

Hochschule Darmstadt

– Fachbereich Informatik–

Synergie von DLT und IOT: Anforderungsanalyse und praktische Verprobung

Abschlussarbeit zur Erlangung des akademischen Grades

Master of Science (M.Sc.)

vorgelegt von

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Darmstadt, 15. Oktober 2019

Sebastian Kanz

ABSTRACT

Short summary of the contents in English. Approximately one page...

BTW: A great guide by Kent Beck how to write good abstracts can be found here:

<https://plg.uwaterloo.ca/~migod/research/beck00PSLA.html>

ZUSAMMENFASSUNG

Das Internet der Dinge (engl. IOT; Internet of Things) erhält immer mehr Einzug in das tägliche Leben. Smart-Home Lösungen, vernetzte und latenzempfindliche Connected-Cars oder die Vision einer Smart-City prägen die Forschungsarbeiten in den jeweiligen Bereichen. Ziel ist eine vollautomatische Machine-to-Machine (M2M) Abwicklung von Prozessen, um unseren Alltag zu automatisieren und zu vereinfachen. Dabei fallen eine Menge Daten an, die verarbeitet, übertragen und gespeichert werden müssen. Mit der Einführung des neuen Mobilfunk-Standards 5G und immer leistungsfähigeren Endgeräten sind Übertragung und Verarbeitung der Daten weitestgehend gesichert; bleibt die Frage offen, wo diese großen Datenmengen gespeichert und weiterprozessiert werden. Daneben erfreut sich das Thema Distributed-Ledger-Technology (DLT) immer größerer Beliebtheit: Es werden täglich neue Anwendungsfälle gefunden, die durch die verteilte Infrastruktur, der Trustless-Eigenschaft und der Dezentralität profitieren. Es bietet sich eine Untersuchung an, um zu überprüfen, inwieweit diese beiden noch recht jungen Technologien IOT und DLT Synergien besitzen und sich gegebenenfalls gegenseitig ergänzen können. Die vorliegende Masterarbeit evaluiert eine Auswahl etablierter DLTs anhand ihrer Tauglichkeit für den Einsatz im IOT-Umfeld mit Fokus auf den M2M-Bereich. Dazu wird zunächst ein IOT-Anwendungsfall erstellt, der stellvertretend für den M2M-Bereich für die weiteren Analysen verwendet wird. Anschließend werden konkrete Anforderungen aus verschiedenen Bereichen Infrastruktur, IT-Security, Performance und weiteren aufgestellt, die eine DLT erfüllen muss, um den Anforderungen des beispielhaften Anwendungsfalls gerecht zu werden. Die erstellten Kriterien werden auf eine Auswahl von DLT-Implementierungen angewandt, evaluiert und bewertet. Mit der am besten geeigneten DLT wird eine prototypische Implementierung des Anwendungsfalls vorgenommen, um die Ergebnisse aus der Anforderungsevaluierung zu überprüfen. Um den Use-Case möglichst realistisch zu simulieren werden Daten aus verschiedenen IOT-Sensoren an die DLT übermittelt und eine M2M-Kommunikation zwischen IOT-Devices via DLT erstellt. Anschließende Load-Tests geben detaillierte Informationen über die Performance. Das Ergebnis ist eine strukturierte und nachvollziehbare Bewertung mehrerer, am Markt etablierter DLTs, inwieweit diese für DLT-sinnvolle IOT-Anwendungsfälle im M2M-Umfeld geeignet sind, sowie ein DLT-basierter Prototyp angelehnt an einen realen Use-Case, der beispielhaft als Nachweis der erarbeiteten Bewertung dient.

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ABKÜRZUNGSVERZEICHNIS

Teil I

THESIS

EINLEITUNG

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1.1 MOTIVATION

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Note: The content of this chapter is just some dummy text. It is not a real language.

1.2 PROBLEMSTELLUNG

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1.3 ZIELSETZUNG & ZIELGRUPPE

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1.4 VERWANDTE ARBEITEN

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1.5 AUFBAU DIESER ARBEIT

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GRUNDLAGEN UND VERWANDTE ARBEITEN

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2.1 DER ERSTE ABSCHNITT DES KAPITELS

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2.1.2 *Ein weiterer Unterabschnitt*

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2.2 EIN ZWEITER ABSCHNITT

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EIN WEITERES KAPITEL

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3.1 LISTEN

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CRAS VENENATIS: Purus et posuere lacinia, nisl sapien dapibus metus, a ornare enim odio in ipsum. Quisque imperdiet nibh metus, in fringilla tellus. Duis varius dui eget orci commodo ac sollicitudin est placerat. Cras varius tincidunt arcu, quis imperdiet nibh rhoncus vel. Sed non justo orci, non accumsan felis. Maecenas condimentum convallis.

3.2 GRAFIKEN

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blandit eros at ante mattis in elementum tortor pharetra. Vivamus molestie mattis orci. Quisque ullamcorper, purus sit amet luctus viverra, turpis arcu imperdiet eros, sit amet viverra nisi ligula ut felis.

3.2.1 Einfache Grafiken

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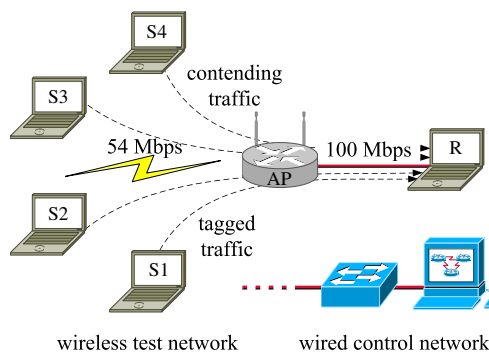


Abbildung 3.1: Dies ist eine einfache Grafik

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3.2.2 Grafiken mit Subfloat

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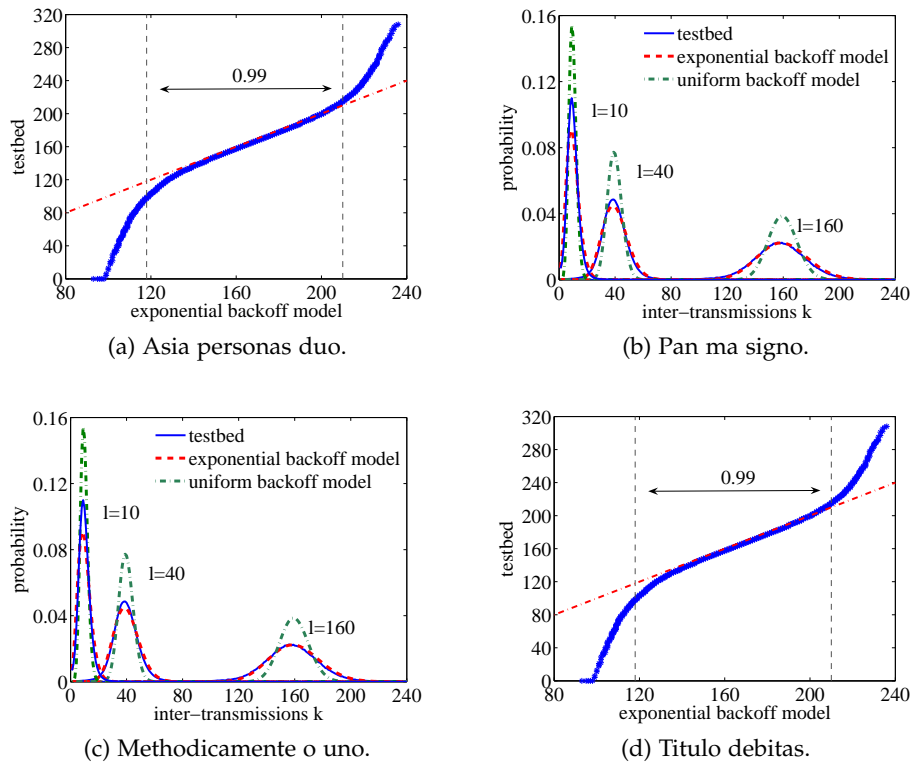


Abbildung 3.2: Mit Subfloat lassen sich mehrere Grafiken neben- und untereinander darstellen. Jeder Figure kann dabei mit einem eigenen Text versehen werden.

3.2.3 Grafiken mit Minipage

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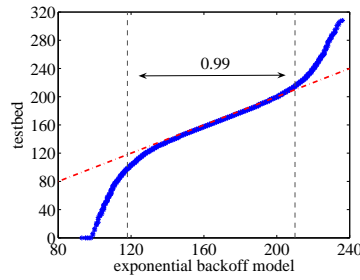


Abbildung 3.3: Minipage-
Grafik Nummer
uno

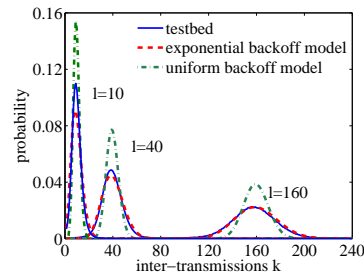


Abbildung 3.4: Minipage-
Grafik Nummer
zwei

ipsum dolor sit amet, consectetur adipiscing elit. In accumsan ornare tellus a porttitor. Etiam facilisis dui et sem eleifend id luctus nisl scelerisque. Aenean quis commodo libero. Nulla quis semper dolor.

3.3 TABELLEN

Sed lobortis vestibulum euismod. Vivamus vestibulum gravida nisi vitae condimentum. Nullam nec lacus nibh. Phasellus arcu magna, varius eget viverra a, elementum eu dolor. Aliquam erat volutpat. Sed nibh leo, vestibulum quis lacinia in, vestibulum sollicitudin nulla. In iaculis, purus in imperdiet sagittis, tortor diam pellentesque lectus, eget faucibus ante elit at tortor.

3.4 LISTINGS

Aliquam ut pretium lectus. Curabitur in eros et sapien aliquet luctus ut sit amet eros. Proin et libero non mi venenatis aliquet at sed lorem. Ut sed enim mi, id viverra eros. Cras metus ante, placerat id commodo at, molestie non libero. Aenean eu risus erat, vel consequat metus. Sed malesuada metus sit amet nisl viverra hendrerit.

3.5 EQUATIONS

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$$U = R * I \quad (3.1)$$

Lorem ipsum dolor sit amet, consectetur adipiscing elit. In accumsan ornare tellus a porttitor. Etiam facilisis dui et sem eleifend id luctus nisl scelerisque. Aenean quis commodo libero. Nulla quis semper dolor.

$$I = \frac{U}{R} \quad (3.2)$$

In the following we use probability theory to derive closed-form expressions for the fairness that is achieved among M contending stations. We tag station M and denote K_i the inter-transmissions of station $i = 1 \dots M-1$ and let $K = \sum_{i=1}^{M-1} K_i$. The conditional probability $P[K=k|l]$ can be defined for $M \geq 2$ as

$$P[K=k|l] = P\left[\sum_{i=1}^{M-1} K_i = k \middle| l\right] \quad (3.3)$$

where the random variables K_i are the integers that satisfy

$$\sum_{j=1}^{K_i} b_i(j) \leq \sum_{j=1}^l b_M(j) \quad \text{and} \quad \sum_{j=1}^{K_i+1} b_i(j) > \sum_{j=1}^l b_M(j).$$

3.6 THEOREM AND PROOF

We use the central limit theorem to derive the long-term fairness. In the sequel, we denote normal random variables $N(\mu, \sigma^2)$ where μ is the mean and σ^2 the variance.

Theorem 1 (Gaussian approximation) *Let the $b_i(j)$ be i.i.d. random variables with mean μ and variance σ^2 and let $M = 2$. For $k, l \gg 1$ (3.3) is approximately Gaussian where*

$$P[K \leq k|l] \approx P\left[N(0, 1) \leq \frac{\mu(k-l)}{\sigma\sqrt{k+l}}\right].$$

Proof For $M = 2$ we have from (3.3) that

$$P[K < k|l] = P\left[\sum_{j=1}^k b_1(j) > \sum_{j=1}^l b_2(j)\right]$$

and after expansion and some normalization this equals

$$= P\left[\frac{\sum_{j=1}^l b_2(j) - l\mu}{\sigma\sqrt{l}} - \frac{\sum_{j=1}^k b_1(j) - k\mu}{\sigma\sqrt{l}} < \frac{\mu(k-l)}{\sigma\sqrt{l}}\right].$$

Using the central limit theorem it follows that

$$P[K < k|l] \approx P\left[N(0, 1) - N\left(0, \frac{k}{l}\right) < \frac{\mu(k-l)}{\sigma\sqrt{l}}\right].$$

Since the normal distribution with zero mean is symmetric we can replace the subtraction of $N(0, k/l)$ by addition. Furthermore, the sum of two nor-

mal random variables $N(\mu_1, \sigma_1^2)$ and $N(\mu_2, \sigma_2^2)$ is normal with $N(\mu_1 + \mu_2, \sigma_1^2 + \sigma_2^2)$ such that

$$\mathbb{P}[K < k|l] \approx \mathbb{P}\left[N\left(0, \frac{k+l}{l}\right) < \frac{\mu(k-l)}{\sigma\sqrt{l}}\right].$$

Finally, we use that if X is $N(a\mu, a^2\sigma^2)$ then $Y = X/a$ is $N(\mu, \sigma^2)$ with $a^2 = (k+l)/l$ to standardize the result. ■

Th. 1 assumes i.i.d. random countdown values. It does, however, not make any assumption about their distribution.

Teil II

APPENDIX



INTRODUCTION TO THE CLASSICTHESIS STYLE

The ClassicThesis bundle for L^AT_EX has two goals:

1. Provide students with an easy-to-use template for their Master's or PhD thesis. (Though it might also be used by other types of authors for reports, books, etc.)
2. Provide a classic, high-quality typographic style that is inspired by Bringhurst's "*The Elements of Typographic Style*" [2].

The bundle is configured to run with a *full* MiK_TE_X or T_EXLive¹ installation right away and, therefore, it uses only freely available fonts. (Minion fans can easily adjust the style to their needs.)

People interested only in the nice style and not the whole bundle can now use the style stand-alone via the file `classicthesis.sty`. This works now also with "plain" L^AT_EX.

As of version 3.0, `classicthesis` can also be easily used with L_YX² thanks to Nicholas Mariette and Ivo Pletikosić. The L_YX version of this manual will contain more information on the details.

This should enable anyone with a basic knowledge of L^AT_EX 2_ε or L_YX to produce beautiful documents without too much effort. In the end, this is my overall goal: more beautiful documents, especially theses, as I am tired of seeing so many ugly ones.

The whole template and the used style is released under the GNU General Public License.

If you like the style then I would appreciate a postcard:

André Miede
Detmolder Straße 32
31737 Rinteln
Germany

The postcards I received so far are available at:

<http://postcards.miede.de>

So far, many theses, some books, and several other publications have been typeset successfully with it. If you are interested in some typographic details behind it, enjoy Robert Bringhurst's wonderful book.

*Synergie von DLT
und IOT:
Anforderungsanalyse
und praktische
Verprobung version
1.0*

*A well-balanced line
width improves the
legibility of the text.
That's what
typography is all
about, right?*

¹ See the file `LISTOFFILES` for needed packages. Furthermore, `classicthesis` works with most other distributions and, thus, with most systems L^AT_EX is available for.

² <http://www.lyx.org>

IMPORTANT NOTE: Some things of this style might look unusual at first glance, many people feel so in the beginning. However, all things are intentionally designed to be as they are, especially these:

- No bold fonts are used. Italics or spaced small caps do the job quite well.
- The size of the text body is intentionally shaped like it is. It supports both legibility and allows a reasonable amount of information to be on a page. And, no: the lines are not too short.
- The tables intentionally do not use vertical or double rules. See the documentation for the booktabs package for a nice discussion of this topic.³
- And last but not least, to provide the reader with a way easier access to page numbers in the table of contents, the page numbers are right behind the titles. Yes, they are *not* neatly aligned at the right side and they are *not* connected with dots that help the eye to bridge a distance that is not necessary. If you are still not convinced: is your reader interested in the page number or does she want to sum the numbers up?

Therefore, please do not break the beauty of the style by changing these things unless you really know what you are doing! Please.

YET ANOTHER IMPORTANT NOTE: Since classicthesis' first release in 2006, many things have changed in the L^AT_EX world. Trying to keep up-to-date, classicthesis grew and evolved into many directions, trying to stay (some kind of) stable and be compatible with its port to L^AX. However, there are still many remains from older times in the code, many dirty workarounds here and there, and several other things I am absolutely not proud of (for example my unwise combination of KOMA and titlesec etc.).

Currently, I am looking into how to completely re-design and re-implement classicthesis making it easier to maintain and to use. As a general idea, classicthesis.sty should be developed and distributed separately from the template bundle itself. Excellent spin-offs such as arsclassica could also be integrated (with permission by their authors) as format configurations. Also, current trends of microtype, fontspec, etc. should be included as well. As I am not really into deep L^AT_EX programming, I will reach out to the L^AT_EX community for their expertise and help.

An outlook into the future of classicthesis.

A.1 ORGANIZATION

A very important factor for successful thesis writing is the organization of the material. This template suggests a structure as the following:

You can use these margins for summaries of the text body...

³ To be found online at <http://mirror.ctan.org/macros/latex/contrib/booktabs/>.

- `Chapters/` is where all the “real” content goes in separate files such as `Chapter01.tex` etc.
- `FrontBackMatter/` is where all the stuff goes that surrounds the “real” content, such as the acknowledgments, dedication, etc.
- `gfx/` is where you put all the graphics you use in the thesis. Maybe they should be organized into subfolders depending on the chapter they are used in, if you have a lot of graphics.
- `Bibliography.bib`: the Bib_TE_X database to organize all the references you might want to cite.
- `classicthesis.sty`: the style definition to get this awesome look and feel. Does not only work with this thesis template but also on its own (see folder `Examples`). Bonus: works with both L^AT_EX and PDF_LA_TE_X... and L_YX. Great tool and it’s free!
- `ClassicThesis.tex`: the main file of your thesis where all gets bundled together.
- `classicthesis-config.tex`: a central place to load all nifty packages that are used.

Make your changes and adjustments here. This means that you specify here the options you want to load `classicthesis.sty` with. You also adjust the title of your thesis, your name, and all similar information here. Refer to [Abschnitt A.3](#) for more information.

This had to change as of version 3.0 in order to enable an easy transition from the “basic” style to L_YX.

In total, this should get you started in no time.

A.2 STYLE OPTIONS

There are a couple of options for `classicthesis.sty` that allow for a bit of freedom concerning the layout:

- General:
 - `drafting`: prints the date and time at the bottom of each page, so you always know which version you are dealing with. Might come in handy not to give your Prof. that old draft.
- Parts and Chapters:
 - `parts`: if you use Part divisions for your document, you should choose this option. (Cannot be used together with `nochapters`.)
 - `linedheaders`: changes the look of the chapter headings a bit by adding a horizontal line above the chapter title. The chapter number will also be moved to the top of the page, above the chapter title.
- Typography:
 - `eulerchapternumbers`: use figures from Hermann Zapf’s Euler math font for the chapter numbers. By default, old style figures from the Palatino font are used.
 - `beramono`: loads Bera Mono as typewriter font. (Default setting is using the standard CM typewriter font.)
 - `eulermath`: loads the awesome Euler fonts for math. Palatino is used as default font.
- Table of Contents:
 - `tocaligned`: aligns the whole table of contents on the left side. Some people like that, some don’t.
 - `dottedtoc`: sets `pagenumbers` flushed right in the table of contents.
 - `manychapters`: if you need more than nine chapters for your document, you might not be happy with the spacing between the chapter number and the chapter title in the Table of Contents. This option allows for additional space in this context. However, it does not look as “perfect” if you use `\parts` for structuring your document.
- Floats:
 - `listings`: loads the `listings` package (if not already done) and configures the List of Listings accordingly.
 - `floatperchapter`: activates numbering per chapter for all floats such as figures, tables, and listings (if used).

...or your supervisor might use the margins for some comments of her own while reading.

Options are enabled via `option=true`

Furthermore, pre-defined margins for different paper sizes are available, e.g., a4paper, a5paper, and letterpaper. These are based on your chosen option of \documentclass.

The best way to figure these options out is to try the different possibilities and see what you and your supervisor like best.

In order to make things easier, classicthesis-config.tex contains some useful commands that might help you.

A.3 CUSTOMIZATION

This section will show you some hints how to adapt classicthesis to your needs.

The file classicthesis.sty contains the core functionality of the style and in most cases will be left intact, whereas the file classicthesis-config.tex is used for some common user customizations.

The first customization you are about to make is to alter the document title, author name, and other thesis details. In order to do this, replace the data in the following lines of classicthesis-config.tex:

*Modifications in
classic-
thesis-config.tex*

```
% *****
% 2. Personal data and user ad-hoc commands
% *****
\newcommand{\myTitle}{A Classic Thesis Style\xspace}
\newcommand{\mySubtitle}{An Homage to...\xspace}
```

Further customization can be made in classicthesis-config.tex by choosing the options to classicthesis.sty (see [Abschnitt A.2](#)) in a line that looks like this:

```
\PassOptionsToPackage{
  drafting=true,      % print version information on the bottom of the
                      pages
  totaligned=false, % the left column of the toc will be aligned (no
                      indentation)
  dottedtoc=false,   % page numbers in ToC flushed right
  parts=true,        % use part division
  eulerchapternumbers=true, % use AMS Euler for chapter font (
                      otherwise Palatino)
  linedheaders=false, % chapter headers will have line above and
                      beneath
  floatperchapter=true, % numbering per chapter for all floats (i.
                      e., Figure 1.1)
  listings=true,     % load listings package and setup LoL
  subfig=true,       % setup for preloaded subfig package
  eulermath=false,   % use awesome Euler fonts for mathematical
                      formulae (only with pdfLaTeX)
  beramono=true,     % toggle a nice monospaced font (w/ bold)
  minionpro=false    % setup for minion pro font; use minion pro small
                      caps as well (only with pdfLaTeX)
}{classicthesis}
```

Many other customizations in `classicthesis-config.tex` are possible, but you should be careful making changes there, since some changes could cause errors.

A.4 ISSUES

This section will list some information about problems using `classicthesis` in general or using it with other packages.

Beta versions of `classicthesis` can be found at Bitbucket:

<https://bitbucket.org/amiede/classicthesis/>

There, you can also post serious bugs and problems you encounter.

A.5 FUTURE WORK

So far, this is a quite stable version that served a couple of people well during their thesis time. However, some things are still not as they should be. Proper documentation in the standard format is still missing. In the long run, the style should probably be published separately, with the template bundle being only an application of the style. Alas, there is no time for that at the moment... it could be a nice task for a small group of \LaTeX ncians.

Please do not send me email with questions concerning \LaTeX or the template, as I do not have time for an answer. But if you have comments, suggestions, or improvements for the style or the template in general, do not hesitate to write them on that postcard of yours.

A.6 BEYOND A THESIS

The layout of `classicthesis.sty` can be easily used without the framework of this template. A few examples where it was used to typeset an article, a book or a curriculum vitae can be found in the folder `Examples`. The examples have been tested with `latex` and `pdflatex` and are easy to compile. To encourage you even more, PDFs built from the sources can be found in the same folder.

A.7 LICENSE

GNU GENERAL PUBLIC LICENSE: This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but *without any warranty*; without even the implied warranty of *merchantability* or *fitness for a particular purpose*. See the GNU General Public License for more details.

You should have received a copy of the GNU General Public License along with this program; see the file COPYING. If not, write to the Free Software Foundation, Inc., 59 Temple Place - Suite 330, Boston, MA 02111-1307, USA.

CLASSICHTHESIS AUTHORS' NOTE: There have been some discussions about the GPL's implications on using classicthesis for theses etc. Details can be found here:

<https://bitbucket.org/amiede/classicthesis/issues/123/>

We chose (and currently stick with) the GPL because we would not like to compete with proprietary modified versions of our own work. However, the whole template is free as free beer and free speech. We will not demand the sources for theses, books, CVs, etc. that were created using classicthesis.

Postcards are still highly appreciated.

APPENDIX TEST

Lorem ipsum at nusquam appellantur his, ut eos erant homero concludaturque. Albucius appellantur deterruisset id eam, vivendum partiendo dissentiet ei ius. Vis melius facilisis ea, sea id convenire referrentur, takimata adolescens ex duo. Ei harum argumentum per. Eam vidit exerci appetere ad, ut vel zzril intellegam interpretaris.

More dummy text.

B.1 APPENDIX SECTION TEST

Test: [Tabelle B.1](#) (This reference should have a lowercase, small caps A if the option floatperchapter is activated, just as in the table itself → however, this does not work at the moment.)

LABITUR BONORUM PRI NO	QUE VISTA	HUMAN
fastidii ea ius	germano	demonstratea
suscipit instructor	titulo	personas
quaestio philosophia	facto	demonstrated

Tabelle B.1: Autem usu id.

B.2 ANOTHER APPENDIX SECTION TEST

Equidem detraxit cu nam, vix eu delenit periculis. Eos ut vero constituto, no vidit propriae complectitur sea. Diceret nonummy in has, no qui eligendi recteque consetetur. Mel eu dictas suscipiantur, et sed placerat oporteat. At ipsum electram mei, ad aequae atomorum mea. There is also a useless Pascal listing below: [Listing B.1](#).

Listing B.1: A floating example (listings manual)

```
for i:=maxint downto 0 do
begin
{ do nothing }
end;
```

LITERATUR

- [1] Jon Bentley. *Programming Pearls*. 2. Aufl. Boston, MA, USA: Addison-Wesley, 1999.
- [2] Robert Bringhurst. *The Elements of Typographic Style*. Version 4.0: 20th Anniversary Edition. Point Roberts, WA, USA: Hartley & Marks Publishers, 2013.
- [3] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest und Clifford Stein. *Introduction to Algorithms*. 3. Aufl. Cambridge, MA, USA: The MIT Press, 2009.
- [4] Gunter Dueck. *Dueck's Trilogie 2.1: Omnisophie – Supramanie – Topothesie*. Berlin, Germany: Springer, 2013.