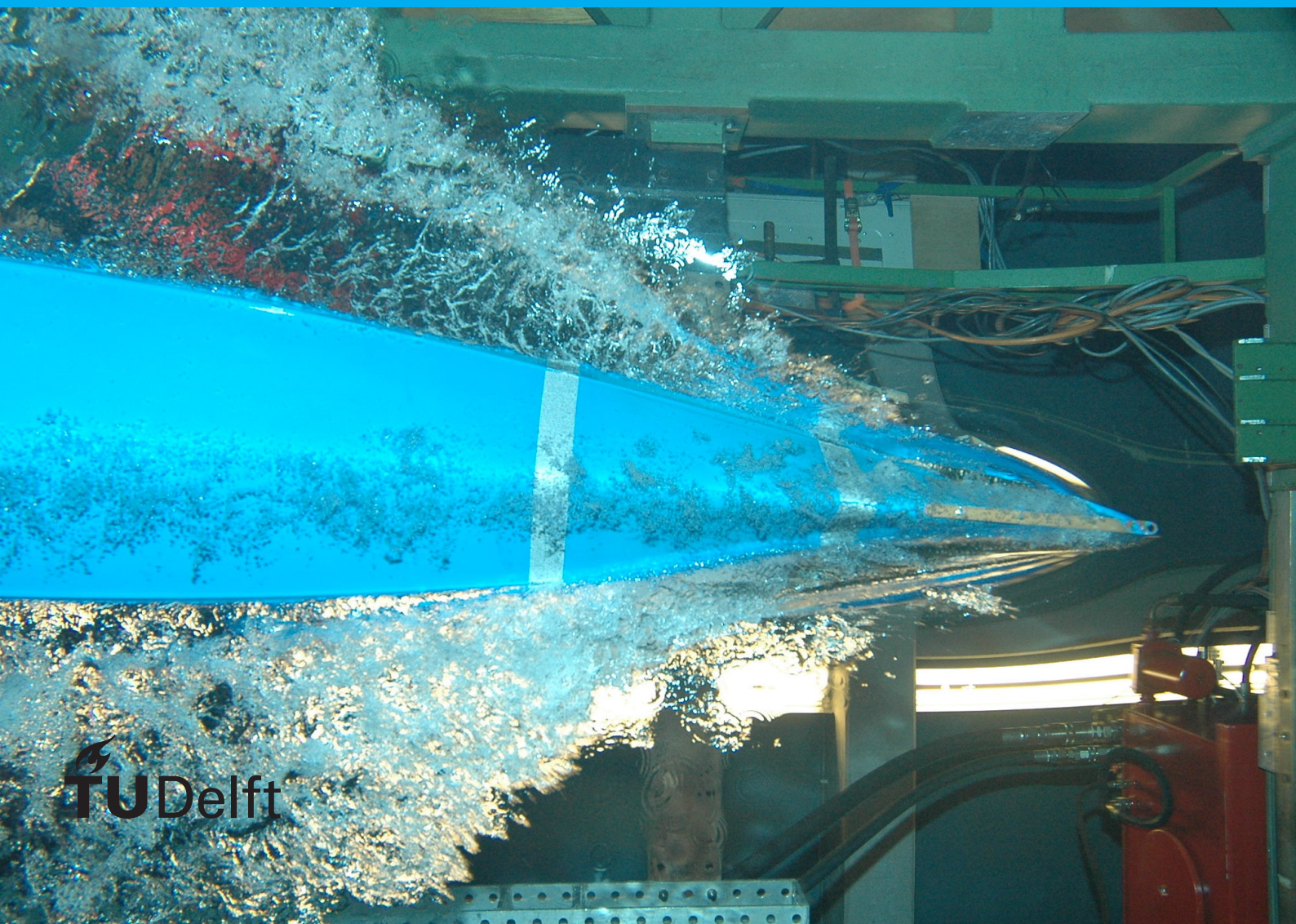
NS-3 Assignment

J.B Miog



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by

J.B Miog

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Date: April 2016

An electronic version of this report and the project files are available at
`https://github.com/JBmiog/ET4394-Wireless-Networking`.

TU Delft

Contents

1 Introduction

This document is intended to be both an example of the TU Delft LaTeX template for reports and theses, as well as a short introduction to its use. It is not intended to be a general introduction to LaTeX itself,[1] and we will assume the reader to be familiar with the basics of creating and compiling documents.

Instructions on how to use this template under Windows and Linux, and which LaTeX packages are required, can be found in `README.txt`.

1.1. Document Structure

Since a report, and especially a thesis, might be a substantial document, it is convenient to break it up into smaller pieces. In this template we therefore give every chapter its own file. The chapters (and appendices) are gathered together in `report.tex`, which is the master file describing the overall structure of the document. `report.tex` starts with the line

```
\documentclass{tudelft-report}
```

which loads the TU Delft report template. The template is based on the LaTeX `book` document class and stored in `tudelft-report.cls`. The document class accepts several comma-separated options. The default language is English, but this can be changed to Dutch (*e.g.*, for bachelor theses) by specifying the `dutch` option:

```
\documentclass[dutch]{tudelft-report}
```

Furthermore, hyperlinks are shown in blue, which is convenient when reader the report on a computer, but can be expensive when printing. They can be turned black with the `print` option. This will also turn the headers black instead of cyan.

If the document becomes large, it is easy to miss warnings about the layout in the LaTeX output. In order to locate problem areas, add the `draft` option to the `\documentclass` line. This will display a vertical bar in the margins next to the paragraphs that require attention. Finally, the `nativefonts` option can be used to override the automatic font selection (see below).

This template has the option to automatically generate a cover page with the `\makecover` command. See the next section for a detailed description.

The contents of the report are included between the `\begin{document}` and `\end{document}` commands, and split into three parts by

1. `\frontmatter`, which uses Roman numerals for the page numbers and is used for the title page and the table of contents;

2. `\mainmatter`, which uses Arabic numerals for the page numbers and is the style for the chapters;

3. `\appendix`, which uses letters for the chapter numbers, starting with 'A'.

[1] We recommend `http://en.wikibooks.org/wiki/LaTeX` as a reference and a starting point for new users.

The title page is defined in a separate file, *e.g.*, `title.tex`, and included verbatim with `\input{title}`.[2] Additionally, it is possible to include a preface, containing, for example, the acknowledgements. An example can be found in `preface.tex`. The table of contents is generated automatically with the `\tableofcontents` command. Chapters are included after `\mainmatter` and appendices after `\appendix`. For example, `\input{chapter-1}` includes `chapter-1.tex`, which contains this introduction.

The bibliography, finally, is generated automatically with

```
\bibliography{report}
```

from `report.bib`. The bibliography style is specified in `tudelft-report.bst`, which is a modified version of `apsrev4-1.bst` (from REVTeX) designed to also display the titles of referenced articles. The template will automatically generate clickable hyperlinks if a URL or DOI (digital object identifier) is present for the reference. As an example, we cite the paper by Nobel laureate Andrei Geim and his pet hamster [2]. Although it is possible to manage the bibliography by hand, we recommend using EndNote (available from Blackboard) or JabRef (available from `http://jabref.sourceforge.net/`).

1.2. Cover and Title Page

This template will automatically generate a cover page if you issue the `\makecover` command. There are two formats for the cover page: one with a page-filling ('bleeding') illustration, with the title(s) and author(s) in large ultrathin typeface, and the other where the illustration fills the lower half of the A4, whereas title(s), author(s) and additional text are set in the standard sans-serif font on a plain background with a color chosen by the user. The last option is selected by the optional key `split`: `\makecover[split]` yields a page with the illustration on the lower half. All illustrations are bleeding, in accordance with the TU Delft style.

Before generating the cover, you need to provide the information to put on it. This can be done with the following commands:

- `\title[Optional Color]{Title}`
  This command is used to provide the title of the document. The title title is also printed on the spine. If you use a title page (see below), this information will be used there as well. As the title, subtitle and author name are printed directly over the cover photo, it will often be necessary to adjust the print color in order to have sufficient contrast between the text and the background. The optional color argument is used for this.

- `\title[Optional Color]{Subtitle}`
  This command is used to provide a subtitle for the document. If you use a title page (see below), this information will be used there as well. It possible to adjust the print color in order to have sufficient contrast between the text and the background – the optional color argument is used for this.

- `\author{J. Random Author}`
  This command specifies the author. The default color is `tudelft-white`, but this may be adjusted in the same way as the titles.

- `\affiliation{Technische Universiteit Delft}`
  The affiliation is the text printed vertically on the front cover. It can be the affiliation, such as the university or department name, or be used for the document type (*e.g.*, Master's thesis). The default color is again `tudelft-white`, adjustable through the `color` option.

- `\coverimage{cover.jpg}`
  With this command you can specify the filename of the cover image. The image is stretched to fill the full width of the front cover (including the spine if a back cover is present).

- `\covertext{Cover Text}`
  If a back cover is present, the cover text is printed on the back. Internally, this text box is created using the LaTeX `minipage` environment, so it supports line breaks.

- `\titleoffsetx{OffsetX},\titleoffsety{OffsetY}` If the cover page contains a page-filling picture (i.e., `split` is not specified with the `makecover` command, the best position of the title depends

[2] Note that it is not necessary to specify the file extension.

a lot on the picture chosen for it. The lower left corner of the minipage containing title, subtitle and author is specified by these two commands. The offsets are measured from the top left corner of the page.

- `\afiloffsetx{AfilX}, \afiloffsety{AfilY}` specifies the lower left corner of the text containing the affiliation, measured from the top left corner of the page.

In addition to `[split]`, the `\makecover` command accepts several additional options for customizing the layout of the cover. The most important of these is `back`. Supplying this option will generate a back cover as well as a front, including the spine. Since this requires a page size slightly larger than twice A4 (to make room for the spine), and LaTeX does not support different page sizes within the same document, it is wise to create a separate file for the cover. `cover.tex` contains an example. The recommended page size for the full cover can be set with

```
\geometry{papersize={1226bp,851bp}}
```

after the document class and before `\begin{document}`.

The other options `\makecover` accepts are

- `nospine`
  If a back cover is generated, the title will also be printed in a black box on the spine. However, for smaller documents the spine might not be wide enough. Specifying this option disables printing the title on the spine.

- `frontbottom`
  By default the black box on the front is situated above the blue box. Specifying this option will place the black box below the blue one.

- `spinewidth`
  If a back cover is present, this option can be used to set the width of the spine. The default is `spinewidth=1cm`.

- `frontboxwidth`, `frontboxheight`, `backboxwidth`, `backboxheight`
  As their names suggest, these options are used to set the width and height of the front (black) and back (blue) boxes. The default widths and heights are `4.375in` and `2.1875in`, respectively.

- `x`, `y`
  The blue and black boxes touch each other in a corner. The location of this corner can be set with these options. It is defined with respect to the top left corner of the front cover. The default values are `x=0.8125in` and `y=3in`.

- `margin`
  This option sets the margin between the borders of the boxes and their text. The default value is `12pt`.

For a thesis it is desirable to have a title page within the document, containing information like the thesis committee members. To give you greater flexibility over the layout of this page, it is not generated by a command like `\makecover`, but instead described in the file `title.tex`. Modify this file according to your needs. The example text is in English, but Dutch translations are provided in the comments. Note that for a thesis, the title page is subject to requirements which differ by faculty. Make sure to check these requirements before printing.

1.3. Chapters

Each chapter has its own file. For example, the LaTeX source of this chapter can be found in `chapter-1.tex`. A chapter starts with the command

```
\chapter{Chapter title}
```

This starts a new page, prints the chapter number and title and adds a link in the table of contents. If the title is very long, it may be desirable to use a shorter version in the page headers and the table of contents. This can be achieved by specifying the short title in brackets:

```
\chapter[Short title]{Very long title with many words which could not possibly
fit on one line}
```

Unnumbered chapters, such as the preface, can be created with `\chapter*{Chapter title}`. Such a chapter will not show up in the table of contents or in the page header. To create a table of contents entry anyway, add

```
\addcontentsline{toc}{chapter}{Chapter title}
```

after the `\chapter` command. To print the chapter title in the page header, add

```
\setheader{Chapter title}
```

Chapters are subdivided into sections, subsections, subsubsections, and, optionally, paragraphs and subparagraphs. All can have a title, but only sections and subsections are numbered. As with chapters, the numbering can be turned off by using `\section*{...}` instead of `\section{...}`, and similarly for the subsection.

1.4. \section{...}

1.4.1. \subsection{...}

\subsubsection{...}

\paragraph{...} Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

1.5. Fonts and Colors

The fonts used by this template depend on which version of LaTeX you use. Regular LaTeX, *i.e.*, if you compile your document with with `latex`, `pslatex` or `pdflatex`, will use Utopia for text, Fourier for math and Latin Modern for sans-serif and monospaced text. However, if you want to adhere to the TU Delft house style, you will need to use XeLaTeX, as it supports TrueType and OpenType fonts. Compiling with `xelatex` will use Arial for most titles and text, Courier New for monospace and Cambria for math. If you want to haf a sans-serif font for the main text, while using `latex`, `pslatex` or `pdflatex`, you can use the option `noroman` in the report style: `\usepackage[...,noroman]tudelft-report`. For document and part titles, TU Delft Ultra Light is used. For quotes, columns and text in boxes, you use Georgia. If you want to use XeLaTeX, but do not want to use the TU Delft house style fonts, you can add the `nativefonts` option to the document class. This will still use TU Delft Utra Light and Arial on the cover, but not for the body of the document. If you need to use these fonts for certain sections in the main text, they are available via `\tudrmfamily` (Georgia) and `\tudtitlefamily` (TU Delft Utra Light).

> You have to learn the rules of the game. And then you have to play better than anyone else.
> *Albert Einstein*

The corporate colors of the TU Delft are cyan, black and white, available via `\color{tudelft-cyan}`, `\color{tudelft-black}` (which differs slightly from the default `\color{black}`) and `\color{tudelft-white}`, respectively. Apart from these three, the house style defines the basic colors `tudelft-sea-green`, `tudelft-green`, `tudelft-dark-blue`, `tudelft-purple`, `tudelft-turquoise` and `tudelft-sky-blue`, as well as the accent colors `tudelft-lavendel`, `tudelft-orange`, `tudelft-warm-purple`, `tudelft-fuchsia`, `tudelft-bright-green` and `tudelft-yellow`.

2

Introduction

2.1. assignment description

This assignment is one of two assignments given in the course of Wireless Networks [4393] at the Technical University of Delft. The assignment consist of writing a simulation in C++, using the NS-3 Network simulator, in order to simulate IEEE802.11b properties with respect to changing network properties.

2.2. The NS-3 Network simulator

NS-3 is a discreet-event network simulator, which is free to download at `https://www.nsnam.org/`. It contains models for Wi-Fi and Wi-Max, among others. The software is licensed under the GNU GPLv2 license. Although simulation files are originally written in c++, recent features also support python scripts. The simulator supports WiFi simulation up to layer 3.

2.3. 802.11b specification

802.11b operates in the 2.4 GHz band and is capable of transferring data with rates up to 11Mbps. It uses the CSMA/CA technique to let nodes communicate. It is Complementary Code Keyed (CCK) modulated, which is based on Direct Sequence Spread Spectrum modulation (DSSS) [**?**].

3

project description

3.1. objective

In this simulation, results are obtained to formulate an answer to the following question; What happens to the average throughput of stations in a 802.11b network when an increasing number of Acces Points (AP's) fail? During simulation, the amount of nodes stays constant, while the number of AP's decreases. The failure of an AP is mimicked by redoing the simulation with an altered distribution of stations, with one AP less.

3.2. Hypothesis

As the number of nodes per AP will increase, the average throughput of all nodes is expected to decrease as well.

4

Implementation

4.1. overview

The simulation consist of multiple runs, each run corresponds to pre-determined amount of access points k and stations n as depicted in figure 4.1. After each run, the average throughput is measured.

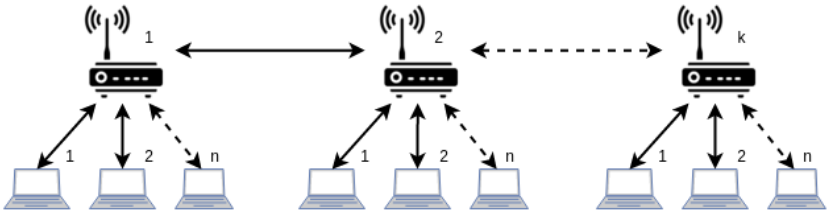

Figure 4.1

4.2. detailed description of the script

The simulator script is heavily based upon the wifi-wired-bridging.cc file that can be found in the examples/wireless folder of the NS3 installation. The nodes are arbitrarily instantiated using the corresponding containers and helpers, which, for the purpose of this simulation, are placed in a c++ std::vector variable for easy scalability. The AP's that form the backbone architecture of this simulation are suited with a CSMA NetDevice, and form a CSMA network. This is choosen as the CSMA implementation in NS3 are instantaneous, faster than light, and transmission do not get jammed [1]. Thus, during the simulation we can purely focus on the 802.11b, and can leave IEEE 802.3 inter AP communication issues out of scope.

YansWifiHelper and YansChanneHelper are used in order to make the connection between AP and stations, as well as defining the properties of the channels.

Next, the Mobility helper is used to let the nodes move around in a pre-defined square, and the stations are connected to the AP's. Next IPv4 packets are generated by an application which is installed on each node, that will transmit these packets to the access point k.

Unfortunatly, the Random Mobility Model does not

The average throughput of all nodes is calculated using FlowMonitor.

The simulation is run with 30 stations, having 30, 15, 10, 6, 5 and 2 Access Points respectively. The DataRate is set to a constant of 5000kb/s.

5 results

5.1. Througput vs. Stations per Access Points

// bla bla, for various data rates?

5.2. Throughput vs. mobility models

Bibliography

[1] title. URL https://www.nsnam.org/docs/release/3.13/models/html/csma.html.

[2] A. K. Geim and H. A. M. S. ter Tisha. Detection of earth rotation with a diamagnetically levitating gyroscope. *Physica B: Condensed Matter*, 294–295:736–739, 2001. doi: 10.1016/S0921-4526(00)00753-5.