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# EDACC

## User Guide

### version 0.1

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#### **Zusammenfassung**

We present the main capabilities of EDACC and describe how to use EDACC for managing solvers and instances, create experiments with them, launch them on different computer clusters, monitor them and then analyze the results.

disclaimer!

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# 1 User guide zum User Guide

Bevor Ihr etwas in diesem user guide was reinschreiben wollt/sollt bitte diesen Kapitel durchlesen. Alle Autoren sollten versuchen die folgenden Richtlinien zu folgen, sodass die Arbeit ein homogenes Erscheinen bekommt auch wenn viele Autoren dran arbeiten.

## 1.1 Darstellungskonventionen

Das ist ein User Guide, folglich sollten die wichtigen Informationen für den Benutzer sehr schnell auffindbar sein. Dazu verhelfen folgende Konzepte:

Index	Indexierung aller wichtigen Wörter; insbesondere Schlüsselwörter. Der Index und die pdf-hyperreferenzen sollen ein schnelles suchen ermöglichen. Setzen von index wörter mit <code>\index{wort}</code> .
seitlicher Hinweis auf	Um wichtige Dinge schnell zu finden sollen auch seitliche Hinweise helfen. diese werden mit <code>\marginlabel{schlüsselwort}</code> gesetzt.
Example 1:	Auf Beispiele weist man am besten mit <code>\marginlabel{Eexample}</code> hin.
Verweise	Wenn man auf eine andere stelle im Text referenzieren will, was man so oft wie möglich machen sollte dann erscheint die Referenz auch im linken Rand mit: <code>\seealso{label}</code> . Wie zum Beispiel: Ein Überblick über diesen user-guide gibts in Kapitel 2 .
→ Section 2	
Hinweise ! →	Falls etwas doch sehr wichtig sein sollt, im Regel Besonderheiten auf die man achten sollte so kann man den Leser mit <code>\attention</code> darauf aufmerksam machen!
Glosareinträge	Wichtige Terme sollten am besten auch eine Definition haben, oder wenigstens eine Erklärung was damit gemeint ist. Das kann man am besten mit <code>\glossary{name={Glosareintrag}, description={Beschreibung}}</code> .

## 1.2 Inhaltliche Konventionen

Audienz identifizieren	Ich gehe davon aus, dass die meisten Leute die EDACC verwenden werden Informatiker sein werden, oder eine Unterart davon. Folglich können wir davon ausgehen, dass sie mit den gängigsten Begriffe vertraut sind (Ein Glosareintrag zu diesen würde trotzdem nicht schaden). Der Benutzer
Verwendungsart des user-guides	wird immer als <b>user</b> im Text angesprochen. Ich gehe auch davon aus, dass die meisten users diese Hilfe als Nachschlagewerk verwenden werden. Folglich soll auch der Inhalt task-orientiert sein. Das bedeutet dass man nicht das System an sich versucht zu beschreiben sondern die Aufgaben beschreibt und dadurch eher die Systembeschreibung entsteht. Es ist ungefähr das Gegenteil von dem Paper, wo nur die abstrakten Konzepte des Systems beschrieben worden sind. Also wenn Eure Doku zu sehr nach paper klingt seid ihr auf dem falschen Weg.
System definieren	Das System wenn es als Ganzes erwähnt wird sollte mit <b>EDACC</b> erwähnt werden. Allerdings sollte man vermeiden das Obersystem in Beschreibungen zu verwenden. Besser ist es wenn man sich immer auf dessen Teilkomponenten bezieht: <b>DB</b> , <b>GUI</b> , <b>client</b> , <b>WF</b> . <b>Monitor</b> wird nur als ein Teil des <b>WF</b> betrachtet.
Workflow angelehnte Beschreibung	Die Beschreibung der einzelnen Aufgaben sollte an dem typischen Workflow von EDACC orientiert sein. Die allgeinen Konzepte und Probleme

werden in der Anleitung sehr gut beschrieben sein. Im Hauptteil des user-guides sollen die Aufgaben beschrieben werden die man mit EDACC lösen kann. Dabei achtet man auf:

1. Identifizierung der Aufgaben (z.B: "Solver hinzufügen")
2. Aufteilung der Aufgabe in Unteraufgaben: (z.B: "Solver binaries verwalten und die Parameter spezifizieren")
3. Jede Aufgabe wird in Schritten beschrieben die durchnummeriert werden. (z.B: 1. name des solvers eintragen 2. Author eintragen 3. Version (name und version müssen eindeutig sein))
4. Fallunterscheidungen sollen explizit beschrieben werden wenn der Benutzer eine Entscheidung treffen muss (if-then-else Formulierungen). z.B: (Falls ein Parameter als Boolean markiert wird so ...)
5. Reichlich referenzieren und verweisen auf Glossar, Index und andere Stellen im Text wo (verwandte / benötigte) ( Aufgaben / Konzepte ) beschrieben werden.

## 2 Outline

Here we will have an overview of this user guide specifying where the user can find what!

## 3 Introduction

Specification of the problems algorithm engineers are often confronted with!

Algorithm engineering: When designing and implementing algorithms one is at the end of the process confronted with the problem of evaluating the implementation on the targeted problem set. As the authors of *EDACC* are familiar with algorithms for the satisfiability problem we will take this sort of algorithms as examples. After designing and implementing a SAT solver we would like to see how this performs on a set of instance problems (let us suppose that our solver is an implementation of a stochastic one i.e., the result of the solver on the same instance will be a random variable).

Normally we would start our solver on each instance and record the runtime or some quality measure. This is a sequential process and could be easily performed with the help of a simple shell script. But there are some questions that have to be answered before starting this evaluation process.

1. How long is the solver allowed to compute on one instance?
2. In the case of randomized solvers, how often do we call the solver on each problem set?
3. Do we limit the resources used by the solver (i.e., maximum of memory, maximum stack size)?

What is the task?

What are the tools?

What would we like to achieve?

Description of two example scenarios:

**Example 2:** See how the performance of a deterministic solver differs from other solvers!

### Example 3:

#### 3.1 What is EDACC

Describe the main tasks of EDACC, what is it for, what problems can be solved with EDACC?

#### 3.2 System Requirements

#### 3.3 Getting started

Components of EDACC

DB: Here we are going to describe the data that EDACC uses.

UI: How to work with EDACC.

Client:

→ Chapter 6

For more details about the requirements of the client and the command line see 6

## 4 User Interface

### 4.1 Experiment Mode

#### 4.1.1 Experiments

**Experiment** An experiment consists of solver configurations, instances and the number of runs for each solver configuration and instance. In the experiment tab the user can create/remove/edit experiments.

**Create** By using the create-button in the first tab of the experiment mode an experiment can be created. This will open a dialog where you have to provide some data.

1. Name: the name for the new experiment
2. Description: a description for the experiment. Provide some useful information about the experiment to quickly identify experiments in the experiments table.

After pressing the create-button the newly created experiment will be loaded automatically.

**Remove** To remove an experiment use the appropriate button.

**Edit** To edit an experiment use the appropriate button. There you can edit the data you provided by creating the experiment. If you want to change the priority of an experiment you can do this by directly editing this property in the experiment table. The same applies to activating and deactivating experiments. For more details about the effect of the priority property, see section ???. Deactivated experiments won't be computed by clients.

**Discard** To discard an experiment use the appropriate button. This button is only available if an experiment is loaded.

**Load** To load an experiment use the appropriate button or double click the experiment you want to load in the experiment table.

**Import** It is possible to import data from other experiments. To import data from other experiments the following steps have to be applied:

1. Load the experiment you want to import data to

2. Press the import button in the experiment tab. This will open a new window with three tables for experiments, solver configurations and instances.
3. Select the experiments you want to import data from. This will update the solver configuration and instance tables to show all solver configurations and instances for the selected experiments. Orange rows mean that the solver configuration or instance in that row exists in the currently loaded experiment. Two solver configurations are considered as equal if they have the same solver binary associated and have the same launch parameters.
4. Select the solver configurations and instances to import
5. Select *import finished jobs* if you also want to import jobs
6. Press *Import*

! → Note that this action might generate new jobs. This *might* happen if you import solver configurations and instances with their jobs to an experiment where some of the solver configurations and instances actually exist and they are in the *same seed group*.

#### 4.1.2 Client Browser

Dead clients The client browser represents all clients currently connected to the database. Red rows denote dead clients. A client is considered as dead if the client didn't communicate with the database for a period of time.

The client browser also deals as the only way to directly communicate with clients.

Kill clients After selecting the clients you can open the context menu with the right mouse button and select *Kill Clients Hard* or *Kill Clients Soft*. Hard means that the clients will terminate all currently computing jobs and sign off. Soft means that the clients won't start new jobs and will wait for the currently computing jobs to finish.

Client details To view the jobs which a client has computed in his lifetime you can double click a client entry in the client table. This will show a dialog with a table containing all jobs the client calculated and is currently calculating. You can also send messages to the clients in this dialog.

#### 4.1.3 Solvers

Choosing solvers Creating solver configurations is done in the solvers tab. This tab contains two tables on the right side and a panel with all solver configurations currently associated with this experiment. To create solver configurations you have to choose solvers for which you want create solver configurations. This can be done in the first table, the solvers table. By selecting some solvers and finally pressing the *choose*-button, solver configuration prototypes will be created for the solvers. You can see the newly created solver configurations in the panel in the left side. This panel is organized as follows. For each solver exists one layer. Each layer contains all solver configuration for the associated solver. A solver configuration is titled with a name. This name can be changed and is used in the other areas of the GUI to identify a solver configuration. So it might be good practice to choose different names for the solver configurations in an experiment.

Modifying solver configurations A solver configuration consists of a solver binary, parameters and a seed group. The solver binary is chosen in the first combo box. The parameters

can be specified in the parameters table. Just select the parameters you want for this solver configuration and specify their values if they have some. Finally you have to specify the seed group. The default seed group is *0*. You might want to change that. See section ?? for more information about seed groups.

Importing solver configurations To import solver configurations from other experiments you can import them in the experiments tab (see section 4.1.1) or if you just want to import a solver configuration without jobs for a solver, you can select the solver in the solver table which will show all solver configurations in the database for that solver in the solver configuration table. Simply select the solver configurations you want to import and press the *choose*-button.

Tabular view for solver configurations To change the view of the solver configuration panel to a tabular view, press the *Change View*-button. This will change the panel into a table. Here you can remove multiple solver configurations by selecting them and opening the context menu by pressing the right mouse button and choose *Remove*. It is also possible to edit solver configurations in that view by double clicking a solver configuration or by using the context menu.

! → All modifications to solver configurations are not directly saved in the database. You can use the *Undo*-button to undo all changes and load the last save state. By pressing the save button all modified and new solver configurations will be saved to and deleted solver configurations will be removed from the database.

! → Modifying and saving solver configurations which have calculated runs might be not a good idea. Therefore the GUI supplies a possibility to reset the affected jobs. This might not be needed if the changed parameters have no effects to the results.

#### 4.1.4 Instances

#### 4.1.5 Generate Jobs

#### 4.1.6 Job Browser

#### 4.1.7 Analysis

## 5 Parameter search space specification [Draft]

### 5.1 Definitions

A parameter is an input variable of a program and is defined by a name, a domain, a prefix (which can also be empty) and an order number. Additionally there are two booleans. "space" that indicates whether to put a space between the prefix and the value. "attach to previous" indicates whether there should be a space between the previous parameter (according to order) and this one. "attach to previous" can be useful for parameters that look like "-prefix v1[,v2,v3]". ",v2" and ",v3" can be modeled as parameters that attach to the preceding "-prefix" parameter.

**Definition 5.1:**

A solver configuration is a list of parameters and their assigned values.

**Definition 5.2:**

A domain defines the set of possible values that can be assigned to a parameter (in a solver configuration). It can be one of the following or the union of any number of them (except for the flag domain, which can only occur on its own).

1. real: values between a lower and an upper bound
2. integer: values between a lower and an upper bound
3. ordinal: list of values in a min to max order
4. categorial: set of possible values
5. optional: consists only of a special value not specified"
6. flag: consists of two special values "on" and "off" (for parameters that are flags, i.e. present or not)

**Definition 5.3:**

The parameter space of a solver is defined by its parameters and their possible values. The parameter space can be further constrained by dependencies between parameters such as

1. Parameter X can be specified if parameter Y takes on certain values
2. Parameter X has to be specified if parameter Y takes on certain values
3. Parameter X has to take on certain values depending on the values of parameters Y, Z, ...

There are several tasks that come up in the context of EDACC: Determine if a given solver configuration is valid, i.e. in the solver's parameter space. Given the parameter space, construct a valid solver configuration. Given a valid solver configuration, find a "neighbouring" solver configuration that is also valid.

**Definition 5.4:**

A parameter graph is a directed, acyclic graph that represents the parameter space. It consists of AND-Nodes and OR-Nodes and edges between them. Edges are directed and allowed only between different types of nodes. OR-Nodes can have multiple incoming edges, while AND-Nodes can only have exactly one incoming edge. Additionally edges have a group number which is 0 if the edge doesn't belong to any group. Parameter graphs have a single unique AND-Node without any incoming edges. This node will be referred to as start node.



**Definition 5.5:**

OR-Nodes have a reference to a parameter.

**Definition 5.6:**

AND-Nodes have a domain and a parameter reference to the same parameter as the preceding OR-node. AND-Nodes partition the possible values of the parameter that they (and the preceding OR-node) reference. The domain of an AND-Node has to be a subset of the domain of the preceding OR-Node.

The general idea is that the parameter space is specified by following the structure of the graph from the start node and constraining the parameters using the domains encountered on the nodes. AND-Nodes imply that all outgoing edges have to be followed while OR-Nodes mean that exactly one edge has to be followed.

More formally:

**Definition 5.7:**

A solver configuration is valid if the start node (an AND-Node) of the parameter graph is satisfied. Satisfied means:

1. an AND-Node is satisfied if the corresponding parameter value lies in its domain and all OR-nodes adjacent via ungrouped edges are satisfied.
2. an OR-Node is satisfied if exactly one adjacent AND-Node is satisfied and for at least one set of incoming edges with common group number the preceding AND-Nodes are all satisfied.

## 5.2 Algorithms on parameter graphs

Constructing a valid, random solver configuration:

Input: parameter graph; Output: (random) solver configuration

done\_and := {startnode} # set containing only the start node

done\_or := {} # empty set

L := list of OR-nodes adjacent to startnode

while (L has nodes with  $\geq 1$  group of edges coming from \ AND-nodes in done\_and):

    or\_node := choose and remove such a node randomly from L  
    done\_or.add(or\_node)

    and\_node := choose an AND-node adjacent to or\_node  
                    randomly (or with user input)

    done\_and.add(and\_node)

    Assign a random (or user chosen) value from and\_node.domain to  
    the and\_node.parameter of the solver configuration

    Add all OR-nodes that are adjacent to and\_node, not yet in  
    L and not in done\_or to L

return the solver configuration

Validating a solver configuration (TODO: issues with optional parameters):

Input: Parameter Graph, Solver configuration; Output: Boolean

assigned\_and\_nodes := Set of AND-nodes with parameters that are  
                            part of the solver config

Test if all required OR-node parameters are present  
i.e. of OR-nodes that have at least one incoming edge  
group from assigned AND nodes

or\_nodes := Set of preceding OR-nodes of assigned\_and\_nodes

for each or\_node in or\_nodes:

- Test if or\_node has exactly one adjacent AND-node in assigned\_and\_nodes
- Test if at least one group of edges comes from assigned AND-nodes

Test if all OR-nodes adjacent to start node are in or\_nodes

return True if all tests were passed

Open problems:

- Discretise real valued parameters. Especially the discretisation of domains divided into several domains (several AND-Nodes) is unclear.
- find an algorithm to iterate over the neighbourhood of a given solver configuration (with discretised parameters)
- crossover and mutation operators for genetic algorithms

### 5.3 Example

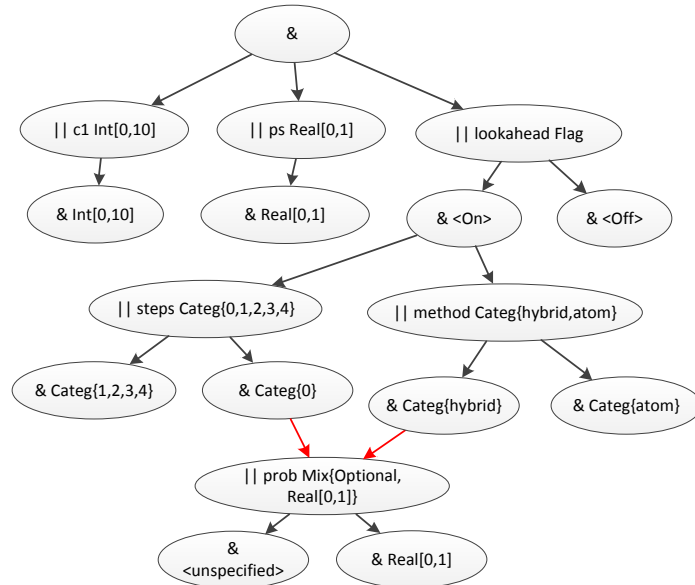
Example 4: Consider a solver that has the following parameters:

- $c1$  which takes on integer values in  $[1, 10]$ .
- $ps$  which takes on real values in  $[0, 1]$ .
- A flag called *lookahead* which can be present or not.
- A categorical parameter *steps* which takes on values in  $\{0, 1, 2, 3, 4\}$ .
- Another categorical parameter *method* whose value is either "hybrid" or "atom".
- A parameter *prob* which can be left out or take on real values in  $[0, 1]$ .

Furthermore there are some restrictions and requirements:

- Both  $c1$  and  $ps$  have to be always specified.
- If the *lookahead* flag is present, both *steps* and *method* have to be present.
- If *steps* takes on the value 0 and *method* takes on the value "hybrid", then the parameter *prob* can take on values in its real domain  $[0, 1]$  or be left out.

This parameter space can be encoded in a parameter graph as defined earlier in the following way:



The two red edges imply the membership of the edges to the same edge group  $\neq 0$ . Black edges mean that the edge doesn't belong to any group. For simplicity, the parameter references of AND-Nodes (to the same parameter as the preceding OR-Node) are not shown in the graph.

#### 5.4 Implementation etc.

- define parameter graphs in XML / GUI
- API documentation for configurators

## 6 Client

### 6.1 Introduction

The computation is client is used to compute the jobs of experiments. Usually there have to be a lot of jobs computed to evaluate experiments and since they are independent from each other, this task can be parallelized across many CPU cores. The computation client can be started on arbitrarily many machines and will manage the available CPUs and fetch and jobs from the created experiments. It connects to the central database and downloads all required resources such as instances and solver binaries and writes back the results to the database.

### 6.2 System requirements

The client is written in C/C++ and should be able to run on most Linux distributions where a MySQL C connector library is available.

TCP/IP Connections: Because the central storage location for all required computational resources, experiment metadata and results is a MySQL database, the client has to be able to establish a connection to the machine that hosts the database. This means that the machines where the client runs on have to be able to establish a TCP/IP connection to the database machine.

Connection alternatives: The client was mainly tested on the bwGRID<sup>1</sup>, a distributed computer cluster that consists of several hundred nodes at several physical locations at universities of Baden-Württemberg, Germany. Even though the machine hardware is homogenous, the network topology of bwGRID is not. In cases where direct network access from the computation nodes back to the database server is not possible it is usually possible to tunnel a connection over the cluster's login node back to the database via SSH.

Other than that, the client has to be able to write temporary files to some location on the filesystem. This can be configured (6.3.1) if it differs from the client binary location.

Shared filesystems: Because the client will download missing solver binaries and instances and upload results it also needs a reasonably fast network connection to the database. Shared filesystems can considerably reduce the required bandwidth since every file is only downloaded once. As alternative you can pre-package the required files and put them into the correct folders before starting the client. However, if you modify experiments while the client is running it will still download missing files.

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<sup>1</sup> <http://www.bw-grid.de/>

## 6.3 Usage

### 6.3.1 Configuration

Configuration file: Configuration is done by some command line arguments and a simple configuration file, called "config". This file has to be in the **working directory** of the client at runtime. In the configuration file you have to specify the database connection details and which hardware the client runs on. This is done by configuring so called "grid queues" in the GUI application. They contain some basic information about the computation hardware such as number of CPUs per machine. The client will then use this information to run as many parallel jobs as the grid queue information allows it on each machine where it is launched. Here is a sample configuration file:

Example 5:

```
host = database.host.foo.com
port = 3306
username = dbusername
password = dbpassword
database = dbname
gridqueue = 3
verifier = ./verifiers/SAT
```

Note that the gridqueue value is simply the ID of the grid queue. Another (optional) configuration option is the verifier line. It tells the client if it should run a program on the output that a solver generated. For example, if your experiments consist of attempting to solve boolean propositional logic formulas you can use a SAT verifier that tests if the solution given by a solver is actually correct. The verifier configuration option is simply a path to an executable that the client calls with standardized parameters. See section 6.4 for more information on verifiers.

Command line arguments: Beside the configuration file there are several command line options the client accepts, please also see ". /client -help":

```
-v <verbosity>:
    Integer value between 0 and 4 (from lowest to
    highest verbosity)
-l:
    If flag is set, the log output is written to a file
    instead of stdout.
-w <wait for jobs time (s)>:
    How long the client should wait for jobs after
    it didn't get any new jobs before exiting.
-i <handle workers interval ms>:
    How long the client should wait after handling
    workers and before looking for a new job.
-k:
    Whether to keep the solver and watcher output files after
    uploading to the DB. Default behaviour is to delete them.
-b <path>:
    Base path for creating temporary directories and files.
-h:
    Toggles whether the client should continue to run even
    though the CPU hardware of the grid queue is not homogenous.
```

Verbosity controls the amount of log output the client generates. A value of 4 is only useful for debugging purposes, a value of 0 will make the client log important messages and all errors.

If the "l" flag is set, log output goes to a file whose name includes the hostname and IP address of the machine the client runs on to avoid name clashes in shared filesystems typically found in computer clusters. Otherwise log output goes to standard output.

With the "-w" option you can tell the client how long to wait before exiting after it didn't start any jobs. This can be useful to keep the clients running and ready to process new jobs while you evaluate preliminary results and add new jobs or whole experiments. The wait option is also used to determine how long attempts should be made to reconnect to the database after connection losses. The default value is 10 seconds.

The "-i" option controls how long the client should wait between its main processing loop iterations. If this value is low, it will more often look for new jobs when there are unused CPUs. For maximum job throughput this value should be lower than the average job processing time but lower values will also put more strain on the database and increase the client's CPU usage. The default value is 100ms which should work fine in most cases. The client will also adapt to situations where there are free CPUs but no more jobs and increase the interval internally and fall back to the configured value once it got another job.

The "-k" flag tells the client if it should keep temporary job output files after a job is finished or if it should delete them. The default is to delete them.

The "-b" base path option can be used to specify a directory the client can use to write temporary files to. The default value is ".", i.e. the working directory at runtime.

- ! → The first client to start with a particular grid queue will write the information about the machine it runs on to the grid queue entry in the database. All following clients will then compare their machines to the information in the grid queue and exit, unless the number of cores and the CPU model name match. With the "-h" option you can override this behaviour.

### 6.3.2 Launching

After configuration you can simply run the client on your computation machines. On computer clusters there are often queuing systems that you have to use to gain access to the nodes. On bwGRID for example, we could use the following short PBS (portable batch script) and submit (*qsub scriptname*) our client to a node with 8 cores:

```
#!/bin/sh
#PBS -l walltime=10:00:00
#PBS -l nodes=1:ppn=8
cd /path/to/shared/fs/with/client/executable
./client -v0 -l -i200 -w120
```

- ! → You should always run the client from within its directory (i.e. cd to the directory) to avoid problems with relative paths such as the verifier path from the example configuration above.

As soon as clients start you should be able to see jobs changing their status from "not started" to "running" in the GUI's or Web frontend's job browsers.

### 6.3.3 Troubleshooting

If errors or failures occur the client will always attempt to shut down cleanly, that is stop all running jobs and set their status to "client crashed" and write the last lines of its log output as "launcher output" to each job. This can fail when network connections fail or the client receives a SIGKILL signal causing it to exit immediately. In case of network failures you should still be able to find useful information in the client's logfile on the local filesystem.

### 6.4 Verifiers

Verifiers are programs that the client runs after a job finishes. Verifiers are getting passed the instance of the job and the solver output as arguments and are supposed to exit with a status code that conveys some information about the result of the job. For example whether the output is correct given the problem instance. This code will be written to the database as "result code" and "verifier exit code". Any output the verifier writes to standard out will be written as "verifier output". The call specification for a verifier binary looks like this:

```
./verifier_binary <path_to_instance> <path_to_solver_output>
```

! → We provide a verifier for the SAT problem that works on CNF instances in DIMACS format and solvers that adhere to a certain output format (see the source code). Note that you have to make sure that your possible result codes are specified in the *ResultCodes* table in the database before running clients or there will be errors when the client tries to write results. By convention, the web frontend and GUI application consider status codes that begin with a decimal "1" as correct answers.

### 6.5 Experiment prioritization

Sometimes it can be useful to compute several experiments in parallel but give some a higher priority than others. In order to accomplish that, experiments can be marked as inactive and individual jobs can be prioritized. Only jobs of active experiments with priority equal to or greater than 0 are considered for processing by the client. Furthermore, experiments can be assigned a priority. The clients will then try to match the relative number of CPUs working on an experiment with its relative priority to all other experiments that are assigned to the same grid queue. For example, if you have three experiments with priorities 100, 200 and 300 respectively the running clients will try to have 16% of CPUs working on the first, 33% of CPUs working on the second and 50% of CPUs working on the third experiment.



! → The client is running solely on Unix and is not distributed yet for Windows systems.

## 7 Web Frontend

### 7.1 Introduction

The Web Frontend provides access to experiment information and analysis tools in a read-only manner and accessible by a web browser.

### 7.2 System requirements

The web frontend is implemented as Python WSGI web application and makes use of several libraries. Since it interfaces with R to draw plots it also depends on R and a Python interface to R, which unfortunately only works properly on Linux right now. WSGI applications can be deployed on a variety of web servers or even run standalone on a web server that comes with the Python standard library. The following list contains all dependencies and prerequisites of the Web Frontend (see 7.3 for installation instructions).

- Python 2.6.5 or 2.7 <http://www.python.org>
- R 2.11 (language for statistical computing and graphics)
- R package 'np' (available via R's CRAN)
- SQLAlchemy 0.6.5 (SQL Toolkit and Object Relational Mapper)
- mysql-python 1.2.3c1 (Python MySQL adapter)
- Flask 0.6 (Micro Webframework)
- Flask-WTF 0.3.3 (Flask extension for WTForms)
- Flask-Actions 0.5.2 (Flask extension)
- Werkzeug 0.6.2 (Webframework, Flask dependency)
- Jinja2 2.5 (Template Engine)
- PyLZMA 0.4.2 (Python LZMA SDK bindings)
- rpy2 2.1.4 (Python R interface)
- PIL 1.1.7 (Python Imaging Library)
- Numpy 1.5.1
- pygame 1.9 (Graphics library)

### 7.3 Installation

To get rpy2 working the GNU linker (ld) has to be able to find libR.so. Add the folder containing libR.so (usually /usr/lib/R/lib) to the ld config: Create a file called R.conf containing the path in the folder /etc/ld.so.conf.d/ and run ldconfig without parameters as root to update. Additionally, you have to install the R package 'np' which provides non-parametric statistical methods. This package can be installed by running "install.packages('np')" within the R interpreter (as root).

The following installation example outlines the step that have to be taken to install the web frontend on Ubuntu 10.04 running on the Apache 2.2.14 web server. For performance reasons (e.g. query latency) the web frontend should run on the same machine that the EDACC database runs on.

#### Example 6:

1. Install Apache and the WSGI module:

```
apt-get install apache2 libapache2-mod-wsgi
```

2. Copy the web frontend files to /srv/edacc\_web/, create an empty error.log file and change their ownership to the Apache user:

```
touch /srv/edacc_web/error.log
chown www-data:www-data -R /srv/edacc_web
```

3. Create an Apache virtual host  
(new file at /etc/apache2/sites-available/edacc\_web)

```
<VirtualHost *:80>
    ServerAdmin email@email.com
    ServerName foo.server.com

    LimitRequestLine 51200000

    WSGIDaemonProcess edacc processes=1 threads=15
    WSGIScriptAlias / /srv/edacc_web/edacc_web.wsgi

    Alias /static/ /srv/edacc_web/edacc/static/

    <Directory /srv/edacc_web>
        WSGIProcessGroup edacc
        WSGIApplicationGroup %{GLOBAL}
        Order deny,allow
        Allow from all
    </Directory>

    <Directory /srv/edacc_web/edacc/static>
        Order allow,deny
        Allow from all
    </Directory>
</VirtualHost>
```

4. Install dependencies and create a virtual environment for Python libraries:

```
apt-get install python-pip python-virtualenv python-scipy
apt-get install python-pygame python-imaging
virtualenv /srv/edacc_web/env
apt-get build-dep python-mysqldb
apt-get install r-base
echo "/usr/lib/R/lib" > /etc/ld.so.conf.d/R.config
ldconfig
source /srv/edacc_web/env/bin/activate
pip install mysql-python
pip install rpy2
pip install flask flask-wtf flask-actions
pip install sqlalchemy pylzma numpy
```

5. Install R libraries ("R" launches the R interpreter):

```
R
install.packages('np')
```

6. Create a WSGI file at /srv/edacc\_web/edacc\_web.wsgi with the following contents:

```
import site, sys, os
site.addsitedir('/srv/edacc_web/env/lib/python2.6/site-packages')
sys.path.append('/srv/edacc_web')
```

```

sys.path.append('/srv/edacc_web/edacc')
os.environ['PYTHON_EGG_CACHE'] = '/tmp'
sys.stdout = sys.stderr
from edacc.web import app as application

```

7. Configure the web frontend by editing `/srv/edacc_web/edacc/config.py`, see 7.4 for details.

8. Enable the Apache virtual host created earlier:

```

a2ensite edacc_web
service apache2 restart

```

9. The web frontend should now be running under `http://foo.server.com/`

## 7.4 Configuration

! → All configuration is done in a Python file located at `"edacc/config.py"`. The options are documented in the sample configuration file which is included in the distribution package. Please read through the configuration options and modify those marked as important. Most importantly, you should disable debugging mode and change the secret key when making the Web Frontend accessible from the network to avoid security problems. Logging is also quite useful to make it easier to find the cause of bugs in the application. At the end of the file you can configure the database connection and the list of EDACC databases that should be made available by the Web Frontend.

Database configuration

## 7.5 Troubleshooting

When there are errors or bugs and you have set up the Web Frontend under Apache as described in the installation section, Apache will display an "Internal Server Error" page. If you have configured logging, the application will write tracebacks to the logging file. If you haven't set up logging, these tracebacks will end up in Apache's `error.log` file.

## 7.6 Features

This section gives a short overview of the features of the Web Frontend. Most features should be self-explanatory or have some additional documentation on the pages themselves.

The Web Frontend was designed as monitoring and analysis tools of experiments that are created with the GUI application. Once you have set up some databases and added them to the configuration file of the Web Frontend, the top level page will allow the user to select one of the databases. This leads to a page that displays all experiments of the chosen database and some basic information about their creation date, number of solvers, instances and jobs.

Experiments An experiment page displays further information about the experiment, such as the number of total, running and crashed jobs. If the experiment is currently being computed, an estimation of the time of completion is displayed next to "ETA".

Monitor progress Under "Progress" a colored bar visualizes the computation progress. Green color corresponds to finished jobs, red to crashed jobs and orange to jobs that are currently being computed. The links following the progress bar lead to information and analysis pages.

Job browser	The progress page provides a job browser similar to the GUI application. It allows to sort, filter for certain words, show and hide specific columns and download currently displayed data in CSV (comma-separated values) format.
Export data	Displaying more than 1000 results at once can become rather slow, since the browser's Javascript engine has to do a lot of processing to color and format the table.
Download instances	The solver configurations and instances pages show the solver configurations and instances that are part of the experiment. The instances page provides a download link for all instance files in a tarball. Instances are shown in a table by name, MD5 checksum and their properties (TODO reference), if there are any. The instance name links to a page that displays the first and last few characters of the instance file and provides a download link.
View results	The result pages display the results of the jobs in various formats. "Unsolved instances" and "Solved instances" list the instances that were not solved by any solver or solved by at least one solver respectively. "By solver configuration" leads to a page, where after selecting a solver configuration that is part of the experiment a table is displayed containing all the results of the jobs of the solver configuration by instance and run number. "By instance" leads to a page, where after selecting an instance all results obtained on this instance are displayed by solver configuration and run number. All tables can be exported (i.e. downloaded) in CSV format.
Export results	
Analyse results	Analysis pages provide various plots of results and statistical tools such as correlation and probabilistic domination calculations. All plots can be directly saved in PNG format as they are displayed in the browser or downloaded in PDF or EPS format. For some plots the application generates an R script which can be adjusted as necessary. Most plots allow to download the underlying data in CSV format.
Export plots	
	Some plots allow the selection of multiple instances. In this case, you can use a filter to narrow the selection of the instances listed. Please refer to the example which is displayed next to the filter text field.
Ranking of solver configurations	The ranking is determined by the number of successful runs but the ranking table can be sorted by any of the displayed measures.

**8 Monitor**

**9 Troubleshooting**

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