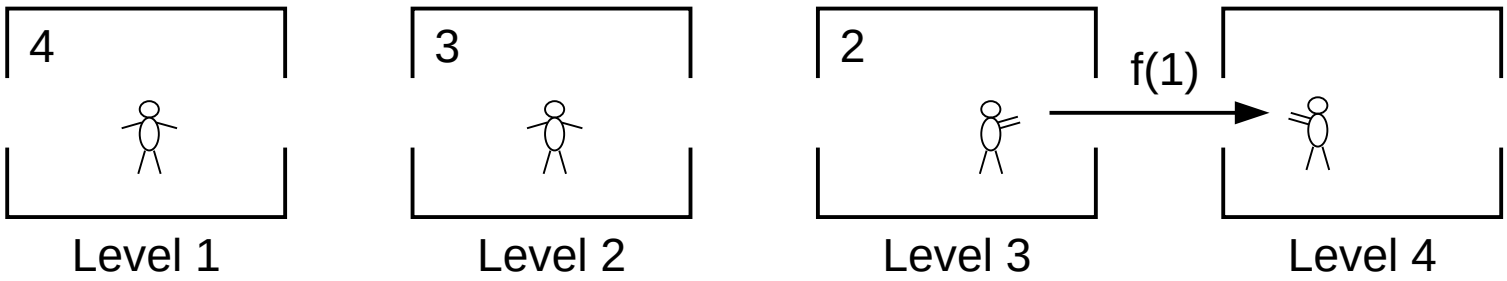
$4 \neq 1$, so he stores the 4 and pass $4 - 1 = 3$ to the next room.

An Analogy



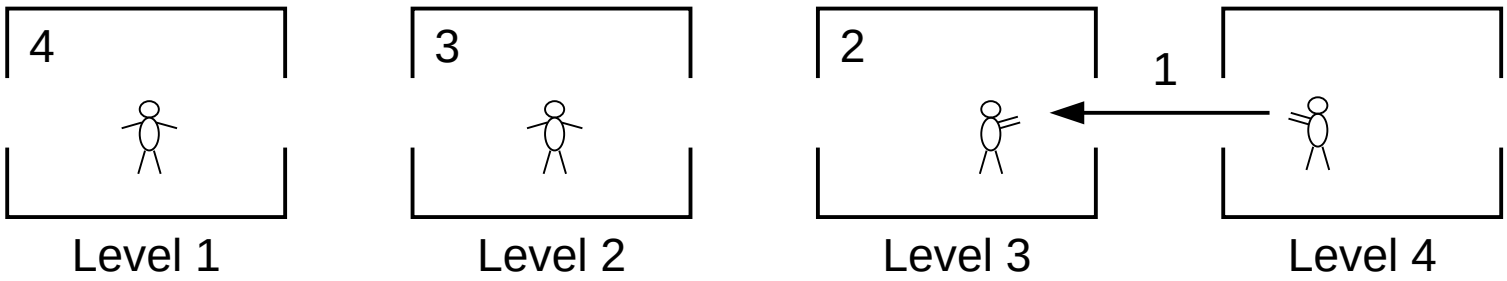
$3 \neq 1$, so he stores the 3 and pass $3 - 1 = 2$ to the next room.

An Analogy



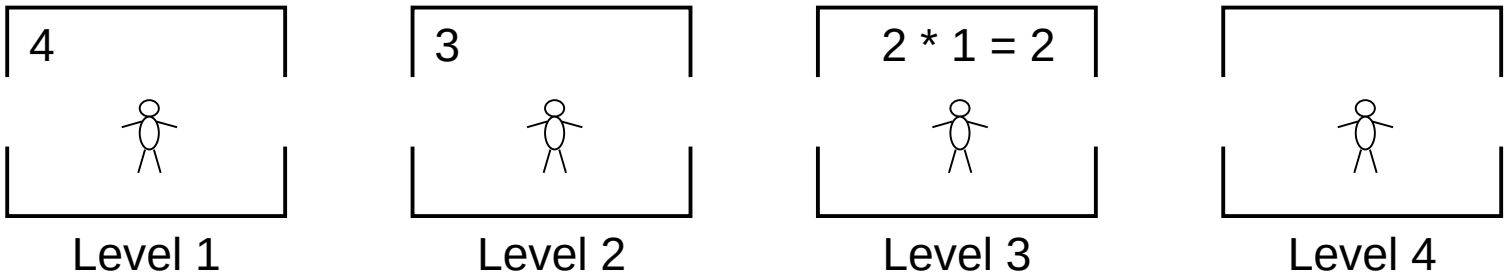
$2 \neq 1$, so he stores the 2 and pass $2 - 1 = 1$ to the next room.

An Analogy



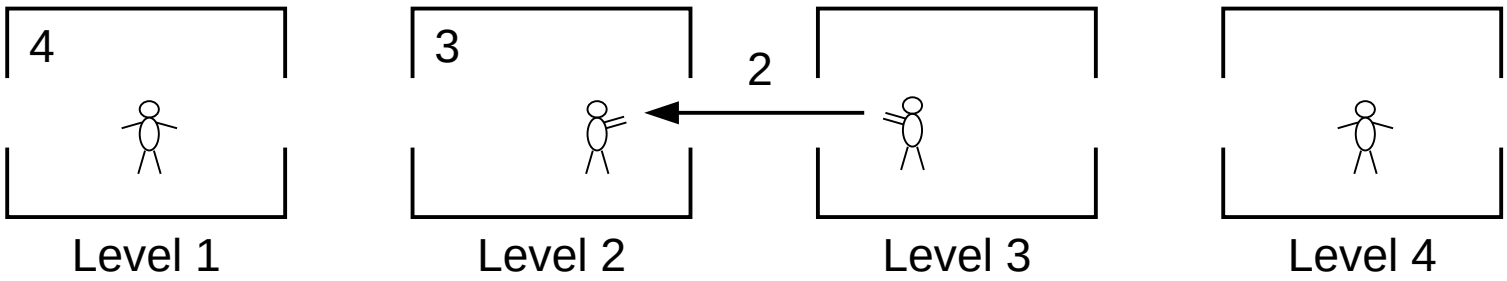
$1 = 1$, so he returns 1 to the previous room.

An Analogy



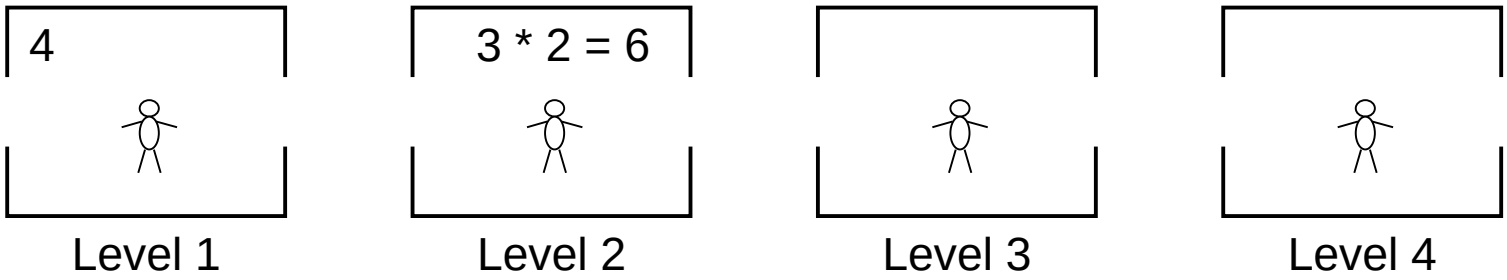
He computes $2 * 1 = 2$ and...

An Analogy



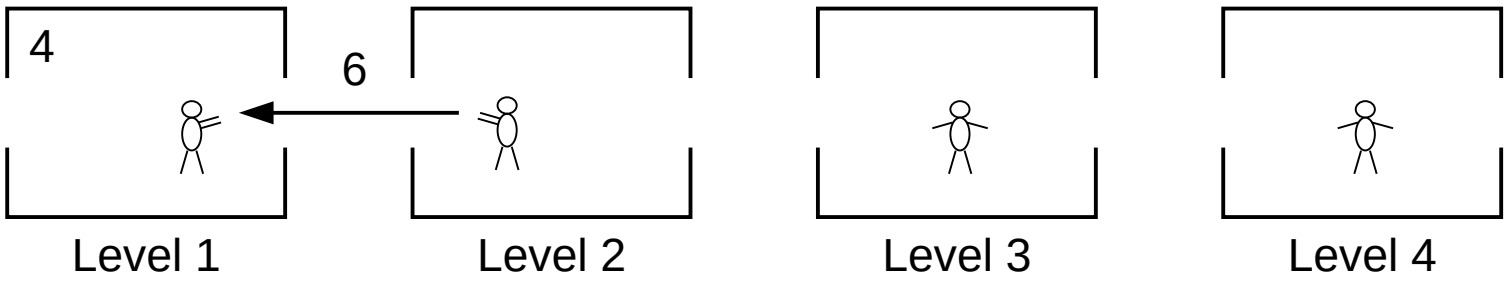
...returns 2 to the previous room.

An Analogy



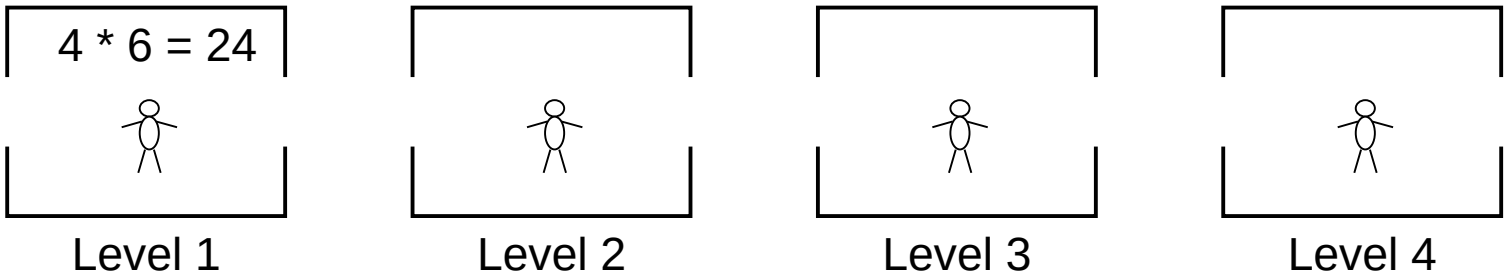
He computes $3 * 2 = 6$ and...

An Analogy



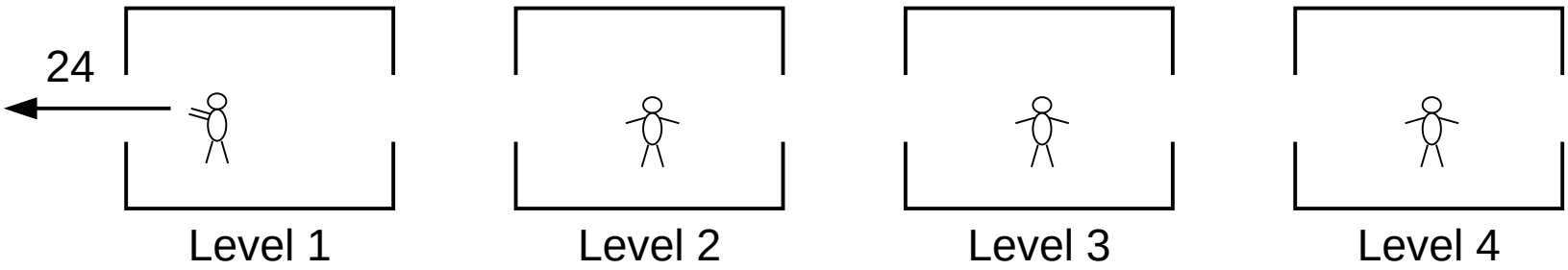
...returns 6 to the previous room.

An Analogy



He computes $4 * 6 = 24$ and...

An Analogy



...returns 6 to the previous room.

2nd-Order Recursion

Example (The Fibonacci Sequence)

```
int fibon(int n)
{
    if (n == 0 || n == 1)
        return n;
    else
        return fibon(n - 1) + fibon(n - 2);
}
```

Greatest Common Divisor

Example (Greatest Common Divisor)

```
int gcd(int a, int b)
{
    if (b == 0)
        return a;
    else
        return gcd(b, a % b);
}
```

Binomial Coefficients

Example (Binomial Coefficients)

```
int binom(int n, int r)
{
    if (r == 0 || r == n)
        return 1;
    else
        return binom(n - 1, r) + binom(n - 1, r - 1);
}
```

Outline

Advantages of Recursion

- Advantages
  - The code may be much easier to write.
  - Some situations are naturally recursive.

Advantages of Recursion

- Naturally recursive data structures:
  - Linked lists.
  - Binary trees.
- Naturally recursive problems:
  - Traversing linked lists.
  - Traversing binary trees.
  - Evaluating expressions.
  - Differentiating functions.

Disadvantages of Recursion

- Disadvantages
  - Recursive functions are generally slower than nonrecursive functions.
  - Excessive recursion may overflow the run-time stack.
  - One must be very careful when writing recursive functions; they can be tricky.

Disadvantages of Recursion

- There is shallow recursion and there is deep recursion.
- Shallow recursion will not overflow the stack, but it may take an excessively long time to execute.
- Deep recursion is generally much faster, but it may overflow the stack.
- Sometimes each function call generates two or more recursive calls at that level.
- This has the potential to consume an enormous amount of time.

Outline

Examples of Recursive Functions

- `GCD.cpp`.
- `BinomialCoefficients.cpp`.
- `TowersOfHanoi.cpp`.

Outline

Assignment

Assignment

- Read Sections 20.1 - 20.4.