Technische Universität Braunschweig

Institut für Programmierung und Reaktive Systeme

Bachelor Thesis

The Nut Shell – A Framework for Creating Interactive Command Line Tutorials

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2013–11–27

Motivation

- *Command line*: Powerful, efficient user interface

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Core idea

Interweave tutorial text with CLI output and react to user's commands, the system's state and output.

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- But: Steep learning curve
- Common teaching approach: Static text. Inflexible!
- This thesis: More direct, interactive teaching approach

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Interweave tutorial text with CLI output and react to user's commands, the system's state and output.

- Inspiration: Text adventures!

Example *Nut Shell* session

```
$
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$ cd kitchen
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Example *Nut Shell* session

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elephant fridge/
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   [The elephant does not fit into the fridge]

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[Display of the man page, skipped here]
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Example *Nut Shell* session (cont.)

```
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```

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```
$ ls -l elephant
```

Example *Nut Shell* session (cont.)

```
$ ls -l elephant
-rw------- 1 seb users 10485760 27. Okt 22:25 elephant

   Okay, about ten million bytes. ls has the option -sh to display
   that in a more comprehensible order of magnitude.

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Okay, about ten million bytes. ls has the option -sh to display that in a more comprehensible order of magnitude.

```
$ ls -sh
 10M elephant
```

10 megabytes? Indeed, the fridge isn't that large. We have to make the elephant smaller.

Overview

Goal

Design, implementation, application and evaluation of a framework that allows the creation of command line tutorials with this interactive teaching approach: The *Nut Shell*.

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2. Introduce new language to describe tutorial lessons

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Design, implementation, application and evaluation of a framework that allows the creation of command line tutorials with this interactive teaching approach: The *Nut Shell*.

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1. Construct abstraction layer for uniform access to arbitrary CLIs
2. Introduce new language to describe tutorial lessons
3. Comparative evaluation with about 120 participants

Outline

Introduction

The CLI Abstraction Layer

The nutsh Language

Application and Evaluation

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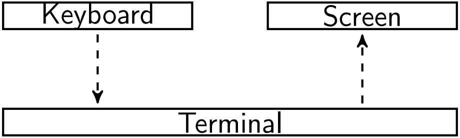
- Keep all editing features intact
- Maintain the CLI's state

Architecture

Keyboard

Screen

Architecture



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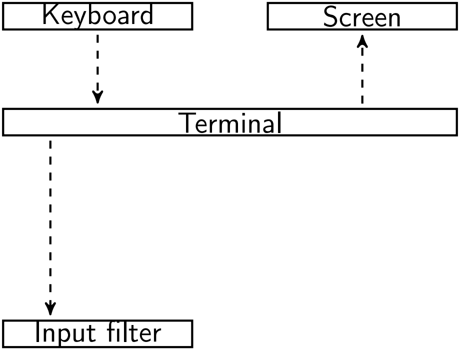

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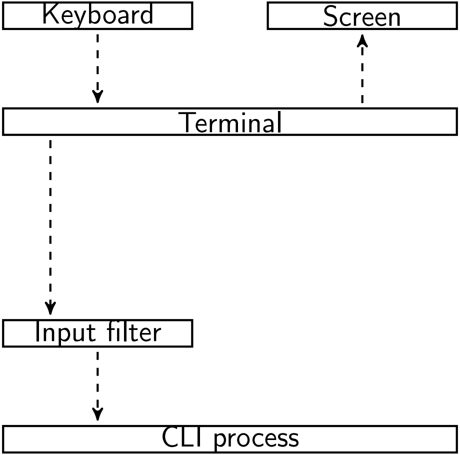

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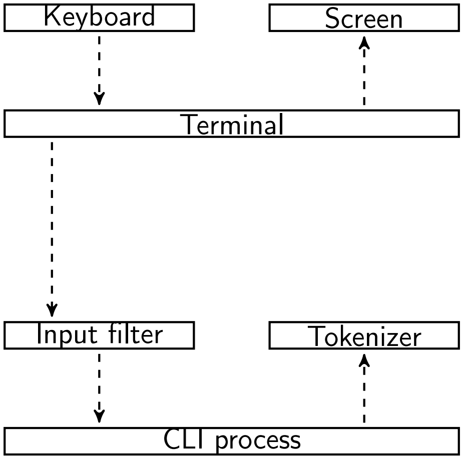

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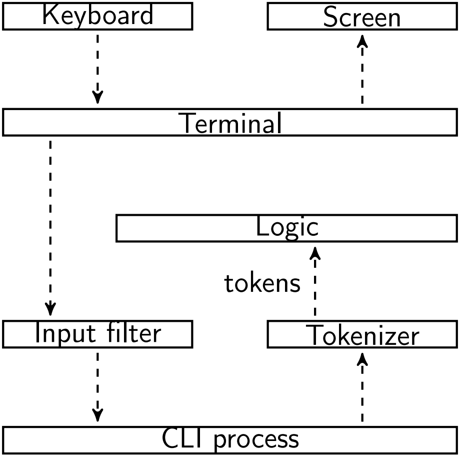

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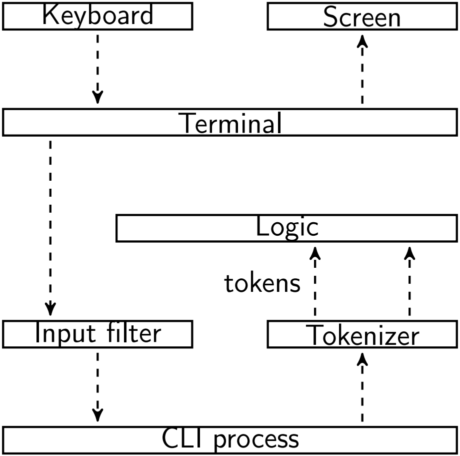

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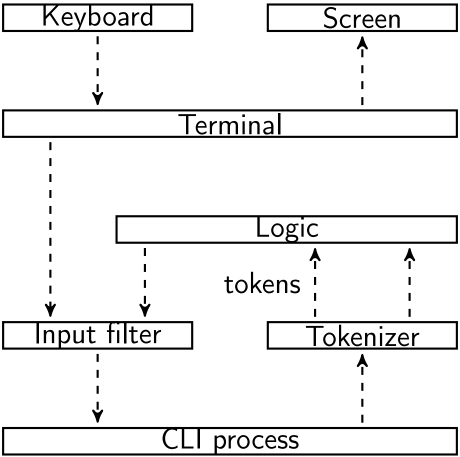

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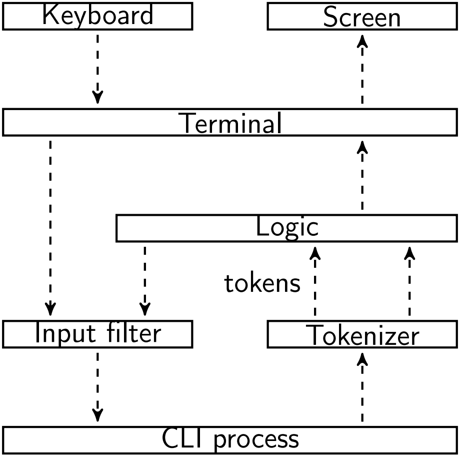

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  - SQL consoles
  - Mathematics software (Gnuplot, Sage, Octave)

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- *inputFilter*: Wait for *line feed*, send sequence to repeat command between markers

Command line operations

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2. Send a hidden command to the CLI
   - Send command directly to *Input Filter*
   - Capture command and output tokens, but don't display them

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Introduction

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Application and Evaluation

Design goals

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  - Use regular expressions
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- Syntactic support for often-used semantical constellations

Lexical elements

As usual:

- Comments
- White space
- Identifiers
- Keywords: `break`, `def`, `else`, `if`, `prompt`, `return`
- Operators, delimiters
- String literals

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- Check for equality: `"foo"+"foo" == "foofoo"`
- Check for (exact) regex match: `"foo" =~ "f[aio]."`
- Empty string has truth value *false*, others *true*
- Boolean operators: `!`, &&, and `||` as usual

Built-in functions

- `say`: Output explanation text (indented, colored)

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- `run`: Execute hidden command, return output

```
run("1+1")
```

If statements

```
if "test" == "test" {
   "Everything is OK."
} else {
   "Wait, what?"
}
```

Prompt statements

```
"Please calculate the product of 6 and 7."
prompt {
   if output == "42" {
      break
   } else {
      "Please try again."
   }
}
"Well done!"
```

Infinite loop, prompt user for command before each pass.

Define `command` and `output` functions

Function definitions

Only at top level, avoid name masking!

```
def say_twice(text) {
   say(text)
   say(text)
}

say_twice("Hey!")
```

Nesting statements

Use case: Check same conditions for group of prompt statements.

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```
def respond_to_help {
   if command =~ "help" {
      "Sorry, you're on your own."
   }
}

respond_to_help {
   prompt { /* ... */ }
   prompt { /* ... */ }
}
```

Parsing

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- Framework uses a standard parser generator, YACC
- Parser creates a *syntax tree*

Interpretation

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- Lazy evaluation, *pass-by-value*
- Nesting statements: Calls are pushed on a stack when entering, and are removed when leaving the statement

Automated testing

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```
run("text = ’stressed’")
"Reverse the content of `text` and save it in `text2`!"
prompt {
   if test("text2 == ’desserts’") {
      expect("text2 = text.reverse")
      expect("text.reverse!; text2 = text")
      break
   } else {
      expect("text2 = ’somethingdifferent’")
   }
}
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- 2576 source lines of code
- Tutorial representation:
  - Directory, contains several lesson files written in *nutsh*

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Setting

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- Split into two groups: Two thirds Nut Shell, one third paper exercises

Content

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1. Introduction - first examples with `cal`
2. Looking and moving around - `ls` and `cd`
3. Helping users to help themselves - `man`
4. File system and paths
5. Creating and editing files - `mkdir` and editors
6. History and tab completion
7. Java
8. Deleting files and directories - `rmdir`, `rm`
9. Copying, moving and linking files - `cp`, `mv`, `ln`
10. Process management - `ps`
11. Aliases
12. Variables

Content (cont.)

13. Commandline editing
14. Wildcards
15. Quoting
16. Compressing files - `tar`, `gzip`, `bzip2`
17. Redirection and pipes
18. Looking for patterns - `grep`
19. Small useful commands
20. `wget` and `curl`
21. Typesetting with LaTeX
22. Java, part 2
23. Comparing files - `cmp`, `diff`, `patch`
24. Searching - `find`, `locate`
25. Sorting
26. Shell scripts
27. Version control with Git
28. Working remotely with SSH
29. Automation with makefiles

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  - State a general problem

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- Let user choose among several paths
- Use analogies, virtual "home" environment

Survey

After the sixth day, online survey with three parts:

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3. Nut Shell assessment

Results

First part: 64 answers in total. 53 Nut Shell users, 11 exercise sheet users

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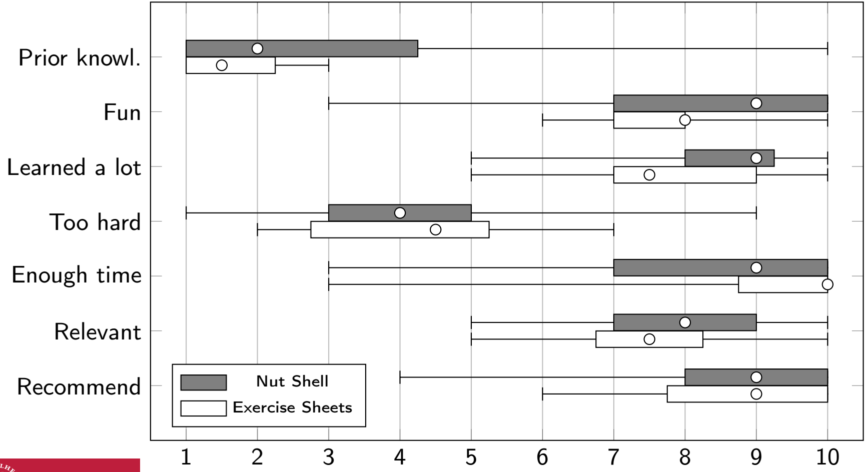

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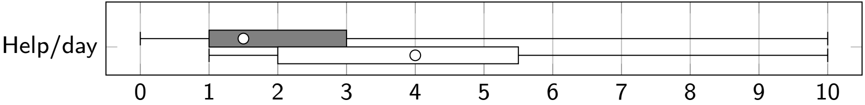

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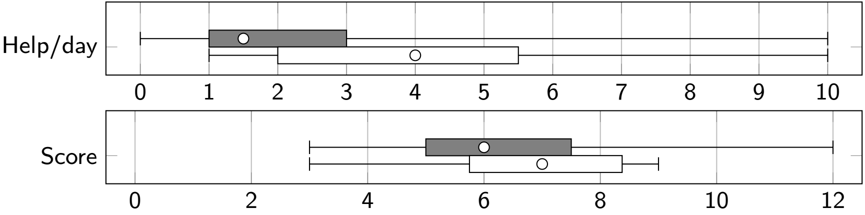

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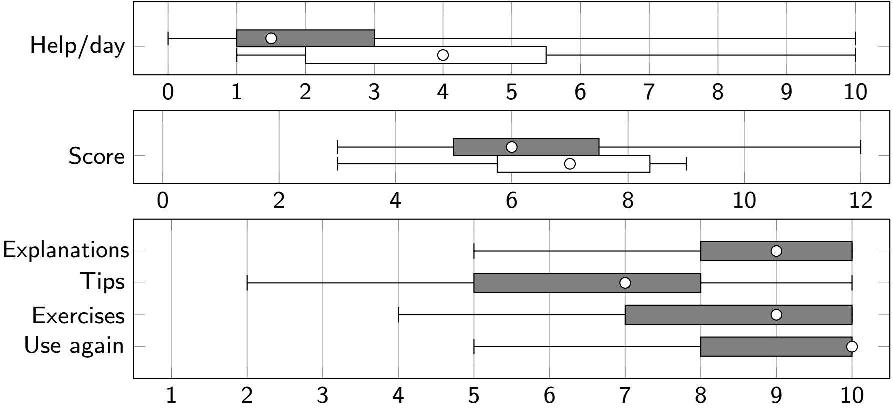

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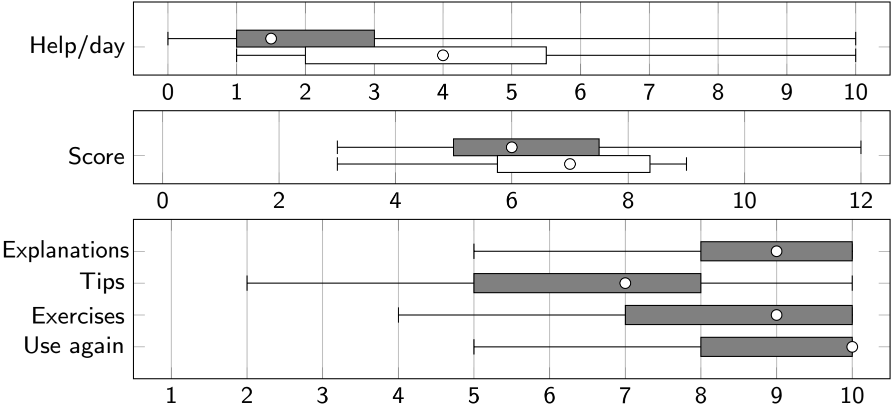

Few participants in the control group. Warped results?

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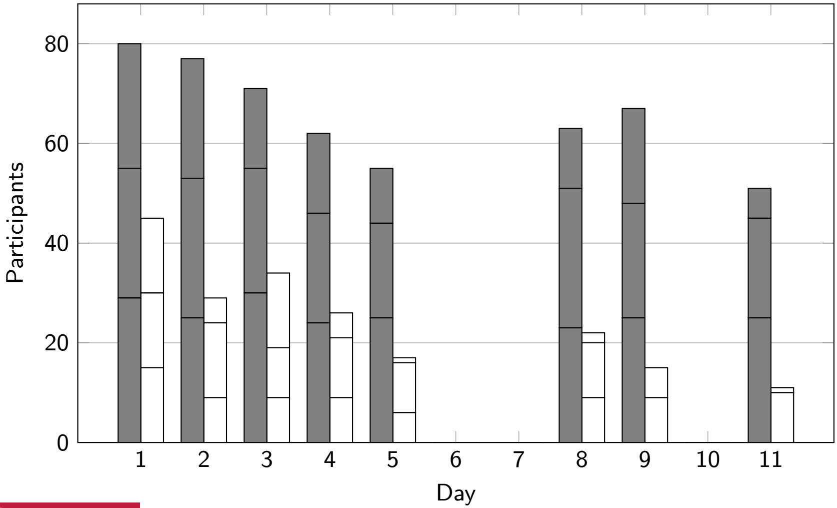

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- Main results:
  - Nut Shell motivated students to attend to the course
    - Having over 63% attending over the whole timespan is highly gratifying!
  - Lowered demand for external help: More independent students

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- Student's general feedback very positive

Conclusions

- Due to positive effects, Nut Shell will be used for upcoming preparatory courses
- Another institute has shown interest to use Nut Shell for a Git course
- Participant wants to use Nut Shell to teach command line concepts to pupils
- Student's general feedback very positive
- Software and tutorial will be released under a free, open source license

Summary

Content of the thesis

1. Design
   - Universal CLI abstraction layer
   - DSL for writing and testing lessons
2. Implementation
3. Application
   - Bash tutorial with 29 lessons
4. Evaluation

Thank you!

Questions?