LabLua
programming language research

Programming in Lua – Data Structures

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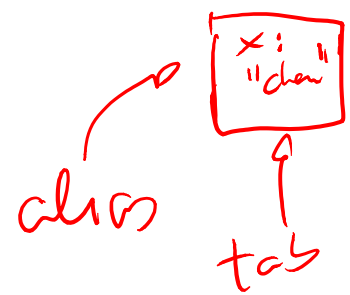
Tables for everything

- Unless you resort to C code, tables are the only way to structure data in Lua
- They can represent arrays, sets, records, objects, and other data structures efficiently, with a nice syntax
- The basic operations that a table supports are *construction* ({}), to make a new table, and *indexing* ([]), to read/write values

```
> tab = {}            -- make a new table assign to tab
> tab["x"] = 5        -- write 5 to “x” field
> print(tab["x"])     -- read value of “x” field and print it
5
```



- Tables are a *mutable reference type*, so they have the same aliasing issues as C pointers and Java arrays and objects

```
> alias = tab
> alias["x"] = "changed"
> print(tab["x"])
changed
```

Arrays

- A Lua array is a table with values assigned to *sequential* integer keys, starting with 1

```
local a = {}
for i = 1, 6 do
  a[i] = math.random(10)
end
```

- You can initialize an array using a table constructor with a list of expressions inside it

```
-- an array like the previous one
local a = { math.random(10), math.random(10), math.random(10),
            math.random(10), math.random(10), math.random(10) }
```

- An array cannot have *holes*: none of the values can be `nil`. But you can fill the array in any order you want, as long as you plug all the holes before using the array

Length

- The length operator (#) gives the number of elements in an array

- You can use the length and a for loop to iterate over an array:

```
local a = { math.random(10), math.random(10), math.random(10),
            math.random(10), math.random(10), math.random(10) }
for i = 1, #a do
  print(a[i])
end
```

- The length operator is also useful for adding elements to the end of an array, and removing the last element:

```
a[#a] = nil                  -- remove the last element
a[#a + 1] = math.random(10) -- add a new element to the end
```

Inserting, removing, sorting

- Two functions in the `table` module can insert and remove elements in any position of the array (shifting the other elements to make space or plug the hole, respectively):

```
> a = { 1, 2, 3, 4, 5 }
> table.insert(a, 3, 10) -- insert 10 in position 3
> print_array(a)
{ 1, 2, 10, 3, 4, 5 }
> table.remove(a, 4)     -- remove fourth element
> print_array(a)
{ 1, 2, 10, 4, 5 }
```

- The function `table.sort` sorts an array (using an efficient sorting algorithm):

```
> a = { "Python", "Lua", "C", "JavaScript", "Java", "Lisp" }
> table.sort(a)
> print_array(a)
{ C, Java, JavaScript, Lisp, Lua, Python }
```

Concatenation

- The table.concat function concatenates an array of strings using an optional separator:

```
function print_array(a)
  print("{" .. table.concat(a, ", ") .. "}")
end
```

- If we do not give a separator then `concat` uses `""`

- A common idiom is to use an array of strings as a buffer, using table.concat when we need the contents of the buffer as a single string

Iteration with `ipairs`

- Another way to iterate over an array is to use the *generic* for loop and the `ipairs` built-in function:

```
local a = { 1, 3, 5, 7, 9 }
local sum = 0
for i, x in ipairs(a) do
  print("adding element " .. i)
  sum = sum + x
end
print("the sum is " .. sum)
```

- This loop has two control variables, the first gets the indices, the second gets the elements

- Usually we are only interested in the elements and not the index, so it is common to use _ as the name of the control variable for the indices

Matrices

- One way to represent multi-dimensional arrays is with “jagged arrays”, as in Java, where you have an array of arrays for two dimensions, an array of arrays of arrays for three, etc.

```
local mt = {}
for i = 1, 3 do
  mt[i] = {}
  for j = 1, 5 do
    mt[i][j] = 0
  end
end
```

- A more efficient way is to compose the indices using multiplication, as C does for you:

```
local mt = {}
for i = 1, 3 do
  for j = 1, 5 do
    mt[(i-1)*5+j] = 0
  end
end
```

Records

- A Lua record is a table with string keys, where they keys are valid Lua identifiers; you can initialize record fields in the table constructor by passing key/value pairs:

```
point1 = { x = 10, y = 20 }
point2 = { x = 50, y = 5  }
line   = { from = point1, to = point2, color = "blue" }
```

- You can read and write record fields with the `.` operator:

```
line.color = "red"                  -- same as line["color"] = "red"
print(line.from.x, line["color"])
```

- A table can be both a record and an array, and you can initialize both parts in a single table constructor

Sets

- A nice way to represent sets in Lua is with a table where the *keys* are the elements of the set, and the values are *true*

- This way, you can test membership in the set and add or remove elements to the set by indexing

- You can initialize the set with a third table constructor syntax:

```
-- a set of four random integers from 1 to 10
local set = { [math.random(10)] = true, [math.random(10)] = true,
              [math.random(10)] = true, [math.random(10)] = true }
```

- If you replace true by a number and use it as a counter you have a *multiset*, or a set that can have more than one copy of each element

Iteration with `pairs`

- A for loop using the pairs built-in function iterates over *all keys and values* of a table:

```
local tab = { x = 5, y = 3, 10, "foo" }
for k, v in pairs(tab) do
  print(tostring(k) .. " = " .. tostring(v))
end
```

- The first control variable gets the keys, the second gets the values

- `pairs` does not guarantee an order of iteration, even among numeric keys; use `ipairs` if you want to iterate over an array

- But pairs is great to iterate over a set, use _ as the name of the control variable for the values, as you will not need it (unless you have a multiset, of course!)

Quiz

- What will be the output of the following program?

```
sunday = "monday"; monday = "sunday"
t = { sunday = "monday", [sunday] = monday }
print(t.sunday, t[sunday], t[t.sunday])
```

→ monday sunday sunday

t["sunday"] t["monday"] t["monday"]

t = { }

t["sunday"] = "monday"

t[sunday] = monday → t["monday"] = "sunday"

{ sunday = "monday", monday = "sunday" }