The Nim programming language

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Chapter 1

Hello, World!

Since you are reading this tutorial, I assume that you want to learn the Nim computer language. It is a long tradition in Computer Science to start a tutorial concerning programming with a demo that shows how to output messages to a terminal. However, you must learn many things before actually being able to make such a demo work. Therefore, I suggest that you call a geek who has majored in Computer Science to run the applications presented in this first chapter, which will deal with sending messages for printing on a terminal. I will use exercises created by Kaushal Modi to get your attention, and entice you into Nim programming. Here is the first program:

```
import os, std/[Terminal]

styledEcho  "Hello, ", styleBright, fgCyan, paramStr(1)
```

Let us assume that the geek, who you hired to coach you through this demo, has discovered a way of writing the above program into the `hi.nim` file. For instance, she could use the `cat` command as shown below.

```
> cat <<EOT > hi.nim
import os, std/[Terminal]
styledEcho "Hi, ", styleItalic, fgGreen, paramStr(1)
EOT
```

The next step is to check whether the `hi.nim` file indeed contains the program code. The geek will use the `cat` command once more.

```
> cat hi.nim
import os, std/[Terminal]
styledEcho "Hi, ", styleItalic, fgBlue, paramStr(1)
```

Finally, it is necessary to compile the program. This means that the geek will convert the `hi.nim` source file into an object file, which the machine understands well enough in order to carry out the instructions that send a message to the terminal.

```
> nim c -o:hi.x --nimcache:xx hi.nim
```

The final step is to execute the object file to test whether it is functioning correctly. Since the Nim compiler reported that it generated code with *Success*, you can expect that the file `hi.x` is executable. Therefore, let us execute it:

```
› ./hi.x Edward
Hi, Edward
```

In chapter 13, I will discuss knowledge. Then you will learn that knowledge can be explicit, tacit and shared. To discover how this can affect your study of the Nim programming language, let us see what Socrates said about knowledge.

Calias had two sons. Of course, he spent a lot of money hiring teachers for his sons. So, Socrates asked him: *"Calias, if your sons were colts or calves, we could find and engage a trainer for them who would make them excel in their proper qualities, some horse breeder or farmer. Now since they are men, whom do you have in mind to coach them? Who is an expert in this kind of excellence, oratory and political debate? I think you must have given thought to this since you have sons. Is there such a person,"* Socrates asked, *"or is there not?" "For sure there is,"* Calias said. *"Who is he?"* Socrates asked, *"What is his name, where is he from? and what is his fee?"* Calias replied: *"The coach you are looking for, dear Socrates, is Evenus, a citizen from Paras. His fee is five minas."*

At the time of Socrates, the all important human activity was political discussion, thus Evenus taught how to debate in assemblies and councils. Nowadays, people are more interested in computer programming, since these Weapons of Math Destruction, as Cathy O'Neil calls them, rule our lives. However, let us make an analogy. Let us suppose that you have two children, like Calias. If you wanted them to play the violin, instead of programming, you will start out buying a violin primer, such as Suzuki's Violin School, Volume 1, but you would not expect that your children learn music just by reading a book. Therefore, you will hire a music coach that will go to your house three times a week, in order to supervise your children's progress. If the coach insists in explaining only music theory, you will probably fire her, as you know one must practice a lot to become a proficient musician.

You can use the same rules that apply to music for learning computer programming. Then you need a book, a coach and a lot of practice, if you want to learn how to write effective code. In consequence, it is a good idea that you really hire a major in computer science to guide your first steps in the computer world. The coach will explain the meaning of such terminologies as compiler, library, terminal, files, source editors and applications. Another thing that you can expect from the coach is that she will perform many activities on the computer for you to observe and repeat.

Chapter 2

State machines

My private library has many books in Ancient Greek, Latin, German, Esperanto, French, Japanese, Chinese, Guarany, Russian and other languages that I don't speak. Even so, I read the first two pages of these books, to know whether it was worthwhile to learn the language and read until the end. War and Peace is written in French and Russian, thus I read the French part of the first page and put the book back on the shelf, where it remained over many years as a feast for cockroaches that ate the glue on the cover.

Keeping with my bad reading habits, I read only the first page of Wittgenstein's Tratactus Logico-Philosophicus, which has a title in Latin, but is written in German. Here is the first line of the Tratactus:

1. Die Welt ist alles, was der Fall ist.
    - 1.1. Die Welt ist die Gesamtheit der Tatsachen, nicht der Dinge.

On the first line, an English speaker can recognize a lot of words, for instance, *Welt* must mean *World*, *alles* can be translated by *all* and *Fall* is *fall*. There was that Roman deity, Fortune, who decided the destiny of the World by throwing dice. It seems that Wittgenstein is saying that the World is all that the state of the Fortune's dice indicates that it is.

On the second line, Wittgenstein is saying that the World is the totality of facts, not of things. Of course, things do exist, but the World is something beyond a set of things. What is the entity, which is beyond a mere collection of things? Let us read a little further to see if the philosopher sheds light on the subject.

> Was der Fall ist, die Tatsache, ist das Bestehen von Sachverhalten.

David Pears translates the above line as

> *What is a case – a fact – is the existence of states of affairs.*

In Latin, the word *STATUS* (Romans used to write only in uppercase letters) means the temporary attributes of a person or thing. What is an attribute? It is the position, station, place, posture, order, arrangement, condition, characteristic, aspect, feature, quality or trait that a thing can possess. An attribute has values, for instance, the attribute *color* can have

values such as red, green, blue, yellow, etc. The *position* attribute can be given by the values of the Cartesian coordinates of the object.

Computers are state machines, therefore they are good for modeling the world and its evolution through change of states. Computers themselves have registers, where they can store the values of the attributes that the machine represents. Computer programs abstract the registers into variables. Therefore, a program represents states by sets of values for its variables. To understand this point, let us consider a concrete problem.

```
# File: zeller.nim
import os, strutils

proc roman_order(m : int): int=
  let wm= (14 - m) div 12
  result= m + wm*12 - 2

proc zr(y:int, m:int, day:int): int=
  let
    roman_month= roman_order(m)
    roman_year= y - (14 - m) div 12
    century=  roman_year div 100
    decade= roman_year mod 100
  result= (day + (13*roman_month - 1) div 5 +
                 decade + decade div 4 +
                 century div 4 +
                 century * -2) mod 7

proc main () =
  let
    year = paramStr(1).parseInt
    month = paramStr(2).parseInt
    day = paramStr(3).parseInt
  echo zr(year, month, day)

main()
```

(1) Day of the week by Zeller's congruence

You certainly know that the word `December` means the tenth month; it comes from the Latin word for ten, as attested in words such as:

- decimal – base ten.
- decimeter – tenth part of a meter.
- decimate – the killing of every tenth Roman soldier that performed badly in battle.

October is named after the Latin numeral for *eighth*. In fact, the radical *Oct-* can be translated as *eight*, like in *octave*, *octal*, and *octagon*. One could continue with this exercise, placing September in the seventh, and November in the ninth position in the sequence of months.

But everybody and his brother know that December is the twelfth, and that October is the tenth month of the year. Why did the Romans give misleading names to these months?

Rome was purportedly founded by Romulus, who designed a calendar. March was the first month of the year in the Romulus calendar. In order to get acquainted with programming and the accompanying concepts, let us follow the Canadian programmer Nia Vardalos, while she explores the Nim programming language and calendar calculations.

If Nia wants the order for a given month in this mythical calendar created by Romulus, she must subtract 2 from the order in the Gregorian calendar, which happens to be in current use in the Western World since it was instituted by Pope Gregory XIII in 1582. After the subtraction, September becomes the seventh month; October, the eight; November, the ninth and December, therefore, the tenth month.

Farming and plunder were the main occupations of the Romans, and since winter is not the ideal season for either of these activities, the Romans did not care much for January and February. However, Sosigenes of Alexandria, at the request of Cleopatra and Julius Cæsar, designed the Julian calendar, where January and February, the two deep winter months, appear in positions 1 and 2 respectively. Therefore, a need for a formula that converts from the modern month numbering to the old sequence has arisen. In listing 1, this is done by the following algorithm:

```
proc roman_order(m : int): int=
  let wm= (14 - m) div 12
  result= m + wm*12 - 2
```

In the above formula, the variable `wm` will pick the value 1 for months 1 and 2, and 0 for months from 3 to 12. In fact, for months from 3 to 12, `(14-m)` produces a number less than 12, and `(14-m) div 12` is equal to 0. Therefore, the state of the program for all months from March through December is given by `wm=0` and `result=m-2`. When the variable `wm=0`, the expression to calculate `result` is reduced from `result=m+wm×12-2` to `result=m-2`. This means that March will become the Roman month 1, and December will become the Roman month 10.

The variable `wm` models the state of the world for the winter months. By the way, `wm` stands for *winter months*. Since January is month 1, and February is month 2 in the Gregorian calendar, `wm` is equal to 1 for these two winter months. In the case of January, the state is given by: `m=1`, `wm=1`, `result=11`. For February, the state becomes `m=2`, `wm=1`, `result=12`.

The program of the listing 1 calculates the day of the week through Zeller's congruence. In the procedure `zr(y, m, day)`, the let-statement binds values to the following state variables: `roman_month`, `roman_year`, `century` and `decade`. The listing 1 shows that a state variable avoids recalculating values that appear more than once in a program. This is the case of `roman_year`, which appears four times in the `zr(y,m,day)` procedure. Besides this, by identifying important subexpressions with meaningful names, the program becomes clearer and cleaner.

2.1 Compile and run

After compiling the program of listing 1, one can calculate the day of the week as a number between 0 and 6, which correspond to Sunday, Monday, Tuesday, Wednesday, Thursday, Friday and Saturday. For the time being, you do not need to worry about compilation and running a program on the terminal. This book dedicates a whole chapter to the use of a text terminal. In any case, here is an example of running the zeller congruence:

```
> nim c -o:zeller.x -d:release --hints:off --nimcache:xx zeller.nim
CC: zeller.nim

> ./zeller.x 2016 8 31
3
```

This means that August 31 of 2016 fell on a Wednesday.

2.2 Sequence of statement

In linguistics, a statement is a declarative sentence that describes a state or a state variable. In a program, one may need a sequence of statements to determine all state variables. In the programming language Nim, a sequence of statements is indicated by indentation, i.e., all statements that start at the same column belong to the same sequence.

2.3 Procedures

In computer programming, a procedure is a sequence of statements that isolates and determines a state. In Nim, the procedure can cause change of state by performing destructive assignment into variables introduced by the key word `var`, but there is no way of changing the value of variables introduced by the keyword `let`, such as the variables that appear in listing 1.

2.4 How to repeat a sequence of statements

During a programmer's life, he or she may need to repeat a sequence of statements to generate a succession of steps that will approach an end state or value. This repetition process is called iteration after the Latin word for path.

Leonardo Bigollo Pisano, a.k.a. Fibonacci, was speculating on how fast the reproduction of rabbits would be. His breeding of rabbits has the interesting properties of mating at the age of one month, thus, at the end of her second month, the female produces a new pair of rabbits, a male and a female. Then she keeps producing two babies a month for one year.

Fibonacci concluded that the number A_n of adult pairs in a given month is equal to the total number R_{n-1} of rabbits, both babies and adults, from the previous month. The clever fellow also perceived that, since each adult pair produces two babies a month, the number of baby pairs in a given month is the number of adult pairs from the previous month, which is the total number of rabbits from two months before. The total number of rabbit pairs, that is adults plus babies, in any given month is the sum of the pairs from the previous two months.

```
# File: iterfib.nim
import os, strutils

proc fib(n: int): int =
  var (r1, r2) = (2, 1)
  for i in 2..n:
    (r1, r2) = (r1+r2, r1)
  result= r1

echo fib(paramStr(1).parseInt)
```

In the above program, the iteration is controlled by the for-loop, that repeats a change of state over generations from 2 through `n` of rabbits. Here is how the program is compiled and executed:

```
> nim c --nimcache:xx -o:rabbits.x -d:release --hints:off iterfib.nim
> ./rabbits.x 5
13
```

2.5 Recursion

Another way to discover the number of pairs in the previous generation is to sum the number of pairs from three generations ago to the number of pairs from two generations ago. This reasoning does nothing more than apply the rule of finding the total number of pairs in the present generation over the previous generation. Here is a program that uses this idea:

```
#> nim c --nimcache:xx -o:recfib.x -d:danger --hints:off recfib.nim
import os, strutils
proc fib(n: int): int =
  if n<2: result= n+1
  elif n<3: result= fib(n-1)+fib(n-2)
  else: result= fib(n-3)+fib(n-2)+fib(n-2)

echo fib(paramStr(1).parseInt)
```

(2) Recursive Fibonacci function

The program of listing 2 has many novelties. The first one is the conditional execution of a sequence of statements. For instance, `result=n+1` sets `result` to `n+1`, but only if

the condition `n<2` is met. On the same token, `result=fib(n-1)+fib(n-2)` sets `result` to `fib(n-1)+fib(n-2)`, if `n<3`.

However, the strangest feature of listing 2, is the use of the `fib` function in the definition of `fib`. In other words, the definition of `fib` calls itself. When such a thing happens, computer scientists say that the definition is recursive.

Typically a recursive definition has two kinds of conditions, which in Nim are introduced by the if-statement:

- Trivial conditions, which can be resolved using primitive operations.
- General conditions, which can be broken down into simpler cases.

In listing 2, the trivial condition is –

- `if n<2: result=n+1`

The general conditions are introduced by the `elif` and `else` clauses for rewriting the expression `fib(n)` into one of the following expressions:

```
elif n<3: result= fib(n-1)+fib(n-2)
else: result= fib(n-3)+fib(n-2)+fib(n-2)
```

Where each occurrence of a call to `fib` is closer to the trivial case than `fib(n)`, which was the original call.

The mathematician Peano invented a very interesting axiomatic theory for natural numbers, that can be summarized thus:

1. Zero is a natural number.
2. Every natural number has a successor: The successor of 0 is 1, the successor of 1 is 2, the successor of 2 is 3, and so on.
3. If a property is true for zero and, after assuming that it is true for n, you prove that it is true for n+1, then it is true for any natural number.

Did you get the idea? For this very idea can be applied to many other situations, even in programming a computer.

Luciano Lima and Roger Alan think that it is very important to reproduce Peano's theory in the Latin original. However, I decided against meeting their demands for many reasons. In his book, Arithmetices Principia, Peano adopted a notation that is beyond the reach of most readers. Besides this, the 1889 edition by the Fratres Bocca has many typos that I need to fix before considering it for inclusion in this book.

Sergio Teixeira and Stephanie Bourdieu said that my implementation of the Fibonacci procedure was not faithful to the 1228 edition of the Liber Abaci. I changed the algorithms as recommended by them, and also reproduced the fable of the 377 rabbits that appear in chapter 12 of Fibonacci's book.

Readers who do not know Latin, or are not interested in Fibonacci's original work, can skip the rest of this chapter without any loss of important information.

Liber Abaci – Chapter XII: The Fable of the Rabbits

A certain man keeps one pair of rabbits in an enclosed place. This man wishes to know how many rabbits will be generated by the original pair in a period of one year. It is the nature of this breed of rabbits in a single month to bear another pair, and in the second month those born to bear also.

Since the individuals of the first pair of rabbits are adults, in the first month, they will bear a pair of kittens, therefore the number of animals will double; so, there will be two pairs in one month. One of these, namely the first, bears in the second month, and thus there are in the second month 3 pairs; of these in one month two are pregnant, and in the third month 2 pairs of rabbits are born, and thus there are 5 pairs in the month; in this month 3 pairs are pregnant, and in the fourth month there are 8 pairs, of which 5 pairs bear another 5 pairs; these are added to the 8 pairs making 13 pairs in the fifth month; these 5 pairs that are born in this month do not mate in this month, but another 8 pairs are pregnant, and thus there are in the sixth month 21 pairs; to these are added the 13 pairs that are born in the seventh month; there will be 34 pairs in this month; to this are added the 21 pairs that are born in the eighth month; there will be 55 pairs in this month; to these are added the 34 pairs that are born in the ninth month; there will be 89 pairs in this month; to these are added again the 55 pairs that are born in the tenth month; there will be 144 pairs in this month; to these are added again the 89 pairs that are born in the eleventh month; there will be 233 pairs in this month.

To these are still added the 144 pairs that are born in the last month; there will be 377 pairs, and this many pairs are produced from the aforementioned pair of rabbits in the enclosed place at the end of the one year.

You can indeed see in the margin how we operated, namely that we added the first number to the second, namely the 1 to the 2, and the second to the third, and the third to the fourth, and the fourth to the fifth, and thus one after another until we added the tenth to the eleventh, namely the 144 to the 233, and we had the total sum of rabbits, i.e. 377. Thus, you can systematically find the number of rabbits for an indeterminate number of months.

Liber Abaci – Capitulum XII: Fabula Cuniculorim

Quot paria coniculorum in uno anno ex uno pario germinentur?

Quidam posuit unum par cuniculorum in quodam loco, qui erat undique pariete circundatus, ut sciret, quot ex eo paria germinarentur in uno anno: cum natura eorum sit per singulum mensem aliud par germinare; et in secundo mense ab eorum nativitate germinant.

Quia suprascriptum par in primo mense germinat, duplicabis ipsum, erunt paria duo in uno mense. Ex quibus unum, silicet primum, in secundo mense geminat; et sic sunt in secundo mense paria 3; ex quibus in uno mense duo pregnantur; et geminantur in tercio mense paria 2 coniculorum; et sic sunt paria 5 in ipso mense; ex quibus in ipso pregnantur paria 3; et sunt in quarto mense paria 8; ex quibus paria 5 geminant alia paria 5: quibus additis cum

pariis 8, faciunt paria 13 in quinto mense; ex quibus paria 5, que geminata fuerunt in ipso mense, non concipiunt in ipso mense, sed alia 8 paria pregnantur; et sic sunt in sexto mense paria 21; cum quibus additis parijs 13, que geminantur in septimo, erunt in ipso paria 34, cum quibus additis parijs 21, que geminantur in octavo mense, erunt in ipso paria 55; cum quibus additis parijs 34, que geminantur in nono mense, erunt in ipso paria 89; cum quibus additis rursum parijs 55, que geminantur in decimo, erunt in ipso paria 144; cum quibus additis rursum parijs 89, que geminantur in undecimo mense, erunt in ipso paria 233. Cum quibus etiam additis parijs 144, que geminantur in ultimo mense, erunt paria 377, et tot paria peperit suprascriptum par in prefato loco in capite unius anni. Potes enim videre in hac margine, qualiter hoc operati fuimus, scilicet quod iunximus primum numerum cum secundo, videlicet 1 cum 2; et secundum cum tercio; et tercium cum quarto; et quartum cum quinto, et sic deinceps, donec iunximus decimum cum undecimo, videlicet 144 cum 233; et habuimus suprascriptorum cuniculorum summam, videlicet 377; et sic posses facere per ordinem de infinitis numeris mensibus.

The farmer of Fibonacci's fable starts with a pair of addult rabbits. Therefore, at the end of month 1, there were two pairs of rabbits. In the instant zero of the experiment there was only the original pair. Therefore, in listing 2, one has the following clause for `n<2`:

```
if n<2: result= n+1
```

Since in the most general clause Stephanie needed three generations of rabbits, she added a clause for the second month, to wit:

```
elif n<3: result= fib(n-1)+fib(n-2)
```

From the second month onward Stephanie can use the most general clause:

```
else: result= fib(n-3)+fib(n-2)+fib(n-2)
```

In general, recursive calculation of Fibonacci's function is very inefficient, and is often used in benchmarks. However, good compilers succeed to optimize the recursion away, therefore the algorithm given by listing 2 is very fast.

Chapter 3

Shell

Nia, a young Greek woman, has an account on a well-known social network. She visits her friends' postings on a daily basis, and when she finds an interesting picture or video, she presses the *Like*-button. However, when she needs to discuss her upcoming holidays on the Saba Island with her Argentinian boyfriend, she uses the live chat box. After all, hitting buttons and icons offers only a very limited interaction tool, and does not produce a highly detailed level of information that is possible in a chat box.

Using a chat service needs to be very easy and fun, otherwise teenagers would be doing something else. I am telling you this, because there are two ways of commanding the operating system (OS) that the computer uses to control mouse, keyboard, mass storage devices, etc. The first is called Graphical User Interface (GUI) and consists of moving a mouse and clicking over a menu option or an icon, such as the `Like` button. As previously mentioned, a GUI often does not generate adequate information for making a request to the OS. In addition, finding the right object to press can become difficult in a labyrinth of menu options.

The other method of interacting with the computer is known as Shell, and is similar to a chat service. On a Shell interface, Nia issues instructions that the operating system (OS) answers by fulfilling the assigned tasks. The language that Nia uses to chat with the OS is called *bash*. Another option is *zsh*, but it is so similar to *bash* that it does not require a separate tutorial. Languages such as *bash* and *zsh* have commands to go through folders, browser files, create new directories, copy objects from one place to the other, configure the machine, install applications, change the permissions of a file, etc. When accessing the OS through a text-based terminal, a shell language is the main way of executing programs and doing work on a computer.

In order not to scare off the feeble-minded, many operating systems hide access to the text terminal. In some distribution of Linux, you need to maintain the `Alt` key down, then press the `F2` key to open a dialog box, where you must type the name of the terminal you want to open. If you are really lucky, you may find the icon of the terminal on the tool bar. If the method for opening the text terminal is not so obvious, you should ask for help from a student majoring in Computer Science.

The prompt

The shell prompt is where one types commands. The prompt has different aspects, depending on the configuration of the terminal. In Nia's machine, it looks something like this:

```
~$ _
```

Files are stored in folders. Typically, the prompt shows the folder where the user is currently working. The main duty of the operating system is to maintain the content of the mass storage devices in a tree structure of files and folders. Folders are also called *directories*, and like physical folders or cabinets, they organize files. A folder can be put inside another folder. In a given machine, there is a folder reserved for duties carried out by the administrator. This special folder is called `HOME` or personal directory.

Now, let us learn a few commands to control the terminal and get things moving.

```
nim/nimacros# cd ~
~$ mkdir wrk
~$ cd wrk
~/wrk$ cat <<EOF > hi.nim
heredoc> import os
heredoc> stdout.writeLine "Hello ", paramStr(1)
heredoc> EOF
~/wrk$ ls
hi.nim
~/wrk$ cat hi.nim
import os
stdout.writeLine "Hello ", paramStr(1)
```

The first command in the above dialog is `cd ~` that changes the prompt to the `HOME` folder, which is represented by a tilde. The second command, `mkdir wrk`, creates the `wrk` folder inside the `HOME` directory. The `cd wrk` statement puts the cursor prompt inside the newly created `wrk` directory.

The `cat <<EOF > hi.nim` command sends to the `hi.nim` file a text that terminates with the `EOF` token. The terminating token does not need to be `EOF`, in fact, you can choose anything to close the input. The `<<EOF` is a kind of arrow pointing to `cat`, in order to indicate that the input will be delivered to the `cat` command. By analogy, `>` points to file `hi.nim`, which is the destination of the `cat` output.

In general, people use `cat` for printing the contents of a file, exactly as Nia did when she issued the `cat hi.nim` command in the above example. However, I could not resist the idea of providing you with a more interesting use for the `cat` command.

Finally, in the above example, the `ls` command lists the files, which are stored inside the `wrk` folder. The combination of `ls` and `cd` permits the browsing of the tree of files and folders, therefore one must learn how to use it well, which will be taught in the following pages.

pwd

The `pwd` command informs the cursor prompt position in the file tree. A folder can be placed inside another folder. For example, in a Macintosh, the `HOME` folder is inside the `/Users` directory, therefore, if Nia issues the `pwd` command from her `HOME` folder, she obtains the result that is shown below.

```
~$ set -k
~$ pwd      # shows the current folder.
Users/nia
```

One uses a path to identify a nest of folders. In a path, a sub-folder is separated from the parent folder by a slash bar. If one needs to know the path to the current folder, there is the `pwd` command.

When Nia issues a command, she may add comments to it, so her boyfriend that does not know the Bourne-again shell (*bash*) can understand what is going on and learn something in the process. Just like in Nim, comments are prefixed with the `#` hash char, as you can see in the above chat. Therefore, when the computer sees a `#` hash char, it ignores everything to the end of the line.

In the *Z shell* (*zsh*), it is necessary to use the `set -k` command to activate comments, but in the *bash* shell, comments are always active by default.

mkdir wrk

The command **mkdir wrk** creates a `wrk` folder inside the current directory, where `wrk` can be replaced with any other name. Therefore, if Nia issues the `mkdir wrk` command from her `HOME` directory, she creates a new folder with the `Users/nia/wrk` path.

cd wrk

One can use the `cd <folder name>` command to enter the named directory. The `cd ..` command takes Nia to the parent of the current directory. You also learned that `ch ~` sends the prompt to the `HOME` directory. Thanks to the `cd` command, one can navigate through the tree of folders and directories.

Tab

If you want to go to a given directory, type part of the directory path, and then press *Tab*. The shell will complete the folder name for you.

Home directory

A ~ tilde represents the home directory. For instance, `cd ~` will send Nia to her personal folder. The `cd $HOME` has exactly the same effect.

```
~/wrk$ ls
hi.nim
~/wrk$ cd ~
~$ cd wrk
~/wrk$ cd $HOME
~$
```

echo and cat

The `echo` command prints its arguments. Therefore, `echo $HOME` prints the contents of the `HOME` environment variable. Environment variables store the terminal configuration. For instance, the `HOME` variable contains the user's personal directory identifier. One needs to prefix environment variables with the `$` char to access their contents:

```
~$ echo $HOME
/Users/nia
```

The instruction `echo "import os, strutils" > fb.nim` creates a `fb.nim` file and writes the argument of the `echo` command there. If the file exists, this command supersedes it.

The command `echo "# Fibonacci function" >> ifib.nim` appends a string to a text file. It does not erase the previous content of the `ifib.nim` file. Of course, you should replace the string or the file name, as necessity dictates.

```
~$ cd wrk      # transfer action to the wrk file
~/wrk$ echo 'import os, strutils\n' > ifib.nim
~/wrk$ {
cursh> echo 'proc fib(n: int): int ='
cursh> echo '   var (r1, r2) = (2, 1)'
cursh> } >> ifib.nim
~/mwrk$ ls
hi.nim ifib.nim
~/wrk$ cat ifib.nim
import os, strutils

proc fib(n: int): int =
   var (r1, r2) = (2, 1)
```

The above example shows that you can use braces to create a sequence of `echo` commands. The `cat ifib.nim` prints the contents of file `ifib.nim`, as you learned before.

Extended example of cat

Below you will find an extended example of a chat between Nia and *zsh* with many examples of `cat` and `echo`. The `\n` directive in the string `import os, strutils\n` provokes a line break. Note that Nia replaced `EOF` with `EOT` just to show that it can be done.

```
~$ cd wrk       # transfer action to the wrk file
~/wrk$ echo 'import os, strutils\n' > ifib.nim
~/wrk$ {
cursh> echo 'proc fib(n: int): int ='
cursh> echo '   var (r1, r2) = (2, 1)'
cursh> } >> ifib.nim
~/wrk$ ls
hi.nim   ifib.nim
~/wrk$ cat <<EOT >> ifib.nim
heredoc>    for i in 2..n:
heredoc>       (r1, r2) = (r1+r2, r1)
heredoc>    result= r1
heredoc>
heredoc> echo fib(paramStr(1).parseInt)
heredoc> EOT
~/wrk$ cat ifib.nim
import os, strutils

proc fib(n: int): int =
   var (r1, r2) = (2, 1)
   for i in 2..n:
      (r1, r2) = (r1+r2, r1)
   result= r1

echo fib(paramStr(1).parseInt)
```

ls

By convention, a file name has two parts, the *id* and the *extension*. The id is separated from the extension by a dot. The `ls` command lists all files and sub-folders present in the current folder. The `ls *.nim` prints only files with the `.txt` extension.

The `*.nim` pattern is called wild card. In a wild card, the `*` asterisk matches any sequence of chars, while the `?` interrogation mark matches a single char. The command `ls -lia *.nim` prints detailed information about the `.nim` files, like date of creation, size, etc.

```
~/wrk$ ls -lia *.nim
1291 -rw-r--r--  1 ed  staff   49 Nov  2 08:44 hi.nim
1292 -rw-r--r--  1 ed  staff  163 Nov  2 10:44 ifib.nim
```

Files starting with a dot are called hidden files, due to the fact that the `ls` command does not normally show them. All the same, the `ls -a` option includes the hidden files in the listing.

In the preceding examples, the first character in each list entry is either a dash `(-)` or the letter `d`. A dash `(-)` indicates that the file is a regular file. The letter `d` indicates that the entry is a folder. A special file type that might appear in a `ls -la` command is the `symlink`. It begins with a lowercase `l`, and points to another location in the file system. Directly after the file classification comes the permissions, represented by the following letters:

- `r` – read permission.
- `w` – write permission.
- `x` – execute permission.

cp

The `cp ifib.nim fib.nim` makes a copy of a file. You can copy a whole directory with the `-rf` options, as shown below.

```
~/wrk$ ls
hi.nim   ifib.nim
~/wrk$ cp ifib.nim fib.nim
~/wrk$ ls
fib.nim  hi.nim   ifib.nim
~/wrk$ cd ..
~$ cp -rf wrk discard
~$ cd discard
~/discard$ ls
fib.nim  hi.nim   ifib.nim
```

rm

The `rm ifb.nim` command removes a file. The `-rf` option removes a whole folder.

```
~/discard$ ls
fib.nim  hi.nim   ifib.nim
~/discard$ ls
fib.nim  hi.nim   ifib.nim
~/discard$ rm ifib.nim
~/discard$ ls
fib.nim hi.nim
~/discard$ cd ..
~$ rm -rf discard
~$ ls discard
ls: discard: No such file or directory
```

mv

The `mv wrk work` command changes the name of a file or folder, or even permits the moving of a file or folder to another location. By the way, the `cp bkp/ifib.nim .` copies the `ifib.nim` file to the current directory, which is represented by a `(.)` dot. You can use a `(.)` dot to represent the current directory with any shell command.

```
~# mv wrk work
~$ cd work
~/work$ ls
fib.nim  hi.nim   ifib.nim
~/work$ mkdir bkp
~/work$ mv ifib.nim bkp
~/work$ ls
bkp     fib.nim hi.nim
~/work$ ls bkp
ifib.nim
~/work$ cp bkp/ifib.nim .
~/work$ ls
bkp      fib.nim  hi.nim   ifib.nim
```

Pen drive

In most Linux distributions, the pen drive is seen as a folder inside the `/media/nia/` directory, where you should replace `nia` with your user name. However, in the Macintosh, the pen drive appears at the `/Volume/` folder. The commands `cp`, `rm` and `ls` see the pen drive as a normal folder.

Nim distribution package

The distribution package for a piece of software such as Nim is called archive, since it contains many files stored together in a compact way, that you will need to decompress and extract.

A popular tool for decompressing an archive is `tar` that accepts files with extensions `.tar.xz`, `.bz2` or `tar.xz` depending on the method of compression. Extraction is performed by the `tar` application.

You will learn in this book that it is impossible to write down all details of a craft. For becoming really proficient, you need practice. In any case, I will provide some guidance on the installation of the Nim compiler, but you will learn to get the thing done if you put in some efforts of your own. Ask for help from a computer science major, if you think that the task is above your station.

You should search the Internet for the Nim language compiler and download it. Then, extract, build and install the distribution, as shown below.

To protect you against malware attacks, one needs a password to write into the folders where critical applications are installed. The `sudo` tool will ask you for a password. If you type the correct password, the `install.sh` script will be granted the permission to install Nim in your computer.

```
~$ mkdir source
~$ cd source
~/source$ mv ~/Downloads/nim-x.y.z-os.tar.xz .
~/source$ tar xfJ nim-x.y.z-os.tar.xz
~/source$ cd nim-x.y.z
source/nim-x.y.z$ ls *.sh
build.sh     deinstall.sh install.sh
source/nim-x.y.z$ ./build.sh
source/nim-x.y.z$ sudo ./install.sh /usr/local/bin
```

Finally, you should test the installation with a small program, as shown in the shell chat below. During the process of compilation, Nim creates auxiliary files in the folder indicated by the `--nimcache` option. I usually place these files in the `xx` folder, which I remove to liberate space in my machine.

```
source/nim-1.0.3$ cd ..
~/source$ mkdir tests
~/source$ cd tests
source/tests$ cat <<EOT > hi.nim
heredoc> import os
heredoc>
heredoc> stdout.writeLine "Hello ", paramStr(1)
heredoc> EOT
source/tests$ nim c -o:hi.x -d:release --hints:off --nimcache:xx hi.nim
CC: stdlib_io.nim
CC: stdlib_system.nim
CC: stdlib_posix.nim
CC: stdlib_times.nim
CC: stdlib_os.nim
CC: hi.nim
source/tests$ ./hi.x Ed
Hello Ed
source/tests$ ls
hi.nim hi.x   xx
source/tests$ rm -rf xx
```

Chapter 4

Emacs / lem

You can create source files by using the `cat` command. However, for serious work, you need a text editor such as lem, which is a clone of Emacs written in the Common Lisp programming language. I will not try to explain how to install lem, since the procedure changes over time and from machine to machine. Therefore, search the web for adequate binaries and instruction on how to install the thing on your computer.

In the following cheat sheet for lem, `C-` is the `Ctrl` key, `M-` denotes the `Alt` key, κ can be any key, and `Spc` represents the space bar. Thus, `C-`κ means: Press and release the `Ctrl` key and the κ key simultaneously.

- `C-s` – search for a string of text. Press `C-s`, then type in the text you want to find
- `C-s` again – After the first occurrence, press `C-s` again to find other text instances
- C-r – reverse search
- `C-k` – kill the text from the cursor, until the end of the line
- `C-h` – backspace: erase the char before the cursor and move backwards
- `C-d` – delete char under the cursor
- `C-Spc` then move the cursor – select a region
- `M-w` – save selected region in the kill ring
- `C-w` – kill region, but save its contents in the kill ring
- `C-y` – insert killed/saved region at current cursor position
- `C-g` – cancel minibuffer reading
- `C-a` – go to beginning of line
- `C-e` – go to end of line
- `C-/` – undo
- `INS` – toggle overwrite mode
- `C-b` – move back one character
- `C-f` – move forward one character
- `C-n` – move cursor to the next line
- `C-p` – move cursor to the previous line
- $\leftarrow\uparrow\downarrow\rightarrow$ – the arrow keys also move the cursor

Ctrl-x commands

The convention `C-x C-κ` means that you should keep the `Ctrl` key down and press `x` and `κ` in sequence. You must try to issue the commands in a way that is ergonomic and comfortable. Keep the `Ctrl` key pressed with the index finger of the left hand, and use the index finger of the right hand to press the keys `x` and `κ`, one after the other.

- `C-x C-f` – open a file into a new buffer
- `C-x C-w` – write file with new name
- `C-x C-s` – save the current file
- `C-x C-c` – exit the lem source editor
- `C-x C-i` – insert file at current cursor position

The `C-x ?` command – describes a key stroke. Press the `Ctrl` key and the `x` key at the same time, release both keys, then press the `?` question mark. The one-line buffer at the bottom of the page is called the minibuffer. The command `C-x C-f` that finds a file reads the name of the file from the minibuffer. This time, the minibuffer will prompt you with the `describe-key` invitation. If you type `C-x C-f`, the following description shows up:

- `describe-key: C-x C-f find-file`

The `C-x @` command – pipes a shell instruction. Keep the `Ctrl` key down, then press the `x` key. Release both keys, then press the `@` key. The lem editor will prompt for a shell command. Type `ls`, for instance. It will open a temporary buffer and show a list of file names. There are many commands that read information from the minibuffer:

- `C-x C-f` – retrieves the file you want to open from the minibuffer
- `C-x C-s` – reads the text sample you search for from the minibuffer
- `C-x C-i` – in the minibuffer, type a file name to insert at current cursor position

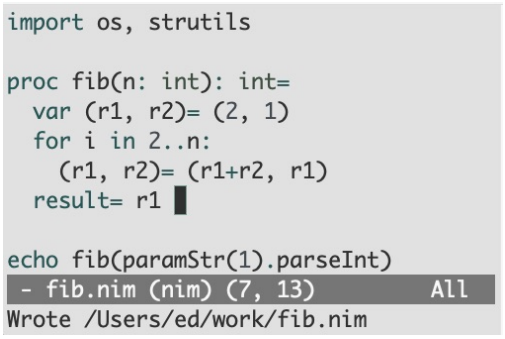
You must type `C-g`, whenever you want to cancel any command that needs to read a complement from the minibuffer.

Window commands

One can have more than one window on the screen at any given moment. In the list below, you will find commands that deal with this situation. In commands of the form `C-x κ` – keep the `Ctrl` key down and press `x`, then release both keys and hit the `κ` key.

- `C-x b` – next buffer
- `C-x C-b` – list buffers available
- `C-x k` – kill current buffer
- `C-x 2` – split window into cursor window and other window
- `C-x o` – jump to the other window
- `C-x 1` – close the other window
- `C-x 0` – close the cursor window

You can maintain many files open at the same time. I mean, when you open a new file with the `C-x C-f` command, the buffer on which you were working is not discarded, but remains in the background. When you type `C-x b`, lem takes the cursor to the minibuffer, where you can use the arrow keys to scroll and choose the next buffer you want to edit. If you press `C-x C-b`, lem provides a list of all buffers available, so you can choose one. In this case, issue a `C-x o` command so that the cursor switches to the buffer list window, from where you can choose the destination buffer.



(3) Fibonacci Function

The figure above shows the editor. On the minibuffer you can read the following message that was left there as the byproduct of a `C-x C-s` save file command:

```
Wrote /Users/ed/work/fib.nim
```

Let us test the editor. Call `lem` from the `work` directory that you created previously:

```
~$ cd work
~/work$ ls
bkp  hi.nim   ifib.nim xx
~/work$ lem fib.nim
```

Type the code shown in figure 3, then exit the editor with the `C-x C-c` command. Next, compile and run the program, as shown below.

```
~/work$ nim c -o:fib.x -d:release --nimcache:xx --hints:off fib.nim
~/work$ ./fib.x 5
13
```

Meta keys

To issue commands in the `M-κ` form, keep the `Alt` key down and press the `κ` key.

- `M-b` – move back one word
- `M-f` – move forward one word
- `M-g` – go to the line given on the minibuffer
- `M->` – go to the end of buffer
- `M-<` – go to the beginning of buffer

It is pretty hard to press the `M-<` command. You must keep the `Alt` key down, then press the `Shft` and `<` keys together. However, there is a `~/.lem/init.el` initialization file where one can define new commands. So, let's add the following commands to the `~/.lem/init.el` file:

```
;; -*- lisp -*-
(in-package :lem)

(define-key *global-keymap* "Escape" 'keyboard-quit)

(define-key *global-keymap* "C-/" 'undo)

(define-key *global-keymap* "M-p" 'move-to-beginning-of-buffer)
(define-key *global-keymap* "M-n" 'move-to-end-of-buffer)
```

Now, next time you enter lem, if you press `M-p`, you will go to the beginning of the buffer. Likewise, if you press `M-n`, the cursor will be sent to the end of the buffer.

Search

If you press `C-s`, the computer enters into search mode. First, lem prompts you for the text snippet S that you want it to find in the current buffer. While you are still typing, the cursor jumps to the first occurrence of the text snippet S. To repeat the search, all you need to do is press `C-s` again. Finally, you must type `C-r` to reverse the direction of the search.

Go to line

When you try to compile code containing errors, the compiler usually reports the line number where the error occurred. If you press `M-g`, lem prompts for a line number. As soon as you type the number and press the `Enter` key, the cursor jumps to the line where the error occurred.

Transport and Copy

To transport a region from one place to another, Nia presses `C-Spc` to start the selection process and moves the cursor to select the region. Then she presses `C-w` to kill her selection. Finally, she moves the cursor to the insertion place, and presses the `C-y` shortcut.

To copy a region, Nia presses `C-Spc` and moves the cursor to select the region. Then she presses `M-w` to save the selection into the kill ring. Finally, she takes the cursor to the destination where the copy is to be inserted and issues the `C-y` command.

Chapter 5

The Nim computer language

```
# nim c -d:release --nimcache:lixo -o:rd.x rd.nim
import os, strutils, sequtils, sugar
proc avg(xs: seq[float]): float =
  result= 0.0
  var n= 0.0
  for x in xs:
    result= result + x
    n= n+1.0
  result= result/n

proc main() =
  if paramCount() < 1: quit("Usage: " & paramStr(0) & " <filename.data>")
  let s = readFile(paramStr(1)).splitWhitespace.map(x => x.parseFloat)
  echo "Sum= ", s.foldl(a + b), " / Average= ", avg(s)

main()
```

(4) Read and process a file

Let us find out how many students graduate from medical schools in California. The `grad.data` file gives the number of graduates from each school. The `rd.nim` program prints the addition and the average. Here is how to compile and run the program of listing 4:

```
src> nim c -o:rd.x -d:release rd.nim  # Compile
src> cat nums.data                    # Check the data
190   45 23 34 89 96 78
97 14 17 54 345 3 42

src> ./rd.x nums.data                 # Run the program
Sum= 1127.0 / Average= 80.5
```

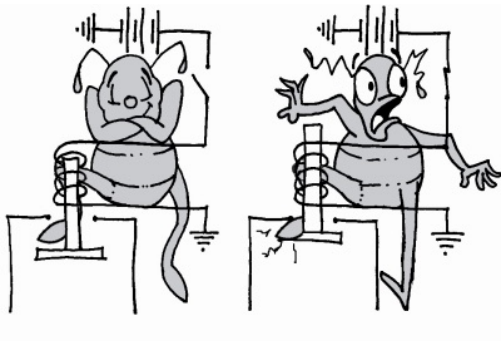
The predicate `paramCount() < 1` checks whether the file name is present on the command line. If it is not, the program quits with a request for the file name. In the snippet below, taken from application 4, the `paramStr(0)` string contains the application name.

```
if paramCount() < 1:
  quit("Usage: " & paramStr(0) & " <filename.data>")
```

The local variable `s` receives the result of a sequence of operations concerning the file contents.

The `readFile(paramStr(1))` operation reads the file whose name is on the command line. The `nums.data` file contains space separated numbers that `.splitWhitespace` parses and produces a sequence of strings.

Finally, `map(x => x.parseFloat)` transforms this sequence into floating point numbers that `foldl(a+b)` adds together. The `avg(xs: seq[float])` sums the floating point numbers together into the `result` variable and calculates the length of the sequence into `n`. The average is `result/n`.



The first computer was constructed by Konrad Zuse, a German civil engineer, and his assistant, Ms. Ursula Walk, née Hebekeuser. Ancient computers, like those of Zuse and Walk, were based on relays. These are bulky electrical devices, typically incorporating an electromagnet, which is activated by a current in one circuit to turn on or off another circuit. Computers made of such a contrivance were enormous, slow, and unreliable. Therefore, on September 9th, 1945, a moth flew into one of the relays of the Harvard Mark II computer and jammed it. From that time on, *bug* became the standard word to indicate an error that prevents a computer from working as intended.

Due to bugs, compilers of languages like Nim and Haskell frequently return error messages, instead of generating code and running the corresponding programs. The Steel Bank Common Lisp language does not interrupt code generation when the compiler spots a bug, all the same it does issue warnings that help find the problem before the embarassment of failure is manifest on the client's terminal.

Chapter 6

Comma separated values

```
# nim c -d:release -o:csv.x --nimcache:lixo csv.nim
import os, strutils, sequtils, sugar

proc main() =
  if paramCount() < 1: quit("Usage: " & paramStr(0) & "fname.data")
  let
    s = readFile(paramStr(1)).split(Whitespace+{','})
    xs= s.filter(x => x.len > 0).map(x => x.parseFloat)
  echo "Average= ", xs.foldl(a+b)/float(xs.len)

main()

#[
   Compile:  nim c -d:release -o:csv.x --nimcache:lixo csv.nim
   src> cat csv.data
   190, 180, 170, 160, 120,  100
   100,90

   src> ./csv.x csv.data
   Average= 138.75
]#
```

The above program calculates the average of comma separated values. Everything that comes between `#[` and `]#` is a comment. In the listing above, the comments provide an example of how to compile and use the program. Text that comes after `#` and the end of a line is also a comment. This second kind of comment is very common in shell commands. The `split(Whitespace+{','})` operation splits a string with values that can be separated by any combination of chars that belong to the `Whitespace+{','}` set. Since `split` produces empty `""` strings, the program applies `filter(x => x.len > 0)` to the result, in order to eliminate zero-length strings from the sequence.

6.1 Iterators

```
# nim c -d:release -o:ird.x --nimcache:lixo ird.nim
import os, strutils

iterator valid[T](a: seq[T]): T=
  for x in a:
     if x.len != 0: yield x

proc avg(xs: seq[string]): float =
  result= 0.0
  var n= 0.0
  for x in valid(xs):
    n= n+1
    result= result+x.parseFloat
  result= result/n

proc main() =
  if paramCount() < 1: quit("Usage: " & paramStr(0) & " fname")
  let
    s = readFile(paramStr(1)).split(Whitespace+{','})
  echo avg(s)

main()

#[
src> nim c -o:ird.x -d:release --nimcache:./lixo ird.nim
src> ./ird.x csv.data
138.75
]#
```

In the procedure that reads a file and splits it into an `int` sequence, the split function generates empty strings at the end of the file and possibly at the end of each line as well. Therefore, I designed an iterator that feeds a `for-loop` with valid strings that can be parsed into floats, which one can use to calculate the average of a sequence of values.

In Nim, iterators are as easy to design as normal functions. In fact, iterators are functions that produce values more than once. They are defined like procedures, but the keyword *iterator* replaces the keyword *proc* that defines procedures. Another difference between iterators and functions is that an iterator uses the keyword *yield*, instead of the keyword *return* to produce a value. In general, iterators are used to feed a `for-loop` with a sequence of values. After yielding a value, the iterator can resume the computation to produce the next value. In the example, the iterator `valid` yields a sequence of strings that can be parsed to produce floating point numbers.

Chapter 7

Exceptions

```
# nim c -d:release -o:xrd.x rd.nim

import os, strutils, sequtils, sugar
proc main() =
  proc avg(xs: seq[string]): float=
     var sm, n = 0.0
     for i, x in xs:
       try:
          sm = sm + x.strip.parseFloat
          n= n + 1.0
       except: discard
       finally: result= sm/n

  if paramCount() < 1: quit("Usage: " & paramStr(0) & " filename")
  let xs = readFile(paramStr(1)).split(Whitespace+{','})
  echo avg(xs)

main()
```

You will find `exceptions` in many languages, therefore I believe that the above program will not pose difficulties. The `avg` procedure does not try to eliminate invalid strings from the sequence. Since the program is not sure that the string represents a valid floating point number, it tries to parse it. If the `avg` procedure fails to parse a string, the error is captured in an exception section and immediately discarded. Let us compile and test it:

```
> nim c -o:excrd.x -d:release --nimcache:del --hints:off excrd.nim

~/nim/tutorial/src
> ./excrd.x csv.data
138.75
```

I defined the `avg` procedure inside the `main` procedure, just to demonstrate that this is possible. The procedure `strip` eliminates blanks surrounding the string, before parsing it to floating point numbers. This is not strictly necessary, but I did it just to be on the safe side.

7.1 Ready

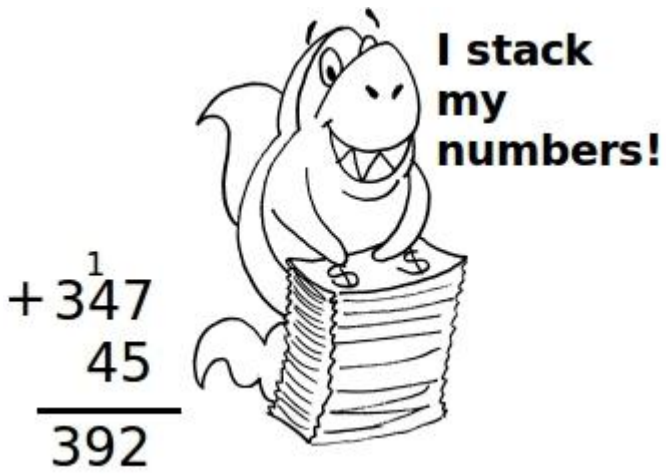
If you installed Nim and tested the programs on the previous pages of this tutorial, you are ready for action. Listing 5 shows an implementation of an rpn calculator.

```
# nim c -d:release -o:rpn.x --nimcache:lixo rpn.nim
import os, strutils
type LL= ref object of RootObj
    car: float
    cdr: LL

template car(a:untyped) : untyped=
  if a == nil: quit("Empty stack")
  else: a.car
template `>>` (a,b:untyped): untyped= LL(car: a, cdr: b)

proc eval(x: string, s: var LL)=
  try: s= x.strip.parseFloat >> s
  except:
    case  x:
      of "+": s= (car s) + (car s.cdr) >> s.cdr.cdr
      of "x": s= (car s) * (car s.cdr) >> s.cdr.cdr
      of "/": s= (car s.cdr) / (car s) >> s.cdr.cdr
      of "-": s= (car s.cdr) - (car s) >> s.cdr.cdr
      of "neg": s= -(car s) >> s.cdr
      else: quit("Error in eval")

var stk: LL = nil
for i in 1 .. paramCount(): eval(paramStr(i), stk)
while stk != nil:
  echo stk.car
  stk= stk.cdr
```

(5) Implementation of an rpn calculator

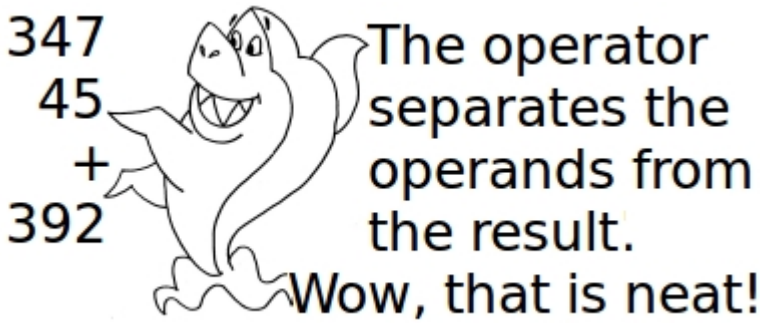
Before trying to understand the program of listing 5, let us see how to use it. The program is an emulator of the famous hp calculators.

In pre-algebra, students learn to place arithmetic operators, such as (+, -, × and ÷), between their operands; e.g. 345+47. However, when doing sums and subtractions on paper, they stack the operands.



(6) Adding to numbers

Accountants and engineers use the operator itself to separate the result from the operands, instead of drawing a line under the last operand.



Here is the story of a Texan who went on vacation to a beach in Mexico. While he was freely dallying with the local beauties, unbeknownst to him a blackmailer took some rather incriminating photos.

After a week long gallivanting, the Texan returns to his ranch in a small town near Austin. Arriving at his door shortly after is the blackmailer full of bad intentions.

Unaware of any malice, the Texan allows the so called photographer to enter and sit in front of his desk. Without delay, the blackmailer spread out a number of photos on the desk, along with his demands: “For the photo in front of the hotel, that will cost you $25,320.00. Well, the one on the beach that’s got to be $ 56,750.00. Finally, this definitively I can’t let go for less than $136,000.00.”

Once finished with his presentation, the blackmailer snaps up the photos, and looks to the Texan with a sinister grin, awaiting his reply.

Delighted with the selection of pictures, the Texan in an elated voice says: "I thought I would have no recollection of my wonderful time. I want 3 copies of the hotel shot, half a dozen of the beach. And the last one, I need two copies for myself, and please, send one to my ex-wife. Make sure you leave me your contact details; I might need some more.

In order to calculate how much the Texan should pay his supposed blackmailer, his bookkeeper needs to perform the following operations:

```
3×25320+6×56750+2×136000+136000
```

Below, you can see how the Texan's bookkeeper calculates the blackmailer's payment with the calculator from listing 5.

```
src> ./rpn.x 3 25320 x  6 56750 x + 3 136000 x +
824460.0
```

7.2 Nimscript

Up to this point, you have used the command line to call the Nim compiler. A better approach to manage compilation is to create a nimscript as the one suggested by SolitudeSF and RSDuck.

```
#!/usr/bin/env -S nim --hints:off
mode = ScriptMode.Silent
from os import `/`
if paramCount() > 2 and fileExists(paramStr(3) & ".nim"):
  let
    app = paramStr(3)
    src = app & ".nim"
    exe = app & ".x"
    c = "nim c --hints:off --nimcache:xx -d:danger -o:"

  exec c & exe & " " & src
  echo c & exe & " " & src
  mvFile exe, "bin" / exe
else: echo "Usage: ./build.nims <app without extension>"
```

(7) A Nimscript for building small applications

A nimscript contains rules for building programs and managing files. The rules state how to make or remake certain files that are called the rule targets. A variable in nimscript has the same meaning as in Nim, therefore variables are ids defined in a script to represent a string of text, called value. When you call a script, for instance `./build.nims rpn`, to build a program, you can specify the value of the `app` variable through `paramStr(3)`.

In the script of listing 7, the variables `src`, `exe` and `c` contain parts of the command line that will be passed to `exec` and build the application. The first line of the script, which is prefixed by `#!` (she bang), will call the `nim` compiler to execute the script. Thus, the command below executes the `build.nims` of the previous page and compiles the `rpn.nim` program.

```
src> chmod a+x build.nims
src> ./build.nims rpn
CC: rpn.nim
src>
```

In the above example, the `chmod` command will give permission to execute the script.

When you call `./build.nims rpn` from the command line, the `app` variable receives the `rpn` value, which will be expanded into the recipe below:

```
exec nim c --hints:off --nimcache:xx -d:danger -o:rpn.x rpn.nim
```

The result of the expansion will compile the `rpn.nim` program, and output the `rpn.x` executable code.

7.3 Linked List

Let us understand the program of listing 5. A list is a sequence of connected links, like a chain. In listing 5, links are represented by the `LL(car: a, cdr: b)` type.

```
CL-USER> (draw-cons-tree::draw-tree (list 2 4 8 16))
[o|o]---[o|o]---[o|o]---[o|/]
 |       |       |       |
 2       4       8       16
```

In the Lisp community, where the idea of linked list gained momentum, links have two parts, the `car` field contains the datum and the `cdr` field contains the address of the next link. In order to facilitate the creation of a sequence of links, listing 5 defines the `a >> b` template, which assigns the `a` value to the `car` field, and the `b` address to the `cdr` field.

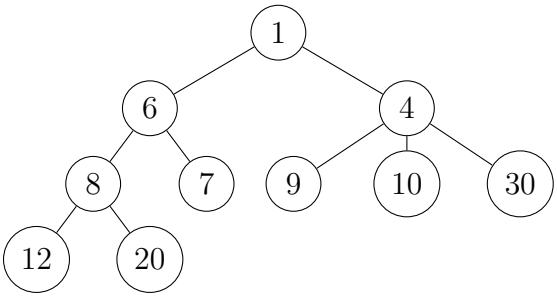
The `eval(x: string, s: var LL)` tries to parse `x` into a float pointing number. If it succeeds, the result is linked to the `stk` var. If `x` does not parse, `eval` checks whether it is an arithmetic operator through the `except` branch of the case-command. Let us suppose that it is the `"+"` operator. In this case, `"+"` fetches its two arguments from the stack, adds them, and pushes the result to the stack. The first argument is given by the `(car s)` template, and the second argument is given by `(car s.cdr)`.

In the `eval(x: string, s:var LL)` procedure, `s` is declared as `var`, which means that it can destructively assign values to the `stk` var, in the `eval(paramStr(i), stk)` call.

7.4 Symbolic computation

The concept of linked list was introduced in the Lisp language for symbolic computation, i.e., modeling mechanical machinery in Computer Aid Design, performing algebraic manipulations and constructing syntactical trees for analysing natural, etc. The name list give the misleading impression that this data structure represent mainly sequences. In fact, lists represent trees.

I will make a few statements about lists that you will accept for its face value. As you gain experience with computers, you will see that they are indeed true. The first statement is that lists represents trees.



(8) A small tree

Consider the tree on figure 8. You can represent each node as list, where the first element is the node label, and the other elements are branches. Therefore, the subtree that branches from node 8 is represented thus:

```
(8 12 20)
```

The subtree that starts at node 6 has two branches, and can be represented as shown below:

```
(6 (8 12 20) 7)
```

The list representation for the whole tree of figure 8 is shown below:

```
(1 (6 (8 12 20)
      7)
   (4 (9 10 30)))
```

The best way to go through such a tree is by using recursion together with the car/cdr selectors, as you will see in chapter 17.

Chapter 8

Web pages

In this chapter, you will learn how to write a web application in pure Nim. But firstly, let us learn what cloud computing is.

Cloud computing is an Internet based computer that provides shared processing on demand for those people connected to a service provider. When a company adheres to cloud computing, it avoids infrastructure costs, such as purchasing servers, and keeping them in working order.

At the time of this writing, fees for cloud computing can be pretty steep. However, one can hire a normal hosting service and use it for creating pages that are able to run quite interesting applications.

When you hire a hosting service, you will receive a user name and will be requested to buy a domain name. Let us assume that a resident owns the `medicina.tips` domain, where *medicina* means health care in Latin. The domain may be any sequence of chars, but it is a good idea to choose names that raise interest in Web users. Since doctors usually know some Latin, if one wants to offer expert medical consultancy, `medicina.tips` is a good name. Now that our resident physician has a user name and a domain, he must install a few programs in his cloud machine. Here is how he enters the shell:

```
~$ ssh -p2222 nia@medicina.tips
nia@medicina.tips's password: ***
```

The 2222 port is used in the secure shell protocol that connects the administrator of the page to the cloud computer. The administrator needs a password to complete the connection.

```
Last login: Sep 25 18:03:00 2022 from 179.155.71.6
~$ cd public_html
~/public_html$ mkdir nim
~/public_html$ cd nim
~/public_html/nim$ echo "Addhandler cgi-script .cgi .s .k .n" > .htaccess
```

The `.htaccess` file specifies an extension for running Nim applications on the web. It is possible that, in your cloud machine, the protocol for running Nim programs is different from what is described in this tutorial. You must ask the vendor for details.

```
# File: web.nim
import strutils, os, strscans, unicode, uri

let input = open("rage.md")
let form = """
   <form name='form' method='get'>
       Visitor: <input type='type='text' name='$#'/>
    </form> <br/>
  """

echo "Content-type: text/html\n\n<html>"
echo """
  <head>
    <meta http-equiv= 'Content-type'
      content= 'text/html; charset=utf-8' />
  </head>
<body>
"""

proc tl(input: string; match: var string, start: int): int =
  match = input[start .. input.high]
  result = max(1, input.len - start)

var html: string
for line in input.lines:
  if scanf(line, "## ${tl}", html): echo "<h2> $1 </h2>" % html
  elif scanf(line, "# ${tl}", html): echo "<h1>$1</h1>" % html
  elif scanf(line, "in: ${tl}", html): echo form % html
  elif scanf(line, "${tl}", html): echo "$#<br/>" % html

let qs = getEnv("QUERY_STRING", "none")
if qs != "none" and qs.len > 0:
  let vs = open("visitors.txt", fmAppend)
  if scanf(qs, "N=${tl}", html):
     let n= "$#" % html
     if n != "" and not isSpace(n): write(vs, n.decodeUrl(true) & "\n")
  vs.close

let inputVisitors= open("visitors.txt")
for line in inputVisitors.lines: echo line&"<br/>"
inputVisitors.close
echo "</body></html>"
input.close
```

(9) A web application

The idea is to run the program of listing 9 from the Internet. However, it is not enough to compile the program in your home computer and install it in the cloud machine, since the two computers are likely different. You need to install a tool chain of the cloud computer in your home computer, then use the `nim.cfg` file to inform where it is located:

```
amd64.linux.gcc.path:"/usr/local/Cellar/musl-cross/0.9.8/bin"
amd64.linux.gcc.exe:"x86_64-linux-musl-gcc"
amd64.linux.gcc.linkerexe:"x86_64-linux-musl-gcc"
```

(10) The `nim.cfg` file

Script for cross compiling

Of course, this `nim.cfg` file refers to my tool chain installation. If necessary, ask for the help of a computer science major to install an adequate tool chain.

The task of compiling a web application in your home computer is called cross compilation, and needs a special script.

```
#!/usr/bin/env -S nim --hints:off
mode = ScriptMode.Silent
if paramCount() > 2 and fileExists(paramStr(3) & ".nim"):
  let
    app = paramStr(3)
    src = app & ".nim"
    exe = "nim" & app & ".k "
    c = "nim c --nimcache:xx --os:linux --cpu:amd64 -d:release -o:"
    cc= " --passL:\"-static\""
  exec c & exe & " " & cc & " " & src
  echo c & exe & " " & cc & " " & src
else: echo "Usage: ./build.nims <app without extension>"
```

(11) Script for cross compilation: `cross.nims`

It is advisable to place the three components of the cross compilation in the same directory, say `~/nim/os`. Then you can use the script to compile the program, as shown below.

```
~/nim/os> ./cross.nims web
Hint: used config file '/etc/nim/nim.cfg' [Conf]
Hint: used config file '/Users/ed/nim/os/nim.cfg' [Conf]
Hint: web [Processing]
CC: stdlib_os.nim
CC: web.nim
Hint:  [Link]
Hint: operation successful (Release Build) [SuccessX]
nim c --nimcache:xx --os:linux --cpu:amd64\
  -d:release -o:nimweb.n   --passL:"-static" web.nim
```

The last step is to send the compiled program to the cloud machine, which can be done through the `scp` command, a version of the `cp` command that can send files from a point in the cloud to another.

```
scp -P2222 nimweb.n strue028@medicina.tips:~/public_html/nim/
```

How the application works

Let us analyse how the application of listing 9 works. The `rage.md` file contain a few lines of a poem without any structure. The idea is to write it in html, so the poem can be visualized through a web browser. The `open` command does what its name indicates, it opens a file and place the descriptor in the `input` variable.

The `input.lines` iterator feeds the file lines to the code that will format them. Basically, if the line has a sharp `"#"` prefix, it is marked as title.

If a visitor types his or her name on the `Name` field, the name is captured by the `"QUERY_STRING"` variable and saved in the `visitors.txt` file.

I hope you will be able to modify the program of listing 9, and use its concept in your own applications. You can use the web for opinion polling, collecting and processing data, e-commerce, or just to spread your ideas. In the last case, you can use Nim to count how many people visited your site.

Chapter 9

Macros

```
# ./build.nims quoteLoop
import macros, strutils, os

macro magicWord(statments: untyped): untyped =
    ## Designed by Steve Kellock
    result = statments
    for st in statments:
          for node in st:
                if node.kind == nnkStrLit:
                     node.strVal = node.strVal & ", Please."

macro rpt(ix: untyped, cnt: int, statements: untyped)=
  quote do:
    for `ix` in 1..`cnt`:
      `statements`

rpt j, paramStr(1).parseInt :
  magicWord:
     echo j, "- Give me some beer"
     echo "Now"
```

(12) My first macro

Until not long ago, Lisp was the only language that had macros. Not any more. Nim macros will allow you to design new commands for the language.

The first thing to understand about macros is that they don't belong to the application that you wrote, but are part of the compiler.

9.1 Domain Specific Language: DSL

A macro rewrites a form from a Domain Specific Language that is convenient for solving a given problem into something that the compiler understands. In listing 12, before compilation even starts, the macro `rpt` will rewrite the macro form below ...

```
rpt j, paramStr(1).parseInt :
  magicWord:
     echo j, "- Give me some beer"
     echo "Now"
```

... into the following:

```
for j in 1..paramStr(1):
  magicWord:
    echo j, "- Give me some beer"
    echo "Now"
```

Then, the `magicWord` macro will add `", Please"` to the `echo` statements:

```
for j in 1..paramStr(1):
  magicWord:
    echo j, "- Give me some beer, Please."
    echo "Now, Please."
```

Only at this point, after the two macros have finished their work, will the compilation process start. The `rpt` macro inserts `` `ix` ``, `` `count` `` and `` `statements` `` into a *for-pattern* introduced by the quote statement.

The `magicWord` macro does not work by filling in gaps into a pattern, as the `rpt` macro. The first step of compilation transform your program into a branching data structure known as the *Abstract Syntax Tree*, or `AST` for short. The argument of the AST is a sequence of statements. The first loop of the `magicWord` macro goes through all statements. The second `for`-loop examines all nodes of each statement. If there is a node of the `nnkStrLit` kind, the macro concatenates `", Please"` to it. Here below is how the program works:

```
~/nim/nimacros/src master ×
> ./build.nims quoteLoop
CC: quoteLoop.nim
nim c --hints:off --nimcache:xx -d:danger -o:quoteLoop.x quoteLoop.nim

~/nim/nimacros/src master ×
> bin/quoteLoop.x 2
1- Give me some beer, Please.
Now, Please.
2- Give me some beer, Please.
Now, Please.
```

9.2 Dealing with the AST directly

```
# ./build.nims rep
# Based on a model by Juan Carlos Paco
import macros

macro iter(i:untyped, c1:untyped,
           c2:untyped, stm:untyped): untyped =
  result = newNimNode(nnkStmtList)  # creates an empty result
  var for_loop=
    newNimNode(nnkForStmt) # creates a for-loop
  for_loop.add(i) # adds index `i` to the for-loop

  var rng = # creates a range
    newNimNode(nnkInfix).add(ident("..")).add(c1,c2)
  for_loop.add(rng)  # inserts the range into for_loop
  let spc= newLit("- ") # Creates a space string Lit
  var wrt = newCall(ident("write"),ident("stdout"), i, spc)
  var stmList= newNimNode(nnkStmtList)
  stmList.add(wrt)
  for s in stm: stmList.add(s)
  for_loop.add(stmList)
  result.add(for_loop) # insert for_loop into result

iter(i, 0, 3):
  echo "Hello, world."
```

(13) Tinkering with the AST

Professional programmers, such as the Argentinean Juan Carlos Paco, don't use a quote pattern to define a macro, they prefer to tinker with the AST tree data structure directly. Listing 13 shows how to define a macro to iterate through a list of commands, which in the example contains only echo statements.

```
> ./build.nims quoteLoop
nim c -o:quoteLoop.x -d:danger --hints:off --nimcache:lixo quoteLoop.nim
CC: stdlib_io.nim
CC: stdlib_system.nim

~/nim/tutorial/src
> bin/quoteLoop.x 3
1- Give me some beer, Please.
2- Give me some beer, Please.
3- Give me some beer, Please.
```

Let us describe the macro of Listing 13. It starts by creating a `nnkForStmt` and stores it in the `for_loop` variable. The next step is to add the `i` index to the `for_loop` variable. Then it creates a range for the variable `i` and adds it into the `for_loop` variable. Finally, the macro creates a `stmList` (statement list) that will be repeated in the loop. The macro starts by inserting `stdout.write i` into the `stmList` var, then proceeds to insert the remaining `stm` commands. The last step is to insert `stmList` into the `for_loop` variable, and the `for_loop` variable into the `result`.

It seems that I have a lot of space for explaining Juan's macro. I promise that I will come back here, when I have time and answer all questions you have about tinkering with the Abstract Syntactic Tree. For the time being, you will need to be content with the examples, which Juan Carlos left here and there.

Chapter 10

An improved rpn calculator

Now, let us revisit the problem of writing an rpn calculator. The previous calculator had a serious problem, it quitted the program between one calculation and the next, and the values stored on the stack were consequently lost. This problem was solved in the version shown in listing 14. The calculators of listing 5 and 14 are quite similar, and I believe that you will be able to figure out what is going on in listing 14 without further explanations.

The novelty in listing 14 is the `stdin.readLine(s)` function that tries to read a line into `s` from `stdin` and produces a Boolean `true` in case of success. Then, the `s` var is tokenized and each token `x` is presented to `eval(x, stk)` to be evaluated, as before.

10.1 Future value

Suppose that you wanted to buy a $ 100,000 red Ferrari, and the forecourt salesperson gives you the following two payment options:

- $ 100,000 now *or*
- $ 115,000 at the end of three years.

What to do when facing an increase in price to cover postponement of payment? The best policy is to ask your banker how much interest she is willing to pay you over your granted grace period.

Since the economy performance is far from spectacular, your banker offers you an interest rate of 2.5%, compound annually. She explains that compound interest arises when interest is paid on both the principal and also on any interest from past years.

The value of money changes with time. Therefore, the longer you keep control of your money, the higher its value becomes, as it can earn interest. Time Value of Money, or TVM for short, is a concept that conveys the idea that money available now is worth more than the same amount in the future.

```
import os, strutils, math

type LL= ref object of RootObj
    car: float
    cdr: LL

template car(a:untyped) : untyped=
  if a == nil: quit("Empty stack")
  else: a.car

template `>>` (a,b:untyped): untyped= LL(car: a, cdr: b)

proc eval(x: string, s: var LL)=
  try: s= x.strip.parseFloat >> s
  except:
    case  x:
      of "+": s= (car s) + (car s.cdr) >> s.cdr.cdr
      of "x": s= (car s) * (car s.cdr) >> s.cdr.cdr
      of "/": s= (car s.cdr) / (car s) >> s.cdr.cdr
      of "-": s= (car s.cdr) - (car s) >> s.cdr.cdr
      of "expt": s= pow(s.cdr.car, s.car)  >> s.cdr.cdr
      of "fv": s= pow(1.0 + s.cdr.car/100, s.car) *
                      s.cdr.cdr.car >> s.cdr.cdr.cdr
      of "neg": s= -(car s) >> s.cdr
      else: quit("Error in eval")

var s=  ""
var stk: LL= nil
var stack: LL= nil

stdout.write "> "
while stdin.readline(s) and s != "quit":
  for x in s.splitWhitespace:
    eval(x, stk)
  stack= stk
  while stack != nil:
    echo stack.car
    stack= stack.cdr
  stdout.write "> "
```

(14) An improved calculator

10.2 Expression for calculating the future value

If you have $ 100,000.00 in a savings account now, that amount is called *present value*, since it is what your investment would give you, if you were to spend it today.

Future value of an investment is the amount you have today plus the interest that your investment will bring at the end of a specified period. Here is the relationship between the present value and the future value:

$$FV = PV \times (1 + i/100)^n \tag{10.1}$$

where FV is the future value, PV is the present value, i is the interest rate, and n is the number of periods.

In the case of postponing the payment of a $ 100,000.00 car for 3 years, at an interest rate of 0.025, the future value of the money would be 107,689.06; therefore, I stongly recomend against postponing the payment in this case. Let us use the calculator of listing 14 to check these amounts:

```
~/nim/tutorial/src
> ./build.nims rdwrt
nim c -o:rdwrt.x -d:danger --hints:off --nimcache:lixo rdwrt.nim

~/nim/tutorial/src
> bin/rdwrt.x
> 2.5 100 /
0.025
> 1 +
1.025
> 3 expt
1.076890625
> 100_000.00 x
107689.0625
```

10.3 The Texan strikes again

Our Texan decides he needs a break. Thus he walks into a New York City bank and asks for the loan officer. He tells a story of how through his doctor's recommendation he was taking it easy at his property in the south of France for two whole years and for such a medical emergency he needs a $ 10,000.00 loan.

The loan officer said that the interest was a compound 8% a year, but the bank would need some collateral for the loan.

> *"Well, I have a 60 year old car that I like very much. Of course, I cannot take it with me to France. Would you accept it as collateral?"*

Unsure whether or not the old car was worth the amount of the loan, the officer summons the bank manager. The manager inspects the vehicle that was parked on the street in front of the bank. After a close examination, he gives a nod of approval: "*It's a Tucker Torpedo. Give him the loan.*" Two years later the Texan returned, and asked how much he owed the bank. The loan officer started the rpn calculator, and calculated the total debt as $ 11,664.00.

```
~/nim/tutorial/src
> ./rdwrt.x
> 1.0 0.08 + 2 expt 10000 x
11664.0
> quit
```

After receiving the full amount due, the loan officer said: "*We appreciated doing business with you, but I am a little perplexed. I checked that a Tucker Torpedo in mint conditions is worth more than 10 million dollars. Therefore, you must be a very rich man. Why you would bother to borrow $10,000?*" The Texan replied: "*Where else in New York City could I park my car for a whole two years for just a litle over one grand?*"

Future value calculations are so important that I have included it in the rpn calculator of listing 14, as you can check.

```
~/nim/tutorial/src
> ./rdwrt.x
> 10_000.00 8 2 fv
11664.0
```

Chapter 11

Anthropology of Money

In order to build a computer able to perform medical diagnoses, launch the Luna 3 to photograph the far side of the Moon, or even apply for medical residency programs in 110 hospitals, you need three things: Money, training and collaboration. If I had not obtained the collaboration of Vindaar and Juan Carlos Paco, I would not be able to write about Nim macros. If the members of the Della-Vos group were not trained in such fields as biotechnologies, microelectronics and medicine, they would not be able to build bioFETs or measure ion-drifts in the ionosphere. Later, I will elaborate on training and collaboration. For the time being, let us learn the basics of money.

Money is a tool that provides three functions or services: Medium of exchange, store of value and unit of account.

To understand medium of exchange, let us perform a thought experiment. What does the economy in an Indian tribe of Brazil look like, considering that the tribe has lived without any significant contact with modern global civilization? Let us give this tribe a name– Awa, since I lived among the Awaians for almost three years and could observe their customs, and became a friend to many members of the tribe.

There are people among the Awaians that I will call croppers, because they work in agriculture: they plant manioc, corn, rice and beans. There are also breeders that raise poultry for the eggs. The artisans produce artifacts like bows, arrows, wicker baskets, hammocks, etc. A potter provides ceramic ware, and also cups carved from wood. The healer knows the secrets of manufacturing medicines and alkaloids for arrow poisons. There are also the hunter-gatherers that obtain food and other goods by foraging, i.e., collecting plants from the forest and pursuing wild animals.

A hunter-gatherer girl, my friend Jurema, uses a blowdart for capturing small animals and defending herself. Curare is a common name for various arrow poisons that cause muscle weakness by competitively inhibiting one of the acetylcholine receptors. Let us assume that Jurema needs this concoction for her blowdarts that she uses for defending herself against the illegal gold panners that often invade the Awaian territory in the eastern Amazon rainforest. She goes to the healer and barters a parrot chick that she captured in the forest for a small

quantity of curare. If the healer needs a ceramic cauldron for preparing chemicals and herbs, he may go to the potter's tent and trade a quinine based malaria medication in exchange for the ceramics. A cropper can provide corn to the artisan and barters it for a hammock that she needs at home.

The aforementioned social organization is what anthropologists call a barter economy. The idea behind such an economy is that goods or services are exchanged directly and immediately, without delay. Of course, long term barter societies do not exist, and never did, although they can appear for short periods in countries plagued with rampant inflation.

To understand why a barter society would face serious economic crisis, let us suppose that the healer arrives with the quinine at the potter's tent, but the potter already has all the quinine he needs for the time being:

> "*I am sorry my friend, but I still have the whole lot of quinine that you provided me the last time we bartered. Since Madam Tu Youyou discovered artemisin and Chinese merchants are providing us with the drug, quinine is not much in demand anymore.*"

In this case, he would not provide the cauldron that the healer needs so badly. It is also possible that Jurema will not be able to get the curare in exchange for the parrot chick: The healer may not like parrot chicks, or his daughter may already have five parrot chicks, and he does not want to humor her and add a sixth chick to her collection.

The problem with a barter economy is that the buyer pays with a very specific item that the seller may not need or cannot store at that particular moment. A small improvement to the barter economy that could make it viable would be a gift exchange system, where the buyer pays with a debt of gratitude. In such a social organization, Jurema goes to the healer and obtains the needed curare without any immediate exchange of goods. This therefore means that she now owes a favor to the healer, which is better known as a debt of gratitude. How does one pay a debt of gratitude? In this case, in the future, when the healer needs feathers for ceremonial dress in a ritual, he can order Jurema to collect feathers of the colors and type he needs during her next forage in the forest. On the other hand, the healer would receive the cauldron from the potter without immediate payment. When the potter needs a mosquito repellent from the healer, all he needs to do in order to obtain it is to remind the healer of the cauldron received as a gift.

The Awa tribe actually exists as a gift culture. This is only possible due to the fact that the Awaian population consists of few individuals. Awaians can remember the persons to whom they owe favors, and who owes favors to them. If a society becomes large, it is difficult for a seller to track the many people who have debts of gratitude to pay. It is also difficult to decide what could be considered as equal payment between debts of gratitude. How many times does the healer need to provide medicine for a cauldron? Is a repellent for mosquitoes equivalent to a bottle of quinine? How many feathers are necessary to pay for a portion of curare?

Therefore, large human populations created tokens to remind people of their debts of gratitude. For instance, Mayans used cocoa beans as debt reminders. The advantage of such a system is

that a Mayan did not have to receive the debt only from the person to whom he provided a service. In such an organization, a Mayan healer could take the cocoa beans that he received from the hunter-gatherer girl and use them to pay the potter for the cauldron.

Cocoa beans as a medium of exchange also have a problem: It is very easy to cheat the system. For instance, a Mayan crook could find a cocoa tree, harvest a lot of cocoa beans, and tell the potter, the healer or the hunter-gather girl that they owe him that many favors. To avoid this kind of dishonest behavior, most civilizations replaced simple tokens, such as cocoa beans, with something harder to falsify, the likes of coins made of gold, silver and other rare metals.

Of course, falsifications continued even after the introduction of metal coins. People minted coins of tin, and gold plated them. Therefore, the gypsies used to bite the gold coins to check that they had the consistency of gold. Another trick to cheat the system was to scrape some gold from the edge of a coin. To prevent this, minters added ridges to the edges. Now you know why coins have ridged edges.

Coin is the name that experts give to metallic tokens for debts of gratitude. Gold and silver provides a good method of preventing people from counterfeiting coins. However, governments decided to replace gold with a less expensive token. The substitution has the added advantage of liberating gold reserves for other uses, such as manufacturing gold nano particles for biomedical diagnostic assays. In fact, gold is very good for building a device called lateral flow assay, since it has low toxicity. Besides this, there exist simple synthesis methods for producing Gold Nano Particles quickly and inexpensively. If you don't find a discussion of the subject in this book, get in touch with the authors and ask for a chapter on the subject.

For the reasons stated above, gold and silver coins were replaced by banknotes. In order to counteract forgery, tampering and counterfeiting, manufacturers of banknotes introduced many technological security measures, such as special types of paper, micro printing, intaglio printing, watermarks, guilloché, holograms, security threads, magnetic ink, etc. One of the most famous experts in security printing, who helped in the creation of these technologies, was Thomas de la Rue (1793 – 1866). He founded the De La Rue plc, which today sells high-security paper and printing technology for over 150 national currencies.

The function of banknotes, which a citizen holds in his or her possession, is to remind society that its members owe a certain value of services and goods to that particular citizen. It was introduced when the number of citizens became so large that a person, like the Awaian girl, could not remember who should pay her a debt of gratitude. The advent of computers permitted the storing of commercial transaction records in a database. The buyer and seller can access the database through a smart card personalized to the buyer. This new technology is known as digital currency.

It is easy to forecast the type of technology that the future holds for money: The seller and the banking system will not need the smart card, in order to identify the buyer, since they can easily be identified through their DNA.

Chapter 12

A syntax changing macro

```nim
# A syntax changing macro by Vindaar
import macros, strutils, os

proc parseArgs(cmd: NimNode): (NimNode, NimNode) =
  doAssert cmd.len == 2
  expectKind(cmd[1], nnkInfix)
  expectKind(cmd[1][0], nnkIdent)
  expectKind(cmd[1][1], nnkIdent)
  expectKind(cmd[1][2], nnkIdent)
  doAssert cmd[1][0].strVal == "->"
  doAssert cmd[1][1].strVal == "times"
  result = (cmd[0], # cmd[0] must be valid integer
            cmd[1][2]) # identifier to use for loop

macro rpt(cmd: untyped, stmts: untyped): untyped =
  expectKind(cmd, nnkCommand)
  expectKind(stmts, nnkStmtList)
  let (toIdx, iterVar) = parseArgs(cmd)
  result = quote do:
    for `iterVar` in 1..`toIdx`:
      `stmts`
  echo result.repr

rpt paramStr(1).parseInt times -> j:
    echo j, "- Give me some beer"
    echo "Now"
```

(15) A syntactic sugar macro

In listing 15, the `untyped` `stmts` behave exactly as in the other macros used for repetition that I discussed previously. However, `cmd` is a `NimNode` that bundles the number of repetitions,

along with the keyword `times`, the infix arrow `->` and the `j` counting variable. These roles are determined by the `parseArgs` procedure that extracts the important components of this complex syntax, to wit, the integer `toIdx` parameter that indicates the number of repetitions and the `iterVar`, which in the example is `j`.

The `parseArgs` procedure is amazing, and I would not be able to design it the way Vindaar did. It starts with a `doAssert cmd.len == 2` that checks whether `cmd` has length 2. Of course, `cmd[0]` contains the integer number of repetitions. As for `cmd[1]`, it contains three components, the arrow (component `cmd[1][0]`), the keyword `times` (component `cmd[1][1]`) and the `iterVar`, which is `j` in the example. Of course, the result will be the `(cmd[0], cmd[1][2])` tuple. With the four examples of macros that you and I discussed, you will become proficient in meta programming through deliberate practice.

Chapter 13

The tacit dimension

There are two persons that are helping me with this book, I will call them edu500ac and Marcus. I do not know much about Marcus, except that he has three daughters, one that plays the violin, while the other two play the cello. Mr. edu500ac told me that much about Dr. Marcus, therefore that much is all I know about him.

Brian Caplan says that if a girl, like Marcus' daughter, wants to play the violin at Carnegie Hall, she needs to practice a lot. I think that you do not dispute this assertion.

Airline transport pilots must have a minimum of 1500 hours flight time. From this training, at least 500 hours should be cross-country flight time and 100 hours should be night flight. I don't know why I am trying to make this point, since everybody accepts that a pilot must practice a lot before flying a passenger jet. It is interesting that people, who accept that musicians and pilots need training, do not apply this idea to their own activities.

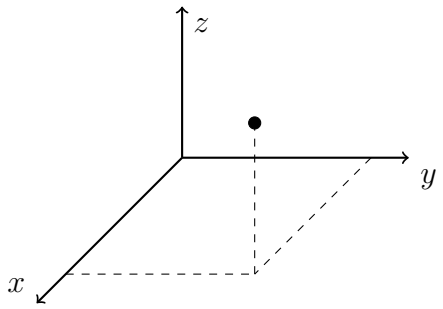


Figure 13.1: Position

In this chapter, you will learn that knowledge has 3 dimensions, explicit, tacit and shared knowledge. You can acquire explicit knowledge from books and classes, but you need practice in order to gain tacit knowledge. For instance, you learned the structure of Nim macros, but without writing a lot of macros you will never become as proficient as Vindaar.

How to recognize an object? How to distinguish a screwdriver from a monkey wrench? A set of attributes that characterize an object is called data. Examples of attributes that could be used in a classification system are color, position, mass, volume, density, material, etc.

Each attribute can have different values. For instance, the color attribute can be *black*, *white*, *yellow*, *blue*, and so on. The position on Earth is an attribute that is usually given by latitude and longitude. Mass can be measured in kilograms, grams, pounds, etc. Volume may be given in liters or gallons.

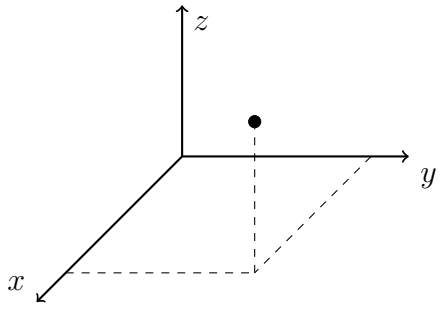
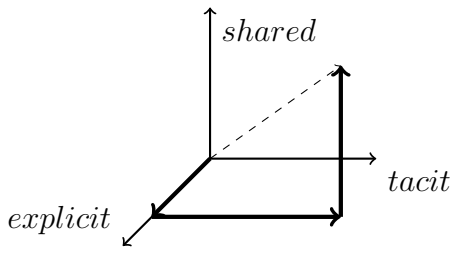


Figure 13.2: Position

According to Descartes, there exists multidimensional attributes. In modern terminology, one says that the values of such an attribute are vectors that can be broken into parts, those parts are called components. For instance, the position attribute has three dimensions, which are the `x`, `y` and `z` coordinates. Likewise, one can see knowledge as having three dimensions, which are the *explicit*, *tacit* and *shared* components.

Explicit knowledge is anything that one can write in a book, code into a computer program or teach in a classroom. Tacit knowledge is something that one knows, but cannot explain how she learned it or uses it. Mexicans know Spanish, but they aren't able to write a primer, where a resident physician from Miami could learn to speak fluently to his patients. The difficulty in teaching Spanish to an adult shows that Michael Polanyi was right when he stated that *we can know more than we can say.*



(16) Dimensions of knowledge

In figure 16, one can see a path to knowledge. Around the year 1418, Prince Henry the Navigator founded a School of Navigation in Sagres. In the classroom, a future sailor was trained in map-making and reading, which is explicit knowledge that one can write in books. The student would advance along the explicit axis, as shown in figure 16. Then he would embark on a vessel, where he would acquire actual job skills through hands-on training. Could a sailor learn about maps while already on a ship? Such a training method is represented by

the dotted path in figure 16 and is very dangerous. It is like a physician who would consult the Sobotta to learn Anatomy while performing surgery.

One acquires tacit knowledge through training, there is no other way. Don't expect to learn how to play the violin, become a wrestler, deliver babies or pilot a jet plane exclusively from a classroom setting or from books and youtube videos.

The shared knowledge is the one that cannot be found between our two ears. It is distributed throughout organizations or expert guilds. For instance, the knowledge about air combat, on which Manfred von Richthofen – the Red Baron – excelled, was distributed between the pilot, who was the Baron himself, and Anthony Fokker, the Dutch engineer that designed Manfred's triplane. This knowledge was seamed so well that the Baron could not perceive the stitches. The Red Baron was not able to note the gaps in his dominance of the airplane, even when those gaps were filled by automatic contrivances hard wired into the controls by Anthony Fokker. In fact, any perceptible transition between engineering expertise and flight tacit knowledge could hinder the pilot's ability to anticipate the consequences of his actions and be fatal in a battle.

I am telling you all this in a attempt to convince you that this book alone will not take you very far from the axis of explicit knowledge.

Chapter 14

Variations on a theme of Vindaar

```nim
# counter.nim
import macros, strutils, os

proc parseArgs(cmd: NimNode): (NimNode, NimNode) =
  doAssert cmd.len == 2
  expectKind(cmd[0], nnkIdent)
  result = (cmd[0], # cmd[0] has an integer expr
            cmd[1]) # identifier to use for loop

macro cnt(cmd: untyped, stmts: untyped): untyped =
  expectKind(cmd, nnkCommand)
  expectKind(stmts, nnkStmtList)
  let (iterVar, toIdx) = parseArgs(cmd)
  result = quote do:
    for `iterVar` in 1..`toIdx`:
      `stmts`
  echo result.repr

cnt j paramStr(1).parseInt:
    echo j, "- Give me some beer"

#[ > ./build.nim scounter
   nim c -o:counter.x -d:danger --hints:off --nimcache:lixo counter.nim
   for j in 1 .. paramStr(1).parseInt:
       echo j, "- Give me some beer"
   > bin/counter.x 2
   1- Give me some beer
   2- Give me some beer
]#
```

(17) A simpler counting macro

When Vindaar provided us with the macro on listing 15, he gave us explicit knowledge. In fact, since he could present the macro on paper, it was explicit knowledge. In order to learn macro design, it is necessary to practice, and one should start practicing with simple stuff. In listing 17, the definition of `cnt` couldn't be simpler. The `cmd` parameter has 2 elements, the first one must be a variable. The statements below check whether these two conditions are met by the `cnt` macro.

```
doAssert cmd.len == 2
expectKind(cmd[0], nnkIdent)
```

Chapter 15

More Variations

```nim
# infixLoop.nim
import macros, strutils, os

proc parseArgs(cmd: NimNode): (NimNode, NimNode) =
  expectKind(cmd[0], nnkIdent)
  expectKind(cmd[1], nnkIdent)
  doAssert cmd[0].strVal == "++="
  result = (cmd[1], cmd[2])

macro rpt(cmd: untyped, stmts: untyped): untyped =
  expectKind(cmd, nnkInfix)
  expectKind(stmts, nnkStmtList)
  let (iterVar, toIdx) = parseArgs(cmd)
  result = quote do:
    for `iterVar` in 1..`toIdx`:
      `stmts`

rpt j ++= paramStr(1).parseInt:
    echo j, "- Give me some beer"

#[
> nim c -o:infixLoop.x -d:danger --hints:off infixLoop.nim

> ./infixLoop.x 3
1- Give me some beer
2- Give me some beer
3- Give me some beer
]#
```

(18) Macro with an infix operator

Listing 18 is my second attempt at building an interesting macro. This time, `cmd` has a single infix expression. I learned that I should not place an assertion on the length of infix expressions. For instance, the compiler protests if I add the following check on the definition of `parseArgs` in listing 18:

```
proc parseArgs(cmd: NimNode): (NimNode, NimNode) =
  doAssert cmd.len == 2
  expectKind(cmd[0], nnkIdent)
  expectKind(cmd[1], nnkIdent)
  doAssert cmd[0].strVal == "++="
  result = (cmd[1], cmd[2])
```

It seems that infix expressions do not have length. I would never discover this if I had not been practicing over the last three days.

Chapter 16

Tree constructors

```nim
# ./build.nims akavelIter
import macros, strutils, os

macro iter(cmd: untyped, stmts: untyped): untyped =
  expectKind(cmd, nnkInfix)
  expectKind(cmd[0], nnKIdent)
  doAssert cmd[0].strVal == "->"
  expectKind(cmd[2], nnkIdent)
  expectKind(stmts, nnkStmtList)
  let (ix, rng) = (cmd[2], cmd[1])
  result = nnkStmtList.newTree(nnkForStmt.newTree(ix, rng, stmts))

iter 3..paramStr(1).parseInt -> j:
    echo j, "- Give me some beer"
```

(19) An iterating program by akavel

Here is an example of running iter:

```
~/nim/nimacros/src master ×
> ./build.nims akavelIter
nim c -o:akavelIter.x -d:danger --hints:off akavelIter.nim

~/nim/nimacros/src master ×
> bin/akavelIter.x 5
3- Give me some beer
4- Give me some beer
5- Give me some beer
```

Program 19 shows that different people choose different solutions to the same problem. The programmer whose nickname is *vindaar* used a quote pattern for creating the Abstract Syntactic Tree of a loop.

Another programmer, whose nickname is *akavel*, I believe his true name is Mateusz Czapliński, prefers to use the tree constructor directly.

Languages such as Lisp and Scheme use the same kind of node for any tree, the `consp` data structure, therefore, Lisp and Scheme need only a tree constructor, to wit, the `cons` function. In an Abstract Syntactic Tree, when it is necessary to differentiate one node from the other, a Lisp programmer will put the identifier as the first element in the list of ramifications. This is an elegant solution that makes Lisp terse and powerful.

The design of Nim opted by using different nodes. Consider the program of listing 19. The node that represents the statement list, `nnkStmtList`, is completely different from the `nnkForStmt` node, which represents the `for-loop`. The Nim approach to AST construction has the advantage of preventing a kind of error that is very common in Lisp, which is inserting a wrong node identifier in the tree. However, the Nim system has also a serious drawback, which is memorizing a different node constructing method for each kind of node.

In listing 20 below, you will find a variation of the `iter` loop. As far as I understand, a Nim command has two components, the part that comes before the colon, and the part that comes after the colon. The difference between listings 19 and 20 is restricted to the syntax of the part that comes before the colon.

```
# ./build.nims akavelLoop
import macros, strutils, os

macro iter(cmd: untyped, sts: untyped): untyped =
  # Checking syntax of command
  expectKind(cmd, nnkCommand)
  doAssert cmd.len == 2
  expectKind(cmd[1], nnkInfix)
  for i in 0..2: expectKind(cmd[1][i], nnkIdent)
  doAssert cmd[1][0].strVal == "->"
  doAssert cmd[1][1].strVal == "times"
  expectKind(sts, nnkStmtList)
  let
    rng = cmd[0]
    ix = cmd[1][2]
  result = nnkStmtList.newTree(nnkForStmt.newTree(ix, rng, sts))

iter (3..paramStr(1).parseInt) times -> j:
    echo j, "- Give me some beer"
    echo "Now"
```

(20) A more elaborate syntax for `iter`

Chapter 17

A Lisp-like macro toolkit

```nim
# nim c -o:cons.x -d:danger --hints:off --nimcache:xx lispmacros.nim
import os, strutils, macros, consp

macro def(id:untyped, x:untyped, y:untyped): untyped=
  let ix= x.strVal.sy
  let iy= y.strVal.sy
  let body= cons(plus, cons(ix, cons(iy, nil))).walkAST
  quote do:
    proc `id`(`x`: int, `y`: int): int=
       `body`

def(sum, cx, cy)

echo cons("hi".sy, cons(42.mI, cons(cons("world".sy, nil), nil)))
echo sum(paramStr(1).parseInt, 8)
```

(21) A Lisp style macro

Here is an example of the above program in action:

```
> nim c -o:cons.x -d:danger --hints:off --nimcache:xx lispmacros.nim
> ./cons.x 34
(hi 42 (world))
42
```

In Lisp, it is customary to represent any kind of tree as a combination of binary trees. The great advantage of this approach is that Lisp programmers need to learn only one constructor of branches, the `cons` node. In a future version of this tutorial, I intend to give a lengthy introduction to the Lisp method of dealing with tree. One last thing, in order to compile the program of listing 21, you need to keep the library of listing 22 in the same folder.

```
# Library: consp.nim
import strutils, macros
type
  SExprKind = enum Intp, Floatp, St, Sym, consp
  SExpr = ref object
       case kind: SExprKind
       of Intp: intVal: int
       of Floatp: floatVal: float
       of Sym: symb: string
       of St: str: string
       of consp: h, t: SExpr

template mI*(a:int): SExpr= SExpr(kind: Intp, intVal: a)
template sy*(s: string): SExpr= SExpr(kind: Sym, symb: `s`)
template car*(s:SExpr): SExpr= s.h
template cdr*(s:SExpr): Sexpr= s.t
template cons*(x:SExpr, y:SExpr): SExpr= SExpr(kind: consp, h: x, t: y)

proc `$`*(se: SExpr): string =
  case se.kind
  of Intp: result= $se.intVal
  of Floatp: result = $se.floatVal
  of ST: result = '"' & se.str & '"'
  of Sym: result = se.symb
  of consp:
    result.add("(")
    var (r, ind) = (se, 0)
    while r != nil:
      result.add(indent($r.car, ind))
      (r, ind)= (r.cdr, 1)
    result.add(")")

let plus*{.compileTime.}=  "+".sy
proc walkAST*(e:SExpr): NimNode =
   case e.kind:
     of Sym: return newIdentNode e.symb
     of Intp: return newLit e.intVal
     of consp:
       if car(e) == plus:
         return nnkCall.newTree( newIdentNode"+",
                                 e.cdr.car.walkAST,
                                 e.cdr.cdr.car.walkAST)
     else: return newLit "Erro"
```

(22) A Library for the consp data structure

Chapter 18

Finite Automaton

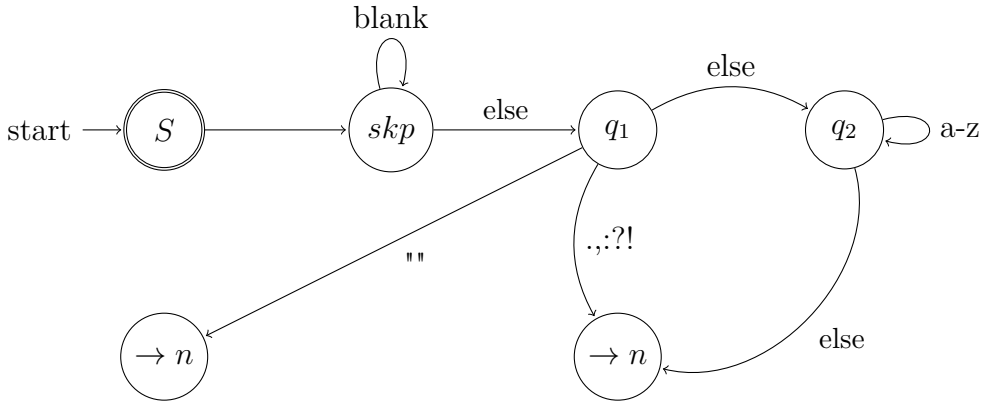


Fig. 18.1: Finite automaton that recognizes English words

A deterministic finite automaton is a finite state machine that accepts or rejects finite strings of chars and only produces a unique computation for each input string. Figure 18.1 above illustrates a deterministic finite automaton using a state diagram. The aforementioned automaton recognizes words and puctuation marks from a text using the Roman alphabet, which is the same as in English. Therefore, this automaton can accept a stream of words and punctuation from an English text.

In the automaton of figure 18.1, there are three states: *skp*, q_1 and q_2. The automaton remains in the state *skp*, while the stream produces blank chars, i.e., `' '`, `newline` or `TAB`. If the computation reaches the end of the string, the automaton stops. If a punctuation mark appears in the stream, the automaton accepts it, and returns $\rightarrow n$. If the q_1 state receives an alphabetical letter, the automaton goes to state q_2 and remains there, while the reader keeps feeding letters.

The program of listing 23 implements the finite automaton and stores the tokens into a singly linked list, of the same sort that you learned in chapter 17. I hope that by now you will be able to compile and test the program without the need for detailed instruction.

```
type
   LLKind = enum Sym, consp
   LL= ref object of RootObj
     case kind: LLKind
     of Sym: symb: string
     of consp: car, cdr: LL

template sy*(s: string):  LL= LL(kind: Sym,  symb: `s`)
template `>>` (a,b: LL): LL= LL(kind: consp, car: a, cdr: b)

proc tkz*(s: string,  ix: int): LL =
  proc skp(s: string, i: int): int=
    if i >= s.len: result= s.len
    elif s[i] == ' ' : result= skp(s, i+1)
    else: result= i

  proc q1(s: string, i: int): int=
    if i >= s.len: result= i-1
    elif s[i] in {' ', ',', ';', '?'}: result= i-1
    else: result= q1(s, i+1)

  var i= skp(s, ix)
  if i >= s.len: return nil
  if s[i] in {',', ';', '?'}: return s[i..i].sy >> tkz(s, i+1)
  var j= q1(s, i)
  if j >= s.len: return s[i..s.len-1].sy >> nil
  else: return s[i..j].sy >> tkz(s, j+1)

proc `$`*(se: LL): string=
 case se.kind
 of Sym: result = se.symb
 of consp:
   result.add("(")
   var (r, ind) = (se, "")
   while r != nil:
     result.add(ind & $r.car)
     (r, ind)= (r.cdr, " ")
   result.add(")")

echo tkz("  She walks in beauty, like the night",  0) >>
         (tkz("Of cloudless climes and starry skies;", 0) >> nil)
```

(23) Finite Automaton in Nim

Chapter 19

Nightmares

I was born in Provo, a small town in Utah, about 82 miles from Salt Lake City. If you are not acquainted with customary units, you will find a good opportunity to practice Nim in the American units of measurement. Therefore, let us interrupt my story and deal with unit conversions. Let us consider only conversions between miles and kilometers for the time being. You will discover easily how to deal with other units. Below, you can see how to use the program of listing 24.

```
~/nim/tutorial/src
> ./build.nims units
nim c -o:units.x -d:danger --hints:off --nimcache:lixo units.nim

~/nim/tutorial/src
> bin/units.x
> 82 mi km
131.938km
> q
```

As you are probably aware, there are a lot of Mormons in that region of the United States. I myself am an atheist, as befits a physician. The rest of my family are members of The Church of Jesus Christ of Latter-day Saints, which is the official name of the Mormon Church. Since The Church of Jesus Christ of Latter-day Saints is a very long name to write or pronounce, Mormons often abbreviate it as The LDS Church, an acronym that reminds me of a popular hallucinogenic drug.

A Mormon believes in many weird doctrines. According to the doctrine of continuing revelation, Jesus Christ leads the LDS Church by revealing his will to its president. The belief is also that each individual member of the church can receive personal revelation from God, while getting on with conducting his or her personal life. However, I never did, which makes me the only Mormon to whom God never revealed anything!

Who is this guy that calls himself God? Apparently, he is a king that rules the Earth from his throne somewhere near the star Kolob.

```
# ./build.nims units
import os, strutils

type
  LL= ref object of RootObj
          h:  U
          t: LL
  UnitKind= enum mi= "mi", km= "km", nm= "nm"
  U = ref object
        case kind: UnitKind
           of mi, km, nm: fVal: float

template car(a:untyped) : untyped=
  if a == nil: quit("Empty stack") else: a.h

template psh(knd: untyped, v: untyped, s: untyped) =
  s = LL(h: U(kind: knd, fVal: v), t: s.t)

proc eval(x: string, s: var LL)=
  try: s= LL(h: U(kind: nm, fVal: x.strip.parseFloat), t: s)
  except:
    case x :
      of "km":
         if (car s).kind == nm: (car s).kind= km
         elif (car s).kind == mi: psh(km, s.h.fVal * 1.609, s)
      of "mi":
        if (car s).kind == nm: (car s).kind= mi
        elif (car s).kind == km: psh(mi, s.h.fVal / 1.609, s)
      else: echo "?"

var s=  ""
var stk: LL= nil
var stack: LL= nil
stdout.write "> "
while stdin.readline(s) and s != "q":
  for x in s.splitWhitespace: eval(x, stk)
  stack= stk
  while stack != nil:
    echo stack.h.fVal, stack.h.kind
    stack= stack.t
  stdout.write "> "
```

(24) Unit conversion

I am not entirely sure whether the existence of Kolob is truly an official doctrine of the LDS Church. In fact, I never cared to ask for an audience with the Mormon Church President, in

order to learn the whereabouts of God. But my grandmother was said to have received a revelation that firmly placed God's home in the neighborhood of Kolob.

A Mormon male who abides by the convenants that he himself or by proxy made with God may be considered for priesthood as early as the age of 12. Let me give you my impressions concerning this particular doctrine. I think that religion should have a content rating system similar to the Motion Picture film rating system. Buddhism and Jainism could be classified as entertainment for general audiences. The Seventh-day Adventist Church do have some material that may not be suitable for children. Therefore, a child, who wants to attend the Seventh-day Adventist Church, should receive guidance from a biology teacher or a philosopher. Teenagers under 17 must be accompanied by an adult guardian, in order to attend any other Christian Church. Finally, no one, 17 and under, should be admitted in a mosque or synagogue.

There are people, such as the biologist Richard Dawkins, who think taking a kid to a Christian temple is tantamount to child abuse. Perhaps due to a degree of ignorance about Dawkins' books, my grandmother started to take me to church, while I was still indeed very young. I cannot remember how old I was when I entered a temple for the first time, but I can assure you that I was under 17. Notwithstanding, I don't want to discuss this child abuse issue any longer.

Another strange doctrine preached by the LDS Church is the so called *law of chastity*, which prohibits adultery, all homosexual behavior, and any sexual relations outside of marriage. The impact that this law had on my life was that I only started a normal sex life at almost 30 years old; it was then that I discovered all doctrines of the LDS Church to be bullshit.

To be fair, I must accept that Mormons are very tolerant, as the following story will bear witness. A Study in Scarlet is novel by Arthur Conan Doyle, where this Scottish author introduced Sherlock Holmes and Dr. Watson to the world. Arthur Conan Doyle imitates the style of the French detective novels by Émile Gaboriau, who always starts his stories with an investigation and presents a long flash back at the second part of the book.

Doyle's story flashes back to a valley in Utah, where nowadays is Salt Lake City. If you read the book, you know that it paints a bleak portrait of Mormonism that includes forced marriage and violence. I was browsing the novel in a large bookstore in Logan, Utah, when many members of the LDS church approached and recommended the book. They have no hard feelings against the Arthur Conan Doyle, and I am sure that I will not lose a single Mormon friend for my bland humor directed against the Church.

There is a custom among members of the LDS Church that is worth preserving. Young Mormons often go to distant countries as missionaries. This means that many couples teach foreign languages to their kids, when they are quite young, so that they are apt to spread God's word to non-English speakers. For instance, my parents wanted me to serve as a missionary among South American Indians. To fulfill my father's design for me, I started learning Portuguese and Spanish when I was 3 years old. Of course, we did not know at the time that Indians, as a rule, do not speak either Portuguese or Spanish.

To my regret, my father never saw me taking an airplane from Salt Lake City airport, in

order to teach the Book of Mormon to Brazilian, Peruvian, Bolivian or Paraguayan Indians. Instead of giving this simple joy to my father, I decided to go to college when I was 16 years old, and started medical school when I was 20. After medical school at the Johns Hopkins School of Medicine, I spent an additional five years in a general surgery residency. Therefore, I was over thirty years old when I finally took an airplane to Brazil. My father did not go to the airport to say goodbye. He passed away three years before due to a colorectal cancer.

As I said before, my father was not at the airport for reasons of force majeure. But my grandmother was there. She entrusted me with two large boxes for the Indians, or Lamanites, as she used to call them. One of the boxes contained Portuguese translations of The Book of Mormon. The other box was heavy with Spanish versions of the same book. The sacred books were quite useful in South America, since my stock of toilet paper became soaked due to bilge water in the boat, which I used for traveling along the Amazon river. On the other hand, my grandmother's boxes were so carefully packaged that no single book was touched by water. So the exemplars of the Book of Mormon provided a good replacement for my lost toilet paper.

Believe me, I will provide you with a full account of my years in college, the medical school at Johns Hopkins, and my residency training. However, right now I want to report on an event that happened while I was living among members of an Indian tribe in the north of Brazil. I will not name the tribe, due to the Hippocratic oath, that forbids me to divulge in any shape or form whatever I see or hear in the course of my profession. In any case, I already named it when I was writing a chapter on money. The fact is that, when I writing about women, money or Italian poetry, I don't consider myself a physician, and am not bound to ancient oaths and convenants.

Upon arriving in Brazil, I heard of a government program by the name of Mais Medicos, which issues a temporary medical license, on the condition that the applying physician takes a job in a remote region of the country. The pay amounts to 3000 US dollars a month. In this list of remote regions, there are a few Indian tribal territories.

By the way, the word Indian is the accepted term that Brazilians use, when they refer to people descended from the Pre-Columbian indigenous population of the land. Instead of calling these populations by some polite noun phrase like Native American, while depriving them of their lands and properties, Brazilians reserved 12.5% of the national territory for Indians. All the same, Brazilians still call them bluntly – Indians. If a tribe proves that its ancestors lived in a given region, it can incorporate that region to their current tribal land. This constitutional act applies to any tribe, no matter how large the region is, or how few individuals belong to the tribe. For instance, Fox/Sun Hills Indigenous Land is the home to 20000 members of the Macuxi people. Its perimeter is 629 miles long. In May 2009, the Brazilian Supreme Court ruled that the Fox/Sun Hills Indigenous Land should be inhabited only by indigenous people, and ordered a military operation to remove all non-indigenous inhabitants. With the addition of Fox/Sun Hills reservation, 46% of the State of Roraima is set aside for Indians.

Of course, Brazilian doctors don't want their practices in a reservation. Therefore, Brazilians who live in large cities like Salvador or Rio de Janeiro form long lines in front of large hospitals

staffed by physicians from prestigious local medical schools, like Unipac or Unifeso. The Indians must be content with a doctor graduated in places like Johns Hopkins School of Medicine, Harvard Medical School or Université de Médicine Paris Descartes.

I must confess that, when I applied for the job, my goal was not to help poor Indians who live somewhere in the north of Brazil. I was envisioning trips along large rivers on a jet ski with a pretty French female doctor riding the pillion.

I must avow that the reality departed from my daydreams in many aspects. The girl who often rode on the pillion was not French, but an American of Danish descent. If you know Logan, the home town of the Utah State University, my Alma Mater, you know that there are a lot of people of Danish heritage there. Family names like Jensen, Mikkelsen and Jorgensen are commonplace in Logan. Therefore, I was very disappointed when I discovered that the closest European girl from my practice was in fact not only Danish, but a Mormon Dane.

I am sure that you will ask: "Well, what is the difference if the girl is French or Danish?" As a French man would say, *Il y a une différence* (there is a qualitative difference).

You certainly noticed that American or English men go simply crazy over French, Iranian or Armenian women. But if a French or Armenian man shows interest in an American woman, he wants to marry her to obtain the right to stay in the United States. Sorry, guys, what I said is politically incorrect, but Truth is often politically incorrect.

A research team showed pictures of pretty women from different countries to 44000 men in the United States. The preference rating of American men was as follows. Armenian women came first. Bajan women came in second place in the preference of American men. Don't ask me where Bajan women come from. I do not have the slightest idea. French women come third, followed by Colombian, Brazilian and Bulgarian women in that order. American and English women occupied the 9th and 10th place in men's preference respectively. This result would be great for American women, if the number of contestants were not 10.

Why do men prefer certain nationalities? The answer is *the ass*. Germanic women often have square butts. By Germanic women, I mean Anglo-Saxon, German and Scandinavian women. A square or H shaped butt is due to the position of the hip bones, excess fat around the waist, love handles or genetics. Armenian, Colombian and French women have a bigger, rounder and shapely booty. Before proceeding with my narrative, I will answer the question that my American female readers are impatient to ask. "Doctor, is there a cure for a square shaped butt?"

Before answering the question, I will remind the reader, be it female or male, that Brazilian indigenous people don't mind being called Indians, provided that they receive 12.5% of the national territory. I hope that American women will forgive me for being rude to the point of saying that most of them have square butts, provided that I tell them how to get an Armenian butt. And that is the main point of this book: A sure and safe way to loose weight and get a round and shapely ass.

As for my Danish girlfriend, after two years with me in the Amazon rain forest, and through following my advice, her butt became so pretty that you would take her for a Colombian

Wayuu Indian, if she were not blond. Unfortunately, since she is a Mormon, the only kind of intimacy that I shared with my Danish girlfriend were jet ski trips.

Now, I will start my narrative at the point in time, when I was traveling on foot to the Indian reservation that the Mais Medicos program assigned to me. Pülowi, my guide, was a young Wayuu Indian girl that entered Brazil illegally across the Venezuelan border. Due to the economic crisis in Venezuela, many Wayuu Indians like Pülowi moved to Brazil, where they pretend to be native Macuxi.

I did not care to ask the name of the town that Pülowi and I were crossing on that occasion, because a village in the middle of the jungle like that one often doesn't have an official name. It is also possible that different groups of people call it by a different name. A policeman that the authorities have sent to keep law and order may call it Hellgate! On the other hand, a drug dealer who takes a break there while traveling to Colombia or Peru prefers Stopover. Since I did not learn its name, I cannot point to that weird settlement on a map or give you any information about its location. What I can say is that the river that flows through the town flooded, a phenomenon that very often accompanies the rainy season in that part of Brazil. As long the rain lasts, a torrent of water flows along the street that runs parallel to the river, and at that time it was no different.

At last the rain ceased. The right hand sidewalk and the street itself was almost dried out. There was no car to be seen. I must add that there are not many cars in the small towns of the Amazonian rain forest. A boat is more useful in that region than a car. In that particular town that Pülowi and I were crossing, one could use their fingers to count the number of cars.

On the right hand sidewalk, instead of normal buildings and houses, I noted only white painted walls. The height of the walls was not uniform, but changed according to the plot of land that it was marking. Notwithstanding, every estate seemed to be surrounded by walls tall enough to hide from view the terrain and every building that one could imagine on it.

What secrets were being hidden from inquisitive eyes? Perhaps smuggled goods? Maybe, that street was a string of chemical laboratories manufacturing illegal drugs. Another reasonable hypothesis is that the plots of land were used to park containers of weapons or stolen goods. I know that, when you reach the end of this book without learning the purpose of these high walls around the tracts of land you will be extremely frustrated. But, believe it or not, I was too scared to stay any longer in that unwelcoming place. What follows will show you that my fear was not misplaced. Due to my unwillingness for any additional exploration, those walls brought only one contribution to this logbook: The inhabitants of the town that Pülowi and I were traversing are not good and law abiding people. It would not take long before my suspicion was confirmed.

Before proceeding with the narrative, I will ask the reader to ponder for a moment about the layout and surprising aspect of the scenery in the street, through which I and Pülowi were walking. A river flows on the left hand side. On the right, there is a line of walls without gates or entryways. How can the owners or their employees reach the buildings or tracts of land that the walls surround? In my mind, I was asking these questions, and to which I never found a satisfying answer.

Only a far away building broke the disparate line of uneven walls. In front of the building, that perhaps was a movie theater, there was a compact mass of people.

The building still was far away, nonetheless I started planning how to make my way through the mass of people to carry on my journey.

I walked slowly due to the heat that danced in the still air. One hundred meters in front of me, Pülowi was running. She was close enough for me to see with pleasure the swinging movement of her buttocks. Whenever she thought that she had distanced far enough away from me, Pülowi would reverse the step, run in my direction, and stop 50 meters in front of me. There she would practice the monkey jump, the half moon, and other moves very popular among Brazilian martial arts practitioners. After this display, she would run again forward along the chosen path.

This way, I was walking with regular steps, while Pülowi kept running forward and backward, in a zigzag movement. Of course, she would displace herself in ever longer distances going forward than coming backward, so she could advance at the same speed as her companion, of course that was me.

Since that town seemed to be so dangerous, people may wonder why I kept such a slow pace. The northern part of Brazil is hot as hell, that is why! During the day, the temperature often reaches 100 Fahrenheit. What I think is amazing is not my lumbering, but the zigzag jogging of the Indian girl.

Although we were advancing very slowly, due the slow pace that the heat imposed on me, and Pülowi's zigzag jogging, we finally reached the throng of men in front of the movie theater. The methods that each one of us chose to cross the horde could be used by a psychologist to draw our profile.

The Indian girl penetrated the crowd boldly, poking people who were at her right and left sides, kicking anyone in front of her, squeezing herself forward like a determined winding snake, while stepping on any foot that was in her way. Don't ask me how she was able to avoid harassments from the bullies and attacks from the thugs that were gathered in their element. It is possible that the ruffians thought that she was the lover of a local drug lord. After all, what kind of woman could dare to jump in the middle of such a dangerous crowd, unless she felt herself protected by a top dog?

As I told you, there is a river that flows along the left hand side of the street. The overflowing water spread over the left hand sidewalk. A long flatboat was moored across the throng. The layout was such that the crowd took up completely the narrow space between the river ship and the movie theater leaving no room for easy passing. In fact, the river ship was in itself long enough in that the bow and stern were free of this multitude. I figured that if I entered the vessel at the bow, walked along its deck, and disembarked at the stern, I would get around the crowd. The point for me was the boat, in that position, stood out like an invitation around trouble. I guess that an FBI profiler who might observe me performing this maneuver, would deem me a coward, a man prone at all cost to avoid confrontation. Pülowi, to the contrary, would be classified by the same profiler as a risk taker.

The ship's taffrail formed the outermost wall of the cabin. Judging from the size of the cabin,

one could infer that the boat was a floating home. However, the owner was elsewhere in all likelihood. He could even be mingled in with the crowd in front of the movie theater, trying to do whatever the others were doing. The cabin door opened on deck side, towards the river. Then I could not see the man who was crouched at the entrance, and the circumstances seemed to indicate that nobody was home. Therefore, when I jumped on the deck, and started towards the stern, I was startled by a voice coming from my right hand side shouting – "What are you doing on my boat?"

My error is understandable. At the time of these events, I did not know that people do not leave their houses unattended in Brazil. If somebody is stupid enough to leave his house without a guardian, theft is certain, and invasion followed by squatting is very likely. I cannot resist the temptation of comparing Brazilians with Russians in this particular. When I studied at the Bauman University, in Russia, I knew Victor Bojarczuk, a mathematician whose parents and brothers lived somewhere in Siberia.

When the Bojarczuk family traveled to a far away town, in order to buy supplies and tools, Mother Bojarczuk would prepare non perishable food and fuel for heating. Therefore, if a traveler should get lost in those vast frozen expanses, he would find a welcoming abode, a refuge, which would protect him from the cold, through providing firewood, food and water. Mother Bojarczuk did not hope for gratitude from the men and women that she helped along her life. It is a fact that many men, women and even children enjoyed the anonymous hospitality of the Bojarczuk family and other Russians that share these beautiful traditions and practices. But Mother Bojarczuk never met any of these persons that she saved from a horrible and almost certain death. On the other hand, Victor told me that his family never missed anything of value that they left in the house. Travelers would eat the food, use the firewood, sleep in the beds, but would not steal a thing. Since I don't want to leave this behavior without witness and mention, I will list here the names of some people who are members of the Bojarczuk family: Leon, Victor, Nina and Tom.

The deck of the flat bottomed boat sat only 2 feet above the water level. Therefore, the design of the ship made it easy for me to throw my medical bag over the rail, and raise myself onto the bow deck. There, I quickly recovered my medical bag, and started to walk friskily towards the stern. As I said before, the ship master's voice stopped me abruptly in my tracks: "What are you doing on my boat?".

The man, to my reckoning, was about fifty years old. However, it is hard to know the exact age of people who live in that region of Brazil by appearances, as their skin is marked by wrinkles and grooves. These deep skin furrows can be explained both through old age, or constant exposure to the hot tropical sun, which also accentuates skin grooves.

If natives from northern Brazil were there with me in front of the boat dweller, they would not be able to say for sure whether that man had ancestors among South American Indians, Africans or Europeans, but his forefathers certainly came from one of these parts of the world. In Brazil, the climate and the methods used to earn a living have deeper influence on the phenotypical aspect than does ethnic origin.

The boat dweller had a length of tobacco, which looked like a thick piece of rope. This he was chopping very finely with a curved knife. The making of straw cigarettes from rope tobacco

is very popular among Brazilian men who live in the country side. The behavior of chopping tobacco is relaxing, and this psychological addiction adds to the effect of the nicotine. In fact, many Brazilians claim that they managed to get rid of the habit of smoking, but they could not stop tobacco chopping and hand rolling straw cigarettes. An important component of the behavior is to perform tobacco chopping while crouching on one's heels. Researchers observed that chopping tobacco and hand rolling straw cigarettes consume so much time that country side Brazilians end up smoking moderately. At least, if one has to chop tobacco and hand roll one's own cigarettes, chain smoking becomes impossible.

When I mentioned the curved knife that the Brazilian boat dweller was using to chop tobacco, the reader certainly imagined some kind of weapon similar to the Turkish scimitar. However, the tobacco chopper's knife did not have the cutting edge on the outer part of the blade curvature. The edge of the Brazilian knife is in fact found within the curved blade. A good way to imagine this knife is as a cutting hook. The ship master did not wait for me to arrive at any conclusion as to the goal of such a knife design.

"What are you doing on my boat? I will answer this question myself. You thought that I am an old man, therefore you can enter my house, steal my property and kill me in the process, if necessary. After that, you would probably rape my granddaughter. But I have something to tell you. I may be stronger than you, or perhaps you are stronger than me. In any case, do you see this hooked knife? Do you know why it has a cutting edge curved to the inside? I will answer you this question as well, for you do not seem to know local customs. In my land, that you are visiting, one uses this kind of knife to castrate pigs. The curvature hooks around the testicles, and all one needs do is pull on the knife, in order to complete the task. Since you are a curious man, you certainly have another question. Why do I need such a long knife for castrating piglets? The fact is that this knife has two functions. The first one is to castrate pigs, as I already made clear. The other one is to gut intruders. I am a civilized fellow, and do not usually castrate men before gutting them. However, I may make an exception in your case, since you certainly intended to rape my granddaughter. In this special circumstance, castrate before killing is not an unusual or cruel punishment."

I tried to show myself as being calm and collect in light of the circumstances I now found myself in, while replying to the long diatribe of the boatman. "You are mistaken, my friend. I am not a thief, murderer or rapist. All I want to do is to go around that mob over there. That is the only reason for my entering your flat bottomed ship."

At this moment a girl came out of the cabin. She was the granddaughter of the old man, to be sure. She was wearing a sooted dress, which was white at some point in time. However, the girl often held and shook it over an open flame in order to kill fleas and ticks. The girl's hair was tangled and dirty. She was holding a rag doll, which had lost the two arms and one leg. The doll's skirt was also gray with soot, just like the girl's dress. I guess that the girl held and shook the doll over the fire, in order to kill imaginary ticks. Another possibility is that she used her old clothes to make skirts and dresses for the doll.

Suddenly, the girl spoke. "Grandfather, after killing this bad man, and before throwing the body into the river, cut his hair off for me. I need it for Rachel's wig. The hair of the other bad man, which I sewed to my doll's head has almost entirely gone."

The old man answered the girl: “I am not sure whether this man is really evil. After all, he has not hurt you or me. Of course, I don’t know what he would do, given the chance. For the time being, he is only a trespasser. Anyway, my dear, I still have not had the time to interrogate this individual, as to whether he did not attack us for lack of opportunity or for not being of violent intent. In the latter case, I will give him a speedy death by cutting his throat, and throwing his body over the rail. Besides this, if he is only a trespasser or a mere thief, I don’t intend to mutilate his face or defile his body. But if he is a rapist or a murderer of children, then I need to make him an example for others with like character. A rapist deserves to be gutted and lay in agony on the deck before being thrown into the river. Whatever is my decision, I think you should enter the cabin. You are too young to witness an execution.”

At this moment, I felt the need to interrupt this not so delicate conversation between this loving grandfather and his lovely granddaughter. This was not due to my having any preference concerning the methods proposed for my death, but purely to gain some time. “I ask you, dear Sir, do not try to cut my throat, because I don’t think I deserve dying so young. I am a doctor, a physician. I was born in the United States, a country where doctors are held in high esteem and usually do not get involved in crimes. On the contrary, they are always ready to help people. For instance, you have a skin condition that I suspect to be basal cell carcinoma. In simple terms, you have cancer, but not a dangerous and aggressive kind of malignancy. I can heal you.”

The talk about cancer was contrived in order to gain time. I could not diagnose cancer through a glimpse from two meters away, let alone classify the disease as basal cell carcinoma. However, if the man were to buy my talk, I could fake a medical procedure and try to win his good will. At the very least, I could divert his attention long enough for a quick escape. Unfortunately he seemed too stupid to understand the meaning of carcinoma. Anyway, without waiting for his reaction to my words, I kept my eyes on him, while stepping backwards, in the direction of the stern. However, I was so unfortunate that I tripped on that kind of step produced through those differences that often exist between the prow and the stern of a deck. I tripped and fell on my back.

The first thing that a retreating person thinks when she or he falls back is to prop on both hands to get up. This strategy is dangerous, since it precludes the use of hands for defense or attack. Therefore, practitioners of Brazilian Jiu Jitsu developed techniques for taking the fight to the ground. I learned these techniques while still at Logan, but they proved to be ineffective on this particular occasion, since my opponent did not make any gesture towards attacking me. He merely shouted orders to his granddaughter. “Darling, could you bring my shotgun here? It is fixed on the wall, above my bed.”

Masters of Brazilian Jiu Jitsu never told me anything about shotguns. Then I forgot their excellent lessons, turned by back to the boat dweller, raised on my foot and started the six meters that separated me from the stern. Of course, I am not sure about the distance that separated me from the stern and safety. Probably I would not be safe even after jumping out of the boat, since the crowd in front of the movie theater could side with the boat dweller. In any case, when I was making the final steps to the stern, my way was interrupted by the presence of two uniformed men blocking my way.

The policemen seemed to be more interested in the boatman than in me. Therefore, it was to my enemy that one of the policemen, a tall European looking fellow, said: “So, did you kill the Bolivian? I mean, the Bolivian policeman who was found floating down the river, with large patches of missing hair.” The other policeman, a short and stout mulatto complemented the thought: “I wondered who would kill a man to steal his hair. Now I have a good explanation for the event.”

One thing that I learned from Brazilians is to trust policemen less than gangsters. Therefore, while the two policemen were interrogating the boatman, I started to walk around them in order to escape from that ambiguous situation, where I could not tell the intent of the new arrivals. But the stout mulatto tried to interrupt my get away. “My partner and me, we just saved your balls and maybe your life. Aren’t you going to show your gratitude?” I was in Brazil long enough to know how to show gratitude, therefore I asked: “How much do you want?” The response of the police officer did not help to make the negotiations advance: “How much do you have there?”

At that moment, I saw Pülowi standing by the door of a car and frantically signaling me. I did not give further heed to the two policemen, and reached for the low rail around the stern, jumped to the sidewalk, and ran to the car. Pülowi entered the car ahead of me, slided on the seat over to the other side. With that movement, she left the open door ready for me to enter the vehicle. As soon as I was half sat, the driver accelerated the car so fast that the door closed on its own inertia.

Pülowi started a conversation in Russian to keep me a par of developments. “I guess you speak Russian, as I saw you reading a novel by Boris Akunin on your Kindle. When I hired this fake taxi driver, I pretended not to know Portuguese or Spanish. Therefore, when he hears us speaking Russian, he probably will think that we are conversing in an Indian language, such as Quechua. I would doubt very much that he can tell the difference between Russian and Quechua. The point is that we are not safe yet, since this man clearly intends to steal your money and rape me. He avowed these plans to his companions, since he thought that I could not understand what he was saying. Therefore, whatever he does, don’t react. Let me handle the situation. My job is to get you safe to Raposa do Sol, so don’t let your amateurish maneuvers make this task harder than it already is.”

The street along the banks of the river ended at a glade that grazing animals had cleared in the forest. The driver stopped the car and told me: “Start walking, leave the little Chinese girl entrusted to my care.” People in Brazil often confuse native Indians with Chinese or Japanese, since they display oriental features.

The assassin spoke in coloquial Portuguese, when he made the suggestion that I should depart and leave Pülowi behind. However, he was not sure that I could understand Portuguese. Therefore he made his meaning clear with a Glock pistol that he brandished, using the weapon to make a gesture in the direction of a single line track that penetrated into the forest.

I am not brave enough to face an armed drug trafficker. Even so, I did not hide myself in the forest, as the fake driver suggested. In fact, I stayed put, in doubt about what to do. Even if I would be coward enough to run into the wood, after raping the girl, the ruffian would

remember that I could be carrying money. In that case, he would chase me and kill me easily, since he knew the land. Evasion was not a good option for an intelligent coward, like myself.

After suggesting me the way into the woods, the bully focused his attention on Pülowi. Initially, he pointed the gun on her head, in order to bend the girl to his will. Then he probably concluded that a gun was an excessive resource for taming a young woman, and it could get in his way during the rape. I could infer that the man concluded that a gun was not necessary for the task at hand, because he dropped the pistol on the ground. I immediately thought that an opportunity could arise, where my taking hold of the pistol could be attainable, when the rapist started doing what rapists do best.

I cannot remember what plans I had created in my mind for wrestling the gun away from the thug. In any case, my plans did not come to bear. As soon as the rapist dropped his pants, the girl drew a knife from a sheath on her lower left leg and cut his penis off. The proceeding stage of Pülowi's master plan was to get hold of the gun. Upon doing so, she liberated the wounded man from his misery by shooting him in the head.

I followed the wild woman in silence to wherever she wanted to lead me. We followed the river downstream through the dense forest until we found a motorized boat hidden among the canopies of the low lying trees that grew on adjacent swampland. It seems that Pülowi left that boat there a few days before for the sole purpose of providing us a quick getaway.

Pülowi piloted the boat to a much bigger town, with well constructed and conserved buildings. There were many warehouses and illegal sawmills built in their essence from premolded concrete. The Indian girl guided me to a two floor office facility. Only one of the offices was occupied, and even here there was a lone middle aged man, who was sat in a very comfortable chair behind a desk. The girl and me stood, as there were no additional chairs for possible visitors.

The Indian girl told the owner of the establishment: "Here is your man, safe and sound as I had promised you. I hope that my payment has been transfered to my account in Colombia."

"I still need your services, young woman, and as long as I need you, be rest assured that I will deposit your money as agreed. Do you need ready cash for your trip back home?"

"I am not crazy enough to carry cash on me in such a place. When I need something, such as food and tools, I prefer to steal or rob, instead of drawing attention to myself by paying in cash for an item and showing everybody that their attack on me could be profitable."

"Since you are satisfied that matters between us are settled, you can leave me with the doctor to talk business."

I thought that the man behind the desk was some sort of government officer in charge of administrating the Indian reservation. Therefore, I asked him when I would depart for the Indian village, where I was supposed to work.

"There is no Indian village. In fact, there is no Pirunucu tribe. The bureaucrats in Brasilia created many fictional towns and villages for bogus medical positions. Politicians and fake entrepreneurs keep half of the payment that should go to the doctors in charge of inexistent

practices. The doctors themselves receive the other half for doing nothing, which is a good deal for everybody!

"Creating fake ids or borrowing the id from a dead person is a common practice in Brazil. For instance, crooks often claim that a deceased person is alive to collect benefits from social security or medical insurance companies. In practice, long after the death of the client, hospitals and lawyers keep collecting pension checks, benefits and payments for providing health care. The case of Mais Medicos is interesting, because the swindlers have created whole tribes, towns and cities for embezzling money. However, this is by no means the largest scheme for stealing public money! For example, the supplying of water to urban populations provided interesting opportunities for corrupt politicians to rake off some good cash.

"The most notorious case of such schemes to earn money with water transference projects, which in fact deliver little or next to nothing of the promised resource, is the transference of water from the San Francisco River to smaller streams in the Northeast of Brazil. The civil engineering works should have taken at least 10 years. The fake engineering firms asked for two billion dollars in small installments for completing the project, only to revise the value upward to 4 billion, when arriving at the deadline of completion. It is pointless to say that at the deadline there were no channels to speak of. The make-believe engineers counted on time for removing the necessity of accountability: In ten years, honest engineers and politicians involved in the project would be dead from natural causes, killed or removed from the political process, and the surviving engineers and corrupt politicians would have time for making the money untraceable. The other possibility is that the incumbent government would go bankrupt and stop paying the installments, which would provide a good excuse for interrupting the works, thus keeping the amount already paid.

“In this town of ours, the world and his wife are organizing schemes for accumulating wealth. There are people who are chopping down the forest to obtain wood, which will worsen global warming, but not before making the criminals rich from selling the wood to furniture manufacturers in Denmark. There are also people that are mining gold in the Indian reservations, which is by the way illegal. I represent the miners and panners. Since I am not half as bad as many of the criminals here, I saw to it that the Indians receive their fair share of the criminal operation. I am talking about real Indians, flesh and blood human beings, not imagined tribes, such as the Pirunucus. These Indians do need physicians and dentists, and have the money to pay you. What do you think about working for my Indians? Not that I care about these Indians, but they have low immune resistance to European infectious diseases. If all of them die from the contact with civilization, squatters will occupy their land, and I will not have the monopoly of buying the gold that belongs to them.”

“If what you are telling me is true, I am involved in a criminal scheme, and I will denounce it to the authorities.”

I must reveal a few things about myself. The first revelation is that I am not like Archie Goodwin. This means that I cannot reproduce a conversation verbatim. For those of you who do not know who is Archie Goodwin, Rex Stout wrote many books about an old man, Nero Wolfe, who was so fat that he rarely left his brownstone house voluntarily. Therefore, he spent a lot of money to make his home amenable to all his needs, hobbies, desires, impulses

and cravings. One of his passions was eating, the other was orchids, in that order. Therefore, he hired a Swiss chef and a German gardener. Of course, the Swiss chef was born in that region of Switzerland, where the locals speak French. It was in French that Nero Wolfe discussed the everyday menu with Fritz, this is the name of the Swiss chef.

In September 1934, Nero Wolfe left his home willingly for the privilege of dining at the same table as Albert Einstein. I guess that he accepted the invitation not because he would sit with Einstein, but because the food was good.

How could Nero Wolfe manage to sustain such an expensive life style? Well, he owned a detective agency, where the only fixed employee was Archie Goodwin. The peculiar ability of Archie Goodwin in repeating conversations verbatim came to my mind because the top of the desk was full of books on Nero Wolfe. The man in front of me certainly was fond of tales about the obese *bon vivant*. However, let us return to that strange office with only two pieces of furniture, a desk and a chair. Before this long digression, where I explained who Archie Goodwin was, this report came to a stop at the point, where I was strongly putting the case to my host of the need to inform the authorities about this scheme for hiring fake physicians.

“I repeat, it seems that I became one of the victims of a criminal scheme for hiring unscrupulous doctors. The authorities must be told of
this embezzlement of public funds.”

"From your choice of vocabulary, gestures and tone of voice, I got the impression that you believe that I am part of these criminal activities. I can also infer that you are a newcomer to Brazil, since you believe that the local authorities are engaged in crime fighting operations in the broader sense. This may be true, if the criminals are disrupting crimes committed by the authorities themselves, such as corruption, misconduct, passing legislation without rising above self-interest, overpricing, report falsification and fake bids. I could keep on listing the different transgressions of the laws of the land and crimes against humanity that Brazilian authorities have devised to increase their income or for a comfortable retirement plan in Paraguay. Unfortunately, I am not sure whether the English language has all the technical words for describing the variety of unlawful acts that Brazilian public officers commit on a daily basis.

"You need to wise up. For instance, did you notice that there is no chair for visitors in my office? The reasons for a person coming to me are many. Very few people enter through that front door, in order to propose a mutually beneficial deal, but given the opportunity through a lapse on my part, they will force the tide to turn in their favor. A slightly larger class of callers want to profit at my expense. Finally, there is a large group of men and women that appear with the clear intention of killing me or taking me for everything they can.

“In any case, when you say that you will report the misappropriation of public funds, you sound as you were threatening somebody. Since I am the only person in this room, it seems as though your threat is aimed at me. The fact is that I have nothing to do with this health scam. I found out that it existed through pure chance. When people in Brasilia discovered that you would come here to take up a doctor’s position for an inexistent tribe, they decided it would be best to kill you, since you could call public attention to what they are doing. As things stand, the criminals do not have operatives in this part of the country, and so they

contacted my cousin Pafuncio to do the job, who subcontracted me. I don't know what I would do if the amount paid were large enough. However, I am a little soft and sympathize with your predicament. Therefore, I am proposing a deal, where you will do exactly what you intended to do at the start of your long wending journey to this place, to wit, provide health services to an Indian tribe."

"Sorry for being rude. I guess I will accept your offer for no other reason than to discover a way for returning to civilization."

"I don't know why this place cannot be considered as civilized. Perhaps because people here prefer to do business with Indians, instead of exterminating them with the intent of bringing a doubtful brand of civilization. Don't worry. You won't find civilization in the abstract sense of the word, but you will enjoy all benefits of civilization. In the restaurant downtown, you can drink French wine, eat ratatouille and hear La Vie en Rose on an old jukebox. Sorry, the waiter does not speak French, only the whores do. I am not sure whether our health service is as good as in Paris, but providing health care is your job, isn't it?"

At that moment, a blond young woman appeared behind me and poked my ribs with the muzzle of a handgun. Since I was not expecting an interruption in that strange conversation, hearing a voice behind me coupled with the poke in the ribs, really gave me a fright. The official, at least, let's call him that, explained the situation, both to calm me and prevent the new arrival from becoming overly protective by shooting me.

"Sorry, Doctor. I called Ms Anita Nikolaisen, who will show you your accommodations, and teach you the basics of Nheengatu, that is the language spoken by the tribe where your practice will be located. To make sure that I receive what is due for my intermediary services over this whole arrangement, the hired doctor, in this case you, should double as my interpreter in my dealings with the council that governs the Indians. Therefore, it is important that you learn at least some Nheengatu with the help of Ms. Nikolaisen."

After signaling to the blond woman that everything was fine and that I posed no threat, the man continued his rambling.

"Since I couldn't imagine a better way of calling Ms. Nicolaisen, I pressed the panic button under the top of my desk. When Anita hears the signal from the panic button, she enters my office shooting. I raised my hand, as a signal for her not kill you. The hand signal sometimes works as intended."

Anita continued the explanation, giving her side of the whole episode, as an excuse for her behavior toward me.

"The problem is that I did not know anything about the signal. When I received the panic signal, I thought that we were under attack. I entered here ready for shooting. What is your name? Well, Mr. Jensen, I refrained from killing you, not because of Mr. Rafael's raised hand. For one thing, I was afraid that the bullet could hit my boss, after going through your body. Besides this, I don't know what you carry in this suitcase, but it may be a bomb ready to explode if you drop dead and release a possible trigger that you keep pressed while you are alive and conscious. While the terrorist keeps such a trigger down, the bomb does not

explode, but if an agent of law kills the fanatic, he automatically releases the trigger, and the bomb goes off. I heard that Islamic fundamentalists rely on such a device."

"Now that I have learned of my narrow escape from death, let us discuss my wages."

"I am afraid you didn't understand what is going on. My business is not health care. I do not run a charity institution. I am a racketeer. The contract is very simple: You pay 20% of every penny you earn in the Indian Reservation. The value is so low, because you are going to render me invaluable services as an interpreter and bookkeeper of the gold extracted from the mines."

"Then, how will I earn my money?"

"That is a good question. Should I answer that this is your problem? You bet I should! However, since you are a foreigner unaccustomed with the practices of the land, I will elaborate on the standard answer. The Indians have their share of the valuable minerals extracted from their land. Therefore, they can pay your fees. Then you have the gold diggers, that are stabbed from time to time. If you save the life of a stabbed man, or a shot man for that matter, you can send him a fat bill. When I say *send a fat bill*, I don't mean really send a fat bill. Brazilian miners carry their valuables, such as gold nuggets, precious stones and even foreign currency in their underpants. Everybody knows that. Therefore, at airports, the first thing that a customs officer checks are the underpants of any individual suspected of smuggling money from one place to the other. Even though most people know where the valuables are, nobody steals from a wounded miner. Except his doctor and nurses of course. If you save the life of a man, you can collect some 70% of his belongings as fee. Please, collect at least 20%, that is my part of the deal. Leave him with 30% of his money or gold nuggets, for the trip back home.

"There is another way of making your stay in Brazil profitable. From time to time, French cosmetologists come to this particular region of Brazil to buy raw material for soaps, perfumes and the like from the Indians. You can intermediate the sale of such products and realize a sizable amount of euros. Don't forget about my 20% here as well."