**Master Degree Course in**

**Communications and Computer Networks Engineering**

# Implementation of an Asset Management Solution for an International Company

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*Don't stop imagining,*
*the day that you do*
*is the day that you die.*

# Abstract

For my Master Thesis, I was looking for a dynamic project and I wanted to have my first experience in an international company. After my one-year-long Erasmus in Barcelona (Spain) at the UPC (Universitat Politècnica de Catalunya), I was really enjoying the city and speaking Spanish excited me very much, so I found a job proposal as IT in TomTom Telematics Spain. Telematics is a unit of TomTom based in Germany dedicated to fleet management, vehicle telematics and connected car services which is present in more than 30 countries around the world. My internship program has lasted from 15th of September 2018 until the 31st of March of 2019 and has been managed by the Alex Garcia, which is Sr System Engineer in TomTom from many years. He helped me through my project but in particular, in this months I had the chance to increase a lot of transversal IT and networking knowledge. During this period I helped him with the troubleshooting for anything happening in the Barcelona office, in where there are more or less 200 employees. We were in charge also for every technological problem affecting the offices in Noisy in France, Mexico and Chile using remote control to help the employees. Telematics IT team needed a solution to manage remotely information about their assets, i.e. an Asset Management and I have been asked to develop a solution for it, so this has been part of my internship program. The amount of devices in Telematics incremented exponentially with time so the information about the assets was really needed and it was also necessary to link them to the employees, not knowing how. This project has been developed using the joint advices from the group and my manager. In the first period, some existing solutions have been analysed to compare what the market is giving nowadays. The creation of a software from the scratch was not considered since it would require too much effort and stability problems. After this period a freeware software called GLPI has been chosen for our purpose.

# Summary

GLPI is an IT Asset Management and as an open source technology, anyone can run, modify or develop the code. GLPI being a Web application works with an Apache web server, PHP and a MariaDB database. For this reason, taking advantage of all these technologies it has been possible to customise the software as desired. After some different trials on CentOS, it has been installed on a Windows Server 2016. Some characteristics which were desired initially for the solution and which have been achieved are the following: having a Web-Based Application; manually add any type of device and track the software installed in each machine; add assets through agents installed on computers (combined with tools like FusionInventory plugin or OCS Inventory); specify where the asset owner is working; Life Cycle monitoring; Support of LDAP integration; differentiate rights among users. OCS has been chosen and set in a server of Telematics in Leipzig (DE). An interesting data from the IT point of view is knowing when the warranty of an asset expires. Getting in contact with the technical support of DELL it has been possible to retrieve this information by the APIs. From that the shipping date, start end and type of warranty were added to the database and shown in the profile of every asset. Since every employee is provided with valuable assets the team was interested in the possibility to integrate signed documents to create whenever an asset is given, so a plugin has been developed to create for every user a PDF containing the list of the assets and the possibility to sign and save this document in case of issues. Jira is the IT helpdesk tickets service that Telematics is currently using. nFeed is a JSD plugin, which brings the external data, inside Jira custom fields. It is added the possibility to retrieve the information about the assets of the issue requester in every ticket. It is interesting from the IT point of view, because the technician can see when and which asset was given to the employee and know how to proceed without physically check it.

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# Chapter 1

# Introduction

## 1.1 History of telematics

Telematics is the combination of telecommunications and information processing.

The term "telematics" refers to many things in the academic world, but in everyday conversation it's usually about vehicles sending and receiving information.

Courier companies use telematics to track their vehicles; shipping companies use telematics to track their containers. In newer cars, drivers can use telematics to locate their vehicles and remotely unlock their doors. [2]

Telematics sector was born in the 1960s, when the U.S. Department of Defense and Johns Hopkins University's Applied Physics Laboratory began developing the Global Positioning System (GPS).[3]

GPS used satellites in the sky and receivers on the ground to help the U.S. military keep track of soldiers and equipment and made their missiles more accurate as well. In 1978, the first GPS satellite, NAVSTAR of first generation, was launched.[4] Over the next ten years, nine more satellites were successfully launched and added to the system. Today, GPS uses a constellation of 31 satellites.[5] 1978 was also the year when the term "telematics" first came into use. It appeared in a report to the French government about the computerization of society. They called it "télématique". Translated into English,

this became "telematics". Originally, the U.S. government had no plans to make the GPS public, but in 1983, a Korean airliner drifted into Soviet airspace and was shot down, killing all 269 passengers and crew members aboard.After this event, President Ronald Reagan announced that GPS would be made available to civilians. The hope was that improving everyone's access to information would help prevent miscommunications with such terrible consequences.[2] There was a catch, though – public GPS was hampered by Selective Availability (SA). The U.S. Military didn't want GPS technology to be turned against it, so it limited public GPS to an accuracy. On March 29, 1996, President Clinton signed a directive making GPS an international utility. Private citizens and businesses would be able to use GPS free of charge.[6]

Normally a telematics service like the one in TomTom, tracks devices taking advantage of the GPS signal received in the vehicle by a GPS receiver and sends the data through the cellular network up to the servers. In this way the fleet manager or the owner of the product can track and trace its assets through a graphic interface via web or via software. Actually telematics purposes are not only focused on fleet management but also in remote diagnostics of vehicles, safety and security, car sharing, data analytics, traffic and in the future to applications like Vehicle to Vehicle communications and Internet Of Things.
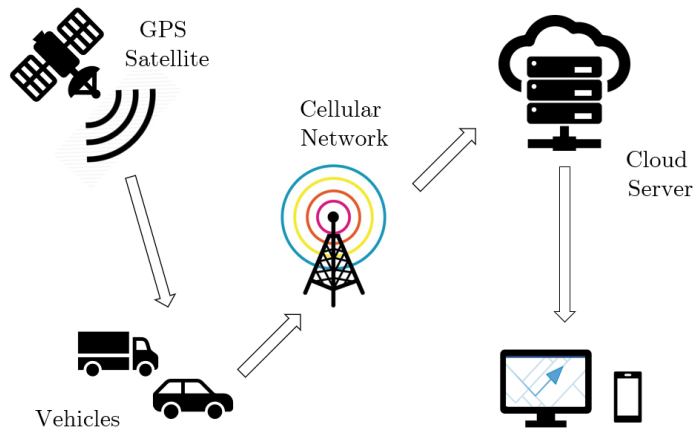


Figure 1.1.1: Typical fleet management scenario.

## 1.2 Company Description

TomTom is a Dutch company founded in 1991 and headquartered in Amsterdam, that produces traffic, navigation and mapping products. It also makes action cameras, GPS sport watches, fleet management systems, and location-based products. TomTom launched the world's first mass market consumer GPS satellite navigation device (sat-nav) in 2004. This development would change how people across the world navigate when driving.[7]

TomTom Telematics is a unit of TomTom based in Germany dedicated to fleet management, vehicle telematics and connected car services that from now on it will be referred to as Telematics only. The company services drivers in more than 30 countries, giving them the industry's strongest local support network and widest range of sector-specific third-party applications and integrations.[8]

Telematics sector of TomTom is right now a mainly software related company and it is willing to expand in this area getting further from the hardware. The main software is WEBFLEET which is a Software-as-a-Service solution, used by small to large businesses to improve vehicle performance, save fuel, support drivers and increase overall fleet efficiency. In addition, Telematics provides services for the insurance, rental and leasing industries, car importers and companies that address businesses as well as consumers, depending on the product.

Regulation (EC) No 561/2006 provides a common set of EU rules for maximum daily and fortnightly driving times, as well as daily and weekly minimum rest periods for all drivers of road haulage and passenger transport vehicles, subject to specified exceptions and national derogations. The software is 18-years-old and today supports more than

Figure 1.2.1: TomTom Telematics Logo.

Figure 1.2.2: WEBFLEET Logo.

848,000 vehicles around the world worldwide of around 50,000 companies. The key benefits of fleet management, according to the company are: knowing the positions of your vehicles in real-time anytime, reduce fuel costs, ensure a safer driving, higher productivity, make a better decision making and connect your fleet with other business applications. WEBFLEET gives the possibility to analyse the data from the Tachograph, which is a device fitted to a vehicle that automatically records its speed and distance, together with the driver's activity selected from a choice of modes. [8]

The aim of this set of rules is to avoid distortion of competition, improve road safety and ensure drivers' good working conditions within the European Union. These rules establish that daily driving period shall not exceed 9 hours, with an exemption of twice a week when it can be extended to 10 hours. The compliance with these provisions is subject to continuous monitoring and controls, which are carried out on a national and international level via checking tachograph records at the roadside and at the premises of undertakings.[9]
This is why Webfleet becomes interesting for the market. It is a web-browser solution that
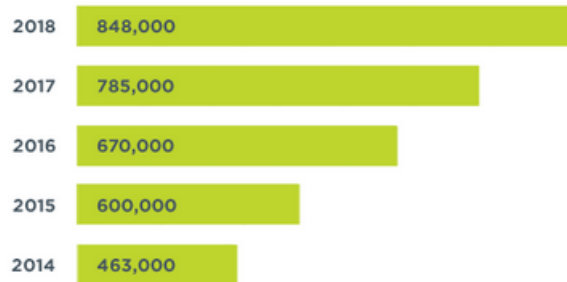


Figure 1.2.3: WEBFLEET number of vehicles growth through 2014-now.

also works on tablets and mobile phones, depending on the needs of the fleet managers and drivers. Telematics offers several options and depending is a Lite, Link or Life option is chosen it is possible to get a more in detail data of the tracked device or a more innovative technology.

Nextfleet is instead used by for example leasing and car rental companies in order to get information by the vehicle without corrupting the privacy requirement of any individual which are set in the country of use.
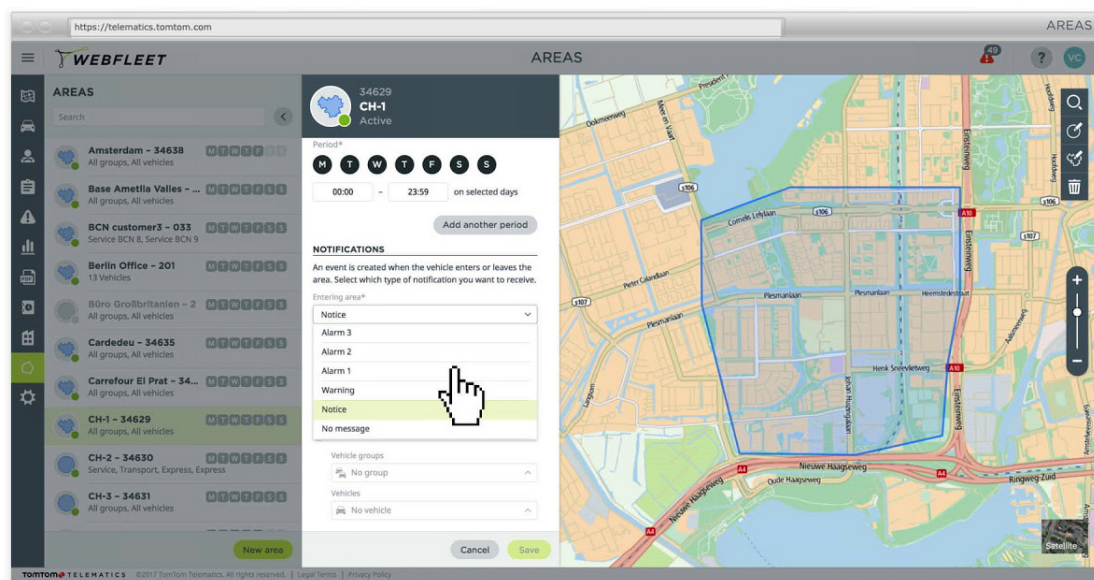


Figure 1.2.4: WEBFLEET demo.

## 1.3   Current Scenario

TomTom Telematics has offices in every continent in the world, in 35 countries.

The IT team for Telematics now is constituted by six people in Europe: me and Alex G. in Barcelona, Stefan G. and Norman D. in Leipzig (Germany) and Darius R. and Robert R. in Warsaw (Poland).

The profiles in the company are many: sales, customer support, developers, fulfilment, IT, sales support, HR and more. Every type of employee has slightly different computer deploy, depending on the software needed. Furthermore, for offices in France, Chile and Mexico remote help is given through ConnectWise control, which is a web application that offers remote support, remote access and remote meeting capabilities. Compared to the possibilities of the shared screen in Skype, with this software is possible to obtain administrative rights in the connected computer.

Any computer in Telematics is bought by the DELL official seller and through the buying procedure is declared the necessity to put a sticker containing the TomTom logo, the Asset Tag (numeric code declaring the number of the asset in the company) and the Service Tag (alphanumeric code useful to retrieve information in the DELL website). This is useful since these data are the ones which are visualized every asset inventory. Every device is then deployed by the Microsoft Deployment Tool for Windows 10 and for Ubuntu via MAAS Controller.

All the computers and the employees themselves are saved in Active Directory.

Active Directory (AD) is a Microsoft product that consists of several services that run on a Windows Server to manage permissions and access to networked resources. It stores data as objects. An object is a single element, such as a user, group, application or device, such as a printer. Objects are normally defined as either resource, such as printers or computers, or security principals, such as users or groups. AD categorizes objects by name and attributes. For example, the name of a user might include the name string, along with information associated with the user, such as passwords and Secure

Shell (SSH) keys. [10]

The main service in Active Directory is Domain Services (AD DS), which stores direc-tory information and handles the interaction of the user with the domain. AD DS verifies access when a user signs into a device or attempts to connect to a server over a network. AD DS controls which users have access to each resource. For example, an administrator typically has a different level of access to data than an end user. [11]

The structure on any computer hostname, which is the one saved in Active Directory in Telematics is the following:

$$ES2WXL - asset\ tag$$

Where:

- the first two letters indicate the country, for example ES for Spain,

- the number which office is referring to, for example ES2 is Barcelona, since 1 is Madrid,

- The operating system, WX for Windows 10, W7 for Windows 7 and LX for Linux,

- L for Laptop or D for Desktop,

- The last number of 6 digits is the DELL asset tag of the computer.

To enter in any website or service provided by the company the username and password of Office 365 are used, which is a Microsoft application evolved from Microsoft Office in a cloud way. Mainly is used to enter in the account for the Office packet as Microsoft Word, Power Point, One Note and Outlook but also Skype and any other website like Workday, which is the HR portal or Jira Service Desk. The same credentials are also used to enter the employee computers and are all saved in Active Directory.

In particular this service is called Single Sign-on (SSO), which is an authentication process that allows the employees to access multiple applications with one pair of credentials. Its main advantages are: the possibility to get a centralized database, eliminate credential authentication and in general increase productivity. Later on we'll see how this helps to enter any system through the LDAP technology. [12]

Telematics has its own work network called TTG. From every Windows computer any user enters with the credentials through this network.

### 1.3.1    Microsoft Deployment Toolkit

Microsoft Deployment Toolkit (MDT) is a computer program that permits network deployment of Microsoft Windows and Microsoft Office. In our case it is used to deploy new computers in the Telematics environment. [13]

MDT can help build an automated installation source for deploying Windows operating systems from Windows 7 and Windows Server 2008 onwards, from either a single machine or a central server distribution tool, such as Windows Deployment Services (WDS) or System Center Configuration Manager (SCCM). Device drivers, Windows updates and software can be included with the build.

All the software intended for installation (Operating System, drivers, updates and applications) are added to a pool of available software and packaged into deployment packages. The Operating System and drivers to be included with this package are selected, and the administrator password, owner information, and product key are specified. [14]

The MDT supports three types of deployments: Zero Touch Installation (ZTI), Lite Touch Installation (LTI), and User Driven Installation (UDI). ZTI is a fully automated deployment scheme in which installation requires no user interaction whatsoever.

In Telematics a Lite Touch version is used since the IT person can decide the type of installation between Normal and Developer, the keyboard settings, the languages and choosing among some tools to install.

The useful aspect of this tool is adding software to any computer from the very beginning of the deploy.

## 1.3.2   MAAS Controller

To deploy Ubuntu machines in Telematics, MAAS is used. MAAS is an acronym that stands for Metal As A Service, which is a provisioning construct created by Canonical, developers of the Ubuntu Linux-based operating system. MAAS is designed to help facilitate and automate the deployment of a big number of devices. Adding a node to MAAS is typically done via a combination of DHCP, which should be enabled in the MAAS environments, and the Preboot eXecution Environment (PXE), which you tell the system in question to use when it boots. PXE is a way to execute the boot of a computer through an ethernet network connection and the support of a server, without the necessity of a physical disk storage. Once a node is added to MAAS the next logical step is to commission it and test the hardware requirements. Once a node has been commissioned the next logical step is to deploy it. Deploying a node means, effectively, to install an operating system on it. [15]

## 1.4   Problem Statement

Telematics IT team needed a solution to manage remotely information about their assets
and this has been part of my internship program. This project has been developed using
the joint advices from the group and my manager.

The key needs were in first place to save in a database the data for all the desktops
and laptops of the company, in an automated way. The information about the assets was
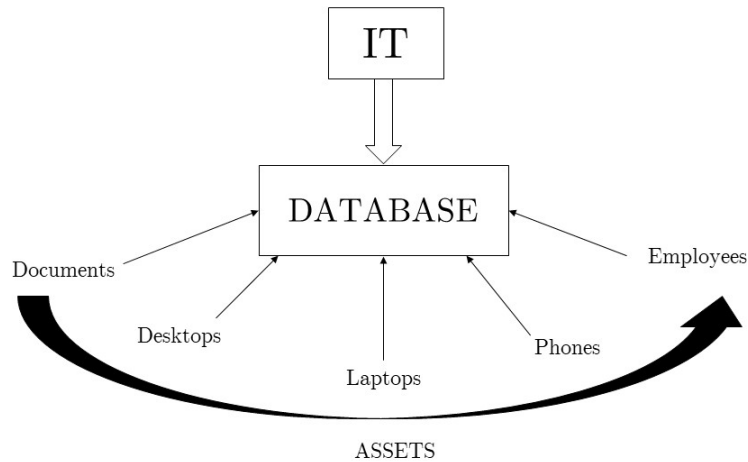request linked to the profile of the employees not knowing how.



Figure 1.4.1: Basic idea of the project.

The company is using JIRA Service Desk to solve tickets for the IT requests. An
integration was fully needed in order to take advantage of the created database from this
portal, to know for example all the assets which are owned by the user requiring the issue
and much more.

In the first period, some existing solutions were analysed to compare what the market
is given nowadays. The creation of software from scratch was not considered since it

would require too much effort and stability problems.

## 1.5   Timeline

My internship has lasted from the 15th of September until the 31st of March. The following is a brief timeline of the phases of the project development:

- *September 2018*: Market Analysis, advantages and disadvantages of every solution.

- *October 2018*: Environment studies, learning the technologies and choosing the platform. Starting with GLPI software.

- *November 2018*: Understanding of the system with the devices import through an Agent. Comparison between Fusion Inventory and OCS Inventory.

- *5-8 November 2018*: The first draft of my idea was discussed by me in Warsaw during a business trip.

- *December 2018*: Increasing the information database and testing.

- *January 2019*: Planning add-ons and the fulfillment of the requisites which were planned at the beginning of the project.

- *February 2019*: Developing add ons.

- *March 2019*: Planning future steps.

# Chapter 2

# Asset Management

## 2.1 Definition

The dictionary definition of an asset is "*any item of economic value owned by an individual or corporation.*"

Usually, as physical asset can be referred to items which are tangible such as buildings, utility infrastructure such as electrical cables, water pipes, rail lines and metro tunnels, and industrial assets such as oil rigs, chemical plants and process plant conveyors. [16]

In the ICT environment we refer to computers (laptop and desktops), phones but also intangible assets such as licences of software, human capital, intellectual property or financial assets.

Asset management is the recognition that assets have a life cycle, an approach that looks to get the best out of the assets for the benefit of the organisation and/or its stakeholders and about understanding and managing the risk associated with owning assets. [17]

It is important because it can help organisations to reduce the total costs of operating their assets, improve the operating performance of their assets (reduce failure rates, increase availability, etc), reduce the safety risks of operating the assets, minimise the en-

vironmental impact of operating the assets, maintain and improve the reputation of the organisation, improve the regulatory performance of the organisation and reduce legal risks associated with operating assets.

The key to good Asset Management is that it optimizes these benefits, which means that asset management takes all of the above into account and determines the best blend of activity to achieve the best balance for the benefit of the organisation. Asset Management is explicitly focused on helping organisations to achieve their defined objectives and to determine the optimal blend of activities based on these objectives. [18]

Usually the steps of every asset's life cycle are [19]:

- **Planning and Acquiring**: Planning is the first stage of the asset life cycle that establishes and verifies asset requirements to purchase orders. Establishment of asset requirements is based on evaluation of the existing assets and their potential to meet service delivery needs. Identification of management strategies is required in order to include and analyse the need for an asset. Desktop computers are generally cheaper than laptops. Portable computers are given to employees with the necessity of moving their work environment out of their desk. Telematics has an agreement with Dell in every country and needs to pass through the official seller. They always need PO (Purchase Order) Approvals from the person in charge of it.

- **Commission**: This covers the activities of installing / creating or building the asset and ensuring that it is fully functional. It is a recognised fact that there is a higher incidence of failure after first installation / building of an asset. This is reflected in the need for the commissioning stage in the life cycle to oversee the initial operation of the assets.

- **Operate**: This is normally the bulk of the life cycle for an asset during which it provides the function for which it was designed. During this period the asset should be subject to appropriate monitoring, maintenance, refurbishment and potential upgrade to meet any change in condition or operational requirement. Usually this

time is about years. This stage also includes the support of IT.

- **Retirement and Disposal**: When an asset reaches its end of a useful life, it can be treated as a surplus, or otherwise is considered as an underperforming asset. Disposal should be treated in the perspective of the effects of the decision on service delivery and any departmental responsibilities.



Figure 2.1.1: Asset Life Cycle.

One of the newest standards for managing assets is "ISO 55001 *Asset management – Management systems – Requirements*". According to it, this new standard leaves an open topic to organizations to determine what to consider asset, so ISO 55001 specifies the requirements for the establishment, implementation, maintenance and improvement of a management system for asset management, referred to as an "asset management system" [20].

### 2.1.1   ISO/IEC 27001

TomTom Telematics is interested in guaranteeing the security of information and privacy of the clients.

They have implemented and applied an information Security Management System (ISMS) according to the 'Statement of Applicability' for Architecture, Engineering, Quality Assurance, as well as IT operations of the TomTom Telematics Service Platform including Business Continuity Management provided to the TomTom Telematics BV, at the Technology Headquarters and at the Data Center co-locations in Germany in accordance with the ISO/IEC 27001:2013 international standard.

An ISMS is a systematic approach to managing sensitive company information so that it remains secure. It includes people, processes and IT systems by applying a risk management process. [21]

ISO/IEC 27001 is an information security standard, part of the ISO/IEC 27000 family of standards, of which the last version was published in 2013, with a few minor updates since then. It is published by the International Organization for Standardization (ISO). The ISO/IEC 27000 family of standards helps organizations keep information assets secure.

Most organizations have several information security controls. However, without an ISMS, controls tend to be somewhat disorganized and disjointed, having been implemented often as point solutions to specific situations or simply as a matter of convention.

Security controls in operation typically address certain aspects of IT or data security specifically; leaving non-IT information assets (such as paperwork and proprietary knowledge) less protected overall.

Moreover, business continuity planning and physical security may be managed quite independently of IT or information security while Human Resources practices may make little reference to the need to define and assign information security roles and responsibilities throughout the organization. [22]

ISO/IEC 27001 requires enterprises to:

- Systematically examine the organization's information security risks, taking account of the threats, vulnerabilities, and impacts;

- Design and implement a coherent and comprehensive suite of information security controls and/or other forms of risk treatment to address those risks that are deemed unacceptable;

- Adopt an global management process to ensure that the information security controls continue to meet the organization's information security needs on an continuing basis.[22]

Using this family of standards help the organization to manage the security of assets such as financial information, intellectual property, employee details or information entrusted to you by third parties. It can help small, medium and large businesses in any sector keep information assets secure.

Like other ISO management system standards, certification to ISO/IEC 27001 is possible but not obligatory. Some organizations choose to implement the standard to benefit from the best practice it contains while others decide they also want to get certified to reassure customers and clients that its recommendations have been followed.

## 2.2    Services characteristics

Some characteristics to consider for the desired asset management solution are the
following:

- If the solution can be installed on a computer/server or Web-Based,

- **Asset Location:** specify where the asset owner is working.

- Differentiate the rights among users,

- **Life cycle monitoring**: it is needed the possibility to set the current state of
  the asset if it available or not.  Usually TomTom considers 3 years as a computer
  lifetime,

- **Warranty Monitoring**: discover the end of the warranty,

- **Support of LDAP integration**: import from Active Directory the employee data
  and passwords,

- **Digital Signing**: possibility to integrate documents signed by the employees when
  an asset is given,

- **Jira Service Desk Integration**: IT helpdesk tickets integration,

- Supported by Windows, Linux, MacOS, Android, iOS,

- Track the software installed in each machine,

- ISO 27001 Compliance tooling,

- Stock Hardware overview as spare,

- **Asset Discovery**: In TomTom Telematics the assets which are more relevant to
  manage are computers (laptop and desktops) and they can be discovered and added

to the database in different ways. Each method has advantages and a lot depends on the depth of information needed to make informed decisions.

– **Auto-Discovery**: It is possible to discover assets using an automatic discovery scanning some specific IP ranges in the network. Agentless technology is the use of a machine's native, embedded management functionality to retrieve information. Even if a technology is dubbed as agentless, retrieving data from a device requires a process or processes to run, which consumes resources. During the discovery phase, several data sources can be used, and for network scanning, agentless is the best method, but when you are looking to optimize spend and reduce financial exposure, you will need to deploy agents at some point [23].

– **Agents**: Another way is to put a client in every asset that sends information about itself to the software. There exist special situations where an agent simply makes more sense, some cases simply cannot be discovered agentlessly either because they are unreachable from the network, or because certain rules don't permit traffic flow. [24]

## 2.3   Market Analysis

Digital Asset Management Market was valued at $1,928 million in 2016 and is projected to reach at $5,287 million by 2023, growing at a compound annual growth rate of 13.7% from 2017 to 2023. It incorporates end-user industries cost on digital asset management solutions and services to store, organize, access, and share their media content. Some of the popular digital asset management solutions are asset analytics, asset and metadata archiving, brand portals, creative tool integration, lifecycle & rights management, video management, and web content management integration.

Growth in demand for collaborative digital workflow especially for sales and marketing activities has encouraged end users to deploy enhanced digital asset management solutions and services. [25]

The cloud-based deployment model aids in collecting large volumes of server-storage resources into an integrated solution, while also providing backup of user database on different servers to guarantee data reliability. Companies worldwide have been identified to deploy cloud-based software as it is cost efficient when compared to the other deployment models. [26]

A good IT asset management software can help to track a company's IT inventory and troubleshoot service desk issues efficiently, among other tasks. A smart way to start comparing the solutions is to sign up for a free trial or demo of the software. In this way you get a guided tour through it given by a technician and it is possible to understand if it suits for the company. Usually all the solutions give the possibility to: monitor the hardware, support a ticketing system, management of the licences, device discovery and inventory management. This can be also useful from the company point of view since it helps the IT team to control the expenses, i.e. not wasting money on new hardware if not needed, avoid penalties because of licences expire and enhance security i.e. take control on who is accessing the devices. There are several solutions in the market trying to accomplish the asset management problem. Their characteristics depend mainly on the

functionalities and the price. Main IT asset management solutions names are Device42, Manage Engine, FreshService, InvGate, Insight, GLPI, etc.

The overview of prices is: for 2500 devices in Device42 is 10k€/year, for 3000 devices In Manage Engine is 8k€/year, InvGate depends on an accurate price quotation and GLPI is a free open-source.

The following table describes briefly the characteristics of the analysed software in the market:

|  | Device42 | ManageEngine | InvGate | GLPI |
|---|---|---|---|---|
| ISO Compliance Tooling | Yes | Yes | Yes | No |
| Cloud or self-hosted version | Both | Self-hosted | Both | Cloud |
| Auto-network detection | Yes | Yes | Yes | Yes |
| Customizable User Roles | Yes | Yes | No | Yes |
| Stock Hardware | Yes | Yes | Yes | Yes |
| Asset Allocation | Manually | Manually | Manually | Manually |
| Digital Signing Register | No | No | No | No |
| Life Cycle monitoring | Yes | No | Yes | Yes |
| Supports LDAP | Yes | Yes | Yes | Yes |
| Warranty monitoring | Yes, through Dell APIs. | No | No | No |
| JIRA Integration | Yes | Not sure | No | No |
| Track Installed Software | Yes, Cost++ | Yes | Yes | Yes |

Table 2.1: IT Asset Management platforms characteristics comparison.

## 2.3.1   Device42 Trial

A software that has been tested by demos, has been Device42, which now is a leader in the Configuration Management Database (CMDB), Application Dependency Mapping (ADM) and delivers comprehensives that helps companies automatically maintain an up-to-date inventory of their IP-based Devices and non-IP Assets, whether physical, logical, or virtual. Device42 provides customers with understanding and advanced visualization of their infrastructure and its inter-dependencies and centralizes data centre knowledge into a single source of truth making IT ecosystems.

Device42 offers several different auto-discovery tools, some of which are internal while some run externally, i.e. provided as agent-less auto-discovery or with agents.

For the Auto-Discovery case in Device42, the Simple Network Management Protocol

Figure 2.3.1: Device42 Logo.

(SNMP) is used. [27] It is an application-layer protocol used to manage and monitor network devices and their functions. In our case, as for example in Device42 it is used to retrieve information about the devices in the network. SNMP has a simple architecture based on a client-server model. The servers, called managers, collect and process information about devices on the network. The clients, i.e. the agents, are any type of device or device component connected to the network. They can include not just computers but also network switches, phones, printers, and so on.

Another option is the Ping sweep utility, which is an open source, standalone tool that uses NMAP protocol in the background to run ping sweeps against the selected network(s), i.e. makes a port scanning focused on looking for open ports in an IP range. This retrieves poor data information, only the device hostname and its IP.

It is possible to automate inventory management and integrate with your own scripts or other programs also using the Device42 RESTful APIs.

After this trial, the final consideration has been that this software is expensive and not very customizable. GLPI, which will be discussed further is a free asset management solution which provides network discovery by agents. It is also open source and completely free, so therefore it was very interesting from our point view. It is supported by a strong community and by several plugins.

# Chapter 3

# GLPI

## 3.1 Overview

GLPI (acronym: French: Gestionnaire Libre de Parc Informatique, or "Free IT Equipment Manager" in English) is a free IT Asset Management, issue tracking system and service desk system. This open source software is written in PHP and distributed under GPL (General Public License) license.

As an open source technology, anyone can run, modify or develop the code. In this way, contributors can participate in the development of the software by committing free and open source supplementary modules on GitHub.

The solution is able to build an inventory of all the organization's assets and to manage administrative and financial tasks. The systems's functionalities help IT Administrators to create a database of technical resources, as well as a management and history of maintenances actions. Users can declare incidents or requests (based on asset or not) thanks to the Helpdesk feature. [28]

We are not going to analyse this aspect since another helpdesk solution is already in use for Telematics, Jira Service Desk.

The GLPI Community based-project started in 2003 and was directed by the INDEP-NET association. Through the years, GLPI became widely used by both communities

and companies, leading to a need for professional services around the system. Whereas the INDEPNET Association did not intend to offer services around the software, in 2008 the Association created a Partners' Network in order to achieve various objectives. [29]

The first objective was to build an ecosystem where Partners could participate in GLPI Project. Secondly, Partners would financially support the association, in order to ensure the necessary software development. Finally, the ecosystem guaranteed a service delivery through a known and identified Network, directly connected to INDEPNET. [30]

In 2009, Teclib' started to integrate the software, developed the GLPI code and implemented new features. During summer 2015, the GLPI's Community leaders decided to transfer the roadmap management and the development leadership to Teclib', so that Teclib´ becomes editor of the GLPI system ensuring the software R&D. [31]

The code remained under a GPL license and keeps its open source nature. The GLPI system continues to be improved thanks to the co-partnership between the community and the editor.

GLPI uses the following technologies :

- PHP for language

- MySQL for the database,

- HTML for web pages,



Figure 3.1.1: GLPI Logo.

- CSS style sheets,

- CSV, PDF and SLK for data exports ,

- AJAX for dynamic elements of the interface,

- SVG and PNG for images and graphics.

GLPI being a Web application, will need:

- a webserver,

- PHP,

- a database.

PHP (recursive acronym for PHP: Hypertext Preprocessor) is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. In PHP the code is executed on the server, generating HTML which is sent to the client. The client receives the results of running the script but without knowing the underlying code. [32]

GLPI needs the utilization of a web browser and the optimized behaviour is obtained with the most modern ones conformed to the web standards, such as Firefox, Chrome, Internet Explorer (> 9.0), Opera and Safari. It is also compatible with mobile phones and tablets. To enter in the website is necessary to put at web address http://{IP}/glpi, where IP is the IP address of the server where GLPI is located. Using a DNS, or the Domain Name System, is then possible put an human readable domain name (for example, www.website.com) to the machine readable IP address.

Figure 3.1.2:  Original view of GLPI assets.



Figure 3.1.3:  Modified view of GLPI assets.

## 3.2    Environment

Telematics network is a managed with Multiprotocol Label Switching (MPLS), which is a routing technique protocol designed to speed up and shape traffic flows across enterprise-wide area and service provider networks.

It directs data from one node to the next one based on labels rather than long network addresses, avoiding complex lookups in a routing table and speeding traffic flows.

These labels identify virtual links (paths) between distant nodes rather than endpoints. MPLS can encapsulate packets of various network protocols, so it is considered multipro-tocol. MPLS allows most data packets to be forwarded at Layer 2, the switching level, rather than having to be passed up to Layer 3, the routing level. [33]

In an MPLS network, with private IPs, each packet gets labeled on entry into the service provider's network by the ingress router, as shown in Figure 13, also known as the label edge router (LER). This is also the router that decides the LSP the packet will take until it reaches its destination address.

By connecting different sites to MPLS WANs, companies can provide convenient internal network connectivity between sites. Often, the MPLS routers deployed are connected to the internal network through the firewall, providing visibility and control for the traffic passing across the MPLS. [34] In this way is possible to get access to the application we will be focusing on from every office of the Telematics group without going directly to the global internet. On the other hand this is necessary also to ensure that every asset within the network can be discovered.

This environment is created to ensure ISO/IEC 27001 certification requirements of se-curity. There are several measures of the safety to ensure this, including the physical permission of access in the offices through specific badges, the necessity to have a permit-ted username and password to enter the system and the need of specific accounts called "sysaccounts" to access the servers physically or remotely.
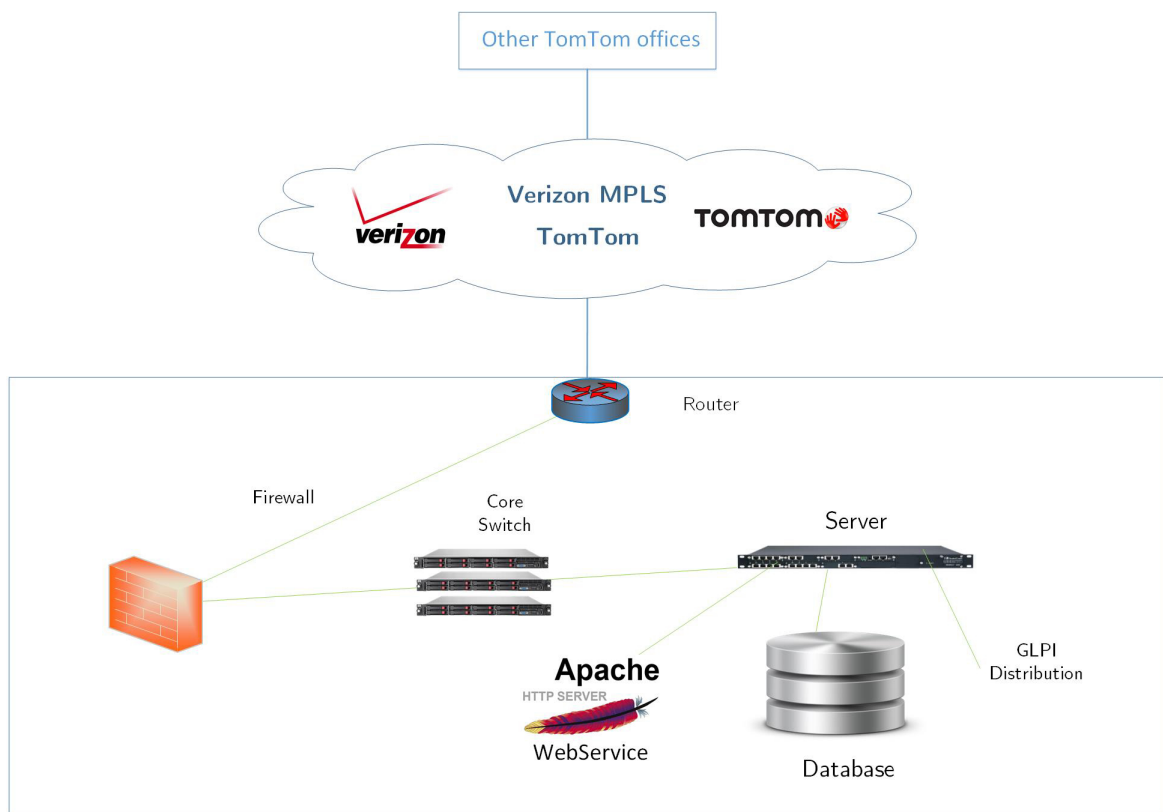
Figure 3.2.1: GLPI Architecture.

### 3.2.1    Server

GLPI requires a web server that supports PHP, like Apache 2 (or more recent), Nginx or Microsoft IIS. As of 9.2 release, GLPI requires PHP 5.6 or more recent. The following extensions are required for optional features of the application :

- CLI : Using PHP from the command line for automatic actions,

- CURL : CAS for authentication,

- DOMXML : CAS for authentication,

- GD : Image generation,

- IMAP : mail servers use to collect the tickets or user authentication,

- LDAP : use of an external directory for authentication,

- OpenSSL : encrypted communication.

The php.ini file is where you declare changes to your PHP settings. You can use the default settings for the server, change specific settings by editing the existing php.ini, or create a new text file and name it `php.ini`.

Our web server is an Apache, which is the now the most widely used one. It was developed and maintained by Apache Software Foundation and is an open source software available for free. It is designed to create web servers that have the ability to host one or more HTTP-based websites.

It is also widely used by web hosting companies for the purpose of providing shared/virtual hosting, as by default, Apache Web Server supports and distinguishes between different hosts that reside on the same machine. [35] Obviously the IP is fixed in order to ensure to have always the possibility to access remotely.

### 3.2.2   Database

Currently, only MySQL database server and MariaDB database server are supported by GLPI. [36]

Current GLPI database contains more than 250 tables; the goal of the current documentation is to help you to understand the logic of the project, not to detail each table and possibility.

As on every database, there are tables, relations between them (more or less complex), some relations have descriptions stored in another table, some tables may be linked with themselves. In this image there is the bone of the structure:
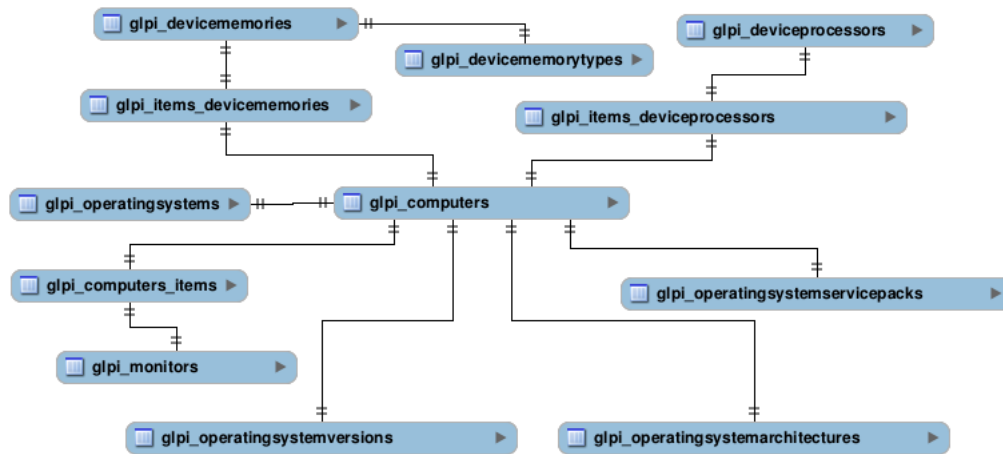


Figure 3.2.2: Database Model. [1]

Computers are directly linked to operating systems, operating systems versions, operating systems architectures, memories, processors and monitors using a relation table.

Tables names are linked with PHP classes names; they are all prefixed with glpi_, and class name is set to plural. Plugins tables must be prefixed by glpi_plugin_; followed by the plugin name, another dash, and then pluralized class name. Each table must have an auto-incremented primary key named "id".

Here a few examples:

| PHP Class Name | Table Name |
|---|---|
| Computers | glpi_computers |
| Users | glpi_users |
| .. | |
| ExamplePluginProfile | glpi_plugin_example_profiles |

MySQL is an Oracle-backed open source relational database management system (RDBMS) based on Structured Query Language (SQL). MySQL runs on virtually all platforms, including Linux, UNIX and Windows. Although it can be used in a wide range of applications, MySQL is most often associated with web applications and online publishing. [37]

It is based on a client-server model. The core of MySQL is MySQL server, which handles all of the database instructions (or commands). MySQL server is available as a separate program for use in a client-server networked environment and as a library that can be embedded (or linked) into separate applications.

MySQL operates along with several utility programs which support the administration of MySQL databases. Commands are sent to MySQLServer via the MySQL client, which is installed on a computer.

MySQL was originally developed to handle large databases quickly. Although MySQL is typically installed on only one machine, it can send the database to multiple locations, as users are able to access it via different MySQL client interfaces. These interfaces send SQL statements to the server and then display the results. MySQL enables data to be stored and accessed across multiple storage engines, including InnoDB, CSV, and NDB. MySQL is also capable of replicating data and partitioning tables for better performance and durability. MySQL users aren't required to learn new commands; they can access their data using standard SQL commands. MySQL is written in C and C++.

MariaDB Server is also one of the most popular database servers in the world. It's

made by the original developers of MySQL and guaranteed to stay open source. MariaDB is developed as open source software and as a relational database it provides an SQL interface for accessing data. The latest versions of MariaDB also include GIS and JSON features.

Since MariaDB is a fork of MySQL, the database structure and indexes of MariaDB are the same as MySQL. This allows you to switch from MySQL to MariaDB without having to alter your applications since the data and data structures will not need to change. This means that data and table definition files are compatible client protocols, structures, and APIs are identical MySQL connectors will work with MariaDB without modification. Gradually, MySQL and MariaDB will diverge. Main differences are licensing, support services and community distributions. [38]
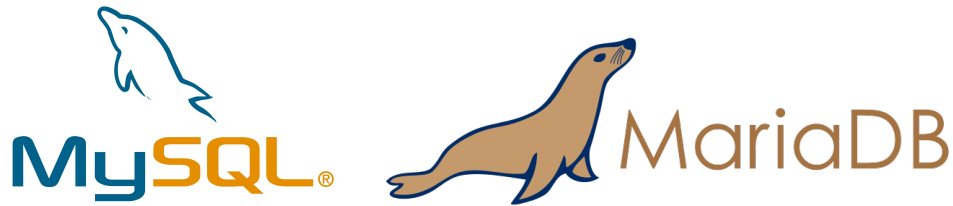
Figure 3.2.3: MySQL and MariaDB logos.

## 3.3   Data inventory

Combined with tools like FusionInventory or OCS Inventory NG, GLPI is a powerful solution for managing software and licenses.  They both work installing agents on the asset in order to retrieve information.

### 3.3.1   Fusion Inventory

Fusion Inventory is an Open Source french project born in 2010 with the objective to give a better integration for asset management for GLPI. It acts as a gateway and collects information sent by the agents. It will create or update the information in GLPI.

By now, these class of devices is supported: computers, network devices, printers, virtual machines and android phones. [39]

The FusionInventory Agent is a generic multi-platform agent.  It can perform a large array of management tasks, such as local inventory, software deployment or network discovery.  It can be used either standalone or in combination with a compatible server (OCS Inventory, GLPI, OTRS, Uranos, . . . ) acting as a centralized control point.  Two of these tasks are included in agent source distribution, local inventory and Wake-On-Lan.  Other tasks are distributed separately, except for binary distributions where they are bundled together.  The agent is available on Windows, OS X, Linux, FreeBSD, OpenBSD, NetBSD, DragonFlyBSD, AIX, Solaris, HP-UX. The agent shares the same codebase on all these platforms.

This client sends information directly from the asset to GLPI and in general, is more



Figure 3.3.1: Fusion Inventory Logo.

compatible.

The FusionInventory agent is compatible with OCS Inventory NG Server, by configuring
it to accept the Fusioninventory UserAgent in the ocsinventory-server.conf file.

Like GLPI has automatic actions like optimize database, alerts on end of contracts, the
plugin of FusionInventory has own automatic actions like the *taskscheduler* used to prepare
the tasks. It is needed to make an inventory how often is desired, creating a cron on their
operating system to run the GLPI cron. For Linux, is needed to modify in the file crontab:

`* * * * * /usr/bin/php5 /var/www/glpi/front/cron.php &>/dev/null`

For windows, is needed to create in Task Scheduler all 1 or 5 minutes:

`"c:\path\to\php.exe c:\path\to\glpi\front\cron.php"`

### 3.3.2    OCS Inventory

Open Computer and Software Inventory Next Generation (OCS inventory NG) is free
software that enables users to inventory IT assets.

OCS-NG collects information about the hardware and software of networked machines
running the OCS client program ("OCS Inventory Agent"). OCS can visualize the in-
ventory through a web interface. Furthermore, OCS includes the capability of deploying
applications on computers according to search criteria. It is written in Perl and PHP.

The open-source OCS Inventory NG project started in late 2005 and produced its
first release version of OCS Inventory in early 2007. Since version 1.0rc3, most of OCS
Inventory functionality can be adapted or extended via a module system. The dialogue
between OCS client machines and the server depends on the Hypertext Transfer Protocol
(HTTP). The management server uses Apache, MySQL and Perl. OCS runs on multiple



Figure 3.3.2: OCS Inventory Logo.

platforms: under Unixes and under Microsoft Windows (95 or later). A web-interface written in PHP offers consultation of the inventory, user-rights management, and technical support features. OCS Inventory can be used to feed the manager of GLPI and thus offers part of an ITAM solution.

Differently than Fusion Inventory, OCS sets it data on a different database, then using the OCS plugin agent is possible to import the data in GLPI because it is automatically able to convert the names of the databases. After trying the two options the OCS solution was chosen and set on a CentOS server in Leipzig (Germany), since the Fusion Inventory one was not always trustable due to the cron. On the majority of the cases, it was not able to recognise the data from the asset correctly.

## 3.4    LDAP integration
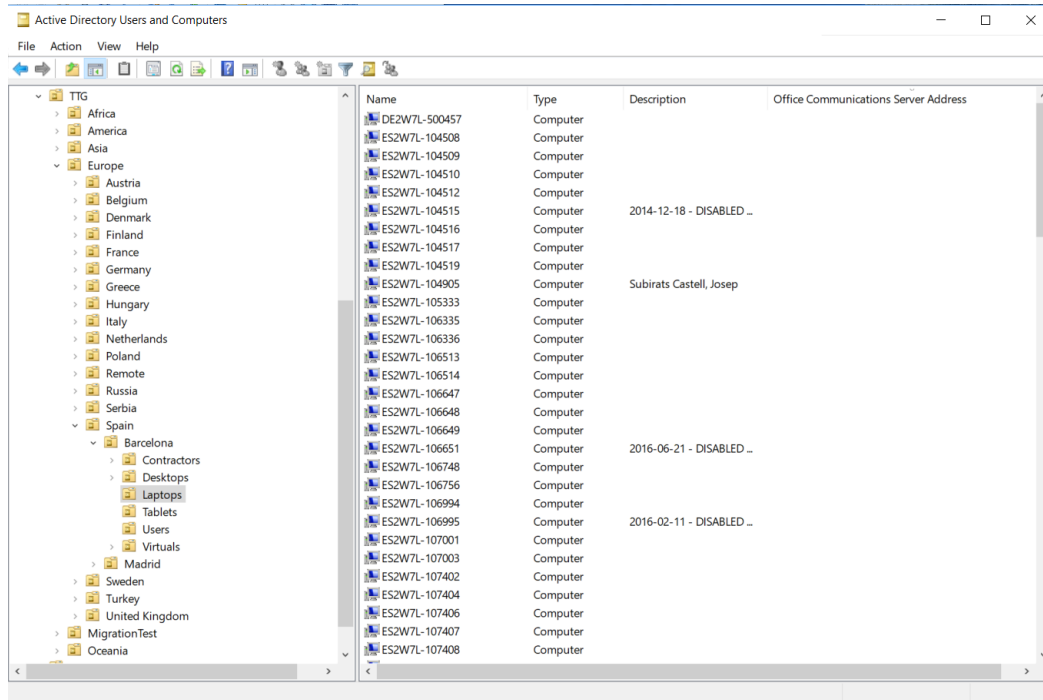


Figure 3.4.1: Example of Active Directory, Barcelona laptops. The tree structure on the left.

LDAP is an application protocol used to access and maintain directory services over a network, accessing and maintaining distributed directory information services over an Internet Protocol (IP) network.

LDAP stores objects, such as usernames and passwords, in directory services such as Active Directory and shares that object data across the network.

Certificate Services (AD CS) generates, manages and shares certificates. A certificate uses encryption to enable a user to exchange information over the internet securely with a public key.

Active Directory Federation Services (AD FS) authenticates user access to multiple applications -- even on different networks, using single sign-on (SSO). As the name indicates, SSO only requires the user to sign on once rather than use multiple dedicated

authentication keys for each service, for example receiving a message on the mobile phone
to prove its identity. [40]

Organizational Units (OUs) organize users, groups and devices. Each domain can
contain its own OU. However, OUs cannot have separate namespaces, as each user or
object in a domain must be unique. For example, a user account with the same username
cannot be created. [41]

LDAP servers index all the data in their entries, and "filters" may be used to select
just the person or group you want, and return just the information you want. It is
not limited to contact information, or even information about people. LDAP is used to
look up encryption certificates, pointers to printers and other services on a network, and
provide "single sign-on" where one password for a user is shared between many services.
LDAP is appropriate for any kind of directory-like information, where fast lookups and
less-frequent updates are the norm.

It exists a preconfigured model of Active Directory to retrieve data through LDAP.

In GLPI, going in Setup > Authentication > LDAP Directions is possible to specify
the data to retrieve the user data and passwords, like in Figure 15. Some settings are
needed:

- Server Name, Login Name and Password

- BaseDN: setting specifies the directory location in the Active Directory from which
  searches and reads will be performed.

    – in our case is OU=TT, OU=Employees,O=tomtom,C=global.

- RootDN: is the Distinguished Name (DN) for a user who is unrestricted by access
  controls or administrative limit parameters set for operations on the LDAP direc-
  tory. The rootdn user can be thought of as the root user for the LDAP directory.

– In our case is CN=svc_ttt-ldapread,OU=Telematics,OU=Service Accounts,O=tomtom,C=global.

Through this integration is possible to import all the users of telematics and get all their information. Furthermore, the IT team users has been set as admins and it is possible to enter with their username/password in the system. This means that the password and not set locally but instead the same that the users are typing when entering in any service connected to the employee as Windows computer, Office 365, Skype.

## 3.5   Operating System

### 3.5.1   Windows

In Windows environment to easily provide a webserver and a database by the XAMPP software. XAMPP is an open source free software developed by Apache friends. This software gives to the user suitable environment for testing MYSQL, PHP, Apache and Perl projects on the local computer. [42]

In first place, the GLPI solution has been put locally in a Windows 10 computer as localhost, i.e. in the same machine where I was working. The second step has been setting it on another W10 machine to simulation a server-like scenario. After Linux, as last option it has been put on a machine with Windows Server 2016. It is basically the same compared to Windows 10 in term of environment and differs for the aspects and the applications. It is possible to access in the Windows host remotely by other Windows machine by the software Remote Desktop Connection.

### 3.5.2   Centos 7

CentOS, which stands for the Community Enterprise Operating System, is a distribution of the Linux operating system based on RHEL (Red Hat Enterprise Linux). It runs on the x86 PAE and x86-64 architectures, and is currently the most popular Linux

distribution for web servers. [43]

The CentOS Linux distribution is a stable, predictable, manageable and reproducible platform derived from the sources of Red Hat Enterprise Linux (RHEL). Since March 2004, CentOS Linux has been a community-supported distribution derived from sources freely provided to the public by Red Hat.

CentOS Linux is developed by a small but growing team of core developers. In turn the core developers are supported by an active user community including system administrators, network administrators, managers, core Linux contributors, and Linux enthusiasts from around the world.

Over the coming year, the CentOS Project will expand its mission to establish CentOS Linux as a leading community platform for emerging open source technologies coming from other projects such as OpenStack. These technologies will be at the center of multiple variations of CentOS, as individual downloads or accessed from a custom installer. Read more about the variants and Special Interest Groups that produce them. PuTTY software has been always used to connect to the CentOs server remotely, via terminal.

PuTTY is a free implementation of SSH and Telnet for Windows and Unix platforms, along with an xterm terminal emulator. [44] It is a versatile terminal program for Windows. It is the world's most popular free SSH client. It supports SSH, telnet, and raw socket connections with good terminal emulation. It supports public key authentication and Kerberos single-sign-on. It also includes command-line SFTP and SCP implementations. [45]

The perk of CentOs, as any other Linux distribution is being a freeware and this is why is used everywhere in the world. On the other hand, Windows Server sometimes is not the best options since it involves the costs of the licence and several users prefer a unix-environment.

In our case the Windows Server licence was already acquired in Telematics previously, so this is why it has been chosen for the user-friendly environment and because Windows ensure being always up-to-date and available for support. Furthermore, several problems

related on putting crons necessity, i.e. a time-based process scheduler, have been faced when using CentOs and instead in Windows it can be easily done by the app called "Scheduled Tasks".

# Chapter 4

# Add-ons

## 4.1 Warranty Monitoring

An interesting data from the IT point of view is knowing when the warranty of an asset expires, and the goal was to see it through a GLPI plugin. For Telematics assets which are acquired by the DELL vendor, they have a 3 years warranty.

Getting in contact with the technical support of DELL it has been possible to retrieve this information by the DELL APIs, getting an alphanumeric code that is called DELL API Key. API is the acronym for Application Programming Interface, which is a software intermediary that allows two applications to talk to each other. In other words, an API is a messenger that delivers your request to the provider that you're requesting it from and then delivers the response back to you. [46]

In our case, through GLPI is possible to access to the following url:

`https://api.dell.com/support/assetinfo/v4/getassetwarranty/{id}?apikey={apikey}`

The "id" field is the service tag of the computer, retrieved by the database in `glpi.glpi_computers`. The data from the API url can be read as XML and JSON (JavaScript Object Notation) format.

To retrieve content such as the end of the warranty date from it is possible to do in

```
Array
(
    [AssetWarrantyResponse] => Array
        (
            [0] => Array
                (
                    [AssetHeaderData] => Array
                        (
                            [BUID] => 1919
                            [ServiceTag] => GCV2JM2
                            [ShipDate] => 2018-01-27T18:00:00
                            [CountryLookupCode] => ES
                            [LocalChannel] => GCPR
                            [CustomerNumber] =>
                            [ItemClassCode] => OD002
                            [IsDuplicate] =>
                            [MachineDescription] => Latitude 7480
                            [OrderNumber] =>
                            [ParentServiceTag] =>
                            [CompanyNumber] =>
                        )

                    [ProductHeaderData] => Array
                        (
                            [SystemDescription] => Latitude 7480
                            [ProductId] => latitude-14-7480-laptop
                            [ProductFamily] => Laptops
                            [LOB] => Latitude
                            [LOBFriendlyName] => Latitude
                        )

                    [AssetEntitlementData] => Array
                        (
                            [0] => Array
                                (
                                    [StartDate] => 2018-01-27T18:00:00
                                    [EndDate] => 2021-01-28T17:59:59
                                    [ServiceLevelDescription] => Onsite Service After Remote Diagnosis (Consumer Customer).
                                    [ServiceLevelCode] => ND
                                    [ServiceLevelGroup] => 5
                                    [EntitlementType] => INITIAL
                                    [ServiceProvider] =>
                                    [ItemNumber] => 709-12355
                                )

                            [1] => Array
                                (
                                    [StartDate] => 2018-01-27T18:00:00
                                    [EndDate] => 2021-01-28T17:59:59
                                    [ServiceLevelDescription] => Keep Your Hard drive Service
                                    [ServiceLevelCode] => KH
                                    [ServiceLevelGroup] => 11
                                    [EntitlementType] => INITIAL
                                    [ServiceProvider] =>
                                    [ItemNumber] => 711-12048
                                )
```

Figure 4.1.1: Example of the DELL JSON response.

this way:

```
$data = file_get_contents($url) or die("Can't cannot to URL");

$json = json_decode($data, true);

echo "<br><br><strong>End of Warranty:</strong> ";

$endDate = $json['AssetWarrantyResponse'][0]['AssetEntitlementData'][0]['EndDate'];

echo substr($endDate,0,10);
```

After this step is possible to retrieve the data of all the assets and put them in the database.

It is important to consider that, according to the environment of Telematics we have been talking about previously, the server cannot access directly to the internet and this is the case where instead is needed. If we need to communicate with other companies' database, the Network Address Translation (NAT) technology is used. It permits to modify the IP addresses in the headers of the packets in transit in a system.

## 4.2   Data Export

Since every employee is provided with expensive and valuable assets, the possibility to show legally the donation of these ones, for example signing documents, could be necessary. For this reason a plugin have been developed in order to create for every user a PDF containing the list of the assets, as phones, computers or other devices, and the possibility to sign and save this document in case of future issues.

It works by pointing to the database position of the wanted information and retrieving them in an HTML page.

It is coded in PHP and styled by CSS. In the page is shown the current day, the name and username of the employee, in the middle we have the list of the assets given to the person, which big spaces then to sign the document. The footer has been customised following the company guidelines. The result of this export can be simply be printed on paper, on signed by opening in from a mobile phone.

A future deploy that has been thought but not yet deployed is the possibility to open trough APIs the document in DocuSign or PandaDOC, which are software that provide electronic signature technology and digital transaction management services to facilitate electronic exchanges of signed documents.

They provide authentication services, user identity management and workflow automation in a way that signatures processed by these websites are compliant with the US ESIGN Act and the European Union's Electronic Signatures Directive (1999/93/EC) , meaning that this type of signature provides the same legal standing as a handwritten signature as long as it adheres to the requirements of the specific regulations. [47][48]

Figure 4.2.1: Example of Data export file to be signed.

## 4.3 Integration with ticketing service

A help desk is a resource intended to provide the customer or end user with information and support related to a company's or institution's products and services. The purpose of a help desk is usually to troubleshoot problems or provide guidance about products such as computers, phones, server and cloud services. A typical help desk can effectively perform several functions. It provides a single (or multiple) point of contact for users to gain assistance in troubleshooting, get answers to questions, and solve known problems. A help desk generally manages its requests using software such as issue tracking systems or incident ticket system. Indeed in TomTom Telematics any IT related problem passes through Jira Service Desk portal. Every user knows the link to make a request and followingly the team can provide solutions and answer to the employee. [49]

Jira Service Desk is a helpdesk request tracker. It lets you receive, track, manage and resolve requests from your team's customers. The app comes with a self-service web portal where customers fill out forms to ask for help. Jira Service Desk plays well with another Atlassian product called Confluence. Confluence is a collaborative document management and storage app. With Confluence, your team can create a knowledge base of articles that appear in your web portal. Your customers can read these and help themselves before reaching out to you. [50]

Jira Service Desk organizes and prioritizes the requests your customers submit. It keeps any team on track to resolving requests within your team's goals or Service Level Agreements . You can set up alerts and make sure your working on the most important things first.

Jira Service Desk is built on the Jira platform. There are some jargon and terminology in the app that you might not be familiar with. Service desk agents work on customer requests, tracked as issues in a queue. Each team works on a project that services requests from a certain area – like IT, HR, legal, or finance.

## 4.4    nFeed plugin

nFeed is a Jira plugin, which brings the external data, from the GLPI database for example, inside Jira custom fields. It is possible to retrieve data and put in Jira tickets by writing SQL code.

To retrieve the data for the computer of the employee for example the code is:

```
#if ($issue.reporter and $issue.reporter != '')
SELECT c.id,c.name,LEFT(d.last_ocs_update , 11),os.name,cs.name,cm.name FROM
glpi.glpi_computers as c, glpi.glpi_users as u, glpi.glpi_plugin_ocsinventoryng_ocslinks as d,
glpi.glpi_items_operatingsystems as osn, glpi.glpi_operatingsystems as os, glpi.glpi_states as cs,
glpi.glpi_computermodels as cm
WHERE u.id = c.users_id
AND u.name like '$issue.reporter'
AND c.id = d.computers_id
AND osn.items_id = c.id
AND os.id = osn.operatingsystems_id
AND (cs.id = c.states_id)
AND (c.computermodels_id = cm.id OR (c.computermodels_id=0 AND cm.id=51));
#else
SELECT c.id,c.name,LEFT(d.last_ocs_update , 11),os.name,cs.name,cm.name FROM
glpi.glpi_computers as c, glpi.glpi_users as u, glpi.glpi_plugin_ocsinventoryng_ocslinks as
d,glpi.glpi_items_operatingsystems as osn,glpi.glpi_operatingsystems as os,glpi.glpi_states as
cs,glpi.glpi_computermodels as cm WHERE u.id = c.users_id
AND u.name like '$currentUser'
AND c.id = d.computers_id
AND osn.id = c.id
AND os.id = osn.operatingsystems_id
AND c.computermodels_id = cm.id;
AND cs.id = c.states_id;
#end
```
The cases of the if, include the situation when we are looking at a ticket or when

someone is creating his own ticket to know his data. Also the information about phones (if existing) is shown.

The final result in Jira looks like this:



Figure 4.4.1: Example of GLPI data shown in Jira.



Figure 4.4.2: Example of GLPI data shown in Jira with phone characteristics.

# Conclusions and future development

The asset management solution that has been adjusted for TomTom telematics is now in testing and since is thought to be set up in a secure and dynamic environment some solutions have been imagined for the future:

- **HTTPS**: SSL (Secure Sockets Layer) is the standard technology for keeping an internet connection secure and safeguarding any sensitive data that is being sent between two systems, preventing criminals from reading and modifying any information transferred, including potential personal details. It uses encryption algorithms to scramble data in transit, preventing hackers from reading it as it is sent over the connection between the server and the client.

  HTTPS (Hyper Text Transfer Protocol Secure) appears in the URL when a website is secured by an SSL certificate. To set up HTTPS five steps are needed: host a dedicated IP address, buy a certificate, active it, install it and update your site to use HTTPS.

- **DNS:** set an URL from the Telematics domain instead of the fixed IP address assigned.

- **QR Code**: another option would be to create QR code, which is a type of matrix barcode that contains information. If this kind of images are created and prints, for example, using the camera of a mobile phone it can automatically take a photo of the sticker and send the data on every asset to facilitate the communication of data to the server.

- **DocuSign integration**, as previously discussed.

Its main negative point is the problem in the maintenance, since every version will need us to update the customization made. On the other hand in all the period of testing it has been very useful, increasing the productivity of the team, in particular thanks to the integration with JIRA it fastens the process of troubleshooting.

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# Bibliography

[1] "Glpi developer documentation," *https://glpi-developer-documentation.readthedocs.io/en/master/devapi/database/dbmodel.html.* [Online]. Available: https://glpi-developer-documentation.readthedocs.io/en/master/devapi/database/dbmodel.html

[2] Telematics4me, "The history of telematics," 2017, *https://telematics.route4me.com/blog/the- history-of-telematics.* [Online]. Available: https://telematics.route4me.com/blog/the- history-of-telematics

[3] J. H. U. A. P. Laboratory, "Gps contributions put apl in space hall of fame for third time - press release," *https://www.jhuapl.edu/PressRelease/gps.*

[4] "Gps future and evolutions," *https://www.space.com/19794-navstar.html.* [Online]. Available: textithttps://www.space.com/19794-navstar.html

[5] gps.gov, "Gps.gov: Space segment," *https://www.gps.gov/systems/gps/space/.* [Online]. Available: https://www.gps.gov/systems/gps/space/

[6] Globaltelematics.com, "The meaning of telematics," 2013, *http://www.globaltelematics.com/ telematics.* [Online]. Available: http://www.globaltelematics.com/ telematics

[7] T. Telematics, "A brief guide to the history of telematics," available at: https://static.telematics.tomtom.com/-ttt/lib/assets/ttt/doc/whitepapers/en-za/ttt-history-of-telematics.pdf.

[8] ——, "Fleet management," *https://telematics.tomtom.com/en-ie/webfleet/fleet-management/*. [Online]. Available: https://telematics.tomtom.com/en$_i$e/webfleet/fleet − management/

[9] E. Commission, "Driving time and rest periods," 2006, *https://ec.europa.eu/transport/modes/road/social-provisions/driving-time-en*. [Online]. Available: https://ec.europa.eu/transport/modes/road/social$_p$rovisions/driving$_t$ime$_e$n

[10] WhatIs.com, "What is active directory?" https://searchwindowsserver.techtarget.com/definition/Active-Directory.

[11] M. Solomon, David A.; Russinovich, *Microsoft Windows Internals: Microsoft Windows Server 2003, Windows XP, and Windows 2000 (4th ed.)*, W. M. P. Redmond, Ed., 2005.

[12] technopedia.com, "Single sign-on (sso)," https://www.techopedia.com/definition/4106/single-sign-on-sso.

[13] Microsoft.com, "Microsoft deployment toolkit (mdt)," https://www.microsoft.com/en-gb/download/details.aspx?id=54259.

[14] Microsoft, "Quick start guide for lite touch installation." 2012, https://docs.microsoft.com/en-us/sccm/mdt/lite-touch-installation-guide.

[15] maas.io, "What is maas?" https://docs.maas.io/2.5/en/intro-what-is-maas.

[16] R. Davis, "An introduction to asset management."

[17] D. E. R. Services, "Asset management: A risk-based approach," 2015, https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-risk-based-approach-benchmark-survey.pdf.

[18] mass plc.com, "An introduction to asset management," http://www.mass-plc.com/blog/224/an-introduction-to-asset-management.

[19] A. K. PECB, "4 key stages of asset management life cycle," 2016, *https://pecb.com/article/4-key-stages-of-asset-management-life-cycle-].*

[20] ISO/IEC, "Iso/iec 19770," 2017, *https://www.iso.org/obp/ui/iso:std:iso-iec:19770:-1:ed-3:v1:en.* [Online]. Available:   https://www.iso.org/obp/ui/iso:std:iso-iec:19770:-1:ed-3:v1:en

[21] T.     Telematics,     "Certified     information     security     and     data     privacy,"   *https://telematics.tomtom.com/en-ca/webfleet/company/isms/.*     [Online].     Available:   https://telematics.tomtom.com/en$_c$a/webfleet/company/isms/

[22] I. . family, "Information security management systems," 2017, *https://www.iso.org/isoiec-27001-information-security.html.* [Online]. Available:  https://www.iso.org/isoiec-27001-information-security.html

[23] M.     Lillywhite,     "Agents     vs     agentless:     what     to     use     and     when,"     2017,   https://www.snowsoftware.com/fi/blog/2018/06/16/agents-vs-agentless-what-use-and-when. [Online]. Available:  https://www.snowsoftware.com/fi/blog/2018/06/16/agents-vs-agentless-what-use-and-when

[24] Device42,     "Device42     autodiscovery     agent,"     2018,     *https://docs.device42.com/auto-discovery/agent-based-discovery/.* [Online]. Available:  https://docs.device42.com/auto-discovery/agent-based-discovery/

[25] AlliedMarketResearch.com, "Digital asset management market by type (solution and service) and application (sales, marketing, it, and others) - global opportunity analysis and industry forecast,," 2017-2023.

[26] MordorIntelligence.com, "Digital asset management market - segmented by deployment (on-premise cloud), solution (video management, creative tool integration, asset analytics), end user (healthcare, retail, automotive), and region- growth, trends, and forecasts," 2019-2024, *https://www.mordorintelligence.com/industry-reports/digital-asset-management-dam-market.*

[27] Device42.com, "Network (snmp) auto-discovery," 2018, *https://docs.device42.com/auto-discovery/network-auto-discovery/.*

[28] O. Projects, "Glpi," *https://projects.ow2.org/view/glpi/*. [Online]. Available:
    https://projects.ow2.org/view/glpi/

[29] Alchetron.com, "Glpi," *https://alchetron.com/GLPi*. [Online]. Available:
    https://alchetron.com/GLPi

[30] I. Association, "Association indepnet," 2016, www.indepnet.net (in French). [Online].
    Available: www.indepnet.net (in French)

[31] P. Scoffoni, "Glpi : les porteurs du projet associatif passent la main
    Ã teclib," 2015, *http://everything.explained.today/GLPi/* (in French). [Online].
    Available: http://everything.explained.today/GLPi/ (in French)

[32] php.net, "What is php?" *http://php.net/manual/en/intro-whatis.php*. [Online]. Available:
    http://php.net/manual/en/intro-whatis.php

[33] TechTarget.com, "Multiprotocol label switching (mpls)," 2014,
    *https://searchnetworking.techtarget.com/definition/Multiprotocol-Label-Switching-*
    *MPLS*.

[34] PaloAltoNetworks.com, "How to configure palo alto net-
    works firewalls when connected to an mpls network," 2019,
    *https://knowledgebase.paloaltonetworks.com/KCSArticleDetail?id=kA10g000000ClLwCAK*.

[35] techopedia.com, "Apache web server,"
    *https://www.techopedia.com/definition/4851/apache-web-server*. [Online]. Available:
    https://www.techopedia.com/definition/4851/apache-web-server

[36] G. team, "Glpi english documentation," *https://glpi-project.org/DOC/EN/*. [Online].
    Available: https://glpi-project.org/DOC/EN/

[37] M. Rouse, "Mysql," *https://searchoracle.techtarget.com/definition/MySQL*. [Online].
    Available: https://searchoracle.techtarget.com/definition/MySQL

[38] M. Sarig, "Mariadb vs mysql: In-depth comparison," 2018, *https://blog.panoply.io/a-comparative-vmariadb-vs-mysql.* [Online]. Available: https://blog.panoply.io/a-comparative-vmariadb-vs-mysql

[39] F. I. team, "Fusion inventory feature overview," 2018, *http://fusioninventory.org/overview/.* [Online]. Available: http://fusioninventory.org/overview/

[40] /searchwindowsserver.techtarget.com, "What is active directory," *https://searchwindowsserver.techtarget.com/definition/Active-Directory.* [Online]. Available: https://searchwindowsserver.techtarget.com/definition/Active-Directory

[41] Gracion.com, *http://www.gracion.com/server/whatldap.html.* [Online]. Available: http://www.gracion.com/server/whatldap.html

[42] SourceForge, "An easy to install apache distribution containing mysql, php, and perl," 2016.

[43] centos.org, "Frequently asked questions about centos in general: 1. what is centos linux?" 2014, *https://wiki.centos.org/FAQ/Generalhead-4b2dd1ea6dcc1243d6e3886dc3e5d1ebb252c194.* [Online]. Available: https://wiki.centos.org/FAQ/Generalhead-4b2dd1ea6dcc1243d6e3886dc3e5d1ebb252c194

[44] S. Tatham, "Putty: a free ssh and telnet client," 2018, *https://www.chiark.greenend.org.uk/ sgtatham/putty/.* [Online]. Available: https://www.chiark.greenend.org.uk/ sgtatham/putty/

[45] ssh.com, "Putty - world's most popular free ssh client," 2018, *https://www.ssh.com/ssh/putty/.* [Online]. Available: https://www.ssh.com/ssh/putty/

[46] dell.com, "Dell warranty status api -technical specification guide," 2016, *https://techdirect.dell.com/API-DOCs/apiwarrantyv4.pdf.*

[47] F. T. Commission, "Joint ftc/commerce department report released on "reasonable demonstration" requirement of esign," 2001, *https://www.ftc.gov/news-events/press-releases/2001/06/joint-ftccommerce-department-report-released-reasonable.*

[48] PCMag.com, "Docusign releases updated version of e-signature software," 2010, *https://www.pcmag.com/article2/0,2817,2365899,00.asp.*

[49] I. Middleton, "Key factors in help desk success," 1996.

[50] atlassian.com, "What is jira service desk?" 2017, *https://confluence.atlassian.com/get-started-with-jira-service-desk/what-is-jira-service-desk-917968347.html.* [Online]. Available: https://confluence.atlassian.com/get-started-with-jira-service-desk/what-is-jira-service-desk-917968347.html