PEDRO GOMES BRANQUINHO

Free software in industry and academia

Lorena

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This monograph is presented to the Engineer School of Lorena, the University of São Paulo, so to be obtained the title of Barchelor by the Graduation Program on Engineering Physics with emphasis on the Science of Materials.

University of São Paulo - USP
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Monograph, Conclusion Thesis

Supervisor: Dr. Wei-Liang Qian

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To those whom found me in their own path
and, by finding me, made part of my own.

Acknowledgements

My acknowledgments wouldn't fit in a single page. But, for the purpose of conciseness, I will mention those who are closer to my work. I thank first my advisor, Wei-Liang Qian, who in his patience and kindness knew how to conduce me to produce the present work. I thank Juan Zapata for the support and enthusiasm on teaching Mathematics and showing me the way of how to study it myself. Last but not least, I thank Luiz Eleno who has been a role-model for me, and has teach me so much about computing through out the years.

And, in a big umbrella, I thank all those anonymous people who have contributed for my experience of communal sharing and understanding in the Open Source community. Specially, David Wilson, the founder of System's Crafter, from whom I derived the basis of my Emacs's system.

Abstract

In this work, It's shown how to build a series of application only upon a Free Software system - EXWM, Artix Linux OSS. I explain how the experience of participating in the Open Community can be significant for other Engineers; specially Physics Engineers. It's delineated what are the current trends on the adoption of Free and/or Open Source Software (FOSS). Furthermore, I put forward some of the tools I used in Academia, and in Industry, and some other not so well known software, which could be used in these two contexts - e.g., Freqtrade, OR-Tools, Git(hub) et cetera. I also argue why Linux is such a key software for someone shifting to the Open Source paradigm.

Key-words: trends. foss. academia. industry. linux. freqtrade. or-tools. git. github.

Resumo

Demonstrou-se como é possível construir uma série de aplicações baseada em softwares de licença livre, à partir de um sistema aberto, o Linux com inteface EXWM - Emacs X Window Manager. Além disso, foi propiciado casos reais de aplicações na Indústria e no investimento privado, autônomo. Bem como, utilizações na Academia, à nível de lecionar, e pequisa. Sustenta-se que a economia aberta possui similaridade estrutural ao movimento *Open Source* e seu desenvolvimento, o que aponta que essa é e continuará a ser, paulatinamente mais, o paradigma de desenvolvimento econômico tecnológico. Assim, imprescindível à formação do engenheiro.

Palavras-chaves: software livre. automação. freqtrade. idústria. academia.

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List of abbreviations and acronyms

FOSS	Free and Open Source Software
IDE	:Integrated Development System
abnTeX	ABsurdas Normas para TeX

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1 Introduction

In training a Physics Engineer, of which, by definition, is a generalist professional. The use of Free and Open Sourced Softwares (FOSS), as well as the participation in the Open Source community (OS), are two detrimental experiences to have.

The variability, which open source software (OSS) brings to existence of applications and it's extension, can change altogether user's experience. Thus, taking him closer to acting as a developer. This experience of interloping user and developer roles doesn't require that you are a computer scientist or a Information Technology (IT) professional by training. For, programming can be seen as both a Science and an Art (KNUTH, 1968) - e.g., an exercise of self-expression.

OSS guarantees four fundamental liberties section 2.1, the right to study, copy, modify and redistribute it.

Just as the scientific enterprise benefits, with it's rapid development, by means of the global community's participation, which holds space for individuals with a variety of different training. Also, the computation enterprise benefits from the variety of people's training, which constitute the body of the open source community.

1.1 Objective

We will demonstrate the vality of the hypothesis that a engineer professional, without strong training in computation, lags behind it's current potential. Furthermore, we present a range of different applications developed to the state of the art, which are distributed under open licenses (copy-left). Thus, reinforcing the uniqueness of open source phenomena and the need for it's use - the logic and dynamic FOSS brings has no parallel on the economy or scientific community (HIPPEL; KROGH, 2003; PETERS, 2009).

There exits debate around the meaning of *Open Science*. This term recently became popular and which has a obvious reference to the *Open Source*. Although, in the social literature, it's a phenomena poorly depicted and rarely debated through the point view that the Open Source Movement has anything to do with it. We cite the most cited article on Google Scholar research on the topic "Open Science" - called "The future(s) of open science" - and which only uses trice the term "Open Source" and in dismissive way (MIROWSKI, 2018).

Therefore, I argue that a strong basic knowledge, for engineer training, is fundamental for understanding the movement and how it has been shaped, so to critically asses the validity of the current social-economic shift we live in. This understand can, in turn, shape

the carer path and formation of the working engineer.

1.2 The interconnection between Applications and the OS

The author used an **Application** as to comprise any end product of software development.

1.2.1 Why does GNU/Linux matter?

We will discuss, as a brief introduction, what is the Operational System (OS) GNU/Linux, and why it's the *de facto* opening door to the Open Source Community. Firstly, the GNU/Linux is the first and most successful project carried out in the Open Source paradigm (TU et al., 2000; WEST; DEDRICK, 2001). Therefore, it's use is a way to acquaintance, in practical terms, with how a business dependent on mainly using the open sourced development products might operate (FINK, 2003).

Furthermore, the new user-developer of the GNU/Linux framework must inherently learn about the accompanying software which comes with it's distribution - which increases it's chance of adoption (WEST; DEDRICK, 2001). This way, the user gradually becomes accostumed to participate on development and extend programs (HERTEL; NIEDNER; HERRMANN, 2003).

Beyond it's initial philosophical appeal to user liberty, GNU/Linux is today's standard in Technological Enterprises. And, although fundamentally opposed of many age-old *modus operandus* of the *status quo* of companies, there is no doubt left under analysis of the benefits it brings to the companies, general economy, and the society triad (MOODY, 2009). To make use of GNU/Linux, thus, is a way to be inserted in this new economic paradigm (HIPPEL; KROGH, 2003; PETERS, 2009).

1.2.2 How high level applications benefit from an OS

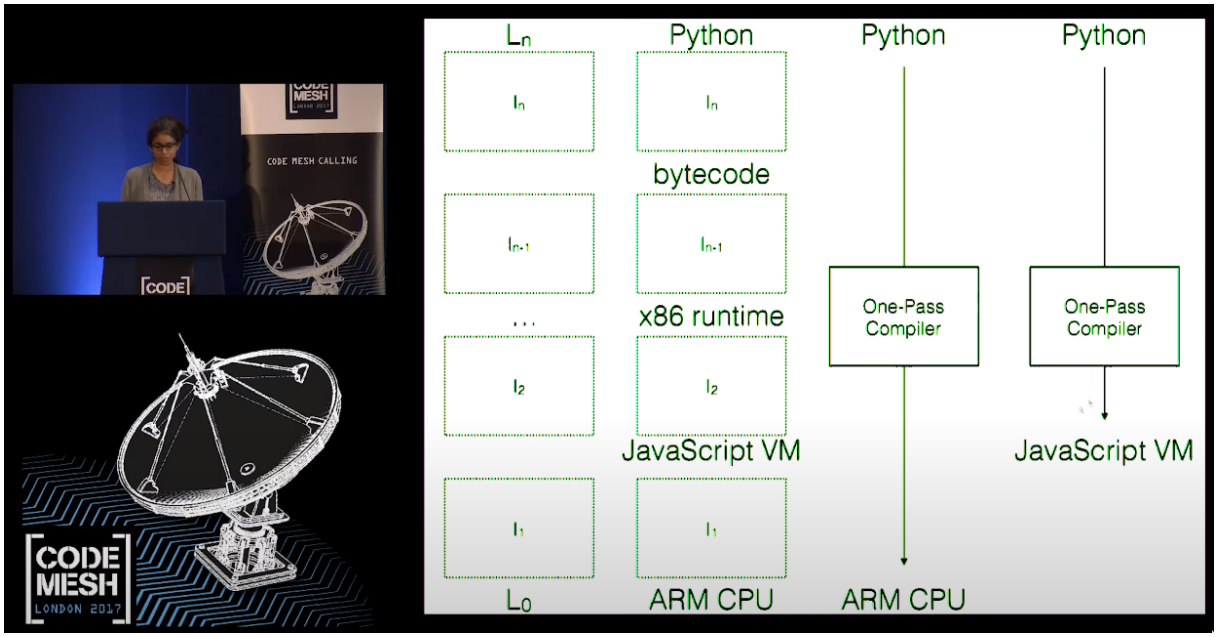
In the hierarchy of software and applications, the Operational Systems (OSes) can be seen as a meta-application or meta-software.

"The evaluator, which determines the meaning of expressions in a programming language, is just another program." (ABELSON; SUSSMAN, 1996)

There exists levels, or layers, of abstractions in virtually any application. That is, the concept of meta-programming and Towers of Interpreters comprise a common situation, for which a devoted field of study exists. Thus this area has direct implication for software development practice, as it's a ubiquitous problem faced in computing.

Any OS, as the GNU/Linux, comprise an essential layer in this tower of interpreters. Particularly, an OS communicates with *firmwares* - low-expressivity and highly-performing software, which control *hardware*. Also, they communicate with high-expressivity software, among which contain the user-developer written or extended software. Therefore, the OS play a fundamental role, mediating between low and high level software. This function categorizes them as a *middleware* software.

Figure 1 – Schema of a tower of interpreters



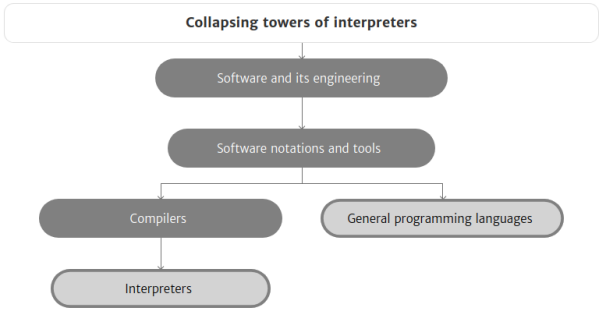
Code Mesh, presentation “Towers of Interpreters”, by Nada Amin

The characteristic problem of concatenate a system of software, one on top of the other, introduces complexity to maintaining compatibility among program's versions and it's performance. The study of these behavior and it's theoretical solutions posses a field of it's own. And, this field is autonomous, detached, for an example, from which languages compose the Tower of Interpreters; or which type of application we are dealing with (AMIN; ROMPF, 2017). The object of study is the final behavior of the system, and if it's a collapsible system.

Finally, the OSes consist in a big tower-collapser of interpreters. They are subordinate to collapsing firmware, middleware and high-level software. Therefore, as well as the OS conduct this task, as much the user-developer experience is facilitated.

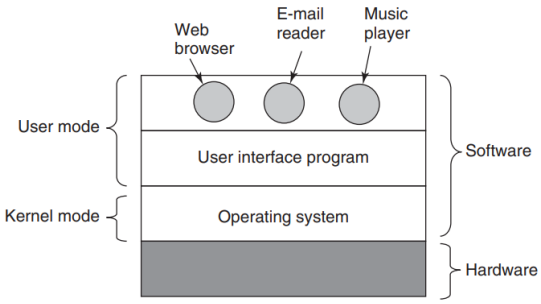
> If every application programmer had to understand how all these things work in detail, no code would ever get written. Furthermore, managing all these components and using them optimally is an exceedingly challenging job. For this reason, computers are equipped with a layer of software called the operating system, whose job is to provide user programs with a better, simpler, cleaner, model of the computer and

Figure 2 – Categorization of the study of towers of interpreters



Reference: (AMIN; ROMPF, 2017)

Figure 3 – Towers of interpreters and the Operational Systems.



Reference: (TANENBAUM; BOS, 2015)

to handle managing all the resources just mentioned. (TANENBAUM; BOS, 2015)

1.3 On the influence of education in adoption

In the bibliographical literature, it's clear that the rate of OSS adoption in the Industrial sector - commonly refereed as"Production" - depends heavily on both: competency and the level of expertise a project require (LI; TAN; YANG, 2013; GALLEGO et al., 2015; SPINELLIS; GIANNIKAS, 2012).

At the same time, the adoption depends directly on the intrinsic inclination of the Informational Technology (IT) team (RACERO; BUENO; GALLEGO, 2021).

Therefore, regardless of how much a professionalizing course may increase the intencity and quickness of adoption. Data shows that, generally, those students and professionals positively correlated to seeking autonomy would adopt it (RACERO; BUENO; GALLEGO, 2020). This means that intrinsic motivation is key (GALLEGO et al., 2015). Nonetheless, it's important to notice that there exist a net-effect in adoption (SPINELLIS; GIANNIKAS, 2012). e.g., how much more peers adopt it, the more likely to any given

individual to adopt it.

1.4 Performance and the current trend as reasons for adoption

Research with different areas of benchmarks state a performance gain, when utilizing GNU/Linux, compared to Windows (SULAIMAN; RAFFI, 2021). Although, even more important, the key benefits are not in the differential performance per se, but in the training one naturally goes through upon utilizing a totally community-dependent Operational System.

Thereof, using GNU/Linux is a door for an individual professional shift. At the same time, this personal use increases the probability of adoption in whichever Industry carrer one may lead (HAUGE; SØRENSEN; CONRADI, 2008). Combined with that fact, the Industry per se has no observable effect on Open Source development of projects - as so far as measured in 2008 (HAUGE; SØRENSEN; CONRADI, 2008).

1.5 The set-conjunction between physics engineer and FOSS's users

We note that the deepness of training proposed, in graduation level, for a physics engineer makes them perfect candidates for the use of FOSS. Because, both trainings imply a *a priori* necessity for autonomy and purposeness (SCHRAPE, 2019; RACERO; BUENO; GALLEGO, 2020); imply a profound and will for generalistic technical knowledge (LI; TAN; YANG, 2013; GALLEGO et al., 2015).

1.6 How to leverage the potencial of OSS in Industry and Academia

In the present work, I utilized of many concept demonstrations, in which the autor has developed or/and extended applications, in a context of free and open source. Also, I present how can one collaborate in the community and how does that collaboration can imply significant professional connections. This way, both the so called "soft skills" and "hard skills" benefits have been elucidated, in practice.

2 Bibliography review

2.1 Open Source

Any program which permits the user-developer to have the following liberties:

1. The right to run the program, as seen fit, for any end.
2. The right to access the source code and study it.
3. The right to copy and redistribute it.
4. The right to modify the software.

Practically, the Open Source community fundamentally base itself upon the free distribution of it's tools and programs. One of the differential advantage of having innumerable other people extending the same software is that the advancement of the frontier of the program, in many directions, increases rapidly in relation to a program controlled by a limited number of programmers.

2.1.1 Diversity

Given that one fundamental right of OSS is the modification and propagation of new modified versions. This right implies in the observable wide range of maintained versions of these software, which doesn't have a parallel in any other technological enterprise.

For an example, one key application in any user's computer is a general Graphical User Interface (GUI)'s manager, commonly known as Window Manager (WM). These can be both Floating or Tilling, or mixed WM, e.g., Floating WM are those that the user must hover windows and adjust them manually; Tilling WM are those that a pre-defined program have a set of rules to resize automatically the windows in a screen.

While private Operational Systems (OS), as Windows and MacOS, have frequent releases - a total of twenty five releases for Windows. Generally, they've few *active* versions; Windows have currently four (MICROSOFT..., 2021). MacOS also have four active versions (MACOS..., 2021).

The fact there are only narrowly supported versions is due to, among many contributing factors, users lack the right to alter and extend the software's behavior. Therefore, they fall victims of discontinued support and restrictive access to the company's official upgrades.

On the other hand, there exists, in parallel, around two hundred seventy eight available distributions of Linux (LINUX..., 2021). Of which, there are main/root distributions, which each embody a set of different principles; theoretical and practical philosophies of

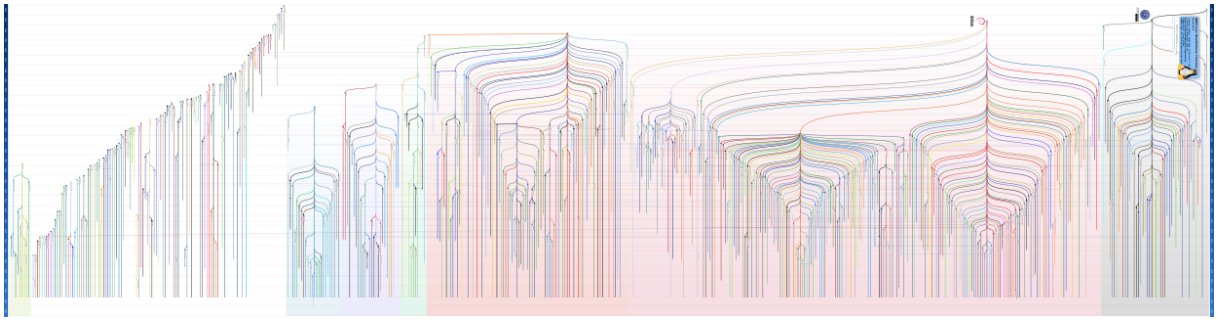
how to extend software.

Thus, just as with any other scope of software, the variability of FOSS always will be grater than monopolized ones.

2.2 GNU/Linux

There are root distributions of Linux, from which many other distributions emanate. Generically, these partitions are called families. We cite some of the most influential and popular ones, Red Hat Linux (), Debian (), CentOS (), Fedora(), Pacman-based (/), OpenSUSE (), Gentoo-based (), Ubuntu-based(), Slackware (), Open Sourced-based and the Independent Distributions (/).

Figure 4 – Genealogy of Linux's Distributions



Genealogical history of Linux Distributions (LINUX..., 2021)

2.2.1 Historical Origin

The GNU/Linux began as two separeted and different directions. GNU stands for "GNU's Not Unix", a recursive name. And GNU initialy has been developed as a collaboration of revolted academics by the restrictive secure system of the MIT Lab (Laboratory of Compuer Science - LCS) (STALLMAN, 2002; EMACS..., 2021). Amongst them, there was the still active Richard Stallman, which heavily worked on the text editor of the time - already ten years into development. This editor became Emacs (EMACS..., 2021).

Parallel to these events, Linus Torvalds had been developing an open portatible operational system, as his master's thesis (TORVALDS, 1997).

Finally, both projects united in a symbiotic system, of which the OS was Linux (the formentined portible kernel) and the GNU's interface program whit all utilities one may have had in their computers at the time (STALLMAN, 1997)

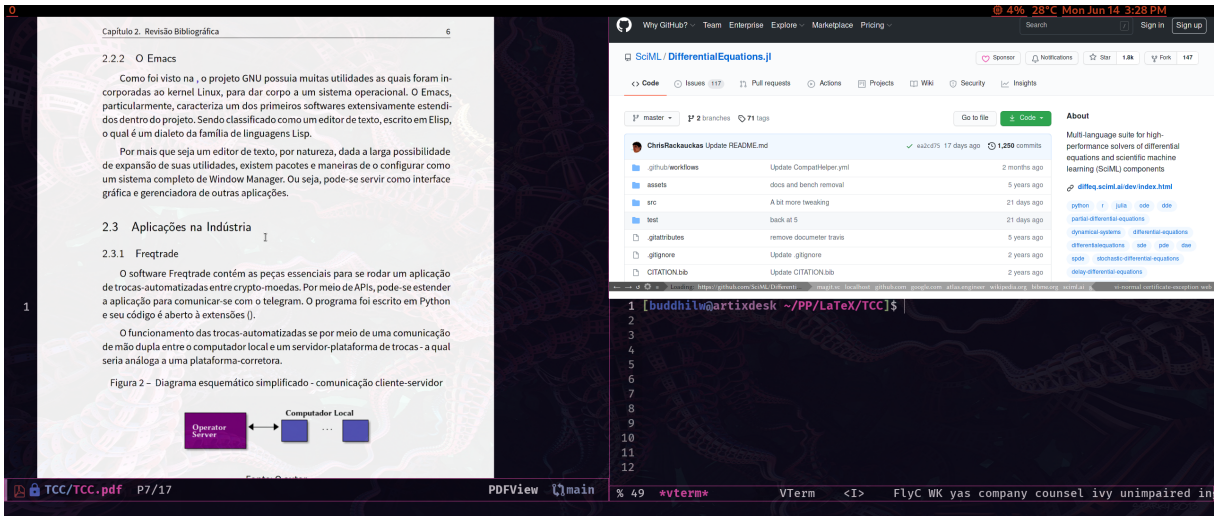
2.2.2 Emacs

As has been seen in , the GNU project already had developed a variety of applications, all of which, incorporated into Linux. This way, the OS gained a "body". The Emacs, particularly, characterize one of the first software extensively extended, as a project, in a open community.

Although, the label given to Emacs as an "editor" covers it's main function. Actually, the fundamental role of Emacs equates to evaluating Elisp expressions. Elisp as in a dialect of Lisp. Therefore, as an interpreter of a language, it has Turing complete capabilities. So it has a complete-system capability [1].

Even though Emacs usual use has been of an Integrated Development System (IDE), by it's unlimited potentiality and expressiveness, there exists packages and applications written in Elisp to become a fully featured Window Manager (WM). That is, Emacs, through Emacs's X Window Manager (EXWM), can serve as a graphical and manager interface to other applications.

Figure 5 – EXWM - Emacs X Window Manager



Source: author's WM ambient.

Figure 5 exemplifies a desktop environment which can render images, PDFs, Browsers et el, through Emacs.

2.3 Performance comparison among OS adoption

operacionais

[1] The GNU/Guix implementation of Linux, has been implemented in Scheme - a cousin with better performance than Elisp

2.3.1 Performance

In user-level applications, the efficiency and processing benchmarks favor Linux over Windows (SULAIMAN; RAFFI, 2021).

In the same hardware, the underground/underlying programs maintaining a stationary Windows consume around 5% of CPU and 41% of RAM. In the mean time, Linux Mint - a popular distribution of Linux - consumed 1.8% of CPU and 24% of RAM. A pronounced difference of more than 200% in CPU use efficiency and approximately 200% in RAM efficienty (SULAIMAN; RAFFI, 2021).

A VBS-program script execution [2] amounts to a difference in time-execution of 4.249 seconds. In which, Linux Mint took 0.501 seconds, against a 4.75 seconds for Windows. E.g., there exist a roughly $\frac{4,75-0,501}{0,501} = 423\%$ in time-execution performance (SULAIMAN; RAFFI, 2021).

Lastly, there also exists other researches done with technical rigor in a broad spectrum of other applications and hardware. To name a few, in wireless (S.DEVAN, 2013); parallelism and management of server applications (AVELEDA et al., 2010); scientific programming (Fast Fourier Transform) et al (D'ELIA; PACIELLO, 2011); performance on Virtual Reality (VR) application (THUBAASINI; RUSNIDA; ROHANI, 2010) etc. All of which present different kinds of advantages for Linux-use compared to Windows. Although, against what is expected in view of Industry sector adoption, Linux has almost no difference, and sometimes can be worst depending of memory usage of the application (RISTOV; GUSEV, 2013), than Windows performance on multi-threaded and parallel systems, typically founded in cloud/cluster server use-case (AVELEDA et al., 2010).

2.3.2 FOSS adoption demography

Fritzgerald enunciated, in 2006, that the adoption profile of users of Open Source Software (OSS) passed through a phase "OSS 2.0". This phase was characterized as a transcendence from the mentality that the only people who would be able to use the system would be "hackers" (FITZGERALD, 2006). And, furthermore that such OS were even becoming "mainstream". That is, it became a common place in society and industry. He also professed the hypothesis that OSS project's activities were significant influenced due to big companies.

In 2008, another research tried to quantitatively verify the hypothesis. The data was obtained by questioners and interviews of Finland software industries. In contrast to the Fritzgerald's characterization, 50% of the companies utilized vastly FOSS, although, they had negligent impact of the development carried by the community. Lastly, more than 30% of these companies told that at least 40% of their companies value on software was

[2] An application concerning the labeled "Office" bundle.

due to services done by the community (HAUGE; SØRENSEN; CONRADI, 2008). Also relevant, these were mostly small to medium size enterprises.

In 2012, a study on big companies use of OSS - a thousand companies listed on US Fortune magazine - have derived some conclusions (SPINELLIS; GIANNIKAS, 2012):

- Adoption is directly related to IT's team need for expertise on the work they would partaken, as well as efficient cautiousness (GALLEGO et al., 2015; LI; TAN; YANG, 2013).
- Exponential growth on adoption, once the existence of an accumulation of users in the company.
- There exist a network effect and the effect is notorious in big companies.

Therefore, adoption in small, medium and big companies process vary, and there are no salient effects caused by companies on the expansion of open source projects. Nonetheless, these companies still benefit from the later (SPINELLIS; GIANNIKAS, 2012; HAUGE; SØRENSEN; CONRADI, 2008; FITZGERALD, 2006). Still, the most relevant positive-effect on the OSS and community is due to small enterprises (KSHETRI, 2004).

Regarding the expansion of the FOSS development paradigm and ecosystem, undoubtedly there is an grow and ubiquity of adoption (**??**). Moreover, FOSS has been considered in economical papers as the innovatory cradle of software industry (SCHRAPE, 2019; SCHMIDT, 2016).

More recent studies, dating to 2021 and 2020, determine that, independent of a company size, adoption depends directly on training of IT and autonomous inclination towards these tools (RACERO; BUENO; GALLEGO, 2020). Finally, individual adoption and belief on the effectiveness of these software depend primarily on intrinsic factors, and is independent of previous training. Even though, training on OSS notoriously escalates those users inclined for it (RACERO; BUENO; GALLEGO, 2021).

2.4 Industry Application Demonstration

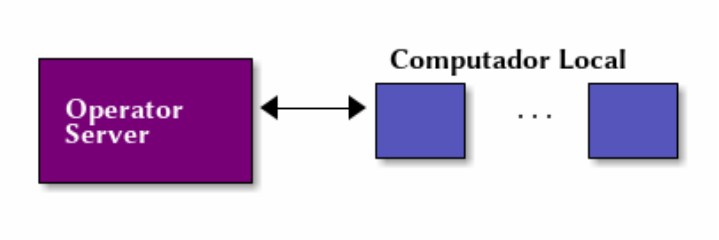
2.4.1 Freqtrade

The *Freqtrade* software contains the essential pieces for a working-application of automated trading of crypto-currencies. By means of APIs, it's possible to extend the application so to communicate with the Telegram app. The program has been written in Python and the code base is open, which rely on one hundred and forty seven contributors. It's existence dates back to may 2017 (FANG et al., 2020).

The functioning of automated trading goes through a two-way communication between the local computer and a platform-server of trading - which would be Angles to a

broker.

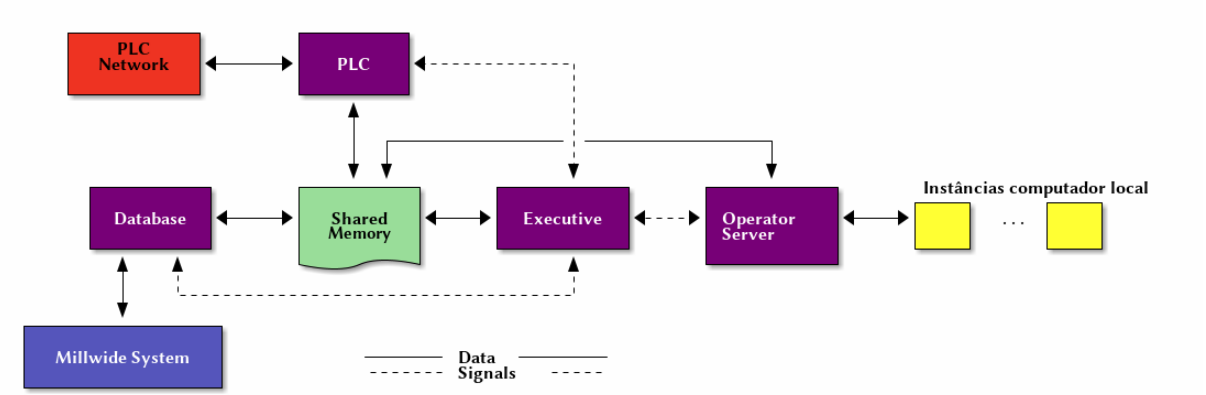
Figure 6 – a simplified schema of client-server communication



Resource: The author.

A great part of the work on writing an automated robot, for any application end, boils down to programming communication protocols with server. Because, the robot should be capable of telling the server which operations should happen, both as means of a response to the client - e.g., a "store data on local machine" request -, as well as internal operations that should take place on the server - e.g., execute buy and sell orders on crypto-current exchanges.

Figure 7 – Schematic representation of client-server communication.



Resource: the author.

Thus, a schematic representation of this complexity could be seen in Figure 7.

By utilizing OSS, all this complexity (Figure 7) becomes close to the first schema (Figure 6). Because, all the structural abstraction has already been dealt of, by this application. To make use of this advantage, one just need to read and comprehend the documentation and extend the application to it's use.

2.4.2 OR-Tools

The OR-Tools project translates into a series of code libraries developed in a open sourced manner, initially developed by Google. Possible ports exist to C++, Python, Java,

C# and .Net.

The use of this tool can help solve the common problem of Scheduling. Structurally, this class of algorithms relate to solving puzzles as Sudoku - for which there are dynamical constraints upon interaction (SIMONIS, 2005).

In general, these problem fall under a mathematical and computational field called Constrained Optimization (BERTSEKAS, 2014).

Not rarely, the typical problem in Constrained Optimization can fall under a NP-hard problem (a problem for which the Combinatorics of the system have a exponential ratio, not describable by a polynomial). A classical example is the "job shop problem", for which a seemly simple and practically ubiquitous task, actually is a NP-hard problem (ZHANG et al., 2019).

Just as in non-deterministic differential equations, or in differential equations which do not have an analytical solution, it's common to use numerical solutions. When there one find a NP-hard problem, analogously, it's used genetic-algorithms and other reinforced-learning algorithms (ZHANG et al., 2019).

P vs NP problem is one of the open problems in mathematics which has deep implications to computing. Furthermore, it's listed among the ten Millennium Prize Problems, of which only one has been solved (COOK, 2006).

The Millenium Prize Problems:

- Birch and Swinnerton-Dyer conjecture
- Hodge conjecture
- Navier–Stokes existence and smoothness
- P versus NP problem
- Poincaré conjecture (solved)
- Riemann hypothesis
- Yang–Mills existence and mass gap

2.5 Demonstration in Academic Applications

2.5.1 DifferentialEquations.jl

The numerical library, DifferentialEquations, has one of the best performances among numerical software (**??**). The performance is comparable to implementations in FORTRAN and C. Also, this library has many ports[3], some of the languages in which you can use it are in Python, R and Julia itself.

Among the many different category of problems this library can deal with are (**??????????????**

[3] Capability to interoperate besides the language it was written in.

- Discrete equations (function maps, discrete stochastic (Gillespie/Markov) simulations)
- Ordinary differential equations (ODEs)
- Split and Partitioned ODEs (Symplectic integrators, IMEX Methods)
- Stochastic ordinary differential equations (SODEs or SDEs)
- Stochastic differential-algebraic equations (SDAEs)
- Random differential equations (RODEs or RDEs)
- Differential algebraic equations (DAEs)
- Delay differential equations (DDEs)
- Neutral, retarded, and algebraic delay differential equations (NDDEs, RDDEs, and DDAEs)
- Stochastic delay differential equations (SDDEs)
- Experimental support for stochastic neutral, retarded, and algebraic delay differential equations (SNDDEs, SRDDEs, and SDDAEs)
- Mixed discrete and continuous equations (Hybrid Equations, Jump Diffusions)
- (Stochastic) partial differential equations ((S)PDEs) (with both finite difference and finite element methods)

2.5.1.1 Julia portability

The steps to use the library in Julia are,

```
# Using the package Pkg, so to manage packages.
using Pkg
# Add and/or download the DifferentialEquations.jl package in the project
Pkg.add("DifferentialEquations")
# Access all the functions defined in the package
using DifferentialEquations
```

2.5.1.2 Python portability

In a terminal using the package manager pip,

```
pip install diffeqpy
```

In a terminal, running the Python interpreter,

```
>>> import diffeqpy
>>> diffeqpy.install()
```

An optional step is to add numba, so to optimize the code performance,

```
pip install numba
```

Finally, import the package in a file and use in a program.

```
import diffeqpy
```

2.5.1.3 R portability

To install, use

```
install.packages("diffeqr")
```

In a first call,

```
diffeqr::diffeq_setup()
```

This way, the package will be downloaded, directly from DifferentialEquations.jl. An alternative is to use the CRAN maintained subset.

2.5.2 LaTeX

The LaTeX has fundamentally differentiate the many tasks in the typography of a document. The language permits a separation of formatting-tasks, and the content-writing. This way, the user can focus exclusively on content, in a fundamental step in document writing. And in another moment, focus solemnly on format and aesthetics.

Therefore, there a quality gain in production. Just as one is rewarded with the total control of the document, because every graphical disposition and behavior is defined by open code. Furthermore, one can extend already written templates and packages which do usual formatting. The typographical system in LaTeX has been considered, also, one of the most sophisticated software of it's category, mostly because of this bottom-up paradigm one naturally uses (**??**).

The LaTeX, technically, is the union between the typographical language TeX, invented by Donald Knuth, for high quality documents (**??**). And, the powerful macro ecosystem, which extend the TeX programming, for which we call LaTeX.

Initially LaTeXwas developed by Leslie Lamport, with his personal use-case formatting programs (**??**). Thus, LaTeX is not just a language, but a conjunction of macros and standard environments, which is actively maintained, modified, and extended by the open community.

2.5.2.1 The canonical ABNT class for scientific production

What is called as canonical are a set of documents following the more general and robust ABNT (Associação Brasileira de Normas Técnicas) norms. These canonical forms exist for scientific articles, technical reports, academic works as thesis, dissertations and research projects, books and presentations (**??**).

> Os documentos indicados tratam-se de "Modelos Canônicos", ou seja, de modelos que não são específicos a nenhuma universidade ou instituição, mas que implementam exclusivamente os requisitos das normas da ABNT, Associação Brasileira de Normas Técnicas. (**??**, Cap. 1)

The norms prescribed by the canonical model are:

- **ABNT NBR 6022:2018:** Informação e documentação - Artigo em publicação periódica científica - Apresentação.
- **ABNT NBR 6023:2002:** Informação e documentação - Referência - Elaboração.
- **ABNT NBR 6024:2012:** Informação e documentação - Numeração progressiva das secções de um documento - Apresentação.
- **ABNT NBR 6027:2012:** Informação e documentação - Sumário - Apresentação.
- **ABNT NBR 6028:2003:** Informação e documentação - Resumo - Apresentação.
- **ABNT NBR 6029:2006:** Informação e documentação - Livros e folhetos - Apresentação.
- **ABNT NBR 6034:2004:** Informação e documentação - Índice - Apresentação.
- **ABNT NBR 10520:2002:** Informação e documentação - Citações.
- **ABNT NBR 10719:2015:** Informação e documentação - Relatórios técnicos e/ou científico - Apresentação.
- **ABNT NBR 14724:2011:** Informação e documentação - Trabalhos acadêmicos - Apresentação.
- **ABNT NBR 15287:2011:** Informação e documentação - Projeto de pesquisa - Apresentação.

2.6 Canonical works on Computer Science

The scientific library of classical mechanics, written in Scheme (a Lisp dialect), has been used to teach master's degree MIT students. Accompanied to the library there is the book, which servers as didactic material for the course (**??**).

The library and the book are open sourced.

2.6.1 Structure and interpretation of computer programs (SICP)

The scheme course (SICP), which is teach as the foundations of computer science course on MIT, has accompanied as textbook one of the most world wide recognized books in computer history (ABELSON; SUSSMAN, 1996).

This course has been the pioneer on givin emphasis to the epistemological activity, when programming. The use of Scheme, which has a uniform notation (only one form), was revolutionary. This has shown to work well, instead of presenting the trending language in Industry, in a given moment - which is the standard approach.

The SCIM (**??**) course as a predecessor to SICP. The course and the text book still are in use in MIT and a number of other universities around the world. A non-exaustive list can be found at <https://mitpress.mit.edu/sites/default/files/sicp/adopt-list.html>. At least twenty universities adopts, distributed in more than eight countries.

These materials, textbook and the MIT classes, are both free and open sourced.

2.6.2 SICMUtils - (SCIM) Portability in Clojure

These are dedicated libraries for rewriting the SCIM programs in Clojure, which ports many functionalities mentioned in the scientific library SCIMThe library and the course's programs are not the same thing (**??**). This library, therefore, has been ported to Clojure, which is the most industry-used Lisp modern-dialect. For example, Nubank bought Cognitect which was the first and most successful application written in Clojure (**??**).

The language has a double quality in it's program. Due to the language supporting multiple definitions of a function under a name (polymorphism), it's possible to very easily switch and integrate numerical and symbolical computations.

Changing inputs one would have one or the other output, by inference of the Clojure compiler. This is particularly interesting when solving, for example, Lagrange equations of motion. One can have both the symbolical results outputted in TEX, and by a change in inputs, in the same procedure, have numerical data which can be used to simulate the behavior of physical systems.

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