Prova Finale

Algoritmi e Strutture Dati

AA 2017/2018

Tutors

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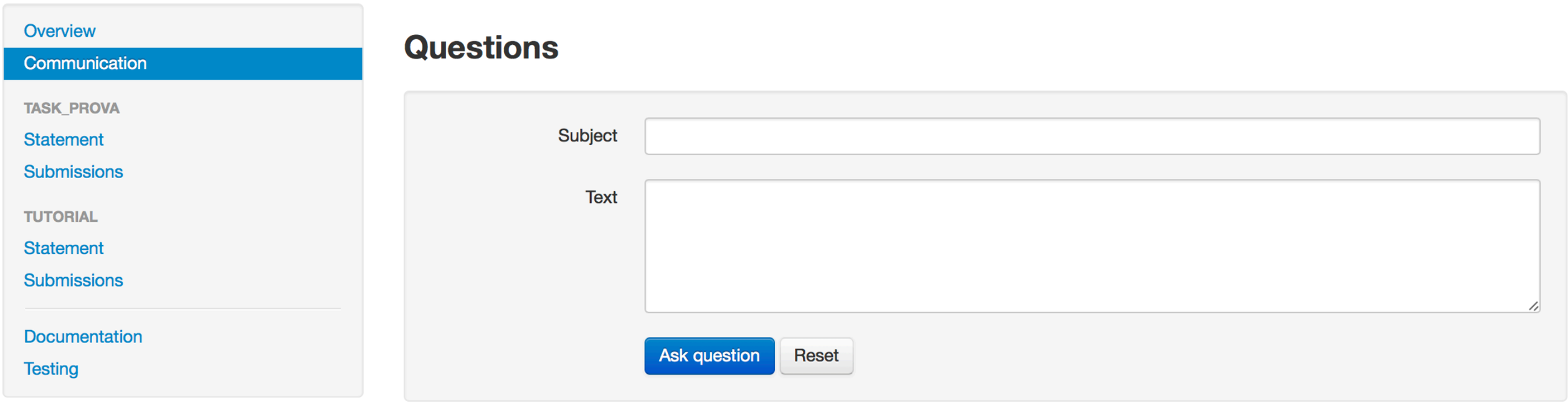
- Email con oggetto: **[ProvaFinaleAPI]**
- Usate la mail ufficiale / specificate la vostra matricola

Tutors

- Usate il form nel sito:



Agenda

- Informazioni pratiche sui tutorati
- Struttura della prova e valutazione
- Demo tool valutazione
- Consigli pratici implementazione
- Tool di supporto (gdb - valgrind - callgrind - kcachegrind)

Logistica Tutorati

- Indicativamente 1-2 a Luglio e 1-2 a Settembre

- Modalità:

  - Risposte a domande individuali

  - Guardando il vostro lavoro ci permette di essere più chiari

  - Possiamo rispondere a **solo a domande tecniche**

Deadlines

12 SETTEMBRE ore 24:00

- Per i **laureandi** di LUGLIO:

11 Luglio ore 24:00

- NO ESTENSIONI, NO RECUPERI

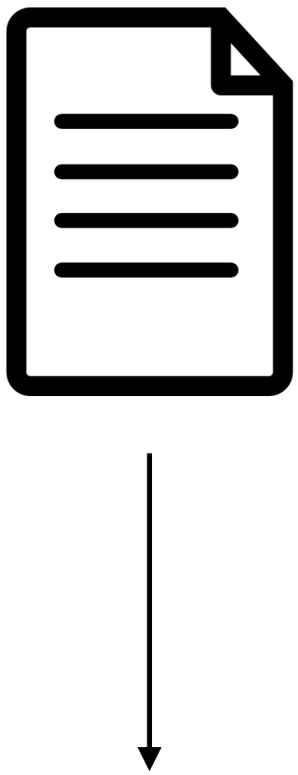
Struttura della prova

Implementazione in linguaggio C standard un interprete di Macchine di Turing non-deterministiche, nella variante a nastro singolo e solo accettori.

Un unico file sorgente contenente la vostra implementazione

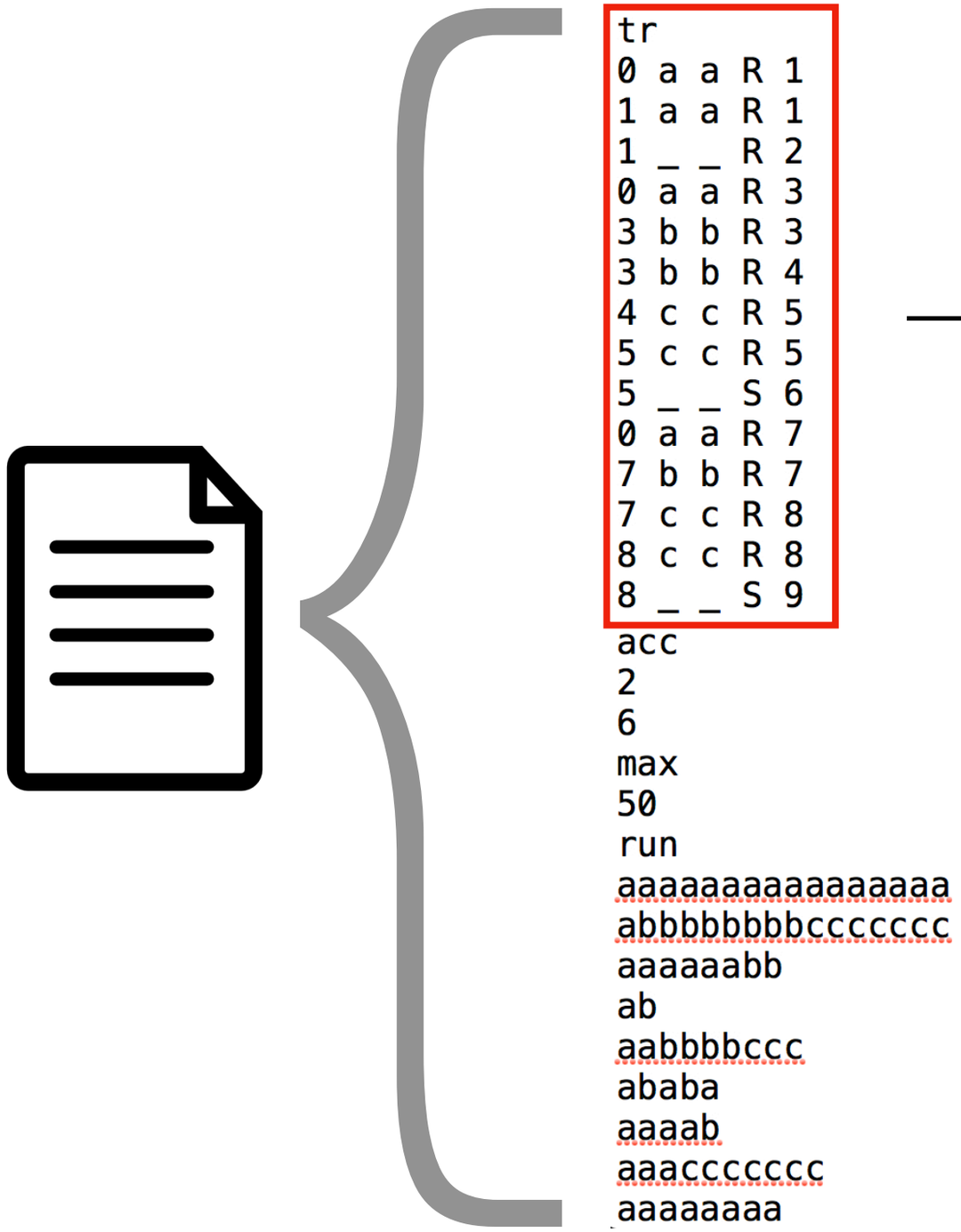
- NO librerie esterne eccetto standard (stdio, stdlib, string, math, ecc…)
- Ma posso usare questa libreria per… ? **NO**

Input



- Unico file di testo fornito tramite lo standard input
- Contiene:
  - funzione di transizione
  - stati accettazione
  - numero max di passi per una singola computazione
  - serie di stringhe da far leggere alla macchina

Input

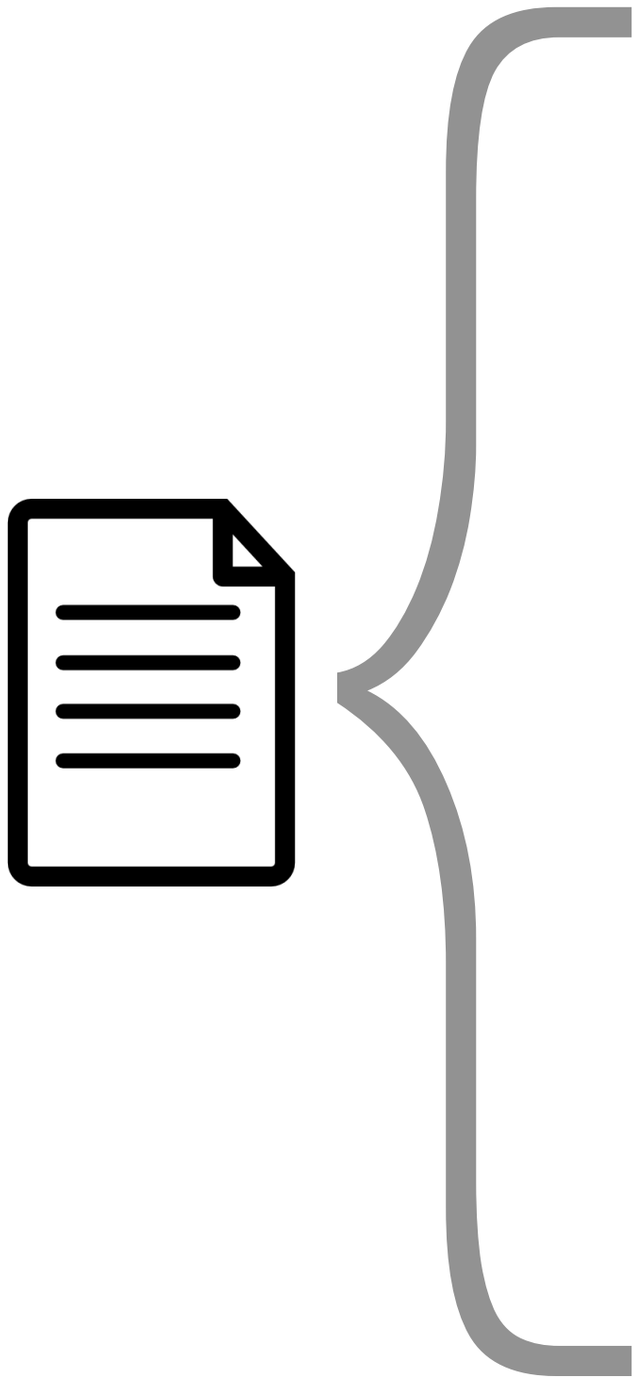


```
tr
0 a a R 1
1 a a R 1
1 _ _ R 2
0 a a R 3
3 b b R 3
3 b b R 4
4 c c R 5
5 c c R 5
5 _ _ S 6
0 a a R 7
7 b b R 7
7 c c R 8
8 c c R 8
8 _ _ S 9
acc
2
6
max
50
run
aaaaaaaaaaaaaaaa
abbbbbbbbccccccc
aaaaaabb
ab
aabbbbccc
ababa
aaaab
aaacccccccc
aaaaaaaa
```

Descrizione TM

- simboli di nastro sono dei *char*
- stati sono *int*
- "_" indica il simbolo "blank".
- I caratteri "L", "R", "S" indicano movimento della testina.
- La macchina parte sempre:
  - stato 0
  - primo carattere della stringa

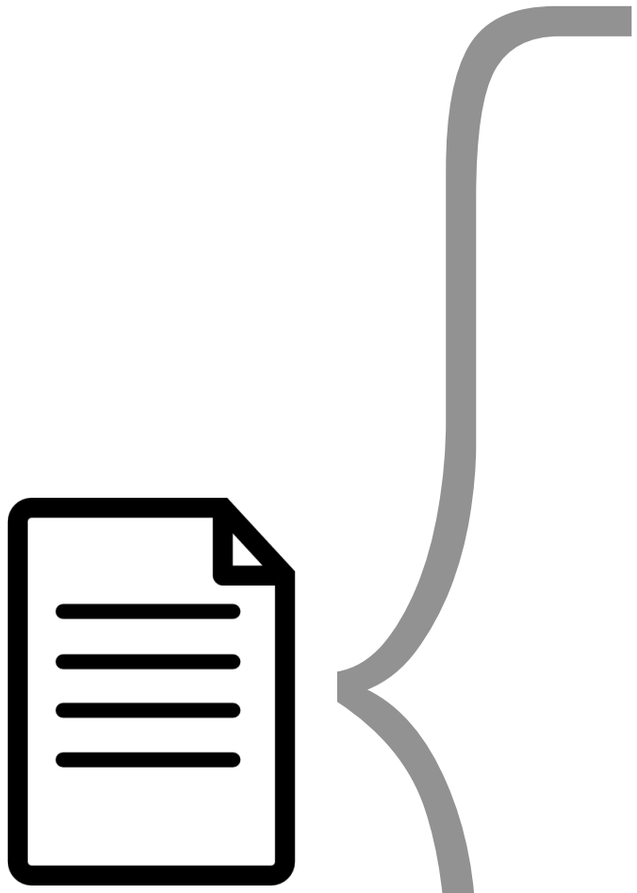
Input



```
tr
0 a a R 1
1 a a R 1
1 _ _ R 2
0 a a R 3
3 b b R 3
3 b b R 4
4 c c R 5
5 c c R 5
5 _ _ S 6
0 a a R 7
7 b b R 7
7 c c R 8
8 c c R 8
8 _ _ S 9
acc
2
6
max
50
run
aaaaaaaaaaaaaaaa
abbbbbbbbccccccc
aaaaaabb
ab
aabbbbccc
ababa
aaaab
aaacccccccc
aaaaaaaa
```

Stati Accettazione

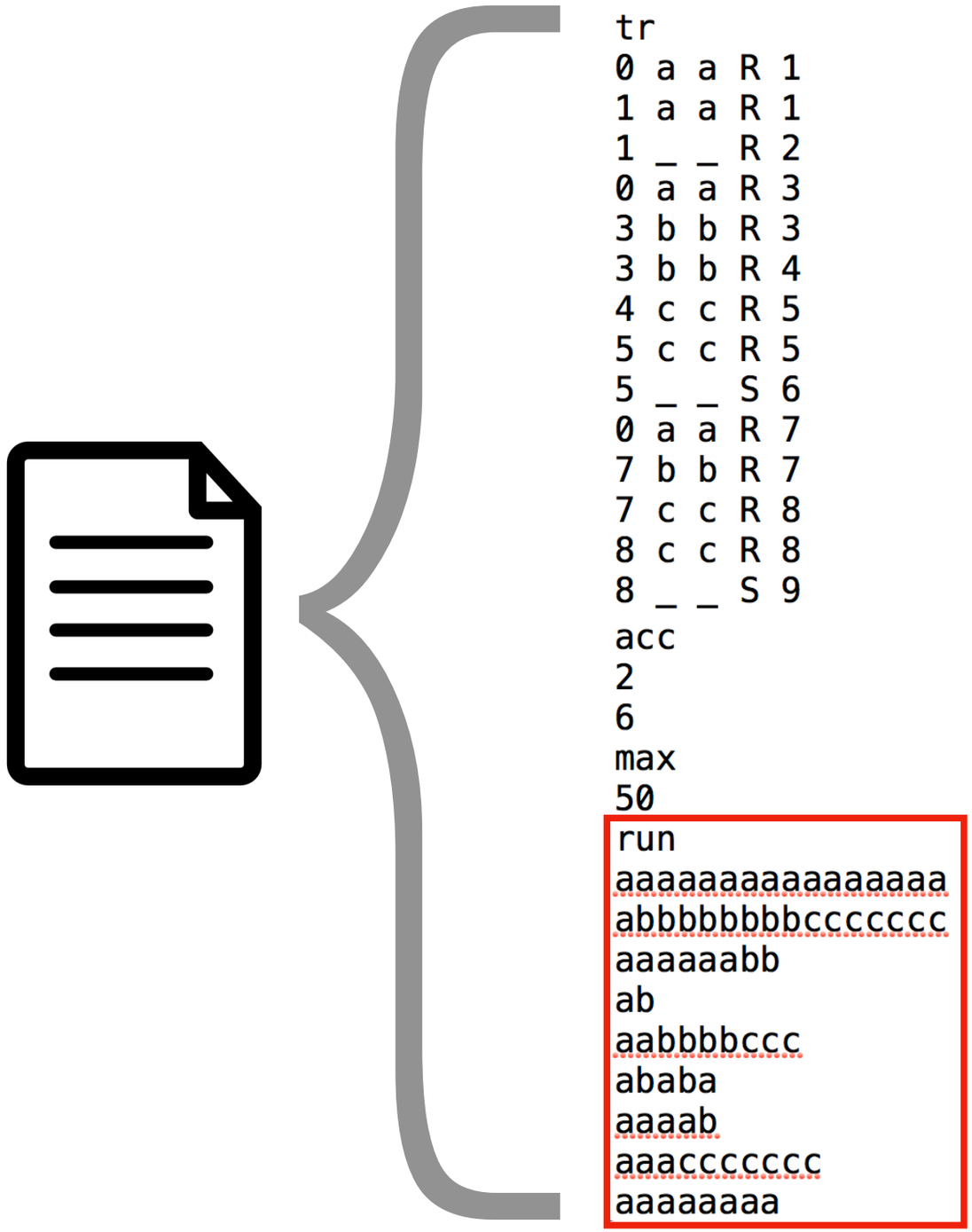
Input



```
tr
0 a a R 1
1 a a R 1
1 _ _ R 2
0 a a R 3
3 b b R 3
3 b b R 4
4 c c R 5
5 c c R 5
5 _ _ S 6
0 a a R 7
7 b b R 7
7 c c R 8
8 c c R 8
8 _ _ S 9
acc
2
6
max
50
run
aaaaaaaaaaaaaaaa
abbbbbbbbccccccc
aaaaaabb
ab
aabbbbccc
ababa
aaaab
aaacccccccc
aaaaaaaa
```

Numero Max Passi

Input

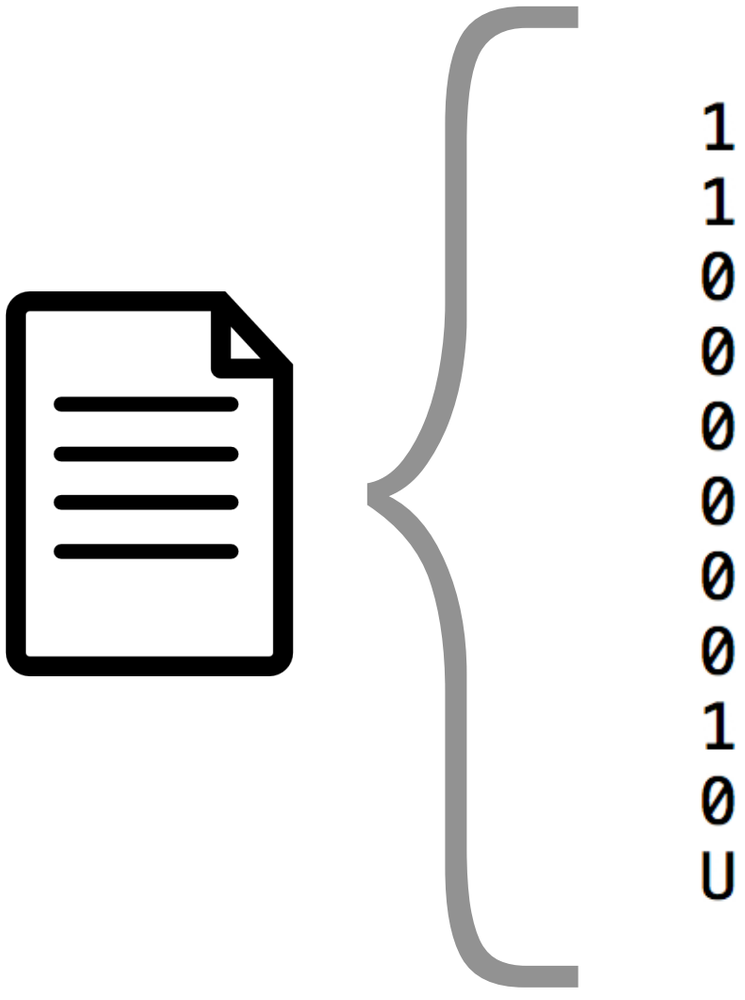


```
tr
0 a a R 1
1 a a R 1
1 _ _ R 2
0 a a R 3
3 b b R 3
3 b b R 4
4 c c R 5
5 c c R 5
5 _ _ S 6
0 a a R 7
7 b b R 7
7 c c R 8
8 c c R 8
8 _ _ S 9
acc
2
6
max
50
run
aaaaaaaaaaaaaaaa
abbbbbbbbccccccc
aaaaaabb
ab
aabbbbccc
ababa
aaaab
aaacccccccc
aaaaaaaa
```

Stringhe

Output

- Unico file di testo fornito tramite lo standard output



1 se stringa viene accettata
0 se stringa non viene accettata
U se non si e’ arrivati ad accettazione

Valutazione della prova

- Upload del codice sorgente
- Compilazione e valutazione automatica
- Valutazione su casi di test pubblici
- Valutazione su casi di test privati
- Esito

Valutazione della prova

TASK PUBLIC

Subtask 1 **(0 / 0)**

#	Outcome	Details	Execution time	Memory used
1	Correct	Output is correct	0.000 s	128 KiB

Non valutato

TASK PRIVATE

Subtask 2 **(3 / 3)**

#	Outcome	Details	Execution time	Memory used
2	Correct	Output is correct	2.199 s	512 KiB

Subtask 3 **(1 / 1)**

#	Outcome	Details	Execution time	Memory used
3	Correct	Output is correct	5.349 s	640 KiB

Subtask 4 **(1 / 1)**

#	Outcome	Details	Execution time	Memory used
4	Correct	Output is correct	18.648 s	896 KiB

Valutazione
3 + 1 + 1

Valutazione della prova

Subtask 1 (0 / 0)

#	Outcome	Details	Execution time	Memory used
1	Correct	Output is correct	0.000 s	128 KiB

- Implementazione deve essere **CORRETTA && EFFICIENTE**
  - tempo di esecuzione
  - memoria occupata

Casi di Test Privati

- Test pubblici da intendersi di base
- Effettuati su centinaia di stringhe
- Stringhe di lunghezza arbitraria
- Verifica della correttezza dell’output
- Vincoli di tempo e memoria incrementali

Assumptions

- Potete assumere che i file di input siano sintatticamente corretti e coerenti con le specifiche
- La funzione di transizione può non essere ordinata per numero di stato
- Non ci saranno archi uscenti da uno stato di accettazione
- Se esiste lo stato N esistono anche gli stani N-1, N-2, …, 0
- Non ci sono vincoli riguardo alla lunghezza del file di input e delle stringhe di input
- Il parametro U in caso di macchina non-deterministica si riferisce al singolo percorso non-deterministico

Be aware…


WHAT IF I TOLD YOU
YOU'RE BEING WATCHED RIGHT NOW
memeshappen.com

We’re watching you

NON COPIATE

- Verranno eseguiti controlli sui sorgenti
- **Tutti** i progetti coinvolti verranno annullati
- Non condividere il proprio sorgente
  - NB: **caricare il proprio sorgente su GitHub = condividere**

Demo Verificatore

http://dum-e.deib.polimi.it

Implementazione

Un unico file sorgente contenente la vostra implementazione

- Non iniziare subito a scrivere codice
- Iniziare ad impostare la soluzione (prima di settembre)
- Pensare alle strutture dati per soddisfare le specifiche sia funzionali che di complessità
- Il codice deve essere leggibile e ben commentato
- Sfruttare il paradigma procedurale (divide et impera)
- Esecuzione sequenziale (no multithreading)

Compilazione

Some details

Type	Batch	
Time limit	1 second	
Memory limit	256 MiB	
Compilation commands	C11 / gcc	`/usr/bin/gcc -DEVAL -std=c11 -O2 -pipe -static -s -o Tutorial Tutorial.c -lm`
Tokens	You have an infinite number of tokens for this task.	

Attachments

input_000.txt *11 B*
plain text document

output_000.txt *6 B*
plain text document

Compilazione e Test in Locale

main.c

input_000.txt

output_000.txt

- Testare sempre in locale prima di caricare il codice (no brute force)

COMPILAZIONE

```
gcc -g -std=c11 -Wall -Werror -o main main.c
```

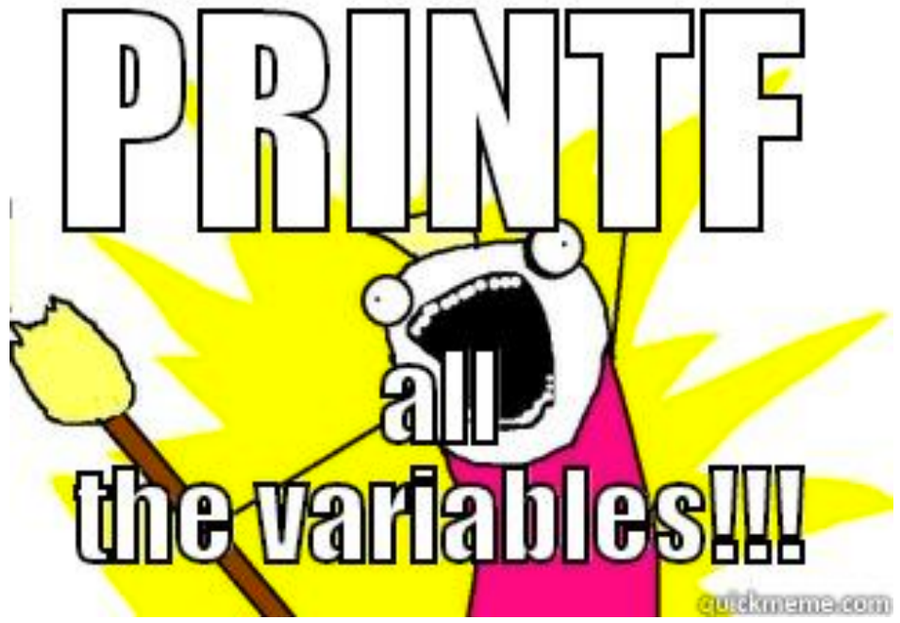
ESECUZIONE

```
cat input_000.txt | ./main > my_output.txt
```

CONTROLLO

```
diff output_000.txt my_output.txt
```

Debugging with GDB



- “GNU Debugger”
- It allows you to inspect what the program is doing at a certain point during execution.
- Useful for logical errors
- https://www.gnu.org/software/gdb/documentation/

GDB - Comandi Utili

- **start** - begin executing your program
- **list** - examine your source code from within the debugger
- **step** - execute the next line of your program
- **next** - execute the next line of your program, but if it's a subroutine call, treat the entire subroutine as a single line
- **print** - examine the contents of a variable
- **x** - examine memory directly
- **watch, rwatch** - set a watch for when a variable is written or read: return to the debugger once this happens
- **break** - set a breakpoint: return to the debugger when this line of code is about to be executed
- **info watch** - show info on watchpoints
- **info break** - show info on breakpoints
- **delete #** - delete watchpoint or breakpoint “#"
- **continue** - continue from a breakpoint, watchpoint, step, next, etc.; basically begin running your program from where it left off
- **set var name=value** set the value of variable "name" to “value"
- **backtrace** - show the call frames for your program
- **frame #** - set the current frame to #. Variables you reference etc. will be those within that context.
- **quit** - leave the debugger

GDB in action

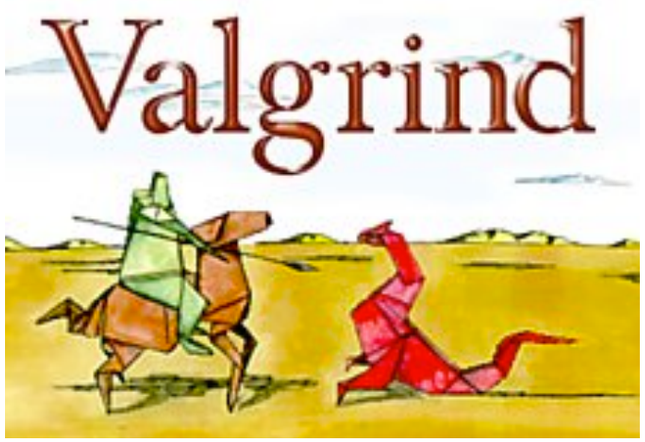
```
 #####  #     # #     #
#     # ##    # #     #
#       # #   # #     #
#  #### #  #  # #     #
#     # #   # # #     #
#     # #    ## #     #
 #####  #     #  #####

(gdb) break main
Breakpoint 1 at 0x8048426: file hello10.c, line 6.
(gdb) run
Starting program: /home/gary/hello10

Breakpoint 1, main () at hello10.c:6
6               for(i=0;i<10;i++)
(gdb)
```

```
######
#     # ###### #####  #    #  ####   ####  ###### #####
#     # #      #    # #    # #    # #    # #      #    #
#     # #####  #    # #    # #      #      #####  #    #
#     # #      #    # #    # #  ### #  ### #      #####
#     # #      #    # #    # #    # #    # #      #   #
######  ###### #####   ####   ####   ####  ###### #    #
```

Valgrind

- Valgrind is a multipurpose code profiling and memory debugging tool for Linux.

- It allows you to run your program in Valgrind's own environment that monitors memory usage such as calls to malloc and free



- Can detect many memory-related errors commonly found in C / C++

- http://valgrind.org/

valgrind --leak-check=yes eseguibile <args>

Understand Valgrind output

- Memory Leak = there is a memory chunk allocated but it’s not accessible
  - **Still Reachable**
    - Still have pointer(s) to the start of the block
    - No problem. You can still free it. Non reported by default
  - **Definitely Lost**
    - No pointers to memory block can be found.
    - You can’t free it.
  - **Indirectly Lost**
    - All pointers to the block are lost
    - e.g. if the root node of a binary tree is lost, all the children are indirectly lost

What can Valgrind detect?

- **Memory Leaks**

Remember to compile with **-g flag!**

```
#include <stdlib.h>
int main()
{
    char *x = malloc(100);
    return 0;
}
```

```
==2330== 100 bytes in 1 blocks are definitely lost in loss record 1 of 1
==2330==    at 0x1B900DD0: malloc (vg_replace_malloc.c:131)
==2330==    by 0x804840F: main (example1.c:5)
```

What can Valgrind detect?

- **Invalid Pointers Use**

```
#include <stdlib.h>

int main()
{
    char *x = malloc(10);
    x[10] = 'a';
    return 0;
}
```

```
==9814==  Invalid write of size 1
==9814==    at 0x804841E: main (example2.c:6)
==9814==  Address 0x1BA3607A is 0 bytes after a block of size 10 alloc'd
==9814==    at 0x1B900DD0: malloc (vg_replace_malloc.c:131)
==9814==    by 0x804840F: main (example2.c:5)
```

What can Valgrind detect?

- **Use of Uninitialized Variables**

```
#include <stdio.h>

int main()
{
    int x;
    if(x == 0)
    {
        printf("X is zero");

    }
    return 0;
}
```

```
==17943== Conditional jump or move depends on uninitialised value(s)
==17943==    at 0x804840A: main (example3.c:6)
```

What can Valgrind detect?

- **Use of Uninitialized Variables (cont.)**

```
#include <stdio.h>

int foo(int x)
{
    if(x < 10)
    {
        printf("x is less than 10\n");
    }
}

int main()
{
    int y;
    foo(y);
}
```

```
==4827== Conditional jump or move depends on uninitialised value(s)
==4827==    at 0x8048366: foo (example4.c:5)
==4827==    by 0x8048394: main (example4.c:14)
```

What **can't** Valgrind detect?

- Valgrind doesn't perform bounds checking on static arrays (allocated on the stack).

```
int main()
{
    char x[10];
    x[11] = 'a';
}
```

Valgrind doesn't detect static buffer overflow

Callgrind

- Callgrind is a profiling tool that records the call history among functions in a program's run as a call-graph.
- Callgrind can also be used to find performance problems
  - What code lines eat up most instructions
- Basic Usage:

```
valgrind --tool=callgrind [callgrind options] program [program options]
```

- While the simulation is running, you can observe execution with:

```
callgrind_control -b
```

Callgrind

- The profile data is written out to a file at program termination.
  - callgrind.out.XXX
- The data file contains information about the calls made in the program among the functions executed, with **Instruction Read** (Ir) event counts.

- To generate a function-by-function summary from the profile data file:

```
callgrind_annotate --auto=yes callgrind.out.XXX
```

- More info: http://valgrind.org/docs/manual/cl-manual.html

Interpreting the result

- The IR counts are basically the count of assembly instructions executed.
- A single C statement can translate to 1, 2, or several assembly instructions.

```
        . void swap(int *a, int *b)
    3,000  {
    3,000      int tmp = *a;
    4,000      *a = *b;
    3,000      *b = tmp;
    2,000  }
        .
        . int find_min(int arr[], int start, int stop)
    3,000  {
    2,000      int min = start;
2,005,000      for(int i = start+1; i <= stop; i++)
4,995,000          if (arr[i] < arr[min])
    6,178              min = i;
    1,000      return min;
    2,000  }
        . void selection_sort(int arr[], int n)
        3  {
    4,005      for (int i = 0; i < n; i++) {
    9,000          int min = find_min(arr, i, n-1);
7,014,178  => sorts.c:find_min (1000x)
   10,000          swap(&arr[i], &arr[min]);
   15,000  => sorts.c:swap (1000x)
        .    }
        2  }
        .
```

Interpreting the result

- The IR counts are basically the count of assembly instructions executed.
- A single C statement can translate to 1, 2, or several assembly instructions.

Details on Instructions

```
. void swap(int *a, int *b)
3,000  {
3,000      int tmp = *a;
4,000      *a = *b;
3,000      *b = tmp;
2,000  }
.
. int find_min(int arr[], int start, int stop)
3,000  {
2,000      int min = start;
2,005,000  for(int i = start+1; i <= stop; i++)
4,995,000      if (arr[i] < arr[min])
6,178              min = i;
1,000      return min;
2,000  }
. void selection_sort(int arr[], int n)
3  {
4,005      for (int i = 0; i < n; i++) {
9,000          int min = find_min(arr, i, n-1);
7,014,178  => sorts.c:find_min (1000x)
10,000         swap(&arr[i], &arr[min]);
15,000 => sorts.c:swap (1000x)
.      }
2  }
.
```

Total Instructions

1,000 calls to swap

Function Summary

- The callgrind_annotate includes a function call summary, sorted in order of decreasing count:

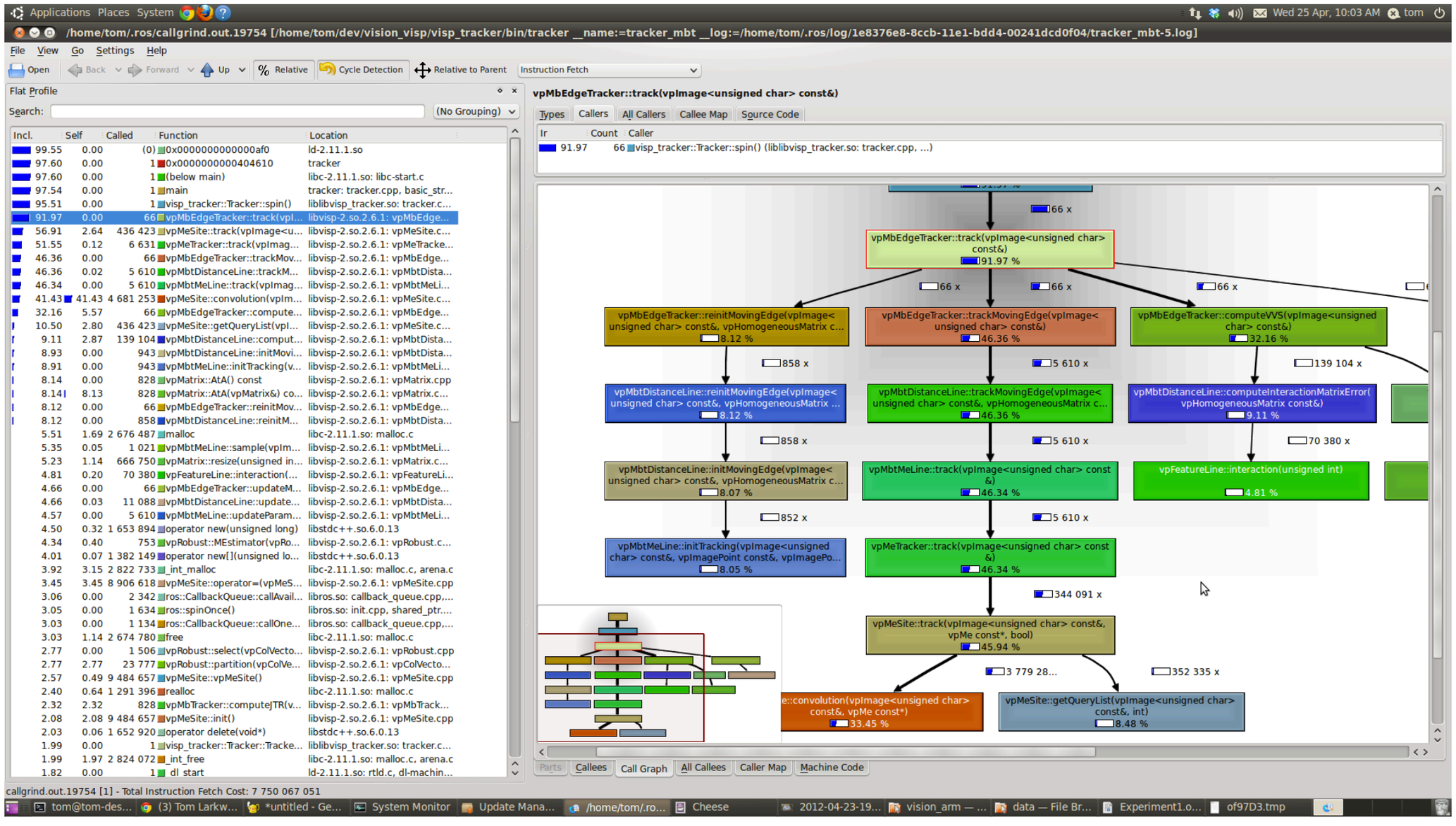
```
7,014,178  sorts.c:find_min [sorts]
   25,059  ???:do_lookup_x [/lib/ld-2.5.so]
   23,010  sorts.c:selection_sort [sorts]
   20,984  ???:_dl_lookup_symbol_x [/lib/ld-2.5.so]
   15,000  sorts.c:swap [sorts]
```

- Counts are *exclusive, they* include only the time spent in that function and not in the functions that it calls.
- Exclusive counts is great way to highlight your bottlenecks
- --inclusive=yes to callgrind_annotate to make it *inclusive*

Kcachegrind

- Visualization tool for Callgrind output
- https://kcachegrind.github.io/

kcachegrind callgrind.out.XXX



Conclusioni

- Fate **sempre riferimento** alle pagine dei professori o al sito della prova per le comunicazioni ufficiali e le specifiche del progetto
- *Ma nelle slide dei tutor c'era scritto che…* **non vale** come giustificazione
- Slide Available: tinyurl.com//slide_api_18

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Credits & More Details

- **Gdb:**
  - https://www.cs.umd.edu/~srhuang/teaching/cmsc212/gdb-tutorial-handout.pdf
  - https://www.cs.cmu.edu/~gilpin/tutorial/
- **Valgrind:**
  - https://www.cprogramming.com/debugging/valgrind.html
  - http://valgrind.org/docs/manual/quick-start.html#quick-start.intro
- **Callgrind:**
  - https://web.stanford.edu/class/cs107/guide/callgrind.html
  - http://valgrind.org/docs/manual/cl-manual.html
- **KCachegrind:**
  - https://kcachegrind.github.io/html/Home.html