

Insert here your thesis' task.



**FACULTY
OF INFORMATION
TECHNOLOGY
CTU IN PRAGUE**

Master's thesis

A Case Study and Proof of Concept of the Application of Machine Learning to Polarion's ALM Software

Bc. Michal Sláma

Katedra . . . softwarového inženýrství

Supervisor: Ing. Jurij Černíkov

May 16, 2018

Acknowledgements

I would like to thank to my supervisor for his extraordinary leading and valuable advices during the whole process of writing this thesis.

Declaration

I hereby declare that the presented thesis is my own work and that I have cited all sources of information in accordance with the Guideline for adhering to ethical principles when elaborating an academic final thesis.

I acknowledge that my thesis is subject to the rights and obligations stipulated by the Act No. 121/2000 Coll., the Copyright Act, as amended. In accordance with Article 46(6) of the Act, I hereby grant a nonexclusive authorization (license) to utilize this thesis, including any and all computer programs incorporated therein or attached thereto and all corresponding documentation (hereinafter collectively referred to as the “Work”), to any and all persons that wish to utilize the Work. Such persons are entitled to use the Work in any way (including for-profit purposes) that does not detract from its value. This authorization is not limited in terms of time, location and quantity. However, all persons that makes use of the above license shall be obliged to grant a license at least in the same scope as defined above with respect to each and every work that is created (wholly or in part) based on the Work, by modifying the Work, by combining the Work with another work, by including the Work in a collection of works or by adapting the Work (including translation), and at the same time make available the source code of such work at least in a way and scope that are comparable to the way and scope in which the source code of the Work is made available.

In V Praze on May 16, 2018

.....

Czech Technical University in Prague

Faculty of Information Technology

© 2018 Michal Sláma. All rights reserved.

This thesis is school work as defined by Copyright Act of the Czech Republic. It has been submitted at Czech Technical University in Prague, Faculty of Information Technology. The thesis is protected by the Copyright Act and its usage without author's permission is prohibited (with exceptions defined by the Copyright Act).

Citation of this thesis

Sláma, Michal. *A Case Study and Proof of Concept of the Application of Machine Learning to Polarion's ALM Software*. Master's thesis. Czech Technical University in Prague, Faculty of Information Technology, 2018.

Abstrakt

Machine learning (ML) is becoming essential part any software application. Its same for application lifecycle management (ALM) which hides great opportunities to improve using, processing or behaviour of the whole system based on the ML principles. This work contains description of ML principles relevant for using in the ALM environment. For the specific software is used Polarion which is worldwide successful enterprise solution for ALM. This thesis provides analysis its core business and user cases and possible ways how to integrate ML to improve Polarion in different areas. As Polarion must that customer's data are not exposed to any possible threat ensure on all levels we will discuss the way how to achieve this goal by a different kind of architecture or implementation.

Klíčová slova Strojové učení, životní cyklus softwarových aplikací, ALM

Abstract

Sem doplňte ekvivalent abstraktu Vaší práce v angličtině.

Keywords Machine learning, application lifecycle management, ALM

Contents

Todo list	1
Introduction	3
1 The aim of the thesis	5
2 Polarion	7
2.1 ALM	7
2.2 A unified solution	8
2.3 Development process in complex or regulated environments . .	12
2.4 Accelerate collaboration	13
2.5 Medical domain	16
3 Machine learning	19
3.1 Algorithms	19
4 Creating work items with ML	21
4.1 User experience	21
4.2 Architecture	21
4.3 Realization of prototype	21
5 ML in production environment	23
6 Security	25
7 Validity	27
8 The value of the enhancement	29
Conclusion	31

Bibliography	33
A List of abbreviations used	35
B CD contains	37

List of Figures

2.1	A unified solution for ALM [1]	9
2.2	Document workflow [1]	11
2.3	Companies expectation from using Agile[1]	12
2.4	Collaboration traceability workflow [1]	14
2.5	Medical risk management workflow [1]	17

Todo list

Introduction

“The revolution is just beginning, but it’s real – and the time to act is now. In fact, it is yours for the taking to harness a broad platform, services and ecosystem to transform your business. A unified approach to application lifecycle management is not a futuristic technology trend. It’s here today, and the good news is that you don’t have to completely stop and reset, but can smoothly transition from squeezing the most out of your existing business processes to making your organization thrive.”

Kurt Bittner
Analyst
Forrester Research

Author of this thesis has been working in software development for more than 10 years. Based on this experiences he got to a question how to manage and keep up to date info for large project where more than dozens people are involved. This is also why he chooses to work as a developer of Polarion.

We live in the world that is changing rapidly. No part of life of free to this changes and the software development needs more then others to adapt every day to new requirements and technologies. This demand leads to a new level of management for software development where tools, process, implementation, testing and reporting are organized on one place with goal to keep and improve traceability and productivity as high as possible. This comes hand by hand with automation in the form of ML that moves user experience and reporting to the next level. One of such product is Polarion[1] and this work will analyze it’s user cases and find out what places are good candidates for using ML techniques to improve business value of the product.

The aim of the thesis

The aim of this thesis is to analyze and identify machine learning (ML) use cases that would prove valuable for Polarion's application lifecycle management (ALM) software. A proof of concept prototype will be supplied for the selected use case.

1. Analyze and describe Polarion in order to identify suitable use cases to apply ML to.
2. Provide a review of ML frameworks and algorithms that are relevant for such an application.
3. Describe several use cases for ML and define their benefit to both ALM as a business and the users that deploy it.
4. Choose a scenario from the previous investigation and implement a proof of concept prototype.
5. Discuss the possibility of the full implementation and deployment of the previous prototype into the production environment.

Polarion

Organizations are often struggling with the old processes of doing things. They focus on isolated process optimization instead of driving business value through comprehensive synchronization. With Polarion, customers have been able to get their teams out of their silos and orchestrate development efforts across the entire application lifecycle. This approach has empowered stakeholders to better perform tasks in context and quickly make sound decisions based on real-time access to information.

Now let's take a look what Polarion comes with and how improves old fashion processes.

2.1 ALM

“ALM is a paradox in the software engineering world, where engineers recognize the need for requirements management, change and configuration management, QA and test management, and so on, but are not familiar with the term ALM. This is a serious problem because ALM is necessary to manage software complexity, and the rise of embedded software in engineered products needs mature management processes and tools.”

Michael Azoff
Principal Analyst

Polarion is a ALM enterprise solution to deal with modern-day challenges. It has emerged with the intent to fasttrack innovation, while safeguarding quality, functional safety and compliance to satisfy that speed in developing and delivering innovative applications is becoming essential to the success of businesses in any industry.

ALM points to these three aspects:

1. application has to be delivered as fast as possible and the time is a new strategy weapon
2. information technologies are fuel accelerating business success
3. errors are not forgiven and can go viral in instant. QA rules must be set and obeyed.

2.2 A unified solution

Polarion is a single solution providing a solution to build whole application from the ground. At the same time it is ensured that data and logic is in persistent state during entire process.

This helps with regulations. This basic word means a lot in the world of software development where processes are regulated by intern or external subject and have essential impact on the cost of product not only during development but after it's release.

What ALM comes with?

The main advantages attributed to ALM process (graphically shown in picture 2.1):

- Agility through improved collaboration.
- Productivity through process integration.
- Auditability through traceability and accountability.
- Quality through transparency and automation.
- Innovation through unlocked team synergy.
- Predictability through better estimation and reporting.

Let's a look more close to some of these advantage.

2.2.1 Agility through improved collaboration

If faster time-to-market is a key success factor in today's competitive environment, real-time collaboration and contextual performance of tasks are the means to stay ahead. In many cases, lightweight Agile software development methods have replaced or augmented incremental waterfall methods to release products more frequently.

Polarion provides flexible support for Agile or Lean, as well as traditional and hybrid environments, including any customized Scrum, feature-driven development, Kanban, extreme programming, or rational unified process methodologies.



Figure 2.1: A unified solution for ALM [1]

The Polarion 100 percent browser-based architecture makes information universally accessible from anywhere for any collaborator. Collaboration is so easy and teams divided around the world can communicate to each other and solve tasks together.

2.2.2 Productivity through process integration

Major part of Polarion customers apply a combination of Agile and DevOps methodologies. The Polarion solution is the perfect conduit to DevOps, allowing easy synchronization of development and delivery processes spanning requirements definition, feature development, quality testing, and maintenance. Any problem can be easily tracked back to the source and time of maintenance is so rapidly reduced even to real time fixes.

Polarion supports integration with other tools. This is done by extension or native integration. Thanks this customers can still use their own tools and data repositories and just integrate them with Polarion. Polarion has it's place on market for many years and during this time many extensions were created by customers or professional services and placed to official Polarion's marketplace from which can be freely downloaded. Common customer will find there with high probability a solution for his needs.

2.2.3 Auditability through traceability and accountability

“We chose Polarion ALM at Phoenix Contact in the Business Unit Automation to consolidate our very heterogeneous tool landscape – PVCS, Bugzilla, OneTree. With Polarion ALM we achieved transparency on all levels of development and we got fast acceptance in the teams. We now see exactly and in detail the status and the progress in our projects in the different project phases.”

Andreas Deuter

Phoenix Contact Electronics

Every change is stored. Polarion stores all you need to track down what, how and by whom happened. In enterprise environment where is working hundreds and hundreds people it's hard to keep in touch who does what. A place where you see it all is priceless and helps to minimize risks of black holes when tasks is left or forgotten without any notice. Such a missing task can have very serious impact on cost or even release date itself.

2.2.4 Quality through transparency and automation

A big problem with this approach is that team members usually get the information about what they need to accomplish from static documents that tend to go out-of-date as quickly as they were created. But perhaps worst of all, changes and ad hoc decisions often fail to take into account the downstream impact.

Processes of Polarion provide way to track all requirement changes and so help to keep in touch with actual state of what needs to be done. For instance if product owner change a task developer is informed and can react by accepting this task or request more information about this change. In both cases every side knows what happened and what comes next.

Time when all operations were done only by people is over and automation plays important role in IT management. Polarion provides environment to run automatic jobs to build, test, check, ... or whatever customer may need. Customers are free to implements their own job and run them in the same way as native ones.

2.2.5 Automating proof of compliance

On the most important aspect is document workflow and will need this further in thesis.

You can understand to document as a normal word document but each task (in Polarion called work item) is external object. That means document is composed from its own text (headings, descriptions...) and work items that also have its description which is shown in the document. All theses together makes customer feel that is working with one unit. If customer wants to edit work item this can be done on document or via work item view easily accessible from document or another part of Polarion as working with work items is the main activity and processes are built on them. Let's look at the workflow shown in 2.2.

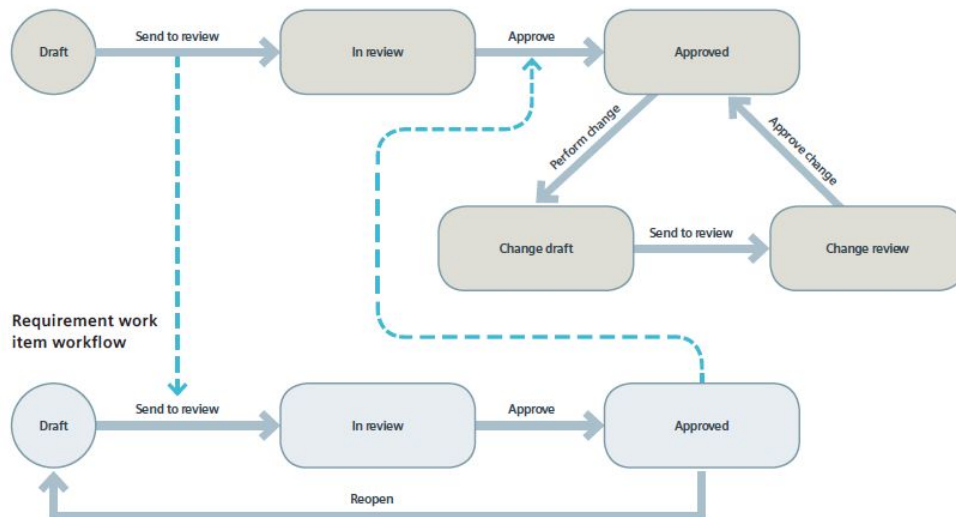


Figure 2.2: Document workflow [1]

Picture ?? shows two separated workflows. One for document and one for work items. Workflows itself does not need explanation but the important part is the relation between them. Document can not move to a next state unless all it's work items are also moved to a desired state. This keep traceability and collaboration consistence by pushing team to accept it's work and remove not desired drafts, fakes and other stuff that is not related to real work.

2.2.6 Innovation through unlocked team synergy

We live in information age. Information are all around us and the hardest part is to find what is important for us or company and what can be forgotten.

2. POLARION

Team is a great way how to share this information but what if team has many people? Polarion contains way how to cooperate and improve your know how as fast possible and share it with other co-workers. Time to solve already solved issued is rapidly reduced and new task can be done based on results of previous work that leads to more accurate estimations and risk assessment.

2.3 Development process in complex or regulated environments

Most collaborators don't have the unified tools environment necessary to get them on the same page at the same time, however, and resulting disconnects have increasingly negative impact, disrupting industries with new records of regulatory warning letters, product failures, recalls, legal sanctions, loss in market position and associated cost explosions.

Topping the list of challenges in the new world of software driven innovation are the need for tight orchestration across disparate teams, growing regulatory demands and the increasing role of suppliers as innovation partners. Companies that are able to shift gears to meet the growing complexity will be well positioned to secure new market opportunities.

Common first step is to welcome agile approach. Companies have different expectations about it's benefits shows in picture below 2.3.

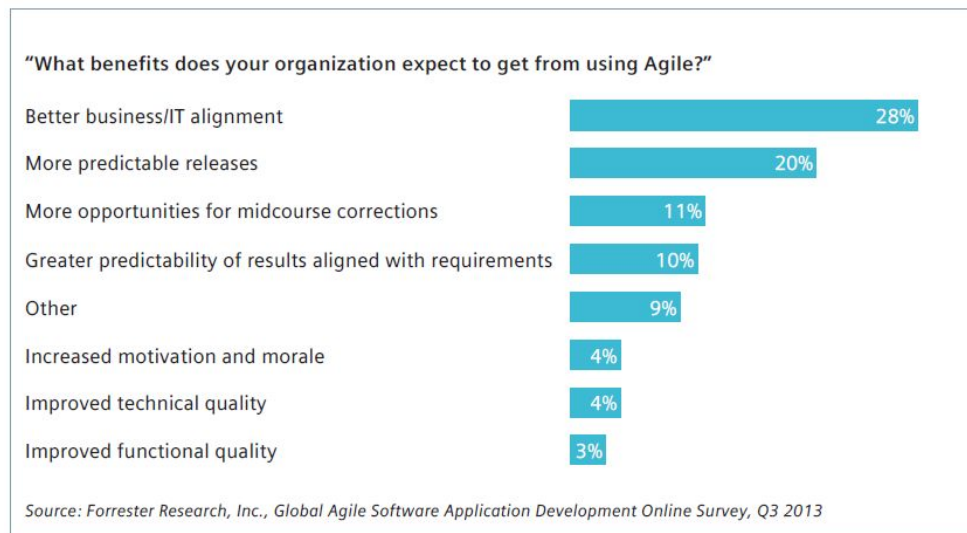


Figure 2.3: Companies expectation from using Agile[1]

Result is clear. Companies feel that IT is starting to be more and more complex and demands from business is harder to satisfy. Polarion support all

agile methods and is ready to help company improves its environment. More importantly this agile templates (how are called) can be modified based on customers demands to fit their needs and specify requirements.

“Siemens PLM Software’s Polarion products presents the opportunity to allocate our complex and formal development rules via one state-of-the-art tool. The modularity and flexibility make the adjustment to our needs simple and effective. The traceability and workflow features are convincing and really assist the everyday activities.”

Christian Kettl
MTU Aero Engines

2.3.1 Integration of ALM and PLM

All the time we are talking about ALM but the main goal is to provide entire solution for product application lifecycle PLM where ALM is just a part of it. Where ALM is concentrated around application there PLM is the process of managing the lifecycle of a product itself from inception to final real item. Polarion is able to provide this functionality by integration with external tool that can use Polarion as the source of ALM work flow.

ALM-PLM integration benefits include:

- Integrated processes make cross-discipline synchronization very easy.
- Access to product and software requirements supports comprehensive understanding of the product definition.
- Bi-directional linking enables cross-discipline lifecycle management and audit readiness.
- Change propagation and automatic notification enable comprehensive change impact analysis.
- Synchronized testing and reporting support cross-functional defect management.
- Linked, versioned data architecture without data duplication delivers closed-loop decision making.
- Integration makes holistic compliance reporting for every aspect of the manufacturing process a reality.

2.4 Accelerate collaboration

Development environments to synchronize team efforts have proliferated. But most of them are cobbled together, posing a wide range of disadvantages. Leveraging Polarion flexibility, customers can choose from different configurations to provide all collaborators with the level of information and functionality they need, while keeping the total cost of ownership the lowest in the industry.

These are the most common:

- Difficulty linking and tracing artifacts across differently structured repositories.
- Problems of low visibility into project status, impact of changes and release predictability.
- Lack of a cohesive feedback loop that brings important context to every stakeholder.



Figure 2.4: Collaboration traceability workflow [1]

2.4.1 The dilemma of requirements documentation

We need to be sure that all side speaks with dialect that respect specify domain. This requirement typically encompass varying pieces of content, including:

- Paragraphs to provide overviews and explain details.

- Lists and tables to detail structured data and rules.
- Images and models to illustrate requirements.
- Flow charts to describe a series of events.

2.4.2 "easy-as-Word functionality"

If we spoke that the base object in Polarion is Document we shall expect that customers will use document in the same way as if they were using in the Microsoft Word. Fortunately behaviour of document in Polarion is very similar in both using and how looks like.

Customers can use known buttons and tools from Microsoft Word to edit and interact with document and this speed up learning curve a lot.

2.4.3 Real-time access to content

Instead of Microsoft word document is Polarion document fully online and each change is immediately visible to everyone. Many users can simultaneously edit one item and Polarion then handle merging of changes. Of course that this can lead to conflict and in this case user have to handle his changes by own.

Consequently, companies that use Polarion Requirements are no longer forced to rely on meetings, sending emails, or circulating formal documents to make decisions, even with their partners and other external collaborators.

2.4.4 Tie in domain experts with their tools

As was said previously Polarion is expandable. Extensions can change or improve some existing functions or add completely new, transfer data from or to Polarion or connect it to external tools providing new functionality.

To complete the picture, connectors for popular third-party tools such as HP® Quality Center® and Atlassian® Jira® are available, and so is an open and fully documented Java API. As a result, a strong community of more than 100,000 members has formed and created extensions, integrations and customizations.

2.4.5 Deliver release predictability

Because every artifact change in the Polarion product is tracked and reported using the underlying configuration management system, customers automatically gain a complete audit trail of who did what, when and why, making it impossible to change anything without leaving a trace.

“Visual Diff” functionality is available to easily detect the changes between different states, and customers report that teams that take advantage of change management and impact analysis are much more successful.

2.4.6 Reduce time-to-marker

All previous parts have one main purpose to deliver product in the shortest time but ensure its quality and traceability.

2.5 Medical domain

One the strongest part of Polarion is in ability to satisfy regulation demands from various types of institutions that making development more complex then before.

Lets talk about medical domain.

Medical device product development work is a highly integrated and regulated process. Two key standards incorporated into medical device risk management are International Organization for Standardization (ISO) 14971:2009, which specifies the process for a manufacturer to identify the hazards associated with medical devices; and ISO Technical Information Report (TIR) 24971:2013, which provides guidance in addressing specific areas of ISO 14971 when implementing risk management. Europe has added to the mix with EN ISO 14971:2012, which is different in several important aspects, and is required if a company is selling medical devices into Europe. You can see this process in Medical risk management workflow picture 2.5.

It was just a example how problematic and regulated this domain is.

To describe how exactly is Polarion used in medical domain s beyond the scope of this thesis. But one point are data. Data are in medical domain valuable asset whose using is restricted by law and violation has serious financial and social impart. If we want to use this data we have to be use that all rules are obeyed and data are safe before abuse or stolen.

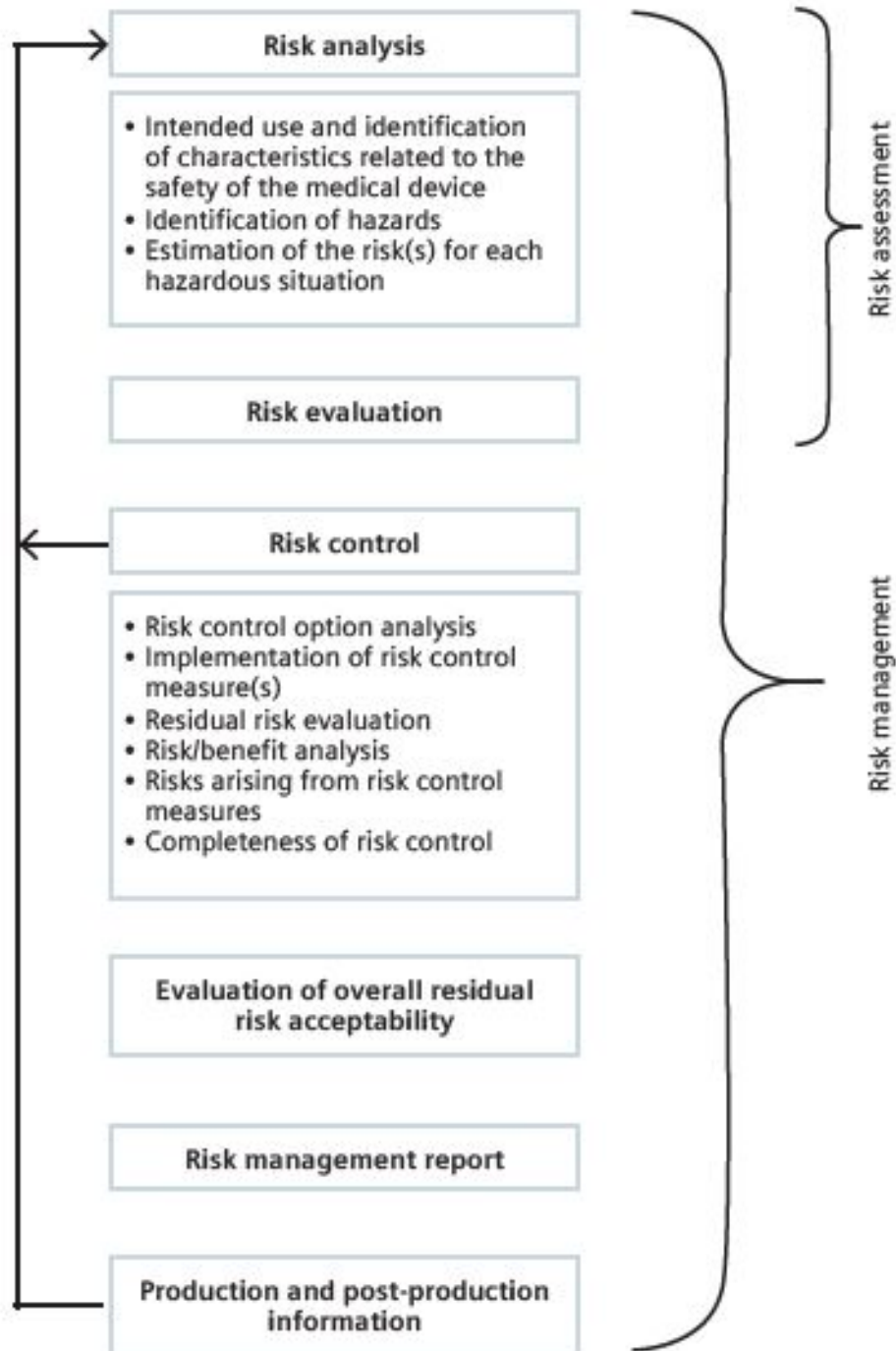


Figure 2.5: Medical risk management workflow [1]

Machine learning

3.0.1 TensorFlow

3.0.2 Theano

3.0.3 Caffe

3.0.4 AML - AWS

3.0.5 Microsoft CNTK

3.1 Algorithms

3.1.1 LDA

Creating work items with ML

- 4.1 User experience
- 4.2 Architecture
- 4.3 Realization of prototype

ML in production environment

Security

implement own ML server using just shareable libraries and provides to customers ability to using ML technics.

Validity

The value of the enhancement

Conclusion

Bibliography

- [1] Polarion ALM. [online], [cit. 2018-05-01s]. Dostupné z: <https://polarion.plm.automation.siemens.com/>

List of abbreviations used

ALM Application lifecycle management

Polarion Polarion ALM

ML Machine learning

CD contains

```

├─ readme.txt ..... stručný popis obsahu CD
├─ thesis ..... zdrojová forma práce ve formátu LATEX
├─ text ..... text práce
├─ thesis.pdf ..... text práce ve formátu PDF
└─ thesis.ps ..... text práce ve formátu PS

```