# Building Java Programs

Chapter 11

Sets and Maps

**reading: 11.2 - 11.3**

# Plan for Lecture

1. Review code and trace output
2. Fix style and add indentation to output
3. Grammars and Regular Expressions
4. Exam Materials

# print

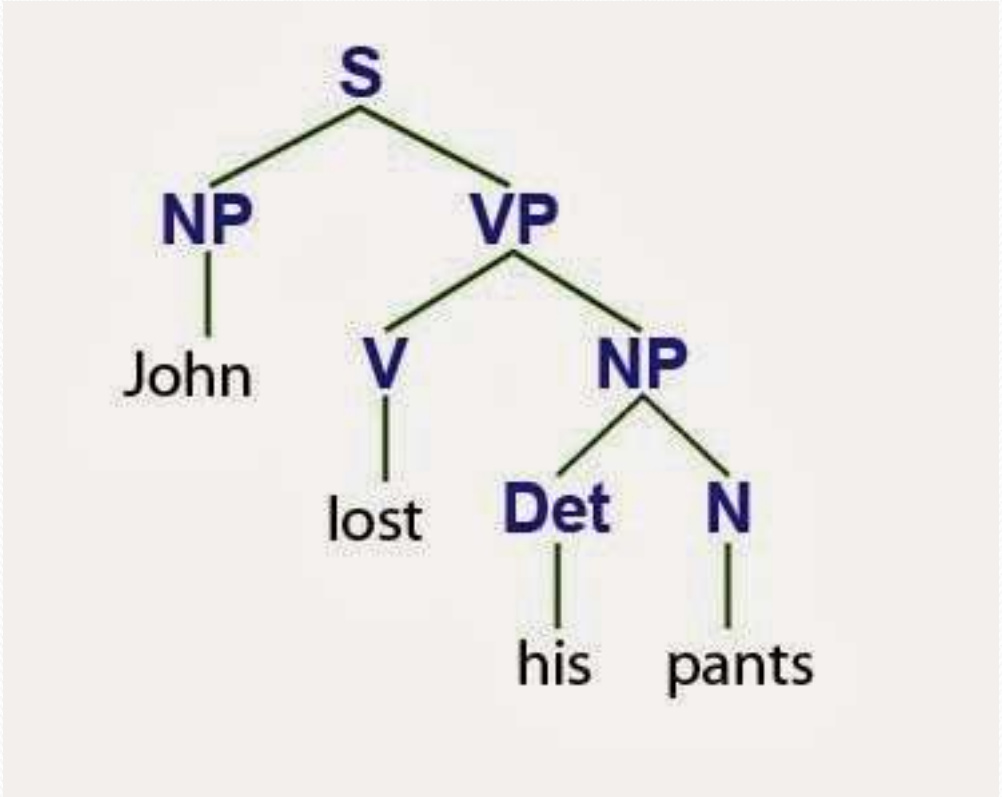

```
public static void print(File file) {
    public static void print(File file) {
        if (!file.isDirectory()) {
            System.out.println(file.getName());
        } else {
            System.out.println(file.getName());
            File[] subFiles = file.listFiles();
            for (int i = 0; i < subFiles.length; i++) {
                print(subFiles[i]);
            }
        }
    }
}
```

file = recursion

...

file = picture2.jpg

cats
cats-and-dogs
picture1.jpg
picture2.jpg
recursion
...


S
NP
VP
John
V
NP
lost
Det
N
his
pants

# Languages and grammars

- (formal) **language**: A set of words or symbols.

- **grammar**: A description of a language that describes which sequences of symbols are allowed in that language.
  - describes language *syntax* (rules) but not *semantics* (meaning)
  - can be used to generate strings from a language, or to determine whether a given string belongs to a given language

# Backus-Naur (BNF)

- **Backus-Naur Form (BNF)**: A syntax for describing language grammars in terms of transformation *rules*, of the form:

  <**symbol**> ::= <**expression**> | <**expression**> *...* | <**expression**>

  - **terminal**: A fundamental symbol of the language.
  - **non-terminal**: A high-level symbol describing language syntax, which can be transformed into other non-terminal or terminal symbol(s) based on the rules of the grammar.

  - developed by two Turing-award-winning computer scientists in 1960 to describe their new ALGOL programming language

# An example BNF grammar

```
<s>::=<n> <v>
<n>::=Marty | Victoria | Stuart | Jessica
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
Marty slept
Jessica belched
Stuart cried
```

# BNF grammar version 2

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <n>
<pn>::=Marty | Victoria | Stuart | Jessica
<dp>::=a | the
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
the carrot cried
Jessica belched
a computer slept
```

# BNF grammar version 3

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <adj> <n>
<pn>::=Marty | Victoria | Stuart | Jessica
<dp>::=a | the
<adj>::=silly | invisible | loud | romantic
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
the invisible carrot cried
Jessica belched
a computer slept
a romantic ball belched
```

# Grammars and recursion

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <adjp> <n>
<pn>::=Marty | Victoria | Stuart | Jessica
<dp>::=a | the
<adjp>::=<adj> <adjp> | <adj>
<adj>::=silly | invisible | loud | romantic
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Grammar rules can be defined *recursively*, so that the expansion of a symbol can contain that same symbol.
  - There must also be expressions that expand the symbol into something non-recursive, so that the recursion eventually ends.

# Grammar, final version

```
<s>::=<np> <vp>
<np>::=<dp> <adjp> <n>|<pn>
<dp>::=the|a
<adjp>::=<adj>|<adj> <adjp>
<adj>::=big|fat|green|wonderful|faulty|subliminal
<n>::=dog|cat|man|university|father|mother|child
<pn>::=John|Jane|Sally|Spot|Fred|Elmo
<vp>::=<tv> <np>|<iv>
<tv>::=hit|honored|kissed|helped
<iv>::=died|collapsed|laughed|wept
```

- Could this grammar generate the following sentences?

  `Fred honored the green wonderful child`

  `big Jane wept the fat man fat`

- Generate a random sentence using this grammar.

# Sentence generation