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The Web-SynDic System

User Manual

Contents

1 Introduction

1.1 Overview

Web-SynDic stands for **web**-based demonstration and test of the **syn**tac**tic** algorithms for solving linear **D**iophantine equations in nonnegative integers. These algorithms, developed at CS Department of PetrSU, are a novel type of algorithms for efficient solving some classes of nonnegative linear Diophantine equations (NLDE or LDE in nonnegative integers) by syntactic (parsing) methods.

These syntactic algorithms seem to be promising tool for solving some classes of NLDE system; more exactly a class of NLDE system, associated with formal grammars (ANLDE systems). For this class the syntactic algorithms allow efficient (polynomial and pseudo-polynomial) computations comparing with the general NLDE case when the same computational problems are NP-complete or even overNP [9].

A user just sends a test ANLDE system to Web-SynDic; the latter responds with the solution and some characteristics of the computation. This allows to present the key features of the syntactic algorithms, test them, estimate the efficiency, etc.

A user is assumed to be a researcher in Diophantine analysis, formal grammars, integer programming, and related fields. She/He has an access to the Internet via a standard browser.

Note, that the web system does not allow a user to have a direct access to the demonstrated&tested algorithms but shows only the outcome of their work. Detailed information about the syntactic algorithms and ANLDE theory can be found in [1, 2, 6, 7].

1.2 Conventions

In this document the following conventions for fonts are used.

`Typewriter font` URL addresses; names of programs and utilities; input text for web forms.

Bold font Names of buttons available in Web-SynDic pages; important notes on using Web-SynDic.

San-serif font Names of forms and text areas available in Web-SynDic pages.

Underlined text Names of links available in Web-SynDic pages.

2 Getting Started

Web-SynDic is a web system for demonstrating and testing novel syntactic method for searching nonnegative integer solutions of Linear Diophantine Equations (LDE in nonnegative integers or Nonnegative LDE or NLDE for short).

Web-SynDic works with a special class of homogeneous NLDE systems that are Associated with context-free grammars (ANLDE systems for short).

2.1 Solving a test ANLDE system

For solving one ANLDE system use ANLDE system link in the left-side part of the main form. This link opens Process an ANLDE System form. Input ANLDE system into the corresponding text area (see Figure 1) or press button **Generate** to generate ANLDE system automatically (see section 2.2), and press button **Solve**. The Solution Report page containing solved system,

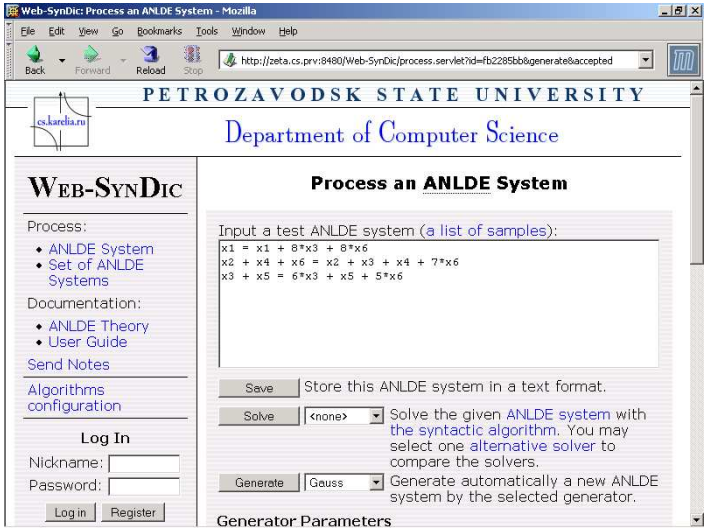

Figure 1: Input a test ANLDE system

resource usage and solutions will be loaded.

More detailed information on solving ANLDE systems can be found in section 3.3.2.

2.2 Generating a test ANLDE system

Web-SynDic allows to generate ANLDE systems instead of manual input. Such a generated system characterized with simple Hilbert basis. The reason is that the generation is based on original methods by Kirill Kulakov [8]. These methods were also used for comprehensive automatic testing of the syntactic solver.

For generating one ANLDE system use ANLDE system link in the left-side part of main form. This link opens Process an ANLDE System form. Press button **Generate** and Web-SynDic returns this form with generated ANLDE system.

To save an ANLDE system, shown in System text field, click on the **Save** button, You will see a new browser window containing the ANLDE system. Then you can save it in a text file using standard browser features like "Save As..." item of the "File" menu.

More detailed information on generating ANLDE systems can be found in section 3.3.1.

2.3 Generating and solving a set of ANLDE systems

Web-SynDic allows to generate and solve a set of ANLDE systems. For generating a set of ANLDE systems use Set of ANLDE systems link in the left-side part of main form. This link opens Process a set of ANLDE Systems form. This form has 3 sections: Load&Solve, Generate&Solve and Generate&Save. Press button **Solve a set** in Generate&Solve section. The Solution Report containing solved system, resource usage and solutions will be loaded.

More detailed information on generating and solving ANLDE system sets can be found in section 3.4.

3 Reference manual

3.1 ANLDE system

3.1.1 ANLDE system theory

Nonnegative Linear Diophantine Equations

Let $\mathbb{Z} = \{0, \pm1, \pm2, \ldots\}$ be a set of integers, $\mathbb{Z}_+ = \{0, 1, 2, \ldots\}$ be a set of nonnegative integers.

A system of nonnegative linear Diophantine equations (NLDE for short) is a linear system

$$Ax = b\,, \qquad A \in \mathbb{Z}^{n\times m}\,, \quad b \in \mathbb{Z}^n\,, \quad x \in \mathbb{Z}_+^m\,, \tag{1}$$

where n is number of equations, m is number of unknowns. Therefore, the solutions of a NLDE system are m-vectors with nonnegative integer components.

For example, consider the NLDE system with $n = 2$ equations and $m = 4$ unknowns:

$$\begin{cases} x_1 - x_2 + 3x_3 = 1 \\ x_1 + 2x_2 - x_4 = -1 \end{cases} \tag{2}$$

This system has infinitely many solutions in $\mathbb{Z}_+^4$. Among them, for instance, solutions $x = (0, 2, 1, 5)^\top$ and $x' = (2, 4, 1, 11)^\top$.

NLDE system (1) is *homogenous*, if b is null vector $\mathbb{O} \in \mathbb{Z}^n$. Any homogenous NLDE system has the trivial solution $x = \mathbb{O} \in \mathbb{Z}_+^m$.

For any NLDE system a corresponding homogenous system can be constructed replacing right-hand side b by $\mathbb{O}$. For example, the corresponding homogenous NLDE system for (2) is

$$\begin{cases} x_1 - x_2 + 3x_3 = 0 \\ x_1 + 2x_2 - x_4 = 0 \end{cases} \tag{3}$$

If x is a solution of (1) and h is a solution of the corresponding homogeneous system, then $x' = x + \alpha h$ is also a solution of (1) for any nonnegative integer α.

Nontrivial solution h of homogenous NLDE system is *indecomposable* if it is not a sum of two nontrivial solutions of the same homogenous system. Solution x of NLDE system (1) is *indecomposable* if it is not a sum of another solution x' and a nontrivial solution h of the corresponding homogenous system. For instance, the solution $x' = (2, 4, 1, 11)^\top = (0, 2, 1, 5)^\top + (2, 2, 0, 6)^\top$ of NLDE system (2) is decomposable. The solution $h' = (2, 2, 0, 6)^\top = (1, 1, 0, 3)^\top + (1, 1, 0, 3)^\top$ of the homogenous system (3) is decomposable. The solutions $x = (0, 2, 1, 5)^\top$ and $h = (1, 1, 0, 3)^\top$ (of NLDE systems (2) and (3) respectively) are indecomposable.

The notion "a indecomposable solution" for NLDE systems is equivalent to "a minimal solution", where the minimality is considered with respect to standard component-wise ordering. For example, $x = (0, 2, 1, 5)^\top$ is minimal (for system (2)) and, therefore, there is no another solution x' such that $x' \le x$; $h = (1, 1, 0, 3)^\top$ is minimal (for system (3)) and, therefore, there is no another (nontrivial) solution h' such that $h' \le h$

Hilbert basis of NLDE system (1) is a pair $(\mathcal{N}, \mathcal{H})$, where $N \subset \mathbb{Z}_+^m$ is the set of all minimal (indecomposable) solutions of the NLDE system, and $\mathcal{H}$ is the set of all minimal (indecomposable) solutions of the corresponding homogenous system.

Sets $\mathcal{N}$ and $\mathcal{H}$ are always finite. They describe the set of all solutions of (1). Namely, any solution x can be computed as:

$$x = x^{(l)} + \sum_{s=1}^{q} \alpha_s h^{(s)} \quad \text{for some } x^{(l)} \in \mathcal{N} \text{ and } \alpha_s \in \mathbb{Z}_+, \tag{4}$$

where p and q are the numbers of solutions in the basis: $\mathcal{N} = \{x^{(1)}, \ldots, x^{(p)}\}$, $\mathcal{H} = \{h^{(1)}, \ldots, h^{(q)}\}$.

For example, all solutions of NLDE system (2) are described by the formula:

$$x = \left[\begin{array}{l} (1,0,0,2)^\top + \alpha(1,1,0,3)^\top + \beta(0,3,1,6)^\top \\ (0,2,1,5)^\top + \alpha(1,1,0,3)^\top + \beta(0,3,1,6)^\top \end{array} \right. \quad \text{for } \forall\, \alpha, \beta \in \mathbb{Z}_+,$$

where the left square bracket means alternation, $p = q = 2$, $\mathcal{N} = \left\{x^{(1)} = (1,0,0,2)^\top, x^{(2)} = (0,2,1,5)^\top\right\}$, $\mathcal{H} = \left\{h^{(1)} = (1,1,0,3)^\top, h^{(2)} = (0,3,1,6)^\top\right\}$. Taking $x^{(2)} = (0,2,1,5)^\top$, $\alpha = 2$, $\beta = 0$ we get the solution $x' = (2,4,1,11)^\top$.

This is very simular to the theory of linear equations: general solution is a sum of a particular solution and a linear combination of homogenous ones. However, the NLDE case has its own specifics: one particular solution is not enough to describe all solutions; there must be a set (but finite) of particular solutions. For the above example, at least two particular solutions are required.

See monograph [9] and papers [10, 11] as classic introduction to the area.

Complexity problems for NLDE systems

The basic computation problems for a given NLDE system are listed below.

1. Is the NLDE system solvable in nonnegative integers? (for the homogeneous case, only nontrivial solvability is considered.)
2. Searching a particular solution of the NLDE system (if any). It may include searching any particular solution or any minimal solution or a particular solution satisfied to some other criteria.
3. Searching Hilbert basis of the NLDE system.

The list can be prolonged. For instance, an interesting problem is counting basis solutions.

The listed problems are very complex in the computational sense. The solvability and particular solution searching problems are NP-complete [9]. The problem of searching Hilbert basis is even more complex—overNP.

This is a reason for dicovering particular classes of NLDE systems that have efficient (polynimial) algorithms for solving. We suggest (basing on the original work of M. Filgueiras and A.-P. Tomás [1]) an interesting approach for this—using formal grammars to establish such classes of NLDE systems.

A formal grammar is assigned to a NLDE system and solution searching is moved from set $\mathbb{Z}_+^m$ to a set of derivations in the grammar—one searches a derivation instead of a NLDE solution (see Figure 2). The idea is the same as in operations calculus, where the problem of solving an integral-differential equation is reduced to solving an algebraic equation in complex numbers.

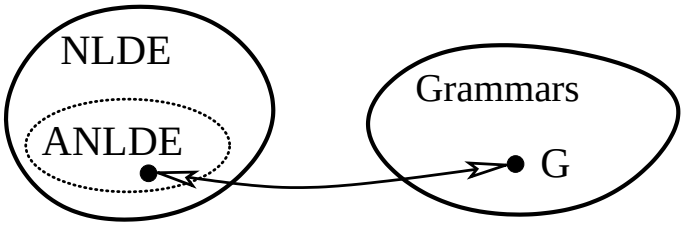

Figure 2: Association between NLDE and formal grammars: a general view

The methods and algorithms of the formal grammars theory have been very developed starting from 50th. Our approach turns out that they can be fruitfully used to construct really efficient algorithms for solving some particular classes of NLDE system. The efficiency means here that the algorithms are polynomial or pseudopolynomial (comparing with the general NP-complete and overNP case with exponential complexity). The pseudopolynomiality allows to select those problems (from the set of complex ones) that are permissible for practical solving.

NLDE systems, associated with CF-grammars. The syntactic algorithms

Consider a CF-grammar $G = (N, \Sigma, P, \cdot)$ and two strings v and w. Let G have m rules ($P = \{r_1, r_2, \ldots, r_m\}$), n nonterminals ($N = \{A_1, A_2, \ldots, A_n\}$), and t terminals ($\Sigma = \{a_1, a_2, \ldots, a_t\}$). Grammar rules r_i has the form $A \to \alpha$, where α is a string in $(N \cup \Sigma)^*$. The start nonterminal symbol is not required.

One can construct *an associated with the grammar NLDE system* (ANLDE system for short) as follows:

$$\left\{ \begin{array}{l} \displaystyle\sum_{i \in I_k} x_i - \sum_{i=1}^{m} \gamma_{ki} x_i = b_k\,, \quad k = 1, 2, \ldots, n \ \text{ (i.e. for each nonterminal } A_k), \\ \displaystyle\sum_{i=1}^{m} \gamma_{ki} x_i = b_k\,, \quad k = n+1, n+2, \ldots, n+t \ \text{ (i.e. for each terminal } a_{k-n}), \end{array} \right. \tag{5}$$

where $I_1 \cup \ldots \cup I_n = \{1, 2, \ldots, m\}$ is a partition of $\{1,\ldots,\mathrm{m}\}$, $\gamma_{ki} \in \mathbb{Z}_+$, $b_k \in \mathbb{Z}$. Let us denote this system as $S(G; v, w)$.

The ANLDE system has m unknowns (correspond to m grammar rules), $n + t$ equations (correspond to $n + t$ grammar symbols). Each set I_k contains indecies i such that rule r_i

has right-hand side with nonternimal A_k, i.e. $A_k \to \alpha$. The coefficients γ_{ki} is the number of occurances of nonterminal A_k ($b_k = \mathrm{occ}(\alpha^{(i)}, A_k)$, $1 \le k \le n$) and terminal a_{k-n} ($b_k = \mathrm{occ}(\alpha^{(i)}, a_{k-n})$, $n+1 \le k \le n+t$) in the right-hand side of the rule $r_i = A \to \alpha^{(i)}$. The coefficients b_k is the difference between the number of occurancies of A_k ($b_k = \mathrm{occ}(w, A_k) - \mathrm{occ}(v, A_k)$, $1 \le k \le n$) and a_{k-n} ($b_k = \mathrm{occ}(w, a_{k-n}) - \mathrm{occ}(v, a_{k-n})$, $n+1 \le k \le n+t$) in the strings w and v.

For example, consider the grammar G_1 with nonterminals A and B ($n = 2$), the only terminal a ($t = 1$) and $m = 4$ rules (listed in Table 1, col. 1). Let $v = B$ and $w = aaAaaa$.

CF-grammar	ANLDE system (original)	ANLDE system (reduced)
$r_1: \ A \to AAB$ $r_2: \ A \to aBBa$ $r_3: \ B \to AAAaB$ $r_4: \ B \to \varepsilon$	$A: \ (x_1 + x_2) - (2x_1 + 3x_3) = -1$ $B: \ (x_3 + x_4) - (x_1 + 2x_2 + x_3) = 1$ $a: \ 2x_2 + x_3 = 5$	$\begin{cases} x_1 - x_2 + 3x_3 = 1 \\ x_1 + 2x_2 - x_4 = -1 \\ 2x_2 + x_3 = 5 \end{cases}$

ε is emty string

Each grammar rule is marked with corresponding r_i

Each equation of the ANLDE system is market with a coresponding grammar symbol

Table 1: An example of ANLDE system

Then the ANLDE system for the grammar G_1 has the form, presented in Table 1, col. 2. The simplified system is shown in col. 3.

Let us note the requirement $I_1 \cup \ldots \cup I_n = \{1, 2, \ldots, m\}$ may be reduced to $I_1 \cup \ldots \cup I_n \subset \{1, 2, \ldots, m\}$. If there is some $i \notin I_1 \cup \ldots \cup I_n$, then one can add x_i to both sides of some equation (but exactly to one equation!). For example, the NLDE system

$$\begin{cases} (x_1 + x_2) - (2x_1 + 3x_3) = -1 \\ x_4 - (x_1 + 2x_2) = 1 \\ 2x_2 + x_3 = 5 \end{cases}$$

is not in form (5), because $3 \notin I_1 \cup I_2 = \{1, 2\} \cup \{4\}$. Adding x_3 to the second equation we get the same ANLDE system as in Table 1

The following theorem shows the relation between derivations in a CF-grammar and solutions of the ANLDE system.

Theorem 1. *Let $v \Rightarrow^* w$ be a derivation in CF-grammar G, x_i is the number of applications of rule r_i in this derivation (i=1,2,...,m). Then $x = (x_1, x_2, \ldots, x_m)$ is a solution of ANLDE system $S(G; v, w)$.*

Therefore, for the ANLDE system form Table 1, each succesfull derivation $B \Rightarrow^* aaAaaa$ corresponds to a solution. Consider such a derivation:

$$B \overset{r_3}{\Longrightarrow} AAAaB \overset{r_4}{\Longrightarrow} AAAa \overset{r_2}{\Longrightarrow} aBBaAAa \overset{r_4,r_4}{\Longrightarrow} aaAAa \overset{r_2}{\Longrightarrow} aaAaBBaa \overset{r_4,r_4}{\Longrightarrow} aaAaaa$$

Rule r_1 is not applied, so $x_1 = 0$; rule r_2 is applied two times, so $x_2 = 2$; rule r_3 is applied one time, $x_3 = 1$; rule r_4 is applied five times, $x_4 = 5$. Thus, we get a solution $x = (0, 2, 1, 5)^\top$.

Definition of ANLDE system does not take into account the order of symbols in strings (v, w, right-hand sides of rules r_i). Let us define $\{\alpha\}^\circ$ as a multiset of all symbols of α (the number of occurances is taken into account!). For example, $\{abaaabA\}^\circ = \{A, a, a, a, a, b, b\} = \{A^1, a^4, b^2\}$. Using this notation, $\{\alpha\}^\circ = \{\beta\}^\circ$ means that the strings α and β differ in order of symbols only. Binary operation $\triangle$ is a symmetric difference of two multisets.

Theorem 2. *Let G' and G'' are CF-grammars with the same alphabet $N \cup \Sigma$; v', w', v'', w'' are strings in this alphabet. If $\{\alpha'_i\}^\circ = \{\alpha''_i\}^\circ \ \forall i = 1, 2, \ldots, m$, where α_i is a right-hand side of rule r_i, and $\{v'\}^\circ \triangle \{v''\}^\circ = \{w'\}^\circ \triangle \{w''\}^\circ$. Then $S(G'; v', w') = S(G''; v'', w'')$.*

According to the theorem, one can take the grammar G_1 (see the above example) and $(v, w) = (BA, aaAaaaA)$. ANLDE system are the same. The derivation

$$BA \overset{r_3}{\Longrightarrow} AAAaBA \overset{r_4}{\Longrightarrow} AAAaA \overset{r_2}{\Longrightarrow} aBBaAAaA \overset{r_4,r_4}{\Longrightarrow} aaAAaA \overset{r_2}{\Longrightarrow} aaAaBBaaA \overset{r_4,r_4}{\Longrightarrow} aaAaaaA$$

constructs the mentioned above solution $x = (0, 2, 1, 5)^\top$. However, for $(v, w) = (B, aaaaaA)$ there is no derivation $B \Rightarrow^* aaaaaA$ in the grammar G_1.

This means one does not take into accont i) the order of symbols in r_i, v, w and ii) symmetric addition/subtraction of symbols in v, w.

Theorem 3. *Vector $x \in \mathbb{Z}_+^m$ is a solution of ANLDE system $S(G, v, w)$ iff x corresponds to a derivation $v' \Rightarrow^* w'$, where $\{v\}^\circ \triangle \{v'\}^\circ = \{w\}^\circ \triangle \{w'\}^\circ$ and the order of symbols in sentential forms is ignored.*

3.1.2 ANLDE system format

The Web-SynDic system uses ANLDE systems in the following format:

```
# Comment
x1 + x2 + ...  + xK2 = c11*x1 + c12*x2 + ...  + c1N*xN
x[K2+1] + x[K2+2] + ...  + xK3 = c21*x1 + c22*x2 + ...  + c2N*xN
...
x[KM+1] + x[KM+2] + ...  + xN = cM1*x1 + cM2*x2 + ...  + cMN*xN
```

The format represents one ANLDE system. `c11`, `c12`, ..., `c1N`, `c21`, `c22`, ..., `cMN` are coefficients (optional, default value is 1). `x1`, `x2`, ..., `xN` are unknowns, may appear in any order, some may be skipped. If there is no unknowns after the "=" sign, write "0". Each unknown must appear in the left-hand side of some equation at most one time. Blank and comment lines are ignored.

The sample of ANLDE system:

```
# Sample ANLDE system
```

```
x1 + x4 = 2*x1 + 3*x3
x2 + x3 = x1 + 2*x2 + x3
```

Format for a set of ANLDE systems is following:

```
<ANLDE system 1>
%
<ANLDE system 2>
%
...
<ANLDE System N>
```

The format represents ANLDE System Set `<ANLDE System 1>`, ..., `<ANLDE System N>`. Each system is in the ANLDE system format. Blank and comment lines are ignored. String with symbols(s) '`%`' is a delimiter for ANLDE systems. These strings may additionally contain blank symbols ('␣', '`\t`') only.

3.2 Algorithms Configuration

One of the important Web-SynDic features is ability to configure external algorithms used for generation and solving ANLDE systems. The algorithms are configured by setting restrictions (limits and parameters). Each restriction has two items: current value and maximum value. The values of items should be integers greater than zero except "maximum number of basis solutions in report" which can be set to zero.

Algorithms configuration form allows to configure solver limits (section 3.2.1), generator limits (section 3.2.2), and generator parameters (section 3.2.3). Example of Algorithms Configuration form is shown in Figure 3.

3.2.1 Solver limits

User can set the following solver limits:

Max. CPU time for solving — maximum CPU time in seconds for solving one task, i.e. single ANLDE system or ANLDE system set. If sum of CPU work times is greater than the restriction then the solving process is interrupted with corresponding error message.

Max. memory for solving — maximum virtual memory for each solving process. If amount of memory exceeds the limit then the solving process is interrupted with corresponding error message.

Max. number of basis solutions in report — maximum number of basis solutions in report. If number of solutions exceeds this limit then other solutions are left out.

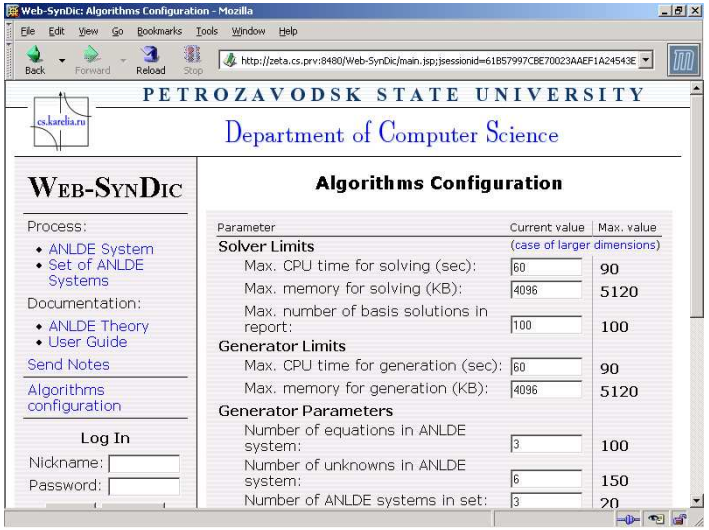

Figure 3: Algorithms Configuration

User is unable to set restrictions for ANLDE systems such us maximum number of equations in ANLDE system. The Web-SynDic system uses maximum values for these restrictions which are described in section 3.2.3.

3.2.2 Generator Limits

User can set the following generator limits:

Max. CPU time for generation — maximum CPU time for ANLDE system generation. If CPU work time is greater than the restriction then the generation process is interrupted with corresponding error message.

Max. memory for generation — maximum virtual memory for each generation process. If amount of memory exceeds the limit then the generation process is interrupted with corresponding error message.

3.2.3 Generator Parameters

User can set various parameters for generation process but in some cases (for example if number of unknowns is much greater than the number of equations and number of solutions is rather small) generator is unable to generate an ANLDE system.

The generator has the following parameters:

Number of equations in ANLDE system — number of equations in each generated ANLDE system. The number of equations should be less than the number of unknowns.

Number of unknowns in ANLDE system — number of unknowns in each generated ANLDE system. The number of unknowns should be greater than the number of equations.

Number of ANLDE systems in set — Number of ANLDE systems in generated set. This parameter is not used while generating single ANLDE system.

Max. values of coefficients for ANLDE system — maximum value of coefficients in generated ANLDE system.

Max. values of components in basis solution — maximum value of components in basis solutions.

Max. number of basis solutions for ANLDE system — maximum number of basis solutions for ANLDE system.

3.3 Processing a test ANLDE system

Web-SynDic can be used for solving test ANLDE system and showing report on solution to the user. The ANLDE system should be given manually by a user or generated automatically by a selected generator. Recently, only homogeneous ANLDE systems are supported by the Web-SynDic system.

Process an ANLDE system form is shown in Figure 4.

Web-SynDic system checks each solution by substitution the solution into the given ANLDE system. Also if user uses alternative solver then the Web-SynDic system compares corresponding solutions.

3.3.1 Creating ANLDE system

The Web-SynDic system supports two ways for creating ANLDE system:

- Manual input. User can input ANLDE system manually into the text area of the corresponding form (see Figure 4). The ANLDE system should be in ANLDE format (see section 3.1).
- Automatic generation. The Web-SynDic system supports two generators called `Gauss` and `Gordano`. After generation user can modify produced ANLDE system.

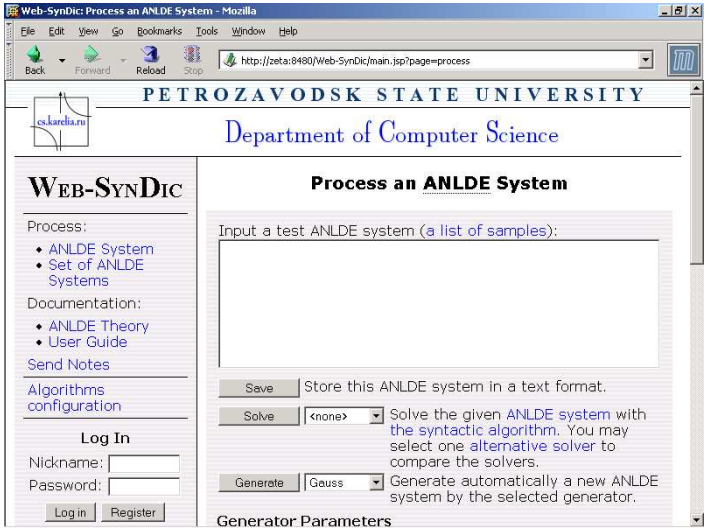

Figure 4: Process ANLDE System

The generation process consists of the following steps:

1. Set generator parameters using Algorithms configuration form (see section 3.2) or in the bottom of the current Process an ANLDE system form (see Figure 5).
2. Choose desired generator and press **Generate** button. All generation queries are put into the Generator Spooler queue. The Web-SynDic displays the number of tasks in the Generator Spooler queue (see section 3.5.2). During generation time the Web-Syndic system shows the processing form (see Figure 6).
3. In the case of successful generation produced ANLDE system will be placed in the text area of Process an ANLDE system form (see Figure 7).
4. If generator is unable to produce an ANLDE system (for example if numbers of equations and unknowns are equal, see Figure 8) you may change generator or generator parameters and try again. In some cases you may try again without changing any parameters.

Generated or manually inserted ANLDE system is stored by the Web-SynDic system as long as you work with it.

The Web-SynDic system may display the following generation errors:

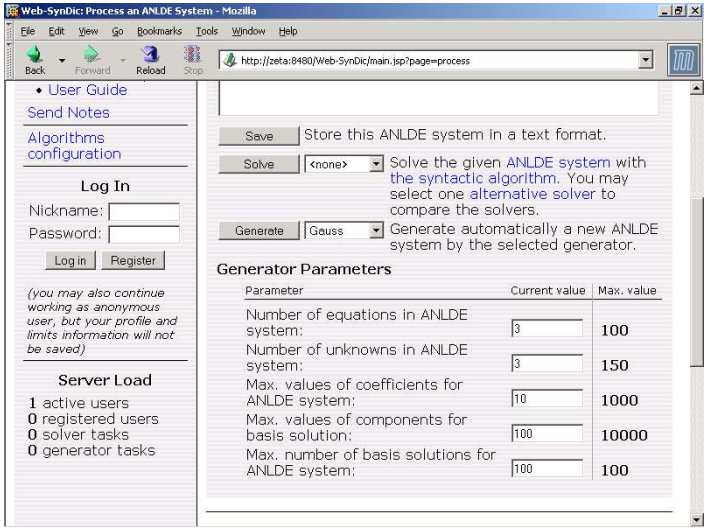

Figure 5: Generator parameters

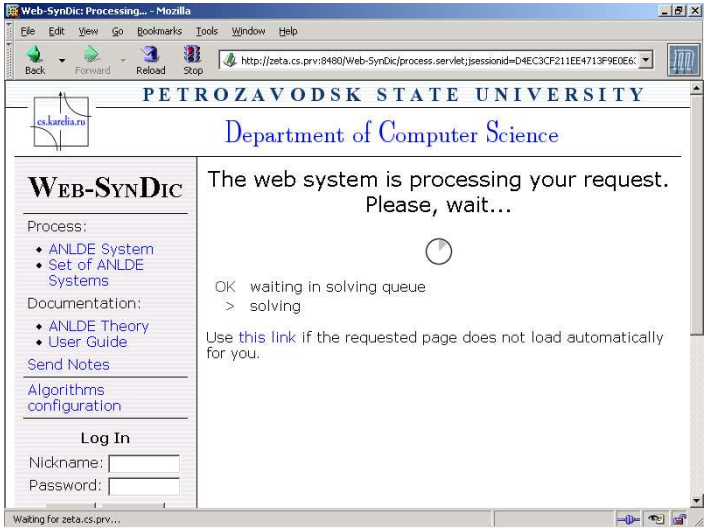

Figure 6: Web-SynDic wait page

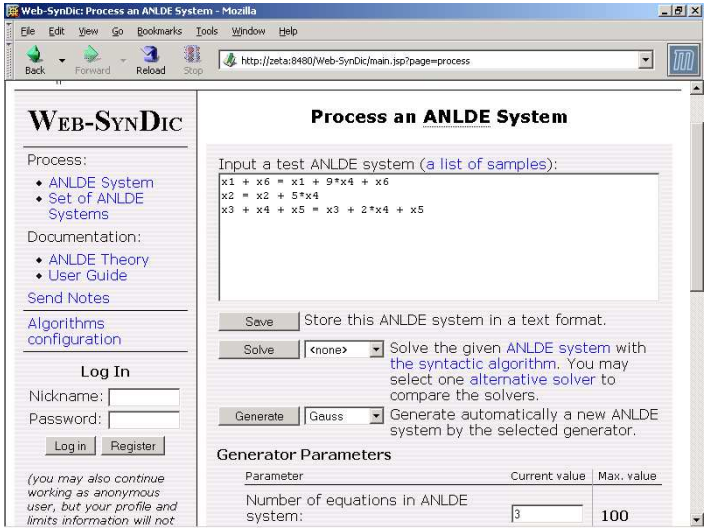

Figure 7: Generated ANLDE system

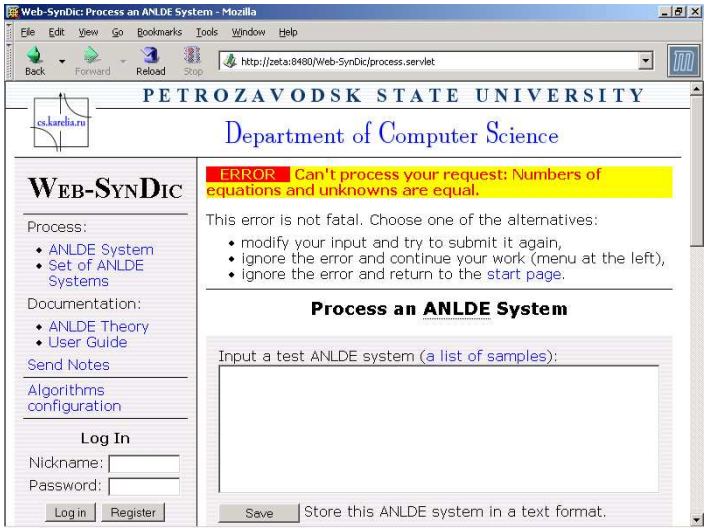

Figure 8: Generator failed

- "Number of equations is greater than number of unknowns". Check that the number of equations is less than the number of unknowns.
- "Numbers of equations and unknowns are equal". The generator does not support this class of ANLDE systems. You can input the system manually.
- "CPU time limit exceeded. Try to increase time limit". Time limit is too small or generator parameters are too large. Try to increase time limit or change generator parameters.
- "Algorithm cannot generate ANLDE system(s) or memory limit exceeded". The generator is unable to generate ANLDE system with current parameters or memory limit is too small. Try to increase memory limit or change generator parameters.
- "Generator failed". The generator parameters are possibly wrong or the program itself failed to execute for some reason. We will be pleased if you will send note (see section 3.8) containing generator parameters in this case.
- "Generator failure: parameter maximum value of coefficients for ANLDE system exceeded". The maximum value of coefficients for ANLDE system is too small. Try to increase it.
- "Generator failure: parameter maximum value of components in basis solutions exceeded". The maximum value of components in basis solutions is too small. Try to increase it.
- "Generator failure: parameter maximum number of basis solutions exceeded". The maximum number of basis solutions is too small. Try to increase it.
- "Generator failure: generated system is not correct". The generator is unable to generate ANLDE system or generated ANLDE system is invalid. We will be pleased if you will send note (see section 3.8) containing generator parameters in this case.

3.3.2 Solving ANLDE system

The Web-SynDic system default solver is `Syntactic`. User can also use alternative solvers: `Slopes` and `Lp_solve`. The solving process consist of the following steps:

1. Insert valid ANLDE system into the text area of the Process an ANLDE system form. Alternatively, you can generate it automatically (see section 3.3.1). If ANLDE system is invalid or text area is empty then the Web-SynDic system prints error message (see Figure 9).

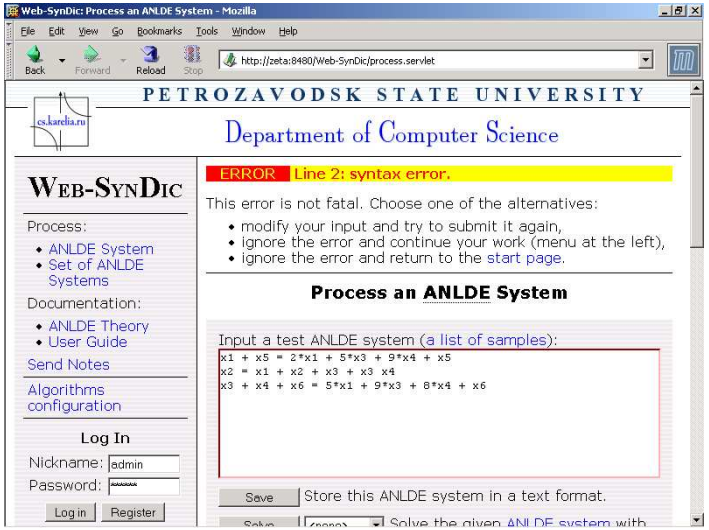

Figure 9: Syntax error message

2. Set solver parameters using Algorithms configuration form (see section 3.2). You may also use default values.
3. Select alternative solver (if needed) and push button **Solve** (see Figure 10). All solving queries are put into the Solver Spooler queue. The Web-SynDic displays the number of tasks in the Solver Spooler queue (see section 3.5.2). During solving time the Web-Syndic system shows the processing form (see Figure 6).

After processing the Web-SynDic system displays Solution Report form (see Figure 11). The Solution Report form contains the following information:

- Test ANLDE system in traditional mathematical style and number of solutions. Current version of the Web-Syndic system obtains the number of solutions from the default solver.
- Waiting time in Solver Spooler buffer. If buffer is empty then Solver Spooler executes new task immediately and waiting time equals to zero.
- Performance metrics of the algorithms:
  - algorithm name;
  - summary CPU work time in seconds;

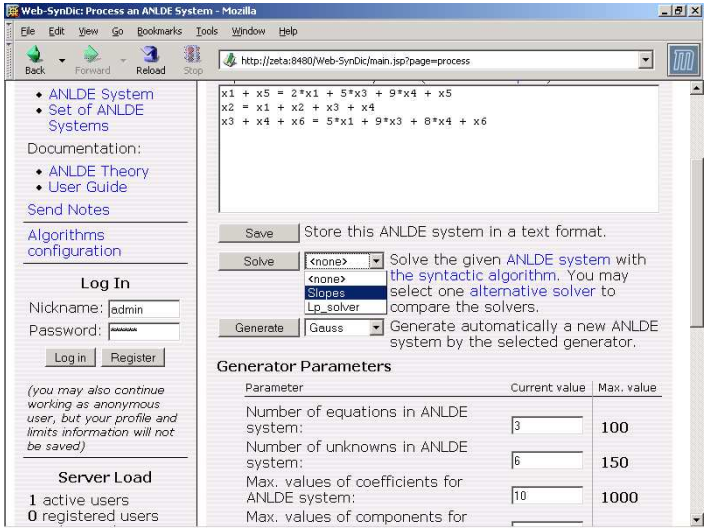

Figure 10: Alternative solvers

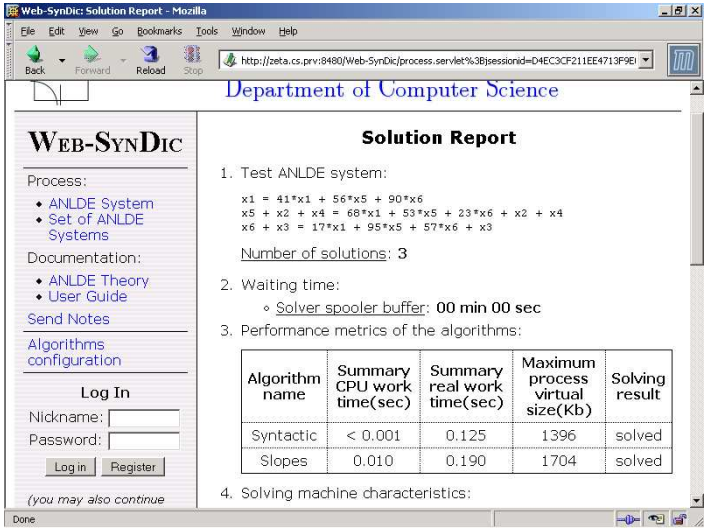

Figure 11: Solution report for one ANLDE system

— summary real work time in seconds;

— maximum process virtual size in kilobytes;

— solving result.

At the present the time unit for CPU work time is 0.001 second. If Solver uses CPU work time which is less than 0.001 second then "< 0.001" is printed in the report page.

If the value is not available (for example Maximum process virtual size is not available when algorithm executes too fast) then "N/A" is displayed in the corresponding field.

The field Solving result contains "solved" if the system is solved successfully. Otherwise error message is displayed.

- Solving machine characteristics like processor, core memory, operating system, Java version, Tomcat version, and Solver process nice value, if they are available.
- Solutions of the test ANLDE system if the system is solved successfully.
- Note on solution. You can simply press **Agree with the result** button or send more detailed message (see section 3.8).

The Web-SynDic system may display the following errors while solving given ANLDE system:

- "Failed to solve the problem". Solver process is abnormally terminated (for example, the process is killed). We will be pleased if you will send note (see section 3.8) containing the ANLDE system and the list of solvers in this case.
- "Limit exceeded: maximum CPU time for solving". Try to increase maximum CPU time for solving parameter.
- "Algorithm failed". The solver produces invalid solution (for example, the solver prints error message). We will be pleased if you will send note (see section 3.8) containing the ANLDE system and the list of solvers in this case.
- "Internal solver error or memory limit exceeded". Try to increase memory limit.
- "CPU time limit exceeded". Try to increase maximum CPU time for solving.
- "Limit exceeded: maximum memory for solving". Try to increase memory limit.
- "Limit exceeded: maximum values of coefficients for basis solutions". Try to increase maximum values of coefficients for basis solution.

- "Limit exceeded: maximum number of unknowns". The solver returns more unknowns than given ANLDE system contains. We will be pleased if you will send note (see section 3.8) containing the ANLDE system and the list of solvers in this case.
- "Limit exceeded: maximum number of solutions". Try to increase maximum number of basis solutions for ANLDE system.

3.3.3 Saving ANLDE system

The Web-SynDic has a feature, which allows user to save ANLDE system in a file. The saving process consists of the following steps:

1. Insert valid ANLDE system into the text area of the Process an ANLDE system form. Alternatively, you can generate it automatically (see section 3.3.1).
2. Press **Save** button to save the ANLDE system in a file. The Web-SynDic system opens new browser window containing the ANLDE system (see Figure 12).

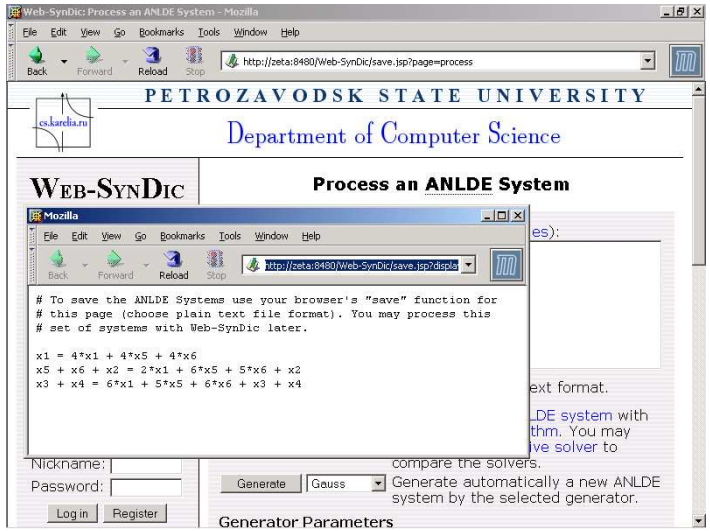

Figure 12: Save ANLDE system

3. Using standard browser functions you can save the system in a file. **The Web-SynDic system uses pop-up windows for saving ANLDE system. Your browser should support pop-up windows.**

3.4 Processing a set of ANLDE systems

The Web-SynDic system allows a user to process a set of ANLDE systems. The set of ANLDE systems should be given manually by a user or generated automatically by a selected generator. Recently, only homogeneous ANLDE systems are supported by Web-SynDic.

Process a Set of ANLDE systems form is shown in Figure 13.

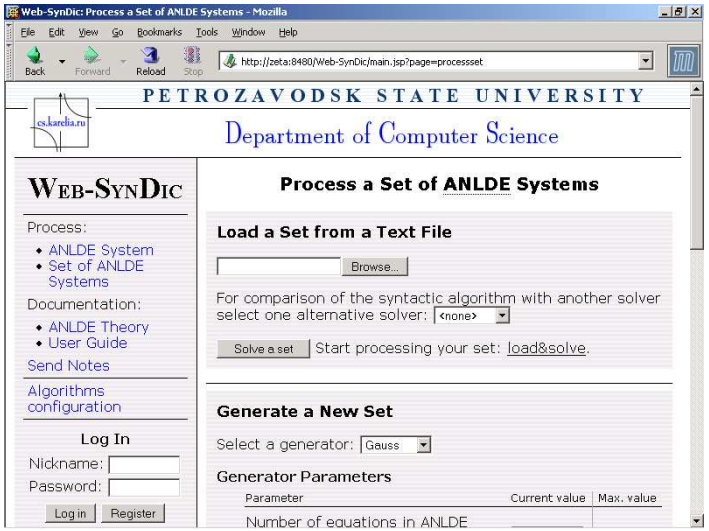

Figure 13: Process a Set of ANLDE Systems

CPU time limit is used as a common restriction for the whole solving process while processing ANLDE system set. If the solver is unable to solve any ANLDE system in the set then the solving process is stopped and descriptive error message is displayed to the user.

3.4.1 Loading and solving ANLDE system set

The Web-SynDic system supports solving a set of ANLDE systems previously loaded from a file. The form for loading and solving ANLDE systems is shown in Figure 13.

The loading and solving process consists of the following steps:

1. Set solver parameters using Algorithms configuration form (see section 3.2). You may also use default values.
2. Use the button **Browse...** to select the file containing the set of ANLDE systems. The ANLDE system set should be in ANLDE system set format (see section 3.1). If ANLDE

system set is invalid or text area is empty then the Web-SynDic system prints error message (see Figure 14).

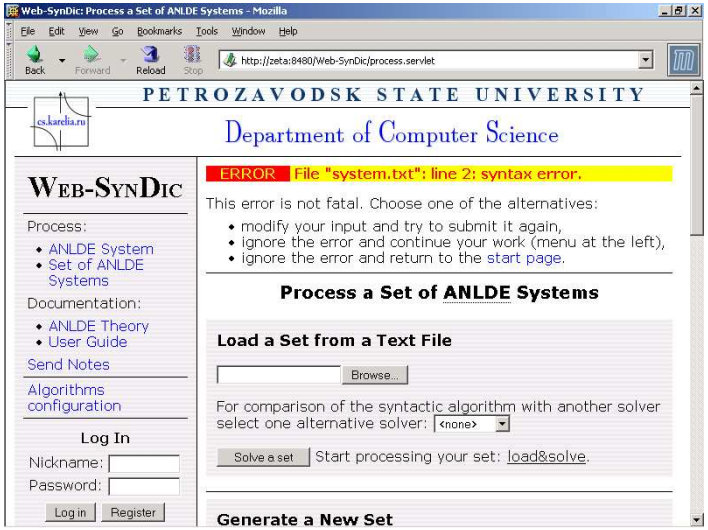

Figure 14: Syntax error message

3. Select alternative solver (if needed) and push button **Solve a set**. All solving queries are put into the Solver Spooler queue. The Web-SynDic displays the number of tasks in the Solver Spooler queue (see section 3.5.2). During solving time the Web-Syndic system shows the processing form (see Figure 6).

After processing the Web-SynDic system displays Solution Report (see Figure 15). The Solution report contains the following information:

- Number of ANLDE systems in the set.
- The characteristics of ANLDE system set:
  - — minimum equations;
  - — average equations;
  - — maximum equations;
  - — minimum unknowns;

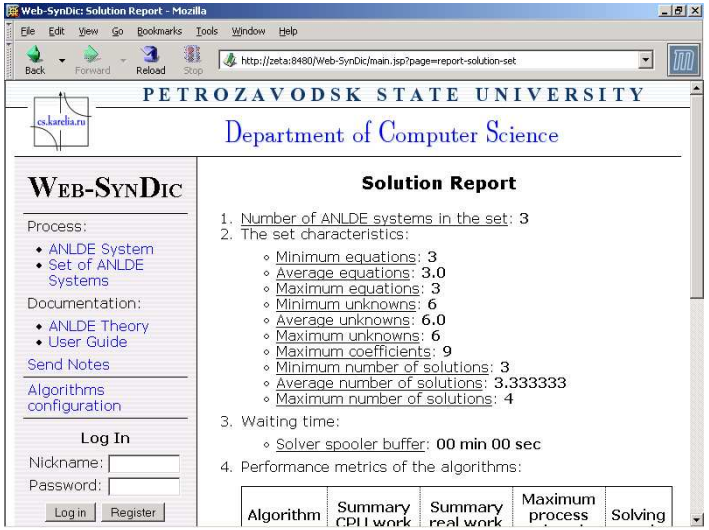

Figure 15: Solution report for the set of ANLDE systems

  - — average unknowns;
  - — maximum unknowns;
  - — maximum coefficients;
  - — minimum number of solutions;
  - — average number of solutions;
  - — maximum number of solutions.

  The solution characteristics are obtained from the default solver. Therefore if the default solver fails then the characteristics are set to “N/A”.
- Waiting time in Solver Spooler buffer. If buffer is empty then Solver Spooler executes new task immediately and waiting time equals to zero.
- Performance metrics of the algorithms:
  - — algorithm name;
  - — summary CPU work time in seconds;
  - — summary real work time in seconds;

— maximum process virtual size in kilobytes;

— solving result.

At the present the time unit for CPU work time is 0.001 second. If Solver uses CPU work time which is less than 0.001 second then "< 0.001" is printed in the report page.

If the value is not available (for example Maximum process virtual size is not available when algorithm executes too fast) then "N/A" is displayed in the corresponding field.

The field Solving result contains "solved" if the system is solved successfully. Otherwise error message is displayed.

- Solving machine characteristics like processor, core memory, operating system, Java version, Tomcat version, and Solver process nice value, if they are available.
- Note on solution. You can simply press **Agree with the result** button or send more detailed message (see section 3.8).

The list of possible solver errors is presented in section 3.3.2.

3.4.2 Generating and solving ANLDE system set

The Web-SynDic system allows a user to generate and solve a set of ANLDE systems at once. The form for generating and solving a set of ANLDE systems is shown in Figure 16.

The generating and solving process consists of the following steps:

1. Set generator parameters using Algorithms configuration form (see section 3.2) or in the bottom of the current Generate a New Set form (see Figure 16). You may also use default values.
2. Choose desired generator and press **Solve a set** button. All generation queries are put into the Generator Spooler queue. The Web-SynDic displays the number of tasks in the Generator Spooler queue (see section 3.5.2). During generation time the Web-Syndic system shows the processing form (see Figure 6).
3. After successful generation produced ANLDE system set is put into the Solver Spooler queue. The Web-SynDic displays the number of tasks in the Solver Spooler queue (see section 3.5.2). During solving time the Web-Syndic system shows the processing form (see Figure 6).

   If Solver Spooler queue is full then the Web-SynDic system prints error message "Unable to process your request: Buffer is full. Task rejected.". You may try to reload this page later, and the generated system set will be put into solver spooler queue if it has available space.

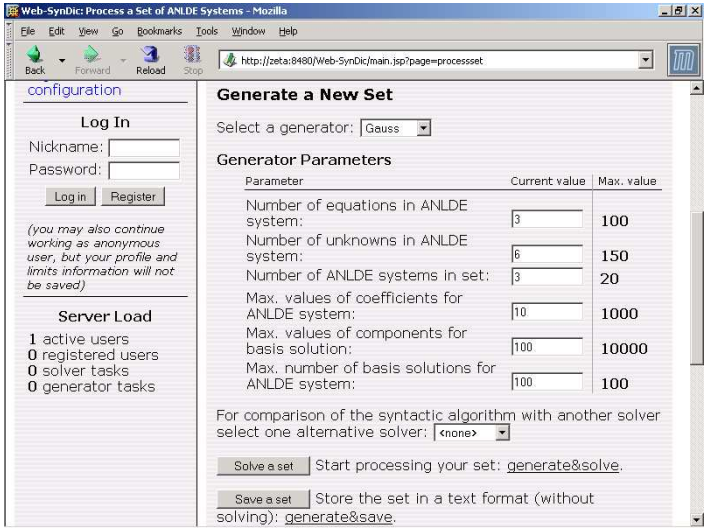

Figure 16: Generation form for set of ANLDE systems

After processing the Web-SynDic system displays Solution Report (see Figure 15). The Solution report contains the information, described in section 3.4.1, and additional field Wait time: Generator spooler buffer, which contains waiting time in Generator Spooler buffer.

The list of possible generator and solver errors is presented in sections 3.3.1, and 3.3.2.

3.4.3 Generating and saving ANLDE system set

The Web-SynDic system allows a user to generate and save a set of ANLDE systems. The form for generating and saving a set of ANLDE systems is shown in Figure 16.

The generating and saving process consists of the following steps:

1. Set generator parameters using Algorithms configuration form (see section 3.2) or in the bottom of the current Generate a New Set form (see Figure 16). You may also use default values.
2. Choose desired generator and press **Save a set** button. All generation queries are put into the Generator Spooler queue. The Web-SynDic displays the number of tasks in the Generator Spooler queue (see section 3.5.2). During generation time the Web-Syndic system shows the processing form (see Figure 6).

3. After processing the Web-SynDic system opens new browser window containing the ANLDE system set (see Figure 17).

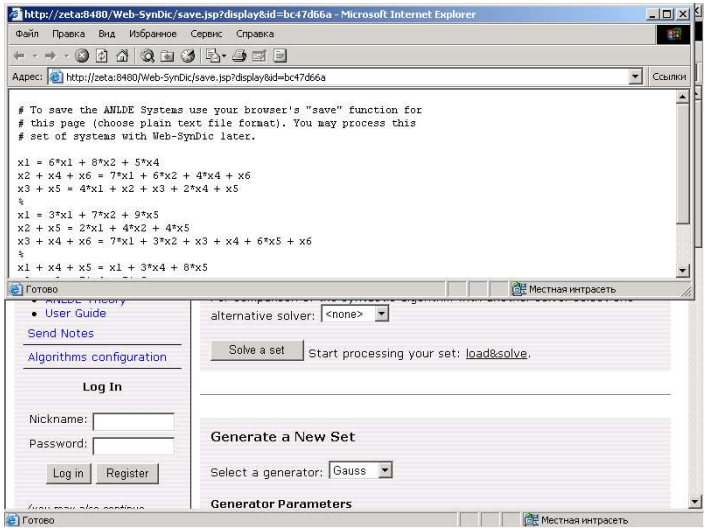

Figure 17: Save a set of ANLDE systems

4. Using standard browser functions you can save the system in a file. **The Web-SynDic system uses pop-up windows for saving ANLDE system set. Your browser should support pop-up windows.**

3.5 Server Load

3.5.1 User Session

One of the main concept of the Web-SynDic system is session. There are two types of sessions: a physical server session and a logical Web-SynDic session. Web-SynDic session is a continuous time period of user's working with the Web-SynDic. Web-SynDic session stores all information about current work in the system, for example ANLDE systems, algorithms configuration etc. Further we will use term "session" instead of "Web-SynDic session".

Session is established when any user (regular on registered) starts using the system. It is open until a user logs out or closes the connection. If a user logs out, then the logical session is closed at once, but if a user closes the connection, for example closes the browser window,

the session is still alive for a some period of time (default is 15 min and configured by Jakarta Tomcat server).

If a user has established a session and is not using the system for a long time, the session is also terminated automatically.

Each session has own identifier on the server side. A new session identifier is generated whenever the session has been established. If cookies are enabled in user's browser, then the cookies are used to store session identifier. Otherwise, the session identifier is passed by the URL string in a browser window.

3.5.2 Server load information

One of the important features of the Web-SynDic system is server load information, presented to each user. According to that information user may estimate waiting time while generating or solving ANLDE systems, and correlate performance metrics of algorithms. The Web-SynDic server load information consists of the following items:

- `active users` — number of all currently active users in the system, i. e. number of all opened sessions (see section 3.5.1 for details);
- `registered users` — number of registered users in the system (see section 3.6 for details);
- `generator tasks` — number of tasks queued for generation;
- `solver tasks` — number of tasks queued for solving.

All this information is shown in the corresponding Server Load form at the left bottom part of the browser window. Example information on server load including active users number, registered users number, solver tasks, and generator tasks is presented in Fig. 18.

3.6 Registration and Log In

There are two general types of users in the Web-SynDic system: a regular user and a registered user. A regular user is any Web-SynDic user and she/he is not required to register and log in the web system. A registered user has to have an account in the web system, and his/her personal information including limits for solving and generating ANLDE systems is saved in personal user profile.

Web-SynDic allows any regular user to register whenever she/he wishes. When the registration is complete, this user may log in the web system (using assigned unique identifier:

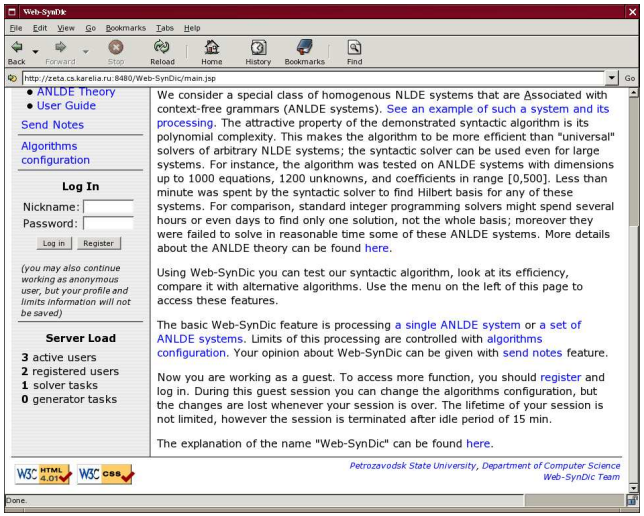

Figure 18: Server load information

nickname and password), afterward some additional Web-SynDic features may be used. Web-SynDic allows a registered user to edit and store personal profile with user limits independently on session lifetime.

The registration is initialized with the **Register** button in the Log In form. Afterward the web system returns the form, shown in Fig. 19. The user feeds the fields of the form with information he/she wishes to provide about himself/herself , and clicks on the **Register** button to complete registration. The required fields for filling are marked with "*" sign. A nickname may contain only latin letters, numbers and underscores; also a nickname contains at least 2 and no more than 32 characters. A password may contain at least 4 and no more than 32 characters. If there is an error in filled fields, then Web-SynDic responds with a corresponding error message; it includes a reason of the error.

When the registration has been completed, the user may log in the Web-SynDic system. To do this, he/she enters login and password in the Log In form and clicks on the **Log in** button.

After successful login, contents of main window are changed. Log In area now contains user status in the Web-SynDic system. User Profile link appears in User Menu to provide additional Web-SynDic feature.

Logout from the web system is performed using Log out link. It appears after successful login in Log In area. It is strongly recommended for every registered user to explicitly log out at the end of her/his session.

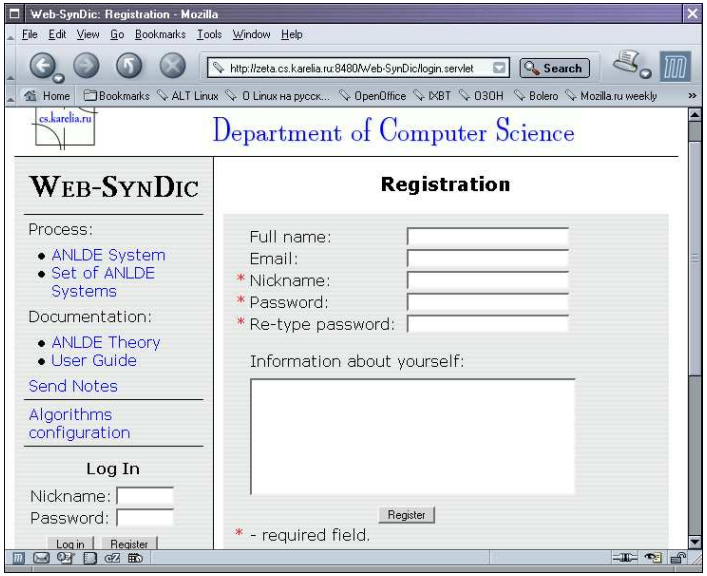

Figure 19: Registration form

3.7 User Profile Configuration

When a user is logged in the web-system (see subsection 3.6) he/she may use User profile link to manage own profile. The User profile (see Fig. 20) form is divided into three parts (subforms): User information form, User password form and User account form.

User information subform is used to configure personal user information, such as full name, email, and other information. After pressing **Submit** button all changes are saved in the user profile.

In the User password subform a user may change own password. He/she should input new password an re-type it. For the security reasons a user should also fill Old password text field. After pressing **Change password** button new password is saved in the user profile.

For removing user account a user should input his/her password in the User account subform and press **Remove account** button. If the password is valid then the user profile is deleted.

If a user has administrator privileges and uses Manage users service (see section 4.2), then Old password text field in the User password subform and Password text field in the User account subform are not shown.

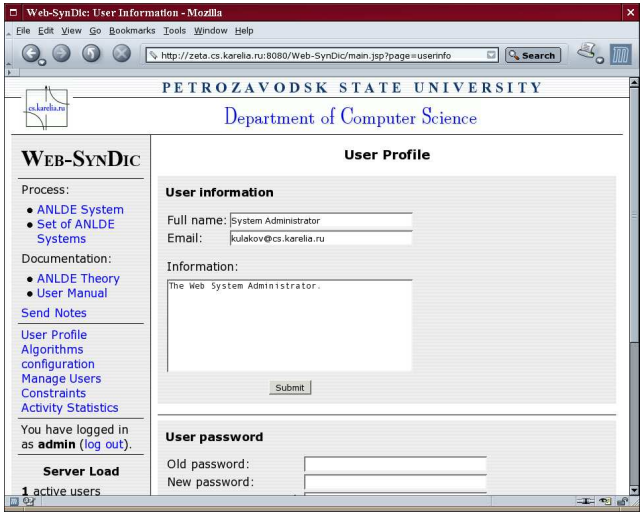

Figure 20: User profile form

3.8 Web-SynDic notes

Web-SynDic allows a user to send any her/his opinion to the Web-SynDic system administrator. A special case here is user's disagreement with found solution(s) of the processed ANLDE system.

To compose a general note, i.e. note about Web-SynDic as a whole system, a user clicks on the Send notes link in Main Menu, whereupon he/she will be returned with the following form (see Fig. 21).

The user writes as plain text what he/she wish to send, and clicks on the **Send note** button. The composed note will be transferred to the Web-SynDic system administrator by email.

Web-SynDic provides a feature to send note about particular solved ANLDE system(s). When a report on solution is returned, a user may select Note on solution link for sending more detailed opinion about this solution or just press the **Agree with the result** button whenever he/she satisfied with the solution.

If a user selects Note on solution, then Notes on Solution form will appear, see Fig. 22.

With the form the user can choose one of the two possibilities:

- Agreement with the result of solving.
  In this case the user may or may not attach ANLDE system(s) to the note, using the Attach processed system checkbox.

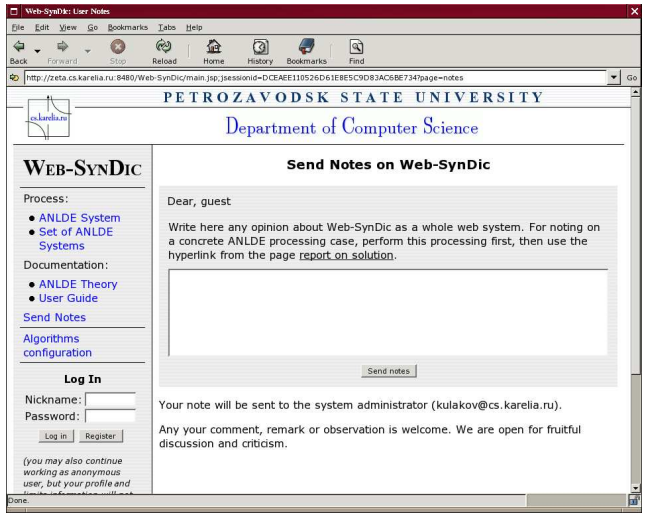

Figure 21: General note

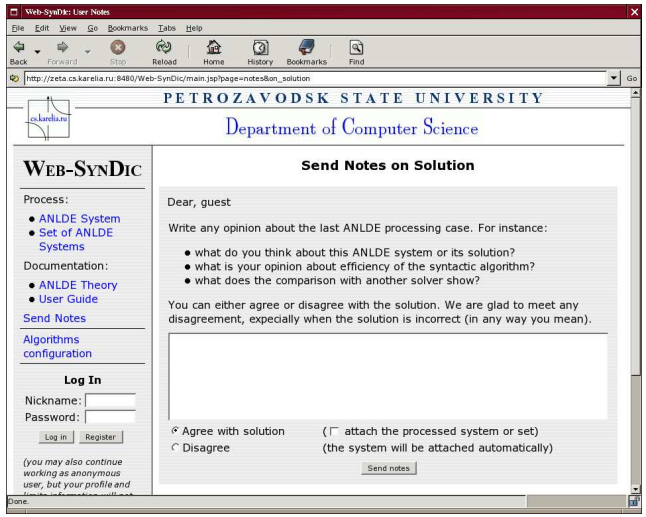

Figure 22: Note on solution

- Disagreement with the result of solving.
  In this case the processed ANLDE system(s) will always be attached to the note automatically.

Both features are used for backward opinions of Web-SynDic users but the latter is also intended for testing the syntactic algorithms.

If a user just presses **Agree with the result** button directly in the report on solution page, a standard message about solution agreement is send to the Web-SynDic system (for statistics).

4 Sysadmin Manual

System administrator is a privileged user; she/he manages and controls the web system. This includes maintainance of the data store, activity statistics usage and management of users and user limits.

4.1 Logging in as an administrator

To access the administrator privileges you need to log in the Web-SynDic system as administrator. There is predefined nickname *admin* for privileged user in the web system, but you can change it or add a new user with administrator's privileges. Logging in is quite typical (see also section 3.6): you enter the nickname and password in the corresponding form and press **Log in** button. If the password is correct and the user with entered nickname has administrator privileges, you will see administrator greeting and some options, which are inaccessible to regular user, see Fig. 23.

If you want to finish your current administrator session and become an anonymous user, just follow log out link. It is dangerous to leave administrator session opened after you have been finished your work, so **don't forget to log out if you have been logged in as administrator.**

4.2 User management

One of the specific administrator options is ability to manage other users. The user management means viewing and changing any existing user information and removing user accounts. Follow Manage Users link to get User Management form, see Fig. 24.

To manage a user you need to enter nickname into the form and press **Get Profile** button. If you have administrator privileges and the nickname is valid, you will see the standard form for editing user profile (see section 3.7). If any error has been occurred you get a message with the error description. After editing the information do not forget to press **Submit** button, if you want the changes to be saved.

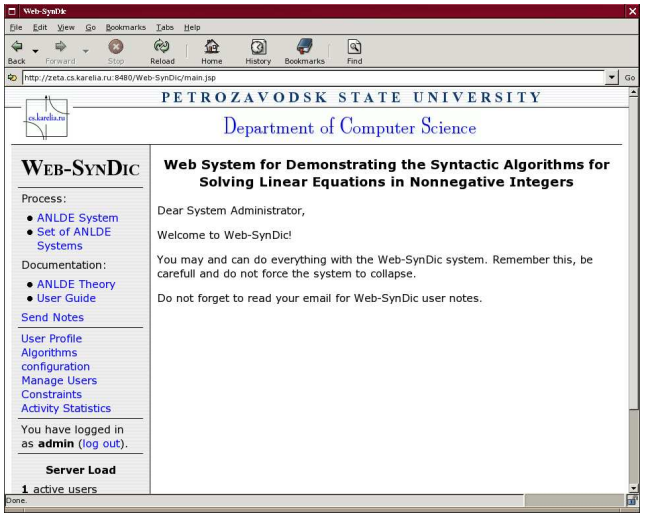

Figure 23: Administrator main window

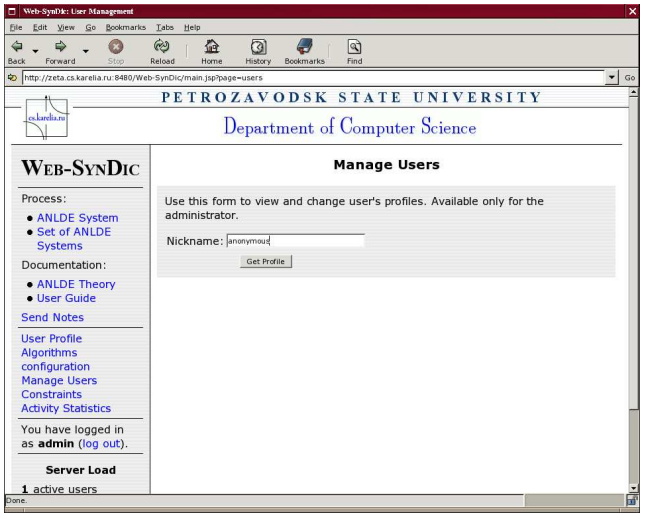

Figure 24: User management

Be careful while changing password and especially removing accounts, you may easily remove even administrator account.

4.3 Changing constraints

Administrator has ability to change the constraints. Constraints are the upper[1] limits for some parameters needed by a solver or generator, e.g. number of ANLDE systems in a set, maximum time for solving, etc. A regular user can not set her/his user limits for generation and solving (section 3.2) to values greater than the constraints.

To change constraints follow Constraints link. If you have administrator privileges you will see the form for changing the constraints, see Fig. 25. After setting some values do not forget to press **Submit** button.

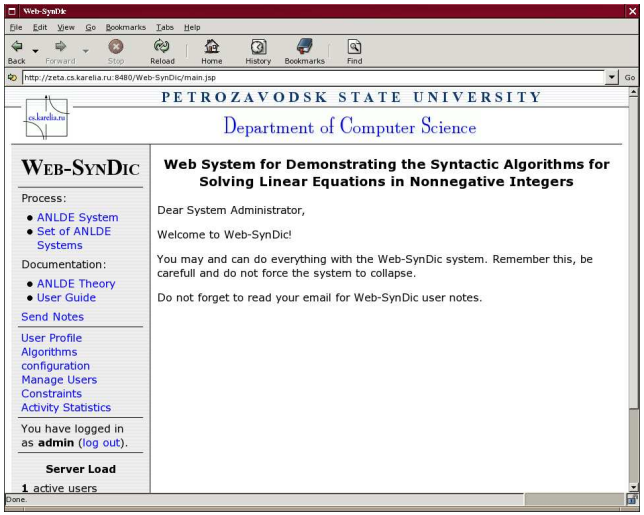

Figure 25: Changing constraints

Be careful while changing bounds on limits, you can overload or even corrupt the web system.

4.4 Viewing activity statistics

Administrator has ability to view activity statistics, collected by the web system. The activity statistics mean summarized information appropriate to selected domain and metrics for current

[1]Perhaps in future there will be lower bounds too.

month. Activity statistics domain is a criterion by which statistics information is summarized, e.g. user nickname or IP address. Activity statistics metrics define categories for statistics report, e.g. requests for solving or number of sessions.

To view activity statistics follow the link Activity Statistics. If you have administrator privileges you will see form for viewing activity statistics, see Fig. 26. Here you can choose the type of statistics report.

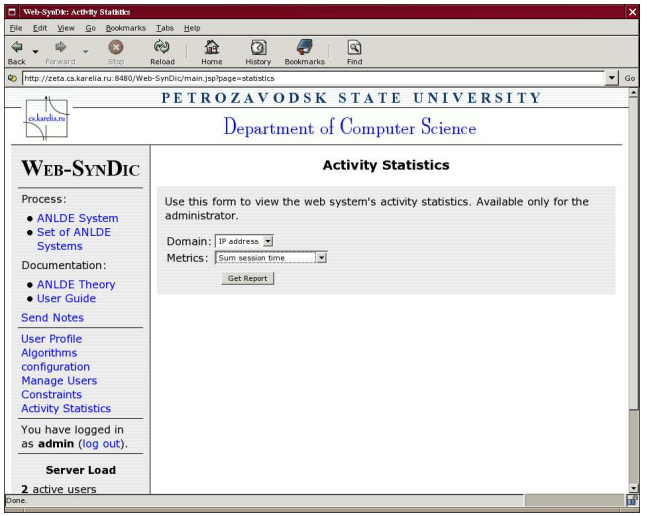

Figure 26: Viewing activity statistics

A statistics report contains time of report generation and statistics information appropriate to selected domain and metrics for current month. You can choose either nickname and IP address as the domain of the report. Number of sessions, total sessions time, requests for solving, requests for generation, total system time, total work time, agreements with solutions can be selected as metrics for a required report. After pressing **Get Report** button you will see the statistics report. Records in the report are sorted by domain. An example of statistics report with nickname selected as domain and number of sessions selected as metrics is shown in Fig. 27.

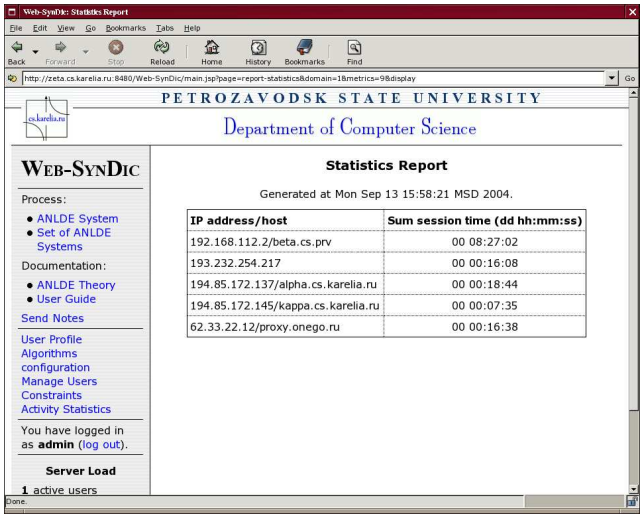

Figure 27: Example of activity statistics report

5 Installation and Configuration Instructions

Software requirements:

Web-SynDic requires Java 1.4 or later (http://java.sun.com/) and Jakarta Tomcat 4.1.x or 5.0.x. (http://jakarta.apache.org/).

Web-SynDic distribution:

The Web-SynDic software consists of the platform-independent part and external solving and generation programs. You will need the versions of these programs compiled for your platform.

Installation instructions:

To install Web-SynDic into Jakarta Tomcat server, copy the Web-SynDic directory or war archive into the Tomcat's webapps directory. Also, you may use the Tomcat Web Application Manager included with the Jakarta Tomcat to install Web-SynDic into the running server. For more details see the Jakarta Tomcat documentation.

Configuration:

Web-SynDic supports the following context parameters:

solver_spooler.path, generator_spooler.path : path to the external programs directories.

datastore.path : path to the data store directory, where user accounts and limits are stored.

admin_email : administrator's email for user notes and bug reports.

server.cpu, server.ram, server.os, server.nice, server.java : server information to be displayed in the report pages.

You may define the context parameters in the WEB-INF/web.xml file in the following format:

```
<context-param>
<param-name>parameter name</param-name>
<param-value>parameter value</param-value>
</context-param>
```

Jakarta Tomcat 5.0 compatibility issues:

At this moment sending notes subsystem is not working correctly under Tomcat 5.0. It ignores configuration of ``mail/Session'' JNDI resource in `${TOMCAT_HOME}/conf/server.xml` and uses ``localhost'' as SMTP server by default.

6 Frequently Asked Questions

Question: I am trying to save ANLDE system (set of ANLDE systems) but browser doesn't open corresponding window with the system as described in documentation. Why?

Answer: The Web-SynDic system uses pop-up windows for saving ANLDE systems. Your browser probably blocks pop-up windows. Enable pop-up windows and try again.

Question: Sometimes Maximum process virtual size in Solution report is "N/A". Why?

Answer: The Web-Syndic system uses external programs for collecting resource usage information. These programs read solver process system information, which should be updated at least one time. So, if solver executes too fast the information is not updated. If you still want to know Maximum process virtual size you may try to solve the system several times until this information is obtained.

Question: I am trying to solve a set of ANLDE systems, but the solver fails. How can I solve this set anyway?

Answer: At present the Web-SynDic system doesn't support detailed error messages for ANLDE system sets. You may try to solve each ANLDE system separately and manually remove unsolvable system from the set.

Question: What does "there is an ANLDE system already in processing" warning mean?

Answer: The Web-SynDic can process no more than one ANLDE system (or set of systems) for a user at the same time. So after you have requested generating or solving a system you can not send new requests until the processing of the previous system is finished.

Question: Why does my task spends so much time waiting in solving and generation queues?

Answer: The Web-SynDic does not solve or generate ANLDE systems concurrently. So if there are many users processing ANLDE systems your task will be added to the end of queue and will wait until all previously requested processings are finished. You may see the number of queued tasks in the "Server Load" section of the left-hand panel on any page of the web system.

Question: Why I may want to register in the web system?

Answer: Your algorithms configuration values will be saved on server and restored every time you log in. Also we will be able to identify notes sent by you.

Question: How can I register in the Web-SynDic system?

Answer: You should click **Register** button of the Log in form and fill all necessary text fields with your information. Then press **Register** button in the User registration form. If all text fields are filled correctly and "Registration succesfull" message is displayed you become a registered user.

Question: How can I contact the Web-SynDic team?

Answer: You may click Web-SynDic Team hypertext link at the bottom right corner of any pageof the web system. Detailed contact information should be displayed on the Web-SynDic Team page.

Question: I want to know more about the Web-SynDic system development. Where can I get Web-SynDic documentation?

Answer: You may find this and all other interesting information about the Web-SynDic system (latest news, publications) at the Web-SynDic website `http://zeta.cs.karelia.ru/Web-SynDic`.

Question: I want to generate and solve set of ANLDE systems. I follow link Set of ANLDE systems and press **Generate&Solve** button. The system successfully finishes generation process, but after that "Buffer is full. Task rejected." error message is shown. What is happening?

Answer: The Web-SynDic system uses two independent spoolers for generating and solving ANLDE systems correspondingly. Each spooler may process only one task at the moment and store limited number of other tasks (ANLDE systems or system sets for processing) in its buffer. After generating ANLDE system set the Web-SynDic system tries to put generated set into the solver spooler queue. Thus, if the solver spooler buffer is already filled with other users' tasks, the corresponding error message is returned to you. This error is not fatal. Moreover, after waiting for a while you can press **Reload** button of your browser, and the generated system set will be put into solver spooler queue if it has available space.

Question: I have logged in as the system administrator, and I want to manage users. I follow Manage Users link and see form which prompts me to enter user nickname. Is it possible to get a list of all users in the Web-SynDic system?

Answer: The list of all users is currently unavailable. This feature will be added in future releases. In this version you have to enter user nickname manually.

Question: I have logged in as the system administrator, and I want to get activity statistics report. I follow Activity Statistics link, set IP address as a report domain, and press

Get Report button. After getting report some fields in the "IP address/Host" column contain only IP addresses. Why?

Answer: Sometimes it is possible to get only IP address of host, not the full host name. In this case only IP address is displayed in the corresponding column of the report.

7 Glossary

Term	Description
Activity statistics	Summarized information about the web system usage appropriate to selected domain and metrics for current month.
ANLDE system	**A**ssociated with a formal grammar, NLDE system. See [2, 6].
CF-grammar	Context-free grammar
CS	Computer Science
CSDept	Computer Science Department. The PetrSU CSDept web-site is `http://www.cs.karelia.ru`
Constraints	Upper limits for some parameters needed by a solver or generator.
Generator	External algorithm used for ANLDE systems and system sets generation depending on given generation parameters.
Hilbert basis	A set of all indecomposable (minimal) solutions of a homogeneous NLDE system.
ILP	Integer linear programming
Indecomposable solution	A particular solution that is not a sum of two particular solutions.
lp_solve	The non-commercial linear programming code, written in ANSI C by Michel Berkelaar. Also it supports ILP problems. Available on `http://www.cs.sunysb.edu/~algorith/implement/lpsolve/implement.shtml`
NLDE	Nonnegative linear Diophantine equations, i.e. their solutions are in nonnegative integers and coefficients are integer. See for example [9, 10, 11].
Particular solution	Any non-trivial solution of a homogenous NLDE system.
PetrSU	Petrozavodsk State University, `http://petrsu.karelia.ru`
Registered user	A user who has complete the registration at Web-SynDic and got a user profile (nickname and password).
Regular user	Any user of the Web-SynDic system. She/He is identified by user ID.

Session	Web-SynDic logical session for continuous time period of user working with the Web-SynDic server.
Slopes	Algorithm of M.Filgueiras and A.-P.Tomás for searching Hilbert basis of a homogenous NLDE system, available on `http://www.ncc.up.pt/~apt/dioph/`
Solver	External algorithm used for solving ANLDE systems and system sets.
Syntactic Algorithms	The algorithms that solve ANLDE system by constructing some derivations in the corresponding formal grammar, see [7, 6]. Web-SynDic is intended to demonstrate and test such algorithms.
System administrator	Privileged user who manages and controls the web system.
Trivial solution	All-zero solution $\mathbb{O} = (0, \ldots, 0)$ of a homogeneous NLDE system.
Web-SynDic	It stands for **Web**–based demonstrating and testing the **Syn**tact**ic** algorithms for solving nonnegative linear **D**iophantine equations (rule tact $\rightarrow$ D is used to transform the string "Syntactic" to the string "SynDic").

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