Script generated by TTT

Title: Petter: Programmiersprachen (14.01.2015)

Date: Wed Jan 14 14:15:23 CET 2015

Duration: 73:30 min

Pages: 29

Outline

Prototype based programming

1. Basic language features
2. Structured data
3. Code reusage
4. Imitating Object Orientation

"Why bother with modelling types for my quick hack?"

Motivation – Polemic

Bothersome features

- Specifying types for singletons
- Getting generic types right inspite of co- and contra-variance
- Massage language-imposed inheritance to (mostly) avoid redundancy

Prototype based programming

- Start by creating examples
- Only very basic concepts
- Introduce complexity only by need
- Shape language features yourself!

“Let’s go back to basic concepts – *Lua*”

Basic Language Features

- Chunks being sequences of statements.
- Global variables implicitely defined

```
s = 0;
i = 1                    -- Single line comment
p = i+s p=42             --[[ Multiline
comment --]]
s = 1
```


Basic Types and Values

- Dynamical types – no type definitions
- Each value carries its type
- `type()` returns a string representation of a value’s type

```
a = true
type(a)                  -- boolean
type("42"+0)             -- number
type("Simon "..1)        -- string
type(type)               -- function
type(nil)                -- nil
type([[<html><body>pretty long string</body>
</html>
]])                      -- string
a = 42
type(a)                  -- number
```


Functions for Code

✓ First class citizens

```
function prettyprint(title, name, age)
  return title.." "..name.." ,born in " (2014-age)
end

a = prettyprint
a("Dr.","Simon",42)

prettyprint = function (title, name, age)
  return name..", "..title
end
```

Introducing Structure

- only one complex data type
- indexing via arbitrary values *except nil* (⇝ Runtime Error)
- arbitrary large and dynamically growing/shrinking

```
a = {}                  -- create empty table
k = 42
a[k] = 3.14159          -- entry 3.14159 at key 42
a["k"] = k              -- entry 42 at key "k"
a[k] = nil              -- deleted entry at key 42
print(a.k)              -- syntactic sugar for a["k"]
```


Table Lifecycle

- created from scratch
- modification is persistent
- assignment with reference-semantics
- garbage collection

```
a = {}                  -- create empty table
a.k = 42
b = a                   -- b refers to same as a
b["k"] = "k"            -- entry "k" at key "k"
print(a.k)              -- yields "k"
a = nil
print(b.k)              -- still "k"
b = nil
print(b.k)              -- nil now
```


Table Lifecycle

- created from scratch
- modification is persistent
- assignment with reference-semantics
- garbage collection

```
a = {}                  -- create empty table
a.k = 42
b = a                   -- b refers to same as a
b["k"] = "k"            -- entry "k" at key "k"
print(a.k)              -- yields "k"
a = nil
print(b.k)              -- still "k"
b = nil
print(b.k)              -- nil now
```


Table Behaviour

Metatables

- are *ordinary tables*, used as collections of special functions
- Naming conventions for special funtions
- Connect to a table via `setmetatable`, retrieve via `getmetatable`
- Changes behaviour of tables

```
meta = {}                           -- create as plain empty table
function meta.__tostring(person)
  return person.prefix .. " " .. person.name
end
a = { prefix="Dr.",name="Simon"} -- create Axel
setmetatable(a,meta)                -- install metatable for a
print(a)                            -- print "Dr. Simon"
```

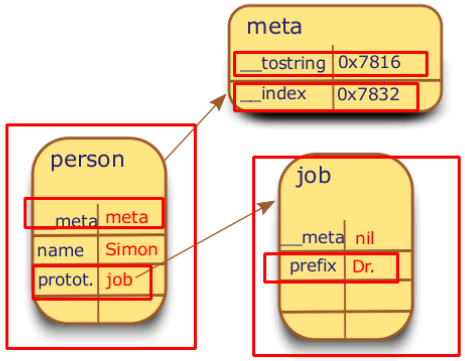
- Overload operators like `__add, __mul, __sub, __div, __pow, __concat, __unm`
- Overload comparators like `__eq, __lt, __le`

Delegation

- ⚠ reserved key `__index` determines *handling* of failed name lookups
- convention for signature: receiver table and key as parameters
- if dispatching to another table ⇝ *Delegation*

```
meta = {}
function meta.__tostring(person)
  return person.prefix .. " " .. person.name
end
function meta.__index(table, key)
  return table.prototype[key]
end
job = { prefix="Dr." }
person = { name="Simon",prototype=job } -- create Axel
setmetatable(person,meta)               -- install metatable
print(person)                           -- print "Dr. Simon"
```


Delegation



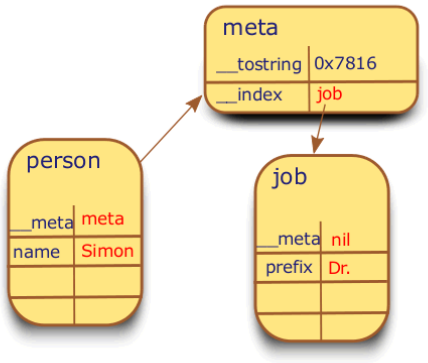

```
function meta.__tostring(person)  -- 0x7816
  return person.prefix .. " " .. person.name
end
function meta.__index(table, key) -- 0x7832
  return table.prototype[key]
end
```


Delegation 2

⇝ Conveniently, `__index` does not need to be a function

```
meta = {}
function meta.__tostring(person)
  return person.prefix .. " " .. person.name
end
job = { prefix="Dr." }
meta.__index = job                      -- delegate to job
person = { name="Simon" }               -- create Axel
setmetatable(person,meta)               -- install metatable
print(person)                           -- print "Dr. Simon"
```


Delegation 2




```
function meta.__tostring(person)  -- 0x7816
  return person.prefix .. " " .. person.name
end
```

Delegation 3

- __newindex handles unresolved updates
- frequently used to implement protection of objects

```
meta = {}
function meta.__newindex(table,key,val)
  if (key == "title" and table.name=="Guttenberg") then
    error("No title for You, sir!")
  else
    table.data[key]=val
  end
end
function meta.__tostring(table)
  return (table.title or "") .. table.name
end
person={ data={} }              -- create person's data
meta.__index = person.data
setmetatable(person,meta)
person.name = "Guttenberg"      -- name KT
person.title = "Dr."            -- try to give him Dr.
```


Object Oriented Programming

⚠ so far no concept for multiple objects

```
Account = { balance=0 }
function Account.withdraw (val)
 Account.balance=Account.balance-val
end
function Account.__tostring()
   return "Balance is "..Account.balance
end
setmetatable(Account,Account)
Account.withdraw(10)
print(Account)
```

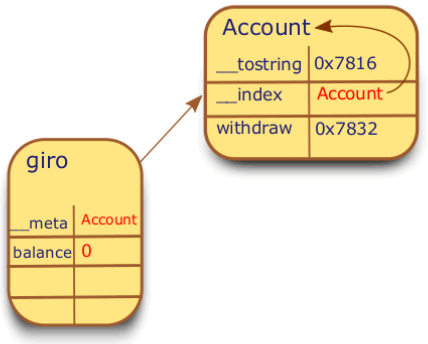

Introducing Identity

- Concept of an object's *own identity* via parameter
- Programming aware of multiple instances
- Share code between instances

```
Account = { balance=0 }
function Account.withdraw (acc, val)
 acc.balance=acc.balance-val
end
function Account.tostring(acc)
   return "Balance is "..acc.balance
end
Account.__index=Account      -- share Account's functions

giro = { balance = 0 }
setmetatable(giro,Account)  -- delegate from giro to Account
Account.withdraw(giro,10)
giro.withdraw(giro,10)       -- withdraw independently
giro:withdraw(10)
print(Account:tostring())
print(giro:tostring())
```


Introducing Identity




```
function Account.withdraw (acc, val)
 acc.balance=acc.balance-val
end
function Account.tostring(acc)
   return "Balance is "..acc.balance
end
```

Introducing “Classes”

- Particular objects *used* as classes
- *self* for accessing own object

```
Account = {  }
function Account:withdraw (val)
 self.balance=self.balance-val
end
function Account:tostring()
   return "Balance is "..self.balance
end
function Account:new(template)
 template = template or {balance=0} -- initialize
 setmetatable(template,self)        -- Account is metatable
 self.__index=self                  -- delegate to Account
 self.__tostring = Account.tostring
 return template
end
giro = Account:new({balance=10})     -- create instance
giro:withdraw(10)
print(giro)
```


Inheriting Functionality

- Differential description possible in child class style
- Easily creating particular singletons

```
LimitedAccount = Account:new({balance=0,limit=100})
function LimitedAccount:withdraw(val)
  if (self.balance+self.limit < val) then
     error("Limit exceeded")
  end
  Account.withdraw(self,val)
end
specialgiro = LimitedAccount:new()
specialgiro:withdraw(90)
print(specialgiro)
```


Multiple Inheritance

⇝ Delegation leads to chain-like inheritance

```
function createClass (parent1,parent2)
  local c = {}                      -- new class
  setmetatable(c, {__index =
    function (t, k)                 -- search for each name
      local v = parent1[k]          -- in both parents
      if v then return v end
      return parent2[k]
    end}
  )
  c.__index = c                     -- c is metatable of instances
  function c:new (o)                -- constructor for this class
    o = o or {}
    setmetatable(o, c)
    return o
  end
  return c                          -- finally return c
end
```


Multiple Inheritance

```
Doctor     = { postfix="Dr. "}
Researcher = { prefix="  ,Ph.D."}

ResearchingDoctor = createClass(Doctor,Researcher)
axel = ResearchingDoctor:new( { name="Axel Simon" } )
print(axel.prefix..axel.name..axel.postfix)
```

⇝ The special case of dual-inheritance can be extended to comprise multiple inheritance

Multiple Inheritance

⇝ Delegation leads to chain-like inheritance

```
function createClass (parent1,parent2)
  local c = {}                    -- new class
  setmetatable(c, {__index =
    function (t, k)               -- search for each name
      local v = parent1[k]        -- in both parents
      if v then return v end
      return parent2[k]
    end}
  )
  c.__index = c                   -- c is metatable of instances
  function c:new (o)              -- constructor for this class
    o = o or {}
    setmetatable(o, c)
    return o
  end
  return c                        -- finally return c
end
```


Multiple Inheritance

```
Doctor     = { postfix="Dr. "}
Researcher = { prefix=" ,Ph.D."}

ResearchingDoctor = createClass(Doctor,Researcher)
axel = ResearchingDoctor:new( { name="Axel Simon" } )
print(axel.prefix..axel.name..axel.postfix)
```

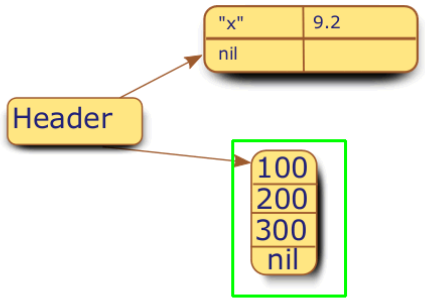
⇝ The special case of dual-inheritance can be extended to comprise multiple inheritance

Implementation of Lua

```
typedef struct {
  int type_id;
  Value v;
} TObject;
```

```
typedef union {
  void *p;
  int b;
  lua_number n;
  GCObject *gc;
} Value;
```

- Datatypes are simple values (Type+union of different flavours)
- Tables at low-level fork into Hashmaps with pairs and an integer-indexed array part



Further Topics in Lua

- Coroutines
- Closures
- Bytecode & Lua-VM

Lessons Learned

Lessons Learned

1. Abandoning fixed inheritance yields ease/speed in development
2. Also leads to horrible runtime errors
3. Object-orientation and multiple-inheritance as special cases of delegation
4. Minimal featureset eases implementation of compiler/interpreter
5. Room for static analyses to find bugs ahead of time

Further Reading...


Roberto Ierusalimschy.
Programming in Lua, Third Edition.
Lua.Org, 2013.
ISBN 859037985X.


Roberto Ierusalimschy, Luiz Henrique de Figueiredo, and Waldemar Celes Filho.
Lua-an extensible extension language.
Softw., Pract. Exper., 1996.


Roberto Ierusalimschy, Luiz Henrique de Figueiredo, and Waldemar Celes.
The implementation of lua 5.0.
Journal of Universal Computer Science, 2005.