



END-OF-STUDIES PROJECT REPORT

EXTENSION OF A BUSINESS PROCESS
COMPLIANCE TOOL
REVISION OF THE PRODUCT'S STRATEGY

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Executive Summary

This report presents the work done around the Regorous software at NICTA during my final year internship. It is divided in two main parts. First a technical one that presents the new features that were added to the code-base and theoretical work on the extension of the model. After a short but thorough introduction to the theory you will find an in-depth presentation of the new components that were implemented. My main contributions are :

- Implementation of Co-occurrence obligation to extend the “vocabulary” available to translate regulation into defeasible rules. This necessitated a rewrite of the core library to introduce this new type and modify the compliance checking algorithm to take into account the special behaviour of this obligation.
- Modifications of the implementation of the compliance checking algorithm to check compliance of compensation chains in the same task they were triggered in instead of waiting for the next task.
- Porting of the eclipse plug-in project to the current version of eclipse and third party libraries. This was an intensive work that taught me a lot about issues related to production environment. This is not something I was used to as a young graduate but the INSA generalist formation helped me go through.

Most of the code in this report is Java code or pseudo algorithmic code. I will not go into too much details about the exact implementation but rather focus on the methodology and the algorithms I used during the project.

I also contributed to the extension of the theoretical framework of defeasible deontic with time. Previous literature had introduced new concepts and semantics to deal with time in the framework. My work was to formally prove that both theories are equivalent. This work led to a paper that is currently under revision for publication in the PRIMA 2014 conference.

Second part is more strategy oriented, it is built around reviewing Regorous marketing strategy. Indeed, NICTA is not only working on technological matters but on how they can impact the “real world” and make it to production use in firms. There has been past attempts to sell the software to companies but all failed. I present an historical review of the work already done and try to build a product strategy and business model based on past feedbacks and academic literature.

I also investigate what are the side effects of Regorous and aim to link these with existing work from both research and the corporate world. I present how Regorous is a great tool of knowledge management within the firm and back my argument with research papers.

The report finds that the lack of a proper marketing study for Regorous is leading to a lot of approximations and hypothesis when it comes to target a market or individuals within the firm. There is an urgent need to pinpoint who are the decision makers in corporations when it comes to buying software and what are their motivation, who they listen to, what is important to them. In short, we must know who are our clients and how they think. I suggest a that a qualitative marketing research should be done and propose a collection of subjects that could be worked on.

Acknowledgement

I would like to take this opportunity to thank all the people who have contributed in some way to this report particularly Mr Guido Governatori who initiated the project, for his attention and for trusting me, making this extraordinary experience possible.

I also thank all the member of NICTA QRL who were always ready to help me and keen on sharing their experiences. It was an amazing adventure both humanely and professionally

Finally, I would like to thank all the members of the Business Process Compliance group for their patience and the time they spent to explain their work to me.

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I | Presenting the Context of the Project

I A Brief Presentation of NICTA

NICTA is Australia's Information and Communication Technologies centre of excellence¹. It was created in 2002 within the framework of the Backing Australia's Ability initiative, a governmental plan to foster innovation in Australia. NICTA won the selection process to become Australia's ICT centre of excellence. It is supported and funded by the Australian federal government as well as states governments where laboratories are running (New South Wales, Victoria, Queensland, Australian Capital Territory). Major universities in each of the previously cited states also participate in the funding.

NICTA has 5 laboratories around Australia and employs over 700 people representing the largest research organisation dedicated to ICT in Australia. Since its foundation it has developed many collaboration with the industry, especially via joint projects and company creation. NICTA not only focuses on research excellence but is actively looking for business opportunities to capture the value created by its research group. Hence an organisation divided in two main groups [NICTA 2010].

Research Groups are aiming to become leaders in their own domain of expertise with a long-term vision for ICT-innovation producing cutting edge results. Each operating in a different areas, they cover a large part of information and communication technologies. They are (in no particular order) :

- **Software Systems** is aiming to provide secure, reliable and safe systems that are proven to achieve “real world” enterprise performance and objectives.
- **Computer Vision** mainly work at a fundamental level in order to provide tools to better analyse the world through 2D videos. Their key areas of research are using the existing mathematics of multiple view geometry with new techniques such as machine learning and optimization.

¹Centre of Excellence are a common term used by Australian government to qualify prestigious centre of expertise where researchers collaborate to maintain Australia's international standing in research areas of national priority [Australian Research Council 2013]

- **Control and Signal Processing** produces theoretical and algorithmic work leading to innovative methods and systems. The focus is set on two main domain of application decentralized control and estimation for large distributed systems as well as the convergence between computer science and biology.
- **Optimization** is working on a new generation of optimization systems that will be operating in dynamic and noisy environment involving huge amounts of data.
- **Machine Learning** develops new algorithms and technologies to make sense of the skyrocketing amount of data generated in all areas of human endeavour.
- **Networks** is improving the user experience in current and next generation networked environment by developing new theories, models and methods.

Business Teams are focused on exploiting the results of research through active market exploration and strategic surveillance. They provide business support for researchers and therefore cover economic sectors related to the above research groups. They are (in no particular order) :

- **Broadband and the Digital Economy** promotes new digital technologies and services in all the Australian market : government, SME, enterprises and end-users.
- **Health** develops and fosters the penetration of information technologies into the biological world leading to a better understanding of biological systems and diseases.
- **Infrastructure, Transports and Logistics** provide innovative ICT solutions to radically improve transportation systems and infrastructure networks.
- **Security and Environment** increases the security of critical and sensitive Australian infrastructure and reduces our impact on the environment.

II The Business Process Compliance Group

The Business Process Compliance group in which I am working is part of the Software Systems group, one of the six research groups. The interest in business process compliance starts from a simple observation. ICT systems are costly and hard to develop because of the constantly evolving framework of norms and requirement within which they operate, leading to less agility and slower development cycles especially in domains with strict legal obligations. Business process compliance is becoming an increasing area of concern in both public and private sectors because of the complexity of regulations and the lack of automated tools. The compliance market is worth tenth of billions of dollars in Australia [NICTA 2013].

From this observation, the BPC group started by selecting a framework to represent both business processes and the laws they must comply to. These research lead to numerous articles aiming to build a model for rules and business processes that would give the end user the most flexibility and the possibility to accurately translate existing body of law. This theoretical work led to more concrete projects. As of today the group is undergoing three main projects : Regor-

ous, SPINdle and extensions to the theoretical framework. These provide a powerful platform for compliance officers in companies.

II | Technical Work on Regorus

I Introducing the Project's Theoretical Framework

1 A Short Introduction to Defeasible Logic

Defeasible reasoning as presented in [Koons 2005] is a non-demonstrative type of reasoning where one cannot reach a full, undoubted conclusion and where a conclusion can be defeated if further evidence of the contrary is demonstrated. Both computer scientists and philosophers has shown an interest in this field. The philosophical interest can be traced back to ancient Greece and Aristotle. Although the scientific reasoning is built on deductive logic, for everyday life, we rely on a defeasible reasoning. We try to make general statements out of personal experience, for example, after seeing a few birds fly, one could say that all birds fly. This proposition would be true until we experience a bird that cannot fly such as a penguin. This would defeat the first rule.

Computer scientist interest in defeasible logic has grown during the last 40 years especially in the field of artificial intelligence. An intelligent program needs a formal representation of the world, a formal language to represent knowledge, causality and ability in order to achieve its given goal. This requirement was first presented in [McCarthy and Hayes 1968].

Defeasible Logic was first introduced by Donal Nute in [Nute 1994] as a proposition to represent defeasible reasoning in a logical way. As stated in [Antoniou et al. 2000] defeasible logic is a flexible non-monotonic formalism able to represent a large set of non-monotonic reasoning. Also several powerful implementations have been proposed with good complexity properties allowing a correct computational time. This has been made possible by the design of defeasible logic that makes implementation easy yet efficient.

Let's describe the basics of Defeasible Logic as in [Antoniou et al. 2001]. A defeasible theory gives us five different ways of representing knowledge *facts*, *strict rules*, *defeasible rules*, *defeaters* and a *superiority relation*.

Facts are indisputable statements for example Tux is a penguin. This can be written formally as *penguin(Tux)*.

Strict rules are rules as in deductive logic. It's the kind of rule we find in scientific reasoning. The conclusion is irrefutable if the premises also are. These are formally represented as :

$$penguin(X) \rightarrow bird(X)$$

Defeasible rules are the ones that can be defeated by evidence of the contrary. To draw a parallel with everyday reasoning one could generalize from experience that "Birds fly" a statement that would be true until the opposite is deducted. These rules are formally represented as :

$$bird(X) \Rightarrow flies(X)$$

Defeaters are weaker rules that cannot be used to draw any conclusion but can prevent one. They are used to defeat other rules (hence the name) because they produce evidence of the contrary.

$$heavy(X) \rightsquigarrow \neg flies(X)$$

From this defeater we cannot conclude that because someone or something is heavy it cannot fly, it is only here to prevent the conclusion of *flies(X)*.

Superiority relation is used to create an order in a rule set. It is important to note that this relation does not have the properties of a proper superiority relation. When we have two different rules which derive something and its negation we cannot draw a conclusion since defeasible logic is sceptical. The superiority relation allows us to come to a conclusion. For example :

$$\begin{aligned} r : \quad & bird(X) \Rightarrow flies(X) \\ r' : \quad & brokenWing(X) \Rightarrow \neg flies(X) \\ & r' > r \end{aligned}$$

In this case we cannot reach a conclusion since *r* and *r'* reach opposite conclusions. By introducing the superiority relation we say that *r'* is strictly stronger than *r* and therefore we can conclude that the bird cannot fly.

Now that we are more familiar with the concepts of defeasible logic we can show how we can reach a defeasible conclusion using proof theory. It exists four proof types for a conclusion D.

$\pm\Delta\mathbf{q}$ means that *q* or $\neg q$ or is definitely provable in D

$\pm\partial\mathbf{q}$ means that *q* or $\neg q$ or is defeasibly provable in D

We won't get into details about how to definitely prove a literal since the focus of this report is more on defeasible proof. All you need to know is that if *q* is definitely provable then it is also defeasibly provable.

In [Antoniou et al. 2001] provability is defined using the concept of *derivation* in a conclusion D which is a set of facts rules and superiority relations ($D = (F, R, >)$). A derivation P can

be seen as several steps in a demonstration. At the step $P(i)$ of the proof we have a given set $(F, R, >)$ from this we can prove $P(i + 1)$ either definitely or defeasibly.

In order to reach a definitive conclusion $\pm\Delta q$ we need to have a strict rule that concludes $(\neg)q$ or have $(\neg)q$ as a fact.

The following definitions exposes how to defeasibly conclude a literal q at $P(i + 1)$.

Definition 1 *If $P(i + 1) = +\partial q$ then either*

1. $+\Delta q \in P(1..i)$ or
2. (a) $\exists r \in R_{sd}[q], \forall a \in A(r) : +\partial a \in P(1..i)$
 (b) $-\Delta q \in P(1..i)$
 (c) $\forall s \in R[\neg q]$ either
 - i. $\exists a \in A(s) : -\partial a \in P(1..i)$ or
 - ii. $\exists t \in R_{sd}[q]$ such that
 $\forall a \in A(t) : +\partial a \in P(1..i)$ and $t > s$

In less mathematical terms this definition means that in order to defeasibly prove q we can follow two paths. Either prove that q is definitely provable or work the defeasible part. Three conditions apply :

1. there is a rule r that concludes q for every literal a such as a has been defeasibly proven in a previous step $P(1..i)$ and,
2. $\neg q$ has not been definitively proven in a previous step $P(1..i)$ and,
3. for every rule s that conclude $\neg q$ for a literal a either
 - (a) $\neg a$ has been defeasibly proven in a previous step $P(1..i)$ or
 - (b) there is a rule t that concludes q such as $t > s$

Please not that the proof for $-\partial q$ is the exact negation of 1.

2 Using Defeasible Deontic Logic to Represent Legal Norms and Regulations

Regulations and legal norms are an important concern for government and businesses. They are complex and hard to study especially when multiple regulations written separately are applied to a given situation. In a world where compliance to regulation is becoming both harder and more important because of their growing number and the sanctions applied for non compliance, a normative logical framework is needed to be able to reason about regulations.

Deontic logic (from ancient Greek $\delta\epsilon\omicron\nu\tau\omicron\varsigma$ meaning duty, what must be done) is a branch of symbolic logic concerned with the logic of obligations and permissions [*Deontic Logic > Challenges in Defining Deontic Logic (Stanford Encyclopedia of Philosophy)*]. Therefore it is exactly

the kind of logical framework we want to be able to express regulations. Unfortunately standard deontic logic is unable to represent simple notions of normative reasoning such as prima-facie obligations or contrary-to-duty obligation. This lack of expressibility has driven away the very people that would have used deontic logic the most[Nute 1997].

Let's take a closer look at prima-facie obligation for example and see how we can express these in the light of defeasible logic. Prima-facie means "at first sight" hence a prima-facie obligation is an obligation that stands at first sight, one that can be defeated if new facts can prove otherwise. We can see that this type of obligation can easily be expressed using defeasible logic, it is defeasible by definition. Furthermore regulations contain exceptions that are easily represented using defeasible logic.

There are many benefits to use a logical framework to represent regulations, some of those are presented in [Antoniou et al. 1999]. They are subdivided into two main area of application :

- **The understanding and application of regulations** for users not familiar with legal writing and don't want to study a regulation yet being under the obligation to comply.

Decision support : If I make this decision, is it compliant ? You can run your process against a set of regulations and see if it complies. This is one of the situations where Regorous is actually effective. A formal framework for expressing processes is needed too in this case.

Explanation : We can return to the user the complete reasoning chain that lead to the given answer. It is therefore easier for the user to understand what cause this answer for their request or what caused non-compliance.

- **The creation of regulation** for assisting legal professional in their work.

Anomaly detection Having a formal logical framework backing the drafting of regulation allows for an easy detection of anomalies such as inconsistencies or loops.

Hypothetical reasoning It is possible, like for decision support, to inspect the effects of a regulation on the entire system.

Debugging When a regulation is not yielding the expected answer to a given query it is possible to debug it.

2.a Different Types of Obligations

Now that we explained the need for a logical framework for legal reasoning and how good deontic defeasible logic is, we can introduce the different types of obligations. Indeed, to accurately represent the complexity of norms and regulations, it is necessary to have a range of different types of obligations to be able to translate legal text into an equivalent logical representation as explained in [Governatori and Rotolo 2010a]. There are three main types of obligations :

- **Achievement Obligation** : There is an obligation to meet once before the deadline. For example *You must change your tires before they are worn out*

- **Maintenance Obligation** : There is an obligation to meet at all instant before the deadline. For example *You must provide for your children until they are 18*
- **Punctual Obligation** : There is an obligation to meet at one instant. They must be fulfilled at the same moment they were triggered.

Achievement obligations can be further detailed to be able to express what happens if a violation of the obligation occurs. Does the obligation persists ? (*You must pay the fine within 90 days otherwise you must pay a 15% tax.* In this case it is obvious that the obligation to pay the fine is persistent after the deadline ; after it was violated.) We therefore introduce a new concept that can apply to an achievement obligation : **Persistent or non Persistent**

We still lack vocabulary to express another subtlety of achievement obligations. Let's consider the following obligation *When shopping for an item a consumer must pay for it after receiving the invoice and no later than 30 days after receiving it.* Now if the customer by mistake or for any other reason transfers the due amount before receiving the invoice. Then it is obvious that the obligation has been fulfilled even though the action was taken outside of the time frame allocated to it. We will call this type of obligation **Pre-emptive and non-Pre-emptive**.

Also, please note that these concepts cannot apply to maintenance or punctual obligations.

The following table summarizes the aforementioned concepts and the notation attached to it.

Operator	Inline Notation	Read as
$O_{pr}^{a,\pi}$	[OAPP]	Achievement Persistent Preemptive
$O_{n-pr}^{a,\pi}$	[OAPNP]	Achievement Persistent non-Preemptive
$O_{pr}^{a,\tau}$	[OANPP]	Achievement non-Persistent Preemptive
$O_{n-pr}^{a,\tau}$	[OANPNP]	Achievement non-Persistent non-Preemptive
O^m	[OM]	Maintenance
O^p	[OP]	Punctual

2.b Expressing Chains of Reparation with the \otimes Operator

Now that we described the broad range of obligation giving us the necessary vocabulary to translate regulations into our logical framework. We are still missing one critical point of regulations : reparation chains. If an obligation is violated, you are not complying with the regulation unless there is a reparation chain that kicks in and leaves you in an unoptimal but still compliant situation.

For example let's consider the following rules :

$$\begin{aligned}
 r : \quad & \text{invoice} \Rightarrow O_{pr}^{a,\pi} \text{pay} \\
 r' : \quad & \neg \text{pay} \Rightarrow O^p \text{pay fine}
 \end{aligned}$$

They can be reduced and be expressed as a \otimes -expression such as these two obligation cannot be seen any more as independent.

$$r : \text{invoice} \Rightarrow O_{pr}^{a,\pi} \text{pay} \otimes O^p \text{pay fine}$$

We can now create chains of obligations started by a given set of literal and giving the actor a chance to stay compliant even if an obligation was violated [Governatori and Rotolo 2010b].

3 Business Process Model and Notation v2.0 a Graphical Representation of Business Processes

The Business Process Model and Notation version 2.0 is a standard set by the Object Management Group which provides a tool for businesses to model and understand their internal business processes. As it is a graphical notation it helps in the understanding and collaboration between businesses and organisations [Object Management Group 2014]. The 2.0 version of the standard is the version of maturity. It integrates with the Business Process Definition Meta-model, it makes easier the interoperability and exchange of business models amongst different modelling tools, it proposes a XML serialization of the processes and other technical details out of the scope of this document [Object Management Group 2011].

The BPMN language is easy to learn and possesses enough expression power to represent most business processes even the most complex ones. It has a lot of support, is widely accepted and is mature enough to be used by corporations in a production environment [*BPM Standards - What is new in BPMN 2.0 and XPD L 2.2*]. Some of the biggest tech companies have participated in producing the standard (IBM, SAP, Oracle, etc.) [Object Management Group 2010].

One of the main alternatives is the BPEL language. It was designed to be computationally efficient but leads to highly complex and unintuitive documents to describe complex processes. BPMN on the other hand has been made to be inter-operable between humans and not only between XML-based webservice. Thus it acknowledge the importance of the human factor in the business process worlds where most of the people don't understand properly computer systems and are used to handle business processes as flow charts. BPMN aims to reduce the gap between the specification of the business process and its execution. Therefore BPMN is a good choice for Regorus as it targets people that are not familiar with complex information systems and successfully hides the complexity of the implementation from the end user. [Object Management Group 2011]

Above is a small example of the BPMN representation of a business process. You can see how clear and straightforward this is. You don't need to understand the BPMN standard or have read the six hundred pages specification to grasp the meaning of this flow chart.

Another reason for using BPMN as a business process modelling tool is the Apomore a Java API already developed that allows us to store, represent and compute models of business processes. Furthermore Apomore is a mature, well written library that facilitates the management of large business processes and models. It also includes a presentation part which is integrated with graphiti (the eclipse plug-in library for presentation) in Regorus. With this library we can

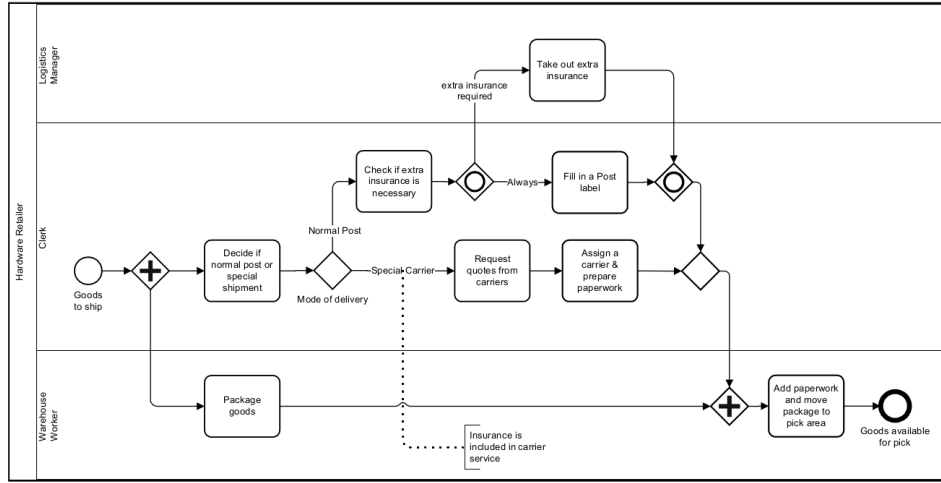


Figure II.1: A simple example of a business process using BPMN from [Object Management Group 2010]

use only one memory model for business processes from graphical specification to compliance checking [Apromore - Advanced Process Model Repository].

4 An Algorithm for Business Process Compliance

In the previous sections we described the framework used to express laws and regulations in a proper logical way. We also presented BPMN 2.0 as a tool to graphically represent business processes. Now that we have a standardized formalism on both sides we can put them together and let the magic happen. In the following we will present the business process compliance algorithm as it is implemented in Regorus and as featured in [Governatori and Rotolo 2010a].

For a given business process the algorithm starts by computing all the possible traces, all possible executions of the business process. In order to do so a reachability graph is computed first using the method described in [Mailund and Westergaard 2004]. From this are drawn all possible executions of the process.

Now that we have all possible traces we will focus on one. For each task in the trace several actions are accomplished. First a call is made to the rule engine with the informations about the task. It will return the new obligations generated by these antecedents. These new rules are added to the Current set which contains all rules in-force at a given task. We consider C as an \otimes -chain of obligations $C = B_1 \otimes B_2 \otimes A_1 \otimes A_2$. The Unfulfilled set contains all achievement and maintenance rules that were triggered but not fulfilled yet.

The Terminated set contains rules that were terminated according to the following definition from [Governatori and Rotolo 2010a]. A chain C is terminated by a task n if C was active at task n and that another rule r triggered at task n derives the opposite of C . The rule r must not be weaker than the rule that originally yielded C .

Algorithm 1 Algorithm for business process compliance [Governatori and Rotolo 2010a]

```

for all  $C \in \text{Current}$  do
  if  $A_1 = O^p B$  then
    if  $B \in S$  then
      remove( $[T, R, A_1 \otimes A_2]$ , Current)
      if  $[T, R, B_1 \otimes B_2 \otimes A_1 \otimes A_2 \otimes, B_2] \in \text{Violated}$  then
        add( $[T, R, B_1 \otimes B_2 \otimes A_1 \otimes A_2 \otimes, B_2]$ , Compensated)
      end if
    else
      remove( $[T, R, A_1 \otimes A_2]$ , Current)
      add( $[T, R, A_1 \otimes A_2, B]$ , Violated)
      add( $[T, R, A_2]$ , Current)
    end if
  end if
  if  $A_1 = O^{a,x} B$  then
    if  $B \in S$  then
      remove( $[T, R, A_1 \otimes A_2]$ , Current)
      remove( $[T, R, A_1 \otimes A_2]$ , Unfulfilled)
      if  $[T, R, B_1 \otimes B_2 \otimes A_1 \otimes A_2 \otimes, B_2] \in \text{Violated}$  then
        add( $[T, R, B_1 \otimes B_2 \otimes A_1 \otimes A_2 \otimes, B_2]$ , Compensated)
      end if
    else
      add( $[T, R, A_1 \otimes A_2 \otimes]$ , Unfulfilled)
    end if
  end if
  if  $A_1 = O^m B$  then
    if  $b \notin S$  or  $\neg B \in S$  then
      add( $[T, R, A_1 \otimes A_2, B]$ , Violated)
      add( $[T, R, A_2]$ , Current)
    end if
  end if
end for

for all  $C \in \text{Terminated}$  do
  if  $C \in \text{Unfulfilled}$  then
    add( $[T, R, A_1 \otimes A_2, B]$ , Violated)
    add( $[T, R, A_2]$ , Current)
  end if
  if  $A_1 = O^{a,\tau}$  then
    remove( $[T, R, A_1 \otimes A_2]$ , Current)
  end if
end for

```

5 Tools Already Developed : Regorus and SPINdle

The business process compliance project takes its roots back about five years ago when the first papers were published [Governatori and Sadiq 2009], [Hoffmann, Weber, and Governatori 2009]. During this time research in both the theoretical framework and its implementation have been conducted leading today to two main tools : SPINdle the rule engine and Regorus the business process compliance tool. In the following section we will portray both software, their functionalities, their use and what improvement could be made.

5.a Regorus

We already mentioned Regorus a few times before but never detailed its functionalities. In this section we will describe what are its main components and how they interact.

Regorus is a business process compliance suite that contains multiple software providing a complete environment for compliance officers. First, the rule editor that offers a web interface to write defeasible rule. It is very easy to use and provides lots of features (auto-completion, English translation of defeasible rule, export rules in XML or DFL) making the rule edition clear and effortless even for people not familiar with defeasible logic. Second, the eclipse plug-in focuses on the business process modelling part. It is possible to create and annotate business processes and check for compliance. It uses the broad APIs of eclipse for graphical modelling and the Apromore library to integrate BPMN 2.0 shapes. Finally the core library is where the business part is happening. It has multiple point of entry for the other software in the suite to interact with it. It offers a complete and comprehensive list of functions for business process compliance checking.

Regorus is a complex software written in Java and uses multiple third-party libraries. It is hard to get a global understanding of all its components. Some of the external libraries don't get much support or are breaking their APIs leading to an ever ending effort of keeping the software up to date with the major releases. This contributes to the complexity of Regorus especially when trying to build it from source. I will explain in more details the work of porting the eclipse plug-in to the new major release of the Eclipse API in a ulterior section.

Regorus is about to undergo major changes in its core and eclipse plug-in parts to implement temporal defeasible logic in the code. New notations and semantics will have to be added to the code-base. At a smaller level I contributed to the extension of Regorus by implementing cooccurrent obligations in both the core libraries and the rule editor.

5.b SPINdle

SPINdle is the rule engine that computes the consequences of a defeasible theory. It derives obligations and facts from literals that can be obtained from annotation on a business process. It is a free software distributed under the GNU general public license and can be used by in any project that want to leverage the power of defeasible logic. [Lam 2014]

SPINdle offers multiple interfaces to interact with it. This allows other programs to rely on this for the logical inference part as we do with Regorus. SPINdle is implemented in Java and therefore integrates smoothly with most JVM based languages. Although a web-service implementation would increase interoperability with other software, it is not an implemented feature yet.

Theories can be submitted and conclusions retrieved using XML or DFL (a specific formalism to describe theories and conclusions). It also gives interfaces for users interested in implementing their own parsers. Using this loosely coupled setup adds makes the use of SPINdle very agile as when there is a change in regulation you only need to change your DFL or XML file and not touch the SPINdle code.

In the specific use case of Regorus and business process compliance, SPINdle is called to get conclusions at each task of all the traces for a given business process. Consequently, SPINdle is highly optimized using algorithms proposed in [Maher 2001] in versions 1.X.X and an improved version [Lam and Governatori 2010] in versions 2.X.X leading to better performance.

The next major release of SPINdle will include support for temporal defeasible logic. This leads to sizeable changes in the core algorithm computing the conclusions of a theory but also in the input method as it needs to include new notations and semantics.

II Adding Features to Regorus

1 Implementing Cooccurrent Obligations

As introduced earlier there is different types of obligation in defeasible logic. This wide range allows us to model precisely and accurately a large number of business processes and rules. However some shortcomings have been spotted leading to imprecise modelling and the need for a new obligation.

1.a Presentation of the Problem

Let's first introduce an example to underline the lack of appropriate obligation. Taken from the Australian privacy act when needing personal information from someone it must be given by the person himself. We could model this rule with a punctual obligation like this :

$$r1 : \text{Need Personal Information} \Rightarrow [\text{Op}] \text{Get it in person} \quad (\text{II.1})$$

In the current implementation of the compliance checking algorithm if the effect of the task triggers the rule $r1$ then the obligation is carried on to the next task where it will be checked in the Current obligation set. In our example that does not really make sense since once we get the information we should check *in the same task* is the information was taken personally or not.

To be able to precisely describe this kind of behaviour we need to introduce a new type of obligation, Cooccurrent Obligation. This represent an extension of punctual obligation which must be fulfilled in the same task where it was triggered. The addition of this new obligation forces us to modify the implementation of the software in the core packages to check compliance as well as in the editor part to let the user add this kind of obligation to their implementation of rules.

First let's see how this new type changes the core compliance checking algorithm :

For now the compliance checking algorithm works in five main steps for each task of the business process :

1. Get the obligations generated from the previous task
2. Get the effects of the current task
3. Generate new effects
4. Check compliance with the given obligations and effects
5. Generate the new obligations for the next task

We need to make a few changes to take into account the new type of obligation. First, in the generated obligations look for Cooccurrent obligations then check these obligations on the literals just generated and see if there is a violation. If this is the case then the chain of reparation is marked as activated and checked for compliance in the task.

As we said before cooccurrent obligations are close relatives of punctual obligations this allows us to leave the compliance checking algorithm and related routines unchanged and just call it again with the freshly generated cooccurrent obligation as punctual obligations and the new effects. To sum up we add three new steps to the pseudo algorithm introduced previously :

1. Get cooccurrent obligation from the set of new obligations
2. Call the compliance checking algorithm to check compliance with the new effects and the cooccurrent obligations
3. Generate new obligations for the next task and forward

Now we need to take into account violation and compensation. If a cooccurrent obligation is violated and if it is part of a compensation chain we will check the rest of the chain in the very same task it was activated.

1.b Implementation in the Codebase

The implementation of the compliance checking algorithm is located in the core library of Regorus in `AbstractSessionImpl.java`. The implementation was fairly straightforward as the existing code was very close to the theoretical algorithm presented earlier. The logic is to identify cooccurrent obligations in the results of SPINdle then put those in the current obligation set so that they are checked in the same task and then add an `if` statement to handle the cooccurrent logic as explained above.

Also I added cooccurrent obligations to the types of obligations already implemented in `ObligationType.java`. All obligations types are created using a single private constructor :

```
private ObligationType( final boolean aAchievement, final boolean aPersistent,
                        final boolean aPreEmptive,  final boolean aMaintenance,
                        final boolean aPunctual,     final boolean aCooccurrent,
                        final String aDisplayName,   final String aModeName);
```

This constructor only sets the associated fields with the value given in parameters.

Static final shortcuts are provided that return any type of obligation. For example in the cooccurrent case :

```
public static final ObligationType COOCCURRENT =
    new ObligationType(false, false, false, false, false, true,
                      "Co-occurrent_Obligation", COOCCURRENT_MODE_NAME);
```

Is also featured some helper functions that had to be modified to include cooccurrent obligations. These are :

- `String` identifiers for different types of obligation ("`OC`" for cooccurrent, "`OANPNP`" for non-persistent, non-preemptive achievement obligations, etc.),
- An array of `String` containing all the obligation modes names
- `public static ObligationType fromModeName(final String aModeString)` which returns an obligation from the `String` representing the obligation's mode.

Changes were also made in the rule editor to be able to create rules using cooccurrent obligations. I added cooccurrent obligations to the auto-completion feature so that this new type is proposed to the user when drafting rules. I also added cooccurrent obligation in the part that interfaces with the core library of Regorus. The work done was mostly, as shown above, searching how features were implemented, understand the algorithms and add the new type of obligation. This was not an easy task since multiple programming languages were involved (Java, Groovy, JavaScript, Scala). I had to adapt to very different situations and train myself on these languages in order to gain a basic understanding of them.

2 XOR Splits and the Condition Associated to Them

In order to be able to implement conditional splits in business processes it is necessary to have XOR splits and corresponding XOR join. Unfortunately with this mandatory tool for business process modelling comes some issues, especially with punctual obligations, that we will try to tackle.

First let see how XOR nodes behave in business process modelling with a little example from a demonstration video of Regorus [NICTA 2012].

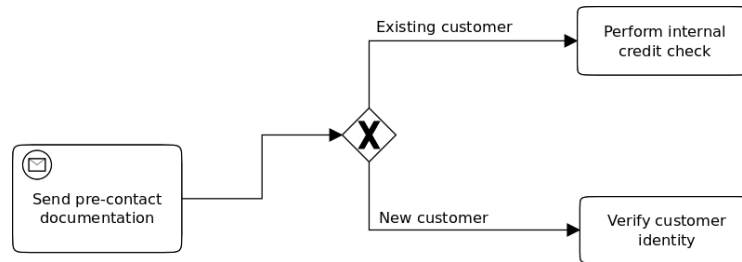


Figure II.2: A simple example of XOR split

This sample shows an important feature of the XOR nodes : annotations on the edges. When checking compliance all the possible executions of a given business process are computed which mean in one case we will have *Existing Customer* as an effect and in another thread we will have *New Customer* as effect. The issue is in the way we take these effects into account to check compliance in the following tasks.

For now Regorus puts “dummy nodes” between the XOR split and the first task as shown in the following illustration.

But a better behaviour would be to take these directly into account without the need for dummy nodes. Indeed punctual and cooccurrent obligations cannot be handled properly in this case. If the node before the XOR split yields an punctual obligation like this one $p \rightarrow [Op]q$ then with the actual implementation the obligation will be checked in the dummy nodes when it should be checked for compliance in the first “real” node following the XOR split.

Again for cooccurrent obligations if the effect associated with the edge of the XOR split yields a cooccurrent obligation like $p \rightarrow [Oc]q$ then it will be checked on the dummy node when it should, once again, be checked for compliance in the first “real” node following the XOR split.

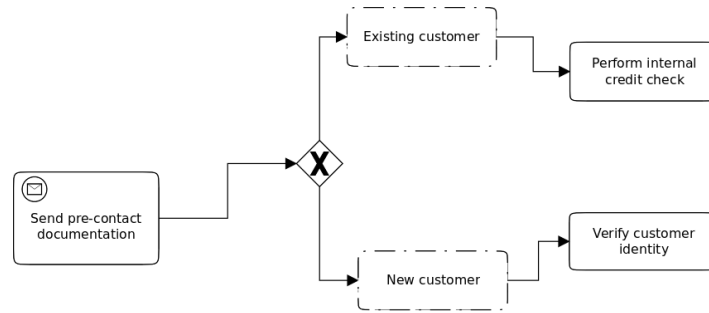


Figure II.3: Illustration of the “dummy nodes” added by regorus

We chose to follow these steps to implement this desired behaviour :

1. Identify the XOR splits in the business process graph.
2. When on a XOR split make a call to SPINdle to generate the obligations triggered by the effect associated with the edge.
3. Forward the new obligations to the next node without calling the compliance checking algorithm.

The problem is that neither the XOR splits or arcs as represented in the bpc core libraries include fields to store conditions. It’s therefore impossible that the information about the condition is stored in the core. This leads me to think that the dummy node thing is done in the eclipse plug-in then a business process graph with dummy nodes is handed to the core library.

I was unsuccessful in locating the part of the eclipse plug-in that was doing what I described just before. What would be interesting is to follow the trace of a business process from the design in the plug-in interface to its translation with the Aprimore library to its handling by the core libraries. This could help us understand where these dummy nodes appear and where we should implement the desired behaviour.

Unfortunately, I didn’t have the time to finish solving this problem. I laid down possible tracks to follow in order to find a solution above. I think I lacked experience searching through huge code and not enough practice going through classes to find a special behaviour. What makes it even harder with Java and other imperative languages is that the name of the function gives absolutely no guarantee whatsoever about the actual implementation of the function. Maybe going towards a more functional and strongly typed language such as Haskell for the core library could reduce dramatically the size of it and definitely improve readability. Sadly this would be done at the expense of interoperability with pre-existing Java libraries.

Nevertheless I gained a lot of practical experience trying to solve this problem and discovered new features of the eclipse IDE that I didn’t know of before. This is a very valuable first encounter with production software and it highlighted the importance of clean, modular code for future projects of my own.

3 Porting the Eclipse Plug-In to the Kepler Version of Eclipse

New releases come with their burden of broken APIs and unresolved functions names. Eclipse is not an exception for that matter. The Eclipse plug-in code has not been touched for two years so when I tried to compile and run it on my machine I stumbled upon a lot of errors. Like other complex software the eclipse plug-in depends on some third-party library to work properly. These evolved quite a bit over time to a point where function that once existed were not even referenced in the last version.

From the moment when Regorus was modified for the last time and the moment I took it back two years had passed. Most of the third party libraries had changed versions. At first I wanted to get everything to work with the latest versions but seeing the number of errors this yielded I reduced my objective to only port the plug-in to the new eclipse libraries. This was already a challenge.

I won't get into much details about the what I had to change to make the plug-in compile again. I will rather explain what this experience taught me as a software engineer.

The *graphiti* library is a component of the "Eclipse Modelling Framework". As one of the main feature of the plug-in is to be able to draw business process, it relies on this library. Like other eclipse core libraries it is pretty well documented and the javadoc is easily available online. Maybe too easily available as there was javadoc websites for every version of eclipse which was a bit troubling at first. After a while, I found the right version that could explain the errors I had on my IDE (One of the methods the code was using wasn't referenced any more in the Kepler version of the library and the type calling this method was marked as deprecated). Even though the new methods were documented, nothing was said about why this had been deprecated and how it was possible to work around this. I eventually found a workaround for my problem but it taught me a great lesson for future software documentation I may write : always not only document what you changed but also why or to what purpose you changed the library.

During this exercise I familiarized myself with build tools such as maven which manage dependencies and make the building process painless. Although from a developer point of view it can be a real mess especially because it relies on hard-coded urls to get the dependencies which can yield 404 errors if the website has changed. This means manually changing the address in the configuration file. Maven with ant are however the de-facto tools for automated building Java applications and it was interesting learn more about them. Once again this is something that can only be covered in a production environment and is hard to actually introduce in class.

This task presented me a part of software development we rarely talk about in class : production environment and dependency management. Developing a software that is portable is really important and it must be a very important concern. Will the libraries I use be available for future developers ? Are the maintainers of these libraries care about backports or keeping legacy software usable ? These are questions a developer should always ask himself and even more difficult to enforce in a Java environment. Sometimes it is better to implement a less good feature with strong, supported libraries.

III Extending the Theoretical Model by Adding Time

We have seen before that obligations in regulations are often closely related to the notion of deadlines for example the obligation *Pay before ten days* holds a deadline information. Defeasible Deontic Logic with BPMN 2.0 as implemented in Regorous is a powerful tool to deal with business process compliance. However defeasible deontic logic does not handles time and deadlines by design. Sure it is possible to use facts as ersatz for time for example the rule introduced before can be modelled as : $r : \neg \text{moreThan10Days} \Rightarrow O_a \text{Pay}$ and this could translate in a task of the business process having the literal $\neg \text{moreThan10Days}$ attached but there is room for improvement.

1 Motivation for Adding Time in Defeasible Logic

Adding time in defeasible deontic logic is a much anticipated feature because it implements at the source the essence of deadline allowing us, as we will see later on, to represent obligation types elegantly. In [Governatori and Terenziani 2007] extensions to include time in the logic are proposed and we will use these semantics and notations.

Moreover time in the framework is expected to improve the computational efficiency of the system. For now we check compliance at each task of the business process collecting the new rules and forwarding them to the next task. With time we could do all of this at once. With temporal rules we would only need to create traces which would yield a set of temporal literals and check this set against the set of temporal rules. Let's take the following little example :

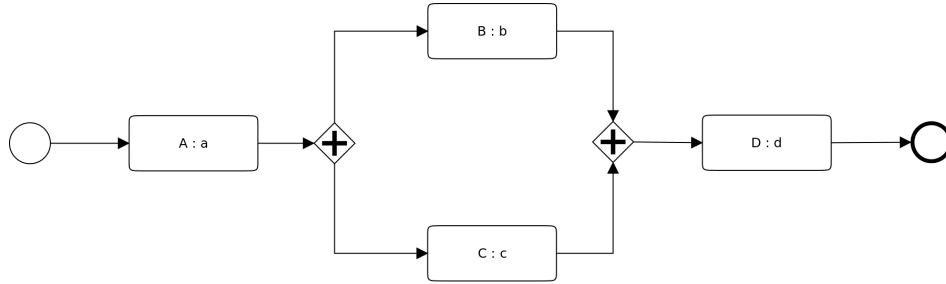


Figure II.4: A simple Business Process example to highlight the advantages of adding time

For this example we would first compute all the possible traces which gives us two possibilities either $A \rightarrow B \rightarrow C \rightarrow D$ or $A \rightarrow C \rightarrow B \rightarrow D$. Now that we have linear processes we go through each task, accumulate effects, derive rules in force, check for compliance and then forward effects and obligations to the next task. For a trace of size n we have to do each operation n times.

If we add time though, we only need to do the computation once for any process size, this is a huge win for scalability. This time we can annotate effects attached to task with the task number in the trace or let the user use its own annotations, we then go through the process once to accumulate all the effects, finally we check compliance against temporal rules using temporal defeasible logic.

2 Temporal Formalism for Deontic Defeasible Logic

[Governatori and Antonino 2011] introduces new notations, semantics and concepts to deal with time in deontic defeasible logic. They represent time as a discrete linear order of instants $\mathcal{T} = (t_1, t_2 \dots t_n)$.

The following list sums up the notations introduced in [Governatori and Antonino 2011] and their semantic :

- if l is a literal then l^t is a temporal literal. We will refer to the set of temporal literal as $TLit$. We also introduce \top and \perp which are also temporal literals, they are propositions that are respectively always complied with and never complied with
- if l^t is a temporal literal then Ol^t and its negation are deontic literals meaning that the obligation to do l holds at time t . We will refer to the set of deontic literals as $DLit$
- if a^{t_a} and b^{t_b} are temporal literals, $t \in \mathcal{T}$ and $x \in \{a, m, p\}$ then $a^{t_a} \otimes_t^x b^{t_b}$ is an \otimes -chain used to express chain of reparation in laws
- if α is an \otimes -chain, t and $t_a \in \mathcal{T}$ and a^{t_a} is a temporal literal then $\alpha \otimes_t^x a^{t_a}$ is an \otimes -chain. A deontic expression is an \otimes -chain composed of temporal literals or sub- \otimes -chain and finishing with \perp

An \otimes -chain like $\alpha \otimes_t^a a^{t_a} \otimes_{t'}^y b^{t_b}$ means that the violation of α triggers an achievement obligation from t_a to t' .

Temporal defeasible logic also defines new defeasible proof conditions. 2 shows when a rule is applicable at index i , meaning that the obligation at index i in the \otimes -chain is in force.

Definition 2 *A rule r is applicable at index i in a proof P at line $P(n+1)$ iff*

1. $\forall a \in A(r)$
 - (a) if $a \in TLit$, then $a \in F$ and
 - (b) i. if $a = Ol^t$ then $+\partial l^t \in P(1..n)$
 - ii. if $a = \neg Ol^t$ then $-\partial l^t \in P(1..n)$ and
2. $\forall c_j \in C(r), 1 \leq j \leq i$
 - (a) if $mode(c_j) = punctual$, then $c_j \notin F$ or $\sim c_j \in F$
 - (b) if $mode(c_j) = achievement$, then $\forall t, start(c_j) \leq t \leq end(c_j), c_j^t \notin F$ or $\sim c_j^t \in F$
 - (c) if $mode(c_j) = maintenance$, then $\exists t, start(c_j) \leq t \leq end(c_j), c_j^t \notin F$ or $\sim c_j^t \in F$

In [Governatori and Antonino 2011] different proof conditions are defined for each obligation type. In 3 we present them in a condensed form. x is used to represent the mode of the obligation, it can be replaced by one of a, m, p .

Definition 3 *If $P(n+1) = +\partial p^t$ then*

1. $\exists r \in R_{\Rightarrow}^x [p^t, i], r$ is applicable at index i

2. $\forall s \in R[\sim p^t, j]$ either
 - (a) s is discarded at index j
 - (b) $\exists w \in R_{\Rightarrow}^x[p^t, k]$, w is applicable at index k and $w \succ s$
3. $\exists x \in R_{\Rightarrow}^{a,m}[p^{t'}, i']$, $t' < t$, $\text{end}(t') \geq t$
 - (a) x is applicable at index i' , and
 - (b) $\forall y \in R[\sim p^{t''}, j']$, $t' \leq t'' < t$ either
 - i. y is discarded at index j' or
 - ii. $\exists z \in R[p^{t''}, k']$, z is applicable at k' and $z \succ y$; and for $+\partial^a$
 - (c) $\forall t'''$, $t'' < t''' \leq t$, $p^{t'''} \notin F$.

Conditions (1) and (2) are enough to defeasibly prove a punctual obligation. (3) only applies for maintenance and achievement obligations. The final line (3.c) only applies to achievement obligations where fulfilment terminates the obligation.

3 Proving that Defeasible Logic and Temporal Defeasible Logic Reach the Same Conclusions

It is important to prove that given the same process and rules both versions of defeasible deontic logic with and without time reach the same conclusions about compliance. This allows us to confidently move on to the implementation of the compliance checking algorithm in temporal defeasible logic.

A defeasible theory is defined by the tuple $(F, R, >)$ where F is a finite set of literals, R a finite set of rules and $>$ a superiority relation on R . In the context of business process compliance we consider $S_1..S_n$ sets of literals representing the literals attached to every task. Therefore for each task we have a different theory. At task n we have $F = \bigcup_{i=1}^n S_i$, the set of rules stays the same although the obligations in force can change from one task to another.

A temporal defeasible theory is not so different from its classical counterpart. It is defined by the tuple (F^t, R^t, \succ) where F^t is a finite set of temporal literals, R^t is a finite set of temporal rules and \succ is a superiority relation on R^t . The Facts and Rule sets are dependent of the current task in a given trace. We highlight this dependence in the following.

We are defining the \mathcal{T} operator which takes a defeasible theory and a point in time and returns the temporal equivalent, formally defined as :

$$\mathcal{T} : \mathbb{N}, (F, R, >) \rightarrow (F^t, R^t, \succ) \quad (\text{II.2})$$

Every literal in F is temporally annotated with the task number it is attached to. We know that at a given task F is the union of the previous S_i therefore at a given task t we have.

$$F^t = \{q^t \mid \forall q \in S_t\} \quad (\text{II.3})$$

Every rule in R is basically translated by annotating temporally with the current task number all its antecedent and consequent. Hence the temporal rule arising from a classical rule depends on the task number in a given trace. For each task in every possible trace we define a set of temporal rules corresponding to the body of “classic” rules. All of the antecedents and effects of the rules are annotated with the task number which will play the role of time as the set of task numbers is isomorphic to \mathbb{N} which is a perfect candidate for time. Since defeasible deontic logic does not include deadlines we transform achievement and maintenance obligations to permanent ones defining a parametric deadline using the *viol* operator.

Let’s first introduce the mode function, an utility operation, that returns the mode of a given obligation :

$$\text{mode}(O) = \begin{cases} a & \text{if } O \text{ is an achievement obligation} \\ p & \text{if } O \text{ is a punctual obligation} \\ m & \text{if } O \text{ is a maintenance obligation} \end{cases} \quad (\text{II.4})$$

Here we will show how the set of temporal rules R^t is derived from the set of classical rules R . First in II.5 we define a general form for classical rules we will use to define how we translate to temporal rules.

$$\forall r \in R, \quad r : a_1, \dots, a_n \Rightarrow p_1 \otimes \dots \otimes p_m \quad (\text{II.5})$$

Let me introduce in ?? one of the tools we will need for this demonstration the *naf* operator. It stand for negation as failure which means that we failed to prove an element. It is defined practically as :

$$\begin{aligned} r_1 : \quad & \Rightarrow \text{naf } p \\ r_2 : \quad & \neg p \Rightarrow \text{naf } p \\ r_3 : \quad & p \Rightarrow \text{naf } p \\ & r_3 > r_2 > r_1 \end{aligned} \quad (\text{II.6})$$

In other words we have *naf* p either when p has not been concluded or $\neg p$ has been concluded. If p is concluded then this rule is stronger than the other two and we conclude $\neg \text{naf } p$

For demonstration purposes we introduce in II.7 the *viol* function which takes an obligation and returns the index of the task where it was violated. If the obligation is never violated it returns the index of the last task. This will allow us to express chain of reparation from the classical framework where no deadlines are defined into the temporal one where we need deadlines. This *viol* operator will create artificial parametrized deadlines for chain of obligations as it will be presented next.

$$viol(X) : Obligations \rightarrow \mathbb{N} \quad (II.7)$$

- For a maintenance obligation $O^m p$, $viol$ will return the index of the first task where the obligation is applicable and we can conclude $naf p$.

$$\begin{aligned} &\text{At task } i \text{ if we have : } O^m p, naf p \in Facts \\ &\text{then : } viol(O^m p) = i \end{aligned} \quad (II.8)$$

- For an achievement obligation $O^a p$, $viol$ will return the index of the first task where the obligation is applicable, we can conclude $naf p$, and the obligation is lifted at the next task (this can be done with defeaters).

$$\begin{aligned} &\text{At task } i \text{ if we have : } O^a p, naf p, \neg O^a p \in Facts \\ &\text{then : } viol(O^a p) = i \end{aligned} \quad (II.9)$$

- It is not necessary to define $viol$ for punctual obligations since they are always violated or fulfilled at the task after they were triggered. For example $O^p p$ is triggered at task i then it is either complied with or $viol$ will return $i + 1$.

Now we will show how we translate temporally each of these rules, given a classical rule r in the form defined in II.5 at a given task t the set of temporal rules is composed of rules.

$$\begin{aligned} r_i : & \quad a_1, \dots, a_n \Rightarrow p_1 \otimes \dots \otimes p_m \\ r_i(task) : & \quad a_1^{task}, \dots, a_n^{task} \Rightarrow^{mode(p_1)} p_1^{task} \otimes_{viol(p_1)}^{mode(p_2)} p_2^{viol(p_1)} \dots \otimes_{viol(p_{m-1})}^{mode(p_m)} p_m^{viol(p_{m-1})} \otimes \perp \end{aligned} \quad (II.10)$$

Consider sets of obligations from the algo Now we are considering the sets of obligation we find in the algorithm for business process compliance checking. In this we find at each task three main sets of obligations and literals : Current, Violated and State. They contain respectively obligations in force at the given task, obligations that were violated in previous tasks and deontic literals attached to the current or previous tasks. We aim to prove that the transformation of these sets from “classical” formalism to temporal is isomorphic and our transformation bijective. All these set are depending on the current task we consider, they will be referred as : $Set(n)$

First let's prove that

$$\text{if } p \in State(n) \text{ then } + \partial p^n$$

this is trivially proven by definition of our translation where every literal associated with a task is annotated temporally with the task number in the trace. Therefore if p is in the $State(n)$ it has been proven at a step $(1..n)$.

Now what about

$$\text{if } q \in Current(n) \text{ then } + \partial Oq^n$$

If an obligation is in force at a task n in the “classical” formalism is it also in the temporal one, in other word is the rule applicable at the index where it triggers q . If q is in the set of current obligation it means that there is a rule r that yields q at task k and that this rule was fired meaning all of the antecedents have been proven. In other words :

$$\begin{aligned} &\forall a \in A(r), a \in \text{State}(k) \\ &\text{so if } a \text{ is a literal then } a \in \text{Facts} \\ &\text{or if } a \text{ is an obligation } Ol \text{ then } +\partial l^{1..k} \end{aligned}$$

Or, the conditions on the Antecedents for a rule to be applicable are :

- if the antecedent is a littéral then it must be in the Facts (attached to a previous task)
- if the antecedent is an obligation then it must have been defeasibly proven beforehand.

Both conditions are met so the rule would also trigger in temporal defeasible logic. Now we have to see if it would trigger at the right index in the \otimes -chain.

If $q = Ol$ is part of an \otimes -chainlike $A_1 \otimes .. \otimes A_n \otimes q \otimes B_1 \otimes .. \otimes B_n$ and if q is in current that means that for all obligation A_i , $-\partial A_i$ has been proven for a previous task $(1..k-1)$. Let m be the task where the rule was triggered first. Which translates into :

- for punctual obligations this means we either have $\neg l$ at task k when the obligation was triggered or that l was not in the State set at task k .
- for achievement obligations this means that we have $\neg l$ at a task between m and $k-1$
- for maintenance obligations this means that we either have $\neg l$ at a task between m and $k-1$ or that l was not in the State set at a given task between m and k

Whatever the obligation this means that at some point we were able to conclude $-\partial A_i$ for all the obligations before q which means that the rule r is also applicable at the index where it triggers q implying that q is also in the set of Current obligations in the temporal formalism.

We can easily translate this reflection to the Violated set. If a obligation Ol is in the violated set this means that at some task between $1..n$ we have one of the three conditions aforementioned for each type of obligation. Which trivially translates into being able to prove $-\partial l$ at some task $(1..n)$ implying that the obligation is also in the Violated set in the temporal formalism.

We have proved that the sets we have in the algorithm for business process compliance stays the same when we translate a theory from the classical to the temporal defeasible logic. This means that a business process that was (non-) compliant in the classical framework is also (non-) compliant in the temporal one. We have a consistent model from a non-temporal to a temporal formalism.

Technical Conclusions

This end-of-studies internship has been a wonderful journey far from my comfort zone. Working in a research environment was a brand new experience topped up with English-speaking surrounding and multicultural workplace. The work I have been asked to do was very demanding and I learned a lot both personally and professionally.

On the professional level I learned plenty of new techniques and theories. This trained a lot of skills that I think are the core ones for an engineer. First I had to be operational on new theories quite fast, processing documentation and research articles in an efficient manner and using this knowledge in my work. During this process I realized that being a bit slower and really understand something can save a lot of time later.

Moreover, the work that I had to do was very demanding and necessitated quite some analysis skills especially when going through vast code-bases. Through this I had the opportunity to learn and apply procedures related to production software and work on a full scaled, professional grade software.

Finally, writing my article taught me that not only I needed to be competent and productive with the technologies but also capable of presenting work of the highest standard. Therefore I has to work on my written English to produce quality contributions.

On the personal level this experience was also demanding. First and foremost, working all day long in an English speaking environment showed me the shortcomings of my English especially the technical one. More profound than the language it was also an incredible cultural experience. I experienced how different the Australian culture is from the French while seeming so close. And all of this was personally very enriching.

Most importantly, during this project I was faced with overwhelming challenges and problems that I had to solve. I often felt powerless in front of those but I was able to find comfort in the basics of the scientific method. I divided and conquered, I cut the problems to pieces, smaller problems that I could solve and then built a solution with those. This was a very valuable lesson as an engineer, no matter how big the problem, I can split it into smaller pieces and try to solve it.

After all this, I feel ready and capable to evolve as an engineer in a firm. I realize what are my limitations and what I need to work on to overcome these. I also appreciate what are my key strengths and skills that I can leverage to surmount problems. To sum it up, at the end of this experience I know myself better as a person and as an engineer and I feel ready for the next steps after graduation.

III | Strategic Reflection on Regorus

I Business Process Management and Compliance

Business processes are at the center of any corporation. They have an influence on everything the company produces or services. They model the work of every employee by determining tasks, jobs and responsibilities. A firm that is aware of its processes can adapt faster and painlessly to change in the market or to new regulations. Despite these clear advantages, business processes have been overlooked for a long time by both the academic literature and the businesses [Dumas et al. 2013].

Global markets more competitive than ever, the need to communicate in a scattered market of technologies and the will for any organization to innovate lead to a reflection in the corporate world to try, adjust and optimize the organizations. This ultimately highlighted the importance of business processes and led to the creation of Business Process Management to unify and strengthen previous approaches from different disciplines [Dumas et al. 2013].

Compliance is a growing concern for any company, it represents on average 4% of the annual expenses [International Business Times 2011]. From the same source, CEOs of surveyed companies admit that compliance is a major cost centre, that has been expanding in the past few years. We are in a situation where businesses have to comply with new regulations that are changing more often. But they are still to find an agile, effective and flexible way to do so. Business process management could help a great deal in this matter [Goedertier and Vanthienen 2006], [Dumas et al. 2013], [Jeston and Nelis 2014].

Revision of regulations is a game changing factor for all companies in a given industry. If we add more flexibility and agility in the compliance world with tools such as Regorus that encourage a compliant-by-design approach for business processes and provides powerful algorithms to check compliance of existing processes, then, corporations could take advantage of this change in rules to gain a strategic advantage over their competitors.

Also most business don't have explicit business processes when, as we exposed in the previous paragraph, it could help them be more efficient and flexible. We will develop the power of explicit business processes for any institution later when we draw a parallel with knowledge management. Business processes, although often seen as rigid, are a real opportunity for any company to be more reactive to change in an always-evolving world.

Finally by releasing companies from the burden and high cost of compliance, money can be better invested especially in innovative activities. Therefore a better management of business processes and compliance contributes to innovation.

Current research in business process management is taking the problem from different angles. A first topic of interest is business process mining where business process management is used as an intelligent IT system. Business processes are automatically generated from the ever-growing data generating from working businesses. From these explicit processes researchers are working on intelligent systems that would give guidelines and propose optimizations of these processes. [Bae 2014] presents a concrete example of how processes can be improved by these techniques. Of course to express all these processes, powerful, efficient modelling languages are needed and this is another subject of research. Finally the field in which I conducted this project, compliance, is making sure that processes are compliant with regulations with the advantages mentioned earlier.

II A Critical Summary of the Work Done

In this section we will aim to summarize previous attempts to commercialize Regorus and to penetrate the compliance market. Multiple opportunities have presented themselves but non of them have succeeded yet. For each of them we will briefly expose the strategic decisions that were made and expose areas for improvement. Though, we will not cite any names for confidentiality reasons.

1 Historic

Since the product was ready for production use in mid 2012, several companies have expressed an interest in integrating Regorus in their compliance teams' workflow. Unfortunately, all these attempts have failed so far. In the following section we will present the previous tries to market Regorus and for each of them try to understand what failed and what are the key strength of Regorus from a business point of view.

The first and real contact was with an Australian telecommunication company (later referred as telco). The telecommunication business in Australia is very large. There are more than 2000 firms ranging from Vodafone or Optus who are huge businesses that reach 95+% of the population to small service providers or system integrators that have 20 or so clients. All these businesses are under the obligation to comply with regulation written by Communication Alliance and enforced by Communication Compliance under the supervision of the Australian Communication and Media Authority.

If Communication Compliance finds a business that is not compliant then it can be put under the scrutiny of the ACMA and be fined or even have its license removed. Therefore compliance is a serious matter for telcos in Australia. The biggest ones are required to be audited by a private third-party auditor when the smaller ones have to ensure compliance by themselves. This is a hard task with very little help from the compliance body apart from some spreadsheets. Thus,

lot, if not all telcos are operating in a grey area where they do not know if their processes are compliant or not, most of them don't even have explicit processes.

A medium size telco CEO visiting a NICTA showcase interested in a compliance system to make up for this less than ideal system showed interest in Regorus. After a demonstration of Regorus she was convinced enough to ask for a trial in her company. The trial was organized around three workshops. The first one was a presentation of Regorus and the underlying theory. The audience was composed mainly of people from the complaint department. Although it was the first time they were exposed to this kind of software the reception was good. The second workshop was focused on helping the staff to model their current processes as they were. In the meantime people at NICTA were implementing a subset of the regulation regarding complaints to check the processes against. During the third and last workshop compliance of processes was tested and yielded interesting results. Some errors were due to incorrect annotations, implementation errors but it also revealed some compliance issues where a redesign of the process was needed.

This workshop was a great opportunity to showcase the power of Regorus on the very same processes these people were working on. This training was a fast and effective introduction, in only three afternoons they were able to understand the basics about the software, how to model their processes and check compliance. These meetings were another indicator that the technology was ready to be shipped into production environment. It also showed that the software was usable by end users with no prior experience with that type of application, they were able to annotate processes, check for compliance, understand the informations and the errors thrown at them, etc.

On a strategic point of view it seems that the end users are particularly interested in the product and that the set-up cost is low, only three half-day seminar were enough to launch a team and teach them how to use the product. Although it is hard to conclude anything from one point of data, it seems fair to say that the low set-up cost is an advantage for the product penetration.

After that, a decision was pending from the certification body, communication compliance, to use Regorus as the compliance checking tool for all small to medium telcos, this represents 90% of the market in number and around 20% in value [Budde, McNamara, and Paul Budde Communication Pty. Ltd 2012]. This was a great idea to target a certification body and have our product advertised by them or even more in that case, a mandatory use of the product. Indeed, the system used at that time was obsolete, it consisted of simple questionnaires on excel spreadsheets to be filled by all telcos. This is a reactive method far from the proactive, compliant-by-design approach of Regorus. Once again, the people who would be actually using Regorus on a regular basis were very happy with the software and were pushing for its adoption. They were also tired of and rejected the actual system.

At this point everything seems good for Regorus, end-users are happy with the product, the technology is ready, present systems are obsolete and far less effective than ours and end-users are craving it.

Unfortunately the final decision from the certification body was a no go. The reason given by Communication Compliance was that they were not willing to invest time and money in training all the telcos. I think that one strategical mistake was made here. Instead of targeting

the decision makers in the company, it was end-users that NICTA tried to seduce hoping that adoption from them would pressure decision takers. This kind of strategy might work in a technological or research environment where end-users have more skills than the managers and therefore are trusted for decisions concerning the use of one's product. But in this case, even though we had a great success with the end-users and even with their direct management, the real decision makers were not satisfied as they have very different objectives. The question is how to seduce, convince these people to change for our software ? We will discuss this further in the section dedicated to market penetration and marketing research.

After the telcos, a few other contacts were exploited but lead to nothing concrete. Until a big Australian insurance company showed interest in Regorus. A few meetings were organised with the people on the field, that would actually use the software. Once again, they were very interested in it, saying that it would save them a lot of time and solve some of their problems. However when NICTA asked for a few man-hours to conduct trainings like it had been done with the telco, the upper management refused to. The height of all this is that this very company was fined tens of millions of dollar for non compliance by the regulation authority a few weeks after this.

Lastly, an important consulting firm also showed interest in Regorus and was given an instance to play with. Unfortunately, once again, this is not followed by a commitment from the management to go with and implement Regorus in their workflow.

2 Comments

All this historic part have been written using detailed documentation from the development team who put a lot of thinking into this. They used classical models to try and pinpoint the right customers and the competitors, to analyse the global industries that would be keen on using Regorus, to explicit the business model of Regorus using the business model canvas and many other attempts. What we found was missing is an actual discussion with the people in the industry they were targeting.

Added to that, the industries targeted by regorus are very different from the ones NICTA teams are working in. A better understanding of the dynamics, habits and culture in these economical sectors would be of great help in the commercialization of Regorus.

Furthermore, we expect that a multi-sided platform business model for Regorus would be a great fit. So far this platform way of thinking has not been though of and this model can give better insights on the actual dynamics of the market. We will expand this in the next section.

All of the above points can be addressed by a qualitative marketing research. As we will see in the dedicated section, this kind of marketing is research is focused on the why which is what we want as we are trying to gain a better understanding of these subjects. This research can also highlight points we didn't even knew we were ignoring, these can be further studied later on.

III Finding a Business Model for Regorus

As discussed above, private companies have been keen in the past on integrating Regorus in their processes. Unfortunately it never went through approval from key individuals in the companies. In the following section we will try to find in which existing business model Regorus could fit and what are the side effects of its use in an organisation. First we will look into Two-sided markets then we will explore how good Regorus is as a knowledge management tool.

1 Two-Sided Markets

Two sided markets are found in many industries but they are particularly found in the high-tech industry. As this market is a high growing one two-sided markets have drawn, over the past decade, a particular interest from researchers in strategy and economics [Hagiu and Wright 2011]. In the following section we will first try to come up with a definition of two-sided market or platforms, then we will discuss how Regorus can fit this model. Indeed, Regorus in its essence is a tool that unites different business (law, BP management, IT) therefore it seems quite straightforward that this model could fit it. In a last part we propose different actors that could interact around our platform and unfold strategies following from these hypotheses.

1.a A Definition for Two-Sided Markets and its Dynamics

Although there is an extensive literature on the matter a precise definition is yet to emerge. It is not the purpose of this document to propose yet another one, we will try to identify key features of such a market in existing definitions and evaluate their relevance.

First, let us start with a definition from [Hagiu and Wright 2011], that defines multi-sided platforms as : “An organization that creates value primarily by enabling direct interactions between two (or more) distinct types of affiliated customers”. This definition shows us the two main things to sort out in a multi-sided platform : defining the customers and the kind of interaction they have.

Interactions and dynamics in multi-sided platforms are far from the ones in traditional markets. Here a new kind of complexity is involved : Networks effects, read non linear behaviour. Usually, the value one side of users attach to the platform depends on the number of users on the other side. This is called **cross-side network effect**. This effect can be either positive meaning that more users on one side will attract more people on the other side or negative meaning more people on one side decreases the attractiveness of the platform for the other side. Cross side effects can be positive in both way creating a positive feedback on the system (more users on one side attracts more user on the other side that attracts even more user on the other side). In such a configuration the main concern for the platform provider is to reach the critical mass, the tipping point from where the number of user on both side will grow by itself [Eisenmann, Parker, and Van Alstyne 2006]. This is the case for Groupon where the more customers join the website, the more attractive it becomes for sellers and a great number of deals is an incentive to attract more customers, and so on. However in some cases cross-side network effects are

positive in one way and negative the other way meaning that the size of one group of users increases the attractiveness of the platform for the other whereas the size of the latter decreases the attractiveness for the former. In this case the system will reach a dynamic equilibrium at some point. An example would be newspaper where the more readers attracts more advertisers but too much advertisement drives away readers. [Parker and Alstyne 2005]

There is another network effect in multi-sided platforms **same-side network effects**, it is the equivalent of cross-side effects but on one side of the platform. An example of positive same-side network effect is Facebook where more users attract even more users as people are keen on joining if their friends are already on the social network website. Unfortunately most of the platform have negative same-side network effects where more people on one side decreases the willingness to join for other users.

If we can forecast positive cross-side and same-side network effects for our platform then the main concern is how to attract the first users to our platform and how many of those do we need to reach a tipping point. We need to find an incentive to make the "penguins jump" [Kyle 2013]. Therefore, it is important to know what our customers value to be able to give them what they want. As reaching the critical mass is very important in a network environment, knowing the needs and expectations of our customers is a must.

Pricing in a platform environment is hard, we have to find a price for each side taking into account the network effects. Usually when we draw demand in function of price we have a linear curve of equation $-ax + b$ but in a platform environment in many cases the demand on one side drops very fast when we go from free to a penny. This is called the penny drop and it is why one side of the platform is generally subsidized. Because the number of users on the subsidized side is highly valued by the other side, the money put into subsidy will be compensated by the price premium we make the other side pay to access our user base. Although most of the classical examples of multi-sided platforms features a subsidized and a money side it is not always the case, if neither sides are money sensitive then we can imagine charging both sides even though one side might be charged less than if we considered a simple-sided classical market. The objective is to use the network effects and attract money side users ; therefore we first need to attract the users that the money side users value. And once we attracted these users we need to find the degree of subsidy we will offer to attract enough users and what premium we will charge the other side for the privilege of accessing them [Rochet and Tirole 2003].

An important thing to note is that the value creation in platforms is not in the idea nor in the number of user but in the interaction in the network, the activity of the users. For example Twitter's idea is worth nothing, just being able to send 140 characters messages through a web application is worthless, its user base is not creating much value either if they don't interact (by tweeting, retweeting, faving other tweets). By doing so they create value for each other [Choudary 2014]. So when looking for a business model for Regorus the quality of the software is not so much relevant. It will at best allow us to make some user jump and hopefully reach the tipping point but the real value of the platform would be the interaction between both sides. How by interacting through Regorous they are creating value for each other. This is an important point that we will consider when looking for solutions to improve market penetration [Economides and Katsamakas 2006].

Because of these non-linear effects, outcomes from multi-sided platform is hard to predict. However history gives us some insight into what we can expect given networks effects in force, multi-homing costs and users sensitivity to new features. Knowing the most likely scenario for the platform tells us if we need to fight to death because we expect a winner take all scenario or to accept competition. Table III.1 gives predicted outcomes depending of the characteristics of the platform. In the case of Regorus, with the knowledge we have of the market from previous experiences we expect a cohabitation situation where we are filling a specific need for a niche market.

Likely outcome	Strategy	Platform characteristics
Winner Take All	Fight to death	High multi-homing costs on at least one side, Strong positive network effects for the users with high multi-homing costs, Neither side have strong preference for special features.
Cohabitation	Accept competition, Find a niche market	One side at least have special needs, Low multi-homing costs.

Table III.1: Outcomes of a multi-sided platform given the platform characteristics

Finally some other assets can help to win the war for platform domination [Eisenmann, Parker, and Van Alstyne 2006] :

- Pre-existing relations with prospective users on at least one side. This helps at the very beginning when we need to attract early users expecting to feed the positive network effects. It is even more useful if our relation are with influential users in their domain.
- Reputation can also help a great deal since users are more likely to join if they can put some trust in the platform provider.
- As we need to reach a critical point for our platform to tip we are likely to subsidize users at the beginning meaning that we could lose money at first. Therefore we will need deep pockets to be able to launch our platform.
- Because once the tipping point is reached user base will increase exponentially we need to make sure our solution is scalable and wont crumble when stressed with too many requests.

2 How Does Regorus Fits the Model

2.a Possible Users of the Platform and Strategies

On one side we have :

- Big firms that already check the compliance of their processes with expensive audits by private firms. They want absolute certainty that this tool will give us reliable results and they want to be able to come back to us if it does not. They don't care about the price because they are already paying lots of money on private audits. The same-side network effects are probably positive as the more companies adopt Regorus the more others will be

willing to adopt it too. In this case the main problem is on the incentive to propose for companies to jump in.

- Small-Mid sized firms that are under complex and strict regulations but don't have the money or the manpower to have private or in-house audits for their processes. In this case they probably care a little bit about the price although saying that this might avoid them a big fine might ease things up. We could primarily target firms that were just fined for non compliance. Same effects than for bigger companies, in this case if a big, well known firm adopts Regorus then it might tempt small firms to copy. The other way around could work too if a successful start-up acknowledge Regorus as an important part of their success it might attract big businesses.

On the other side we have

- Regulation authorities that probably want the most possible compliant firms in their industry. In the past Regorus have been validated by one regulation agency (the one for telecommunication companies) which is good because we have a clear positive cross-side network effect here, the more regulation agencies saying that our product is yielding good results, creating certified rules to check processes against and especially insuring that the fact that Regorus says it's compliant is equivalent to compliance would be huge. Having a "marquee user" on one side can attract a lot of users on the other side especially if it states its commitment to our platform [Eisenmann, Parker, and Van Alstyne 2006]. What could bring user on the other side is if regulation agencies recommend Regorus to firms that have been non-compliant.
- Private audit firm could use our software when conducting audits. Because it has already been proven that Regorus is orders of magnitude faster than manually checking for compliance especially when the processes are explicit. Also they already have the expertise, the reputation and the client base.

Regorus could also leverage work from [Chesbrough 2003] and [Chesbrough and Crowther 2006] and the open model of innovation. This highlights the important role of early users or adopters of a product in the marketing strategy of a firm. They are usually power users in their fields and have a close relationship with innovative firm giving feedback and possible improvement about releases. They could help solve the diffusion problem that so many innovation face from a few users to widespread usage [Rogers 2010]. Regorus is now in a phase where it is still looking for its first customers therefore the "innovators" or "early adopters". By getting feedback from these people and redefining the focus of research towards features requested by these users Regorus could become more attractive for other clients. The qualitative marketing research proposed below will try, among other things, who are the people most likely to be early adopters of Regorus.

2.b Platform Pricing

Since we are considering Business to Business interactions where neither side is money sensitive a subsidy might not be necessary. On the other hand, businesses are extremely quality sensitive and if we want them to integrate Regorus in their processes they need to have some kind of insurance

that it will behave correctly especially because we target the compliance world where an error could cost a lot of money. So to make the penguins jump the price is probably not a problem since these companies are already paying good money for private audits of their processes but quality and certification is highly appreciated. Therefore the pricing strategy is not so difficult but need to be thought of as this was never properly done before. Once again a study of the market could tell us how much money companies are investing in competitors' software and more broadly in compliance.

3 How Business Process Modelling is Integrated in Knowledge Management

We think that one of the ways to promote Regorus and improve its market penetration is to research the ways it can be useful for a company. Apart from its main purpose of asserting compliance of business processes Regorus can be useful at higher levels by being a part of the knowledge management plan of the firm.

Knowledge Management is a relatively new field of study born in the early eighties when researchers in management looked into the importance of knowledge in organization.[Wiig 1997]

With the increasing use of information technologies by firms and the escalation in the size of data stored by those knowledge management became a legitimate concern. How to make sense of these ever growing raw databases and extract tangible information out of it? At the same time organization started to consider knowledge as an asset following the lead of Japanese car manufacturers.[Koenig and Neveroski 2008] How can a firm use its tacit and explicit knowledge to adapt better to the ever changing market ?

Knowledge management was introduced in popular press in the early nineties mainly through the work of Nonaka. [Nonaka 1991] He is the one who later popularized the concept of Ba in his famous article [Nonaka and Konno 1998]. In this article he introduces the SECI model aiming to give a framework for knowledge creation within a firm. This model is based on the interactions between explicit and tacit knowledge through four main phases : Socialization, Externalization, Combination, Internalization. Business process explicitation through Regorus editor can be seen as part of the externalization phase where one's knowledge is expressed using the BPMN formalism. Later on this new material can be used in the Internalization phase where this explicit knowledge is used and put into practice as formely formalizes business processes can help in the training of new employees for example.

Regorus is a great tool for companies because it helps them explicit their practices and internal knowledge into a new figurative language such as BPMN. This allows personal, sticky knowledge to be translated into an explicit, normative form leading to a better understanding and transmission of know-how. In this sense Regorous is more than just a tool to check the compliance of processes it is also a powerful way of managing knowledge in the firm and therefore leading to better results.

Moreover, the BPMN specification explicitly acknowledge that one of its main goal is to be able to explicit internal business process through the organisation Object Management Group

2011. This goal is made even easier by the graphical nature and simple semantics of BPMN. It can be used by all the individuals within the firm. Finally, Regorus helps the firm to not only be compliant but also better manage its knowledge base.

IV What can be done to improve market penetration : Qualitative Marketing Research

As we saw before, a lot of thinking has already been put into strategical reflection for Regorus by the development team. Possible customers and competitors have been identified and the business model have been refined by the previous sections. This is a necessary step in any marketing strategy but it should have been continued by at least a qualitative marketing research to verify if the hypothesis made are right and maybe incorporate new ideas. The following section will show what is a qualitative marketing research and how it can help achieve our goal. After that we focus on one particular technique, the focus group. We explain what it is and provide a comprehensive guide to create one from scratch.

1 Qualitative Marketing Research Explained

1.a Definition and Objectives

Qualitative marketing research main goal is to gather as much information as possible from very different sources, it focuses on the *how* and *why* of the subject under investigation. During the research process it is necessary to adopt an inductive reasoning to build knowledge around what is collected in the different methods put in place. This research method is seeking understanding the reality around marketing and not providing only data without interpretation. [Carson et al. 2001]

Qualitative researches can be used to answer questions about *how* and *why* things happen within an organization. They seek a deep understanding of the matter. The profound reasons that lead to a given phenomenon. They are used to uncover the sense behind a *what*. For example a politician may lose 5 points in quantitative polls but it's the qualitative research that will clarify the feelings of the voters. Then another quantitative research can be conducted to see how many people in the population share these perceptions.

[Mintzberg 1979] argues that to be effective in real organizations a marketing research must be conducted in the field. It is the very complex and dynamic nature of organizations that make laboratory counterproductive because by simplifying we are excluding the actual thing we should be studying. It is therefore necessary to have contacts with companies and not just only rely on views of the mind.

[Van Maanen 1979] defines qualitative methods as

An array of interpretive techniques which seek to describe, decode, translate and otherwise come to terms with the meaning not the frequency of certain more or less naturally occurring phenomena in the social world.

This is particularly adapted to our case where we want to understand more about the environment in which decisions are taken in specific markets. It is important that the research is conducted without any judgement with an open mind. We will see that this is a key to have good results and it will be the main focus when conducting focus groups or interviews.

1.b Interpretation and Reliability of Qualitative Research Results

We can question ourselves about the credibility of results from qualitative research. After all it is defined as a very subjective methodology and challenges the objective standard of general research results. If another research is conducted will it reach the same conclusions ? Would the theory hold for another environment ? In other word can we generalize it ? These questions can be addressed by following a rigorous methodology throughout the research. The quality of a research is endorsed by three factors : credibility, dependability and conformability [Carson et al. 2001].

The same reference proposes a summary of methods and best practices to generate high-quality results. Some of these methods are applicable to our case. First the persons are chosen not on statistical basis but more on their relevance to the subject under research. Also the interviewing must be deep and intimate to gather interesting results. Furthermore, comparing the results coming from different contexts can help highlight the differences between different user cases. Finally having a feedback on the results of the research from the original respondents can yield interesting results, we could imagine organising a focus group where the original respondents are asked what they think of the research and capture insight on whether they agree or not with the findings of the research.

2 What are we Researching ?

Past experiences and field tests of Regorus have shown two main things. On one hand, end-users are very positive about the software and are able to use it smoothly with very little training. Once set-up it saves them a lot of time and they say they are more efficient in their work. On the other hand, the upper management has always rejected any full-scale tests. The reasons arguing the refusal are mostly “not enough time”, “not enough money” or “we are not big enough”. These were taken as the actual reasons but they are obviously just a quick unthoughtful justification and there is definitely more to it than they say. Therefore our first interest will be in finding the actual reason that leads upper-management to reject our project.

Once the “why” of the refusal is sorted out we can actually try to come up with ideas to bypass these roadblocks. But we argue that there is more to that therefore the second interest in our research will try to clarify the decision process of these people. More specifically we will try to identify which incentives they are sensitive to, who are the people they listen to when in doubt, what is important for them.

Finally our last subject of interest is on their expectation for a compliance software such as Regorus. What are the features they like and most importantly why they like it, what are the side effects and improvements they expect by using Regorus and what is their current state of mind regarding compliance software and business process management.

3 The Focus Group, Methodology, Goals and Progress

3.a History and Theoretical Background

Focus groups are known to have emerged in the US in the 1930s. This trend was fast followed by European countries. The theoretical background emerged from the work of psychologist. Indeed, after the world war the number of patient exploded and individual session were no longer possible leading to group therapy. These results have shown that a group is more than just the sum of its part. These characteristics can be used to foster the production of ideas during a focus group but can also lead to biased information.

Focus group have been heavily documented by practitioners and have suffered criticism from the academic world. This is because both sides use literature with different conclusion to back their claims. Practitioners argue that group interaction leads to more information being produced and that this information is also more profound and accurate. Whereas academics respond with articles concluding that group interactions lead to biased answers from participants. Both sides have valid arguments and it is very important when conducting a focus group to be able to foster good group interactions and to identify and stop the bad ones. We will later see the very important role of the animator in this, we will also give some insight and good practices to properly animate a focus group.

There are many schools when it comes to focus group theories. Classifications have been made by both the academic [Calder 1977] and the practitioners [Imms and Ereaud 2002]. We will focus on one particular approach that is the most applicable to our research : the psychodynamic-humanistic approach as described in [Belk 2007]. This approach is used when the individuals under scrutiny won't be able to show their real attitudes or behaviours if asked directly. This may be because the subject is not conscious of the real origin of her behaviour or simply because she is too shy. Therefore the researcher has to use indirect methods of questioning and monitor groups dynamics very closely. This theory implies that consumers and individuals behaviours can not be explained only by their conscious actions but that there are deeper, covert causes.

3.b The Role of the Moderator

As we said before, focus group main force and weakness is group interactions. Therefore the role of the moderator is essential to gather meaningful and strong data. He must be able to identify and break bad group habits such as :

- Compliance : respondents may try to answer in a way they think is expected from them. This leads to biased answered and must be avoided. One way to do so is to detach the moderator as pertaining to a company and to foster participants to express their own ideas.

The moderator can, for example, repeat multiple times to the audience that it is only their opinion that matters and that they can express it freely.

- Groupthink : cohesive groups may tend to maintain consensus on key issues [Janis 1982]. Once again the moderator must challenge this consensus or try to identify dissident opinions and promote them. This can be done using a projective technique with sentences as : “I see that we reached a consensus here, imagine, what would be the arguments of someone who disagrees ?”

The moderator’s behaviour is as important as all the guidelines regarding the line of questioning. In order to let people talk and not influence their answers, the moderator must stay in a friendly open-minded position. He must always bear a kindly smile and show empathy towards the participants. Again to get the most from participants, the moderator must not be afraid of silence as it pressure people to keep talking. When a participant is talking the moderator should encourage him to go on without being judgemental with short verbal responses such as “Uh huh”, “yes” but not “excellent” or “that’s good”.

Focus group are bringing together people with different characters, it is important that the moderator quickly pinpoint problematic behaviors and counter them. [Krueger and Casey 2000] defines four types of people that can cause problems during the execution of a focus group :

- Experts, often self-appointed, can lead others to refrain from express an contradictory opinion. The best way to deal with these people is to say that everyone is an expert and to stress that the opinions of everyone is important. They can be spotted before the event as they usually are the ones with the most experience or with dominant positions within a firm.
- Dominant Talkers, tend to monopolize the discussion and, as for experts, refrain others to express their opinions. They are usually also experts and therefore can be detected before the event or during pre-event smalltalk. To be able to control them they must be sited next to the moderator whom could use body language to discipline them. If that is not enough then the moderator can have a more direct strategy such as “Thank you A., who would like to comment on the question, maybe you S. ?”.
- Shy participants, usually think before they speak and have great insights only it takes more time for them to express those. They should be place across the table from the moderator to maximize eye contact which encourage to speak. If that is not enough the moderator can call them by name and leave them no choice.
- Ramblers participants like to talk, a lot ! and they often drift off track. To control them the moderator can stop the eye contact after 30 seconds and use body language (turn towards someone else for example). The moderator must be ready to trigger another question or a follow up as soon as the Rambler leave an opportunity to do so.

We saw in this section that the moderator has a very important role in the focus group. He must be a very good character reader and express genuine interest in hearing other people opinions. He must show sympathy and empathy towards the participant but also be firm and strong against some kind of participants or fostering for some others. The moderator must be respected by the group to stay within the tracks but also leave space for interaction and

exploration. He is the driver of the focus group and he has the responsibility to take the group to the important points in time and keep up a friendly atmosphere.

3.c How to Come up With Good Questions

Good questions are not an easy thing to come up with. However, there are a few qualities that a focus group question must have [Krueger and Casey 2000]. First of all they must sound conversational to set up and keep on with a casual environment. Also be careful not to use technical jargon or acronyms to not confuse and lose the audience. Furthermore the question must be clear, short and easy to say. The moderator must not stumble over words in the question, the meaning must be straightforward and be given in the least possible number of words. On top of that, the questions must be open-ended, they must beg for explanation, stories, etc. Be careful on the meaning of the word you use too. Words can have multiple dimensions so try not to use synonyms or follow up questions as this might confuse participants.

When faced with extreme point of views always further the discussion with a probing session : “Please elaborate on the reasons why you answered ?” “How ?” “What make you say that ?” Never let a person answer with one word or a short sentence.

We chose to use a psychodynamic-humanistic approach for our focus group and this means we need to use indirect questions to extract covert, unconscious knowledge from our participants. The use of projective techniques helps respondents project their ideas and opinions on other people or objects. Common projective techniques include :

- Sentence Completion : participants are asked to complete a sentence. “People who are responsible of compliance are ...”.
- Stereotyping : a person is described to participants (using words or images) who are asked about these imaginary characters. This is usually followed by a probing session to force participants to explicit their answers.
- Personification : The brand or another abstract concept is personified and participants are asked to imagine their reactions are sayings in a particular situation. “if Regorus was a person how would it dress ?”. This is again only a start that needs to be followed by a probing session to gain more insight on the subconscious reasons.

Another good technique to help participant to dig answers in their subconscious are “think-back” questions. For example we could ask “think back to the last time you had to make a decision about adopting a software. What made you decide ?”

It is important to note that good questions must not influence the audience in their answers. Never include hints or suggestions at first even if you think that it would help people understand the question. Once participants have answered with a few terms then the moderator can use these to go further and get more information or refocus the discussion.

Finally try to avoid “why” questions because they are often aggressive and make the respondent feel confronted but also because they ask for a rational answer when most of the times we make

decisions based on impulses, culture or traditions. This has been particularly true with Regorus strategy. When asking managers for a rational answer to the question “why did you not integrate Regorus ?” they try to come up with one and often say that they either don’t have time or money or both. Indeed the Lazarfeld’s principle of specification [Lazarsfeld 1935] tells us that when asked why, people will answer either what influenced them to make this choice or what attributes led them to make that decision. For the previous question we could, therefore, ask either for influence : “What (influenced, made) you not integrate Regorus ?” or for attributes “What features of Regorus do you dislike ?”. In this case we leave no choice to the respondent to give a more meaningful reason.

3.d Sequence Your Questions to get the Most out of Participants

[Tuckman and Jensen 1977] argues that all groups go through the five stages of forming, storming, norming, performing, mourning. This work has been widely accepted and cited. Table III.2 from [Belk 2007] shows the different stages with their characteristics and the associated moderator’s task.

This model helps us to sequence our questioning to get the most out of the group. First of all the moderator must make an introduction that needs to contain a few essential elements, this relates to the forming stage. Participants usually don’t know each other and might feel a bit anxious or shy. First thank all participant for being present, continue with a presentation of the moderator and its role in the focus group. Stress that opinions of the participants are the only thing that matters and that the moderator won’t give his. Be transparent and say that there will be a recording of the focus group and insist that it will be anonymous and that no names will be mentioned in the final report. Finally state how long the focus group will last and inform participants of a possible gathering after the event or how they can receive their incentive. A final thank you and announce the beginning of the focus group.

After the introduction the group is not yet ready to perform so we need to sequence our questioning from the broader, simpler questions to the more specific, intimate, complex questions. The moderator needs to spend some time with simple questions to get the group going. These are usually question about the experience of the audience with the matter. Time management is critical here, spend just as much time as needed on these questions to leave more time for the actual interesting, meaningful questions.

Once again the experience of the moderator plays an important role here. He must be able to “read” the group and notice when the group is in the performing phase. This is when the important questions must be addressed.

From the previous points we see the need of a well thought-of sequence in the questioning. In order to help the moderator in conducting the focus group we must draft a document containing : the introduction, the main themes that need to be tackled, what are the key or transition questions for each theme and a few conclusion questions. This document will also ensure consistency if multiple focus groups are conducted. In a further section we will provide a draft of such a document.

Stage	Underlying process	What happens	Moderator task
Forming	Participants feel separate, anxious, relatively powerless.	Awkwardness, caution, light social chit-chat, testing behaviours.	Empower and make safe by explaining the task, encourage interaction, react properly to testing behaviour.
Storming	Share of voice, demanding attention, opting out or rebelling	Challenge moderator or others, question the task, emphasize individuality, dominant and passive participant emerge	Signal all opinions are of equal value, accept negative views but look also for positive, stop potentially dominant respondents being overbearing
Norming	Sense of harmony, cohesion and support, norms emerge and group take off	People take turn to speak without moderator having to ask, the energy feels positive and harmonious	Notice and enforce norms, deal with any implicit or explicit rule breaking ; time to get into the real work, make plans and set agendas, keep communication channels flexible.
Performing	Individuals are subservient to the group, roles are flexible and task oriented	Sense of concentration and flow, everything seems easy, high energy, group works without being asked to	This is the time to introduce difficult questions, use projective techniques
The group slips back into one of the previous stages before it can perform again			
Mourning	Completion of task and disbanding, may be sense of loss and anxiety, need for closure	Signal that the end is coming, summarize to give sense of achievement, ask if there is anything else, thank everyone.	

Table III.2: Stages of a focus group according to [Tuckman and Jensen 1977] as in [Belk 2007].

Group dynamics are complex yet the most important part of the focus group. A good sequence of questions and a well designed questioning route leverage group psychology along with a good moderator will ensure maximum results.

3.e Implementation of the Focus Group

Since we sorted out the theoretical background and the progress of the focus group we can direct our attention on the actual implementation. We need to figure out multiple points. First the timing of the focus group, then the number of people attending, next the choice and recruitment of participants and finally logistics matters.

In previous sections we emphasized on the importance of time management by the moderator during the questioning. Indeed, people in general can only be focused on one task for a little time ranging around one hour and forty five minutes plus or minus twenty minutes. Don't plan for a longer focus group and if the discussion lasts longer try to look for the moment where things got out of hand for the next focus group. This timing also has the advantage of permitting two focus groups to be conducted in one half-day [Belk 2007].

In focus group there is group and therefore we need to decide how many people we want around the table. There is a lot of discussion around that subject, some are partisan of mini-focus groups of four to six people, some prefer larger consumer groups of ten to twelve people. The number of participants really depends on what needs to be studied and who are the guests. In our case we attract participants with lot of experience in their fields, people who are keen on talking about their topic for a long time. Therefore we are recommending groups of six to eight people. This can be further adapted. If during a focus group the moderator notices people whispering to the person next to them it means that the group is too big, if the group has trouble talking or sharing experiences that might be because there is not enough participants.

The number of people is important but so is the choice of attendants. This is a tricky part because there are contradicting dynamics here. On one hand we know that people are more prone to express their genuine opinions in front of strangers, especially men (some studies show this is less true for women) [Belk 2007]. On the other hand we need an heterogeneous group so multiple point of views will be discussed. In our case we advocate that participants should be chosen because they share common professional occupation (they get to chose which software use or changes in methodology). Then it would be great if they were of different ages, different companies, with different background (coming from research, climbed the corporate ladder from the bottom, changed companies a lot), different experiences with computer systems and information technologies.

When recruiting people it is important to think of incentives. Attending a focus group is costly for people in both time and energy, they might not be so excited to spend two hours talk about a topic instead of being with their family or relaxing in their sofa. A reflection has to be made to pinpoint the right incentive for the people we want to invite. A good starter would be to meet, maybe share a meal with some people from the targeted audience and ask them what would make them come. Incentives can be as simple as providing a nice meal after the focus group, but it needs to be validated by the very people we try to attract.

Finally it is also important to think of the logistics before hand. First the focus group will need to be recorded, therefore we will need a room with the proper video and sound recording equipment. The location also needs to be calm and feature a round table so that everyone shares the same setting. Perhaps it might be convenient to organize a little gathering with snacks and drinks at the end to let people talk to each other and deal with the mourning stage of the group.

4 Textual Data Analysis : Tools and Methodology

After conducting all the focus groups we are left with a considerable amount of data mostly constituted of transcripts and maybe moderator's feedback and impressions. This constitutes our raw database, in order to extract insights from it we can use different tools and approaches. The textual data analysis may be conducted in parallel with the data collection leading to some tweaks in the progress of the focus group [Pope, Ziebland, and Mays 2000]. The researcher must go back and forth from theory-driven techniques that we present in this section to reading the textual data to never lose sight of the context. [Pope, Ziebland, and Mays 2000] gives extensive informations on different techniques, the ones we focus on below were chosen because they are the most relevant to our case.

Before anything one possible step is to code the answers to the questions. This consists in creating semantic groups of words. For example the words "family" and "doctor" cannot be considered separately if used jointly because then, they refer to the "family doctor". This analysis can be automated to a point using computer software that can reduce expressions by eliminating conjunctions and other small words or by truncate verbs to the infinitive form. Once the semantic groups are made we will have greatly reduced the number of words in the study. This method yields interesting and fast results. It is easy to implement and to understand. It can be cross exploited with other methods such as co-occurrence of themes.

This approach however has a few drawbacks. It can be biased by the person coding the text because this can lead to interpretations or complex choices. Moreover by doing this we lose informations about the tone or the form of the speech and the rare or complex answers are lost.

More complex techniques like the correspondence analysis can also be used and leveraged by specialized software. Correspondence analysis gives us a graphical representation of cross tabulation. Such tables appear when we can compare the frequency of events for different categories. In our example we could compare the frequency of keywords (from previous coding) for each participants [Yelland 2010]. This method outputs a two-dimensional map presenting the different terms and participants. It uses the chi-square as distance between two qualitative variables. The mapping can be (and should be) done by software built for qualitative marketing research analysis.

Figure III.1 is an example of the map output from a correspondence analysis. It is a powerful visual tool. For example we can see that, in the mind of participants, Brand E is seen as more innovative. Precisely this means that the innovative term or semantic group is often associated or co-occurring with Brand E. Also we see that Brand D is associated with lot of words which can be interpreted as a leadership position on the market.

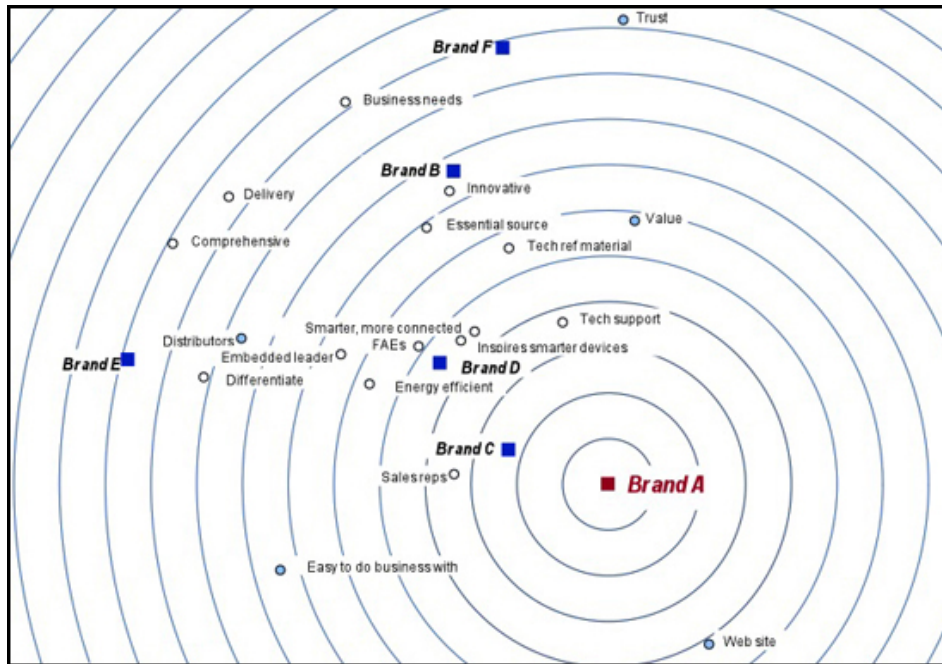


Figure III.1: An example of a correspondence analysis map from [Technology 2010]

5 Proposed Themes and Questioning Route for a Focus Group for Regorus

The table III.3 is a proposition, a draft of a possible execution of a focus group. It describes principal themes and possible questions for each of them with associated intentions behind it. For each questions don't forget the basic rules of questioning and try to get the most out of participants by using probing techniques and follow-up questions. It can be seen as a starting point for a more thorough reflection on conducting a qualitative marketing research in the light of all the previous material.

Introduction		
5 min	Introduction phrase	Introduce the matter, present the moderator and the ground rules, go through the forming phase
10 min	If I ask you about compliance, what comes first to mind ?	Start by asking a simple question, might not be directly related to the research, finish the introduction phase, gauge the group. No need to spend much time here.
Theme 1 : The Decision Making Process		
The group is not ready to perform yet but we're getting there, continue with easy questions, this theme is not asking for complex or unconscious answers. We are at the same time trying to gain some knowledge on the decision making process which we could use to our advantage.		
10 min	Show different words about decision making process and ask the participants to react to them.	This method helps when we want people to react to hints we already have. This is an easy question and will help facilitate speech.
5 min	What are the best and worst possible decision making processes ?	By asking them to exaggerate and amplify their stories we get informations on what are the must do and don't. This will reveal in what ways we can make the decision process smoother.
Theme 2 : Features review (likes, dislikes)		
The group should now be ready to give more important informations. We are trying in this theme to get an understanding of the features they may like in Regorus. Keep in mind that these people might not be the one that use the software.		
10 min	Best-worst case scenarios : Business intelligence software features.	We are asking the participants to imagine what would be their best and worst software features for business process compliance or more broadly business intelligence (user-experience, productivity, scalability, integration).
15 min	Wall of words with features of regorus, ask for reaction.	This question is a bit focused to get constructive feedback on the features of Regorus.

Theme 3 : What influence the choice for a given software ?

We start to dig a little bit more with this theme. We are trying to uncover what or who decision makers listen to when having to make a decision. It is important to drill down and go past simple answers. Do not hesitate to spend more time on questions

10 min	Think back to the last time you had a doubt about a decision, whom or what did you turn to for advices ? why ?	We are projecting participants in the past in a known situation. They are more likely to give us profound meaningful insights of their behaviour.
10 min	If I ask you about research, what comes to mind ? Or maybe use images of a researcher and a businessman and ask for comments	We are probing to understand how research and researchers are perceived by these decision makers. This might shape a future branding strategy.
15 min	How do you feel about using an innovative but unproven software ?	What is the relationship of respondents with innovative, bleeding edge software that are powerful but have not been broadly tested and accepted within the industry. Is the pioneer image attractive ?

Theme 4 : What motivate the choice for a given software ?

This is another important theme, we are looking for motivations that lead to the adoption of a given software. If we uncover this we could be able to target the right incentives. As for the previous theme, don't let the participants get away with easy answers, drill to the profound meaning.

15 min	What makes you chose between equally potent softwares (equally priced) ?	We are trying to find non technical reasons that lead to the adoption of a given software. Each reason must be investigated in depth. Time and money are non acceptable answers.
10 min	Importance of a strong theoretical basis ? If not important what is ?	Regorus is undoubtedly backed with powerful theories. But is it something we should use when advertising it ? There may be more important concerns such as formal proof of concept, insurance, certifications ?

Conclusion		
5 min	Conclusion phrase	This is the moment to properly end the focus group. Thank all the participants, give informations on how to obtain their incentive or where to go for the gathering. Deal with the mourning phase.

Table III.3: Proposed themes and questions for a focus group on Regorus

Strategic Conclusions

This end-of-studies internship has been a wonderful journey far from my comfort zone. Working in a research environment was a brand new experience topped up with an English-speaking surrounding and multicultural workplace. The work I have been asked to do was very demanding and I learned a lot both personally and professionally.

On the professional level I discovered how a research facility is operated and managed. This is a valuable knowledge since I will probably evolve in a scientific or technological world with my double degree. I observed the very special dynamics of a research and development environment. And I think it will help me later on to understand the motivations of researchers as a strategic manager.

I strongly believe that a multicultural workspace is enriching but also very hard to manage. It also highlighted for me the importance of culture in a company, one thing that can blend all these different background and work towards one goal. While I was at NICTA there has been a shift in culture from very research oriented to a more pragmatic market oriented perspective.

I particularly enjoyed the interactions with my co-researchers. I spent a lot of time learning from them and working alongside this team of professionals. We discussed marketing and strategy and I think they were quite receptive. Indeed I found that the researchers at NICTA were very interested by this and put a lot of effort to market the product of their research. But I discovered that they didn't have the theoretical background to build a solid strategy. I hope that my contribution will help in this matter.

This work experience proved to be the perfect place to apply what I've learned in school about marketing and strategy. I was able to use my new skills on real cases and it helped me to turn theoretical ideas or concepts into actual projects and impact. Besides this reassured me and strengthened my conviction that the strategic knowledge I gained during my IAE degree is perfectly applicable in the corporate world and equals to more than the sum of two.

At the very end I feel readier than ever to confront myself to the "real world" after this strong experience. I have faith that my double diploma is a real plus to my technical capabilities. I also discovered myself a bit more, my weaknesses and my strengths.

Technological references

- Antoniou, Grigoris et al. (1999). "On the Modeling and Analysis of Regulations". In: *Proceedings of the Australian Conference Information Systems*, pp. 20–29. URL: <http://www.vuw.ac.nz/acis99/Papers/PaperGovernatori-088.pdf>.
- Antoniou, Grigoris et al. (2000). "A Family of Defeasible Reasoning Logics and its Implementation". In: *ECAI 2000. Proceedings of the 14th European Conference on Artificial Intelligence*. IOS Press, pp. 459–463.
- Antoniou, Grigoris et al. (2001). "Representation Results for Defeasible Logic". In: *ACM Transactions on Computational Logic* 2.2, pp. 255–287. DOI: <http://dx.doi.org/10.1145/371316.371517>.
- Australian Research Council (May 2013). *ARC Centres of Excellence*. URL: http://www.arc.gov.au/ncgp/ce/ce_default.htm.
- Gagne, Denis. *BPM Standards - What is new in BPMN 2.0 and XPDL 2.2*. Technology. Technology. URL: <http://www.slideshare.net/dgagne/bpm-standards-what-is-new-in-bpmn-20-and-xpdl-22-bbc-2011> (visited on 06/19/2014).
- Governatori, Guido and Rotolo Antonino (2011). "Justice Delayed Is Justice Denied: Logics for a Temporal Account of Reparations and Legal Compliance". In: *CLIMA XII, 12th International Workshop on Computational Logic and Multi-Agent Systems*. LNCS. Springer.
- Governatori, Guido and Antonino Rotolo (2008). "An Algorithm for Business Process Compliance". In: *Legal Knowledge and Information Systems*. IOS Press, pp. 186–191. DOI: <http://dx.doi.org/10.3233/978-2-58603-952-3-186>.
- (2010a). "A Conceptually Rich Model of Business Process Compliance". In: *7th Asia-Pacific Conference on Conceptual Modelling (APCCM 2010)*. Vol. 110. ACS, pp. 3–12. URL: <http://crpit.com/confpapers/CRPITV110Governatori.pdf>.
- (2010b). "Norm Compliance in Business Process Modeling". In: *RuleML 2010: 4th International Web Rule Symposium*. 6403. Springer, pp. 194–209. DOI: http://dx.doi.org/10.1007/978-3-642-16289-3_17.
- Governatori, Guido and Shazia Sadiq (2009). "The Journey to Business Process Compliance". In: *Handbook of Research on BPM*. IGI Global, pp. 426–454.
- Governatori, Guido and Paolo Terenziani (2007). "Temporal Extensions to Defeasible Logic". In: *20th Australian Joint Conference on Artificial Intelligence, AI 2007*. Springer, pp. 476–485. DOI: http://dx.doi.org/10.1007/978-3-540-76928-6_49.
- Hoffmann, Jörg, Ingo Weber, and Guido Governatori (2009). "On Compliance Checking for Clausal Constraints in Annotated Process Models". In: *Information Systems Frontiers*. DOI: <http://dx.doi.org/10.1007/s10796-009-9179-7>.
- International Business Times (2011). *Businesses Complain on Rising Costs of Australian Regulations*. International Business Times. URL: <http://au.ibtimes.com/articles/220313/20110927/businesses-complain-on-rising-costs-of-compliance-to-australian-regulations-business-regulation-ai-g.htm> (visited on 06/24/2014).

- Koons, Robert (2005). "Defeasible Reasoning". In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Spring 2014. URL: <http://plato.stanford.edu/archives/spr2014/entries/reasoning-defeasible/> (visited on 05/27/2014).
- Lam, Ho-Pun (2014). *SPINdle User Guide*. Version 2.2.4. NICTA Business Process Compliance Group.
- Lam, Ho-Pun and Guido Governatori (2010). "On the Problem of Computing Ambiguity Propagation and Well-Founded Semantics in Defeasible Logic". English. In: *Semantic Web Rules*. Ed. by Mike Dean et al. Vol. 6403. Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 119–127. ISBN: 978-3-642-16288-6. DOI: 10.1007/978-3-642-16289-3_11. URL: http://dx.doi.org/10.1007/978-3-642-16289-3_11.
- Maher, Michael J (2001). "Propositional defeasible logic has linear complexity". In: *Theory and Practice of Logic Programming* 1.06, pp. 691–711.
- Mailund, Thomas and Michael Westergaard (2004). "Obtaining memory-efficient reachability graph representations using the sweep-line method". In: *Tools and Algorithms for the Construction and Analysis of Systems*. Springer, pp. 177–191.
- Mc Namara, Paul (2014). "Deontic Logic". In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Stanford editions. URL: <http://plato.stanford.edu/archives/spr2014/entries/logic-deontic/> (visited on 05/29/2014).
- McCarthy, John and Patrick Hayes (1968). *Some philosophical problems from the standpoint of artificial intelligence*. Stanford University USA.
- McNamara, Paul. *Deontic Logic > Challenges in Defining Deontic Logic (Stanford Encyclopedia of Philosophy)*. Stanford Encyclopedia of Philosophy. URL: <http://plato.stanford.edu/entries/logic-deontic/challenges.html> (visited on 06/01/2014).
- NICTA (2010). *Research Excellence in ICT, Wealth Creation for Australia*. 24 pp.
- NICTA (2013). *Business Process Compliance*. URL: http://www.nicta.com.au/research/projects/business_process_compliance.
- NICTA (Aug. 16, 2012). *NICTA: Business Process Compliance Technology - Compliance by Design*. In collab. with National ICTA. URL: http://www.youtube.com/watch?v=gFmDQJNai_4&feature=youtube_gdata_player (visited on 04/23/2014).
- Nute, Donald (1994). "Defeasible logic". In: *Handbook of logic in artificial intelligence and logic programming* 3, pp. 353–395.
- (1997). *Defeasible deontic logic*. Vol. 263. Springer.
- Object Management Group (2010). *BPMN 2.0 by example*. URL: <http://www.omg.org/spec/BPMN/2.0/examples/PDF/10-06-02.pdf> (visited on 06/19/2014).
- (2011). *Business Process Model and Notation Version 2.0*, pp. 51–79. URL: <http://www.omg.org/spec/BPMN/2.0> (visited on 06/19/2014).
- (2014). *BPMN Specification - Business Process Model and Notation*. URL: <http://www.bpmn.org/> (visited on 06/19/2014).
- The Apomore Initiative. *Apomore - Advanced Process Model Repository*. Apomore - Advanced Process Model Repository. URL: <http://apomore.org/> (visited on 06/19/2014).

Strategic references

- Bae, Hyerim (2014). "What we can do with business models after we discovered them from error log". In: *AP-BPM 2014, proceedings of the second Asia-Pacific Conference*. Springer, pp. 10–15.
- Belk, Russell W (2007). *Handbook of qualitative research methods in marketing*. Edward Elgar Publishing.
- Budde, Paul, Stephen McNamara, and Paul Budde Communication Pty. Ltd (2012). "Australia, telecoms industry : statistics and forecasts / researcher: Paul Budde, Stephen McNamara". English. In: At head of title: A Buddecomm report.
- Calder, Bobby J (1977). "Focus groups and the nature of qualitative marketing research". In: *Journal of Marketing research*, pp. 353–364.
- Carson, David et al. (2001). *Qualitative marketing research*. Sage.
- Chesbrough, Henry and Adrienne Kardon Crowther (2006). "Beyond high tech: early adopters of open innovation in other industries". In: *R&d Management* 36.3, pp. 229–236.
- Chesbrough, Henry William (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.
- Choudary, Sangeet Paul (2014). *How small ideas like Twitter, WhatsApp and Airbnb create large value through network effects : Platform Thinking*. URL: <http://platformed.info/twitter-whatsapp-uber-airbnb-network-effects/> (visited on 06/13/2014).
- Dumas, Marlon et al. (2013). *Fundamentals of business process management*. Springer.
- Economides, Nicholas and Evangelos Katsamakos (2006). "Two-sided competition of proprietary vs. open source technology platforms and the implications for the software industry". In: *Management Science* 52.7, pp. 1057–1071.
- Eisenmann, Thomas, Geoffrey Parker, and Marshall W Van Alstyne (2006). "Strategies for two-sided markets". In: *Harvard business review* 84.10, p. 92.
- Gagne, Denis. *BPM Standards - What is new in BPMN 2.0 and XPD L 2.2*. Technology. Technology. URL: <http://www.slideshare.net/dgagne/bpm-standards-what-is-new-in-bpmn-20-and-xpdl-22-bbc-2011> (visited on 06/19/2014).
- Goedertier, Stijn and Jan Vanthienen (2006). "Designing compliant business processes with obligations and permissions". In: *Business Process Management Workshops*. Springer, pp. 5–14.
- Hagiu, Andrei and Julian Wright (2011). *Multi-sided platforms*. Harvard Business School.
- Imms, Mike and Gill Ereaut (2002). *An introduction to qualitative market research*. Vol. 1. Sage.
- International Business Times (2011). *Businesses Complain on Rising Costs of Australian Regulations*. International Business Times. URL: <http://au.ibtimes.com/articles/220313/20110927/businesses-complain-on-rising-costs-of-compliance-to-australian-regulations-business-regulation-ai-g.htm> (visited on 06/24/2014).
- Janis, Irving Lester (1982). "Groupthink: Psychological studies of policy decisions and fiascoes". In: Jeston, John and Johan Nelis (2014). *Business process management*. Routledge.

- Koenig, Michael and Kenneth Neveroski (Mar. 2008). "The Origins and Development of Knowledge Management". In: *Journal of Information & Knowledge Management (JIKM)* 7.04, pp. 243–254. URL: <http://ideas.repec.org/a/wsi/jikmxx/v07y2008i04p243-254.html>.
- Krueger, Richard A and Mary Anne Casey (2000). *Focus groups*. 3rd ed.
- Kyle, Margaret (2013). "Strategy in Innovative Industries, Two-sided Platforms". University Lecture.
- Lazarsfeld, Paul F (1935). "The art of asking WHY in marketing research: Three principles underlying the formulation of questionnaires". In: *National marketing review*, pp. 26–38.
- Mintzberg, Henry (1979). "An emerging strategy of" direct" research". In: *Administrative science quarterly*, pp. 582–589.
- Nonaka, Ikujiro (1991). "The knowledge-creating company". In: *Harvard business review* 69.6, pp. 96–104.
- Nonaka, Ikujiro and Noboru Konno (1998). "The concept of "ba": Building a foundation for knowledge creation". In: *California Management Review* 40.3, pp. 40–54. URL: <http://km.camt.cmu.ac.th/mskm/952701/Extra%20materials/Nonaka%201998.pdf>.
- Object Management Group (2010). *BPMN 2.0 by example*. URL: <http://www.omg.org/spec/BPMN/2.0/examples/PDF/10-06-02.pdf> (visited on 06/19/2014).
- (2011). *Business Process Model and Notation Version 2.0*, pp. 51–79. URL: <http://www.omg.org/spec/BPMN/2.0> (visited on 06/19/2014).
- (2014). *BPMN Specification - Business Process Model and Notation*. URL: <http://www.bpmn.org/> (visited on 06/19/2014).
- Parker, Geoffrey G. and Marshall W. van Alstyne (2005). "Two-Sided Network Effects: A Theory of Information Product Design." In: *Management Science* 51.10, pp. 1494–1504. URL: <http://dblp.uni-trier.de/db/journals/mansci/mansci51.html#ParkerA05>.
- Pope, Catherine, Sue Ziebland, and Nicholas Mays (2000). "Analysing qualitative data". In: *Bmj* 320.7227, pp. 114–116.
- Rochet, Jean-Charles and Jean Tirole (2003). "Platform competition in two-sided markets". In: *Journal of the European Economic Association* 1.4, pp. 990–1029.
- Rogers, Everett M (2010). *Diffusion of innovations*. Simon and Schuster.
- Technology, Beacon (2010). *Correspondence Analysis (Perceptual Mapping)*. Beacon Technology Partners. URL: <http://www.beacontech.com/market-research-tools-we-use/quantitative-analysis/correspondence-analysis-tools-perceptual-mapping.asp> (visited on 07/10/2014).
- Tuckman, Bruce W and Mary Ann C Jensen (1977). "Stages of small-group development revisited". In: *Group & Organization Management* 2.4, pp. 419–427.
- Van Maanen, John (1979). "Reclaiming qualitative methods for organizational research: A preface". In: *Administrative Science Quarterly*, pp. 520–526.
- Wiig, Karl M. (1997). "Knowledge management: Where did it come from and where will it go?" In: *Expert Systems with Applications* 13.1. Knowledge management, pp. 1–14. ISSN: 0957-4174. DOI: [http://dx.doi.org/10.1016/S0957-4174\(97\)00018-3](http://dx.doi.org/10.1016/S0957-4174(97)00018-3). URL: <http://www.sciencedirect.com/science/article/pii/S0957417497000183>.

Yelland, Phillip (2010). "An Introduction to Correspondence Analysis". In: *The Mathematica Journal* 12. ISSN: 10971610. URL: <http://www.mathematica-journal.com/2010/09/an-introduction-to-correspondence-analysis/> (visited on 07/10/2014).