# A Pattern-based Approach to Transform Natural Text from Laws into Compliance Controls in the Food Industry

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**Abstract.** In the food industry, regulations support companies to specify what needs to be done to minimize the risks of processing, trade and consumption of inferior food products. Complying with regulations protects companies from expensive and negative perceived product recalls, sanctions and financial penalties. A compliant manufacturing process requires a process design that conforms to legal requirements, quality and safety standards. Regulations are generally described in natural text so that relevant information has to be retrieved and formalized before it can be used for process description. In this contribution, we use a sample of laws and an initial set of generic control patterns to explore the scope of food regulations and the extent of formalization that can be reached by applying control patterns. All in all, we present a pattern-based approach to turn natural text from laws into formalized machine-readable constructs that may serve as basis for a compliant process design.

**Keywords:** Business Process Management, Control Pattern, Business Process Compliance, Regulations, Food Industry

## 1 Motivation and Introduction

The "act of being in alignment with guidelines, regulations and/or legislation" is defined as *compliance* [6]. This definition implies that compliance does not only comprise the adherence to laws but also standards, codes of practice and business partner contracts [9]. Compliance has been driven by reforms of the American banking and insurance sector since the 1990s, when more and more scandals of money laundering and insider trading have been revealed [10, 14]. The increasing reform pressure finally summits in the Sarbanes-Oxley Act (SOX) of 2002 which makes listed companies responsible for establishing and maintaining an internal control system [11].

Similar observations can be made for the food industry, where compliance is seen as a current issue but an old problem that has been subject of many regulative attempts [10, 14]. Most frequent compliance offences in the food industry relate to violations of disclosure information, tax and import regulations and to the processing and trade of spoiled food [4]. *Business process compliance* considers how a business operation or service should be carried out to comply with a normative system while executing a process [5]. In this regard, control patterns are important since they can be understood as high level domain-specific templates which can be applied to specify recurring process requirements like regulations [13]. A regulation is a declarative written statement defined as “a rule or order issued by an executive authority or regulatory agency of a government and having the force of law” [7].

The purpose of this paper is to reduce the complexity regulations making implicit information accessible and machine-readable through the use of control patterns. The challenge is to identify and convert relevant process information from natural text into formalized constructs that can implemented by process execution languages. The investigation’s focus lies on the degree of formalization (extent) and the thematic focus (scope) of a real-world domain (food industry), which is used as empirical basis for specifying control patterns. In behalf of that, the resulting research questions are:

RQ1: *What is the scope of regulations in the food industry?*
RQ2: *To what extent can regulations be formalized by control patterns?*

To answer these two research questions, we discuss related work and present a conceptual model for automating compliance checking in Section 2. In Section 3 we continue with the textual analysis of German food regulations. The regulations have been retrieved by querying the database of the Federal Ministry of Justice and Consumer Protection [2]. The title search for the keyword “food” led to 20 national regulations, which were analyzed to specify requirement, objective and risk for every single regulation. Control patterns that are extracted from regulations are classified with regard to the given process information. Concluding remarks and prospects on future work are given in Section 5.

## 2 Principles of Control Patterns

### 2.1 Related Work and Problem Specification

Considerable work on patterns has been provided by Dwyer, Avrunin and Corbett (1999), who developed a pattern system for finite-state verification based on a large sample of over 500 examples of property specifications [1]. Extensive work on compliance automation has also been conducted by Sadiq, Governatori (2015) [9], Namiri (2007) [8] as well as Turetken et al. (2012) [13] by exploiting formal techniques (e.g. MTL/LTL and FCL) in alignment to the de facto standard COSO for managing internal controls. COSO has been settled by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) to comply with significant regulations like SOX [12]. We decided to build our conceptual model upon the four control patterns *Order*, *Occurrence*, *Resource* and *Time* suggested by Turetken et al. (2012) [13] because of the existence of a framework for the key elements of *business process compliance management* (BPCM) and its alignment to an established control framework like COSO. The key elements of BPCM refer to the operational activities of compliance management (e.g. risk assessment and response) and corresponding entities of the compliance repository (e.g. risk).

### 2.2 Conceptual Model for Capturing Compliance Controls

In order to capture compliance controls in the food industry we adopted the BPCM framework of Turetken et al. (2012) [13]. The focus of the framework has been shifted from operational compliance management activities to the formalization of natural text language through control patterns. *Control Patterns* form a separate layer in the continuum of abstraction ranging from *Regulations* to machine-readable *Process Execution Languages* (see Fig. 1). Each layer contains several process elements represented by different operands (compare Section 3.2). *Regulations* are the source of compliance requirements used to define the requirement, objective and risk of a control. The smallest entity of a *Regulation* is a rule. In this layer relevant rules are adopted, control objectives are set and possible risks are assed. The next layer is assigned to the scope of *Control Patterns.* Within this layer the templates for process controls are defined and classified. In the bottom layer we specified a number of criteria for selecting a compatible *Process Execution Language* to pave the way for automated compliance controls.

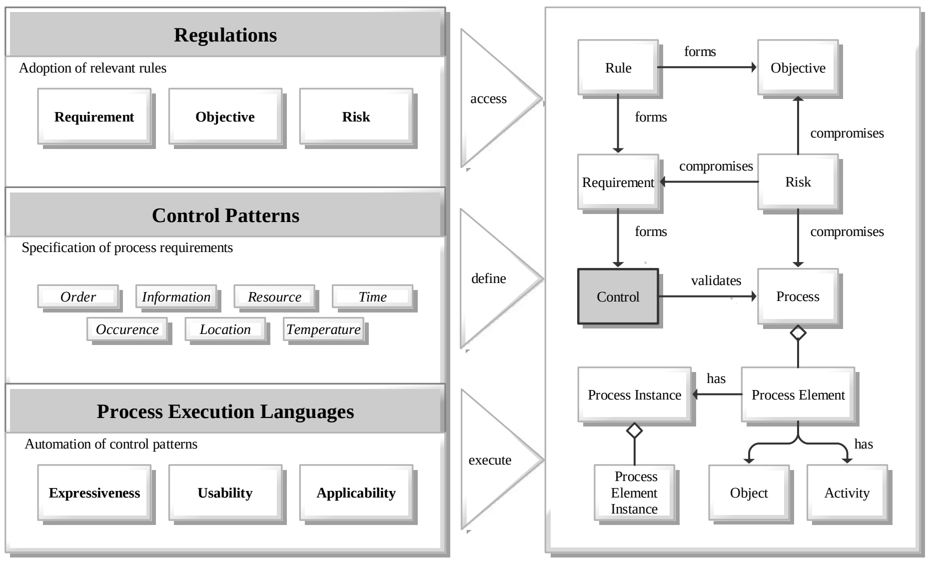


**Fig. 1.** Conceptual model for compliance checking[1]

As we conducted a facet classification on compliance checking approaches in previous work [3], we adopted one of its dimensions to assess the scope of regulations in the food industry. We chose the dimension *Scope* because we wanted to analyze the applicability of its elements in more detail. The dimension *Scope* is based on the compliance concerns identified by COMPAS, a study on Compliance-driven Models, Languages and Architectures for Services (COMPAS), which has been conducted by Tilburg University (2008) [12]. The study introduces two categories of compliance

1 In alignment to Turetken et al. (2012).

concerns that have been aligned from business process modeling. The first category comprises the basic compliance concerns control flow, locative, information, resource and time. The second category describes more advanced compliance concerns (e.g. monitoring, privacy and quality aspects).

# 3 Applying Control Patterns to Capture Compliance Controls

## 3.1 Text Analysis of Regulations in the Food Industry

Regulations for the German food industry have been discovered by searching the database of the Federal Ministry of Justice and Consumer Protection, which claims to offer nearly the entire body of federal law [2]. A title search for the German equivalent for "food" returned 20 hits of national regulations, which were further analyzed to gain information on the requirement, objective and risk of each regulation. The analysis of subsequent paragraphs and sections of each regulation led us to a total of 108 single requirements with process characteristics. The requirements are used to extract important process information for specifying control patterns. While a requirement can be seen as an early stage of a control pattern, the objective is necessary to express the importance of each control and the risk to access the negative consequence of non-compliance. Table 1 shows an excerpt of the complete listing which is addressing the scope of compliance regulations (compare RQ1). The advantage of the chosen examples is that they cover nearly all facets of the dimension *Scope*, which is used in Section 3.2 to demonstrate the transformation from compliance requirements to control patterns. The retrieved types of regulations vary from the definition of:

- quality controls,
- hygiene and purity requirements,
- requirements regarding the processing of goods,
- preventing the spread of animal diseases,
- requirements regarding transport and storage,
- disclosure agreements to
- tax and export regulations.

| | **Regulation** | **Requirement** | **Objective** | **Risk** |
|---|---|---|---|---|
| 01 | LMÜV<br>*§ 5, Sec. 1* | (1) Fulfil occasionally imposed obligations to combat animal diseases.<br>(2) Take precaution if infectious animal diseases occur. | Conduct quality controls if infectious animal diseases are reported. | Spread of infectious animal diseases. |
| 02 | LMEV<br>*§ 9, Sec. 2* | Export goods within 30 days to a third country or store goods within 60 days in an approved or registered national storage unit. | Export goods within a certain time limit or store goods in an approved or registered national storage. | Violation of tax and import regulations. |

| | | | | |
|---|---|---|---|---|
| 03 | LME *Appendix 4, Chapter I, No. 3* | Depending on the statutory sample size, a sensory testing and a legal assessment have to be conducted after opening the packaging. | Conduct quality control to check goods after opening the packaging. | Processing, trade and consumption of spoiled or contaminated goods. |
| 04 | TLMV *§ 2* | During deep freezing, goods have to be separated from specified inadmissible substances. | Prevent contact to forbidden substances. | Processing, trade and consumption of spoiled or contaminated goods. |
| 05 | ATP *§ 5* | Containers classified as thermal maritime by land without transloading the goods does not require an export permit. | Transport goods without permit if containers are classified as thermal maritime by land. | Violation of disclosure agreements. |
| 06 | LMHV *§ 20* | Transport and store chicken eggs 18 days after laying date at a temperature between 5 °C and 8 °C. | Transport special goods within a certain time limit at a given temperature range. | Processing, trade and consumption of spoiled or contaminated goods. |

**Table 1.** Examples for regulations in the food industry

After completing the text analysis by following the example of Table 1, we were able to identify four different risk types that are representative for our sample of regulations in the food industry, namely the:

- processing, trade and consumption of spoiled or contaminated goods,
- spread of infectious animal diseases,
- violation of disclosure agreements and
- violation of tax and import regulations.

Subsequent risks are negative consequences like disposal costs, sanctions and financial penalties or even health hazards. However, these consequences depend on the risks above so they have not been considered as single risk types. Given these explicit information on requirement, objective and risk the next Section is dedicated to the control pattern layer that serves as intermediary to automate compliance controls with process execution languages (compare Section 2.2).

### 3.2 Specification of Control Patterns in the Food Industry

The formalization of legal text implies to find a reasonable abstraction level. This raises the question to what extent regulations can be formalized by simple constructs like control patterns (compare RQ2). Table 2 provides an overview on frequent control patterns in the food industry. Due to space limitations, only those patterns have been listed that have been applied to formalize compliance regulations. The frequency (FRQ) indicates how often a pattern has been used and to which category it belongs. The listing contains 21 unique control patterns that can be combined to express even more complex compliance requirements using operands and Boolean delimiters (see Table 3). Patterns can be defined using simple verb constructs and prepositions (e.g. $O_i$ *CompliesWith* $Q_i$). Operands are either used to specify general process elements (e.g. object $O_i$) or specific compliance concerns (e.g. quality control $Q_i$), which were introduced in Section 2.2. A complete description of operands is given in Table 2.

| | | **Pattern** | **FRQ** | **Description**<br>Given *A, O, l, p, k* and *t* as operands representing process elements: *A* = activity, *O* = object, *l* = location, p = production facility, *k* = time, *t* = temperature and<br>*Q*, *D* and *P* as operands representing compliance concerns: *Q* = quality, *D* = disclosure and P = security precautions, with *i*, *j* = 1, 2, 3, …*n*, $i \neq j$ and constant *m*. |
|---|---|---|---|---|
| **Order** | Basic | $A_j$ *Precedes* $A_i$ | 1 | $A_i$ must be preceded by $A_j$. |
| | | $A_i$ *LeadsTo* $A_j$ | 1 | $A_i$ must be followed by $A_j$. |
| **Res.** | Basic | $O_i$ *Exclusive* $O_j$ | 6 | If $O_i$ is present then $O_j$ must be absent and vice versa. |
| | | $O_i$ *Exists* | 3 | $O_i$ must exist in the process specification. |
| **Location** | Basic | *ProcessedWith* $p_i$ | 5 | Used with order and occurrence patterns to denote a given $O_i$ is processed with production facility $p_i$. |
| | | *StoredIn* $l_i$ | 4 | Used with order and occurrence patterns to denote a given $O_i$ is stored in storage unit $l_i$. |
| | | *MovedFrom* $l_i$ *MovedTo* $l_j$ | 4 | Used with order and occurrence to denote a given $O_i$ is moved from storage unit $l_i$ to another storage unit $l_j$. |
| | | *($O_i$ , …; m) Multi-ProcessedWith* $p_i$ | 3 | A set of objects *($O_i$ , …)* has to be processed with a certain number of *m* different production facilities $p_i$. |
| | | *($O_i$ ,…; m) Multi-StoredIn* $l_i$ | 1 | A set of objects *($O_i$ , …)* has to be stored in a certain number of *m* different storage units $l_i$. |
| **Information** | Advanced | $O_i$ *CompliesWith* $Q_i$ | 24 | Object $O_i$ complies with quality standards, hygiene and purity requirements by passing regular quality controls as well as extraordinary quality controls $Q_i$. Subject of these controls are e.g. temperature, weight, date of expiry, ingredients, texture and consistence. |
| | | $O_i$ *CompliesWith* $D_i$ | 10 | Object $O_i$ complies with disclosure requirements $D_i$. Subject of these requirements are the consumer protection, tax and import regulations e.g. by correct and complete product declaration, complying with quality and security standards, transparent production processes and a traceable supply chain. |
| | | $A_i$ *CompliesWith* $P_i$ | 3 | Activity $A_i$ has to be performed with special security precautions $P_i$ in order to protect users from e.g. infectious animal diseases. |
| | | $A_i$ *CompliesWith* $Q_i$ | 2 | Activity $A_i$ complies with quality standards, hygiene and purity requirements by applying regular quality controls as well as extraordinary quality controls $Q_i$ (e.g. to prevent the spread of animal diseases). |

| | | | | |
|---|---|---|---|---|
| **Time** | Basic | *Within k* | 10 | Used with order pattern to denote a given $A_i$ to happen within *k* time units. |
| | | *Before k* | 2 | Used with order patterns to denote a given $A_i$ to happen before *k* time units. |
| | Adv. | $A_i$ *ExistsMax/Min k* | 2 | $A_i$ must hold at most/minimum k time units once it happens |
| | | $A_i$ *ExistsEvery k* | 1 | $A_i$ must happen in every *k* time unit. |
| **Temperature** | Basic | *Within* $t_j$ *and* $t_i$ | 7 | Used with time patterns to denote a given $O_i$ is tempered within temperature *t* (with i > j). |
| | | *Below t* | 7 | Used with time patterns to denote a given $O_i$ is tempered below temperature *t*. |
| | | *ExactlyAt t* | 1 | Used with time patterns to denote a given $O_i$ is tempered exactly at temperature *t*. |
| | Adv. | $O_i$ *ExistsMax/Min t* | 1 | Object $O_i$ has to be tempered at most/minimum at temperature *t*. |

**Table 2.** Specification of frequent control patterns in the food industry[2]

To formalize the requirements given in Table 2, we distinguish a number of typical keywords for each pattern. For example, a control is often aligned to the assurance of quality standards, so that the word "control" is tied to an *Information* pattern. *Resource* patterns (Res.) are usually described by expressions that indicate how goods should be handled, which is indicated by word orders like "prevent contact". *Location* patterns are clearly addressed if something is about to be "processed", "moved" or "stored". Depending on the context, keywords like "within" or "below" can also indicate if a pattern depends on *Time* and/or *Temperature* pattern. The most important indicators to classify control patterns with regard to our conceptual model for automating checking are:

- temporal order (e.g. precedes or leads),
- occurrence (e.g. exists, absent or universal),
- human resource (e.g. to segregate or merge activities),
- location in conjunction with the process status (e.g. processed, moved or stored),
- time limitation (e.g. interval, minimum or maximum) and
- temperature setting (e.g. within, below, above or exactly at).

Instead of the control flow proposed by COMPAS [12] we used the three patterns *Time*, *Order* and *Occurrence* recommended by Turetken et al. (2012) [13] and expanded the focus of the *Resource* pattern from the segregation of duties to the segregation of input goods. Besides, we added an information, location and temperature pattern. The *Information* pattern indicates which legal source, control objective and risk is addressed or whether the requirements of a quality control, security precaution or disclosure agreement is met. This ensures transparency and provides valuable con-

2 According to Turetken et al. (2012). Newly added control patterns are indicated by a grey filled table row.

text information about the impact of different food regulations. The *Location* pattern considers how goods should be stored, moved or where they are processed with regard to time and temperature constraints. The *Temperature* pattern is necessary to capture compliance regulations regarding the storage and transport of perishable food. The final set of control patterns consists of seven categories: *Order, Occurrence, Resource, Location, Information, Time* and *Temperature*. Table 3 concludes with the formalization of compliance regulations that started with Table 1. It shows simple patterns as well as more complex patterns to demonstrate the applicability of the most frequent compliance patterns in the food industry.

| | **Control Patterns** | **Order** | **Occurrence** | **Resource** | **Location** | **Information** | **Time** | **Temperature** |
|---|---|---|---|---|---|---|---|---|
| 01 | *Oi CompliesWith Qi AND Ai CompliesWith Pi AND Oi ProcessedWith pi* | | | | ■ | ■ | | |
| 02 | *(Oi MovedFrom li MovedTo lj Within k) OR (Oi StoredIn li Within k)* | | | | ■ | | ■ | |
| 03 | *Ai LeadsTo Aj AND Oi CompliesWith Qi* | ■ | | | | ■ | | |
| 04 | *Oi Exclusive Oj* | | | ■ | | | | |
| 05 | *(Oi MovedFrom li MovedTo lj AND Oi Exists) AND Oi CompliesWith Di* | | | ■ | ■ | ■ | | |
| 06 | *(MovedFrom li MovedTo li OR StoredIn li) Within tj and ti* | | | | ■ | | | ■ |

**Table 3.** Examples for control patterns in the food industry

## 4 Conclusion and Outlook

In this contribution we applied a pattern-based approach for specifying compliance controls in the food industry. Based on a sample of 20 legal text documents, provided by the German Federal Ministry of Justice and Consumer Protection law database, we derived 108 legal statements with process character. These were used to analyze the content of every regulation concerning requirement, objective and risk. To access the scope of food regulations we adopted a business process compliance framework and expanded it by refining the *Scope* of control patterns by *Resource, Location, Information* and *Temperature* patterns. Determining the frequency of compliance patterns we were able to present a list of relevant control patterns in the food industry. The use of control patterns has been illustrated by a choice of regulations which address the previously defined facets of the *Scope* dimension. This led to a deeper understanding of the involved process elements and compliance concerns, which will help to evaluate the benefits and boundaries of current process execution languages used for compliance checking. Future work will be guided by the research question, how control patterns can be used to automate compliance controls. Remaining challenges, regarding the syntax of control patterns, deal with the accuracy versus complexity of applied control patterns and a standardized use of patterns and connectors that enable the implementation of compliance patterns by common process execution languages. To improve the approach further, we will evaluate the usability for the average user with basic IT knowledge and the process modeler with high IT affinity as well.

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