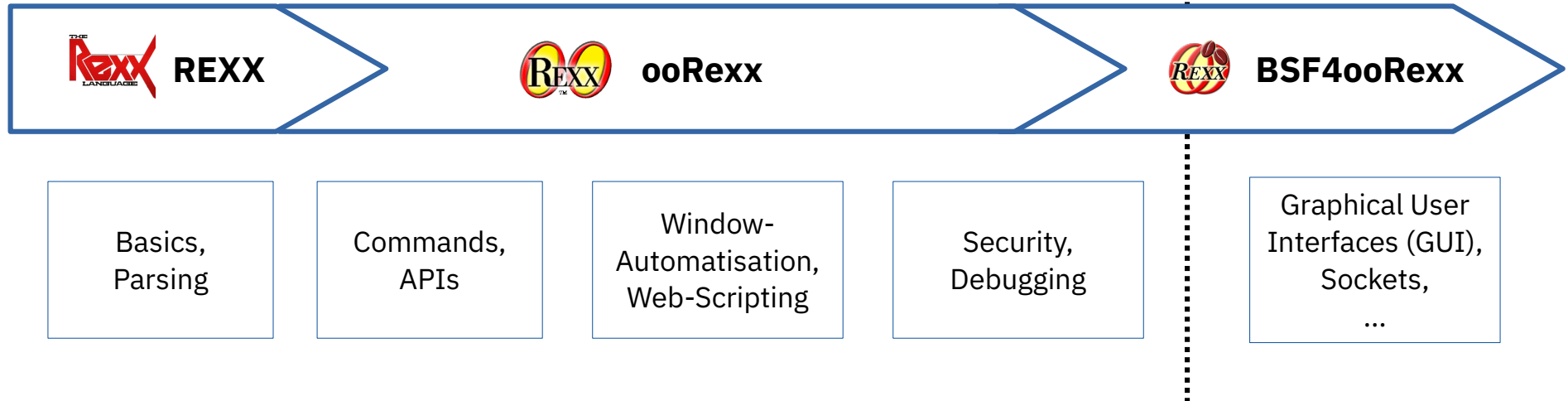


Procedural and Object-oriented Programming 5

Defining Classes ("CLASS" Directive), Defining Methods ("METHOD" Directive),
Object REXX Classes

Business Programming 1

Business Programming 2



Abstract Datatype (ADT)



- Implementing an ADT schema with ooRexx
 - **::CLASS** directive
 - Definition of **attributes** (fields) and therefore the internal datastructure
 - **::ATTRIBUTE** directive
 - **EXPOSE** statement denoting attributes (fields) *within* method routines
 - Definition of **operations** (method routines)
 - **::METHOD** directive
- Instances ("values", "objects") of datatypes ("classes", "types")
 - Individual, unambiguously distinguishable instances of the same type
 - Possess all the same attributes (constitute the datastructure as defined in the class) and operations ("methods of the class")

Object Rexx Messages, 1



- Conceptually, objects are regarded to be living things in ooRexx with which one communicates using messages! :)
 - If an object receives a message (with or without arguments) it
 - Searches for a method by the name of the received message in its class
 - If found, it invokes the method, supplying the received message arguments, if any, and returns any value the method may have returned
 - If not found the object searches the class hierarchy to find and invoke the method as described above
 - If there is no method found by the object it will raise a runtime condition with the error message "Object does not understand message" and the interpreter stops the execution of the program
 - A message consists at least of the receiving object, the message operator (~) and the message name to be sent to the object, e.g.

object = *.birthday*~new

Object Rexx Messages, 2



- Interaction (activating of methods) with objects (instances, values) is *only* possible via messages
 - Names of messages are the names of the methods, that the object must find and invoke on behalf of the programmer
 - Message operator ("twiddle") is the tilde character: ~
 - "ABC"~REVERSE yields: CBA
 - "Cascading" messages, two twiddles: ~~
 - "ABC"~~REVERSE yields (*attention!*): ABC
 - Sent messages activate the respective methods of the receiving object, upon return the interpreter changes the result to be *always* the receiving object!
 - Therefore multiple messages intended for the same object can be "cascaded" one after the other ("cascading messages")
 - Execution (resolution) of messages: from left to right

Using of an Abstract Datatype (ADT), 1



- Object REXX implementation of the ADT **Birthday**

```
/**/  
g1 = .Birthday~New  
g1~Date= "20320901"  
g1~Time= "16:00"  
g2=.Birthday~New~~"Date="("20360229")~~"Time="("19:19")  
SAY g1~date g2~date g1~time g2~time  
  
::CLASS Birthday  
::ATTRIBUTE date  
::ATTRIBUTE time
```

Output:

```
20320901 20360229 16:00 19:19
```

Overview of Scopes



- REXX und Object REXX
 - Standard scope
 - Labels, variables
 - Procedure scope
 - Variables in internal routines (procedures/functions)
- Object REXX
 - Program/Package scope
 - Accessing local and public classes and routines of called/required programs
 - Routine scope
 - Standard+procedure+program/package scope
 - Method scope
 - Standard+procedure+program plus accessibility of attributes
 - Methods assigned to a class: methods, which are defined for a class ("instance/object attributes")
 - Floating methods: methods, that are defined before any class directive ("floating attributes")

- Creating (constructing) a new object (value, instance) can be done by sending the **NEW** message to a class
 - The **NEW** method will create the new object (instance, value) and will send it the message **INIT** to allow it to initialise
 - If the **NEW** message has arguments, they get forwarded with the **INIT** message in the same order
 - The **NEW** method returns the reference to the newly created object (instance, value) as its result
- Hence, if we define an **INIT** method for a class, we can use it to initialise an object immediately after it got created (constructed)
 - The **INIT** method is therefore also called "**constructor**"
 - Always invoke the **INIT** method of the superclass!

Constructor: Method `INIT`

```

/**/
p1 = .Person~New("Albert","Einstein","45000")
p2 = .Person~New("Vera","Withanyname",25000)
SAY p1~firstName p1~familyName p1~salary p2~firstName
SAY p1~firstName p1~salary p1~increaseSalary(10000)~salary
::CLASS Person
::METHOD INIT
  EXPOSE firstName familyName salary
  USE ARG firstName, familyName, salary
  self~init:super -- invoke constructor of superclass
::ATTRIBUTE firstName
::ATTRIBUTE familyName
::ATTRIBUTE salary
::METHOD increaseSalary
  EXPOSE salary
  USE ARG increase
  salary = salary + increase

```

Output:

```

Albert Einstein 45000 Vera
Albert 45000 55000

```

Deleting of Objects



- Objects are automatically deleted from the runtime system, if they are not referenced anymore (becoming "garbage")
 - *If* there is a method named **UNINIT** defined for a class, then this method will be invoked, right before the unreferenced object gets destructed by the garbage collector by sending it the **UNINIT** message.
- The **UNINIT** method is therefore called "***destructor***"

Destructor: Method UNINIT



```
/**/  
p1 = .Person~New("Albert","Einstein","45000")  
p2 = .Person~New("Vera","Withanyname",25000)  
SAY p1~firstName p1~familyName p1~salary p2~firstName  
SAY p1~firstName p1~salary p1~~increaseSalary(10000)~salary  
DROP p1; DROP p2; CALL SysSleep( 15 ); SAY "Finish."  
  
::CLASS Person  
::METHOD INIT  
  EXPOSE firstName familyName salary  
  USE ARG firstName, familyName, salary  
  self~init:super -- invoke constructor of superclass  
  
::METHOD UNINIT  
  EXPOSE firstName familyName salary  
  SAY "Object: <"firstName familyName salary"> is about to be destroyed."  
  
::ATTRIBUTE firstName  
::ATTRIBUTE familyName  
::ATTRIBUTE salary  
::METHOD increaseSalary  
  EXPOSE salary  
  USE ARG increase  
  salary = salary + increase
```

Output:

```
Albert Einstein 45000 Vera  
Albert 45000 55000  
Finish.  
Object: <Vera Withanyname 25000> is about to be destroyed.  
Object: <Albert Einstein 55000> is about to be destroyed.
```

Sequence can
be different on
different runs!

Classification Tree, 1



- Generalization Hierarchy, "Classification Tree"
 - Allows **classification of instances** (Objects), e.g. from biology
 - **Ordering of classes in superclasses and subclasses** (schemata)
 - Subordered classes ("subclasses") **inherit** all properties (attributes and methods) of all superclasses up to and including the root class
 - Subclasses **specialize** in one way or the other the superclass(es)
 - "Defining of differences": simplifies the definition of subclasses
 - Sometimes it may make sense, that a subclass specializes directly more than one superclass at the same time ("**multiple inheritance**")
 - Example: Classes representing landborne and waterborne animals, where there exists a class "amphibians", which inherits directly from the landborne and waterborne animals

Classification Tree, 2



- Prefabricated "class tree"
 - Root class of Object REXX is named **Object**
 - All user defined classes are assumed to specialize the class **Object**, if no superclass is explicitly given
 - Single and multiple inheritance possible

Classification Tree: Search Order, 1



- Conceptually, the object receiving a message, starts searching for a method by the name of the received message and if found invokes it with the supplied arguments
- If such a method is not found in the class, from which the object is created, then the search is continued in the direct superclass up to and including the root class **Object**
- If the method is not even found in the root class **Object**, then an error condition gets thrown ("**Object** does not understand message")
 - If there is a method named **UNKNOWN** defined, then instead of creating an exception the runtime system will invoke that method, supplying the name of the unknown method and its arguments, if any were supplied with the message

Classification Tree: Search Order, 2



- In method routines ooRexx sets the following two variables which are therefore *always available in methods*
 - **super**
 - Always contains a reference to the immediate superclass
 - Allows redirecting the search for methods to the immediate superclass
 - **self**
 - Always contains a reference to the object for which the method got invoked
 - This way it becomes possible to send messages to the object from within a method
- **super** and **self** determine the class, where the search for methods with the message name starts

Example "Dog", 1



- Problem description
 - "Special Interest Group (SIG) Dog Sanctuary"
 - Normal dogs
 - Little dogs
 - Big dogs
 - All dogs possess a name and are able to bark
 - Normal dogs bark "Wuff Wuff"
 - Little dogs bark "wuuf"
 - Big dogs bark "WUFFF! WUFFF!! WUFFF!!!"
 - Define appropriate classes taking advantage of inheritance (search order)

Example "Dog", 2



- Definition of a class "**LittleDog**", which possesses all properties common to all little dogs

```
/**/  
.Dog~NEW      ~~"NAME="("Sweety")  ~Bark  
.BigDog~NEW    ~~"NAME="("Grobian") ~Bark  
.LittleDog~NEW ~~"NAME="("Arnie")   ~Bark  
::CLASS Dog      SUBCLASS Object  
::ATTRIBUTE Name  
::METHOD Bark  
  SAY self~Name:" "Wuff Wuff" "-" self  
::CLASS BigDog   SUBCLASS dog  
::METHOD Bark  
  SAY self~Name:" "WUFFF! WUFFF!! WUFFF!!!" "-" self  
  self~bark:super  
::CLASS "LittleDog" SUBCLASS dog  
::METHOD Bark  
  SAY self~Name:" "wuuf" "-" self
```

Output:

```
Sweety: Wuff Wuff - a DOG  
Grobian: WUFFF! WUFFF!! WUFFF!!! - a BIGDOG  
Grobian: Wuff Wuff - a BIGDOG  
Arnie: wuuf - a LittleDog
```

- Multithreading
 - Multiple parts of a program execute at the same time (in parallel)
 - Possible problems
 - Data integrity (Object integrity)
 - Deadlocks
- Object REXX
 - **Inter** Object-Multithreading
 - Different objects (even of one and the same class) are shielded from each other and can be active at the same time
 - **Intra** Object-Multithreading
 - **Within** an instance (an object) multiple methods can execute at the same time, if they are defined in *different classes*

::CLASS Directive



- This directive causes the interpreter to create a class
 - **::CLASS** *xyz*
 - A class with the name *XYZ* is created
- The following options are available for this directive
 - **PRIVATE, PUBLIC**
 - Optional, default value: **PRIVATE**
 - **SUBCLASS, MIXINCLASS**
 - Optional, default value: **SUBCLASS Object**
 - **METAClass** metaclass
 - Optional, default value: **METAClass Class**
 - **INHERIT**
 - Optional, allows indicating those classes which are inherited in addition: multiple inheritance

::CLASS Directive, 1

Implementing "Vehicle", "RoadVehicle", "WaterVehicle"



```
/**/  
.RoadVehicle ~new("Truck") ~drive  
.WaterVehicle ~new("Boat") ~swim  
  
::CLASS      Vehicle  
::ATTRIBUTE  name  
::METHOD     INIT  
    self~name = ARG(1)  
  
::CLASS      RoadVehicle  SUBCLASS Vehicle  
::METHOD     drive  
    SAY self~name": 'I drive now...'  
  
::CLASS      WaterVehicle SUBCLASS Vehicle  
::METHOD     swim  
    SAY self~name": 'I swim now...'
```

Output:

```
Truck: 'I drive now...'  
Boat: 'I swim now...'
```

::CLASS Directive, 2

Implementing "AmphibianVehicle" Using Multiple Inheritance



```
/* Multiple Inheritance */
.RoadVehicle      ~new("Truck")    ~drive
.WaterVehicle     ~new("Boat")     ~swim
.AmphibianVehicle ~new("SwimCar")  ~show_off

::CLASS      Vehicle
::ATTRIBUTE  name
::METHOD     INIT
    self~name = ARG(1)
::METHOD     tsk
    SAY self~name": 'tsk!'"

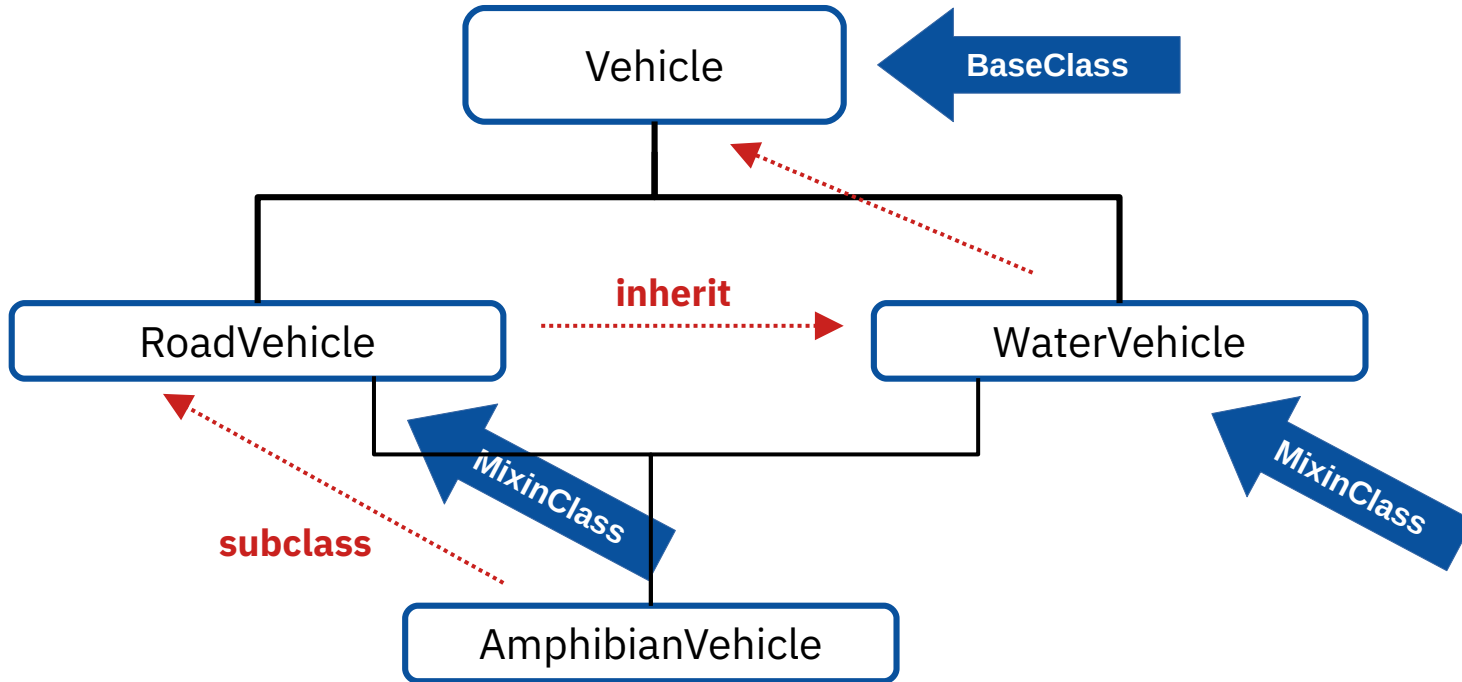
::CLASS      RoadVehicle MIXINCLASS Vehicle
::METHOD     drive
    SAY self~name": 'I drive now...'"

::CLASS      WaterVehicle MIXINCLASS Vehicle
::METHOD     swim
    SAY self~name": 'I swim now...'"

::CLASS      AmphibianVehicle SUBCLASS RoadVehicle INHERIT WaterVehicle
::METHOD     show_off
    self ~~drive ~~swim ~~tsk
```

Output:

```
Truck: 'I drive now...'
Boat: 'I swim now...'
SwimCar: 'I drive now...'
SwimCar: 'I swim now...'
SwimCar: 'tsk!'
```



::METHOD Directive, 1



- This directive causes the interpreter to create a method
 - **::Method** mmm
 - A method with the identifier "MMM" is created
- The following options are available for this directive
 - **ATTRIBUTE**
 - Optional, if supplied the interpreter creates **two** methods:
 - A get ("getter") method "MMM" (returns the attribute's value) like this

```
::METHOD  MMM    /* name of get method "MMM"          */  
EXPOSE   MMM    /* allow direct access to the attribute */  
RETURN   MMM    /* return the attribute's value      */
```

- A set ("setter") method "MMM=" (sets the attribute's value to the supplied argument) like this

```
::METHOD  "MMM=" /* name of the set method "MMM="        */  
EXPOSE   MMM    /* allow direct access to the attribute */  
USE ARG  MMM    /* retrieve argument and assign it to the attribute */
```

::METHOD Directive, 2



- The following options are available for this directive (continued)
 - **PRIVATE, PUBLIC**
 - Optional, default value: **PUBLIC**
 - If set to **PRIVATE** then the message can only be sent as: **self~mmm**
 - **GUARDED, UNGUARDED**
 - Optional, default value: **GUARDED**
 - Determines whether method can be run in parallel to other methods
 - **CLASS**
 - Optional, method is a class method
 - **PROTECTED, UNPROTECTED**
 - Optional, default value: **UNPROTECTED**
 - If set to **PROTECTED** then access to this method can be supervised with the help of the Object REXX *Security Manager*

::ATTRIBUTE Directive



- **::ATTRIBUTE** *mmm* **[GET|SET]**
 - This directive is equivalent to "**::METHOD** *mmm* **ATTRIBUTE**" and causes the interpreter to create the following two methods by default:
 - A getter method named "**MMM**" and
 - A setter method named "**MMM=**"
 - If the option **GET** is given, then only the getter method gets created
 - If the option **SET** is given, then only the setter method gets created

::CONSTANT Directive



- **::CONSTANT** NAME VALUE

- This directive creates a class and an instance method named **NAME** which always returns **VALUE**

```
say "pi:" .MyClass~pi "(from class)"
o=.MyClass~new
say "pi:" o~pi "(from instance)"

::CLASS MyClass
::CONSTANT pi 3.141592653589793238462643383279502884197
```

Output:

```
pi: 3.141592653589793238462643383279502884197 (from class)
pi: 3.141592653589793238462643383279502884197 (from instance)
```

::RESOURCE Directive, 1



- **::RESOURCE** NAME
 - By default this directive needs as delimiter the string "**::END**" starting at the first column of one of the following lines
 - The end marker string can be changed using the **END delimiter** option of the directive
 - All lines between the start and the end of the directive will be stored in an array
 - This array will be stored using **NAME** as its index in the **.RESOURCES** StringTable
- Fetching a resource in the program
 - Send **NAME** as the message to the **.RESOURCES** StringTable
 - Returns an array of text lines representing the named resource
 - To turn an array back into a plain string, send the array the **makeString** or the **toString** message
 - The **SAY** keyword statement will automatically request the string representation

::RESOURCE Directive, 2



- The **RESOURCE** directive makes it easy to define and use multi line strings
 - No need to enquote and concatenate strings spanning multiple lines
- Resources can be used among other things for e.g.
 - Multiline SQL queries
 - XML/HTML chunks to serve client requests in web server applications
 - Any kind of multiline text
 - *Base64* encoded binary data like pictures, sound, cryptographic keys, ...
 - Cf. the methods of the **String** class named [encodeBase64](#) and [decodeBase64](#)

::RESOURCE Directive, 3



```
say "resource named 'info':"
say .resources~info

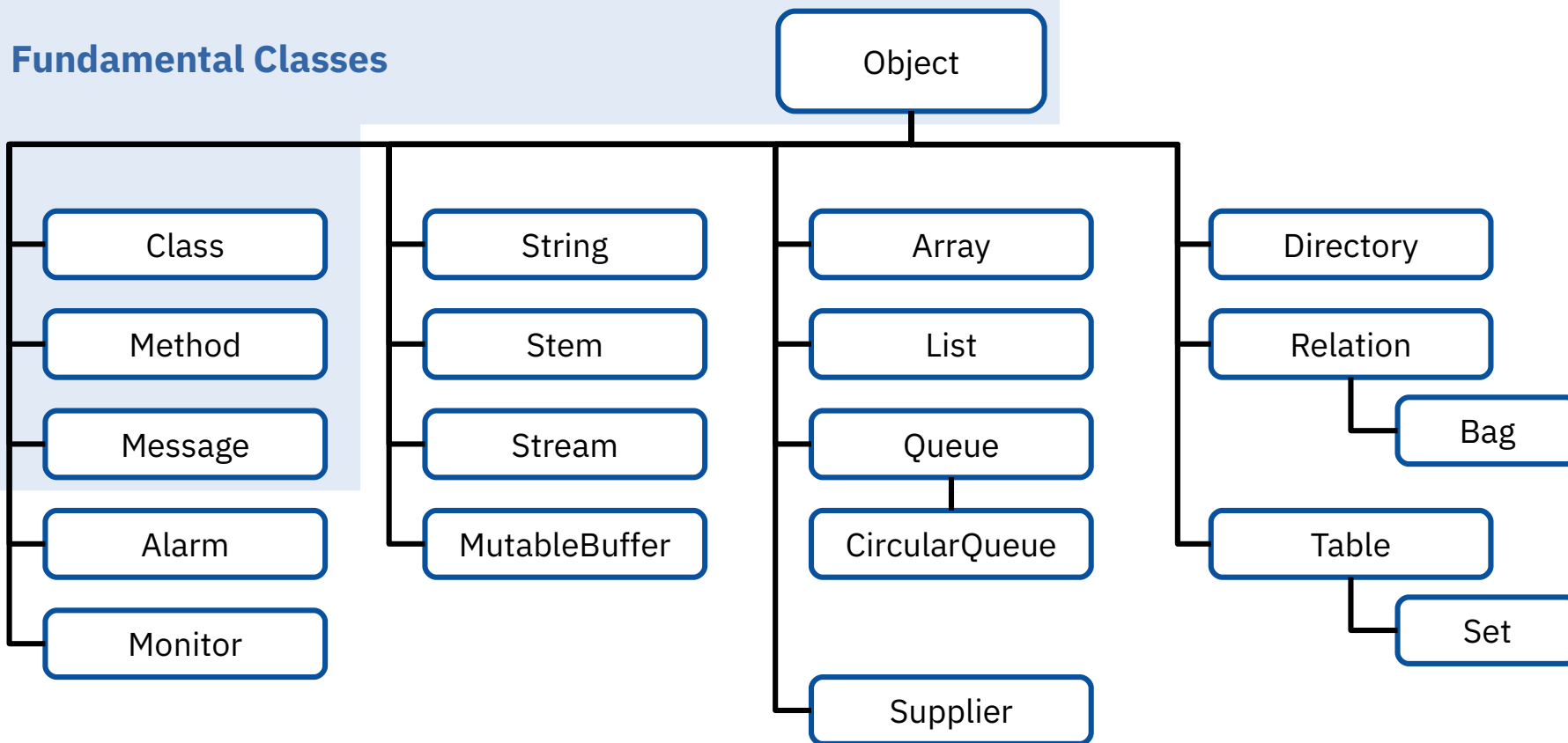
::resource info
*****
*
* This is the secret:
*
*   Eat an apple a day to keep the doctor away! ;)
*
*****
::END
```

Output:

```
resource named 'info':
*****
*
* This is the secret:
*
*   Eat an apple a day to keep the doctor away! ;)
*
*****
```

Fundamental Classes, 1

Fundamental Classes



Fundamental Classes, 2

- **Object**

- Methods and attributes are available to all instances (**objects**, **values**) of any REXX class
 - Example: method **INIT**
 - Constructor, initializes a newly created object

- **Class**

- Interpreter creates an instance of this class ("**class object**") for each **::CLASS** directive
 - Example: method **ID**
 - Returns the name (the "**i**dentification") of the class object
 - Example: method **NEW**
 - Creates a new instance (object, value) of the class, sends it the **INIT** message and returns it

Fundamental Classes, 3

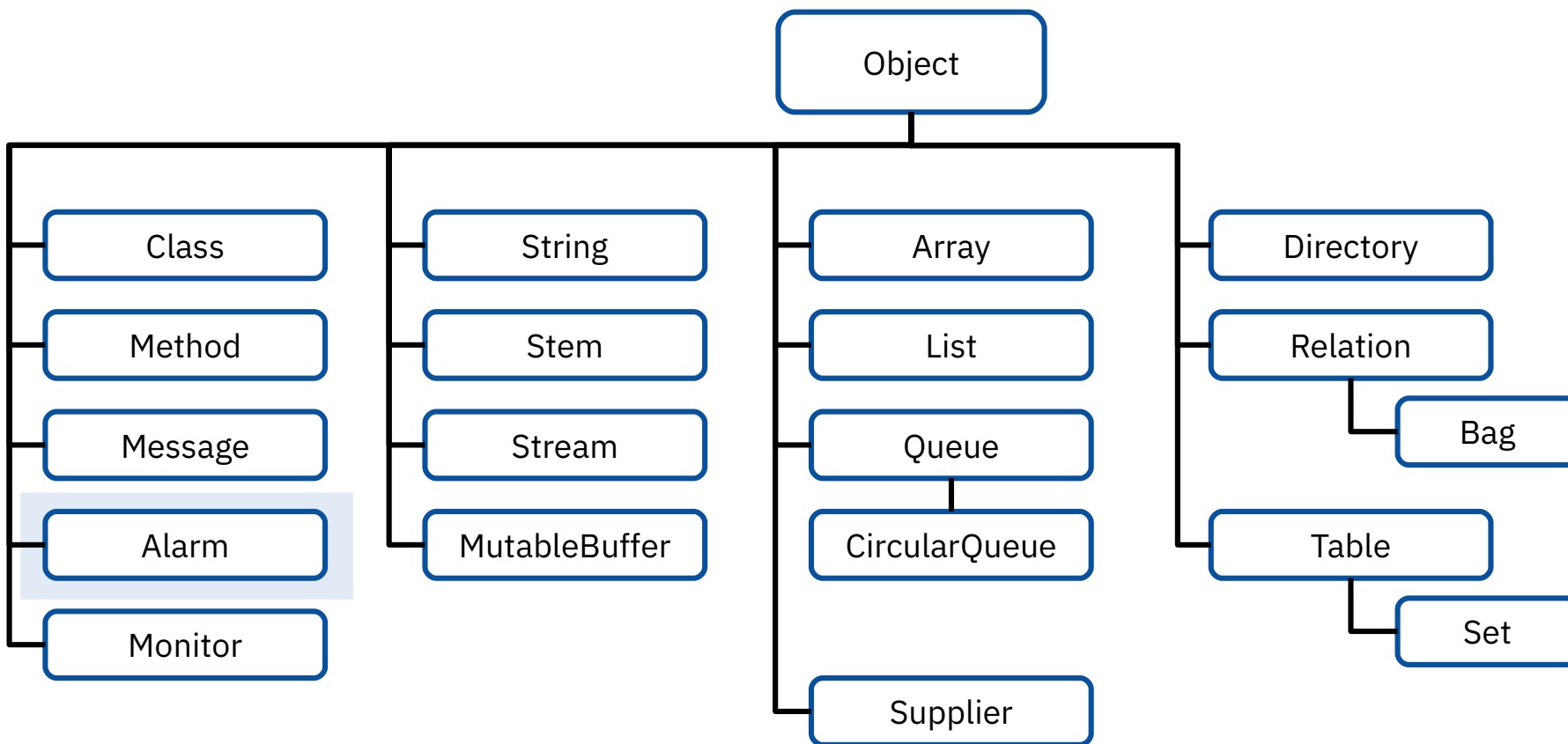
- **Method**

- Interpreter creates an instance of this class ("method object") for each **::METHOD** directive
 - Example: method **SOURCE**
 - Returns the source code of the method, if available

- **Message**

- For each message at runtime the interpreter creates an instance of this class ("message object")
 - Example: method **SEND**
 - Sends (transmits, dispatches) the message to the object and waits until it got processed

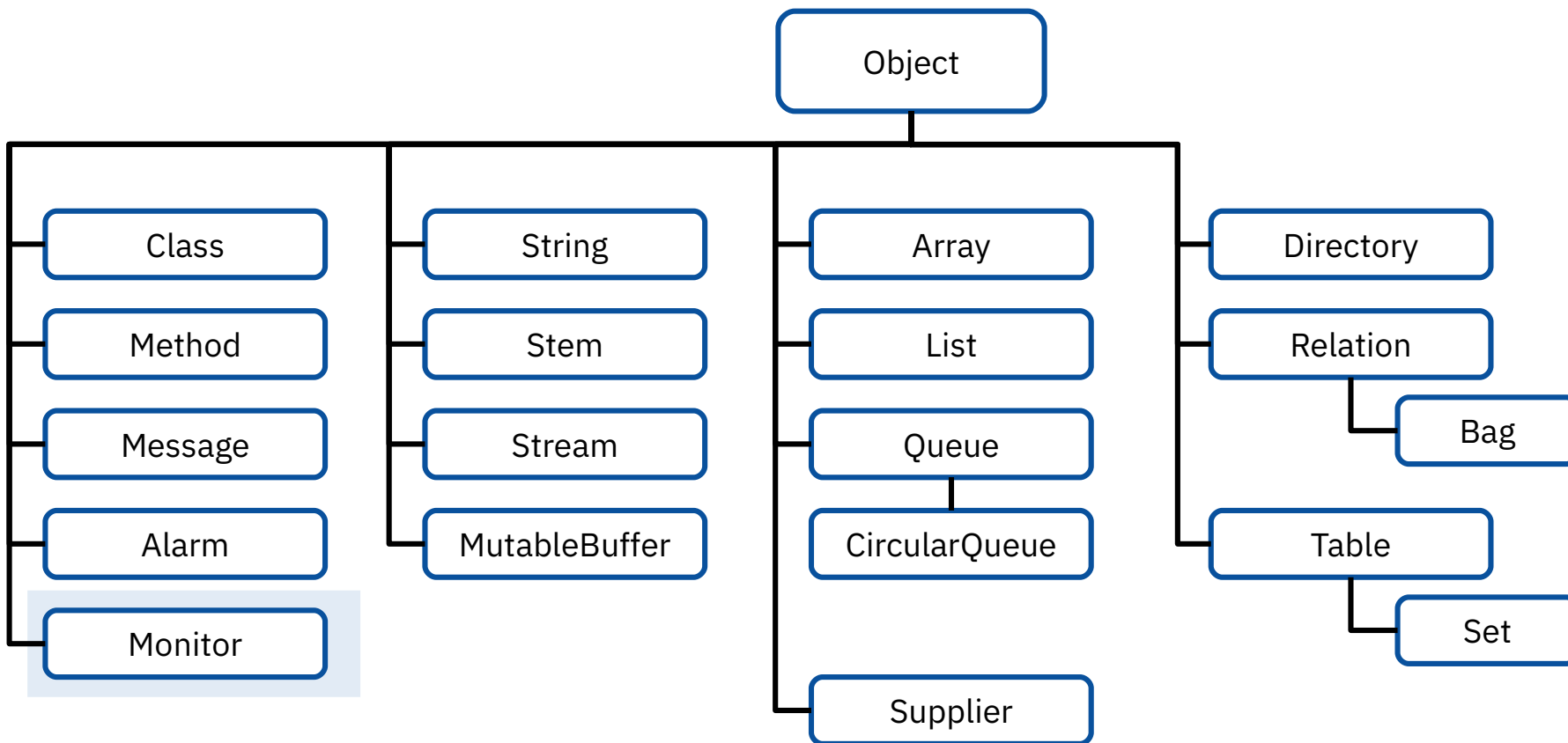
Alarm Class, 1





- **Alarm**
 - Alarm objects allow dispatching messages at a later time
 - Such messages are carried out in parallel to other activities in the Object REXX program ("multithreaded execution")
 - Dispatch time can be given
 - In hours, minutes, seconds starting from the time of initialization of the alarm object
 - As date and time
 - Example: method **CANCEL**
 - Cancels an alarm object, the pending message will not be dispatched

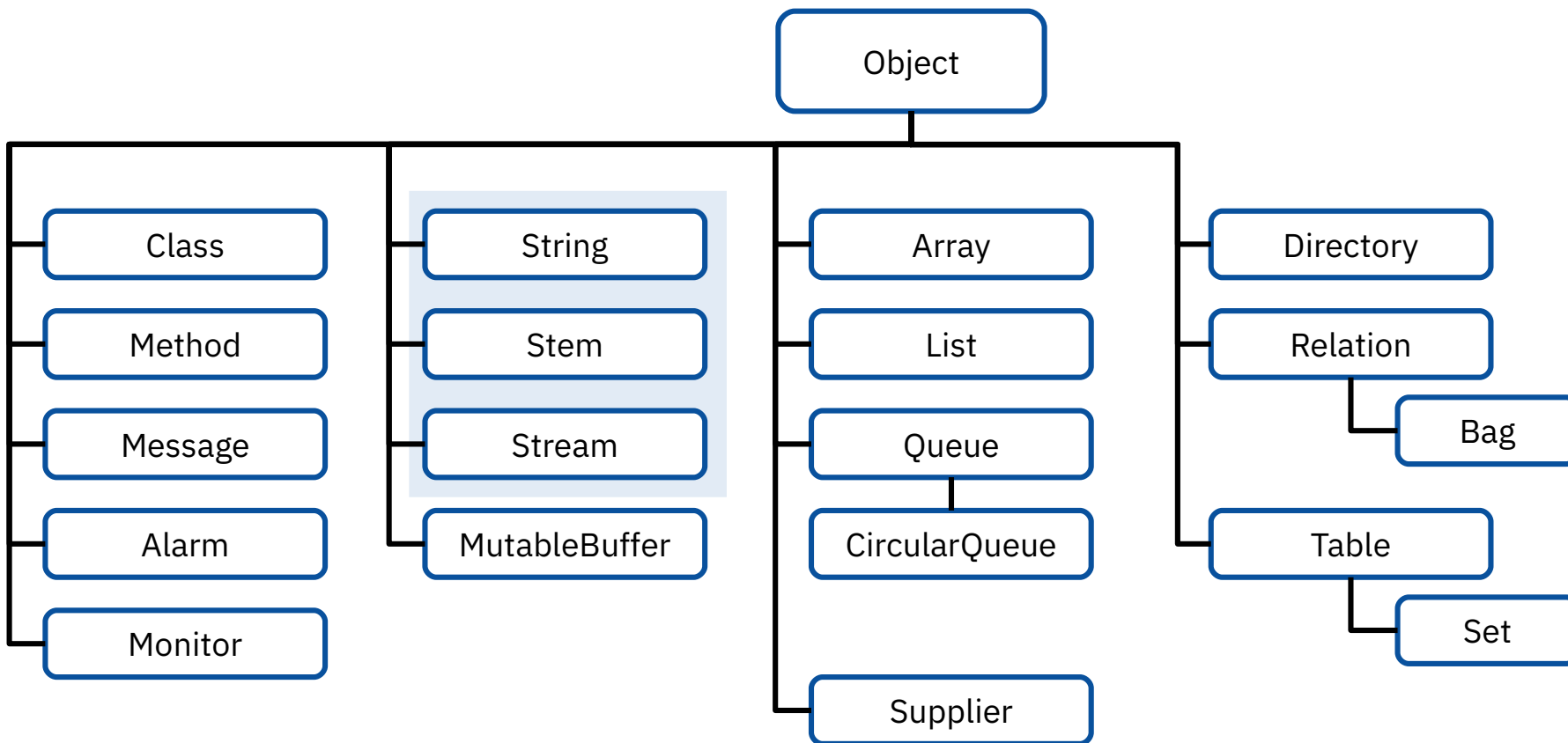
Monitor Class, 1





- **Monitor**
 - Monitor objects allow the monitoring of messages sent to objects
 - Example: method **CURRENT**
 - Returns the currently monitored object
 - Example: method **DESTINATION**
 - Allows to change the destination of the monitor
 - Hint: ooRexx uses monitors in its **.local** environment directory
 - **.input** monitors **.stdin**, the ooRexx *stdin* stream object
 - **.output** monitors **.stdout**, the ooRexx *stdout* stream object
 - **.error** monitors **.stderr**, the ooRexx *stderr* stream object

“Classic REXX” Classes, 1



“Classic REXX” Classes, 2

- **String**

- String objects possess all methods, which are the counterparts of all string functions in classic REXX
 - **Distinctive feature:** string objects never change the value they were created with!

```
a = .string~new("hallo")      /* a new string object          */
a = "hallo"                  /* a new string object with a value of "hallo" */
a = "aloha"                  /* a new string object with a value of "aloha" */
a = "aloha"                  /* a new string object with a value of "aloha" */

a = "a" || "b"               /* a new string object with a value of "ab"    */
a = a || "b"                 /* a new string object with a value of "abb"   */

a = 1 + 3                    /* a new string object with a value of "4"     */
a = a + 3                    /* a new string object with a value of "7"     */
```

“Classic REXX” Classes, 3

- **String**

- String functions will be transformed "behind the curtain" by Object REXX into the appropriate object-oriented version, by sending the appropriate messages to the string object!
 - Example: method **REVERSE**
 - Reverses the sequence of characters in a string

```
SAY REVERSE("d:\path\datei.typ") /* function */  
SAY "d:\path\datei.typ"~REVERSE /* message */
```

Output:

```
pyt.ietad\htap\:d  
pyt.ietad\htap\:d
```

“Classic REXX” Classes, 4

- **Stem**

- Stem objects allow any string to be used as an index

- The stem of the identifier includes the first dot

```
a.2 = "I am a.2"  
SAY a.1.b "/and\" a.2
```

```
A.1.B /and\ I am a.2
```

```
a. = "no value"  
a.2 = "I am a.2"  
SAY a.1.b "/and\" a.2
```

```
no value /and\ I am a.2
```

```
a = .stem~new("no value") /* new stem object */  
a[2] = "I am a.2"  
SAY a[a.1.b] "/and\" a[2]
```

```
no valueno value /and\ I am a.2
```

“Classic REXX” Classes, 5

• Stem

- Stem objects allow the collection of arbitrary objects with the help of string indices
 - Example: methods `[]` and `[]=`

```

DROP a a. b b. /* Make sure that variables are deleted */
a = .stem~new("xyz")
a["holladi"] = "Entry for 'holla.di'"
b. = a /* two references to the same stem object! */
b.di.di.dumm = "Entry for 'DI.DI.DUMM'"
SAY "1:" a["holladi"]           "/and\" a~"["]("DI.DI.DUMM")
tmp1 = "holladi"; tmp2 = "DI.DI.DUMM"
SAY "2:" a.tmp1                 "/and\" a.[tmp2]
SAY "3:" b.tmp1                 "/and\" b.[tmp2]
SAY "4:" a a. a.Unknown b b. b.Unknown a[Unknown]

```

Output:

```

1: Entry for 'holla.di' /and\ Entry for 'DI.DI.DUMM'
2: A.holladi /and\ A.DI.DI.DUMM
3: Entry for 'holla.di' /and\ Entry for 'DI.DI.DUMM'
4: xyz A. A.UNKNOWN B xyz xyzUNKNOWN xyzUNKNOWN

```

“Classic REXX” Classes, 6

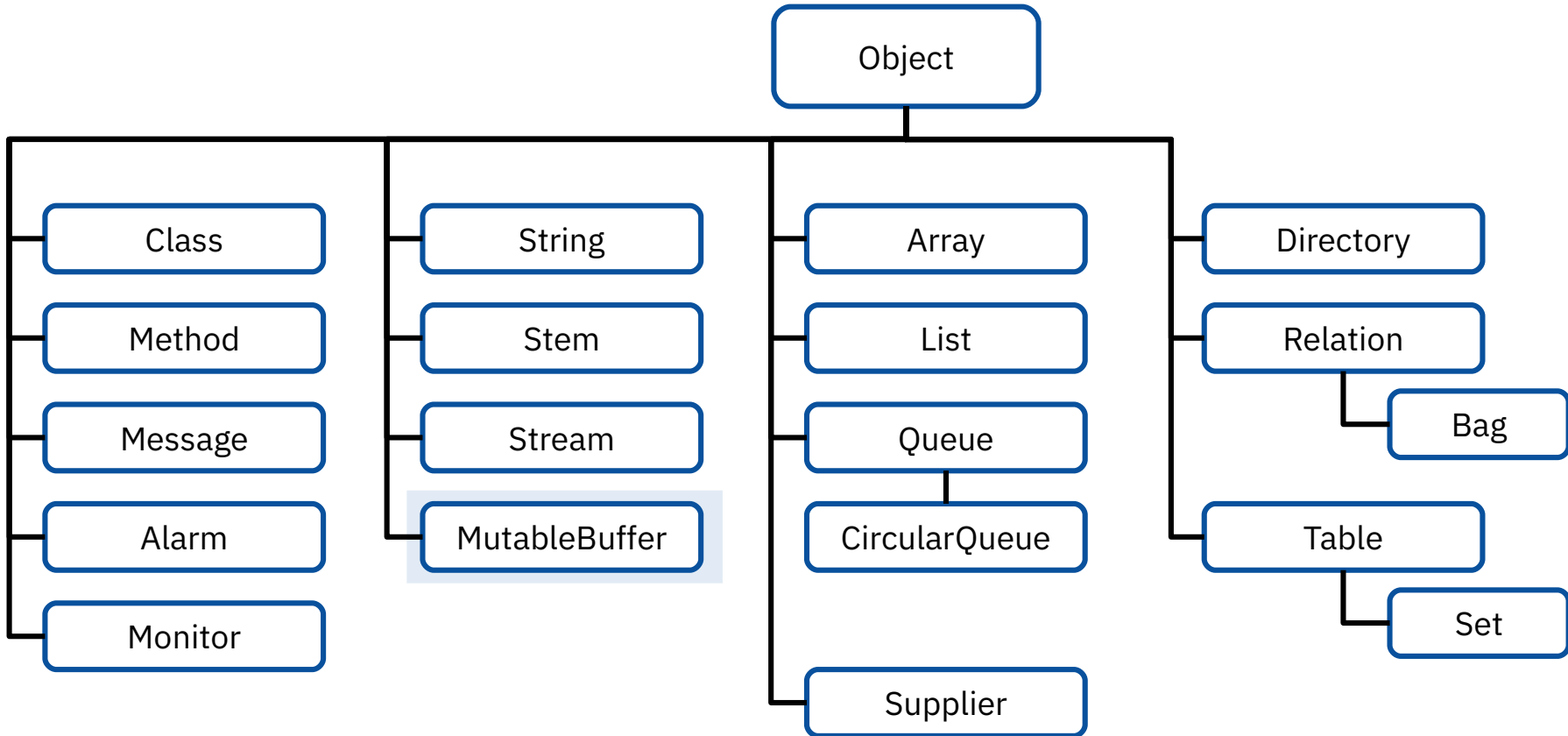
- **Stream**

- Stream objects allow working with files (and communication devices)
 - Example: method **NEW**

```
o = .stream ~NEW("test.dat")
```

- Allows working with the file **test.dat** by sending the stream object **o** the appropriate messages, e.g. **OPEN** for opening, **LINEIN** (**CHARIN**) for reading from the file, **LINEOUT** (**CHAROUT**) for writing to the file, **CLOSE** for closing

MutableBuffer Class, 1



MutableBuffer Class, 2

- **MutableBuffer**
 - Class that allows to create a buffer from many little strings quickly
 - Comparable to Java's *StringBuffer* or *StringBuilder* classes
 - Example methods
 - Method **APPEND**
 - Appends a string chunk to the buffer
 - Method **STRING**
 - Renders the current buffer as a single string object and returns it