

# On-line service for teaching parallel programming

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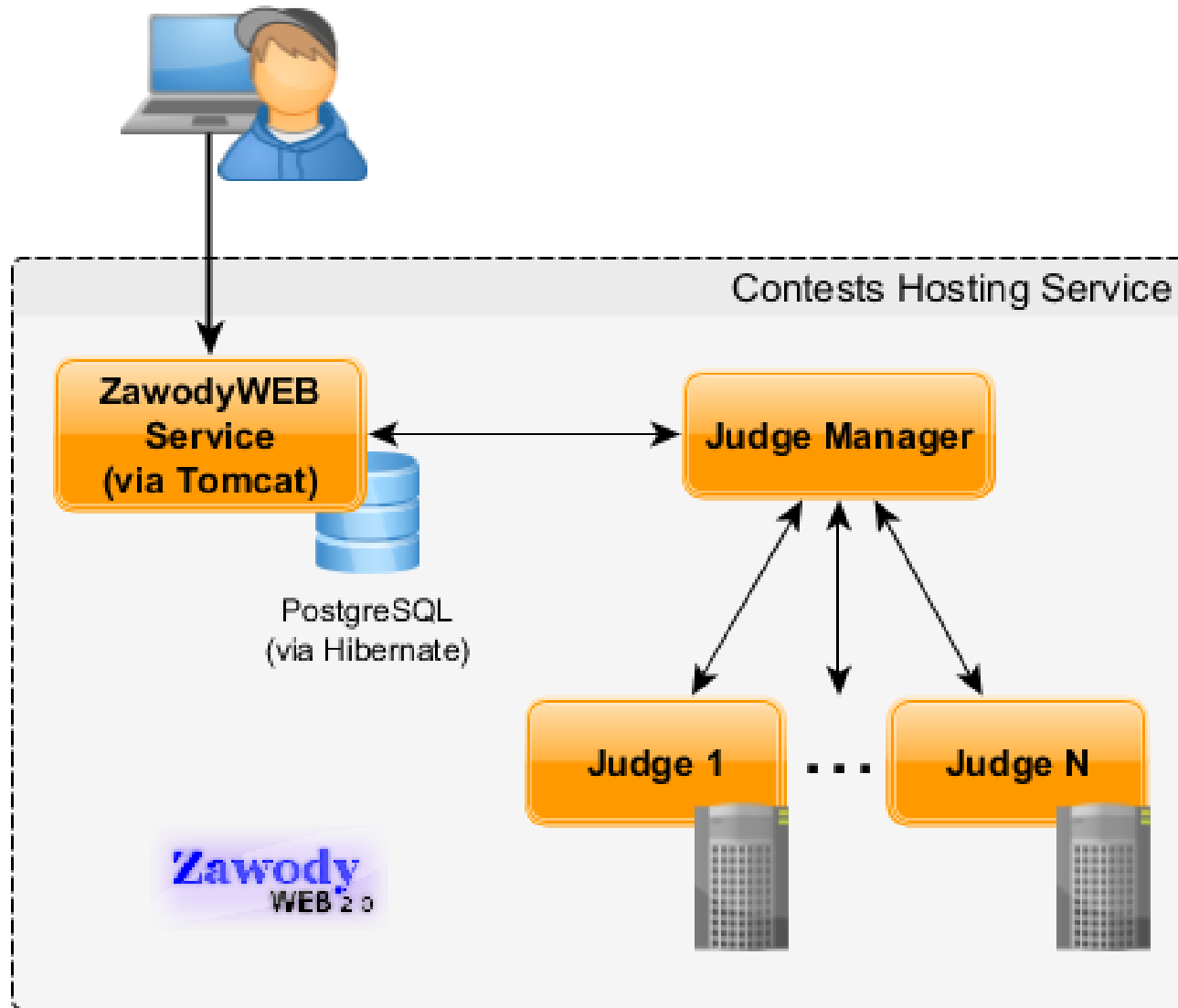
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- Motivation
- *ZawodyWeb* online contest system
- *ZawodyWeb* – support for parallel jobs
  - MPI, OpenMP, PCJ
- PL-Grid infrastructure
- Evaluation
- Conclusions

- Provide on line tools to support teaching of parallel programming
- Reduce technical barriers necessary to run parallel jobs
  - Focus on the parallel programming
- Requirement for seamless access
- Web portal as preferred access method
- Access to the large scale infrastructure
  - Required to test scalability of codes
- Requirement for strong security
  - Access to the production systems
- Support for traditional programming paradigms (MPI, OpenMP)
- Support for new programming libraries (PCJ: Java, PGAS)

- On-line system for automatic evaluation of the programming tasks
- Created at Faculty of Mathematics and Computer Science, Nicolaus Copernicus University, Toruń, Poland
- 2002 – first version created for programming contests for secondary school students
  - PHP, JavaScript, JavaApplets
- 2006 – new version (PHP)
  - PHP, Java, C, C++
- 2009 – current version (J2EE)
- 2014 – support for parallel jobs
  - MPI, OpenMP, Java (PCJ)
- 2015 – Access to large scale computational facilities using UNICORE





22 sier  
10

**Interdyscyplinarne Centrum Modelowania Matematycznego i Komputerowego UW**

**Programowanie równoległe na UKSW**

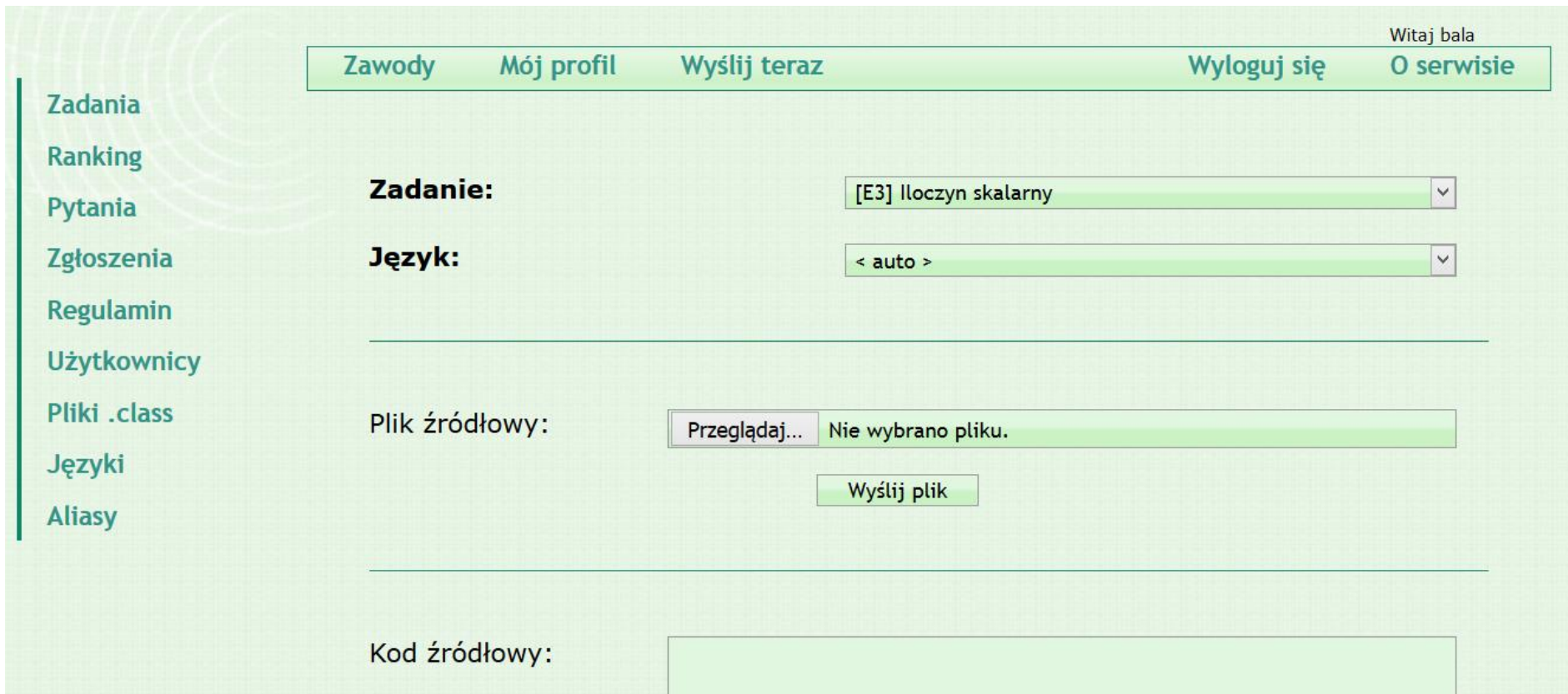
Zawody Zaloguj Rejestracja O serwisie

Zadania  
Ranking  
Pytania  
Regulamin

**E - Zadania do samodzielnego rozwiązania:**  
2015-06-01 12:00  
(2015-07-30 23:00)

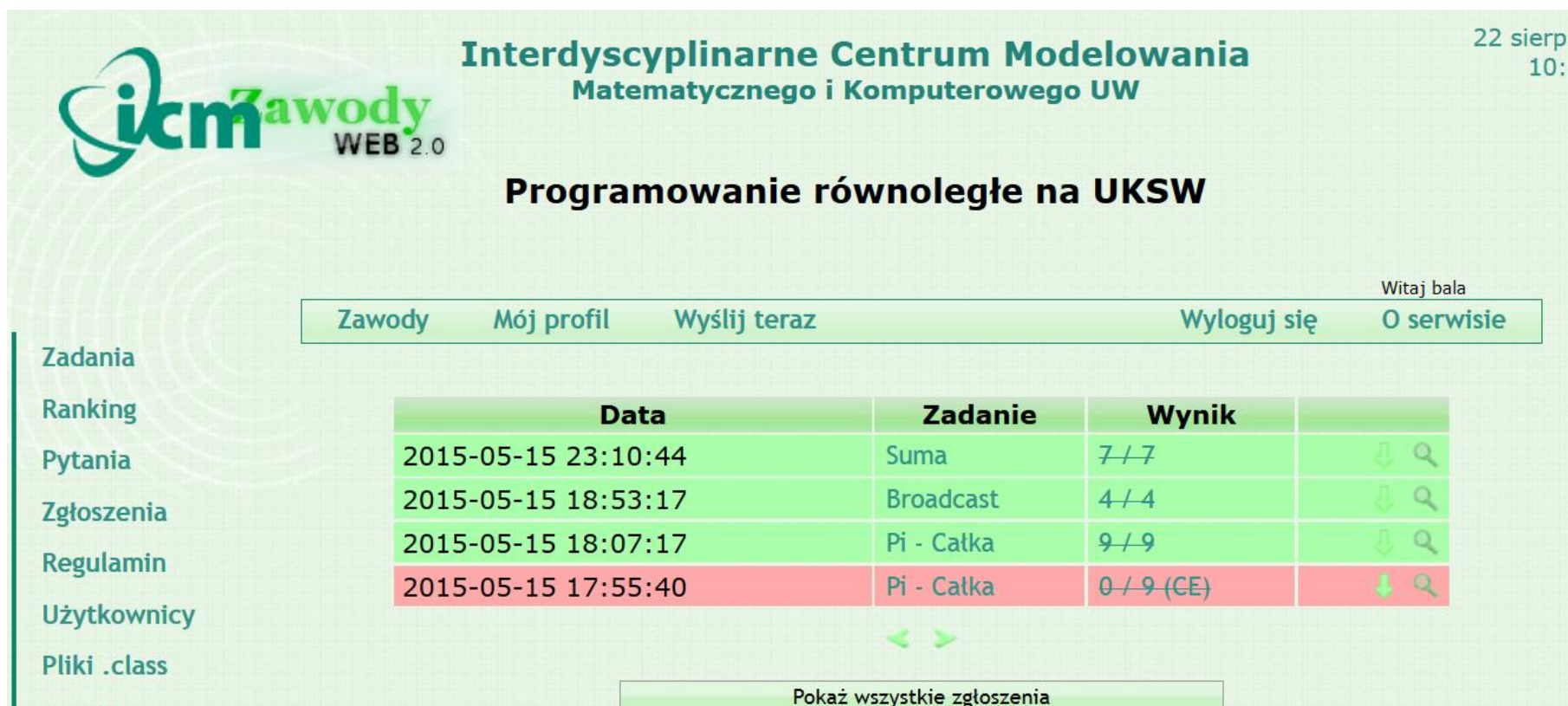
Nazwa zadania	Skrót
Sumowanie po okręgu	E1
Punkt najbliższej prostej	E2
Iloczyn skalarny	E3
Odszumianie obrazu	E4

Problems are grouped in problem sets and programming contests. Each can have separate deadlines.



The screenshot shows the ZawodyWeb solution submission interface. At the top, there is a navigation bar with links: Zawody, Mój profil, Wyślij teraz, Wyloguj się, and O serwisie. The user is logged in as 'Witaj bała'. On the left, there is a sidebar menu with links: Zadania, Ranking, Pytania, Zgłoszenia, Regulamin, Użytkownicy, Pliki .class, Języki, and Aliasy. The main content area is divided into sections. The 'Zadanie' section shows a dropdown menu with the selected option '[E3] Iloczyn skalarny'. The 'Język' section shows a dropdown menu with the selected option '< auto >'. The 'Plik źródłowy' section has a 'Przeglądaj...' button, a text input field containing 'Nie wybrano pliku.', and a 'Wyślij plik' button. The 'Kod źródłowy' section has a large text input field.

User can choose language and submit solution uploading source code as file or through text form.  
The file can be also zip archive.



Interdyscyplinarne Centrum Modelowania Matematycznego i Komputerowego UW

22 sierpnia 10:00

**Programowanie równoległe na UKSW**

Zawody   Mój profil   Wyślij teraz   Wyloguj się   Witaj bała   O serwisie

Data	Zadanie	Wynik	
2015-05-15 23:10:44	Suma	7/7	↓ 🔍
2015-05-15 18:53:17	Broadcast	4/4	↓ 🔍
2015-05-15 18:07:17	Pi - Całka	9/9	↓ 🔍
2015-05-15 17:55:40	Pi - Całka	0/9 (CE)	↓ 🔍

Pokaż wszystkie zgłoszenia

User can submit solution many times, he has access to evaluation results of all submissions.



Witaj bała

Zawody    Mój profil    Wyślij teraz    Wyloguj się    O serwisie

Zadania  
Ranking  
Pytania  
Zgłoszenia  
Regulamin  
Użytkownicy  
Pliki .class  
Języki  
Aliasy

## Suma (B2)

Data: 2015-05-15 23:10:44.22

Test	Status	Czas/Limit	Pamięć/Limit	Wynik	Uwagi
a_01	Zaakceptowane	359/60000	0/1024	1/1	
a_02	Zaakceptowane	308/60000	0/1024	1/1	
a_04	Zaakceptowane	319/60000	0/1024	1/1	
a_08	Zaakceptowane	467/60000	0/1024	2/2	
a_12	Zaakceptowane	436/60000	0/1024	2/2	

[Pobierz rozwiązanie](#)

For the parallel jobs, evaluation is performed using different number of cores. User gets information about execution time.

Each test is scored. Total score is used to generate ranking.

- User code is compiled on the server and executed on the different number of cores.
- Each test has parameters used to define node configuration for the test execution
  - UNICORECC\_RESERVATION =PCJ
  - UNICORECC\_CPU\_PER\_NODE =12
  - UNICORECC\_NODES\_COUNT =2
  - ....

- MPI
  - C/C++, OpenMPI, gcc
  - mpirun
- OpenMP
  - C/C++, gcc
  - OMP\_NUM\_THREADS
  - Execution limited to a single node
- PCJ
  - Java, requires PCJ.jar
  
  - Additional configuration parameters:

```
UNICORECC_JVMARGS =- Dpcj.redirect.out=0 -Dpcj.redirect.err  
=0 -Dpcj.out. node =0
```

Java library developed at ICM

- partitioned global address space (PGAS)
- [pcj.icm.edu.pl](http://pcj.icm.edu.pl)

Features:

- Does not require modification of JVM
- Does not introduce new language syntax nor language constructs, does not use native code (JNI)
- Does not require additional libraries
- Available for all systems with Java7 (and later)
  - *Eg. IBM Java 1.7 for Power7*
- Uses Java SE 7 (NIO, SDP, . . . )
- Tested with Java8, Java9

## HPC CHALLENGE

CLASS2AWARD

PRESENTED AT  **SC14** NOVEMBER 18, 2014  
New Orleans, hpc. LA matters.

**WINNER**  
Most Elegant

PRESENTER  
**Piotr Bała**  
ICM University of Warsaw

LANGUAGE  
**PCJ**

DAVID BAILEY    JEREMY KEPNER    EWING LUSK    JOHN MCCALPIN    DAISUKE TAKAHASHI  
JACK DONGARRA    BOB LUCAS    PIOTR LUSZCZEK    ROLF RABENSEIFNER    JEFFREY VETTER



```
double c;  
if (PCJ.myId()==0) c =(double) PCJ.get(3, "a");  
  
if (PCJ.myId()==0) PCJ.put(3, "a", 5.0);  
  
if (PCJ.myId()==3) PCJ.waitFor("a");  
  
if (PCJ.myId()==0) PCJ.broadcast("a", 5.0);  
  
public static void PCJ.barrier();  
  
public static int PCJ.threadCount()
```

```
import org.pcj.*  
public class PcjHelloWorld extends Storage  
                                implements StartPoint {
```

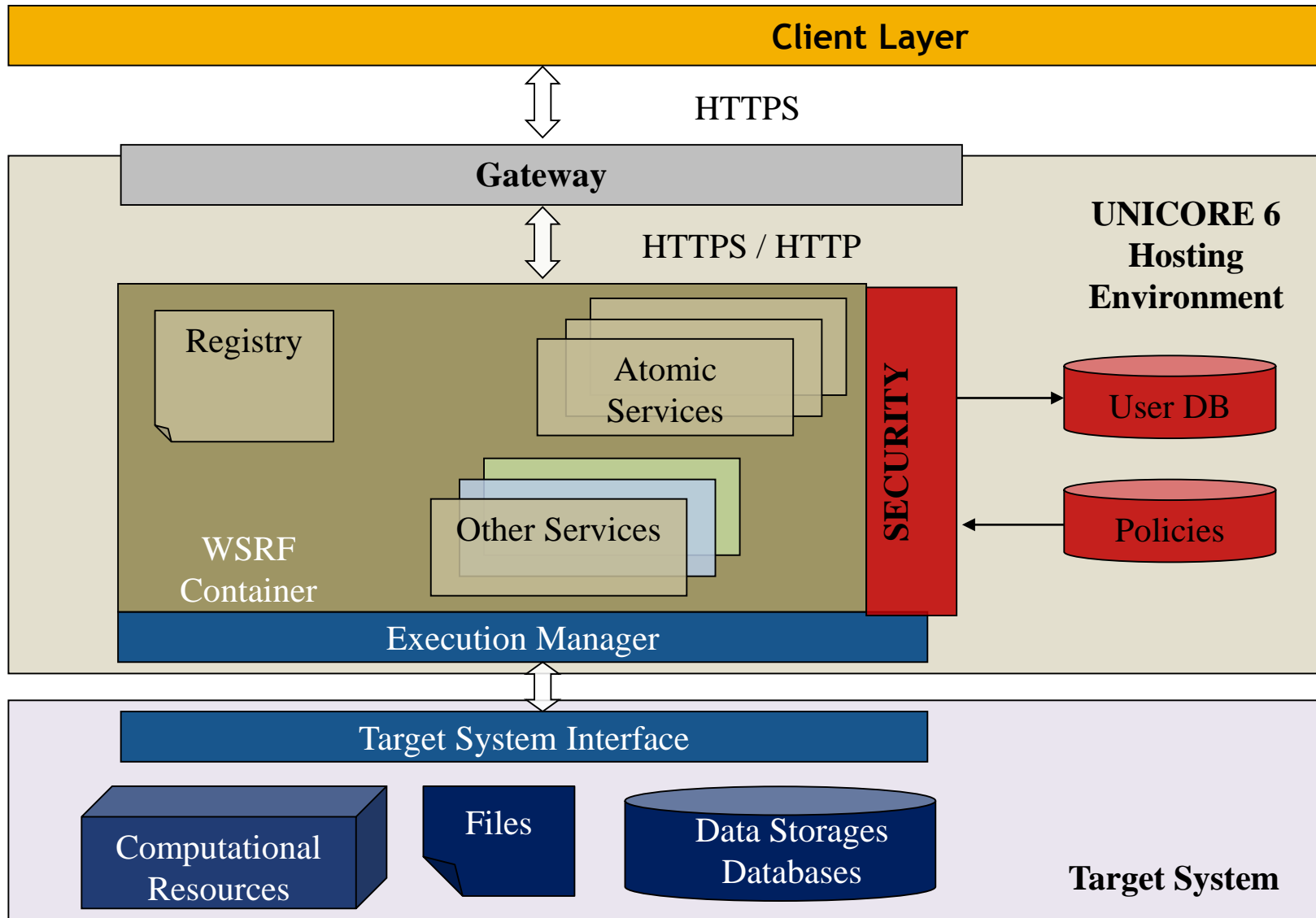
```
    @Override
```

```
    public void main() {  
        System.out.println("Hello!");  
    }
```

```
    public static void main(String[] args) {  
        String[] nodes = new String[]{"localhost", "localhost"};  
        PCJ.deploy(PcjHelloWorld.class,  
                  PcjHelloWorld.class, nodes);  
    }  
}
```

- UNICORE is used to access HPC systems
- UNICORE provides high security based on the X509 certificates
- Jobs are run on the *zawodyweb* account
  
- ZawodyWeb extensions:
  - *External-Checker judge*
  - Information about execution time





- National Grid Initiative
- Partners:
  - Polish supercomputer centers:  
Cyfronet, ICM, PCSS, WCSS, TASK
- Provides access to the HPC systems owned by partners
- Operates Polish National Grid
- Provides training and user's support
- Provides support for application deployment on the grid
- Resources provided by ICM are used:
  - Intel(R) Xeon(R) CPU X5660 (Westmere-EP) processors, Infiniband QDR and 1Gb Ethernet.
  - Dedicated reservation (2 x 2 processors (6 cores each))



- Used for the parallel programming course for undergraduate students (computer science)
  - 3rd year students form Cardinal Stefan Wyszyński University
  - 2nd year students form University of Warsaw (voluntary)
- Introduction to paralel programming (3 h)
- Parallelization of the selected kernels (2 h)
- Introduction to the PCJ (1 h)
- ZawodyWeb/PCJ introduction (2 h lab)
- OPenMP (4 h, 2 h lab)
- MPI (4 h, 2 h lab)
- on-line training

- Practical introduction to the PCJ (45 minutes)
- Practical introduction to ZawodyWeb (15 minutes)
  - HelloWorld – max 7 attempts (av. 3.2)
  
- Parallel programming
  - E1 – Cyclic sum                      max 4 attempts (av. 2.5)
  - E2 – The nearest point            max 6 attempts (av. 2.5)
  - E3 – Dot product                    max 1 attempts (av. 1)
  - E4 – 2D stencil                     max 6 attempts (av. 3)

- The use of ZawodyWeb allowed us to grant students with the possibility to execute problems on the production systems with the thousands of cores.
- We were able to hide all complexity of the large multiprocessor computers.
- UNICORE offers grid interface and hides target system complexity
- The system has been used to support teaching of the computer science students on the undergraduate level.
- The use of PCJ allowed us to Focus on parallel programming rather than technical issues.

- This work has been performed using the PL-Grid infrastructure.
- Partial support from the CHIST-ERA consortium (HPDCJ project) is acknowledged.
- Partial support from National Centre for Research and Development (OCEAN project) is acknowledged.