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Smalltalk Lecture 2

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Review — Objects in Smalltalk

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- *Everything* is an object
  - Things only happen by message passing
  - Variables are dynamically bound
- Each object is an instance of one class
  - A class defines the structure and the behavior of its instances.
  - Single inheritance
  - A class is an instance of a metaclass
- Methods are public
  - private methods by convention in “private” protocol
- Objects have private state
  - Encapsulation boundary is the object

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Object

- `Object` is the root of the inheritance tree (well, almost)
  - Defines the common and minimal behavior for all the objects in the system.
  - Comparison of objects:
    - ==, ~~, =, ~=, *isNil*, *notNil*
  - Printing
    - *printString, printOn:, aStream, print, printNl*
    - *display, displayNl*
    - *Transcript show:, display:, tab, cr*

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Identity vs. Equality

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- == tests Object identity
  - Should never be overridden
- = tests Object value
  - Should normally be overridden
    - *Default implementation is ==*
  - You should override hash too!

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```
'foo','bar' = 'foobar'
'foo','bar' == 'foobar'
```

```
true
false
```

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Printing

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- Override `printOn:` to give your objects a sensible textual representation

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```
Fraction>>printOn: aStream
    aStream nextPut: $(.
    numerator printOn: aStream.
    aStream nextPut: $/.
    denominator printOn: aStream.
    aStream nextPut: $).
```

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Object methods to support the programmer

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`error: aString`	Signal an error
`doesNotUnderstand: aMessage`	Handle unimplemented message
`halt, halt: aString, haltIf: condition`	Invoke the debugger
`subclassResponsibility`	The sending method is abstract
`shouldNotImplement`	Disable an inherited method
`deprecated: anExplanationString`	Warn that the sending method is deprecated.

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Numbers

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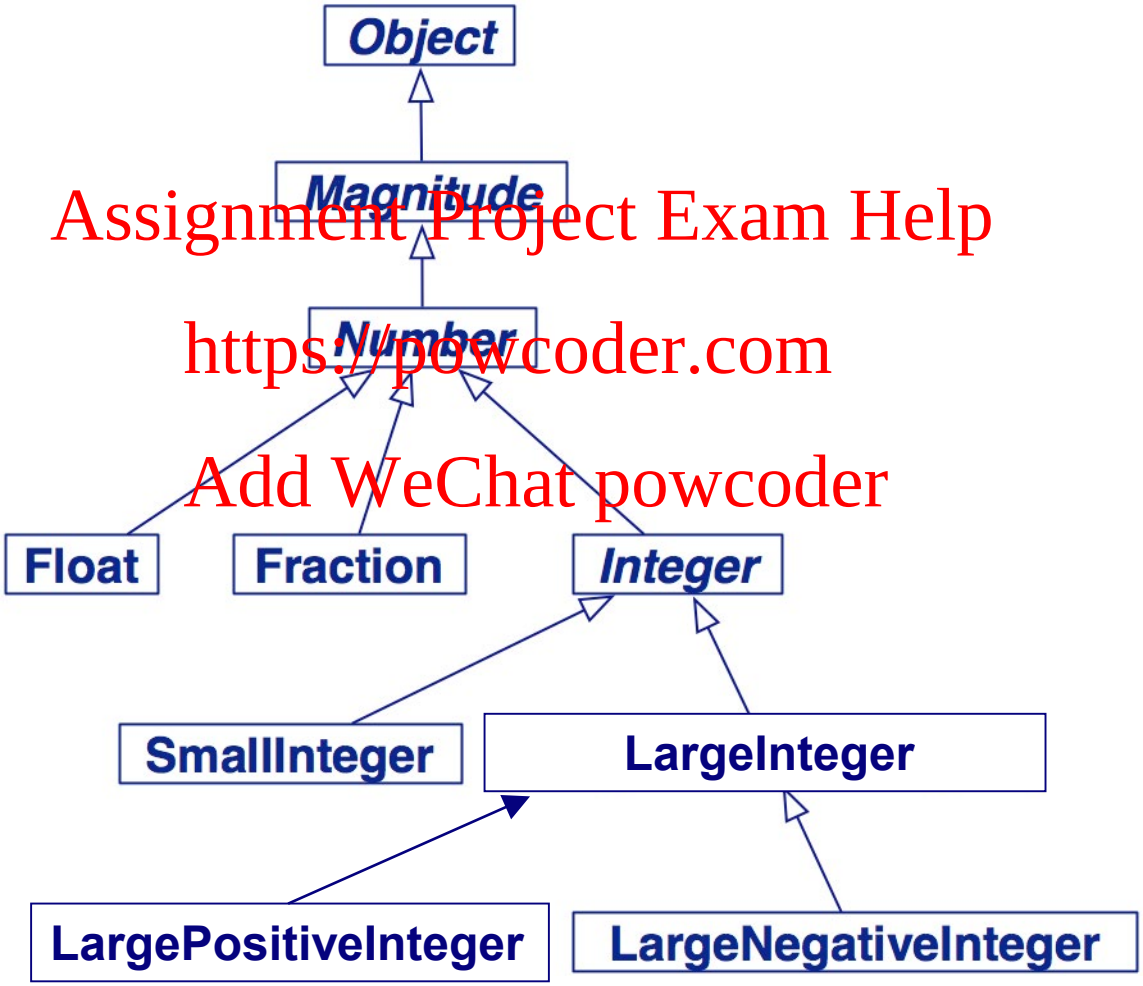

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Abstract methods in Smalltalk

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```
Number>>+ aNumber
   "Answer the sum of the receiver and aNumber."

   self subclassResponsibility
```

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Abstract methods (part 2)

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```
Object>>subclassResponsibility
    "This message sets up a framework for the behavior of the
    class' subclasses. Announce that the subclass should have
    implemented this message."

    self error: 'My subclass should have overridden ',
       thisContext sender selector printString
```

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Automatic coercion

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```
1 + 2.3
1 class
1 class maxVal class
(1 class maxVal + 1) class
(1/3) + (2/3)
1000 factorial / 999 factorial
2/3 + 1
```

```
3.3
SmallInteger
SmallInteger
LargePositiveInteger
1
1000
(5/3)
```

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Try various mixed expressions to see how coercion works.

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Try this in Java!

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1000 factorial

```
40238726007709377354370243392300398571937486421071463254379991042993851239862902059204420848696940480047998861019719605863166687299480855890132382966994459099742450408707375991882362772718873251977950595099527612087497546249704360141827809456469629105639388743788647837119181045825783647849977012476632889835955735432513185323958463075557409114262417474849847553428646576611667797396668820291207379143853719588249808126867838374559731746136085379534524221586593201928090878297308431392844403281231558611036976801357304216168747609675871348312025478589320767169132448426236131412508780208000261683151027341827977704784635868170164365024153691398281264810213092761244896359928705114964975419909342221566832572080821333186115811553615836546984046708975602900951053761647584772842188967964624494516076535340819890138544248798459953319101723355556602139450399736280750137837615307127761926849034352625200015888535147331611702103968175921510907788019393178114194545257223865541461062892187960223838971476088506276862967146674697562911234082439208160153780889893964518263243671616762179168909779911903754031274622289988005595144144292612187361745992642956581746623302955570299024324153181617210465832036786906117260158783520751516284225540265170483304226143974286933061690897968482590125458327168226458066526769958652682272807075781391858178889652208164348344825993266043367660176999612831860788386150279465955131156552036093988180612138558600301435694527224206344631797460594682573103790084024432438465657245014402821885252470935190620929023136493273497565513958720559654228749774011413346962715422845862377387538230483865688976461927383814900140767310446640259899490222221765904339901886018566526485061799702356193897017860040811889729918311021171229845901641921068884387121855646124960798722908519296819372388642614839657382291123125024186649353143970137428531926649875337218940694281434118520158014123344828015051399694290153483077644569099073152433278288269864602789864321139083506217095002597389863554277196742822248757586765752344220207573630569498825087968928162753848863396909959826280956121450994871701244516461260379029309120889086942028510640182154399457156805941872748998094254742173582401063677404595741785160829230135358081840096996372524230560855903700624271243416909004153690105933983835777939410970027753472000000000
```

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Characters

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- Characters:

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```
$a $B $$ $_ $1
```

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- Unprintable characters:

```
Character space, Character tab, Character cr
```

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Strings

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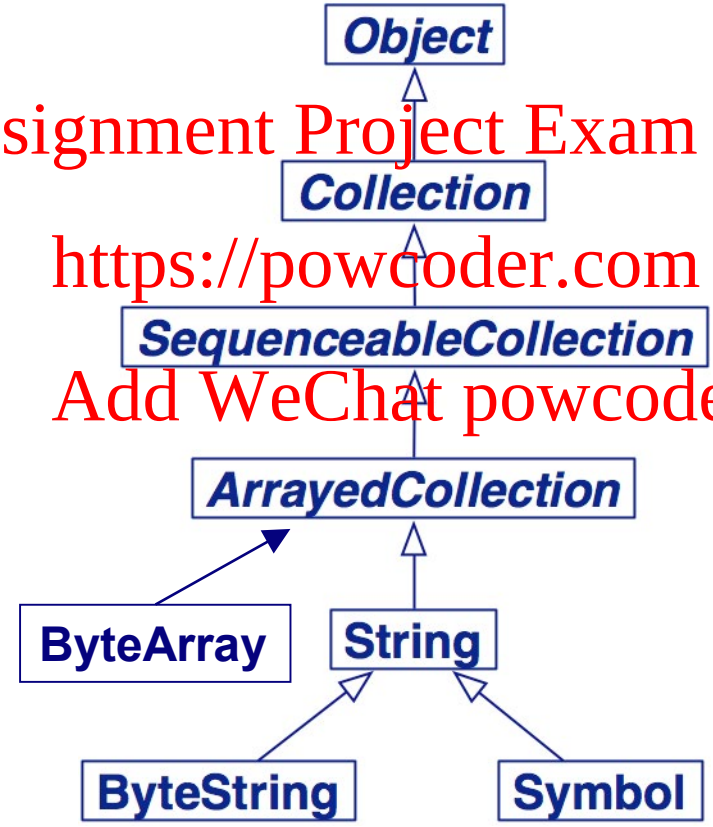

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Strings

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```
#mac asString
12 printString
String with: $A
'can''t' at: 4
'hello', ' ', 'world'
```

```
'mac'
'12'
'A'
$'
'hello world'
```

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- To introduce a single quote inside a string, just double it.

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Comments and Tips

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- A comment can span several lines.

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```
"TestRunner open"
```

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```
"This is a longer
comment that spans
multiple lines"
```

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Literal Arrays

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```
#('hello' #(1 2 3))

#(a b c)
```

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```
#('hello' #(1 2 3))

#(#a #b #c)
```

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Arrays and Literal Arrays

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- Literal Arrays and Arrays only differ in creation time
  - Literal arrays are known at compile time, Arrays at run-time.

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- A literal array with two symbols (not an instance of `Set`)

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```
#(Set new)
```

```
#(#Set #new)
```

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- An array with one element, an instance of `Set`

```
Array with: (Set new)
```

```
an Array(a Set())
```

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Dynamic arrays with { }

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> `{ … }` is a shortcut for `Array new …`

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```
#(5 + 2 . 3 * 4 )
```

Syntax error

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```
{ 5 + 2 . 3 * 4 }
```

#(7 12)

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```
Array with: 5+2 with: 3*4
```

#(7 12)

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Symbols vs. Strings

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- Symbols are used as method selectors and unique keys for dictionaries
  - Symbols are read-only objects, strings are mutable
  - A symbol is unique, strings are not

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```
'calvin' = 'calvin'                    true
'calvin' == 'calvin'                   true
'cal','vin' = 'calvin'                 true
'cal','vin' == 'calvin'                false

#calvin = #calvin                      true
#calvin == #calvin                     true
#cal,#vin = #calvin                    true
#cal,#vin == #calvin                   false
#cal,#vin                              'calvin'
(#cal,#vin) asSymbol == #calvin        true
```

!

NB: Comparing strings is slower than comparing symbols by a factor of 5 to 10. However, converting a string to a symbol is more than 100 times more expensive.

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Variables

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- A variable maintains a reference to an object
  - Dynamically typed
  - Can reference different types of objects
  - Shared (initial uppercase) or local (initial lowercase)

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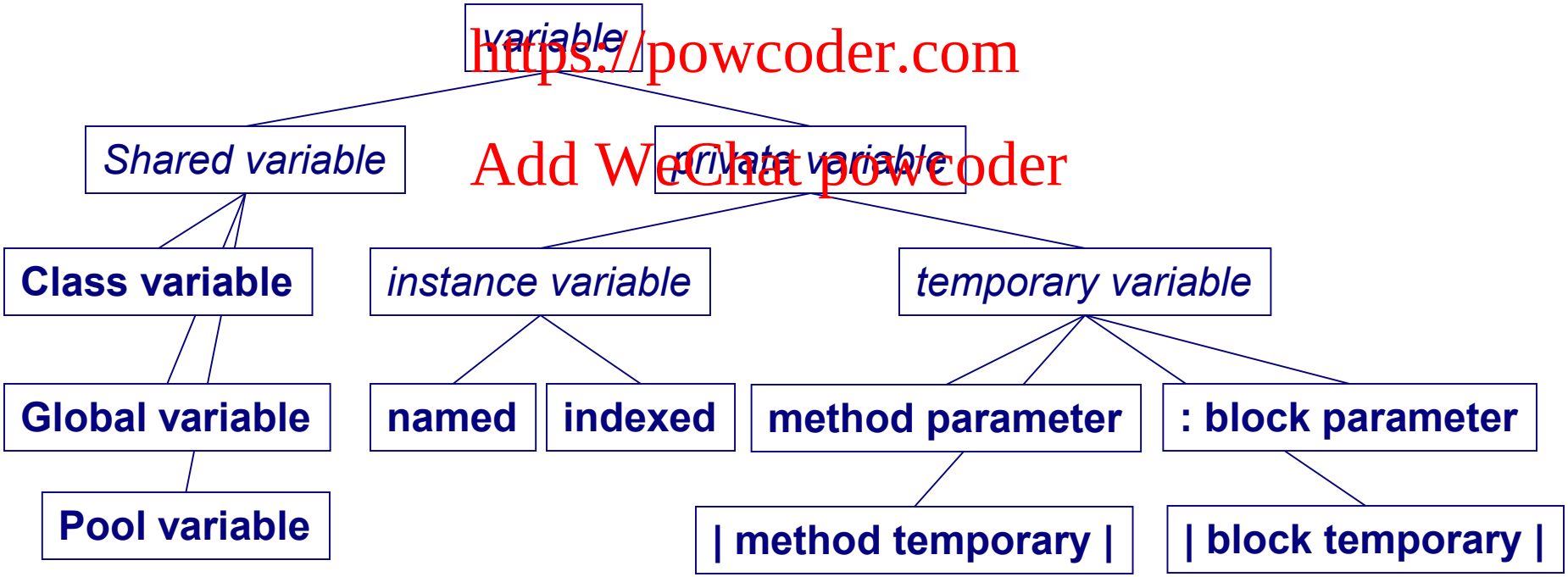

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Assignment

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- Assignment binds a name to an object reference
  - Not done by message passing!
  - Method arguments cannot be assigned to!
    - *Use a temporary instead*
  - Different names can point to the same object!
    - *Watch out for unintended side effects*

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```
|p1 p2|
p1 := 3@4.
p2 := p1.
p1 setX: 5 setY: 6.
p2
```

5@6

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Global Variables

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- Always Capitalized (convention)
  - Stored in the Smalltalk System Dictionary

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- Avoid them!

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Global Variables

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- To remove a global variable:

```
Smalltalk removeKey: #MyGlobal
```

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- Some predefined global variables:

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`Smalltalk`	Classes & Globals
`Undeclared`	A PoolDictionary of undeclared variables accessible from the compiler
`Transcript`	System transcript
`ScheduledControllers`	Window controllers
`Processor`	A ProcessScheduler list of all processes

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Instance Variables

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- Private to an object
  - Visible to instance methods of the defining class and subclasses
  - Has the same lifetime as the object
  - Define accessors (getters and setters) to facilitate initialization
    - *Put accessors in a private category!*

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Six Pseudo-Variables

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- The following pseudo-variables are hard-wired into the Smalltalk interpreter.

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`nil`	A reference to the UndefinedObject
`true`	Singleton instance of the class True
`false`	Singleton instance of the class False
`self`	Reference to this object Method lookup starts from object's class
`super`	Reference to this object (!) Method lookup starts from the superclass
`thisContext`	Reification of execution context You won't need to understand this variable

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Pair class (GNU Smalltalk syntax)

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```
Object subclass: #Pair.
Pair instanceVariableNames: 'x y'.
```

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```
Pair extend [
    getX [ ^x ]
    getY [ ^y ]
    setX: a [ x := a ]
    setY: b [ y := b ]
].
```

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Alternative GNU Smalltalk syntax

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```
Object subclass: Pair [
    | x  y |

    getX [ ^x ]
    getY [ ^y ]
    setX: a [ x := a ]
    setY: b [ y := b ]
].
```

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Pair client

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```
p := Pair new.
p getX printNl.
p getY printNl.
p setX: 100.
p setY: 'hello'.
p getX printNl.
p getY printNl.
```

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```
nil
nil
100
'hello'
```

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Triple subclass and client

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```
Pair subclass: Triple [
    | z |
    getZ [ ^z ]
    setZ: c [ z := c ]
].

t := Triple new setX: 3.14159; setY: $C; setZ: true.
t getX printNl.
t getY printNl.
t getZ printNl.
```

```
3.14159
$C
true
```

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Meta-programming

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```
current := Triple.
[current notNil] whileTrue:
        [Transcript display: current; tab;
                display: current selectors size; cr.
         current := current superclass]
```

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```
Triple   2
Pair     4
Object   127
```

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Recap

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```
Object subclass: #Pair.
p := Pair new.
…
Pair subclass: #Triple.
t := Triple new.
…
```

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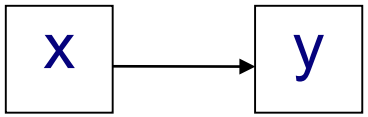
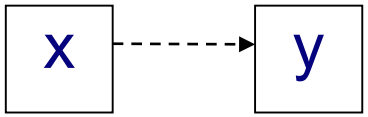
- Subsequent diagrams contain two types of links:
  - If x is a subclass of y, and y is the superclass of x



  - If x is an instance of y, and y is the owner class of x



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Most programmers should visualize the situation this way

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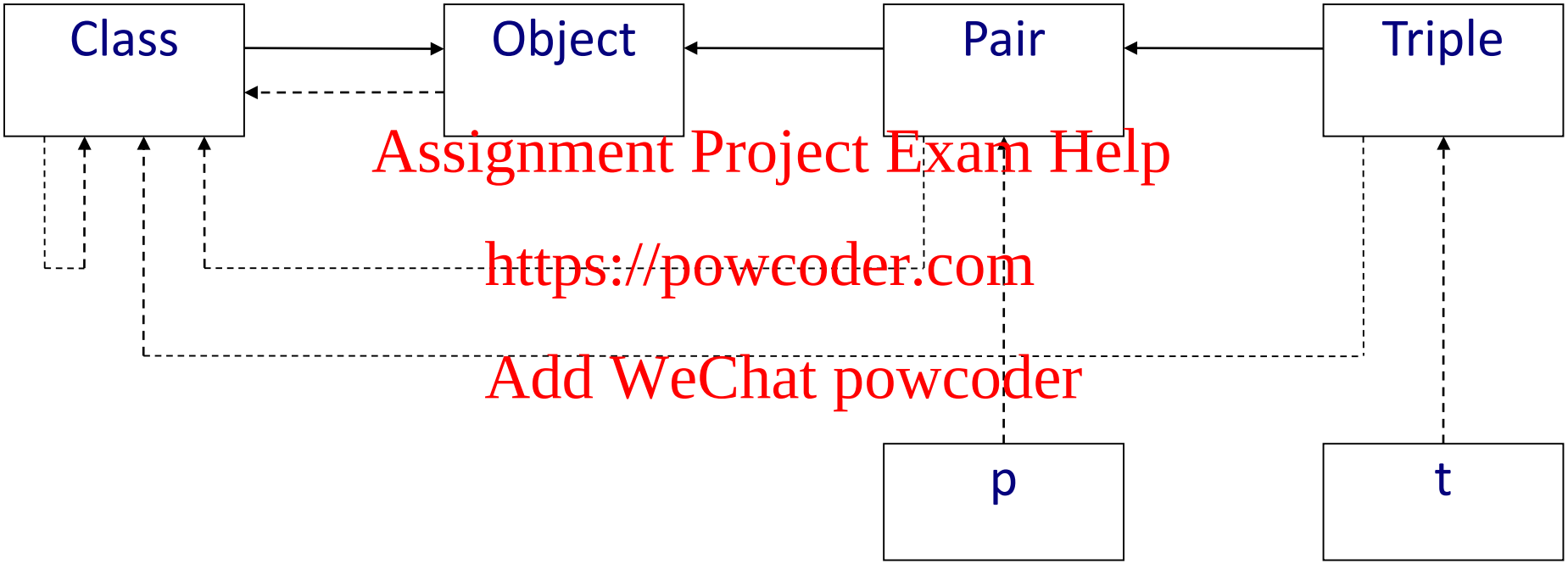

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But here is a more accurate representation

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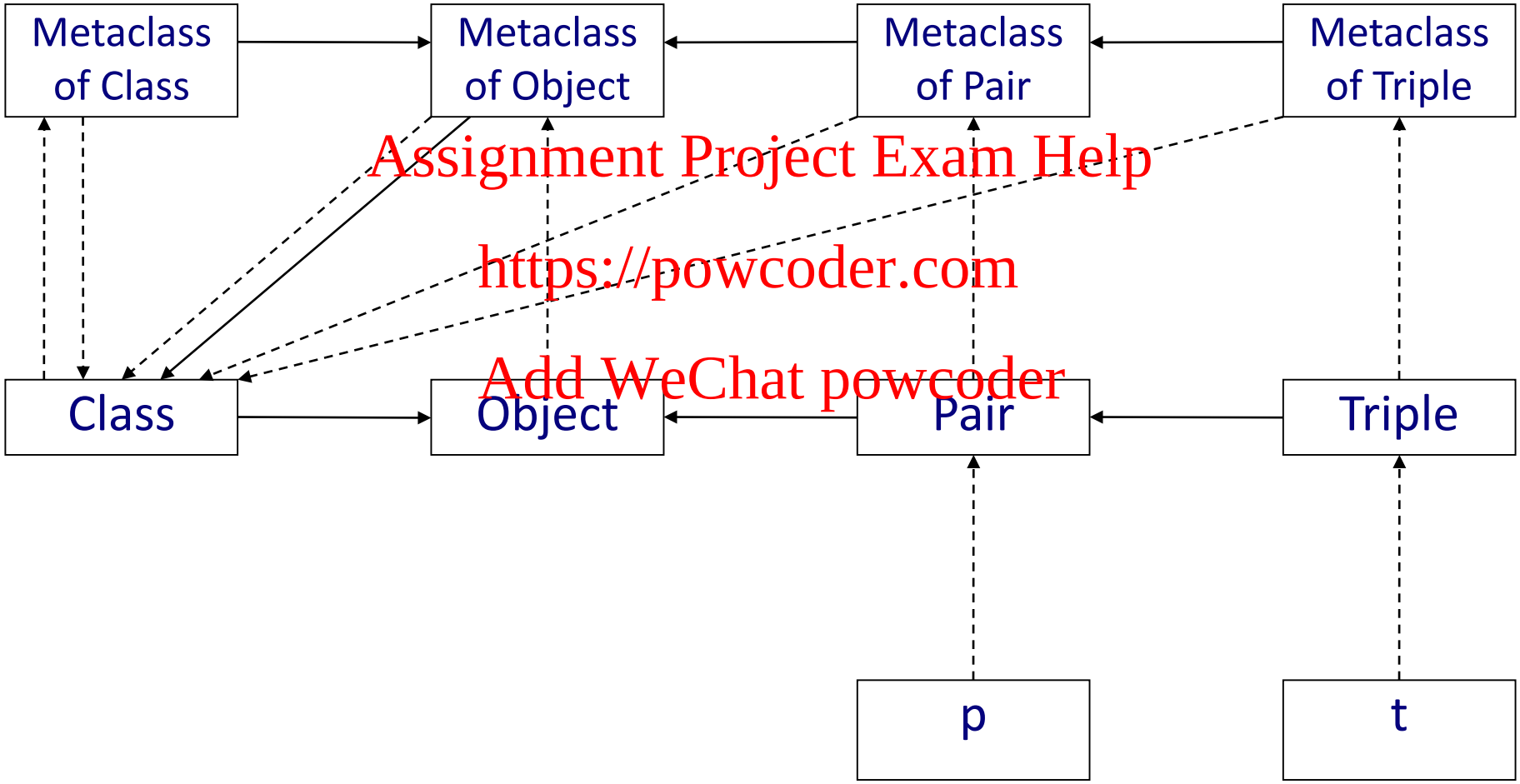

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