Java Main Function Questions

Java Primitive Types

- Can be remember as Java native types
- These numeric types or character types are built in to help calculation
- Java primitive types are really sensitive to the value it get assigns to
  - A floating point number cannot be assigned to a int
  - A non-floating number cannot be assigned to a boolean
- Gramma matters
- Has default value

Java Statement

- A complete Java statement includes identifier, variable name, variable value, and a semicolon.
- A identifier defines the java type, Java primitive type can be a identifier.
- A variable name have to follow the java gramma standard
  - All alphabet (upper case and lower case) are allowed
  - Can connect alphabet with underscore _ or dollar sign $. All other symbols are illegal gramma
  - Number 0-9 are allowed, bet a initial letter is required. Just number alone is invalid
- To finish one Java Statement, the semicolon is a must.

Java Naming

- A variable name have to follow the java gramma standard
  - All alphabet (upper case and lower case) are allowed
  - Can connect alphabet with underscore _ or dollar sign $. All other symbols are illegal gramma
  - Number 0-9 are allowed, bet a initial letter is required. Just number alone is invalid
- Apply to
  - Variable
  - Method name
  - Class name

Numeric Primitive type

```
public class MyProgram {
        public static void main(String[] args) {

            int intValue = 10;
            short shortValue = 128;
            double doubleValue1 = 10d;
            double doubleValue2 = 10D;
            double doubleValue3 = 10.0;
            float floatValue1 = 10f;
            float floatValue2 = 10F;
            float floatValue3 = 10.0;

        }
}
```

boolean

- The boolean identifier is a Java primitive type
- A boolean variable can be assigned with true of false

Java Primitive Cast

- Cast the the operation to convert the target data type to the assigned data type

- <primitive type> var = (primitive type) targetVar

- e.g.

  - short sVar = 19;

  - int var = (int) sVar;

- Cast cross all the boundary. For safety use
  - Use cast follow by the assignment rule
- Cast floating points (safely) to non floating points will lose all the digit
- Cast non floating points (safely) to floating points, will add .0

```
double d = 888.0d;
long longValue = (long) d;
//longValue will be printed out with 888
```

```
int intValue = 223;
double d = (double) intValue;
//d will be printed out with 223.0
```

```
int intValue = 5;
double d =  (double) intValue  /  2;                2.5
```

```
int intValue = 5;                                   2.0
double d =  (double) (intValue  /  2);
```

boolean

```
public class MyProgram {
        public static void main(String[] args) {

            boolean tVal = true;
            boolean fVal = false;
            // default false
            boolean val;

        }
}
```

char

- Represent each single character of string
- Value from 0 to 255

ASCII Table

Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char
0	0000 0000	00	[NUL]	32	0010 0000	20	space	64	0100 0000	40	@	96	0110 0000	60	`
1	0000 0001	01	[SOH]	33	0010 0001	21	!	65	0100 0001	41	A	97	0110 0001	61	a
2	0000 0010	02	[STX]	34	0010 0010	22	"	66	0100 0010	42	B	98	0110 0010	62	b
3	0000 0011	03	[ETX]	35	0010 0011	23	#	67	0100 0011	43	C	99	0110 0011	63	c
4	0000 0100	04	[EOT]	36	0010 0100	24	$	68	0100 0100	44	D	100	0110 0100	64	d
5	0000 0101	05	[ENQ]	37	0010 0101	25	%	69	0100 0101	45	E	101	0110 0101	65	e
6	0000 0110	06	[ACK]	38	0010 0110	26	&	70	0100 0110	46	F	102	0110 0110	66	f
7	0000 0111	07	[BEL]	39	0010 0111	27	'	71	0100 0111	47	G	103	0110 0111	67	g
8	0000 1000	08	[BS]	40	0010 1000	28	(	72	0100 1000	48	H	104	0110 1000	68	h
9	0000 1001	09	[TAB]	41	0010 1001	29	)	73	0100 1001	49	I	105	0110 1001	69	i
10	0000 1010	0A	[LF]	42	0010 1010	2A	*	74	0100 1010	4A	J	106	0110 1010	6A	j
11	0000 1011	0B	[VT]	43	0010 1011	2B	+	75	0100 1011	4B	K	107	0110 1011	6B	k
12	0000 1100	0C	[FF]	44	0010 1100	2C	,	76	0100 1100	4C	L	108	0110 1100	6C	l
13	0000 1101	0D	[CR]	45	0010 1101	2D	-	77	0100 1101	4D	M	109	0110 1101	6D	m
14	0000 1110	0E	[SO]	46	0010 1110	2E	.	78	0100 1110	4E	N	110	0110 1110	6E	n
15	0000 1111	0F	[SI]	47	0010 1111	2F	/	79	0100 1111	4F	O	111	0110 1111	6F	o
16	0001 0000	10	[DLE]	48	0011 0000	30	0	80	0101 0000	50	P	112	0111 0000	70	p
17	0001 0001	11	[DC1]	49	0011 0001	31	1	81	0101 0001	51	Q	113	0111 0001	71	q
18	0001 0010	12	[DC2]	50	0011 0010	32	2	82	0101 0010	52	R	114	0111 0010	72	r
19	0001 0011	13	[DC3]	51	0011 0011	33	3	83	0101 0011	53	S	115	0111 0011	73	s
20	0001 0100	14	[DC4]	52	0011 0100	34	4	84	0101 0100	54	T	116	0111 0100	74	t
21	0001 0101	15	[NAK]	53	0011 0101	35	5	85	0101 0101	55	U	117	0111 0101	75	u
22	0001 0110	16	[SYN]	54	0011 0110	36	6	86	0101 0110	56	V	118	0111 0110	76	v
23	0001 0111	17	[ETB]	55	0011 0111	37	7	87	0101 0111	57	W	119	0111 0111	77	w
24	0001 1000	18	[CAN]	56	0011 1000	38	8	88	0101 1000	58	X	120	0111 1000	78	x
25	0001 1001	19	[EM]	57	0011 1001	39	9	89	0101 1001	59	Y	121	0111 1001	79	y
26	0001 1010	1A	[SUB]	58	0011 1010	3A	:	90	0101 1010	5A	Z	122	0111 1010	7A	z
27	0001 1011	1B	[ESC]	59	0011 1011	3B	;	91	0101 1011	5B	[	123	0111 1011	7B	{
28	0001 1100	1C	[FS]	60	0011 1100	3C	<	92	0101 1100	5C	\	124	0111 1100	7C	|
29	0001 1101	1D	[GS]	61	0011 1101	3D	=	93	0101 1101	5D	]	125	0111 1101	7D	}
30	0001 1110	1E	[RS]	62	0011 1110	3E	>	94	0101 1110	5E	^	126	0111 1110	7E	~
31	0001 1111	1F	[US]	63	0011 1111	3F	?	95	0101 1111	5F	_	127	0111 1111	7F	[DEL]

char

```
public class MyProgram {
        public static void main(String[] args) {

            char c1= 45;
            char c2 = ‘A’;
            char c3 = ‘$’;

        }
}
```

Arithmetic Operators

- +: used for addition
- -: used for subtraction
- *: used for multiply
- /: used for division
- % (mod): used to get the remains of a division

Arithmetic Operators Question

```
public class MyProgram {
        public static void main(String[] args) {

            int a = 10;
            a += 10;

            a = a + 10;

        }
}
```

Special Arithmetic Operators

- ++
- - -

Special Arithmetic Operators

```
public class MyProgram {
        public static void main(String[] args) {

            int a = 10;
            a++;

            a = a + 1;

        }
}
```

Special Arithmetic Operators

```
public class MyProgram {
    public static void main(String[] args) {

        int a = 1;
        int b = 1;

        int c = ++b + a++;

    }
}
```

Relational Operators

- Execute the statement from left to right, relational operators give either true or false
- == : determine whether the left side is equals to the right side value
- !=: determine whether the left side is not equals to the right side value
- >: determine whether the left side is larger than the right side value
- <: determine whether the left side is smaller than right side value
- >=: determine whether the left side is larger or equals to right side value
- <=: determine whether the left side is smaller or equals to right side value

Logical Operators ||

<table>
<tr><th>Statement 1.</th><th>Statement 2.</th><th>Operator.</th><th>Value</th></tr>
<tr><td>true</td><td>true</td><td>| |</td><td>true</td></tr>
<tr><td>true</td><td>false</td><td>| |</td><td>true</td></tr>
<tr><td>false</td><td>true</td><td>| |</td><td>true</td></tr>
<tr><td>false</td><td>false</td><td>| |</td><td>false</td></tr>
</table>

One of the conditions need to be satisfied

Logical Operators &&

Statement 1.	Statement 2.	Operator.	Value
true	true	&&	true
true	false	&&	false
false	true	&&	false
false	false	&&	false

Both condition need to be satisfied

Logical Operators !

Statement	Operator.	Value
true	!	false
false	!	true

Opposite

Logical Operation Append Rules

Condition1 && Condition2 && Condition3 && ….

The more && statements get appended, the more strict the condition is

Condition1 || Condition2 || Condition3 || ….

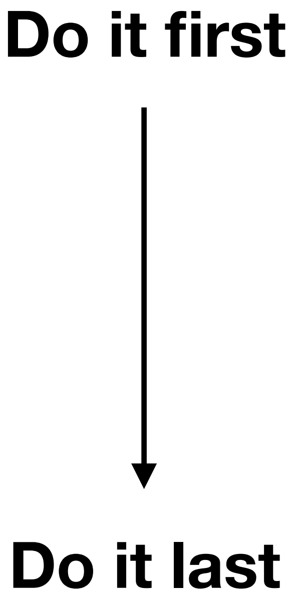
The more || statements get appended, the more flexible the condition is

DeMorgan’s Law

!(a && b) = !a || !b

!(a || b) = !a && !b

Operators Computing Order



Do it first

Do it last

1. !   ++   —
2. *   /   %
3. +   -
4. <   >   <=   >=
5. ==   !=
6. &&
7. ||
8. =   +=   -=   *=   /=   %=

note: The horizontal order does not matter

Java numeric wrapper object

- Short
- Integer
- Long
- Float
- Double
- Boolean

Numeric Primitive type

```
public class MyProgram {
    public static void main(String[] args) {

        Integer intValue = 10;
        Short shortValue = 128;
        Double doubleValue1 = 10d;
        Double doubleValue2 = 10D;
        Double doubleValue3 = 10.0;
        Double doubleValue4 = new Double(10.0);
        Float floatValue1 = 10f;
        Float floatValue2 = 10F;
        Float floatValue3 = 10.0;
        Float doubleValue4 = new Float(10.0);
    }
}
```

Wrapper to primitive type

- This process is called box and unbox
- Wrapper class can be set to null

Object level access

```
public class MyProgram {
        public static void main(String[] args) {
                Integer intValue1 = 10;
                int toIntValue = intValue.intValue();
                short toShortValue = intValue.shortValue();
                double toDoubleValue = intValue.doubleValue();
                long toLongValue = intValue.longValue();
                String toStringValue = intValue.toString();
        }
}
```

Wrapper object level access

- All wrapper class provides function to covert to other primitive type value
- When your conversion is invalid, e.g. max integer to short, it will be over flow. So it still follows the primitive type casting rules

Class level access

```
public class MyProgram {
        public static void main(String[] args) {

            int maxValue = Integer.MAX_VALUE;
            int minValue = Integer.MIN_VALUE
            int convertValue = Integer.valueOf(“123”);

        }
}
```

Wrapper class level access

- Wrapper class provides lots of useful class level access utility function itself
- Instead of object level access, class level functions provides good error handling.
- When a invalid string is get converted, error will be thrown

Maths numerical operations packages

- A complete utility class, only provides class level access
- Provides tons of useful Maths operations
- We called these class pure utility classes

Exam related

- Math.random()
- Math.max(int a, int b)
- Math.min(int a, int b)
- Math.abs(int a)
- Math.round(float a)
- Math.floor(float a)
- Math.pow(double a, double b)

Math random min to max

```
min + (int)(Math.random * (max - min + 1) )
```

Based calculation

Base 2

- Base: 0, 1
- Add the next significant digit when adding 1 to a ‘1’
- Most basic calculation unit of computing science

Base 8

- Base: 0, 1, 2, 3, 4, 5, 6, 7
- Add the next significant digit when adding 1 to a ‘7’
- Used in old computer systems

Base 10

- Base: 0, 1, 2, 3, 4, 5, 6, 7, 8 , 9
- Add the next significant digit when adding 1 to a ‘9’
- Foundation of maths

Base 16

- Base: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Add the next significant digit when adding 1 to a ‘F’
- Foundation of modern 64 bit and 32 bit OS systems

Convert Every other base representation to base 10

Value * base ^ (highest significantIndex)
+NextValue * base ^ (highest significantIndex - 1)
+….
+LastValue * base ^ (0)

1234_{10} to $????_{10}$

$1 * (10 \wedge 3) + 2 * (10 \wedge 2) + 3 * (10 \wedge 1) + 4 * (10 \wedge 0) = 1234_{10}$

1111_{2} to $????_{10}$

$1 * 2 \wedge 3 + 1 * 2 \wedge 2 + 1 * 2 \wedge 1 + 1 * 2 \wedge 0 = 8_{10} + 4_{10} + 2_{10} + 1_{10} = 15_{10}$

1234_{8} to $????_{10}$

$1 * (8 \wedge 3) + 2 * (8 \wedge 2) + 3 * (8 \wedge 1) + 4 * (8 \wedge 0) = 668_{8}$

1234_{16} to $????_{10}$

$1 * (16 \wedge 3) + 2 * (16 \wedge 2) + 3 * (16 \wedge 1) + 4 * (16 \wedge 0) = 4660_{16}$

$ABCD_{16}$ to $????_{10}$

$A * (16 \wedge 3) + B * (16 \wedge 2) + C * (16 \wedge 1) + D * (16 \wedge 0) =$
$10_{10} * (16 \wedge 3) + 11_{10} * (16 \wedge 2) + 12_{10} * (16 \wedge 1) + 13_{10} * (16 \wedge 0) = 43981$

Convert base 10 to every other base

- Step 1: Take the other base as divider
- Step 2: Use Decimal value mod divider
- Step 3: Write down mod value
- If the remaining decimal value is still larger than divider
    - Repeat step 2
    - otherwise write down last mod value

2 | 35 1

2 | 17 1

2 | 8 0

2 | 4 0

2 | 2 0

2 | 1 1

100011_2

8 | 35 3

8 | 4 4

43_8

16 | 35 3

16 | 2 2

23_{16}

Convert base 8 to binary

- The highest single digit of base 8 is 7
- 7 can be represent with just 3 bits: 111
- To convert base 8 to binary, calculate each digit to a 3 bits binary and combine them.
- e.g. 45_8, 4 convert to 100_2 , 5 to 101_2 result is 100101_2

Convert base 16 to binary

- The highest single digit of base 8 is F
- F maps to 15 in base 10,
- F can be represent with just 4 bits: 1111
- To convert base 16 to binary, calculate each digit to a 4 bits binary and combine them.
- e.g. AB_8, A convert to 1010_2 , B to 1011_2 result is 10101011_2

Convert base 16 to base 8

- Convert base 16 to binary, calculate each digit to a 4 bits binary and combine them.

- Regroup the binary to a new group of 3 bits, make up the missing digits with 0

- e.g. AB$_8$, A convert to 1010$_2$, B to 1011$_2$ result is 10101011$_2$, Regroup 010/101/011$_2$ result is 253$_8$

Convert base 8 to base 16

- Convert base 8 to binary, calculate each digit to a 3 bits binary and combine them.

- Regroup the binary to a new group of 4 bits, make up the missing digits with 0

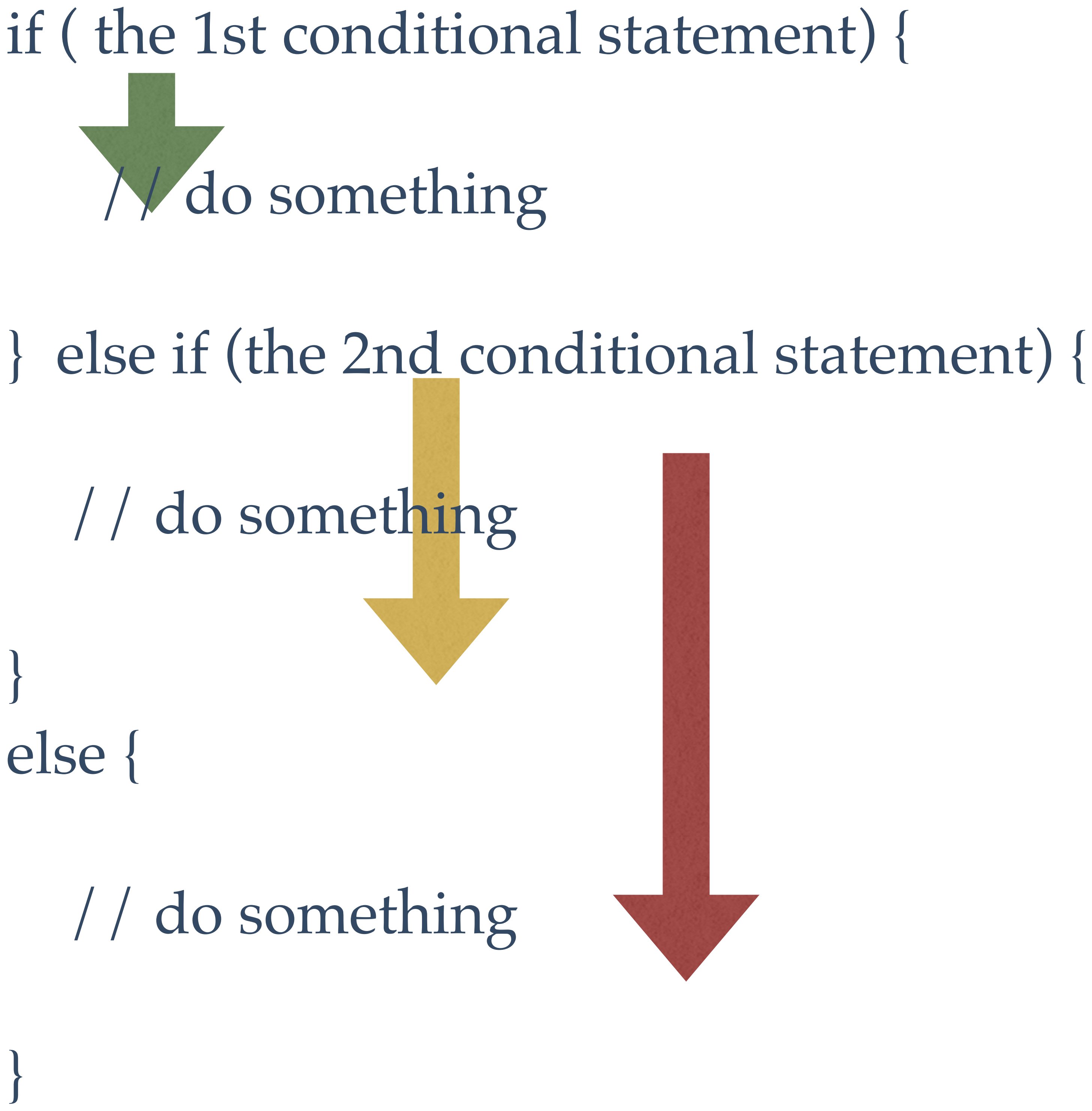
- e.g. 253_8, result is 010101011_2, Regroup $0/1010/1011_2$ result is AB_8

Java Primitive Assignment

- You can always assign value from a lower storage cost to a higher storage cost variable
- Floating points always larger than non floating points
    - You can assign any non floating points value to any floating points variable
    - No other way around

Java if else statement

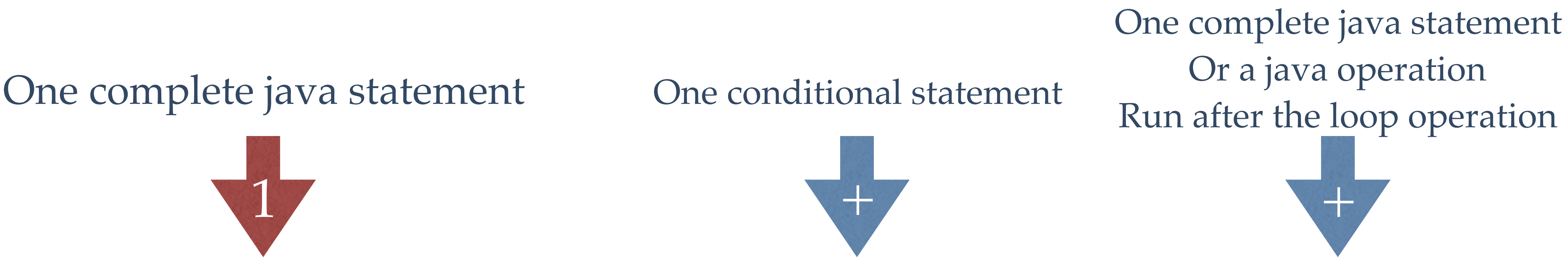
- Control the where the next code execution goes to
- By given one or more logical statement to establish statement
    - if
    - if + else
    - if + else if + … + else
- Nest if else statement
    - The inner statement can be executed only if outer statement is passed
    - Nested statement can be understand as logical condition dependency



```
if ( the 1st conditional statement) {

    / / do something

}  else if (the 2nd conditional statement) {

    / / do something

}
else {

    / / do something

}
```

Java Loop

For loop


One complete java statement
1
One conditional statement
+
One complete java statement
Or a java operation
Run after the loop operation
+

```
for ( [initial control variable declare]; [looping condition check] ; [condition change]) {

        / / do something
}
```

While loop

One conditional statement

+

```
while ( [changeable condition]) {

        / / keep doing something
}
```

Do while loop

```
do {

    // keep doing something

} while ( [changeable condition]);
```

One conditional statement

You can take the initiative and break the loop,
but you need to know what you are doing,
break should be used in side a if condition to be break properly

```
int myNumber = 1024;

while (myNumber > 0) {
    myNumber--;
    if (myNumber == 512) {
      break;
    }
}
System.out.println(myNumber);
```

Prints: 512

Nested for loop example

```
for (int i = 1; i <= 10 ; i++) {
    // code here will be executed for 10 times (i times)
    for (int j = 1; j <= 5 ; j++)  {
    //code here will be executed for 50 times (i*j times)
    // and yes, there are no restrict on how may nested for loops here
    }
}
```

For loop tips

- Do not modify the control variable (e.g. i or j) inside the loop body, it is very easy to mess up the loop logic

- Double check the control variable before you start the loop body writing, it is very easy to make a infinite loop

- Write down detailed steps if you are confused with the looping logic.

Java Variable Scope

Java Variable Scope

- Defines the variable accessibility level
- The deeper the variable get created, the less accessible it gets

```
public class MyProgram {
        public static void main(String[] args) {
              int myVariable = 6;

              if (myVariable >= 3) {
                // you can access myVariable here
                int innerVariable = myVariable;
                // you can only access innerVariable here inside if block
              }

               // you CANNOT access innerVariable here!!! EVER!!!!

              for (int i = 1; i <= 10 ; i++) {
                  // you can access i here
                  // you can access myVariable here
                  for (int j = 1; j <= 5 ; j++)  {
                      // you can access i here
                      // you can access j here
                      // you can access myVariable here
                  }
                  // you CANNOT access j here!!!!!
                  // you can access i here
              }

              // you CANNOT access  i  and j  here!!!!!
              // you can access myVariable here

        }  // nothing get access here
}
```

Java String

What is String

- String represent text form of data
- String is an object
- String is an array of char variables

Initial a String

```
public class MyProgram {
        public static void main(String[] args) {

            // Initial string with directly assign variable
            String value1 = “hello”;
           // Initial string with String class constructor
            String value2 = new String(“Hello”)

       }
}
```

String is a list of char

char: 16 bit - 2 bytes

Index	0	1	2	3	4
Char array	‘H’	‘E’	‘L’	‘L’	‘O’

String value “HELLO”

ASCII Table

Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char	Dec	Bin	Hex	Char
0	0000 0000	00	[NUL]	32	0010 0000	20	space	64	0100 0000	40	@	96	0110 0000	60	`
1	0000 0001	01	[SOH]	33	0010 0001	21	!	65	0100 0001	41	A	97	0110 0001	61	a
2	0000 0010	02	[STX]	34	0010 0010	22	"	66	0100 0010	42	B	98	0110 0010	62	b
3	0000 0011	03	[ETX]	35	0010 0011	23	#	67	0100 0011	43	C	99	0110 0011	63	c
4	0000 0100	04	[EOT]	36	0010 0100	24	$	68	0100 0100	44	D	100	0110 0100	64	d
5	0000 0101	05	[ENQ]	37	0010 0101	25	%	69	0100 0101	45	E	101	0110 0101	65	e
6	0000 0110	06	[ACK]	38	0010 0110	26	&	70	0100 0110	46	F	102	0110 0110	66	f
7	0000 0111	07	[BEL]	39	0010 0111	27	'	71	0100 0111	47	G	103	0110 0111	67	g
8	0000 1000	08	[BS]	40	0010 1000	28	(	72	0100 1000	48	H	104	0110 1000	68	h
9	0000 1001	09	[TAB]	41	0010 1001	29	)	73	0100 1001	49	I	105	0110 1001	69	i
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12	0000 1100	0C	[FF]	44	0010 1100	2C	,	76	0100 1100	4C	L	108	0110 1100	6C	l
13	0000 1101	0D	[CR]	45	0010 1101	2D	-	77	0100 1101	4D	M	109	0110 1101	6D	m
14	0000 1110	0E	[SO]	46	0010 1110	2E	.	78	0100 1110	4E	N	110	0110 1110	6E	n
15	0000 1111	0F	[SI]	47	0010 1111	2F	/	79	0100 1111	4F	O	111	0110 1111	6F	o
16	0001 0000	10	[DLE]	48	0011 0000	30	0	80	0101 0000	50	P	112	0111 0000	70	p
17	0001 0001	11	[DC1]	49	0011 0001	31	1	81	0101 0001	51	Q	113	0111 0001	71	q
18	0001 0010	12	[DC2]	50	0011 0010	32	2	82	0101 0010	52	R	114	0111 0010	72	r
19	0001 0011	13	[DC3]	51	0011 0011	33	3	83	0101 0011	53	S	115	0111 0011	73	s
20	0001 0100	14	[DC4]	52	0011 0100	34	4	84	0101 0100	54	T	116	0111 0100	74	t
21	0001 0101	15	[NAK]	53	0011 0101	35	5	85	0101 0101	55	U	117	0111 0101	75	u
22	0001 0110	16	[SYN]	54	0011 0110	36	6	86	0101 0110	56	V	118	0111 0110	76	v
23	0001 0111	17	[ETB]	55	0011 0111	37	7	87	0101 0111	57	W	119	0111 0111	77	w
24	0001 1000	18	[CAN]	56	0011 1000	38	8	88	0101 1000	58	X	120	0111 1000	78	x
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26	0001 1010	1A	[SUB]	58	0011 1010	3A	:	90	0101 1010	5A	Z	122	0111 1010	7A	z
27	0001 1011	1B	[ESC]	59	0011 1011	3B	;	91	0101 1011	5B	[	123	0111 1011	7B	{
28	0001 1100	1C	[FS]	60	0011 1100	3C	<	92	0101 1100	5C	\	124	0111 1100	7C	|
29	0001 1101	1D	[GS]	61	0011 1101	3D	=	93	0101 1101	5D	]	125	0111 1101	7D	}
30	0001 1110	1E	[RS]	62	0011 1110	3E	>	94	0101 1110	5E	^	126	0111 1110	7E	~
31	0001 1111	1F	[US]	63	0011 1111	3F	?	95	0101 1111	5F	_	127	0111 1111	7F	[DEL]

String length()

```
public class MyProgram {
        public static void main(String[] args) {

            // Initial string with directly assign variable
            String value = “hello”;
            // size is 5
            int size = value.length();

       }
}
```

String toCharArray()

```
public class MyProgram {
        public static void main(String[] args) {

            // Initial string with directly assign variable
            String value = “hello”;
            // value list is h, e, l, l, o
           char[] valuelist = value.toCharArray();

        }
}
```

String charAt(int index)

```
public class MyProgram {
        public static void main(String[] args) {

            // Initial string with directly assign variable
            String value = “hello”;
            // valueChar is  ‘o’
           char valueChar = value.charAt(4);

       }
}
```

String upper/lower case

```
public class MyProgram {
        public static void main(String[] args) {

            // Initial string with directly assign variable
            String value = “Hello”;
            // upper is  HELLO
           String upper = value.toUpperCase();
           // lower is hello
           String lower = value.toLower();

       }
}
```

String subString

```
public class MyProgram {
        public static void main(String[] args) {

             // Initial string with directly assign variable
             String value = “Hello”;
             // upper is llo
            String upper = value.subString(2);
            // lower is Hel
            String lower = value.toLower(0, 2);

       }
}
```

System.out.print rule1

Calculate **Append**

number + number + string + number + number

System.out.print rule1 Escape

\ Special charactor

“\”time\””

- \” print “
- \’ print ‘
- \t print tab
- \n print next line

Java Method

Java Method

- Can see as a function
  - You give input, the function gives output
  - stateless: the same input always gives same output
- Java Method is re-useable
- Can be assign to a Java variable
- If the method returns a value, it can be directly called in System.out.print
- Method can call other method

Format

```
[Modifier] [static/non static] [return type] [method name] ([parameter1], [parameter2] …) {
        // Method body
        return [return value]
 }
```

Java Method Rule

- Naming convention follows Java variable, you can connect words with _ and $, you can include numbers in the name, but the method name has to start with a letter
- Method has to have a return type.
- The final return type needs to match the define return type
- Method body needs to be wrapped by {}
- Method itself will execute, method needs to be called or in official term “invoked”

Java Method Parameter Rule

- Technically, you can have unlimited method parameter
- Parameter declare follows normal Java variable rules
- Parameter can directly be used in the method body
- Method can have zero parameter

A void method

- If there is nothing to return in the method. Define void
- Java main method is a void method

Void method

```
public class MyProgram {
        public static void main(String[] args) {
            functionVoid(1, 3);

        }

        public static void functionVoid(int a, int b) {

            System.out.println(a + b);

        }


}
```

method with return

```
public class MyProgram {
        public static void main(String[] args) {

                int c = sub(addition(1,2), sub(3, 4));

        }

        public static int addition(int a, int b) {

                return a + b;

        }

        public static int sub(int a, int b) {

                return a - b;

        }

}
```

Array Summary

Array

- Represent a list of Same data type
- Everything can be represent as array in Java
- Created with a initial value
- Is an “object” so it will allocate memory

Array Format

- You can have
  - int[], float[], double[]
  - boolean[], String[]
  - The object you created array
    - Student[], Score[]

Initial an array

- When array is initial created it is empty
- It just provides a container to store value
- For primitive type all value goes to the default when created
    - int, short, long, default value is 0
    - float, double default value is 0.0
    - boolean is false
    - The object you created is null value

Access an Array

- Access an element in array with its index
- Array start with index 0

Go through an array

- Looping with for or while
- You can start at any index
- DO NOT go across the index boundary
- The index boundary is array length - 1

Index	0	1	2	3	4	5	6	7
int array	7	4	5	3	11	9	3	1

Example Code

```
public class MyProgram {
          public static void main(String[] args) {

           // create an int array of size 10. You can store 10 integer here
           int[] intArray = new int[10];

         }
}
```

Example Code

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array of size 10. You can store 10 integer here
            int[] intArray = new int[2];
            intArray[0] = 1;
             intArray[1] = 2;

        }
}
```

Example Code

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array of size 10. You can store 10 integer here
            int[] intArray = new int[2];
            intArray[0] = 1;
            intArray[1] = 2;
            System.out.println(intArray.length);

        }
}
```

Print out 2

Since Array is an object Important attribute

- object.length

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array of size 10. You can store 10 integer here
            int[] intArray = new int[10];

            for (int i = 0; i < intArray.length; i ++) {
                 intArray[i] = i  + 1;
            }

            for (int j = 0; j < intArray.length; j ++) {
                 System.out.println(intArray[j] + “ ”);
            }

        }
}
```

Print out 1 2 3 4 5 6 7 8 9 10

Array, Object Memory Reference Summary

Primitive Type

- Primitive type does not go into Java heap memory
- When used by functions, only the value is passed in
- Primitive type value will not be influenced by method

```
public class MyProgram {
        public static void main(String[] args) {

            int a = 10;
            int b = function(a);
            System.out.print(a);
            System.out.print(b);

        }

        public int function(int a) {
                a = a + 10;
                return a;
        }
}
```

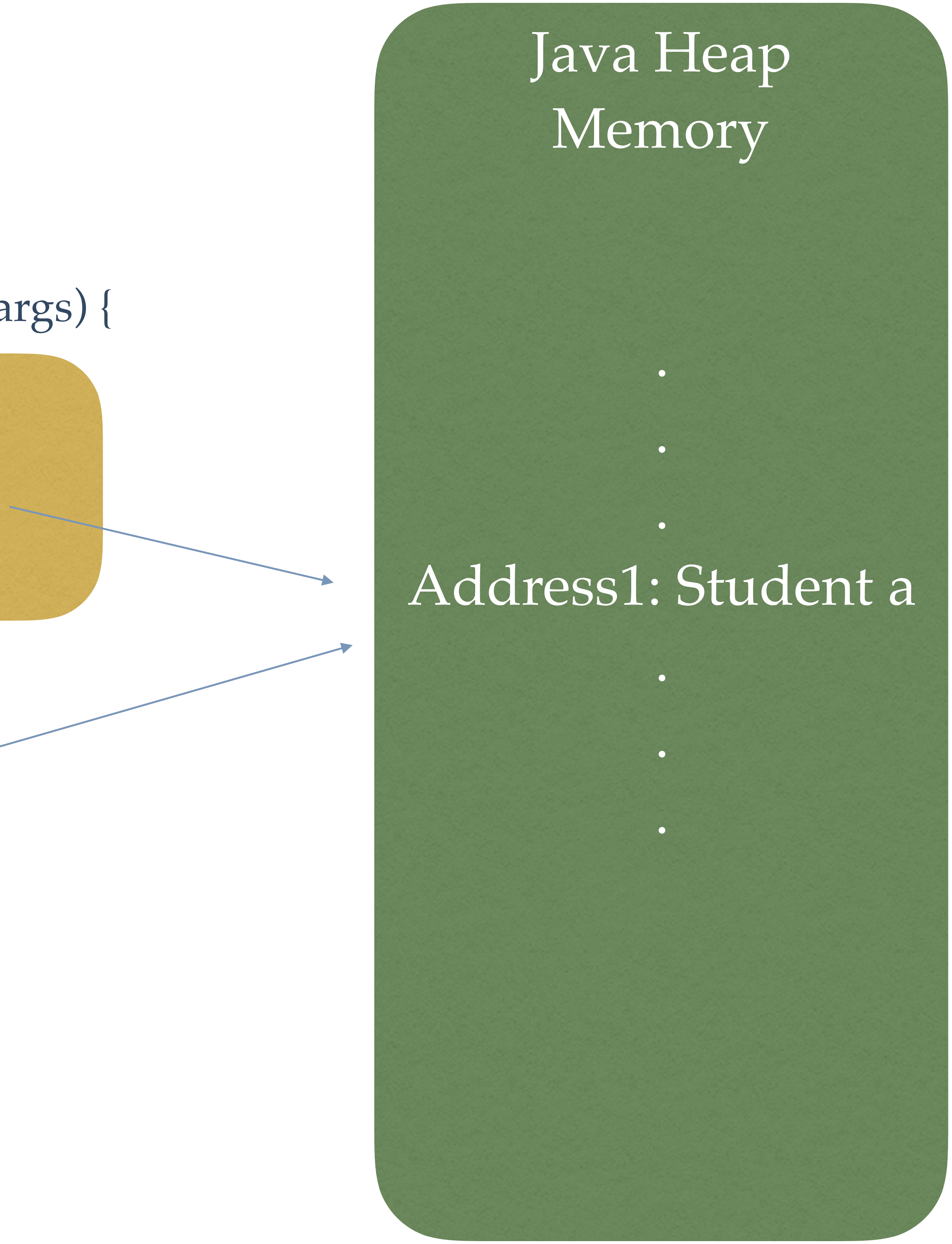
Object Type

- Object types are stored in Java heap memory
- When used by functions, the memory reference is passed in to the function
- Object type value will not be influenced by method, be careful

```
public class MyProgram {
        public static void main(String[] args) {

            int finalScore = 90;
            Student a = new Student(90);
            function(a);
            System.out.print(a.final);

        }

        public void function(Student a) {
                a.finalScore = 100;
        }
}
```

shallow copy

```
public class MyProgram {
        public static void main(String[] args) {

            int finalScore = 90;
            Student a = new Student(90);
            function(a);
             System.out.print(a.final);

        }

        public void function(Student a) {
              a.finalScore = 100;
        }
}
```



Java Heap Memory

.
.
.

Address1: Student a

.
.
.

```
public class MyProgram {
        public static void main(String[] args) {

          int[] myarray = {1,2,3,4,5};
          function(myarray);
          System.out.print(myarray[0]);

        }

        public void function(int[] input) {
                input[0] = 9;
        }
}
```

Object Copy

- Since Object types are stored in Java heap memory
- Directly use “=” will just point to the same memory address, this is shallow copy
- To deep copy, make sure all object values are copied and created a new object using new key word.
- For array, each value should be copied to the new array spot

Java 2D array

Array

- Represent a list of Same data type
- Everything can be represent as array in Java
- Created with a initial value
- Is an “object” so it will allocate memory

An array of array - 2D array
Or Matrix

- Represent a grid of data
- Data spread in 2 dimension
- A grid of same type of data

Access an 2D array

- Access an element in array with its index
- Access an element in 2d array with its coordinate

Index	0	1	2	3	4
0	1	2	3	4	5
1	1	2	3	4	5
2	1	2	3	4	5
3	1	2	3	4	5
4	1	2	3	4	5

int matrix

Important Matrix attribute

- int[][] matrix
- matrix.length return number of rows in matrix
- matrix[index].length return number of columns in matrix

```
public class MyProgram {
    public static void main(String[] args) {

    // create an 4*5 matrix
    int[][] matrix = new int[4][5];

    // rows is now equals to 4
    int rows = matrix.length;

    // columns is now equals to 5
    int columns = matrix[0].length;

    }
}
```

Go through a matrix

- Looping with nested for loop
- Control index with meaningful variable name
- DO NOT go across the index boundary

```
public class MyProgram {
        public static void main(String[] args) {

        // create a 3*3 matrix
        int[] matrix = new int[3][3];


        for (int row = 0; row < matrix.length; row ++) {
            for (int column = 0; column < matrix[0].length; column++) {
                System.out.println(matrix[row][column]);
            }
        }

        }
}
```

Print out 1 2 3 4 5 6 7 8 9 10

Java ArrayList

Basic Type Array Problems

- Need a for loop to do everything
- Hard to copy an array into another
- Hard to remove items
- Need to create with a initial size

Java ArrayList

- A Java built in data structure collection
- Also a container for a list of same typed object
- A Java generic template
- Not for primitive type
- Provided way more functions

ArrayList Format

- ArrayList<ObjectType> variableName = new ArrayList<ObjectType>();
- <> represent as this is a Java generic template collection
- ObjectType defines what object can be put into array list

Example ArrayList

```
public class MyProgram {
    public static void main(String[] args) {

        // create an int array list
        ArrayList<Integer> list = new ArrayList<Integer>();

    }
}
```

Access an ArrayList

- Access an element in arraylist is like access them in array
- Use .add(Object target) to add at tail of list
- Use.remove(Object target) to remove an object
- Use .get(int index) to access element
- Use .set(int index, Object target) to override an element
- When arraylist is created, this is also empty

Add item in ArrayList

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array list
            ArrayList<Integer> list = new ArrayList<Integer>();
            Integer input = 10;
            list.add(input);

        }
}
```

ArrayList size

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array list
            ArrayList<Integer> list = new ArrayList<Integer>();

            int currentSize = list.size();
            list.add(10);
            list.add(12);

            currentSize = list.size();

        }
}
```

Remove by index in ArrayList

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array list
            ArrayList<Integer> list = new ArrayList<Integer>();

            int currentSize = list.size();
            Integer input1 = 10;
            Integer input2 = 12;
            list.add(input1);
            list.add(input2);

            list.remove(0);

        }
}
```

Remove by item in ArrayList

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array list
            ArrayList<Integer> list = new ArrayList<Integer>();

            int currentSize = list.size();
            Integer input1 = 10;
            Integer input2 = 12;
            list.add(input1);
            list.add(input2);

            list.remove(input1);

        }
}
```

Go through ArrayList

```
public class MyProgram {
        public static void main(String[] args) {

            // create an int array list
             ArrayList<Integer> list = new ArrayList<Integer>();

            for ( Integer item : list) {
                System.out.println(item);
            }

        }
}
```

Algorithm

- Find Max
- Find Min
- Go through array, 2D array, forward/backward
- Build array, 2D array, forward/backward

Java Recursion Method

Normal method

```java
public void normalMethod(int a, int b) {
    int c = a + b;
    int d = a * b;

    System.out.println(c);
    System.out.println(d);
}
```

Method with a return type
e.g. given n, return sum of 0 to n

```
public int normalMethod(int n) {
   int sum = 0;
   for (int i = n; i >=0; i--) {
      sum += i;
   }

   return sum;
}
```

Recursion Function

- Function will recursively calling itself
- Can have or not having a return type
- If not careful, can turn into infinite recursion

```java
public void recurMethod(int a) {
    System.out.println(a);
    recurMethod(a + 1);
}
```

```java
public int recurMethod(int a) {
    return recurMethod(a  - 1);
}
```

Proper designed Recursion Function

- Recursion function are usually used to solve problem that answers are depends on the previous calculation result.

- Recursion function should very carefully defined the BASE case, for function to stop

- Then carefully develop the recursion condition

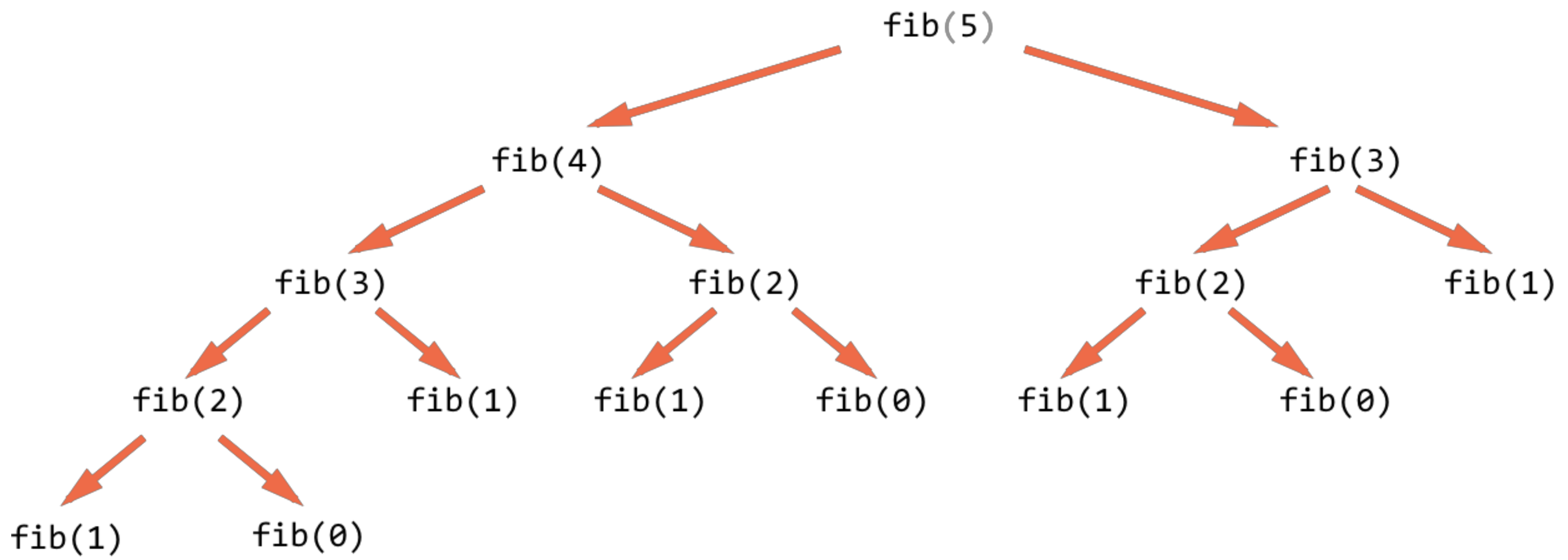
Fibonacci sequence

0 1 1 2 3 5 8 13…….

fib(n) = fib(n - 1) + fib(n -2)

Given int a, a is a number >=0, return the ath fibonacci number

```java
public int fib(int a) {

}
```


fib(5)
fib(4)
fib(3)
fib(3)
fib(2)
fib(2)
fib(1)
fib(2)
fib(1)
fib(1)
fib(0)
fib(1)
fib(0)
fib(1)
fib(0)

N!

N sum

```java
public int factor(int n) {
    if (n == 0) return 1;
    return factor(n - 1) * n;
}
```

```java
public int sum(int n) {
    if (n == 0) return 0;
    return sum(n - 1) + n;
}
```

Binary Search

```java
public boolean binarySearch(int[] a, int key)
{
    int lo = 0;
    int hi = a.length - 1;
    while (lo <= hi)
    {
        // Key is in a[lo..hi] or not present.
        int mid = lo + (hi - lo) / 2; // do this to avoid overflow
        if (key < a[mid])
        {
            hi = mid - 1;
        }
        else if (key > a[mid])
        {

            lo = mid + 1;
        }
        else
        {
            return true;
        }
    }
    return false;
}
```

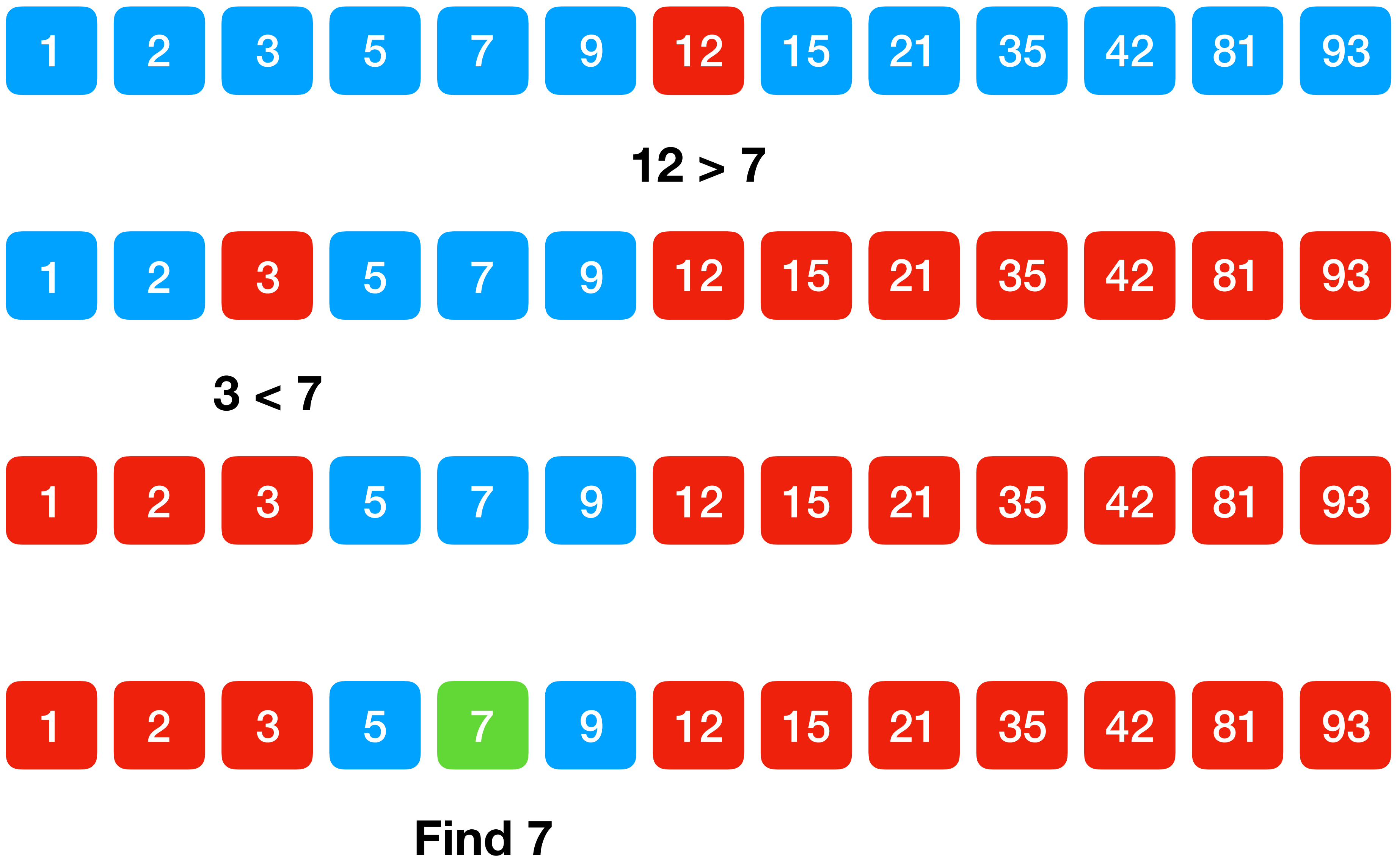
```java
public boolean binarySearch(int[ ] data, int target, int low, int high) {
    if (low > high) {
        return false;
    } else {
        int mid = low + (high - low) / 2; // do this to avoid overflow
        if (target == data[mid])
            return true;
        else if (target < data[mid])
            return binarySearch(data, target, low, mid - 1);
        else
            return binarySearch(data, target, mid + 1, high);
    }
}
```

Sorting And Search

Review of search

```
public static int indexOf(int[] a, int key)
{
    int lo = 0;
    int hi = a.length - 1;
    while (lo <= hi)
    {
        // Key is in a[lo..hi] or not present.
        int mid = lo + (hi - lo) / 2; // do this to avoid overflow
        if (key < a[mid])
        {
            hi = mid - 1;
        }
        else if (key > a[mid])
        {

            lo = mid + 1;
        }
        else
        {
            return mid;
        }
    }
    return -1;
}
```

Search for 7



1 2 3 5 7 9 12 15 21 35 42 81 93

12 > 7

1 2 3 5 7 9 12 15 21 35 42 81 93

3 < 7

1 2 3 5 7 9 12 15 21 35 42 81 93

1 2 3 5 7 9 12 15 21 35 42 81 93

Find 7

Effective Search

- With chaos order, search has to be done linearly
- With order search, we can apply algorithm like binary search to find the target efficiently
- The key pre condition of binary search is that the list has to be sorted
- Sort algorithm therefore is very important

Sorting

- The process to make a random ordered list to a ordered list

- Speed is the most important aspect of sorting

- Some sorting method require extra memory allocation

- For sorting algorithm that require no extra space we call it in place sorting

Need to know for the test

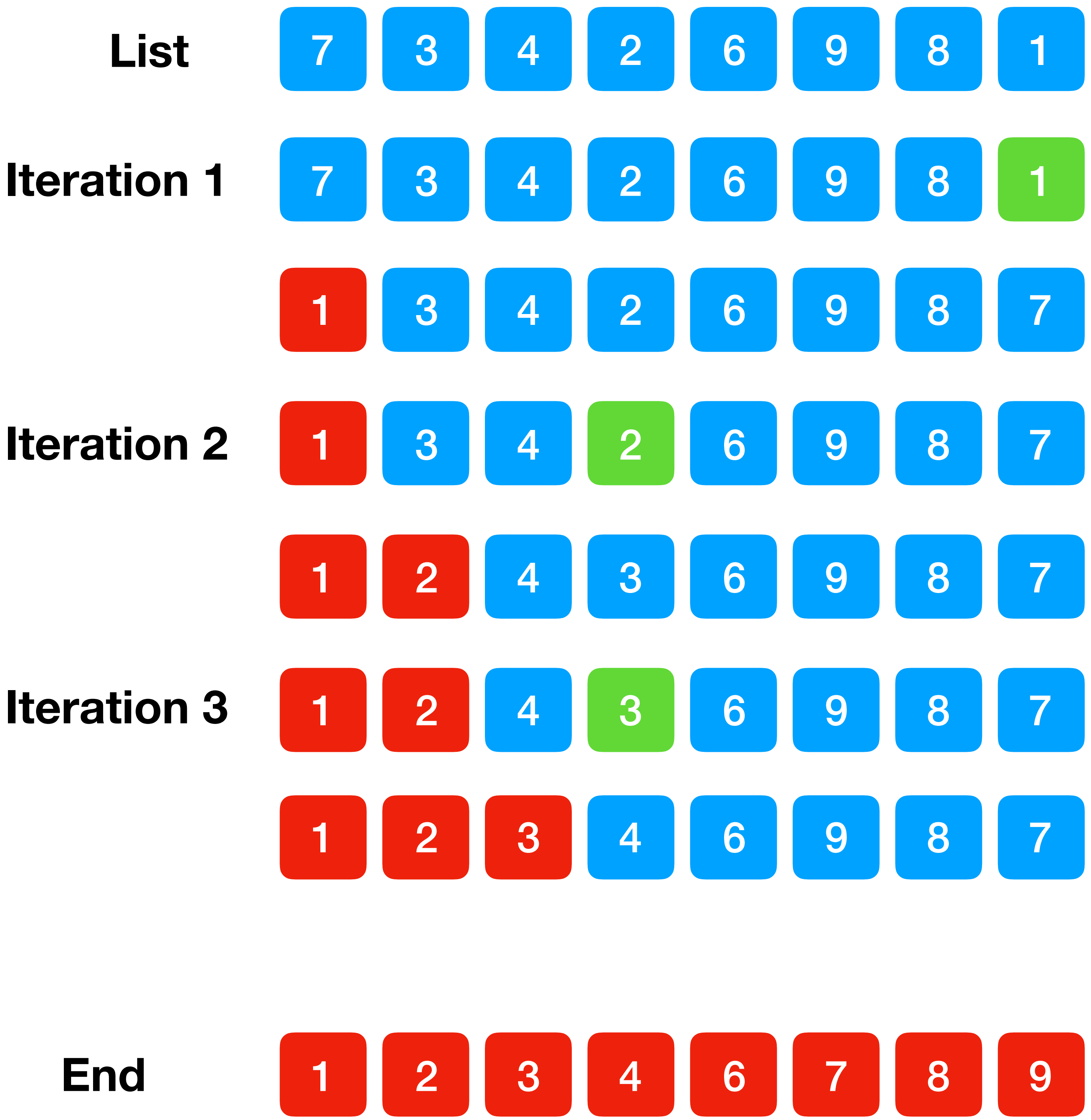
- Selection Sort
- Insertion Sort
- Merge Sort

Selection sort

- Slowest but most easy to understand
- For each iteration, find the next smallest item in the remaining list and put to the front.

Before selection sort

- Write program to find the minimum value in a list and return its index.

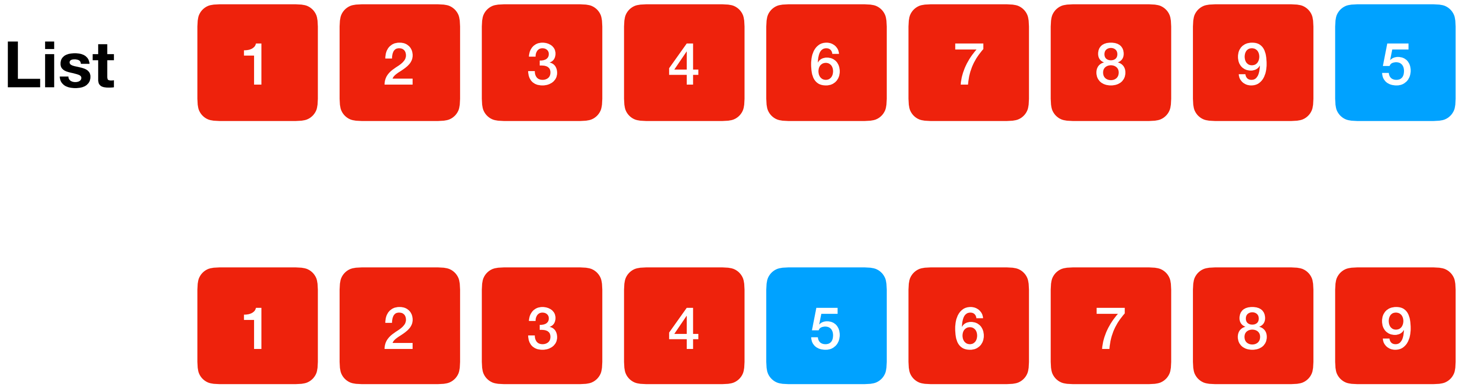


List	7	3	4	2	6	9	8	1
Iteration 1	7	3	4	2	6	9	8	1
	1	3	4	2	6	9	8	7
Iteration 2	1	3	4	2	6	9	8	7
	1	2	4	3	6	9	8	7
Iteration 3	1	2	4	3	6	9	8	7
	1	2	3	4	6	9	8	7
End	1	2	3	4	6	7	8	9

```java
public static void selectionSort(int[] a) {

    int length = a.length;

    for (int i = 0; i < length - 1; ++i) {

        int minIndex = i;
        for (int j = i + 1; j < length; ++j) {
            if (a[j] < a[minIndex]) {
                minIndex = j;
            }
        }

        // swap to the top
        int tmp = a[i];
        a[i] = a[minIndex];
        a[minIndex] = tmp;
    }
}
```

Before insertion sort

- Put a new item at the end of a sorted list.
- Move the new item to the correct position



List

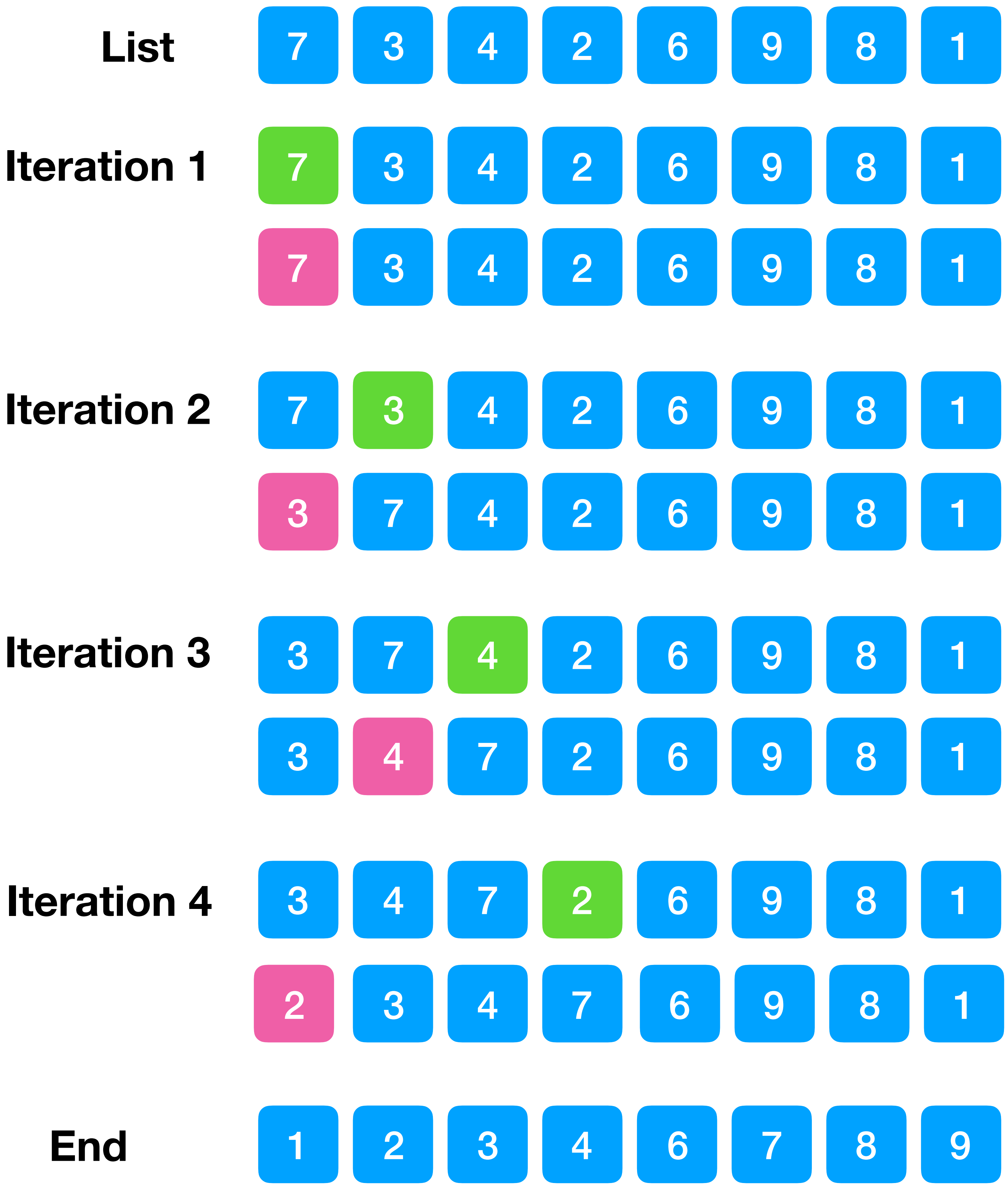
1 2 3 4 6 7 8 9 5

1 2 3 4 5 6 7 8 9

```java
private static int[] testTarget = new int[10];
private static int size = 0;
private static int next = 0;

public static boolean insert(int value) {
    if (size == testTarget.length) {
        return false;
    }

    testTarget[next] = value;
    for (int i = next; i > 0; i--) {
        if (testTarget[i] < testTarget[i - 1]) {
            int temp = testTarget[i - 1];
            testTarget[i - 1] = testTarget[i];
            testTarget[i] = temp;
        } else {
            break; // since all previous list are sorted
        }
    }

    next++;
    size++;
    return true;
}
```

Insertion sort

- Most common used in place sort for short list
- For each iteration, treat the next item as new insertion value, and move to it’s right location

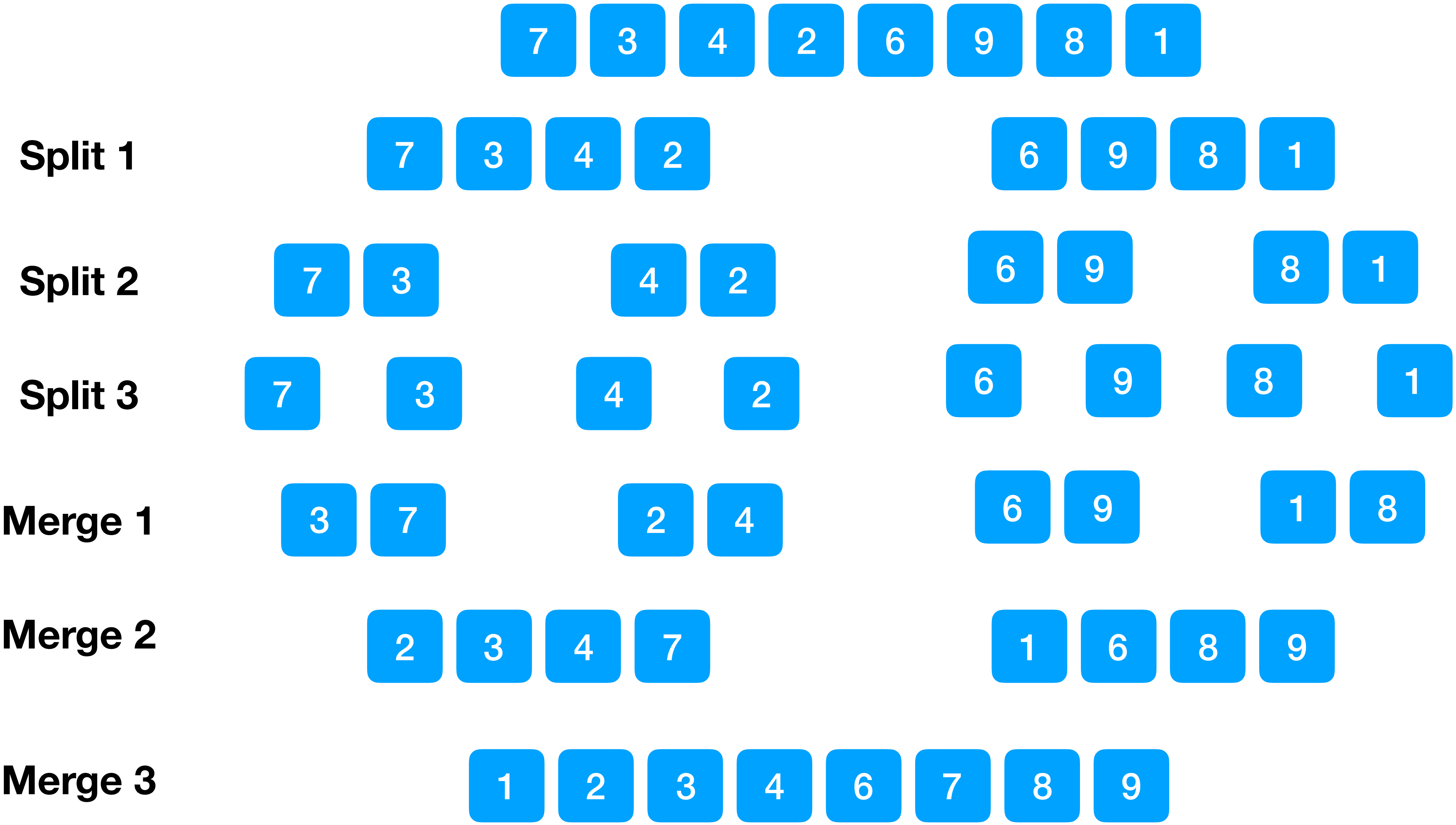


List	7	3	4	2	6	9	8	1
Iteration 1	7	3	4	2	6	9	8	1
	7	3	4	2	6	9	8	1
Iteration 2	7	3	4	2	6	9	8	1
	3	7	4	2	6	9	8	1
Iteration 3	3	7	4	2	6	9	8	1
	3	4	7	2	6	9	8	1
Iteration 4	3	4	7	2	6	9	8	1
	2	3	4	7	6	9	8	1
End	1	2	3	4	6	7	8	9

```java
public static void insertionSort(int[] a) {
    int length = a.length;

    for (int i = 1; i < length; ++i) {
        int insertValue = a[i];

        for (int j = i; j > 0;j--) {
            if (a[j] < a[j - 1]) {
                int temp = a[i - 1];
                a[i - 1] = a[i];
                a[i] = temp;
            } else {
                break; // since all previous list are sorted
            }
        }
    }
}
```

Merge sort

- Fastest sorting method that you need to know for this class
- Require additional memory to finish the sort
- Using recursion method
- Divide and concur solution.
    - split the list into smaller list
    - And merge them one by one



7 3 4 2 6 9 8 1

Split 1 — 7 3 4 2 | 6 9 8 1

Split 2 — 7 3 | 4 2 | 6 9 | 8 1

Split 3 — 7 | 3 | 4 | 2 | 6 | 9 | 8 | 1

Merge 1 — 3 7 | 2 4 | 6 9 | 1 8

Merge 2 — 2 3 4 7 | 1 6 8 9

Merge 3 — 1 2 3 4 6 7 8 9

Merge two sorted list

```
public int[] merge(int[] arr1, int[] arr2) {
    int[] result = new int[arr1.length + arr2.length];

    int index1 = 0;
    int index2 = 0;

    int indexResult = 0;

    while (index1 < arr1.length  && index2 < arr2.length) {
        if (arr1[index1] <= arr2[index2]) {
            result[indexResult] = arr1[index1];
            index1++;
        }
        else {
            result[indexResult] =  arr2[index2];
            index2++;
        }
        indexResult++;
    }

    /* Copy remaining elements of L[] if any */
    while (index1 < arr1.length)
    {
        result[indexResult] = arr1[index1];
        index1++;
        indexResult++;
    }

    /* Copy remaining elements of R[] if any */
    while (index2 < arr2.length)
    {
        result[indexResult] =  arr2[index2];
        index2++;
        indexResult++;
    }

    return result;
}
```

Merge sort

```java
private void split(int arr[], int start, int end)
{
    if (start >= end) {
        return;
    } else {
        // Find the middle point
        int mid = (start + end) / 2;

        // Sort left
        split(arr, start, mid);
        // Sort right
        split(arr, mid + 1, end);

        // Merge the sorted halves
        merge(arr, start, mid, end);
    }
}
```

```java
private void merge(int arr[], int start, int mid, int end)
{
    int leftSize = mid - start + 1;
    int rightSize = end - mid;

    /* Create temp arrays */
    int L[] = new int[leftSize];
    int R[] = new int[rightSize];

    /* Copy data to temp arrays */
    for (int i = 0; i < leftSize; ++i)
        L[i] = arr[start + i];
    for (int j = 0; j < rightSize; ++j)
        R[j] = arr[mid + 1 + j];

    int i = 0, j = 0;

    int currentWalker = start;
    while (i < leftSize && j < rightSize)
    {
        if (L[i] <= R[j])
        {
            arr[currentWalker] = L[i];
            i++;
        }
        else
        {
            arr[currentWalker] = R[j];
            j++;
        }
        currentWalker++;
    }

    /* Copy remaining elements of L[] if any */
    while (i < leftSize)
    {
        arr[currentWalker] = L[i];
        i++;
        currentWalker++;
    }

    /* Copy remaining elements of R[] if any */
    while (j < rightSize)
    {
        arr[currentWalker] = R[j];
        j++;
        currentWalker++;
    }
}
```

Object Oriented Programming

- Java object is mapping the the O in the OOP
- Java is pretty much build with classes and objects
- Object and classes gives a way to describe the programming objects
- It contains instance variables, method and programming logics

public ? private

- Java key word to describe visibility
- public
  - Instance or method has global access outside class
- Private
  - Instance or method has limit access only inside class
- No define
  - By default, instance or method is private

A Java Constructor

- A special type of Java method
    - Every class most, and at least have one
    - Follow all java method rule
    - Can have parameter
    - Can have implication body
- Callers call this to initial the java object

A little more on
Object Oriented Programming

- With Object it pretty much open up all possibility of Java programming
- Object could contains other object instance for more complicate logic
- You can use objects just like java primitive type
    - Compare them (will cover later)
    - Pass them in as a parameter

Object Oriented Programming Best Practice

- As object is a way to describe the programming target
  - Think through every detail of your target
  - Think about the target behaviour
- Before: more algorithm thinking
- Now: more design thinking
- Instance variables: describe what the class have
- Methods: describe what the class can do

Java static

Can be used to define a variable
Can be used to define a method
When marked as static, the variable or method has express access or aka class level access

Class level access
Vs
Object level access

Class level access:

Classname.variableName

Classname.methodName

Object level access:

Need to create the object first

ClassName objectName = new ClassName();

objectName.instanceName

objectName.methodName

Cross Class Relationship

- Class could have other class as its instance attribute
- Method of a class can take other class type as a parameter
- Method in a class can return other class as a return type

Object Oriented Programming

- Java object is mapping the the O in the OOP
- Almost everything in Java are objects
- Object and classes gives a way to describe the programming objects
- It contains instance variables, method and programming logics

Everything we missed in oop

- Detailed in static
- final keyword
- Detailed in constructor
- Detailed into public private
- How to “view” a class
- THE Java Original Object
- Override and Overload
- Class reflection
- Class compare
- Introduction of Concept of inheritance

```java
public class SampleClass {

    // can be only access with initialize a variable.
    public int intAccess = 10;

    public SampleClass() {
        // constructor
    }

    public void Method() {
        // can be access with initialize a variable
    }
}
```

```
public class SampleCaller {

    public static void main(String[] args) {
        SampleClass obj = new SampleClass();

        int intValue = obj.intAccess;
        obj.Method();
    }
}
```

```
public class SampleClass {

    // can be access from outside with ClassName.
    public static int intClassLevelAccess = 10;

    public SampleClass() {
        // constructor
    }

    public static void classLevelMethod() {
        // can be access with class name
    }
}
```

```
public class SampleCaller {

    public static void main(String[] args) {
        SampleClass obj = new SampleClass();
        // there are nothing that we defined that can be accessed here


        int intValue = SampleClass.intClassLevelAccess;
        SampleClass.classLevelMethod();
    }
}
```

Final KeyWord

- describe something that cannot be changed at all
- Can describe a instance variable
- Can describe a method (will cover in latter lecture)
- Can describe a class (will cover in latter lecture)
- Usage:
  - If a public variable has to be exposed, make it final to protected
  - A final variable cannot be modified upon initialed assign
  - A final static variable has to be initialed right away

```
public class SampleClass {

    // can be access from outside with ClassName.
    public final int finalVariable;
    public final static int sharedFinalVariable = 20;

    public SampleClass() {
        // constructor
        finalVariable = 10;
    }

    public static void classLevelMethod() {
        // can be access with class name
    }
}
```

```
public class SampleCaller {

    public static void main(String[] args) {
        SampleClass obj = new SampleClass();
        obj.finalVariable = 20; // wrong


        int intValue = SampleClass.sharedfinalVariable;
        SampleClass.sharedfinalVariable = 100; // wrong
        SampleClass.classLevelMethod();
    }
}
```

Almost everything in Java are objects

```
public class SampleCaller {




    public static void main(String[] args) {
        // Why would this work.
    }
}
```

```java
public class SampleCaller {

    public SampleCaller() {
         // every class has a default constructor
        // default constructor has no parameters
        // default constructor has no implementation body
    }

    public static void main(String[] args) {

    }
}
```

Constructor

- Constructor is the bridge to create the object from the the class

- Every class has a default constructor that with no any parameter and implementation body

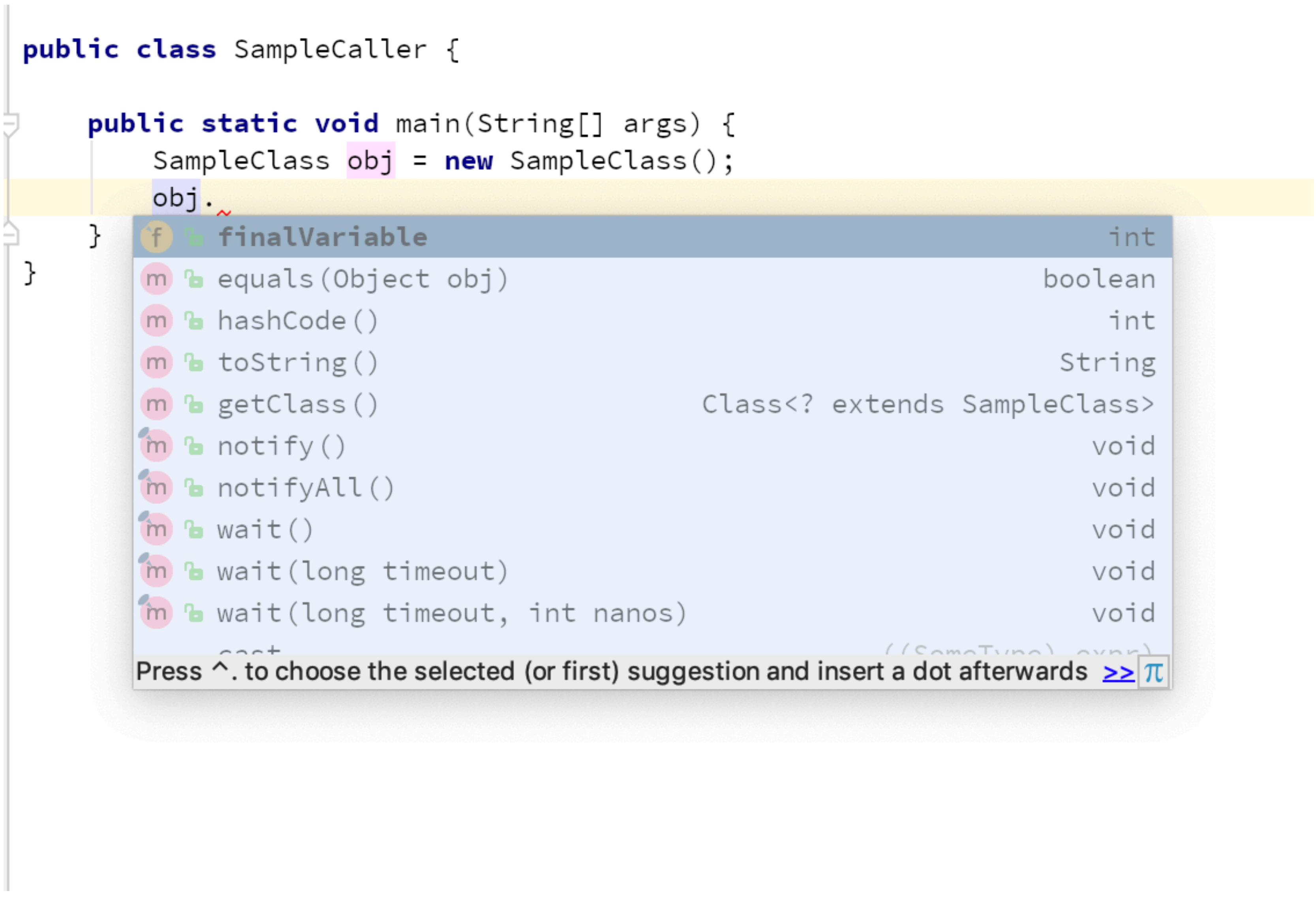
Public && Private

- Public
  - Gives access for everything it declares
  - Can describe instance variable
  - Can describe method
  - Can describe class
- Private
  - Limit everything only private access only for the class
  - Can describe instance variable
  - Can describe method
  - Can describe class (will cover in the later class)

Almost everything in Java are objects

-

The original Java Object



```
public class SampleCaller {

    public static void main(String[] args) {
        SampleClass obj = new SampleClass();
        obj.
    }
}
```

```
finalVariable                                      int
equals(Object obj)                             boolean
hashCode()                                         int
toString()                                      String
getClass()              Class<? extends SampleClass>
notify()                                          void
notifyAll()                                       void
wait()                                            void
wait(long timeout)                                void
wait(long timeout, int nanos)                     void
cast                              ((SomeType) expr)
```

Press ^. to choose the selected (or first) suggestion and insert a dot afterwards >> π

The Object

- The parents class of all java classes
- Object.java
- Contains basic default method for objects
- All java classes extends Object class, but don't have to write this down

```
public class Object {

    public native int hashCode();

    public String toString() {
        return getClass().getName() + "@" + Integer.toHexString(hashCode());
    }

    public boolean equals(Object obj) {
        return (this == obj);
    }
}
```

```
public class SampleClass extends Object {

    // can be access from outside with ClassName.
    public final int finalVariable;
    public final static int sharedfinalVariable = 20;

    public SampleClass() {
        // constructor
        finalVariable = 10;
    }

    public static void classLevelMethod() {
        // can be access with class name
    }
}
```

Override

- A way that child class take over the default behaviour of parents class
- Use @Override to declare it. Can also ignore this

```java
public class SampleClass extends Object {

    // can be access from outside with ClassName.
    public String content;
    public int intValue;

    public SampleClass(String inputcontent, int inputValue) {
        // constructor
        content = inputcontent;
        intValue = inputValue;
    }

    public static void main(String[] args) {
        SampleClass obj = new SampleClass();

        System.out.print(obj);
    }
}
```

```
Midterm.SampleClass@61bbe9ba
```

```java
public class SampleClass extends Object {

	// can be access from outside with ClassName.
	public String content;
	public int intValue;

	public SampleClass(String inputcontent, int inputValue) {
		// constructor
		content = inputcontent;
		intValue = inputValue;
	}

	@Override
	public String toString() {
		return "Print: " + content + " " + intValue;
	}

	public static void main(String[] args) {
		SampleClass obj = new SampleClass("Test", 10);

		System.out.print(obj);
	}
}
```

```
Print: Test 10
```

Overload

- A way to provided different style of function with same method name within the same class
- Has to be the same name
- With same return type
- Only difference allowed is parameter

```
public class SampleClass extends Object {

    // can be access from outside with ClassName.
    public String content;
    public int intValue;

    public SampleClass(String inputcontent, int inputValue) {
        // constructor
        content = inputcontent;
        intValue = inputValue;
    }

    public int calculate(int a) {
        return a++;
    }

    public int calculate(int a, int b) {
        return a + b;
    }

//  this is not allowed
//    public boolean calculate(int a, int b) {
//        return a + b;
//    }

//  this is not allowed
//    public int calculate(int a, int b) {
//        return a - b;
//    }

}
```

Constructor Overload

- Constructor is a special types of a method, so overload also applies
- Constructor overload is more common than normal functions
- Provides different ways to initial the object

```
public class SampleClass extends Object {

    // can be access from outside with ClassName.
    public String content;
    public int intValue;

    public SampleClass() {

    }

    public SampleClass(String inputcontent) {
        content = inputcontent;
    }

    public SampleClass(int inputValue) {
        intValue = inputValue;
    }

    public SampleClass(String inputcontent, int inputValue) {
        content = inputcontent;
        intValue = inputValue;
    }
}
```

Class Reflection: this

- Keyword
- Have access to everything of the current class
- Represent the current class

```
public class SampleClass extends Object {

    // can be access from outside with ClassName.
    public String content;
    public int intValue;

//  wrong way to initial
//  public SampleClass(String content, int intValue) {
//      content = content;
//      intValue = intValue;
//  }

    public SampleClass(String content, int intValue) {
        this.content = content;
        this.intValue = intValue;
    }

    @Override
    public String toString() {
        return this.content;
    }
}
```

Compare between objects

- Objects compare are very different
- Object cannot directly use == to compare
    - == compares the
- Use the equal method to compare object

```java
public class Object {

    public native int hashCode();

    public String toString() {
        return getClass().getName() + "@" + Integer.toHexString(hashCode());
    }

    public boolean equals(Object obj) {
        return (this == obj);
    }
}
```

```
public class SampleClass extends Object {

    public String content;
    public int intValue;

    public SampleClass(String content, int intValue) {
        this.content = content;
        this.intValue = intValue;
    }


    public static void main(String[] args) {
        SampleClass obj1 = new SampleClass("Test", 10);
        SampleClass obj2 = new SampleClass("Test", 10);

        System.out.println(obj1 == obj2);
        System.out.println(obj1.equals(obj2));
    }
}
```

```
false
false
```

```java
public class SampleClass extends Object {

    public String content;
    public int intValue;

    public SampleClass(String content, int intValue) {
        this.content = content;
        this.intValue = intValue;
    }


    public static void main(String[] args) {
        SampleClass obj1 = new SampleClass("Test", 10);
        SampleClass obj2 = new SampleClass("Test", 10);

        System.out.println(obj1 == obj2);
        System.out.println(obj1.equals(obj2));
    }
}
```

```
false
false
```

```java
public class SampleClass extends Object {

    public String content;
    public int intValue;

    public SampleClass(String content, int intValue) {
        this.content = content;
        this.intValue = intValue;
    }

    @Override
    public boolean equals(Object obj) {
        if (((SampleClass)obj).intValue == this.intValue) {
            return true;
        } else {
            return false;
        }
    }

    public static void main(String[] args) {
        SampleClass obj1 = new SampleClass("Test", 10);
        SampleClass obj2 = new SampleClass("Test", 10);

        System.out.println(obj1 == obj2);
        System.out.println(obj1.equals(obj2));
    }
}
```

```
false
true
```

Preview on inheritance

- The way a class inherit the allowed behaviour and allowed attribute of the parent class
- Use key word extends
- public / private / protected controls rules of inheritance

Java Parents to Child Class Inheritance and Polymorphism

Preview on inheritance

- The way a class inherit the allowed behaviour and allowed attribute of the parent class

- Use key word extends

- public / private / protected controls rules of inheritance

Inheritance

- A way that a child class can share some of the parent class behaviour
- Both Attribute and Method can be a inheritance to child class
- Child class can override parent class behaviour

Inheritance Rule

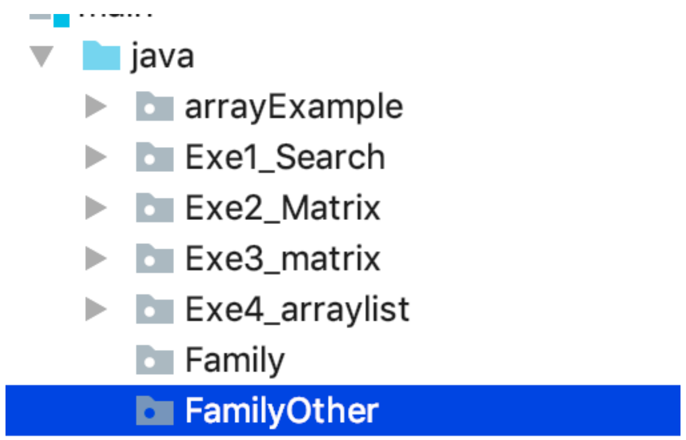
- Public: can be inherited, visible to everything
- Protected: can be inherited by sub class, visible to child class and with in package, not visible outside package
- Private: cannot be inherited, not visible to outside package and project

	Within Class	Package	Child Class	Entire Java Project
Public	✓	✓	✓	✓
Protected	✓	✓	✓	✗
Private	✓	✗	✗	✗

Package

- Just a folder
- To group java class that belong to one group
- A java class that has the same name cannot exist within the same package, but can exist in different package

```
package Family;

public class Parent {

   public final String firstName;
   public final String lastName = "Alex";
   private int bankAccount = 11223344;
   private int bankAccountBalance = 1000000;

   public Parent(String firstName) {
      this.firstName = firstName;
   }

   public final void getName() {
      System.out.println(firstName + lastName);
   }

   protected void educationDirection() {
      System.out.println("Working on Medical field");
   }

   private void manageBankAccount(int input) {
      bankAccountBalance += input;
   }
}
```



```java
package Family;

public class Caller {
    public static void main(String[] args) {
        Parent p = new Parent("John");
        p.educationDirection();
    }
}
```

```java
package FamilyOther;

public class Caller {
    public static void main(String[] args) {
        Parent p = new Parent("John");
        p.educationDirection(); // cannot access
    }
}
```

Child 1 that listens everything to parent

```java
package Family;

public class Child1 extends Parent{

   public Child1(String firstName) {
      super(firstName);
   }
}
```

Class refection 2

- Key word this refer to everything within current class
- Key word super reference to everything within parent class
  - super still keeps the inheritance rule
  - Cannot access private variable and method

```java
package Family;

public class Caller {
    public static void main(String[] args) {
        Child1 c1 = new Child1("Timmy");
        c1.getName();
        c1.educationDirection();
    }
}
```

```
Timmy Alex
Working on Medical field
```

Child 2 that listens nothing to parent

```
package Family;

public class Child2 extends Parent {

    public Child2(String firstName) {
        this.firstName = firstName;
        this.lastName = "Kim";
    }

    @Override
    public void getName() {
        System.out.print(lastName + ", " + firstName);
    }

    @Override
    private void manageBankAccount(int input) {


        bankAccountBalance += input * 10;
    }

    @Override
    protected void educationDirection() {
        System.out.println("Working on Computing science");
    }
}
```

Child 2 that listens nothing to parent

```java
package Family;

public class Child2 extends Parent {

    public Child2(String firstName) {
        this.firstName = firstName; // NOT allowed, have to invoke parent constructor
        this.lastName = "Kim"; // NOT allowed, family name is final
    }

    @Override
    public void getName() {
        System.out.print(lastName + ", " + firstName); // not allowed, final method is not allow to override
    }

    @Override
    private void manageBankAccount(int input) {
        // not allowed, private method is not allow to override
        // not allowed, final variable bankAccountBalance is not allow to access
        bankAccountBalance += input * 10;
    }

    @Override
    protected void educationDirection() {
        System.out.println("Working on Computing science");
    }
}
```

Child 2 corrected

```
public class Child2 extends Parent {

    public Child2(String firstName) {
        super(firstName);
    }

    @Override
    protected void educationDirection() {
        System.out.println("Working on Computing science");
    }
}
```

```java
package Family;

public class Caller {
    public static void main(String[] args) {
        Child2 c2 = new Child2("Jimmy");
        c2.getName();
        c2.educationDirection();
    }
}
```

```
Jimmy Alex
Working on Computing science
```

```java
package Family;

public class GrandParent {

    public final String firstName;
    public final String lastName = "Alexendra";

    public GrandParent(String firstName) {
        this.firstName = firstName;
    }

    protected void singOldSongs() {
        System.out.println("Country road");
    }
}
```

```
package Family;

public class Child1 extends Parent and GrandParent{

   public Child1(String firstName) {
      super(firstName);
   }
}
```

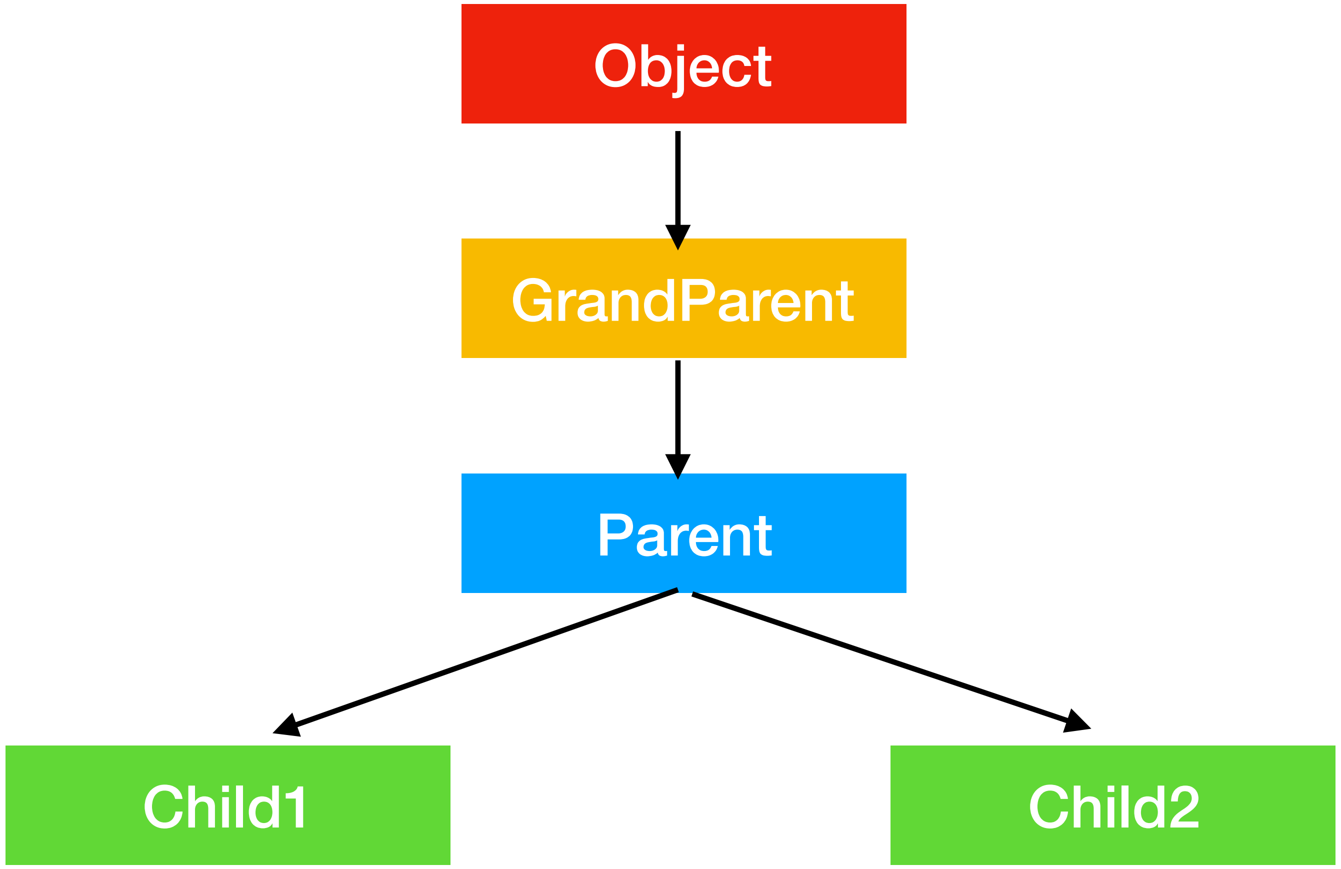
Inheritance Rule

- A parent class can be inherited by multiple child class
- But a child class can only extend only one parent class

```java
package Family;

public class Parent extends GrandParent{

   public final String lastName = "Alex";
   private int bankAccount = 11223344;
   private int bankAccountBalance = 1000000;

   public Parent(String firstName) {
      super(firstName);
   }

   public final void getName() {
      System.out.println(firstName + lastName);
   }

   protected void educationDirection() {
      System.out.println("Working on Medical field");
   }

   private void manageBankAccount(int input) {
      bankAccountBalance += input;
   }
}
```

```java
package Family;

public class Caller {
   public static void main(String[] args) {
      Child2 c2 = new Child2("Jimmy");
      c2.getName();
      c2.educationDirection();
      c2.singOldSongs();
   }
}
```

```
Jimmy Alex
Working on Computing science
Country road
```



Object

GrandParent

Parent

Child1

Child2

Child 2 with it’s own attribute, how to access this?

```java
package Family;

public class Child2 extends Parent {

    public String hobby = "Sport";

    public Child2(String firstName) {
        super(firstName);
    }

    @Override
    protected void educationDirection() {
        System.out.println("Working on Computing science");
    }
}
```

Risk of casting

Allowed

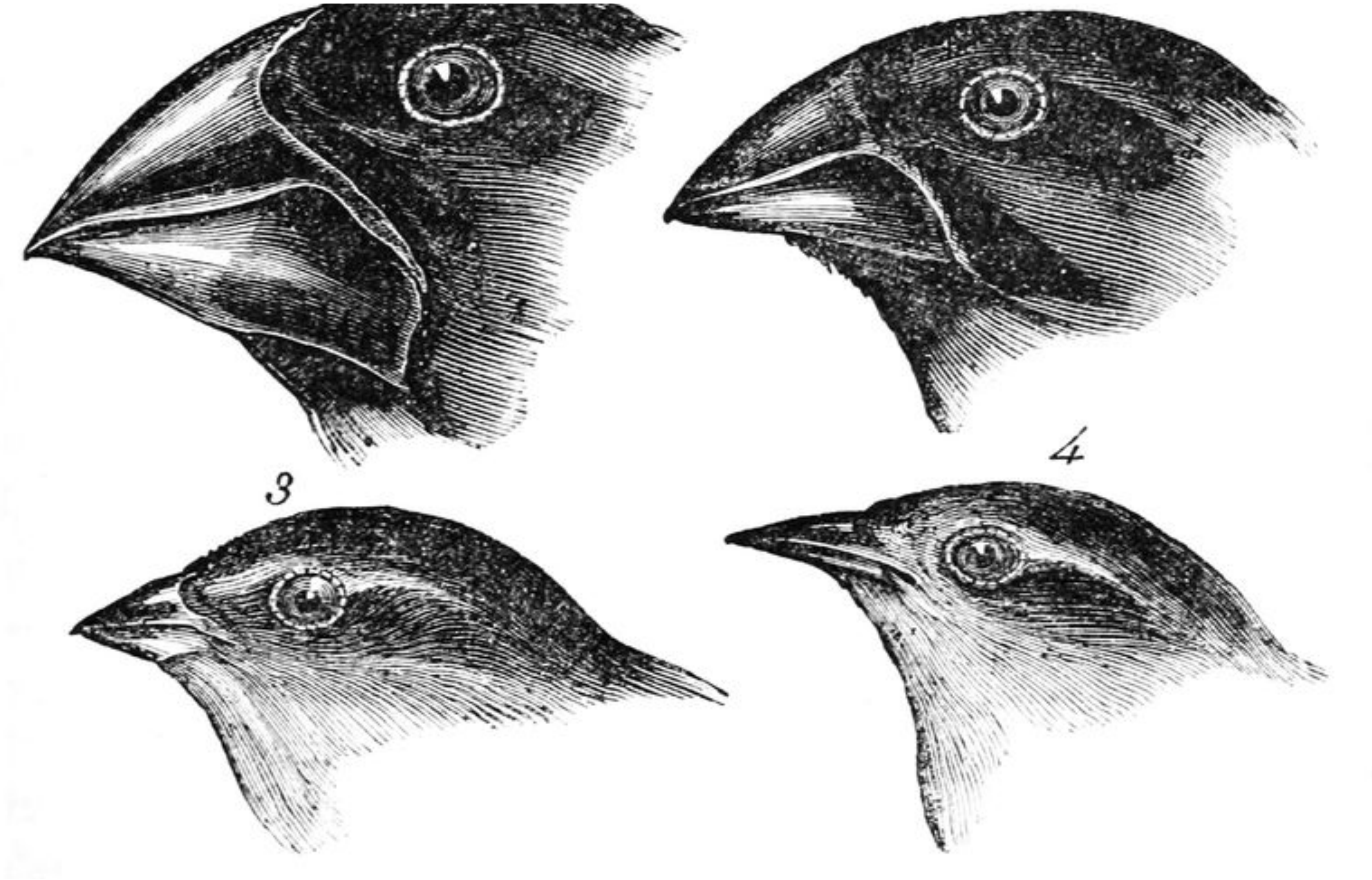
```
public class Caller {
    public static void main(String[] args) {
        Child2 c2 = new Child2("Jimmy");
        System.out.println(c2.hobby);
    }
}
```

Can’t access

```
public class Caller {
    public static void main(String[] args) {
        Parent c2 = new Child2("Jimmy");
        System.out.println(c2.hobby);
    }
}
```

Cast to the child class type to access,
However, there is a risk
Has to make sure Parent object is actually Child2

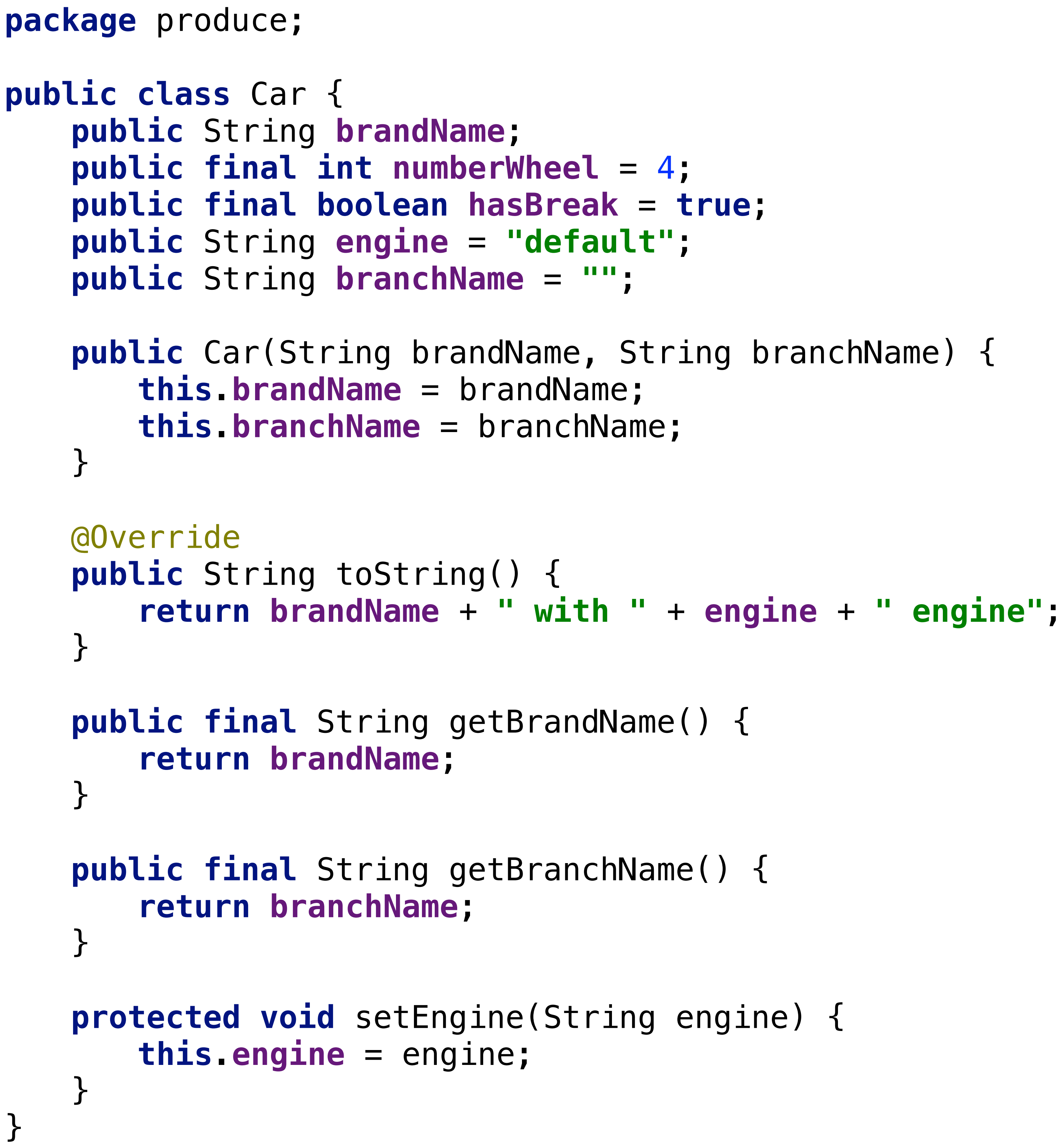
```
public class Caller {
    public static void main(String[] args) {
        Parent c2 = new Child2("Jimmy");
        System.out.println( (Child2)c2.hobby);
    }
}
```



Polymorphism

Polymorphism

- A parents class can be extended by multiple child class
- Child classes could have it’s different behaviour
- Child classes has to be describe as: one kind of parent class



```java
package produce;

public class Car {
    public String brandName;
    public final int numberWheel = 4;
    public final boolean hasBreak = true;
    public String engine = "default";
    public String branchName = "";

    public Car(String brandName, String branchName) {
        this.brandName = brandName;
        this.branchName = branchName;
    }

    @Override
    public String toString() {
        return brandName + " with " + engine + " engine";
    }

    public final String getBrandName() {
        return brandName;
    }

    public final String getBranchName() {
        return branchName;
    }

    protected void setEngine(String engine) {
        this.engine = engine;
    }
}
```

```java
package produce;

public class BMW extends Car{
    public final static String brandName = "BMW";
    public BMW (String branchName) {
        super(brandName, branchName);
    }
}
```

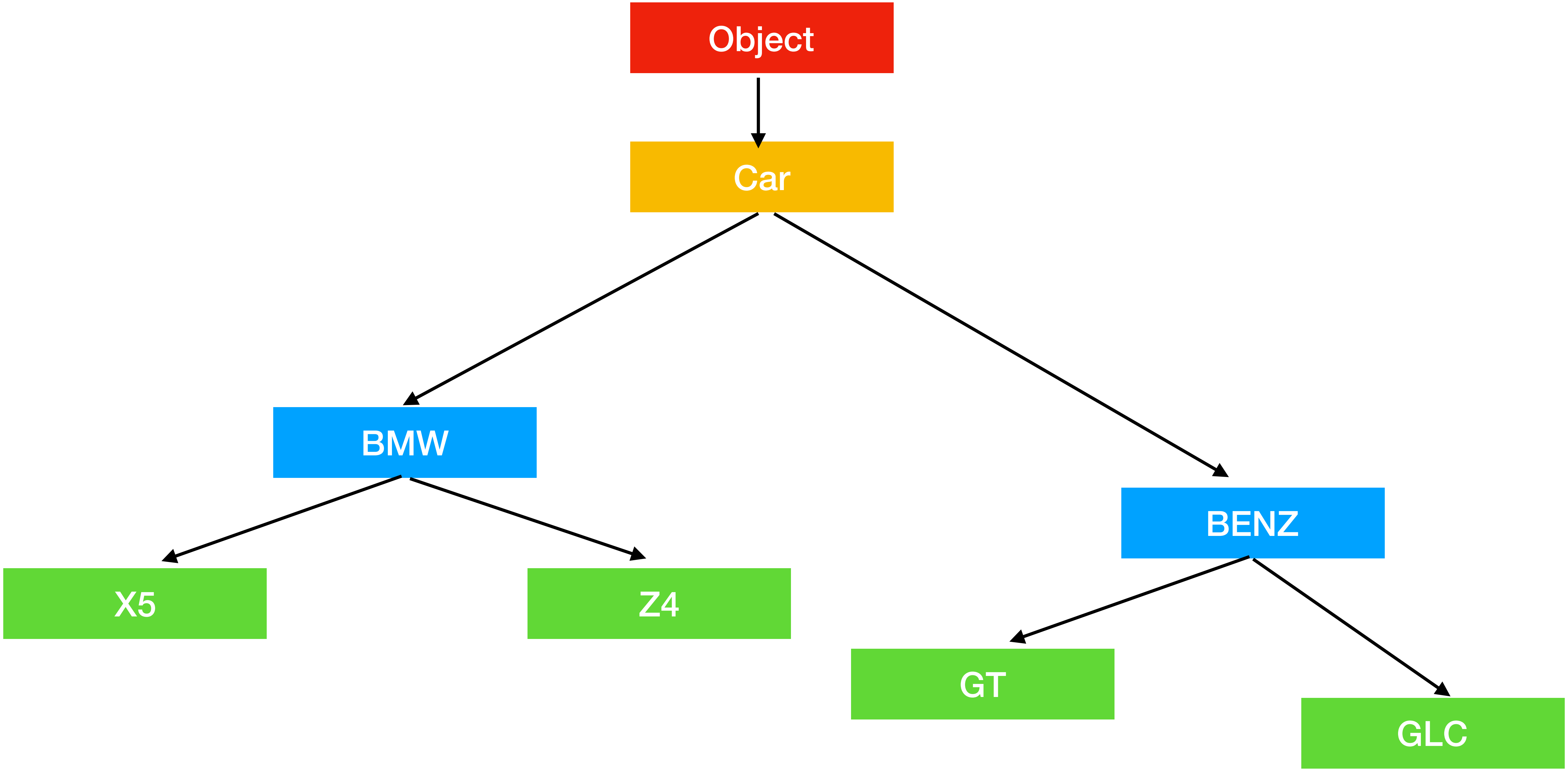
```java
package produce;

public class BENZ extends Car{
    public final static String brandName = "Benz";
    public BENZ(String branchName) {
        super(brandName, branchName);
    }
}
```

```java
package produce;

public class X5 extends BMW{
    public X5() {
        super( "X5");
        setEngine("V6");
    }

    @Override
    protected void setEngine(String engine) {
        this.engine = engine;
    }
}
```

```java
package produce;

public class Z4 extends BMW{
    public Z4() {
        super( "Z5");
        setEngine("V8");
    }

    @Override
    protected void setEngine(String engine) {
        this.engine = engine;
    }
}
```

```java
package produce;

public class GLC extends BENZ{
    public GLC() {
        super("GLC");
        setEngine("V6");
    }

    @Override
    protected void setEngine(String engine) {
        this.engine = engine;
    }
}
```

```java
package produce;

public class GT extends BENZ{
    public GT() {
        super("GT AMG");
        setEngine("V8");
    }

    @Override
    protected void setEngine(String engine) {
        this.engine = engine;
    }
}
```


Object

Car

BMW

BENZ

X5

Z4

GT

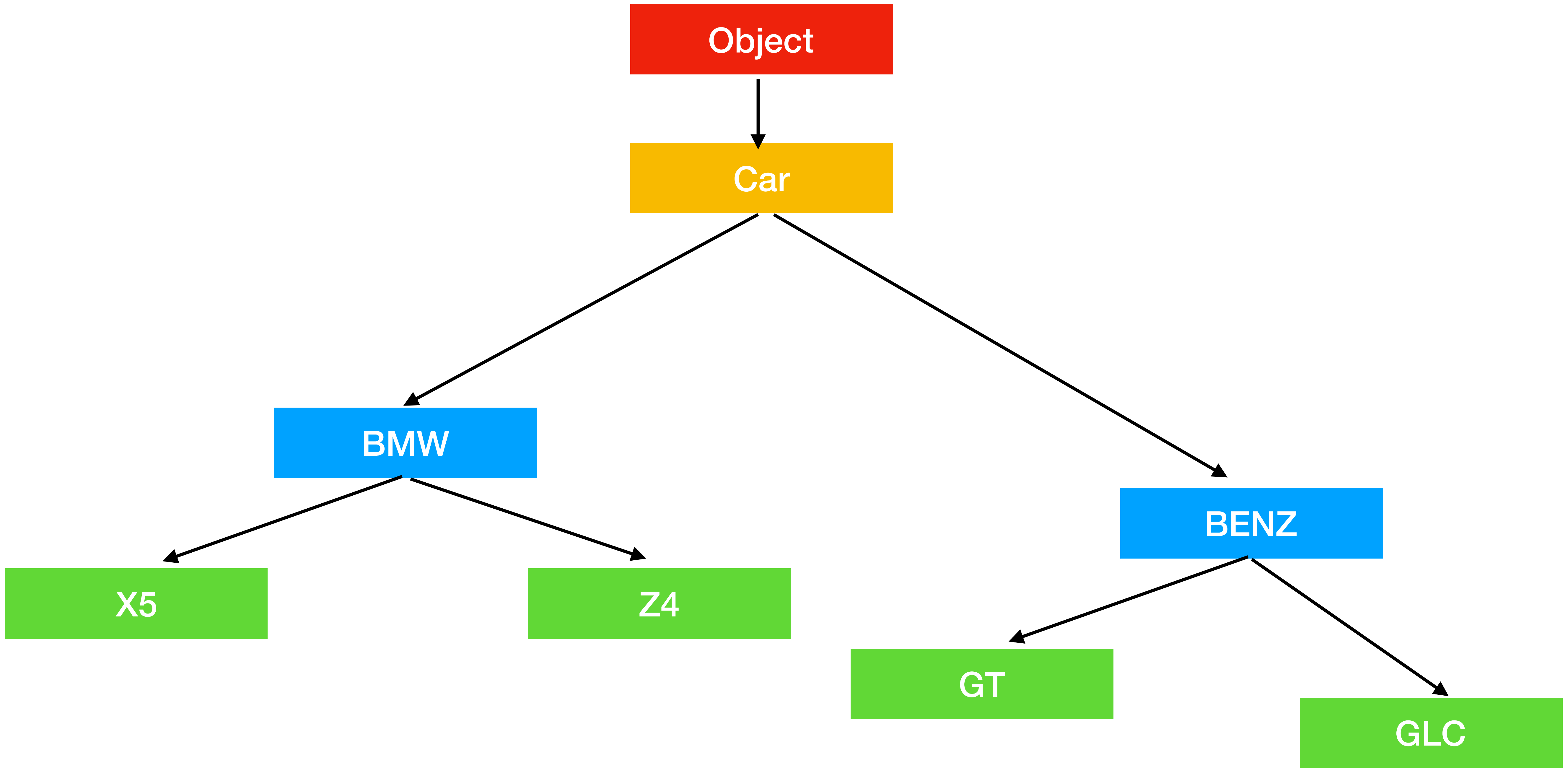
GLC

```java
package produce;

public class Factory {

    public static Car makeCar(String mode,  String branch) {
        if(mode.equals("BMW")) {
            if (branch.equals("X5")) {
                return new X5();
            } else if (branch.equals("Z4")) {
                return new Z4();
            } else {
                return null;
            }

        } else if (mode.equals("BENZ")) {
            if (branch.equals("GLC")) {
                return new GLC();
            } else if (branch.equals("GT")) {
                return new GT();
            } else {
                return null;
            }

        } else {
            return new Car("default", "default");
        }
    }
}
```

```java
package produce;

import Family.Parent;

public class Caller {
   public static void main(String[] args) {
      Car myNewCar = Factory.makeCar("BENZ", "GT");
      System.out.println(myNewCar);
   }
}
```

Benz GT AMG with V8 engine

Java Parents to Child Class Abstract and Interface


Object
Car
BMW
BENZ
X5
Z4
GT
GLC

```java
package produce;

public class Factory {

    public static Car makeCar(String mode,  String branch) {
        if(mode.equals("BMW")) {
            if (branch.equals("X5")) {
                return new X5();
            } else if (branch.equals("Z4")) {
                return new Z4();
            } else {
                return null;
            }

        } else if (mode.equals("BENZ")) {
            if (branch.equals("GLC")) {
                return new GLC();
            } else if (branch.equals("GT")) {
                return new GT();
            } else {
                return null;
            }

        } else {
            return new Car("default", "default");
        }
    }
}
```

```java
package produce;

import Family.Parent;

public class Caller {
   public static void main(String[] args) {
      Car myNewCar = Factory.makeCar("BENZ", "GT");
      System.out.println(myNewCar);
   }
}
```

```
Benz GT AMG with V8 engine
```

Dynamic Binding
Late Binding

- Binding: Car c1 = new Car();
- Late Binding/Dynamic Binding: define which type to assign during run time

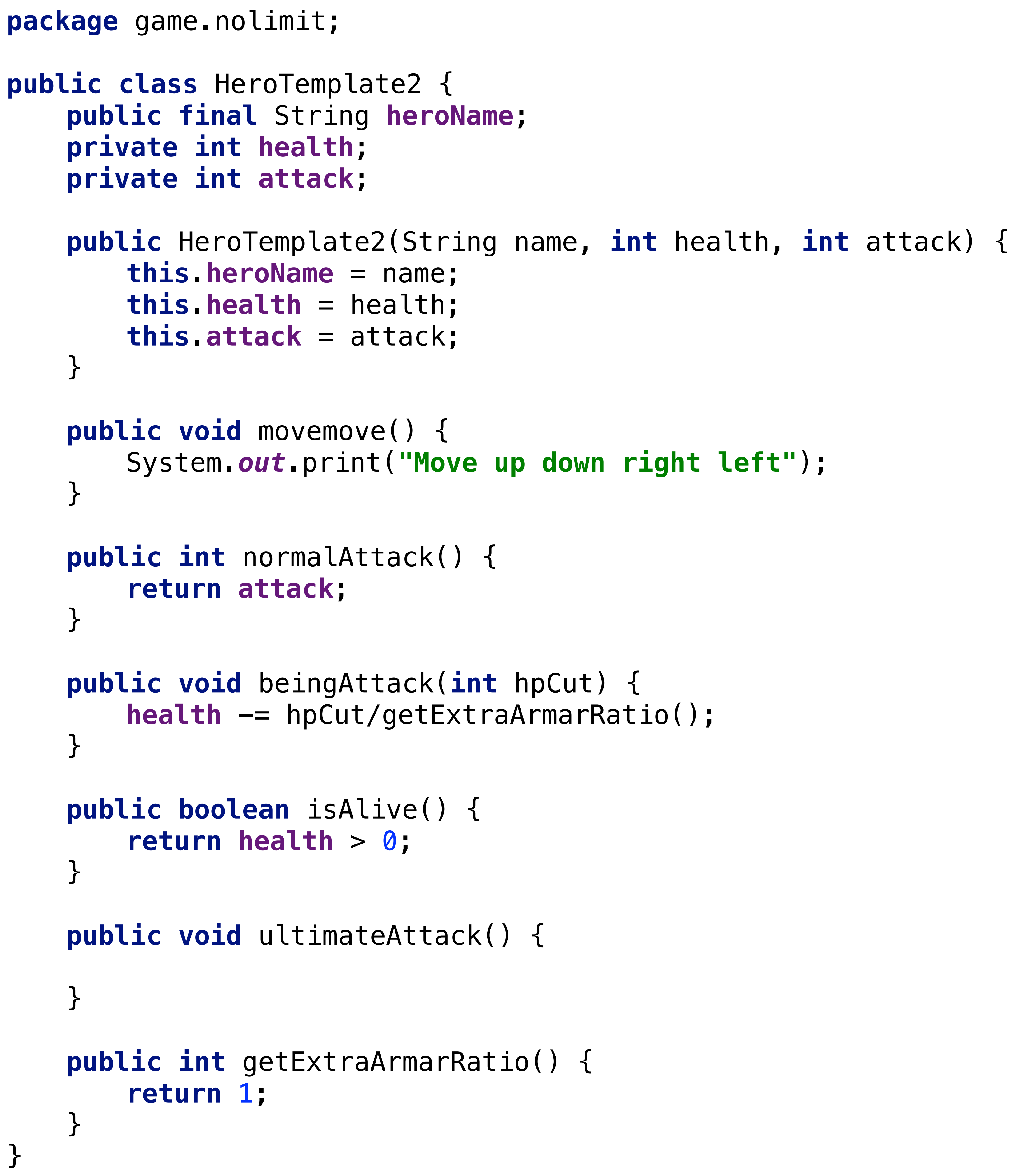
What if

- We don’t know what to define in the beginning
- We just have an abstraction of what is going on
- We just want to apply an enforcement

Problem 1
Meaningless function

```java
package game.nolimit;

public class HeroTemplate {
    public final String heroName;
    private int health;
    private int attack;

    public HeroTemplate(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void move() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack * getCriticalHitRatio();
    }

    public void beingAttack(int hpCut) {
        health -= hpCut/getExtraArmarRatio();
    }

    public boolean isAlive() {
        return health > 0;
    }

    public void ultimateAttack() {

    }

    public int getCriticalHitRatio() {
        return 1;
    }

    public int getExtraArmarRatio() {
        return 1;
    }
}
```

Problem 2
No standard code



```java
package game.nolimit;

public class HeroTemplate2 {
    public final String heroName;
    private int health;
    private int attack;

    public HeroTemplate2(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void movemove() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack;
    }

    public void beingAttack(int hpCut) {
        health -= hpCut/getExtraArmarRatio();
    }

    public boolean isAlive() {
        return health > 0;
    }

    public void ultimateAttack() {

    }

    public int getExtraArmarRatio() {
        return 1;
    }
}
```

Solve problem 1
Abstract class

- Class is declared as abstract
- Abstract class allows you not fully define function name
- BUT you can still use the function
- However you cannot initial an object from an abstract class
- Abstract class enforced the child class to implement the abstract method
- If child class does not know how to implement, declare abstract and parse to next lower level

```
package game.nolimit;

abstract public class AbstractHeroTemplate {
    public final String heroName;
    private int health;
    private int attack;

    public AbstractHeroTemplate(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void move() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack * getCriticalHitRatio();
    }

    public void beingAttack(int hpCut) {
        health -= hpCut;
    }

    public boolean isAlive() {
        return health > 0;
    }

    public void ultimateAttack() {

    }

    abstract public int getCriticalHitRatio();

    abstract public int getExtraArmarRatio();
}
```

```java
package game.nolimit;

public class Hero1 extends AbstractHeroTemplate{
   public Hero1(String name, int health) {
      super("Hero1", 100);
   }

   @Override
   public int getCriticalHitRatio() {
      return 2;
   }

   @Override
   public int getExtraArmarRatio() {
      return 2;
   }
}
```

Wrong initial

```
public static void main(String[] args) {
    AbstractHeroTemplate hero = new AbstractHeroTemplate();
}
```

Solve problem 2
Interface

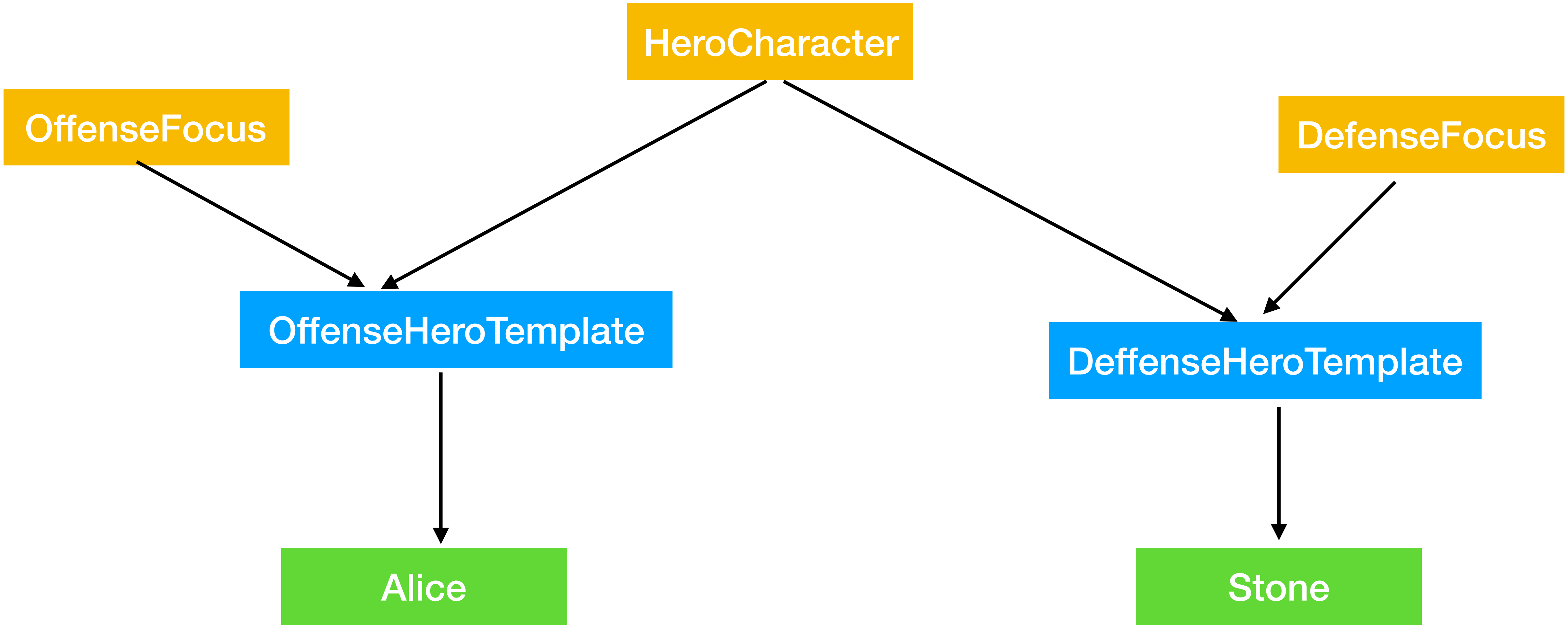
- Class is declared as interface
- Defines a standard
- All function in interface does not have a implementation body
- Interface define the basic function of class
- Interface enforce the class who implements it to implement all the function it defined
- Therefore all interface functions are public

```java
package game.nolimit;

public interface HeroCharacter {
   public void move();
   public int normalAttack();
   public void beingAttack(int hpCut);
   public boolean isAlive();
   public void ultimateAttack();
}
```

```
package game.nolimit;

public class Hero2 implements HeroCharacter{
    public final String heroName;
    private int health;
    private int attack;

    public Hero2(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    @Override
    public void move() {
        System.out.print("Move up down right left");
    }

    @Override
    public int normalAttack() {
        return attack;
    }

    @Override
    public void beingAttack(int hpCut) {
        health -= hpCut;
    }

    @Override
    public boolean isAlive() {
        return health > 0;
    }

    @Override
    public void ultimateAttack() {
        System.out.print("ultimateAttack");
    }
}
```

Advanced structure

- A class can only extends one parent class
- Rule applies to abstract class too
- A class can implements unlimited interfaces
- interfaces provides a view, a list of characteristic, a different flavour of a class



HeroCharacter

OffenseFocus

DefenseFocus

OffenseHeroTemplate

DeffenseHeroTemplate

Alice

Stone

```java
package game;

public interface HeroCharacter {
    public void move();
    public int normalAttack();
    public void beingAttack(int hpCut);
    public boolean isAlive();
    public void ultimateAttack();
}
```

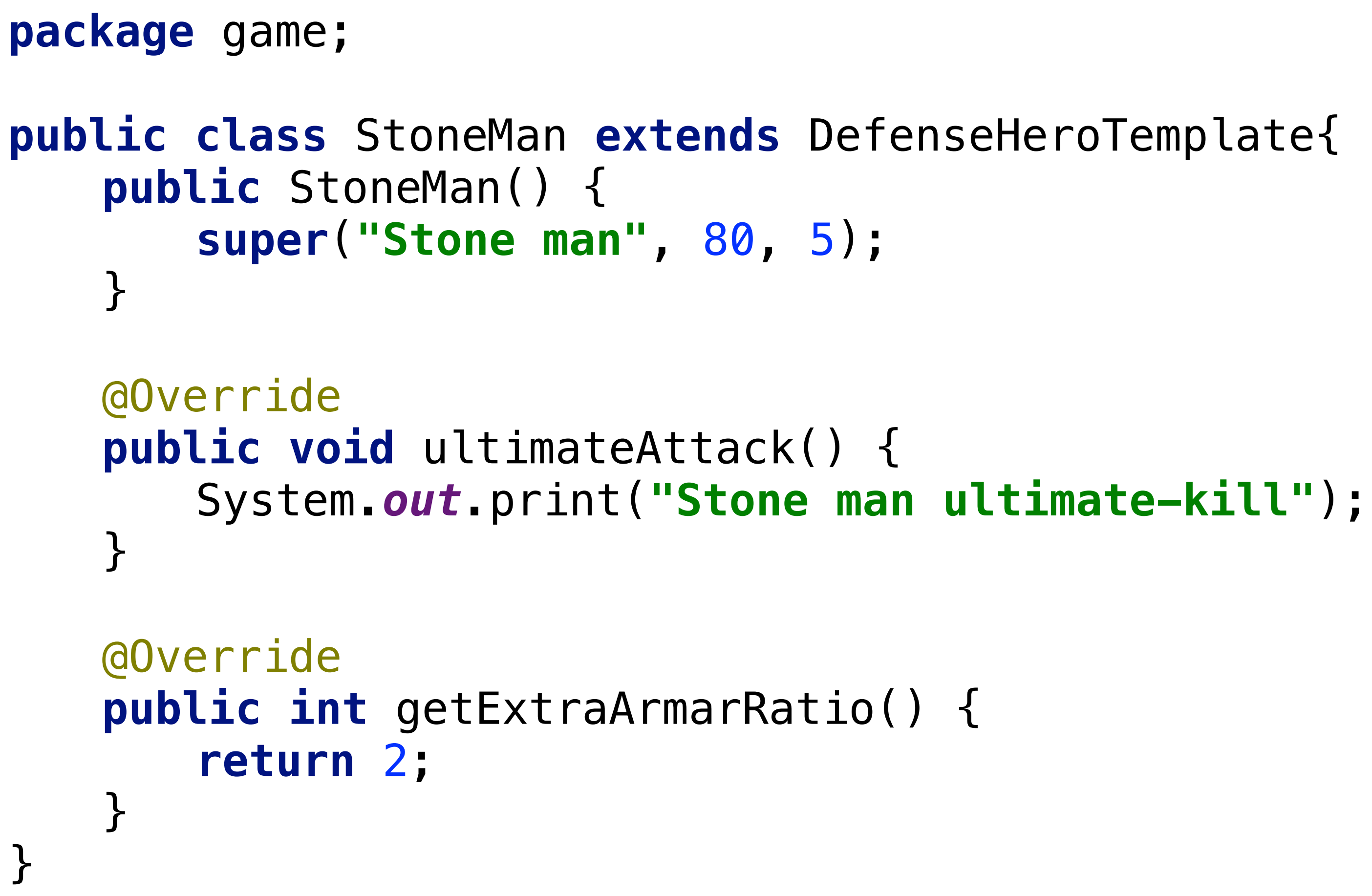
```java
package game;

public interface OffenseFocusHero {
    public int getCriticalHitRatio();
}
```

```java
package game;

public interface DefenseFocusHero {
    public int getExtraArmarRatio();
}
```

```java
package game;

abstract public class OffenseHeroTemplate implements HeroCharacter, OffenseFocusHero {
    public final String heroName;
    private int health;
    private int attack;

    public OffenseHeroTemplate(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void move() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack * getCriticalHitRatio();
    }

    public void beingAttack(int hpCut) {
        health -= hpCut;
    }

    public boolean isAlive() {
        return health > 0;
    }

    abstract public void ultimateAttack();

    abstract public int getCriticalHitRatio();
}
```

```java
package game;

abstract public class DefenseHeroTemplate implements HeroCharacter, DefenseFocusHero {
    public final String heroName;
    private int health;
    private int attack;

    public DefenseHeroTemplate(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void move() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack;
    }

    public void beingAttack(int hpCut) {
        health -= hpCut/getExtraArmarRatio();
    }

    public boolean isAlive() {
        return health > 0;
    }

    abstract public void ultimateAttack();

    abstract public int getExtraArmarRatio();

}
```

```java
package game;

public class AliceTheKiller extends OffenseHeroTemplate{

    public AliceTheKiller() {
        super("Alice", 50, 10);
    }

    @Override
    public void ultimateAttack() {
        System.out.print("Alice the killer ultimate-kill");
    }

    @Override
    public int getCriticalHitRatio() {
        return 2;
    }
}
```



```java
package game;

public class StoneMan extends DefenseHeroTemplate{
    public StoneMan() {
        super("Stone man", 80, 5);
    }

    @Override
    public void ultimateAttack() {
        System.out.print("Stone man ultimate-kill");
    }

    @Override
    public int getExtraArmarRatio() {
        return 2;
    }
}
```

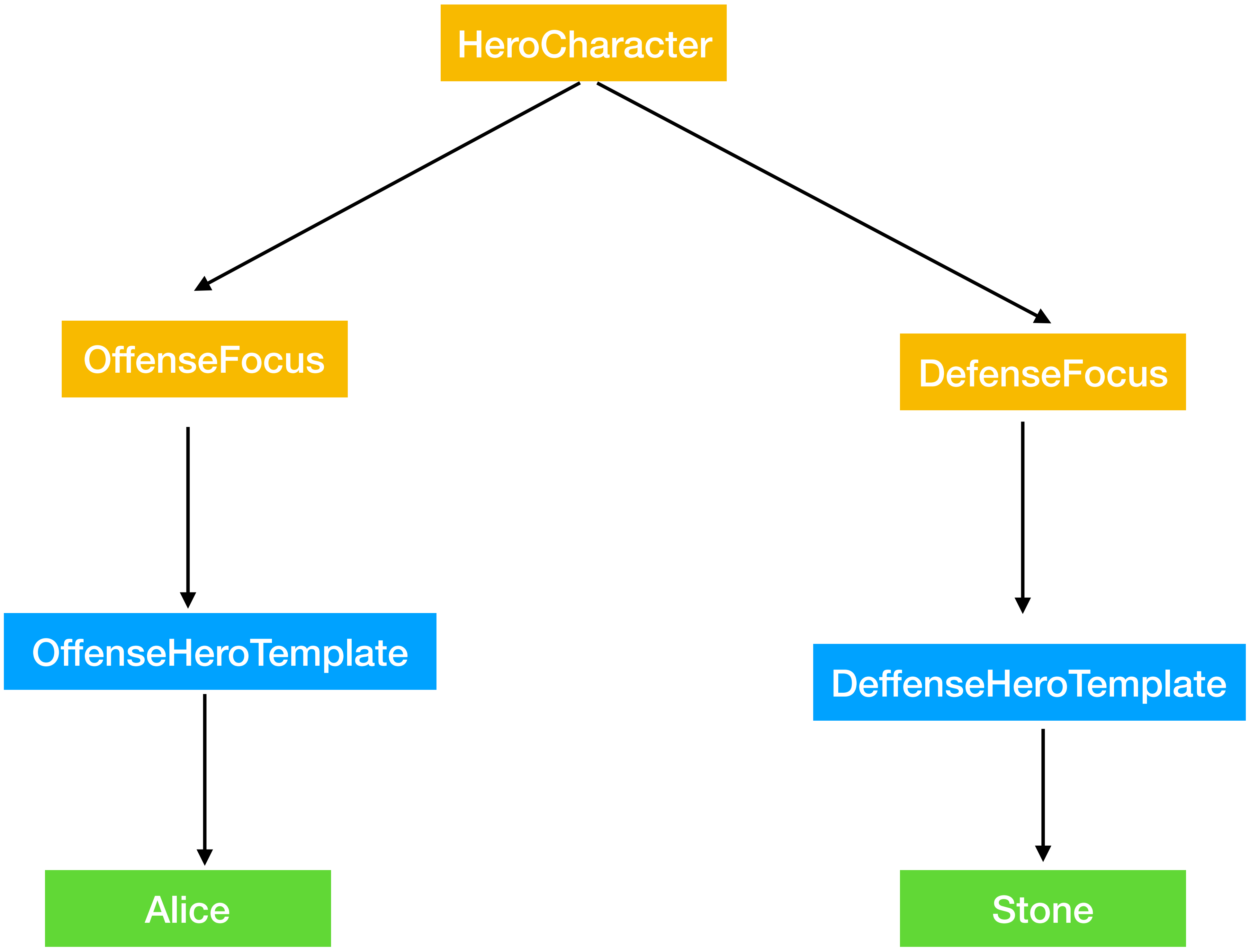
When game is called
The backend logic of
How hero is attacking
How hero get hit
Is well hidden

```java
package game;

import game.nolimit.AbstractHeroTemplate;

public class GameEngine {

    public static void main(String[] args) {

        HeroCharacter hero1 = chooseHero("Alice");

        hero1.move();
        hero1.normalAttack();
        hero1.ultimateAttack();
        hero1.beingAttack(3);

        HeroCharacter hero2 = chooseHero("Stone");

        hero2.move();
        hero2.normalAttack();
        hero2.ultimateAttack();
        hero2.beingAttack(6);
    }

    public static HeroCharacter chooseHero(String name) {
        if (name.equals("Alice")) {
            return new AliceTheKiller();
        } else if (name.equals("Stone")) {
            return new StoneMan();
        } else {
            return null;
        }
    }
}
```

```
package game;

abstract public class HeroTemplate implements Move, Attack, UltiAttack, PurchaseItem{
}
```

Interface relationship

- Interface can extends other interface
- Since all interface function are public, the child interface will inherit all functions from parent interface
- It does not make sense for a interface to implement another interface
- Interface share the same rule of inheritance, can only extends from one interface



HeroCharacter

OffenseFocus

DefenseFocus

OffenseHeroTemplate

DeffenseHeroTemplate

Alice

Stone

```
package game;

public interface HeroCharacter {
    public void move();
    public int normalAttack();
    public void beingAttack(int hpCut);
    public boolean isAlive();
    public void ultimateAttack();
}
```

```
package game;

public interface OffenseFocusHero extends HeroCharacter {
    public int getCriticalHitRatio();
}
```

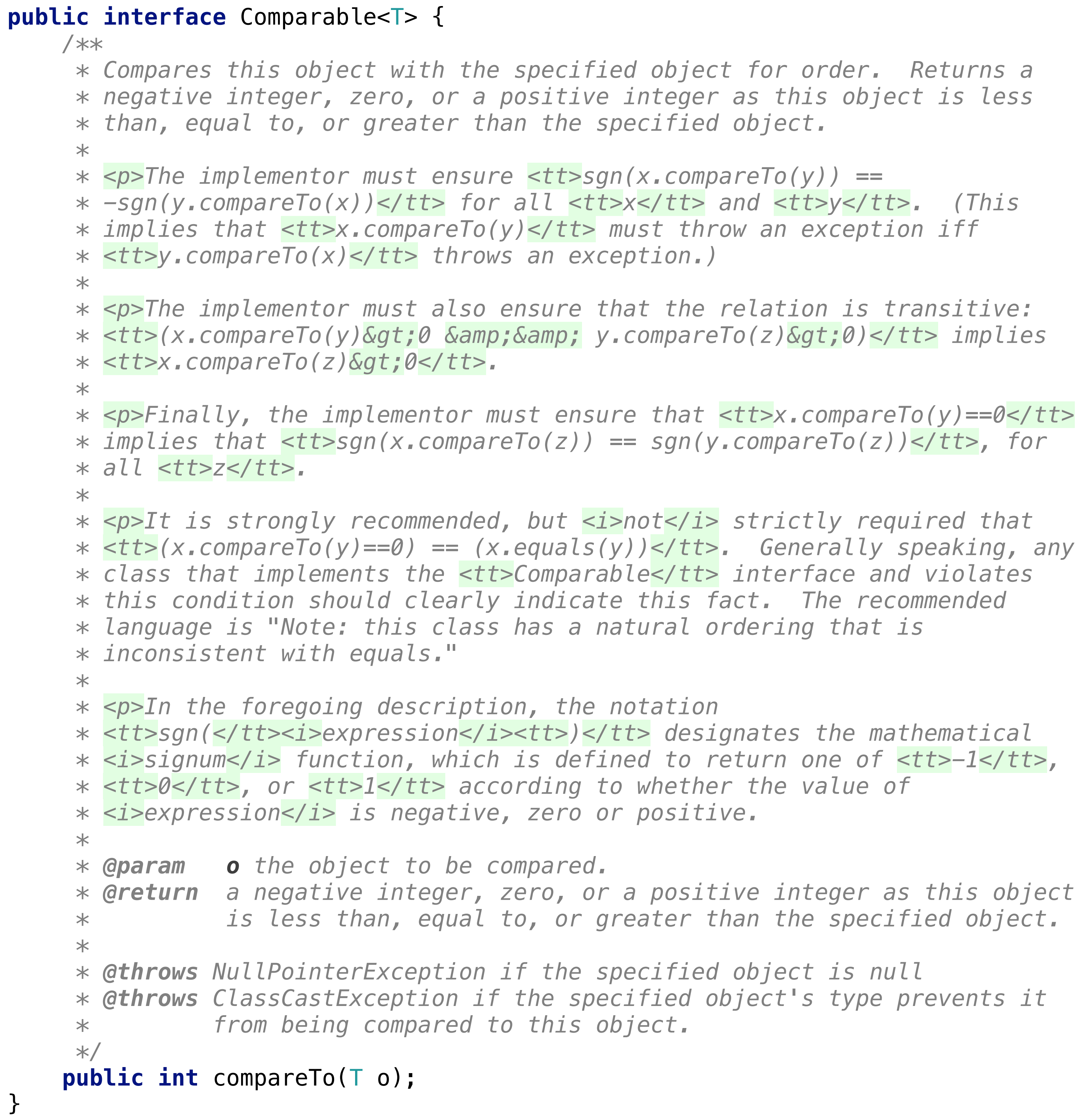
```
package game;

public interface DefenseFocusHero extends HeroCharacter{
    public int getExtraArmarRatio();
}
```

```java
package game;

abstract public class DefenseHeroTemplate implements DefenseFocusHero {
    public final String heroName;
    private int health;
    private int attack;

    public DefenseHeroTemplate(String name, int health, int attack) {
        this.heroName = name;
        this.health = health;
        this.attack = attack;
    }

    public void move() {
        System.out.print("Move up down right left");
    }

    public int normalAttack() {
        return attack;
    }

    public void beingAttack(int hpCut) {
        health -= hpCut/getExtraArmarRatio();
    }

    public boolean isAlive() {
        return health > 0;
    }

    abstract public void ultimateAttack();

    abstract public int getExtraArmarRatio();

}
```

Comparable interface

- Override equal function only allow the operation to compare if two object are same

- Implement Comparable interface allow the customized rule to compare two object



```
public interface Comparable<T> {
    /**
     * Compares this object with the specified object for order.  Returns a
     * negative integer, zero, or a positive integer as this object is less
     * than, equal to, or greater than the specified object.
     *
     * <p>The implementor must ensure <tt>sgn(x.compareTo(y)) ==
     * -sgn(y.compareTo(x))</tt> for all <tt>x</tt> and <tt>y</tt>.  (This
     * implies that <tt>x.compareTo(y)</tt> must throw an exception iff
     * <tt>y.compareTo(x)</tt> throws an exception.)
     *
     * <p>The implementor must also ensure that the relation is transitive:
     * <tt>(x.compareTo(y)&gt;0 &amp;&amp; y.compareTo(z)&gt;0)</tt> implies
     * <tt>x.compareTo(z)&gt;0</tt>.
     *
     * <p>Finally, the implementor must ensure that <tt>x.compareTo(y)==0</tt>
     * implies that <tt>sgn(x.compareTo(z)) == sgn(y.compareTo(z))</tt>, for
     * all <tt>z</tt>.
     *
     * <p>It is strongly recommended, but <i>not</i> strictly required that
     * <tt>(x.compareTo(y)==0) == (x.equals(y))</tt>.  Generally speaking, any
     * class that implements the <tt>Comparable</tt> interface and violates
     * this condition should clearly indicate this fact.  The recommended
     * language is "Note: this class has a natural ordering that is
     * inconsistent with equals."
     *
     * <p>In the foregoing description, the notation
     * <tt>sgn(</tt><i>expression</i><tt>)</tt> designates the mathematical
     * <i>signum</i> function, which is defined to return one of <tt>-1</tt>,
     * <tt>0</tt>, or <tt>1</tt> according to whether the value of
     * <i>expression</i> is negative, zero or positive.
     *
     * @param   o the object to be compared.
     * @return  a negative integer, zero, or a positive integer as this object
     *          is less than, equal to, or greater than the specified object.
     *
     * @throws NullPointerException if the specified object is null
     * @throws ClassCastException if the specified object's type prevents it
     *         from being compared to this object.
     */
    public int compareTo(T o);
}
```

```java
public class Student implements Comparable{

    public int finalScore;
    public String name;
    public int grade;

    public Student(int finalScore, String name) {
        this.finalScore = finalScore;
    }

    public Student(int finalScore, String name, int grade) {
        this.finalScore = finalScore;
        this.name = name;
        this.grade = grade;
    }

    @Override
    public int compareTo(Object o) {
        if(grade == ((Student)o).grade)
            return 0;
        else if(grade > ((Student)o).grade)
            return 1;
        else
            return -1;
    }
}
```

```java
public class Student implements Comparable<Student>{

    public int finalScore;
    public String name;
    public int grade;

    public Student(int finalScore, String name) {
        this.finalScore = finalScore;
    }

    public Student(int finalScore, String name, int grade) {
        this.finalScore = finalScore;
        this.name = name;
        this.grade = grade;
    }

    @Override
    public int compareTo(Student other) {
        if(grade == other.grade)
            return 0;
        else if(grade > other.grade)
            return 1;
        else
            return -1;
    }
}
```

```java
public static void main(String[] args) {
    Student s1 = new Student(80, "Tom", 8);
    Student s2 = new Student(80, "Tim", 12);

    System.out.println(s1.compareTo(s2));
}
```

Print: -1