Recursion

- A method calls itself

```java
void print(int n)
{
    if (n <= 0) System.out.println("b");
    else
    {
        System.out.print("a");
        print(n-1);
    }
}
```

Recursive Process

- Ending Condition
  - When the recursion should stop
  - To avoid infinite recursion, make sure the ending condition exists
    - Exists
    - Reachable
    - Comes before the recursive call

Simple Recursion Examples

- Factorial
- Search
String Permutation

- Output all the permutations of \( n \) characters
  - E.g. "abc"
    - abc, acb
    - bac, bca
- How do we reduce the problem of \( n \) characters to the problem of \( n-1 \) characters?

Fibonacci Series

- 0, 1, 1, 2, 3, 5, 8, 13, 21, ...
- Definition
  - fibonacci(0) = 0
  - fibonacci(1) = 1
  - fibonacci(n) = fibonacci(n-1)+fibonacci(n-2)

Recursive Fibonacci

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

Non-recursive Fibonacci

```java
int fibonacci( int n )
{
    if( n == 0 || n==1 ) return n;
    int last1 = 1, last2 = 0, fibo;
    for( int i=2 ; ?? ; ++i )
    {
        fibo = last1+last2;
        ??
    }
    return fibo;
}
```

Recursion vs. Non-recursion

- Less code != more efficient

Timing

- The best way to appreciate a good algorithm is to see how fast it runs
- And time it
  - System.currentTimeMillis()
  - System.nanoTime()
### When Can We Use Recursion?

- A problem itself is recursively defined
  - Fibonacci \( f(n) = f(n-1) + f(n-2) \)
  - Tree
    - A tree has a root
    - Each child of the root is also a tree
- A problem of size \( n \) can be reduced to a problem of size less than \( n \)
  - Factorial: \( n \rightarrow n-1 \)
  - Sort: \( n \rightarrow n-1 \)
  - Binary search: \( n \rightarrow n/2 \)

### When Should We Use Recursion?

- When the homework problem says so
- When speed of code development takes precedence over code efficiency
- When the problem is naturally recursive
  - Fibonacci Series
- When the non-recursive solution is much harder
  - Hanoi tower
  - Solving maze