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The Web-SynDic Project: Development of Software for Remote Solving of Linear Diophantine Equations in Non-negative Integers

- homNLDE — non-negative homogeneous linear Diophantine equation:
  - integer coefficients,
  - non-negative integer solutions.
- Web-SynDic is oriented to a particular class of homNLDE systems, associated with formal grammars (homANLDE systems).
- The web-system is available at: **http://websyndic.cs.karelia.ru/**

Problems of Solving and Generating homANLDE

- Solving
  1. Searching a particular non-trivial solution.
     - Polynomial complexity.
     - Syntactic algorithm for homANLDE systems is pseudo-polynomial with complexity $O(Q^3m^2n)$, where Q is constant limit for the number of basis elements.
  2. Searching the Hilbert basis.
- The syntactic algorithm is implemented in `syntactic solver`.
- Generating

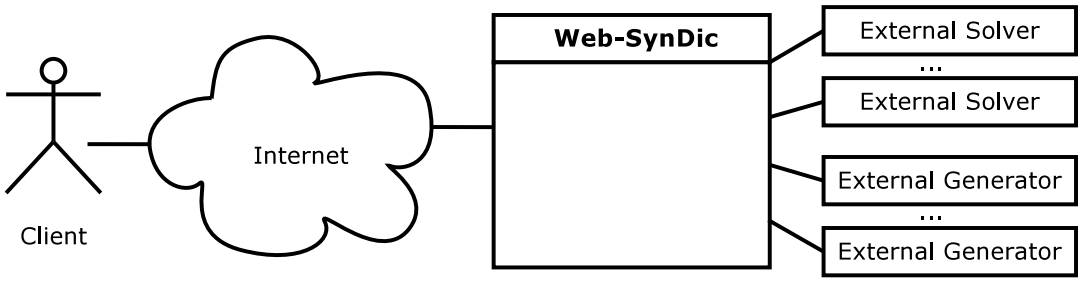
  Estimating `syntactic solver` implementation reliability and comparing it with alternative solvers using automated generation of homANLDE systems.

Basic Functions of Web-SynDic

- Working with a single homANLDE system.
- Working with a set of homANLDE systems.
- User accounting.
- Configuration of parameters for solving and generating.

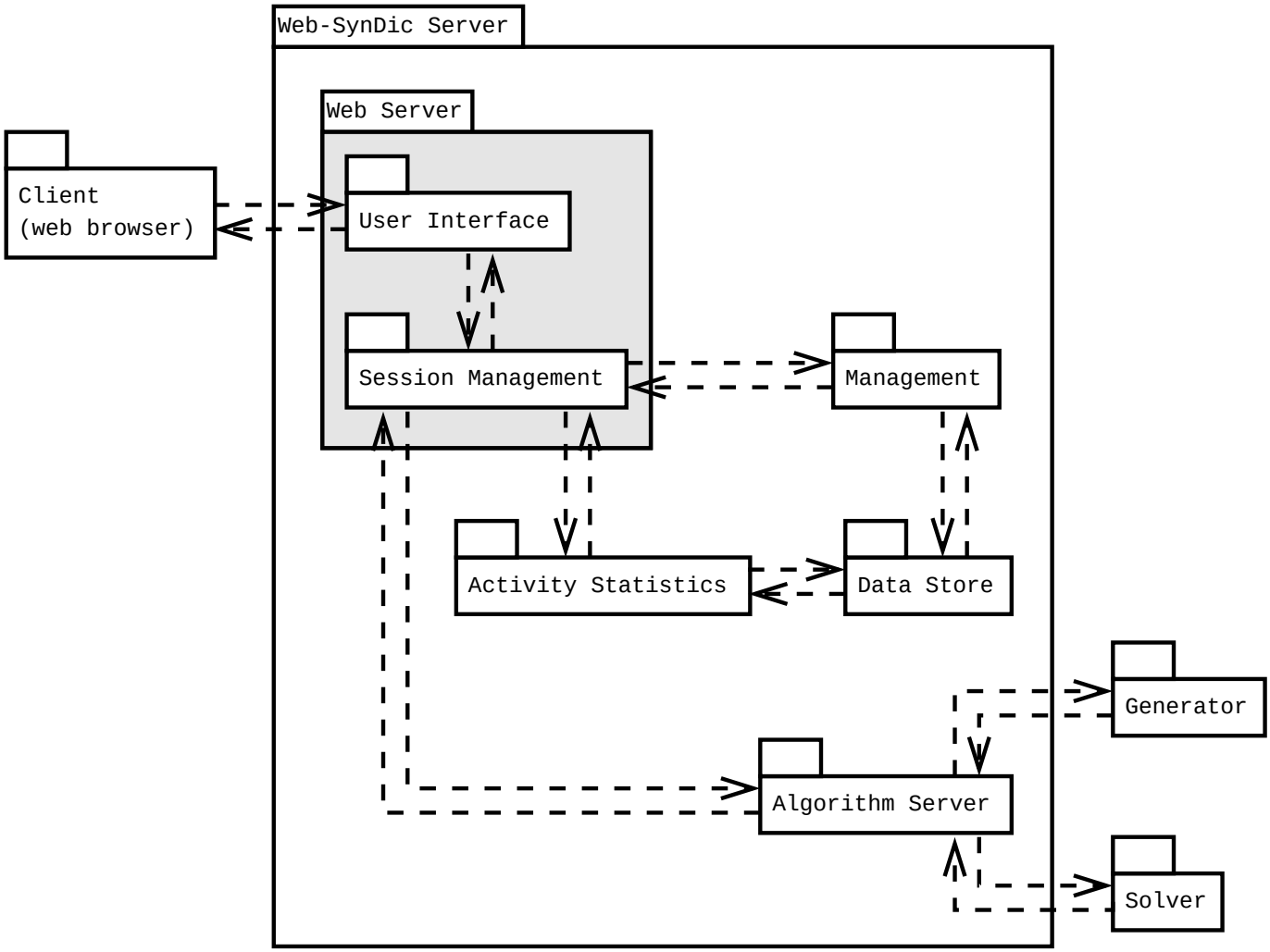
Web-SynDic Architecture

Client-server architecture. Client is a standard web-browser.



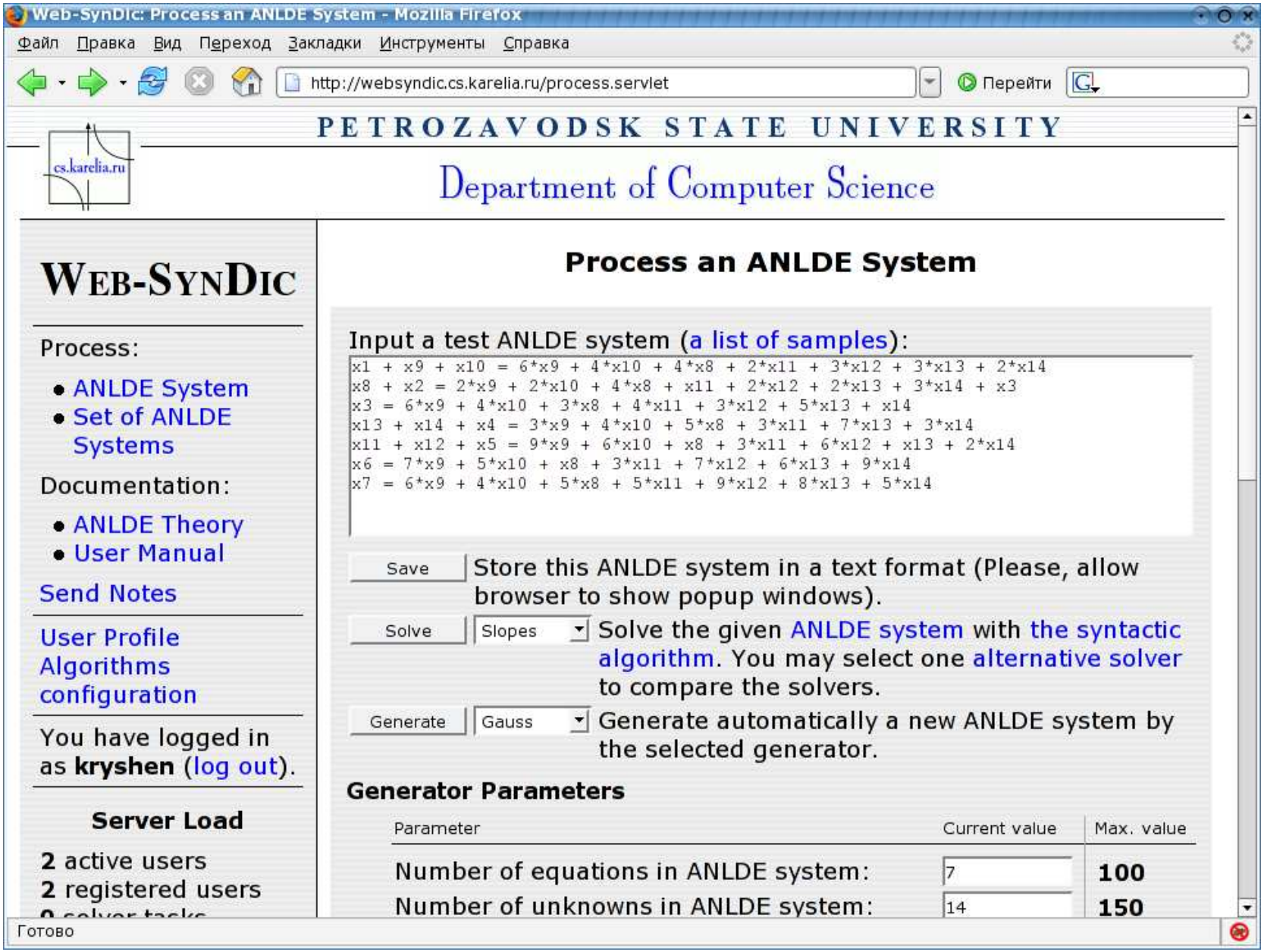
Server supports interaction between user and external solvers and generators.

The diagram below shows interconnection between implemented subsystems.

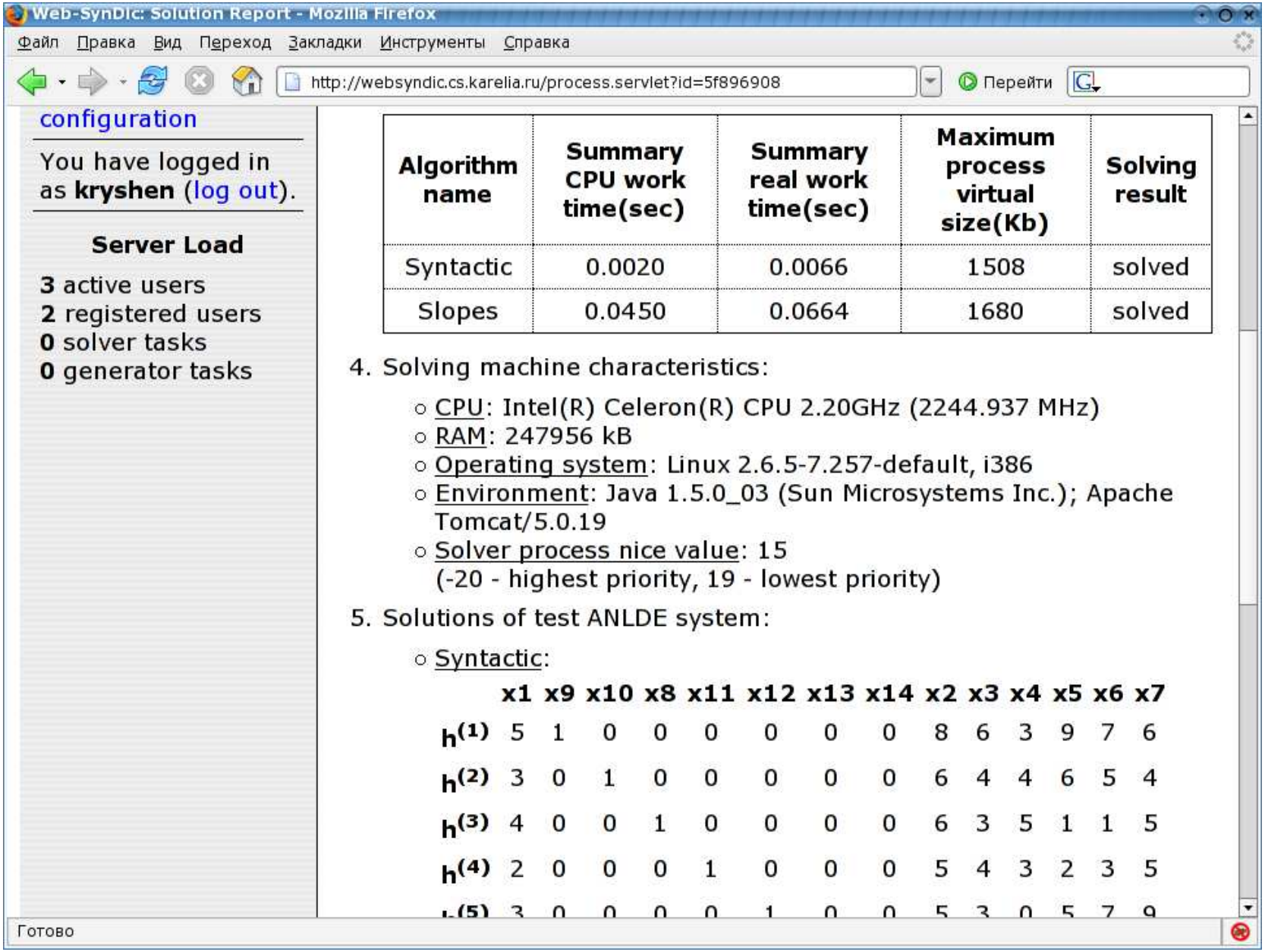


User Interface

"Process an ANLDE System" form.



Correcponding report on solution.



Development Process

- Waterfall model with iterations.
- Official project languages are English and Russian.
- Complete project documentation based on Adaptable Process Model: Requirements Specification, Design Specification, implementation and testing documentation, User Manual, Project Metrics.

The following software tools and technologies were used:

Java Server Pages (JSP), servlets	used to build the web-interface
Apache Tomcat	servlet container
JFlex, byaccj	translate homANLDE systems to the internal format of the web-system.
Java and C++ programming languages	

Project metrics (by December 2005): 2243 man-hours, 363 pages of documentation, 11907 lines of code.

Experiments

1. Testing `syntactic solver`.
   Automated generation and solving of more than 1,5 million homANLDE systems was performed. No implementation errors were found in the solver.
2. Comparing the solvers.
   10000 unique homANLDE systems were used to compare solving metrics of `syntactic solver` and `slopes`. Experiment revealed significant advantage of `syntactic solver` over `slopes` for homANLDE systems with large dimensions.
3. Empirical dependence of time and memory usage on number of unknowns in homANLDE system. Measurements were made for two classes of homANLDE systems, created using Gauss and Jordan generators respectively

Measurement	Method	Number of unknowns, m					
		50	100	200	300	500	1000
Time, seconds	Gauss	0,005	0,014	0,0369	0,0848	0,2521	1,5463
Memory, Kb		1508	1756	2084	2524	3972	8168
Time, seconds	Jordan	0,0059	0,0205	0,1123	0,5344	3,0639	23,5981
Memory, Kb		1508	1756	2184	2632	4048	10188

Measurements were taken at computer with Celeron 1200 MHz CPU, 512 Mb RAM. For every value of m, 20 homANLDE systems were generated.