Java Fundamentals

- **Problem solving**
  - **NIM**
- **Rudiments of Java**
  - **Classes, objects, methods, constructors**
  - **Declarations, statements, output**
- **Backus Naur Form (BNF)**

Goal: Problem Solving

- Problem solving
  - Defining the problem
  - Designing a solution
  - Implementing a solution
  - Testing your solution and debugging it
  - How to decide your solution "works"
- How to do this in an object-oriented style?

Problem Solving

- **Algorithm**
  - **Precise, unambiguous set of steps to follow to solve a problem**
- **Simple game: NIM**
  - **n objects**
  - **players alternate turns**
  - **a player must pickup either 1 or 2 objects**
  - **loser is player who picks up last object**

NIM

- **What is optimal strategy for playing NIM?**
- **Must assume each player tries to win game**
- **What do we know about the game?**
- **If 1 object left,**
  - **Pick it up and declare self “loser” !!??!!**
  - **n=1 is a losing state for whoever has that turn**

NIM

- If 2 objects left,
  - Pick up 1 object and force opponent to lose
  - Pickup 2 objects and lose; NO
  - n=2 is a **winning state**
- If 3 objects left,
  - Pickup 2 objects and force opponent to lose
  - n=3 is **winning state**

NIM Analysis

- A plays from 6 pieces:
  - A removes 2, B removes 2, A removes 1, A wins ☺
  - A removes 2, B removes 1, A removes 2, A wins ☺
  - A removes 1, B removes 2, A removes 2, A wins ☺
  - A removes 1, B removes 1, A removes 2, B removes 1, A loses ☹
  - So A always removes 2 to guarantee a win!

NIM Analysis

- Easier to reason about the game from its end to its beginning.
  - n=1 is a losing state, n=2, n=3 are winning states
  - n=4? if take 1 or 2 put opponent into n=3 or n=2, both winning states; therefore, n=4 is a losing state!
  - n=5? if take 1, put opponent into n=4 which is a loss for him. if take 2, put opponent into n=3 which is a win for him; therefore, will always take 1 and win!

NIM Strategy

- n = 1 2 3 4 5 6 7 8 9 10 11 12

  L W W L W W L W W L W W
- How many objects to remove?
  - Can be calculated each time
  - Can encode in a formula
- Rule:
  - If n is multiple of 3, remove 2
  - If n is not multiple of 3, remove 1

NIM(3)

- **Simple game: NIM(3)**
  - **n objects**
  - **players alternate turns**
  - **player must pickup 1, 2 or 3 objects**
  - **loser is player who picks up last object**
- **What's the optimal strategy for winning?**

NIM(3)

- **n=1 is losing state**
- **n=2 is winning state**
- **n=3 is winning state**
- **n=4 is winning state**
- **n=5 is losing state...**

NIM(3) Strategy

n=	1	2	3	4	5	6	7	8	9	10	11	12	13
	L	W	W	W	L	W	W	W	L	W	W	W	L
r=	0	1	2	3	0	1	2	3	0	1	2	3	0

for r = (n+3)%4 where % yields remainder from integer division

- **If r is not zero, remove r objects**
- **If r is zero, remove 1 object**

NIM(k) Strategy

- **Remove 1, 2, 3,...,(k-1), or k on each move**
- **Rule:**
  - **r = (n+k)%(k+1)**
  - **If r not zero, remove r objects**
  - **If r is zero, remove 1 objects**
- **Works for any game of this family.**

Next Step

- **Write a program that can play NIM against a person, using the winning strategy we derived**
- **Need to know intrinsic components of a Java program before doing this**
- **Basic idea we have used is same notion as in IBM Deep Blue chess program which beat Gary Kasparov last year!**

Example 1, Airport

- **Objects - airplanes, crew members, food trucks, baggage trams, etc.**
- **Actions**
  - **removeBaggage for baggage trams**
  - **takeOff for planes**
  - **loadMeals for food trucks**

Fundamentals

- **Program** - set of interdependent classes with one specified as the distinguished class (where computation starts)
- **Class** (or type) - a description of attributes (properties) and operations (capabilities) shared by some objects in the problem being solved
  - e.g., plane, foodTruck, crew, baggageTram

Fundamentals

- **Class**
  - **Each attribute (sometimes called instance variable) described by a Java declaration**
    - **e.g., Seating capacity of a 747**
  - **Each operation is a Java method**
    - **e.g., Assigning a flight schedule to a crew member**
- **Object - instance of a class; something with specific attribute values for which the class's operations make sense**
    - **e.g., a specific crew member, a particular plane**

Example 1, Airport

Crew Class Attribute	a Crew object
name	Jane Doe
home phone	888-111-2323
based at	EWR
job	co-pilot
specialties	CPR, navigation

Crew Class Operations

assign to flight number

schedule annual training refresher

takes vacation with startdate, enddate

Example 2, NIM

Nim Game Attribute	a Nim Game object
Total stones	6

Nim Class Operations

Remove one stone

Remove two stones

Start game with pile of stones

Java Terms

- **Method - operation consisting of a sequence of instructions**
- **Statement - a complete instruction**
- **Identifier - a name**
  - **Must begin with a letter**
  - **No embedded spaces allowed**
  - **Upper case and lower case distinguished**
    - **e.g., takesVacation and TakesVacation are different!**

More Java Terms

- **Variable - a data item of primitive type**
  - **boolean (Boolean) true, false**
  - **int (integer) -1, 0, 5**
  - **double (real number) 2.5, -.03**
- **Different than objects**
- **Used as auxiliary values in Java, to do simple calculations and as simple properties of objects**

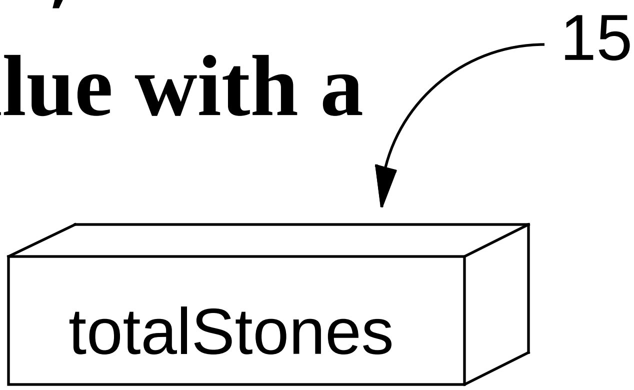
Variables

- **Declaration creates storage for a variable**

```
int totalStones;
int allStones, newpile;
```

- **Assignment associates a value with a variable**

```
totalStones = 15;
```



- **Defined operations**
  - **e.g., arithmetic, comparison**

```
totalStones - 2, totalStones > 20
```

Defining Syntax: Integers

<digit> → 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

<integer-number> → <digit>

<integer-number> → <integer-number> <digit>

<integer-number> can be 1,

<integer-number> can be 2,

<integer-number> can be 12,

<integer-number> can be 21, etc.

Defining Syntax

- Bishop, p 20 "An identifier in Java consists of letters and digits, but must start with a letter. Spaces are not allowed and capital and small letters are considered different..."
- Sequence of letters and digits, starting with a letter

A BNF Definition - Identifier

<digit> → 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

<letter> → A | a | B | b| C | c | D | d | E | e | F| f | G | g | H | h | I | i | J | j | K | k | L | l | M | m | O | o | P | p | Q | q | R | r | S | s | T | t | U | u | V | v | W | w | X | x | Y | y | Z | z

<identifier> → <letter>

<identifier> → <letter> <digit>

<identifier> → <letter> <letter>

<identifier> → <identifier> <letter>

<identifier> → <identifier> < digit>

Identifier

<identifier> → <letter> can be **A**

<identifier> → <letter> <digit> can be **x1**

<identifier> → <letter> <letter> can be **oK**

<identifier> → <identifier> <letter> can be **oKA, x1b** or **AA**

<identifier> → <identifier> <digit> can be **oKA1** or **A123**

Rule: have to build the construct by substituting right-hand-side for the nonterminal on the left of the rule.

Derivation of A123b

<identifier> → *<identifier>* <letter>

→ *<identifier>* <digit> <letter>

→ *<identifier>* <digit><digit> <letter>

→ *<identifier>* <digit> <digit> <digit> <letter>

→ *<letter>* <digit> <digit> <digit> <letter>

→ A *<digit>* <digit> <digit> <letter>

→ A 1*<digit>* <digit> <letter>

→ A 1 2*<digit>* <letter>

→ A 1 2 3 *<letter>*

→ A 1 2 3 b

BNF - Tool for Defining Syntax

Bishop, p 27

output statement
System.out.println (***items*** **);** **System.out.println ();** **System.out.print (** ***items*** **);**

Can be 3 rules in BNF, with → read as "produces",

< output-statement > → System.out.println (<items>);

< output-statement > → System.out.println ( );

< output-statement > → System.out.print (<items>);

or 1 rule written in shorthand, where | means "or",

< output-statement> → System.out.println (<items>); |
System.out.println ( ); | System.out.print (<items>);

Backus Naur Form (BNF)

- **A description language for the "shape" or syntax of programming language constructs**
- **Consists of terminals, nonterminals, rules**
- **Each rule corresponds to a block diagram in Bishop text**
  - **Nonterminal is in top box**
  - **Choices of right-hand-sides are in bottom box**
  - **Terminals are in plain font; nonterminals in italics; keywords (which are terminals) in boldface**

Backus Naur Form

- **Terminals**
  - **Atomic building blocks of the language**
  - **Keywords shown in color**
- **Nonterminals**
  - **Written as < nonterminal name >**
- **Rules for forming constructs use terminals, nonterminals and constructs we already have formed form other rules**

Nonterminal $\rightarrow$ right-hand-side