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Automated evaluation of student homework: Lessons learned

Bohinj, 15. april 2015.



Courses: Basics of Computing (C)

- Variables
- Conditions
- Loops
- Arrays
- Functions
- Pointers
- Strings
- Structures
- Files



Courses: Programming Techniques (C++)

- Comparison C vs. C++
- C++ datatypes and containers
- Generic programming
- C++11 features (lambdas, auto, decltype...)
- Memory management
- Object-based programming
- Operator overloading
- Object-oriented programming
- Files



Courses: Algorithms and Data Structures (C++)

- Complexity and big-O notation
- Arrays and Lists
- Stacks and Queues
- Recursion
- Sorting and Searching
- Trees
- Graphs



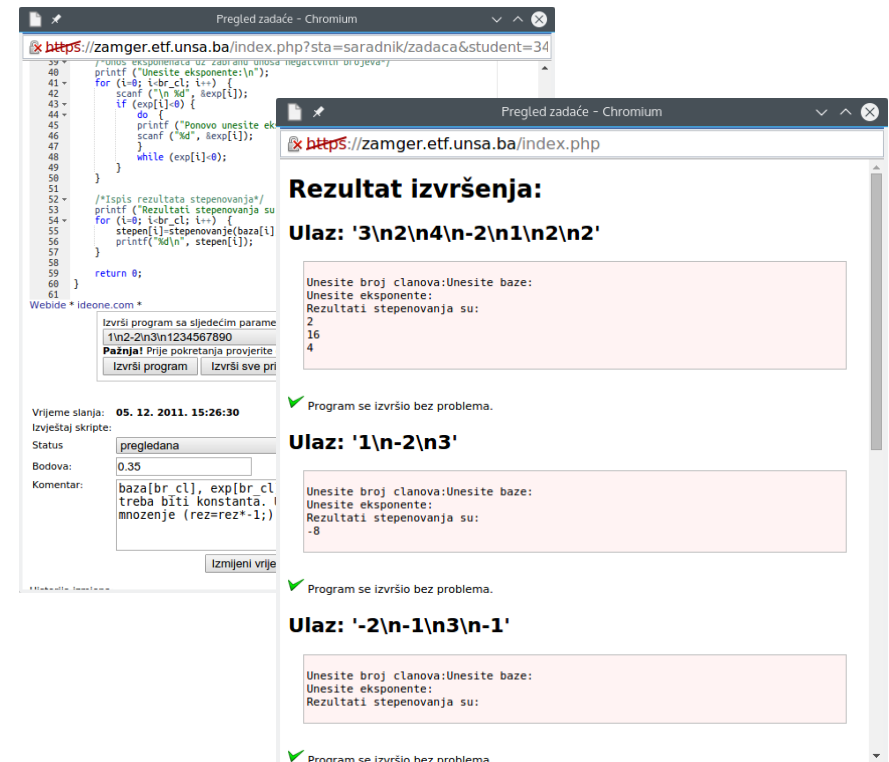
Motivation

- Independent work and practice is crucial for learning programming
- Courses with no homework are passed with memorization and rote practice on paper
- Large number of students (>300), no meaningful manual evaluation is possible



History of automated assessment

- First automated system in 2006.
- Web based homework submission.
- Automated build test, further testing is mostly manual.
- Lots of work for assistants!
- Problem: criteria varied, some assistants did better job than others.





Unit testing

- Introduced in 2010. as “teachers’ aid”, since 2012. score is calculated from unit tests.
- At first only for Programming Techniques
- Not only output comparison!
- Detecting: crashes, memory leaks, memory read errors, uninitialized variables...

06. 06. 2015. 12:32:27

Obrisi sve rezultate testiranja

Test	Rezultat	Vrijeme testiranja	
1	✓ OK	07. 06. 15. 23:22:33	Detalji
2	✓ OK	07. 06. 15. 23:22:36	Detalji
3	✓ OK	07. 06. 15. 23:22:37	Detalji
4	✗ Pogrešan rezultat	07. 06. 15. 23:22:38	Detalji
5	✓ OK	07. 06. 15. 23:22:40	Detalji
6	✓ OK	07. 06. 15. 23:22:41	Detalji
7	✓ OK	07. 06. 15. 23:22:42	Detalji
8	✓ OK	07. 06. 15. 23:22:43	Detalji
9	✓ OK	07. 06. 15. 23:22:44	Detalji
10	✓ OK	07. 06. 15. 23:22:46	Detalji
11	✗ Predugo izvršavanje	07. 06. 15. 23:22:56	Detalji
12	✓ OK	07. 06. 15. 23:22:59	Detalji
13	✗ Testni program se krahira	07. 06. 15. 23:23:02	Detalji
14	✓ OK	07. 06. 15. 23:23:04	Detalji
15	✗ Ne može se kompajlirati	07. 06. 15. 23:23:04	Detalji
16	✗ Curenje memorije	07. 06. 15. 23:23:05	Detalji
17	✓ OK	07. 06. 15. 23:23:06	Detalji
18	✓ OK	07. 06. 15. 23:23:08	Detalji

Rezultati testiranja:

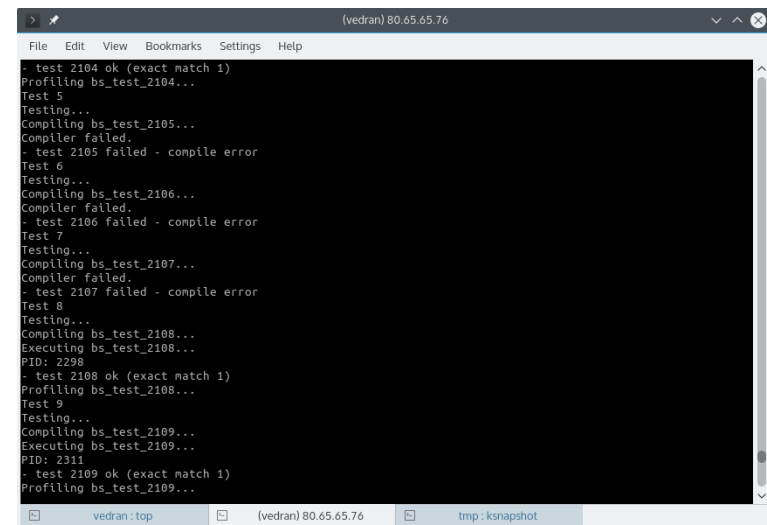
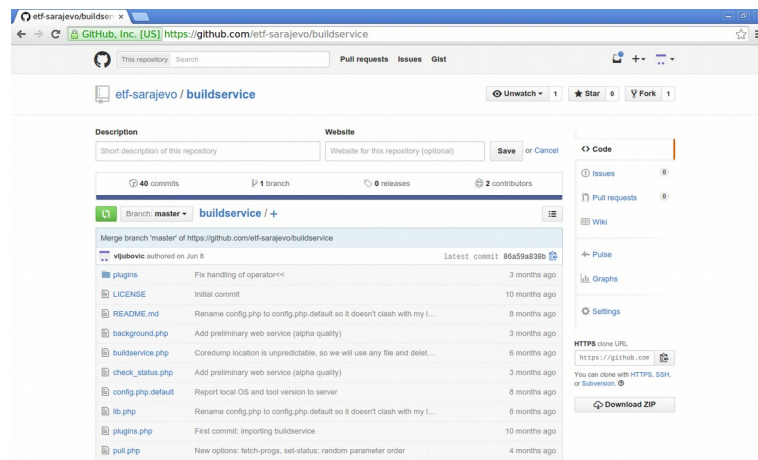
```
3.cpp: In constructor 'TabelarnaFunkcija::TabelarnaFunkcija(int)':
3.cpp:11:9: warning: 'TabelarnaFunkcija::max_broj_parova' will be initialized after [-Wreorder]
int max_broj_parova;
^
3.cpp:10:9: warning: 'int TabelarnaFunkcija::broj_parova' [-Wreorder]
int broj_parova;
^
3.cpp:31:1: warning: when initialized here [-Wreorder]
TabelarnaFunkcija::TabelarnaFunkcija(int broj): max_broj_parova(broj), broj_parova(0)
^
3.cpp: In constructor 'TabelarnaFunkcija::TabelarnaFunkcija(TabelarnaFunkcija&&)':
3.cpp:11:9: warning: 'TabelarnaFunkcija::max_broj_parova' will be initialized after [-
```



Technology

- Integration with GCC, GDB, Valgrind
- Students are unaware of unit testing
- Each test is built separately (e.g. for generics invocation)
- **buildservice** – framework for massive unit testing

<https://github.com/etf-sarajevo/buildservice>





Student complaints

- “Homework became much harder!”
 - ???
- “It works for me!”
 - Better explanation of errors.
- Students can't be disciplined to format their output properly.
 - “Fuzzy matching” - we use regex-es to test output.
- Pressure on teachers to write good tests and explain the errors.



(Un)resolved problems...?

- All student IDEs are bad!
 - Invalid code that runs in IDE...
 - Students do their homework in the web interface.
- Test-bashing
 - Tests are ran periodically (every ~24 hours)
 - Students complain “We want more tests!”
 - Hidden tests (starting 2014.)
 - Avalanche of complaints, “Tests are sadistic”
- The purpose of homework should be to promote **understanding!**



Plagiarism detection

- At the start it was trivial source code matching.
- “Howto cheat plagiarism detection” document found online
 - IDEs have features to: rename variables, reformat...
- Code “normalize” feature.
 - How to deal with false positives?
- Study groups (FB and elsewhere) for reworking programs until they pass plagiarism detection.
- ... It's an arms race.



Are WebIDE's a solution?

- Integrated plagiarism prevention (i.e. no/limited copy-paste).
- Ability to run unit-tests, integration with GCC, GDB, Valgrind.
- Not found in existing IDEs, poor support for C, C++.
- Work on learning support features.

The screenshot shows a WebIDE interface with a file explorer on the left, a code editor in the center, and a terminal at the bottom. The code editor displays a C program named 'hello-world.c' with the following content:

```
1 #include <stdio.h>
2 #include <string.h>
3 #include <ctype.h>
4
5 /* Trazi RJEK u tekstu, ne obziraj se na velike i mala slova */
6 char *trazi_rjek(char *tekst, char *sta)
7 {
8     char *p = sta;
9     unsigned short duzina = strlen(p), polozaj = 0;
10
11     while (*tekst != '\0')
12     {
13         if (tolower(*tekst) == tolower(*sta))
14         {
15             r = tekst;
16         }
17         /* Ispitujemo da li se i ostala slova poklapaju */
18         tekst++;
19         sta++;
20     }
21
22     while (*sta != '\0')
23     {
24         if (tolower(*tekst) != tolower(*sta))
25         {
26             break;
27         }
28         tekst++;
29         sta++;
30     }
31
32     /* Proveravamo da li je pronađena citava rijec, a ne samo dio */
33     if (*sta == '\0' && !strcmp(tekst, sta))
34     {
35         /* Za rijeci dajemo i levo posebno tretman */
36         if ((duzina > 2) || ((polozaj == 0) || ('(tekst - 2) == ')))
37         {
38             return r;
39         }
40     }
41 }
```

The terminal at the bottom shows the command 'bash - /jvlubovic-cher' and the output of the program:

```
Running /home/ubuntu/workspace/hello-c-world.c
Unesite tekst za pretragu: proba
Unesite za pretragu rijeci razdvojene razmakom: proba
Cenzurirani tekst glasi: ***
```



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13/13

Thank you for your
attentions!

Questions & Answers