SWISH: SWI-Prolog for Sharing

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Abstract. Recently, we see a new type of interfaces for programmers based on web technology. For example, JSFiddle, IPython Notebook and R-studio. Web technology enables cloud-based solutions, embedding in tutorial web pages, attractive rendering of results, web-scale cooperative development, etc. This article describes SWISH, a web front-end for Prolog. A public website exposes SWI-Prolog using SWISH, which is used to run small Prolog programs for demonstration, experimentation and education. We connected SWISH to the ClioPatria semantic web toolkit, where it allows for collaborative development of programs and queries related to a dataset as well as performing maintenance tasks on the running server and we embedded SWISH in the Learn Prolog Now! online Prolog book.

1 Introduction

Web technology has emerged to a state where it becomes useable for implementing programming development environments. All major modern browsers now implement HTML5 and JavaScript and there are mature components available such as the CodeMirror$^4$ and ACE$^5$ code editors, the Bootstrap$^6$ framework for styling and UI widgets and visualization libraries such as D3.js$^7$. Using web technology rather than traditional GUI based technology such as Eclipse$^8$, Microsoft Visual Studio$^9$, XEmacs$^{10}$ etc. has various advantages. Being network transparent, it allows for controlling cloud hosted applications as well as Prolog processes running on headless devices. Web technology provides a great infrastructure for mashups, pages that integrate material from several sources. For example, embedding Prolog in tutorial pages or embedding Prolog queries that can be modified and re-evaluated in documents that describe data collections.

\[4\] https://codemirror.net/

\[5\] http://ace.c9.io

\[6\] http://getbootstrap.com/

\[7\] http://d3js.org/

\[8\] https://eclipse.org/

\[9\] https://www.visualstudio.com/

\[10\] http://www.xemacs.org/
With SWISH (SWI-Prolog for Sharing), we provide this technology for (SWI-Prolog). SWISH consists of JavaScript client (browser) code and a number of Prolog libraries that realise the server as a Prolog application. The client code consists of a series of jQuery plugins that deal with editing source code, managing a shared source repository, entering queries and rendering answers produced by Prolog. The server-side libraries serve the overall web application, implement the source store and support the editor with predicate documentation, templates, cross-reference results, etc. For executing Prolog queries, SWISH relies on Pengines (Prolog engines, [3]). A pengine is a Prolog engine that can be controlled similarly to Prolog running in a terminal using HTTP requests. The SWISH infrastructure was originally developed as a Prolog version of JSFiddle. It was later reimplemented as a modular jQuery based infrastructure aiming at collaborative exploration of data hosted on a SQL or SPARQL server. This use-case is described in section 5.2.

This article is organised as follows. Section 2 describes related work, which in our case are the systems that have inspired us. Section 3 describes the architecture and components of SWISH. In section 5 we describe four applications of the current system. We conclude with future work and conclusions.

2 Related work

We are not aware of other initiatives that aim at developing a rich web-based development environment for Prolog. We do not compare SWISH with traditional editor or GUI based development environments for Prolog because web-based environments provide new opportunities and pose new challenges. Instead, we discuss three applications that have served as inspiration for SWISH: JSFiddle, R-Studio, and IPython Notebook.

– As stated, the initial inspiration for SWISH was JSFiddle. Unlike JSFiddle though, Prolog is executed on the server rather than in the browser.
– R-Studio [2] is an interface to the R statistical package. Although not a web application, it is based on the Qt webkit framework and uses web based technology in the background. R-Studio came into the picture when the COMMIT/ project provided a grant for developing SWISH as a toolkit for analysis of relational (SQL) data. The R-studio interface has a similar layout as SWISH, providing a source window, a console and an output plane that typically shows results in tables or charts.
– IPython Notebook [5] allows mixing markdown or HTML text with Python sources. The rendered Notebook shows the text, sources and possible results in the form of numbers, tables or charts.

SWISH embodies most of the ideas behind JSFiddle and R-Studio. Embedding of SWISH in documents is demonstrated in section 5.3. Interactive editing of documents that embed SWISH is discussed in future work (section 6).

[11] https://jquery.com/
[12] https://jsfiddle.net/
[13] http://www.rstudio.com/
[14] http://ipython.org/notebook.html
Both R-Studio and IPython Notebook work on the basis of authentication (either to the OS or application), after which any command may be executed. SWISH can operate both as a public service granting access to non-intrusive queries and as an authenticated service to run arbitrary queries, for example for maintenance purposes. See section 5.2.

3 The SWISH application

SWISH consists of two parts. The client side, running in a browser, is implemented as a series of jQuery plugins, using Bootstrap for styling and RequireJS15 for package management. The server side is completely implemented in SWI-Prolog16. It builds on top of the SWI-Prolog HTTP server libraries, the Pengines library and the IDE support libraries that provide data for auto completion, documentation and highlighting.

In the following sections we describe SWISH in terms of interface components, where we discuss the requirements, the user aspects, the client code and supporting server functionality for each component. First, we provide a screendump that illustrates the main components in figure 1.

![Screendump of SWISH](http://requirejs.org/)

Fig. 1. Screendump of SWISH. The left pane shows the source code, while the top-right pane shows a query runner that exploits the current selected answer renderer and buttons on how to continue after the first answer. The bottom-right pane provides the query editor with access to example queries stored in the source, query history, apply solution modifiers, result presentation and a Run! button to start the query.
3.1 The code editor

A proper editor is the most important component of a usable programming environment. The editor must support the language, including syntax highlighting, auto indentation, code completion based on templates and already existing code and highlighting of errors and warning from the compiler. The editor is used both for editing the source code and editing queries.

Prolog is a difficult language to support in code editors due to the lack of reserved keywords, e.g., the word `if` in C starts an if-statement if not embedded in comment or a string, but the word `is` in Prolog can refer to the built-in predicate `is/2`, but also some predicate with a different arity, just a constant, etc. Another example is $X-Y$ which can both be an arithmetic expression or a pair as used with e.g., `keysort/2`. Next to the lack of keywords the ability to extend the syntax using new operators complicates the implementation of syntax support while editing. SWI-Prolog’s built-in Emacs oriented editor resolves this problem by closely integrating Prolog with the editor. While typing, the current term (clause or directive) is parsed and analysed in the context of the current file and the file’s imports after each keystroke. If the term has valid syntax, all tokens are coloured according to their syntactic role as well their relation to the remainder of the program. For example, a call to a non-existing predicate is coloured red, a call to a built-in or imported predicate is blue and a call to a locally defined predicate is black. The libraries that implement this analysis have been decoupled from the built-in editor, both to support source colouring for the SWI-Prolog documentation system PlDoc [6] and ProDT [16].

There are two dominant open source and actively maintained in-browser code editors available: ACE and CodeMirror. When we started SWISH, ACE had a very basic Prolog mode and CodeMirror had none. We nevertheless opted for CodeMirror because its highlighting is based on raw JavaScript code rather than a regular expression based template language as used for ACE. The low level implementation allows for a novel highlighting implementation. The highlighter consists of a JavaScript implemented Prolog tokeniser. Tokenizing Prolog is sufficient to colour comments, quoted material (strings, quoted atoms), variables and constants (atoms and numbers). It is also sufficient to support smart indentation. As discussed above, it is not sufficient for highlighting the role played by atoms and compound terms [17].

We provide semantic highlighting as illustrated in figure 2 by (1) forwarding the changes to the content of the editor to the server which maintains a mirror of the editor content and (2) asking the server to produce a list of semantically enriched tokens for the source. The tokens are returned as a list-of-lists, where each inner list represents the tokens for a source term (clause or directive). Grouping the tokens per source term allows for incremental update (not yet implemented) as well as re-synchronisation (see below). For example, a fragment of an enriched token list may look like this: `[functor, (undefined_goal), variable (singleton), ...]`. The JavaScript tokeniser matches its tokens

16. [http://prodevtools.sourceforge.net](http://prodevtools.sourceforge.net) these libraries are not yet used by ProDT.
17. An additional complication is formed by CodeMirror’s token-based highlighting which does not support look-ahead. As a consequence, we must decide on the colour of e.g., `asserta( while we do not know the arity of the term.
Fig. 2. The semantic highlighter classifies, in addition to the syntactic category such as comment or variable, terms that define or call predicates based on cross-referencing the source code.

with this list. If the basic type (e.g., ‘functor’ or ‘variable’) matches, it uses the enrichment information (e.g., ‘singleton’) to decide on the style. If the basic token type does not match, it highlights the token using the basic syntactical category and schedules a request to the server for a new list of enriched tokens. This request is sent if the user pauses typing for 2 seconds. The request is accompanied by the full source if this is small or the list of changes since the last request if the source is large. While waiting for up-to-date enriched tokens, the JavaScript highlighting code heuristically tries to re-synchronise and either uses the uncertain results or falls back to the plain tokens. Re-synchronisation checks whether a single added, deleted or modified token gets the token stream in-sync. If this fails it tries to re-synchronise on a full-stop with the next clause or directive.

A CodeMirror hover plugin is used to show basic information about tokens if the pointer hovers over it. For goals, this includes where the goal is defined (ISO, SWI-Prolog built-in, a library, locally) and the documentation summary information if available. This information is requested from the server.

A CodeMirror template plugin is configured from templates (e.g., atom_length(+Atom, -Length)) extracted from the SWI-Prolog manual and PDoc documentation of imported libraries. This plugin shows a menu of applicable predicates with their templates on Control-Space.

Finally, if the user uses the Run! button to execute a query, the program is compiled. If the compiler generates errors or warnings, these are inserted as notes in the source code.

3.2 Source code and query management

As JSFiddle formed the initial inspiration for SWISH, SWISH has a facility to save the program. The current version of SWISH explicitly targets the cooperative development
of Prolog programs and queries related to a dataset (see section 5.2). This triggered the implementation of a more organised storage facility. The server-side storage module is implemented in Prolog and inspired by GIT. Each file is versioned independently rather than maintaining the version of a hierarchy of files. Files can be referenced by content using their GIT compatible SHA1 hash or by name. The name can be considered a version head and refers to the latest version with that name. The file save and load interface provides the following operations:

- Saving a file anonymously, which produces a randomly generated URL similar to JSFiddle.
- Saving a file by name.
- Saving a new version. The interface shows the available versions and the modifications.
- Forking a file under a new name. The history remains linked to the original.

Prolog source files can include other sources on the same server using `:- include(filename).`, including the latest version or `:- include(hash).` to include a specific version.

Prolog source files can embed example queries using structured comments, where each sequence from `?-` to the matching full stop token is added to the Examples menu of the query panel (see figure 6). The comment below illustrates a call to `append/3` embedded in the source window.

```prolog
/** <examples>
?- append([one], [two,three], List).
*/
```

### 3.3 The query editor

The query editor is based on the same jQuery plugin that realises the code editor and thus profits from the syntax highlighting, template insertion and hovering plugins. In addition, it provides three popup menus:

**Examples** This menu is filled from the structured comments described above. The examples menu is shown in figure 6

**History** This menu provides earlier executed queries.

**Solutions** This menu embeds an existing query in a meta-call to alter the result. Currently provided operations are Aggregate (count all), Order by, Distinct, Limit, Time and Debug (trace). Figure 3 shows how the menu is used to count the solutions of a goal.
3.4 Running a query: runners in the answer pane

The answer pane is a placeholder for runners, where each runner represents a query. The answer pane provides a menu for operations on all runners inside it. Provided actions are Collapse all, Expand all, Stop all and Clear. The query may be completed, running or waiting for user input. SWISH can manage multiple active queries at the same time, up to an application defined maximum (default 3).

Each runner provides its own set of commands to control the specific query. During execution a runner provides an Abort button. After query evaluation completes with an answer and more answers may be available the runner allows for asking the next 1, 10, 100 or 1,000 results or to Stop the query. In addition, the runner shows a text input field when the application wants to read input and may show debugger interaction buttons if the tracer is being used (see section 3.4).

A runner can render answers in two modes, the classical Prolog mode or as a table, similar to what many database interfaces provide. The ‘table’ mode is particularly appealing for querying datasets (see figure 3), while the former is more suitable for rendering small amounts of complex answers such as the chessboard position in figure 1.

By default, Prolog terms are rendered as structured HTML objects, where the rendered text is the same as Prolog’s writeq/1 predicate.

The server can provide rendering libraries that render Prolog terms using dedicated HTML. In figure 1 the ‘chess’ renderer is loaded due to the :use_rendering(chess) directive. The ‘chess’ renderer translates a list of length N holding integers in the range 1..N as a chessboard with queens. In addition to the chess rendering library, SWISH provides rendering libraries for sudoku puzzles, parse trees and tables. The ClioPatria version adds a renderer for RDF resources that renders the resource more compactly and provides a hyperlink for obtaining details. If a term

Fig. 3. The Solutions menu can be used to count results, order them, filter duplicates, etc. The upper runner shows answers to the query as a table.
can be rendered in multiple ways, the interface provides a hover menu to select between
the alternatives. Figure 4 illustrates this functionality. The render facility is similar to the
Prolog \texttt{portray/1} hook that allows changing the result printed for terms with a specific
shape. However, it can exploit the full potential of HTML (or SVG) and the interface
allow for switching the selected rendering.

A rendering library is a module that must define a non-terminal (grammar rule)
\texttt{term_rendering//3}, calling \texttt{html//1} to produce HTML from the Prolog input
term, a list of variable bindings (Name = Variable) and user provided options. In the
current version, new rendering modules must be loaded into the SWISH server and
cannot be created by the SWISH user.

\begin{figure}
\centering
\includegraphics[width=0.49\textwidth]{chess.png}
\caption{With the ‘chess’ render library, a list of integers is interpreted as queens on a chessboard.
The user can select rendering as a ‘Prolog term’ to see the actual term.}
\end{figure}

\textbf{Server side execution of the query} Server-side execution of a query is supported
by the Pengines \[3\] library. The Pengines library allows for creating a Prolog engine
represented by a Prolog thread. Optionally, the pengine is handed a Prolog program that
is loaded into the pengine’s workspace (program space). The workspace is a temporary
module that is disposed of after the pengine terminates. The pengine may be asked
questions through HTTP queries, similar to a traditional Prolog user interacting with
Prolog running in a terminal \[19\].

If the SWISH user hits the Run! button, the content of the source pane is used to
create a new pengine. Subsequently, the content of the query pane is sent as the one and
only query that will be executed by the pengine \[20\]. Before execution, the query is verified
to be \textit{safe}, unless sandboxing is disabled (see section \[5.2\]). The sandbox component is
discussed below.

\begin{footnotesize}
\footnotesize
\begin{itemize}
\item \[18\] \url{http://www.swi-prolog.org/pldoc/doc_for?object=html/3}
\item \[19\] \url{https://www.youtube.com/watch?v=G_eYTctG2w8}
\item \[20\] Pengines can execute multiple queries. We do not use this facility because a fresh pengine
starts in a predictable state (standard operators, empty dynamic database).
\end{itemize}
\end{footnotesize}
The pengine’s default working module may be pre-loaded with code. SWISH uses this facility to redefine the Prolog I/O predicates such as `read/1`, `write/1`, `format/1,2,3`, etc. The ClioPatria version (section 5.2) also preloads the RDF libraries, so users can run queries on the RDF database without explicitly importing the required libraries.

**Sandboxing queries** A Prolog environment contains global state in the form of loaded modules, defined operators, dynamic predicates, etc. Prolog exposes a rich and potentially dangerous interface to the operating system. For an anonymous services, we want each query to start in a well defined state and we must ensure that execution of the query does not make unwanted changes to the hosting computer or leaks sensitive information.

Both for education purposes and data analysis one can write meaningful programs without making permanent changes to the server or the server’s filesystem. That is where the sandbox library comes in. The sandbox library is active while loading the source, where it refuses to add clauses to other modules than the pengine’s workspace and where it only accepts a restricted set of directives, also aimed at keeping all changes local to the workspace. Prior to execution, the sandbox unfolds the query and compares all reachable goals with a whitelist. The whitelist contains all side-effect free built-in Prolog predicates, safe meta-predicates (e.g., `findall/3`) and allows for using the dynamic database, provided that the head of the affected predicate is not module-qualified (and thus the referenced predicate lives in the temporary program space of the Pengine) and the body is safe. It does not allow for cross-module calls (Module:Goal) to private predicates and does not provide access to object-enumeration predicates such as `current_atom/1`, `current_predicate/1`, etc., both to avoid leaking sensitive information.

The sandbox test fails under one of these conditions:

- It discovers a (meta-) goal for which it cannot deduce the called code. The traditional example is `read(X), call(X)`. If such a goal is encountered, it signals an instantiation error, together with a trace that explains how the insufficiently instantiated goal can be reached. Note that it can deal with normal high-order predicates if the meta-argument is specified. For example, the following goal is accepted as safe.

```
?- maplist(plus(1), [1,2,3])
```

- It discovers a goal that is not whitelisted. In this case it signals a permission error, again accompanied with a trace that explains how the goal can be reached. Note that pure Prolog predicates are unfolded, also if it concerns predicates from the libraries or belonging to the set of built in predicates.

- It discovers a cross-module (M:Goal) call to a predicate that is not public. Normally, SWI-Prolog, in the tradition of Quintus Prolog, allows for this. Allowing it in SWISH would imply that no data can be kept secret. With this limitation, libraries can keep data in local dynamic predicates that remain invisible to non-authorised users.

**Debugging** The SWISH debugger is based on the traditional 4-port debugging model for Prolog. Figure 5 shows the tracer in action on `sublist/2` from the Lists example.
source. The debugger was triggered by a break-point on line 10 set by clicking on the line-number in the code editor. The debugging interaction is deliberately kept simple and similar to traditional programming environments. A retry button is added to the commonly seen ‘step into’, ‘step over’ and ‘step out’ for highlighting the unique feature of Prolog to re-evaluate a goal.

Fig. 5. Debugging applications in SWISH

4 Portability

The SWISH client libraries are based on mature and well maintained JavaScript libraries. The client runs all modern major browsers with HTML5, CSS and JavaScript support. It is frequently tested on FireFox, Chrome, Safari and Internet Explorer 11.

The server code is basically non-portable. Many of the required libraries and features are shared with at least one other Prolog implementation, but none is capable to support the full range. Below we summarise the main problems.

- The scale of the involved Prolog libraries demands for a closely compatible Prolog module system. Probably only SICStus and YAP can be used without significant rewrites.
The HTTP server libraries are heavily based on C code that interacts with the SWI-Prolog foreign language interface to Prolog streams. YAP has copied the low-level libraries and is capable to run (an old version of) these libraries.

The Pengines library depends on the HTTP library and the multi-thread interface. The SWI-Prolog thread API is also provided by YAP and XSB.

The sandbox library (section 3.4) assumes that whitelisted predicates are indeed safe. This requires robust handling of invalid calls and resource overflows. Few Prolog systems can satisfy this requirement. SICStus Prolog would be a candidate, but SICStus does not support multi-threading.

The semantic syntax highlighting depends on detailed source layout information provided by read_term/3. SWI-Prolog’s support for term layout is an extended version of the Quintus Prolog term layout functionality.

Significant parts of the code rely on SWI-Prolog version 7 extensions, notably the dict and string types that facilitate a natural mapping between Prolog and JSON data.

From the above list it should be clear that a fully functional port of SWISH to another Prolog system is not immediately feasible. YAP probably comes closest but still requires a significant amount of work.

There is a more realistic scenario though. In this setup, SWI-Prolog provides the web interface and most of the development tools and another language, not even necessarily Prolog, provides the query solving. The interface between the two can be based on interprocess communication or, if the target system is robust, safe and capable of supporting threads, by linking the target system into the process and using the C interface for communication.

5 Applications

In this section we describe and evaluate four publicly available SWISH applications. All these services are regularly updated to run the latest version of SWISH and SWI-Prolog.

5.1 SWISH

SWISH\footnote{http://swish.swi-prolog.org} runs a plain publicly accessible copy of SWISH that allows running sandboxed (see section 3.4) Prolog programs. The server has collected 10,800 programs between September 29, 2014 and June 2, 2015. Over the month May 2015, it has executed 258,809 Prolog queries. The web site is regularly used by users of the ##prolog IRC channel to discuss programming solutions and is in active use for education.\footnote{Steve Matuszek, UMBC (via e-mail: “Thank you very much for this fantastic resource! I used it while teaching Prolog this semester, and it really helped tighten the loop for my students. We spent zero time on tool installation and other overhead, and all the time on understanding the concepts. I even had them turn their assignments in via SWISH, with their test queries in the examples block.”}
5.2 ClioPatria

ClioPatria is a semantic web (RDF) framework for SWI-Prolog. It consists of an RDF triple store, a SPARQL server and a web frontend to manage the server and explore the data in the RDF store. ClioPatria can be extended using cpacks (ClioPatria pack or plugin). SWISH is available as a ClioPatria cpack and makes the Prolog shell available for querying as well as maintenance tasks. Without login, user can run side-effect free queries over the RDF data stored in ClioPatria’s RDF database. After login with administrative rights, the sandbox limitations are lifted and the Prolog shell can be used to perform maintenance tasks on the RDF data such as data transformation, cleanup, etc., as well as program maintenance tasks such as reloading modified source files.

SWISH has been used in the Talk Of Europe creative camp to explore data on the speeches in the European parliament. Although still immature, users appreciated the ability to define more efficient and expressive queries than provided by the SPARQL query interface. Above all, the ability to save and share programs that perform interesting tasks on the data was frequently used, in particular to seek help fixing queries.

5.3 Learn Prolog Now!

Learn Prolog Now is an online version of a Prolog book by Patrick Blackburn, Johan Bos, and Kristina Striegnitz. We established a proof of concept that embeds SWISH in the online course material. It is realised as a Prolog hosted proxy that fetches the pages from the main site and serves the enhanced pages to the user. The proxy identifies and classifies the code fragments in terms of ‘source code’ ‘queries’ and dependencies. Next, it adds a button to the source fragments that, when pressed, replaces the HTML <pre> element with in <iframe> running SWISH filled with the source while the example queries are added to the Examples menu (figure). The queries are executed by http://swish.swi-prolog.org/ Program and queries are transferred using the following HTTP parameters: code (the source code), background (source code that is loaded into the pengine but not visible in the editor), examples (queries that appear in the Examples menu) and q (the initial query). The proxy server served 19,700 pages during May 2015.

5.4 cplint on SWISH

cplint on SWISH is a web application based on SWISH for reasoning with probabilistic logic programs under the distribution semantics. The Prolog source window is used to write a logic program with annotated disjunction. A query in the form of a ground atom is answered by returning its probability of being true in the program. The computation of the probability is done with the cplint system in the server using

\[\text{http://cliopatria.swi-prolog.org/packs/swish}\]
\[\text{http://www.talkofeurope.eu/}\]
\[\text{http://purl.org/linkedpolitics}\]
\[\text{http://www.learnprolognow.org}\]
\[\text{http://lpn.swi-prolog.org}\]
\[\text{http://cplint.lamping.unife.it/}\]
Pengines. The input program is translated into an internal representation using source to source transformation.

SWISH was modified only in the JavaScript code for the runner. The source code is prepended code for loading the cplint library and enabling the source to source transformation while the query is wrapped into a call of the inference predicate. This call has a variable argument `Prob` which will hold the probability and will be shown to the user in the answer pane.

### 5.5 TRILL on SWISH

TRILL on SWISH\(^{29}\) is a probabilistic OWL reasoner that reuses SWISH. As SWISH for ClioPatria, described in section 5.2, it is a ClioPatria `cpack`. The Prolog source window is replaced by an RDF/XML editor window that can be used to upload an OWL ontology while the query editor can be used to pose Prolog queries against the OWL ontology.

\(^{29}\) [http://trill.lamping.unife.it/](http://trill.lamping.unife.it/)
ontology. The probability of queries is computed using TRILL [8], a reasoner in Prolog that adopts the distribution semantics for probabilistic description logics.

Also for TRILL on SWISH we had only to modify the JavaScript code for the runner. The source code sent to the Pengine is obtained by adding Prolog code for parsing an RDF/XML string, by calling the parsing predicate and by wrapping the query in a meta-call that performs syntactic checks for misspellings.

6 Future work

Although definitely usable in its current state, SWISH is work in progress. We are confident that the basic component selection and organisation of the server and client code are stable. More work is needed to improve the current system. Notably the semantic highlighting is not yet perfect and often fails to degrade gradually if the server side annotation does not match the client tokens perfectly. The Pengine’s sandbox protection is often too restrictive, while several security flaws have been reported and fixed already. It is, and probably always will be, advised to run public SWISH-enabled services in an operating system sandbox. The current server suffers from memory leaks and stability problems. Although the situation has improved significantly, the main demo server needs to be restarted about once a week.

We foresee several extensions to SWISH that will improve current applications and enable new opportunities for deploying SWISH.

- ClioPatria’s authorised usage of SWISH shows some of the potential for controlling servers or embedded Prolog engines. In addition to small temporary Prolog programs, we would like to be able to edit existing and create new Prolog modules as well as pages in other languages, such as JavaScript, HTML and CSS. Full editing capabilities would allow for shared development of server software without shell access to the server on which SWISH enabled software is running.

- Multi-document editing can enhance the sandboxed SWISH application by providing input and output documents. Compare this to TRILL (section 5.5) using an RDF/XML document as input.

- We plan to provide a markdown-based format specifically for writing tutorials and well as dataset analysis documents. The first will look like the Learn Prolog Now! example discussed in section 5.3. For the second, we envision a document with embedded code and query fragments, where the query fragments produce tables or charts. This is similar to IPython Notebook.

- Turn http://swish.swi-prolog.org into a reliable and scalable resource. Examine the possibility for schools to instantiate a private version that is preloaded with course material and assignments.

30 A restart of the server has only small consequences to active users. Open queries are killed. The source code mirror is lost, but automatically recovered if the client asks for a new set of semantically enriched tokens.
7 Conclusion

This article presented SWISH, SWI-Prolog for Sharing. SWISH provides a web-enabled interface to Prolog that is based on ideas from JSFiddle, R-Studio and IPython Notebook. It consists of a JavaScript client side, while the server side is based on SWI-Prolog’s HTTP and Pengines (Prolog engines) libraries. SWISH can be deployed in many settings, such as education, data analysis and server development and maintenance. SWISH as a whole is tied to SWI-Prolog, but other languages, not even limited to Prolog, could be controlled from SWI-Prolog. SWISH is made available as open source and can be downloaded from github.

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https://github.com/SWI-Prolog/swish