

Thesis of the end-of-study project

TO OBTAIN THE STATE ENGINEERING DIPLOMA

MAJOR: INNOVATION & AMOA

Green IT Integration in DevOps



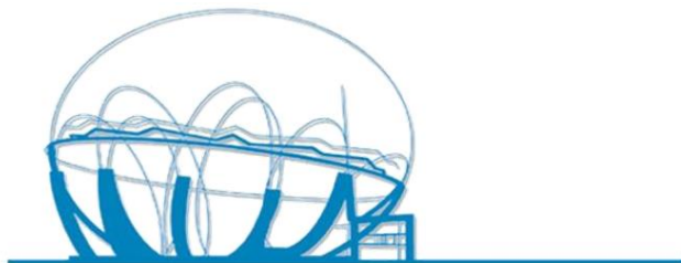
Business

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AGENCE NATIONAL DE RÉGLEMENTATION DES TÉLÉCOMMUNICATIONS
INSTITUT NATIONAL DES POSTES ET TÉLÉCOMMUNICATIONS

Class of : 2023/2024

Dedicated to

I humbly dedicate this work to my dear mother, who gave me life, love, courage, and a reason to live. I also wish to express my gratitude to my father for his support and sacrifices.

A big thank you to my two dear sisters, Alae and Samia, whom I love so much, to all my friends with whom I have shared moments of joy and happiness, as well as to my entire extended family and to all those who love me.

Imad

Acknowledgments

Thank your supervisors (INPT and company), the managers and HR, the teachers at INPT and the jury.

Résumé

Ce rapport reflète le travail réalisé chez Orange Business Maroc dans le cadre de mon projet de fin d'études pour le diplôme d'ingénieur en Télécommunications et Technologies de l'Information.

Dans un contexte où les architectures distribuées et les pratiques de développement agile dominent la conception des applications, intégrer les principes de Green IT dans les pratiques DevOps est devenu essentiel. Cette évolution témoigne de l'importance croissante accordée à la durabilité environnementale dans le secteur de la technologie.

En se concentrant sur la surveillance de la consommation d'énergie et des émissions de CO2 de l'infrastructure, nous mettons en lumière une préoccupation croissante pour l'empreinte écologique de nos systèmes informatiques. Cette prise de conscience a conduit à l'adoption de mesures proactives telles que l'utilisation de Kepler, Prometheus et Grafana pour surveiller et visualiser ces métriques environnementales.

Mon projet de fin d'étude vise à mettre en place Kepler pour surveiller la consommation énergétique et les émissions de CO2 de Kubernetes, et à l'intégrer dans la chaîne CI/CD.

Mots-clés : Green IT, DevOps, Kepler, Prometheus, Grafana, Kubernetes, CI/CD.

Summary

This report reflects the work carried out at Orange Business Morocco as part of my final project for the engineering degree in Telecommunications and Information Technologies.

In a context where distributed architectures and agile development practices dominate application design, integrating Green IT principles into DevOps practices has become essential. This evolution underscores the increasing importance placed on environmental sustainability in the technology sector.

By focusing on monitoring energy consumption and CO2 emissions of the infrastructure, we highlight a growing concern for the ecological footprint of our computer systems. This awareness has led to the adoption of proactive measures such as using Kepler, Prometheus, and Grafana to monitor and visualize these environmental metrics.

My final project aims to implement Kepler to monitor energy consumption and CO2 emissions of Kubernetes, and integrate it into the CI/CD pipeline.

Keywords: Green IT, DevOps, Kepler, Prometheus, Grafana, Kubernetes, CI/CD.

ملخص

يعكس هذا التقرير العمل الذي قمت به في أورانج بيزنس المغرب في إطار من مشروع الختامي للحصول على شهادة مهندس دولة في الاتصالات وتكنولوجيا المعلومات.

في سياق تهيمن فيه الهياكل الموزعة وممارسات التطوير السريعة على تصميم التطبيقات، أصبح دمج مبادئ تكنولوجيا الخضراء في ممارسات ضقوپس أمراً ضرورياً. يؤكد هذا التطور على الأهمية المتزايدة التي تحظى بها الاستدامة البيئية في قطاع التكنولوجيا.

وقد أدى هذا الوعي إلى اعتماد تدابير استباقية مثل استخدام Kepler و Prometheus و Grafana لمراقبة هذه المقاييس البيئية وتصورها.

يهدف مشروع الختامي إلى تطبيق Kepler لمراقبة استهلاك الطاقة وانبعاثات ثاني أكسيد الكربون في Kubernetes و دمجها في سلسلة CI/CD .

الكلمات المفتاحية: Green IT, DevOps, Kepler, Prometheus, Grafana, Kubernetes, CI/CD

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Chapter 1

General Project Context

Introduction

Use this template as you wish, change what you want to change, the section titles are only examples, you don't have to follow them to the letter.

This is an example of me citing the 1st reference in the bibliography at the end of this report [\[1\]](#).
Use it well!

The next section contains the README text that's also found in the left part along with the other files.

1.1 READ_ME

Hi!

This template is a combination of multiple student and teacher PFE report templates that I have compiled into one that hopefully will satisfy your needs.

It is in English, but I have included the french "Page de garde" if you want to use it, and the rest of the paper is easily translatable.

This document is compiled using pdfLatex Compiler, so make sure you select it in the menu on the top left of the page. You can change the font size there along with other things.

Some table, figure, list or formatting codes can be found in the "Codes_needed.tex" file in this same folder, use them well.

The organisation of this template is as follows:

The main compilation file is main.tex, any file you want to add, should be added there using,

Remember to change the PDF Title and author name before the begin document command.

Packages.tex is where you import packages and could modify their options.

The frontmatter folder contains unnumbered chapters that come before the actual chapters, so the resumes and acknowledgments are there. The pages are numbered in Roman numbers.

The chapters folder obviously contains the main chapters of the report, usually the first one is an intro, of both the project and the company, the last one is a conclusion chapter, I made it unnumbered here but you do you.

The endmatter folder contains the appendices, acronyms, glossary, and Complementary figures, tables and codes. Consider checking this link <https://libguides.usc.edu/writingguide/appendices> for more info. Usually you add an appendix for each subject you'll talk about it, each with its own codes, tables, figures and text.

The bibliography can be found at the end of main.tex file.

And to organise your figures better, upload the logos to the logos folder, and content related figures should go in the figures folder, where you can add sub folders.

Along the template, make sure to read my comments, they can be helpful to understand the purpose of a command or option.

When you finish writing your thesis, make sure to verify that you didn't leave any generic line or link. Revise it well.

There are 10 warnings that show up in this template, some I couldn't manage to solve (or understand), and some I left since they are necessary for what I intend of this template.

Obviously this template is only a suggestion, it is not perfect in any sense, you can improve it in the way that suits you, so search away, and get used to reading the documentation.

Also consult with your supervisor, as each teacher has their own opinion on what constitutes the ideal report.

Finally, I hope you have enjoyed your time at INPT as much as I did, and Good Luck :D

-Mery

1.1.1 Codes_Needed

This subsection includes codes for different elements you will need: figures, tables, lists...

Copy the codes you want and test them in the chapter files.

if you want symbols and other text styles, visit this link:

[Symbols](#)

Read the comments !!

1.1.1.1 Text formatting

This text is bold

This text is italic

This text is underlined.

~~This text is struck out.~~

THIS TEXT IS CAPITALIZED.

Some characters like "%", "\$" and "&" are significant in Latex code, so to include them in normal text, use the backslash character before them. To print out backslash, use \

Documentation: [Italics and underlining](#)

1.1.1.2 Figures



Figure 1.1: Caption

Documentation: [Images](#)

1.1.1.3 Tables

Simple table without borders:

First Second

Third Fourth

More complex table with borders:

Left aligned column	Centered column	Right aligned column
Text	Text	Text

Example of a short table

Column1	Column2
Element11	Element21
Element12	Element22
Element13	Element23

Table 1.1: Table Example

Example of a long table (that spans 2 pages or more), Latex will automatically split the table when it reaches the end of the page:

Table 1.2: Long table

Cell	Description
Element11	Element21
Element12	Element22
Element13	Element23
Element14	Element24
Element15	Element25
Element16	Element26
Element17	Element27
Element18	Element28
Element19	Element29
Element110	Element210
Element111	Element211
Element112	Element212
Element113	Element213
Element114	Element214

Documentation: [Tables](#)

1.1.1.4 Lists

To start an unnumbered list, use:

-
-

-

To start a numbered list, use:

- 1.
- 2.
- 3.

Documentation: [Lists](#)

1.1.1.5 Code scripts or terminal

Say you have a script or terminal command you want to include, you use the following code:

```

1
2 root@eve-ng:~# mkdir -p /opt/unetlab/addons/qemu/timos-20.10.R12
3
4
```

Listing 1.1: Code caption

Documentation: [Code Listing](#)

1.1.1.6 Math

Some math formulas for you, test them in your chapters:

These are inline formulas: x , $a_i^2 + b_i^2 \leq a_{i+1}^2$. Afterwards...

These are centered formulas:

$$x,$$

$$a_i^2 + b_i^2 \leq a_{i+1}^2.$$

Afterwards...

Some complex formula:

$$P(|S - E[S]| \geq t) \leq 2 \exp \left(-\frac{2t^2 n^2}{\sum_{i=1}^n (b_i - a_i)^2} \right).$$

Also you can use the first link for math symbols and other useful stuff:

Documentation: [Symbols file again](#)

1.2 Presentation of host organization

1.2.1 Company Overview



Figure 1.2: Company logo

1.2.2 Organizational Chart

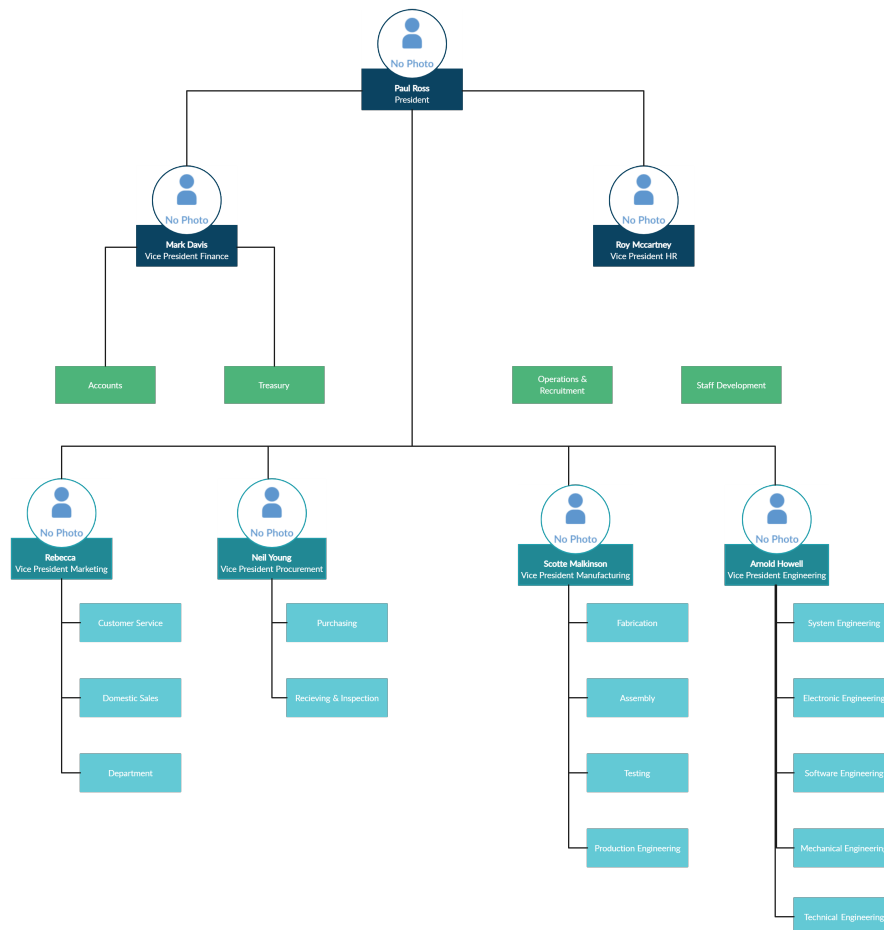


Figure 1.3: Organizational Chart

1.3 Presentation of the project

1.3.1 Project Framework

1.3.2 Project objectives

1.3.3 Project Planning

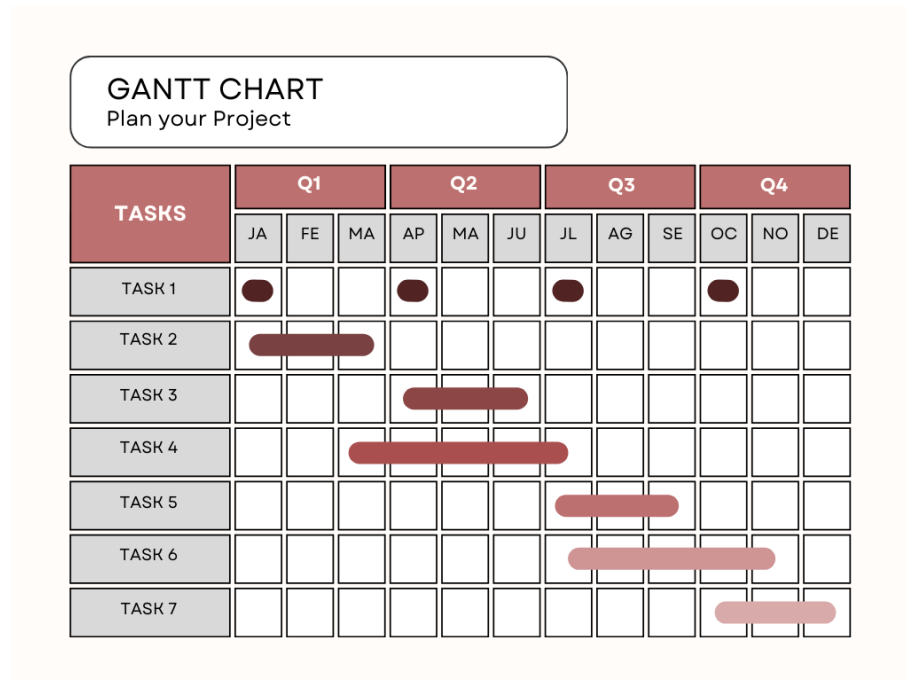


Figure 1.4: Gantt Diagram

Conclusion

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Chapter 2

Chapter 2 title

Introduction

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2.1 Section1

2.1.1 Subsection1

Table 2.1: Long table 1

Cell	Description
Element11	Element21
Element12	Element22
Element13	Element23
Element14	Element24
Element15	Element25
Element16	Element26
Element17	Element27
Element18	Element28
Element19	Element29
Element110	Element210
Element111	Element211
Element112	Element212
Element113	Element213
Element114	Element214

2.1.2 Subsection2

2.1.2.1 Subsubsection1

2.1.2.2 Subsubsection2

2.1.2.2.1 Paragraph a

2.1.2.2.2 Paragraph b

2.2 Section2

2.2.1 Subsection1

2.2.2 Subsection2

2.2.2.1 Subsubsection1

2.2.2.2 Subsubsection2

2.2.2.2.1 Paragraph a

2.2.2.2.2 Paragraph b

Conclusion

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Chapter 3

Chapter 3 title

Introduction

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3.1 Section1

3.1.1 Subsection1

Column1	Column2
Element11	Element21
Element12	Element22
Element13	Element23

Table 3.1: Table 1

3.1.2 Subsection2

3.1.2.1 Subsubsection1

3.1.2.2 Subsubsection2

3.1.2.2.1 Paragraph a

3.1.2.2.2 Paragraph b

3.2 Section2

3.2.1 Subsection1

3.2.2 Subsection2

3.2.2.1 Subsubsection1

3.2.2.2 Subsubsection2

3.2.2.2.1 Paragraph a

3.2.2.2.2 Paragraph b

Conclusion

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Chapter 4

Chapter 4 title

Introduction

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4.1 Section1

4.1.1 Subsection1

4.1.2 Subsection2

4.1.2.1 Subsubsection1

4.1.2.2 Subsubsection2

4.1.2.2.1 Paragraph a

4.1.2.2.2 Paragraph b

4.2 Section2

4.2.1 Subsection1

4.2.2 Subsection2

4.2.2.1 Subsubsection1

4.2.2.2 Subsubsection2

4.2.2.2.1 Paragraph a

4.2.2.2.2 Paragraph b

Conclusion

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Chapter 5

Chapter 5 title

Introduction

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5.1 Section1

5.1.1 Subsection1

5.1.2 Subsection2

5.1.2.1 Subsubsection1

5.1.2.2 Subsubsection2

5.1.2.2.1 Paragraph a

5.1.2.2.2 Paragraph b

5.2 Section2

5.2.1 Subsection1

5.2.2 Subsection2

5.2.2.1 Subsubsection1

5.2.2.2 Subsubsection2

5.2.2.2.1 Paragraph a

5.2.2.2.2 Paragraph b

Conclusion

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General Conclusion and Perspectives

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Appendix A

Glossary

Telnet: Telnet is a network protocol that allows users to establish a remote terminal connection to a computer or network device over a network.

SSH (Secure Shell): SSH is a network protocol used for secure remote administration and secure file transfers.

SNMP (Simple Network Management Protocol): SNMP is a network protocol designed for managing and monitoring network devices and systems.

Appendix B

Acronyms

IP	Internet Protocol
CNS	Cloud and Network Services
MN	Mobile Networks
NI	Network Infrastructure
IoT	Internet of Things
NFV	Network Functions Virtualization
SDN	Software-Defined Network
TCP	Transmission Control Protocol
7750 SR	Nokia 7750 Service Router
OSPF	Open short Path First
BGP	Border Gateway Protocol
VPN	Virtual Private Network
MPLS	Multiprotocol Label Switching
EVE-NG	Emulated Virtual Environment - Next Generation
VM	Virtual Machine
SSH	Secure Shell
WinSCP	Windows Secure Copy
FTP	File Transfer Protocol
SSL	Secure Sockets Layer
TLS	Transport Layer Security
FTPS	FTP over SSL/TLS

SFTP	Secure File Transfer Protocol
SCP	Secure Copy Protocol
CLI	Command-line interface
MD-CLI	Model-Driven Command Line
API	Application Programming Interface
re	Regular Expression
IGP	Internal Gateway Protocol
IS-IS	Intermediate-System Intermediate-System
SPF	Shortest Path First
SF	Switch Fabric
CPM	Control Processing Module
IOM	Input/Output Modules
MDA	Media Dependent Adapters
QoS	Quality of Service
IPsec	Internet Protocol Security
VSR	Virtual Services Router
DDoS	Distributed Denial-of-Service
SROS	Service Router Operating System
NETCONF	Network Configuration Protocol
YANG	Yet Another Next Generation
MP-BGP	Multiprotocol Border Gateway Protocol
IPv6	Internet Protocol Version 6
AS	Autonomous Systems
iBGP	Internal Border Gateway Protocol
eBGP	External Border Gateway Protocol
LAG	Link Aggregation Group
VPRN	Virtual Private Routed Network
SNMP	Simple Network Management Protocol
Telnet	Telecommunication Network
YAML	Yet Another Markup Language
XML	eXtensible Markup Language

Appendix C

Some subject you want to expand on

You can add more appendices depending on the subjects.

```
1
2 [root@host ~]# You can change the language and caption.
3
4
```

Listing C.1: Bash example

```
1
2 # Solve the quadratic equation ax**2 + bx + c = 0
3
4 # import complex math module
5 import cmath
6
7 a = 1
8 b = 5
9 c = 6
10
11 # calculate the discriminant
12 d = (b**2) - (4*a*c)
13
14 # find two solutions
15 sol1 = (-b-cmath.sqrt(d))/(2*a)
16 sol2 = (-b+cmath.sqrt(d))/(2*a)
17
18 print('The solution are {0} and {1}'.format(sol1,sol2))
19
```

Listing C.2: Python example

Column1	Column2
Element11	Element21
Element12	Element22
Element13	Element23

Table C.1: Table Example

Table C.2: Long table Example

Cell	Description
Element11	Element21
Element12	Element22
Element13	Element23
Element14	Element24
Element15	Element25
Element16	Element26
Element17	Element27
Element18	Element28
Element19	Element29
Element110	Element210
Element111	Element211
Element112	Element212
Element113	Element213
Element114	Element214

Bibliography

[1] Author name, Book name.

[2] *Title 1*, **Title 2**