Adaptive DFA – the development of adaptable methods

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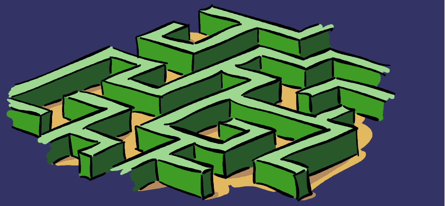
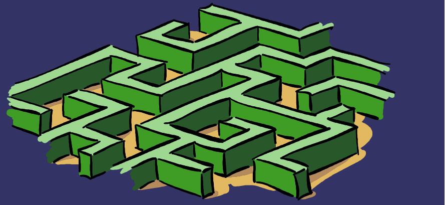


Overview

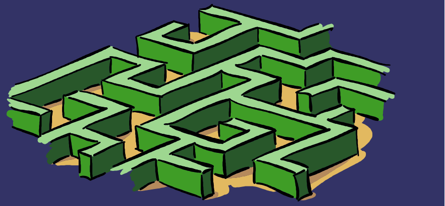
- 5 years ago, in [Pop 04] and [Pop 05] the Adaptive DFA was proposed
- Various implementations was during this years: using Oberon-2, using C and C++, by the original author and his students

- Now we are coming back with a mathematical point of view concerning Adaptive DFA suggested by the use of the VHLL Haskell.



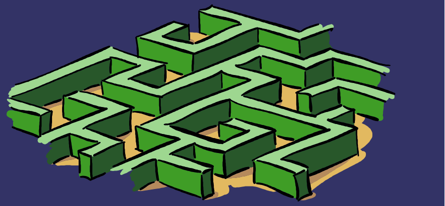
Preliminaries

- The mathematics of Adaptive DFA is here described using a notation high related to Haskell.
- Functions will have long names:
  f(x) will be used together with, for ex:
  funct(x) and even funct x
- Multiple parameters functions will be written not as functia (a, b) but as
  functia a b



Preliminaries (II)

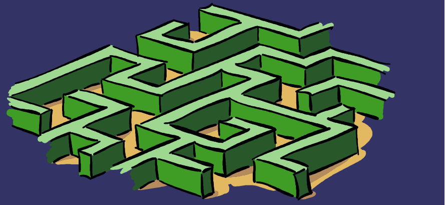
- The sets will be in fact ordered sets with eventually duplicated elements (lists). Ex:
  x= [1,4,5]
  [x | x <- a | x >3]



Preliminaries (III)- The “cradle”

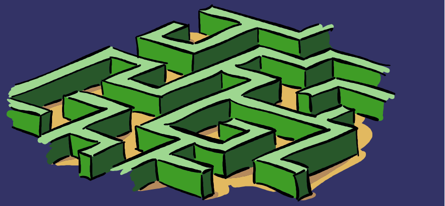
- Every program is having some auxiliary functions. Here, they are:
- --- Intersection of two lists, reloaded ---------

```
intersect a b =
      [ c1 | c1 <- a, c2 <-b , c1 == c2]
```



Preliminaries (IV)- The “cradle”

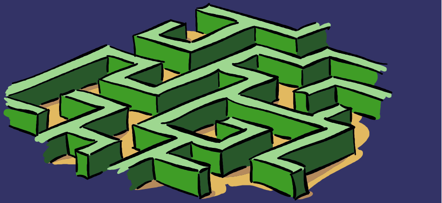
```
-- Adding spaces at the end of the string s

addspace s = ' ':s++" "

-- Also can be written as (not so fast):
-- addspace s = " "++s++" "
```



Classes of characters

- According to the paper [Pop 05] where Adaptive DFA was mathematically presented for the first time, the characters processed by an Adaptive DFA are, first of all classified in :
- Letters,
- Digits
- Spaces etc.

The process is similarly with part of the lexical analysis

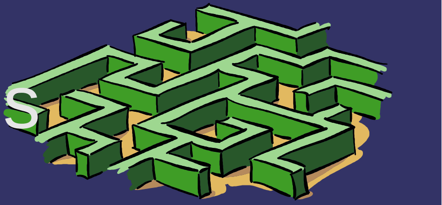


Classes of characters

- -- Simple function to compute the class

```
clasa a =
      if (a >= 'a' && a <= 'z') ||
         (a >= 'A' && a <= 'Z')
          then 'l'
          else if (a >= '0' && a<= '9')
               then 'c'
               else if a == '\t' || a =='\n' || a ==' ' then '_'
                    else '?'
```

- -- 'l' = alphabetic, 'c' = digits, '_' = spaces

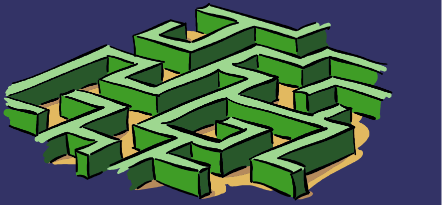


Preparing words for storage

- -- Classifying the characters from a new word
-- means adding spaces and classify the result
-- character after character. What we get will be
- -- called “scheme”. Ex: “_ccc_”

- clasifica = (map clasa). addspace

-- Where,..., you know:
-- map – the usual map of functional languages
-- Ex: map f [x,y,z] = [f x,f y, f z]
-- 'dot' is the product of functions



Simulating the storage in the matrix

{--

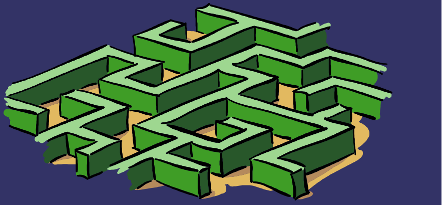
Pentru fiecare tripleta (x,y,z) de clase ale unor simboluri succesive vom pastra schemele cuvintelor care contin acea tripleta intr-o lista asociata tripletei. Aceasta lista devine un al patrulea element.

Lista se poate afla usor filtrand dictionarul:

filter (substr (x,y,z)) dict

unde functia filtru este data de formula:

--}



Simulating the storage in the matrix

{--

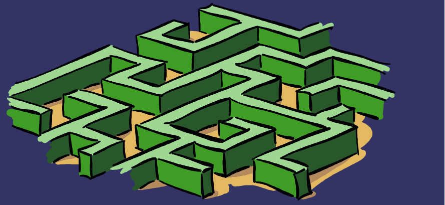
For every triple (x,y,z) (x,y,z being classes of successive symbols of the word) we will preserve the schemes of those words in a list which is associated with the triple, becoming the 4th element.

The list can be easily found by filtering the dictionary itself:

```
filter (substr (x,y,z))  dict
```

where the filter is defined as:

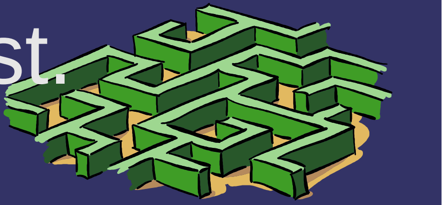
--}



The filter

-
  ```
  substr (x,y,z) (c1:c2:c3:t) =
        if c1==x && c2==y && c3==z
        then True
        else substr (x,y,z) (c2:c3:t)
  substr (x,y,z) (c1:c2:[]) = False
  ```

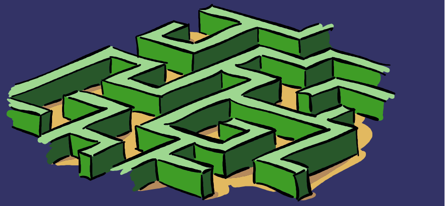
- -- if the sequence of classes “xyz” is found somewhere in the scheme of the word, this fact triggers the placement in that list.



The trained Adaptive DFA

-
  ```
  automat dict =
   [ (x,y,z, filter (substr (x,y,z))  dict )
       |  x <- n, y <- n , z <- n  ]
       where
          n = "lc_"      -- n = map clasificare "D2 "
  ```

- -- Note: The *dict* which is used here is in fact a list of schemes of the words serving as training examples.



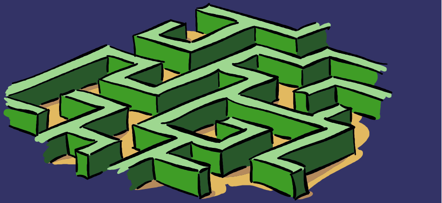
Rebuilding examples from previous papers

- Now, the adaptive DFA from [Popa05] which was trained to accept numbers can be simply defined as:

- a = automat ["_c_", "_cc_", "_ccc_"]

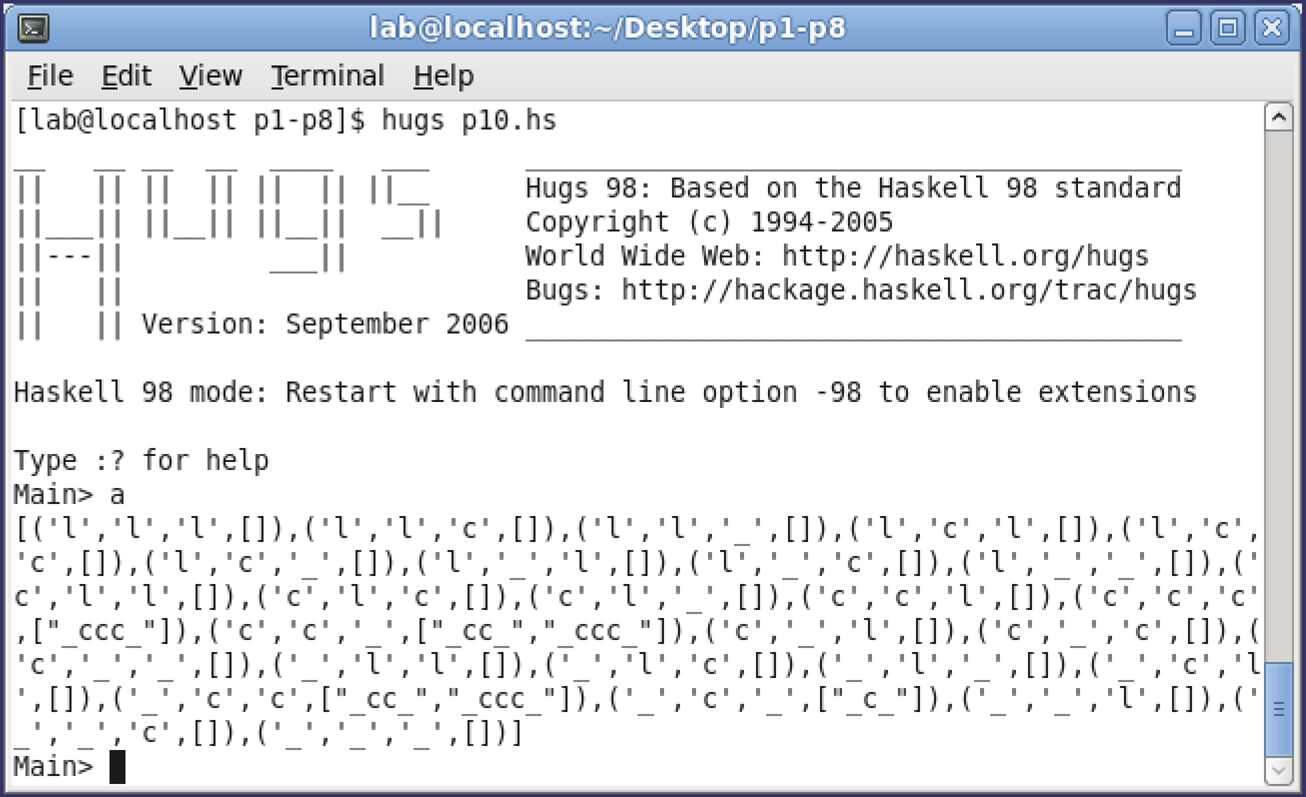
  Or using examples and the classification fct.

- a = automat [clasifica "0", clasifica "21", clasifica "196"]

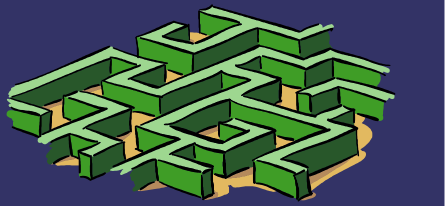


Rebuilding examples from previous papers

- Now, the adaptive DFA from [Popa05] can be established by simply asking Hugs or GHCi to produce an explicit value:



```
[lab@localhost p1-p8]$ hugs p10.hs

__   __ __  __  ____   ___      _________________________________________
||   || ||  || ||  || ||__      Hugs 98: Based on the Haskell 98 standard
||___|| ||__|| ||__||  __||     Copyright (c) 1994-2005
||---||         ___||           World Wide Web: http://haskell.org/hugs
||   ||                         Bugs: http://hackage.haskell.org/trac/hugs
||   || Version: September 2006 _________________________________________

Haskell 98 mode: Restart with command line option -98 to enable extensions

Type :? for help
Main> a
[('l','l','l',[]),('l','l','c',[]),('l','l','_',[]),('l','c','l',[]),('l','c',
'c',[]),('l','c','_',[]),('l','_','l',[]),('l','_','c',[]),('l','_','_',[]),('
c','l','l',[]),('c','l','c',[]),('c','l','_',[]),('c','c','l',[]),('c','c','c'
,["_ccc_"]),('c','c','_',["_cc_","_ccc_"]),('c','_','l',[]),('c','_','c',[]),(
'c','_','_',[]),('_','l','l',[]),('_','l','c',[]),('_','l','_',[]),('_','c','l
',[]),('_','c','c',["_cc_","_ccc_"]),('_','c','_',["_c_"]),('_','_','l',[]),('
_','_','c',[]),('_','_','_',[])]
Main> 
```

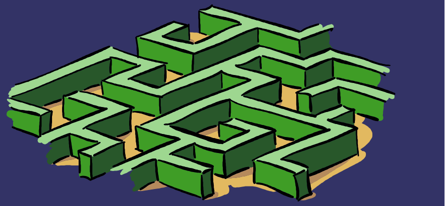


Using a trained Adaptive DFA

-
  ```
  analiza cuvant automat=
    [ m | (x,y,z,m) <- automat
          , (x,y,z) `elem` triplete cuvant]
  ```

-
  ```
  -- and if you want to trace:
  ```

-
  ```
  trace cuvant automat=
    [ (x,y,z,m)| (x,y,z,m) <- automat
          , (x,y,z) `elem` triplete cuvant]
  ```

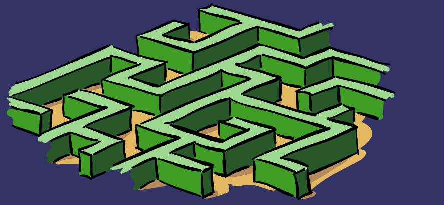


...where the proposed text is broken in “triples”...

- ------------------ Auxiliary---------------

-
  ```
  triplete ::[Char] -> [(Char,Char,Char)]
  --triplete [a,b,c] = [(a,b,c)]
  triplete (a:b:c:d) = (a,b,c) : (triplete (b:c:d ))
  triplete (b:c:_)   = []
  ```

- Note: in the previous slide x `elem` m is the test “if the element x belongs to the list m “

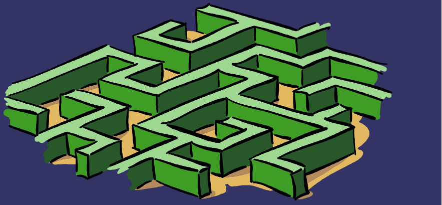


The analyzer's engine

- --- Analyzing the Word using an ADFA --

- analiza cuvant automat=
-   [m | (x,y,z,m) <- automat
-          , (x,y,z) `elem` triplete cuvant]

- Remark: The list may contains more sets of “schemes”. If one “scheme” appears in all this sets -> the word is accepted. See next slide:

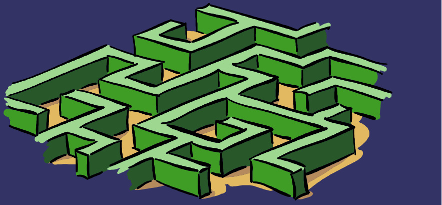


Accepting a word

- -- Acceptance by intersection.
- -- When the ADFA is processing a token, it can identify more than one set of schemes partially matching that token.

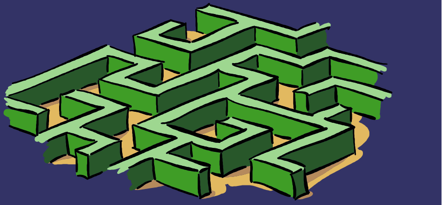
- acceptare cuvant automat

```
acceptare cuvant automat
  = foldl intersect (head a ) a
    where
      a =  analiza cuvant automat
```

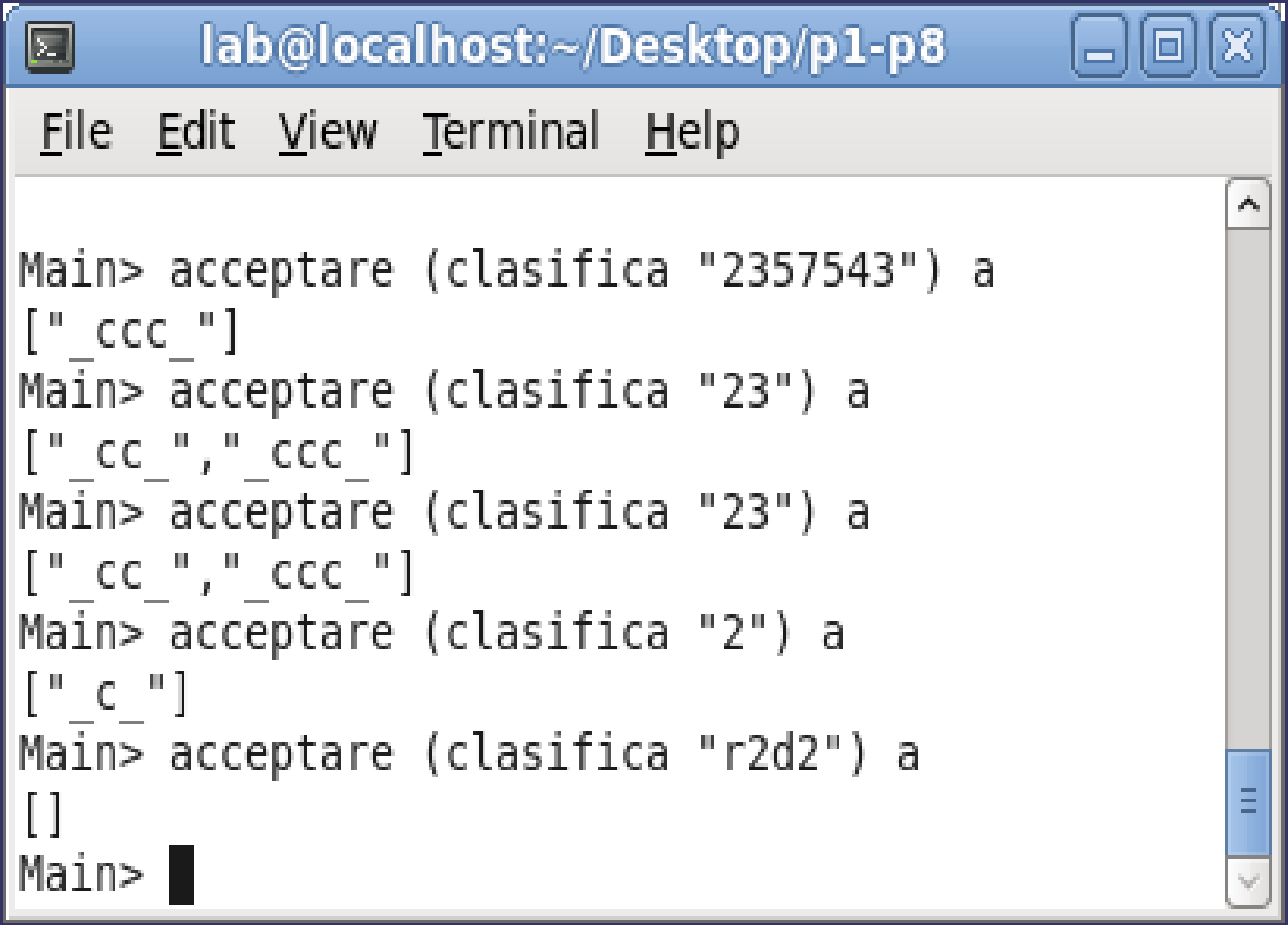


Acceptance criteria

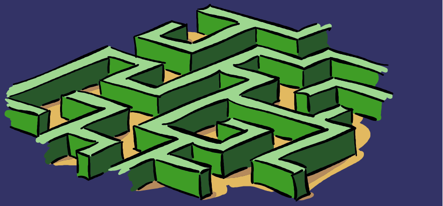
- The intersection contains ONE or more SCHEMEs => Accepted.
- The intersection did not contain a common scheme, so it is [ ] => Not accepted.



The trained ADFA, is working now

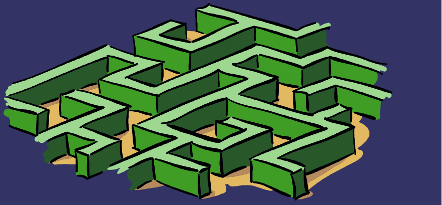


```
Main> acceptare (clasifica "2357543") a
["_ccc_"]
Main> acceptare (clasifica "23") a
["_cc_","_ccc_"]
Main> acceptare (clasifica "23") a
["_cc_","_ccc_"]
Main> acceptare (clasifica "2") a
["_c_"]
Main> acceptare (clasifica "r2d2") a
[]
Main> 
```



Conclusions

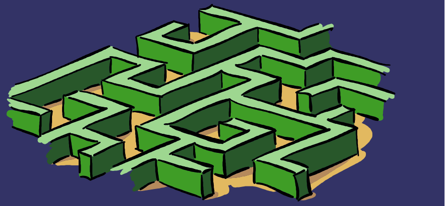
- The adaptive automata can be build using various languages. We have tried: Oberon-2, C++, Haskell.
- The theory and technology may have multiple appliances: video alarm systems, automatic weapons, anti-virus products, automatic observers, music synthesis and recognition, voice identification systems...and maybe more.



Present and the next step

Testing the limits of adaptive automata:

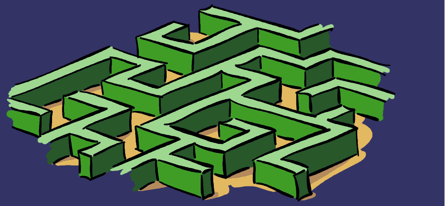
- Compilers, interpreters, DSL's: ok, done
- Allarms triggered by image: ok, done
- Other appliances: working....



References

[Arm01] Armour Philip: The business and software: Zeppelins and jet planes: a methaphor for modern software projects. Comm. Of ACM, 44(10):13-15 Oct.2001

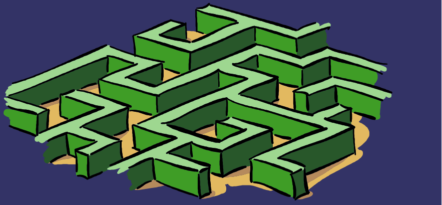
[Aho07] Alfred Aho, Monica Lam, Ravi Sethi, Jeffrey Ullman, Compilers Principles, Techniques, & Tools, sec.ed.2007, Pearson Education (chap 3, pp 109-189)



References

[Pop04] Popa Dan; Adaptable Tokenizer for Programming Languages , Simpozionul International al Tinerilor Cercetatori, ASEM, Chisinau 2004, pg 55-57, ISBN 9975-75-239-x

[Pop05] Popa Dan ; Adaptive DFA based on array of sets, Studii si Cercetari Ştiinţifice, Seria Matematica, Nr 15 (2005) p 113-121, ISSN 1224 - 2519



References

Smeu Florin: Sistem de supraveghere video bazat pe automat adaptiv.
(The student got the first prize :) !)

http://stiinte.ub.ro/cercetare/c-conferinte/106/327