





How Do Brazilian IT Companies Address Ambiguity Resolution in Legal Requirements Specification? - A study focused on data protection laws

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Abstract

[Context] Software requirements are mainly specified using natural language, which is prone to produce ambiguous specifications. This challenge becomes bigger when dealing with requirements that must comply with regulations, the so-called legal requirements. [Objectives] This work investigates the state of practice to tackle ambiguity of legal requirements. The goal is to identify the factors that help or harm ambiguity resolution of legal requirements in companies that need to comply with data protection laws. [Methods] A qualitative study, based on semi-structured interviews, was performed with twenty-two Brazilian IT professionals, from eighteen companies, to gather their views on how to deal with ambiguity resolution of legal requirements. The interview data were recorded, transcribed, and analyzed using qualitative coding techniques, including open and axial coding. [Results] Findings reveal that ambiguity resolution involves the participation of many actors, including the development team, customer, and specialized support areas (Legal, Ambiguity analysis, or Anonymity Sector), also considering the involvement of experienced team members and domain experts. This study also brings a set of factors that positively or negatively influence the quality of legal requirements specifications. [Conclusion] These positive and negative factors, the practices to elicit and specify legal requirements, as well as, the practices to reduce ambiguity in such requirements, can be used as a guide for companies concerned with data protection laws compliance.

Keywords: Legal Requirements; Ambiguity; Regulatory Requirements; Qualitative study; Data Protection Laws

1 Introduction

Information technology (IT) companies must comply with relevant laws and regulations to ensure that their business and system requirements are in legal compliance to avoid the risk of costly penalties, lost reputation, and brand damage resulting from non-compliance [Ghanavati *et al.*, 2014; Akhigbe *et al.*, 2019; Väyrynen *et al.*, 2025].

Data protection laws have emerged as a critical concern because many companies collect, store, and manage user's personal information to deliver their products and services [Gharib *et al.*, 2020]. For example, the legislation of the European Union (EU) named the General Data Protection Regulation - GDPR, which entered into force on 24 May 2016 and applied since 25 May 2018, through the Regulation EU 2016/679 [European-Union, 2018] requires organizations and companies that collect and process personal and sensitive data of European citizens to comply with GDPR [Tankard, 2016]. Personal data refers to information managed by organizations about an identified or identifiable individual [Blix *et al.*, 2017].

The Brazilian General Law of Personal Data Protection or LGPD (in Portuguese, Lei Geral de Proteção de Dados

Pessoais), Law 13.709/2018 [Brasil, 2018], has ten chapters and 65 articles dealing with control measures, evidence of compliance, rights, and obligations regarding the processing of personal data. To achieve compliance with data protection laws, companies must define which regulatory requirements address the law and the appropriate technologies, privacy controls, and safeguards to implement them [Tankard, 2016].

Legal texts are full of ambiguities, often planned ones, called intentional ambiguity [Otto and Antón, 2007; Massey *et al.*, 2014; Väyrynen *et al.*, 2025]. This type of ambiguity allows laws and regulations to avoid dependence on technologies or practices that may change over time [Berry and Kamsties, 2004; Otto, 2009]. To achieve compliance in the context of software development, teams need to resolve ambiguity in legal texts, describing them as unambiguous, testable regulatory requirements (so called, legal requirements).

Recent systematic literature mappings/reviews evidenced that the current literature does not present studies related to how the industry deals with the ambiguity of legal requirements when developing software systems [Akhigbe *et al.*, 2019; Netto *et al.*, 2019a; Andrade *et al.*, 2023; Kosenkov *et al.*, 2025; Spósito *et al.*, 2025].

In fact, many approaches intend to help engineers ad-

dress ambiguity in legal requirements [Bhatia *et al.*, 2016; Ghanavati *et al.*, 2014; Kempe *et al.*, 2024] and align system requirements with legal constraints [Otto and Antón, 2007; Deng *et al.*, 2011; Ayala-Rivera and Pasquale, 2018; Peixoto *et al.*, 2022; Baldassarre *et al.*, 2020; Tsohou *et al.*, 2020; López *et al.*, 2020; Saraiva and Soares, 2023; Ellen Renner Ferrão *et al.*, 2024; Singhal and Breaux, 2025; Abualhaija *et al.*, 2025; Cerqueira *et al.*, 2025]. However, these works did not include empirical studies exploring and identifying current practices used in industry to address ambiguity resolution in legal requirements.

In this context, this paper presents the results of an exploratory study to collect evidence about how IT organizations address ambiguity in legal requirements specification when implementing software that must comply with data protection laws. To achieve this, we conducted 22 semi-structured interviews with professionals in the Midwest (4), Northeast (15), and Southeast (3) regions of Brazil. Previous work [Netto *et al.*, 2019b] reported the findings of three public and four private companies in Brazil. This more extensive work is the result of 18 Brazilian public (6) and private (12) IT companies. As a result, we discovered some factors to create a story representing how the companies involved in this study resolve ambiguities in the specification of legal requirements. A story is simply a descriptive narrative about the phenomenon of study [Pandit, 1996]. In addition to providing an enriched story that depicts factors that help and hamper the quality of legal requirements specifications, this new work also uncovered and described the practices adopted in industry to elicit and specify legal requirements as well as to resolve the inherent ambiguity present in such requirements. These practices form a guide that can help practitioners in the software industry comply with data protection laws.

This paper is structured as follows. Section 2 discusses related work. Section 3 describes the research method. Section 4 presents our analysis and results. Finally, section 5 presents the conclusions and future directions of this research.

2 Related Work

Identifying and extracting ambiguity in software requirements from legal texts is a recurring problem in Requirements Engineering (RE). Boella *et al.* [2014] contrasted the methodologies for extracting legal requirements adopted by the RE community (software analysts) and by legal practitioners. Their critical analysis shows that most approaches are devised without direct involvement of practicing lawyers, yielding oversimplified legal models that hinder acceptance in real world projects. They propose that systems enable dialogue between legal and industry experts, raise awareness of the cultural gap between those experts, and facilitate clear communication in the legal RE process. Boella *et al.* [2014] present a conceptual critique rather than an empirical study. The interpretation of legal provisions for legal requirements should be entrusted to legal experts. A recent work confirms these findings [Klymenko *et al.*, 2022].

Canedo *et al.* [2020] and Sirur *et al.* [2018] identify professionals' perceptions of how companies are developing systems in compliance with personal data protection laws

(LGPD and GDPR, respectively). Canedo *et al.* [2022], in other work, investigated the guidelines adopted by Brazilian agile teams to perform privacy requirements elicitation to achieve compliance with LGPD. However, these works are not concerned with identifying how ambiguity is solved in the specification of legal requirements in the context of compliance with personal data protection laws.

Ambiguities are prevalent in laws and regulations [Massey *et al.*, 2014]. According to Massey *et al.* [2015], many of the approaches developed to mitigate or disambiguate the requirements specifications are not appropriate for dealing with legal ambiguities. They cannot quickly rewrite legal texts, and they must be clarified through interpretation rather than a reformulation if ambiguity appears in current law or regulation. Lawyers and engineers bring different, sometimes conflicting perspectives to interpreting legal texts [Swire and Anton, 2014]. In 2024, the same research group investigated whether a heuristic-based approach could support developers modeling, analyzing, and communicating regulatory ambiguity. The findings revealed several challenges in modeling ambiguous requirements. Nevertheless, the modeling process improved how ambiguities were communicated and analyzed among team members [Kempe *et al.*, 2024].

Recent studies (e.g., [Raj *et al.*, 2025; Berry *et al.*, 2025]) rely on automated solutions to detect and resolve ambiguity in requirements specifications, but neither of them was evaluated in the context of regulatory requirements. In fact, evidence has shown that “disambiguation process is mostly a manual processes that depends on the expertise of the compliance officer”, according to López *et al.* [2020]

Li *et al.* [2022] performed an empirical study in a single company using design science research during 16 months to understand the company's practices to achieve GDPR compliance. In this study, ambiguity was identified as a challenge to achieving legal compliance. Depending only on developers to perform ambiguity resolution may produce wrong or inaccurate requirements. The study also found that asking advice from external consultancy may produce conflicting answers regarding the ambiguous requirement. Although some insights emerged from the in-depth ethnographically performed by the authors, the study's goals didn't include the identification of practices to address ambiguity resolution in legal requirements.

This work aims at bringing empirical evidence on how practitioners deal with ambiguity in legal requirements.

3 Research Method

This section presents the design and planning of an interview-based study involving professionals from different companies and stakeholders who support the software development process (e.g., legal specialists, project managers, analysts, among others). The study aims to understand how the software development industry (public and private organizations) deals with the ambiguity inherent in specifying legal requirements. To conduct this study, we followed five phases of the research method proposed by Kitchenham *et al.* [2002]: (i) Definition of goals and research questions; (ii) Design and planning of the interview protocol, including interview script;

(iii) Evidence collection through interviews; (iv) Data analysis (recording audio files transcripts, coding, interpreting); (v) Reporting the results.

Definition of Goals. This paper aims to understand better how companies (public and private) deal with the inherent ambiguity in the legal requirements specification in a software development process involving legal compliance. Thus, the following research question guides this study: *RQ1: How do organizations deal with ambiguity in legal requirements specification?*, according to the practitioner's perspective. To get a more complete picture of the phenomenon under study, two other questions must be answered:

- *RQ1.1: How do companies perform legal requirements elicitation?* and
- *RQ1.2: How do companies perform legal requirements specification?*

Study Design and Planning. Interviews allow a better understanding of the questions and explain the aspect under study. Besides, interviews allow discussions and clarifications when gathering the data, making it possible to investigate and compensate for differences in understanding and terminology [Franch et al., 2020]. It is essential to consider that requirements practices and requirements-related concepts can differ from project to project. Then, the interviews were transcribed, codified, and analyzed.

Participants. The sample of participants consists of employees of public and private companies consolidated in the Brazilian software development market. In this study, public companies are governmental organizations in charge of developing software and providing IT services for public administration companies. These companies typically have a robust legal department composed of legal experts involved in understanding the rules they have to comply with when regulations like LGPD [Brasil, 2018], GDPR [European-Union, 2018], or others come into force.

To increase data diversity, we looked for companies with different characteristics regarding size (large and small, having respectively more and fewer than 50 workers), sector (public or private), and domain (see Table 1). We use the domain classification of software companies defined by Franch et al. [2020]: (i) *Software Consultancy Companies (SCCs)* that performed software development tasks for different Clients as their primary business; (ii) *IT Departments (ITDs)* that usually performed or outsourced some software development tasks for covering the organization's internal demands; (iii) *Software Houses (SHs)* that develop and commercialize specific proprietary solutions.

About 70 IT professionals of different positions (developers, requirements analysts, project managers, legal specialists, and others) were invited by email to be interviewed (available in Netto et al. [2026]). From these, 22 agreed to be interviewed voluntarily. Those who agreed were required to sign a Consent Term (available in Netto et al. [2026]), which guaranteed confidentiality of the data, anonymity, and the right to withdraw from the research at the moment.

We aimed for good coverage of age, background, education, years of employment, and participation in different organizations to ensure a potentially fertile sample. The average participants' experience is 14.7 years, with values ranging

from 3 to 31 years (see Table 1). Of the 22 participants, thirteen have more than ten years of experience.

Data Collection. The second stage of the interview-based study protocol is to perform the semi-structured interviews. We are using an interview script specifically designed and composed of 15 open-ended questions (interview script for IT professionals available in Netto et al. [2026], interview script for other professionals available in Netto et al. [2026], following Strandberg's guidelines for ethical interviews [Strandberg, 2019]). The questions were presented in a funnel format, with more general questions presented initially (i.e., interviewee education, background, professional experience, company characterization, which are relatively simple to answer). The preliminary questions were followed by the more specific questions related to the context of this work [Runeson et al., 2012]. Two researchers with more than 15 years of experience in the RE field analyzed the interview script. A pilot interview was performed with a senior IT professional from a public Company, validated the interview script, and improved it. Then, the answers from the pilot interview were discarded.

Before the interview, each participant received by email the Consent Term (available in Netto et al. [2026]), which explained the overall objective and importance of the research, guaranteed data confidentiality, participation anonymity, and the right to withdraw from the research at any moment.

The first author conducted the interviews using a remote call, such as phone call, Skype, Google Meet, or Hangouts and recorded all interviews with each interviewee's permission. They occurred between November 2018 and October 2019. Each interview lasted an average of 47 min and, altogether, it resulted in 17h and 23 min of audio time. Collected data were discussed between the authors, and inconsistencies were addressed in discussions and/or complementary explanations provided by the participants. When doubts arose regarding answers, we contacted the interviewee again to clarify these doubts.

Data Analysis We followed the guidelines provided by Corbin and Strauss [2014] to categorize and synthesize data to identify the practices adopted to reduce ambiguity in legal requirements specification. The first author transcribed each audio interview, all interviews were anonymized, and QDA Miner Provalis Research [2024] was used to support the analysis process. The manual transcription process was valuable for the research because it allowed a more accurate interpretation of the data. The interview transcripts lasted an average of 2h and 12 min, and, altogether, it lasted 48h 40 min.

Portions of the text were labeled using codes (we started using open coding, then axial coding, and, finally, selective coding) [Corbin and Strauss, 2014]. Coding consists of assigning conceptual labels (representing a specific theme, area, construct) to essential portions of the interview transcript. One code is usually assigned to many pieces of text, and one piece of text can be assigned more than one code [Runeson and Höst, 2009]. At the beginning of the analysis, we used open coding to identify relevant portions of each interview transcript and created the nodes from the interviewees' excerpts.

According to Corbin and Strauss [2014], axial coding is used to analyze the relationships between the concepts and categories identified during the open coding phase. While

Table 1. Characterization of the Participants

ID [1]	IT Exp. [2]	Position	C. ID [3]	Pub. or Priv.	C. Dom. [4]	C. Age [5]	Emp. [6]
S1	31	IT Director	C01	Public	SCC / ITD	50+	1000-5000
S2	10	Project Mgr.	C01	Public	SCC / ITD	50+	1000-5000
S3	5	Programmer Analyst	C02	Private	ITD	20-30	6000+
S4	18	Senior Mgr.	C03	Public	ITD	20-30	51-200
S5	22	Program Analyst	C04	Public	SCC	10-19	11-50
S6	3	Deployment Analyst	C05	Private	SCC	10-19	51-200
S7	9	Req. Analyst	C06	Private	SCC	20-30	501-1000
S8	3	Req. Analyst	C07	Private	SCC	0-5	11-50
S9	15	Project Mgr.	C01	Public	SCC / ITD	50+	1000-5000
S10	7	Product Owner	C08	Private	SH	10-19	11-50
S11	8	Req. Analyst	C09	Public	ITD	50+	501-1000
S12	9	Privacy and Security Mgr.	C10	Private	SCC / SH	5-10	51-200
S13	5	Anonymization Mgr.	C10	Private	SCC / SH	5-10	51-200
S14	18	IT Lawyer	C11	Private	SCC	20-30	51-200
S15	17	Project Mgr.	C12	Private	SH	10-19	300+
S16	23	Project Mgr.	C13	Private	SH / ITD	20-30	51-200
S17	20	Senior Dev.	C14	Private	SH	15	201-300
S18	14	Quality Analyst	C15	Public	SCC / ITD	50+	1000-5000
S19	8	Security Consultant	C16	Private	SCC	0-5	1-10
S20	15	Project Mgr.	C17	Private	SCC	20-30	300+
S21	30	IT Mgr.	C06	Private	SCC	20-30	501-1000
S22	18	IT Lawyer	C18	Public	Educ.	20-30	501-1000

[1] Interviewed ID; [2] Years of IT Experience in Industry; [3] Company ID; [4] Company Domain; [5] Company Age; [6] Number of Employees.

open coding involves breaking down the data and grouping them in similar codes, axial coding examines how these categories relate to one another. Vollstedt and Rezat [2019] states that, after the data have been fragmented during open coding, axial coding reorganizes them by establishing links between a category and its subcategories, enabling a deeper understanding of the structure and relationships within the emerging theory.

Figure 1 presents the general grounded theory analysis workflow adopted in this study, while Figure 2 illustrates concrete examples of how interview excerpts were coded and interpreted.

Figure 1 illustrates the process started from interview transcripts which were examined through open coding to identify relevant excerpts and generate initial codes. Similar codes were then compared and grouped into categories through axial coding. During this stage, codes were iteratively refined as new evidence emerged. The generated codes were continuously compared across interviews using the constant comparison method, enabling continuous refinement of codes and categories by comparing data segments within and across interviews. And then grouped into categories through axial coding. Categories were also revisited and refined whenever new codes or interpretations emerged, ensuring consistency and conceptual alignment. Next, factors with positive or negative influence on the categories were identified through

interpretation of the interview evidence. Finally, selective coding was used to integrated the identified categories into the core categories and the emerging explanation of how companies address ambiguity in legal requirements specification.

The coding process was iterative and involved constant comparison across interviews, allowing categories to evolve as new data emerged. Although theoretical saturation was not formally measured, no substantially new categories were identified in the later stages of analysis, suggesting sufficient coverage of the phenomenon.

Figure 2 provides concrete examples of how excerpts from the interviews were coded and interpreted during the analysis. We started from the interview transcripts by marking and coding relevant parts of the text (Figure 2 (a)), which gave rise to the codes (Figure 2 (b)). Then, we compared all codes built in the first step and grouped the codes referring to the same concept into a category (Figure 2 (c)). To perform this step, we analyzed the coded interview transcripts again to ensure that the similar codes referred to the same concept. This example illustrates how multiple codes reflecting similar concepts were abstracted into a higher-level category during axial coding.

For example, analyzing the excerpt from interview 09, “...The customer comes, he brings expert people in that business who are people who will test the system...”, we assigned the code **customer’s specialized team**. In the excerpt from in-

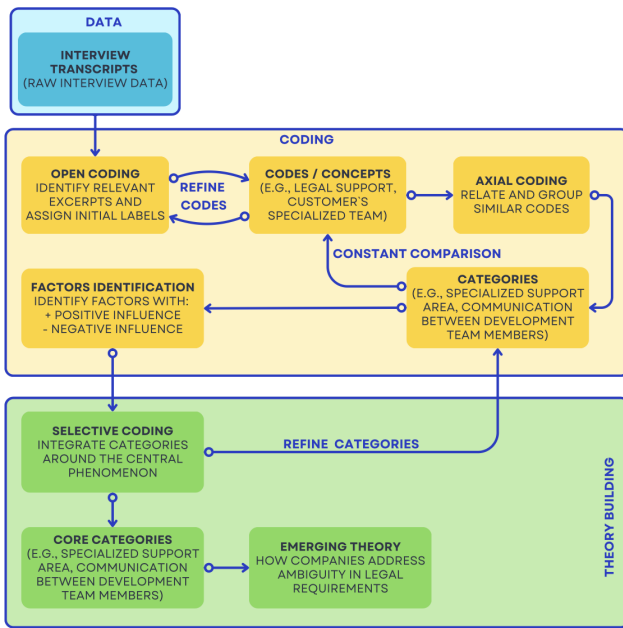


Figure 1. Grounded theory analysis workflow used in this study

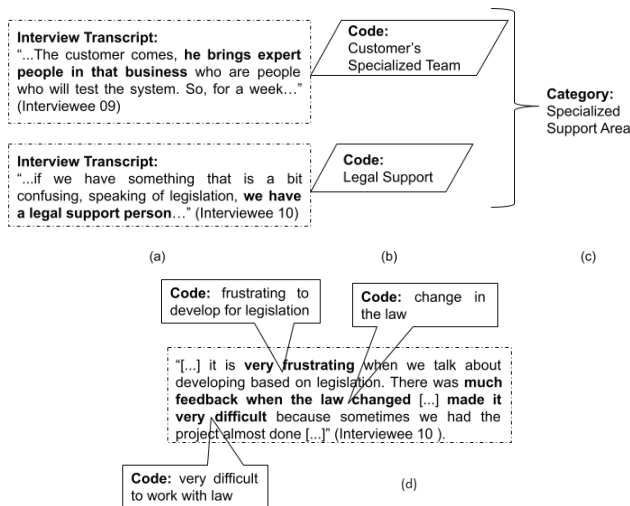


Figure 2. Illustrative examples of the coding process. (a) Open coding of interview transcripts; (b) generated codes; (c) category building from related codes; (d) example of identifying a factor with negative influence.

terview 10, “...if we have something a bit confusing, speaking of legislation, we have a legal support person...”, we assigned the code **legal support**. These codes were constantly compared to codes in the same interview and other interviews. We perceived the similarity between these codes (customer’s specialized team and legal support) and merged them to create the “specialized support area” category in axial coding.

To improve reliability, two authors independently coded the data and discussed discrepancies until consensus was reached. Disagreements were resolved through discussion with the remaining authors, ensuring consistency and reducing individual bias. Each transcript was analyzed again to ensure that all relevant detail was captured and correctly codified. The categories represent how the industry addresses ambiguity in privacy requirements specification.

In addition to categories, we identified secondary factors (represented as a statement with an arrow to a category) that positively (+) or negatively (–) influence them. These factors were derived through interpretation of the interview data and

represent conditions that either support or hinder ambiguity resolution.

In the following, we have an excerpt from an interview interpreted as a negative influence (we highlighted, in bold, the terms that caught our attention when we were coding): “[...] it is **very frustrating** when we talk about developing based on legislation. There was **much feedback when the law changed** [...] **made it very difficult** because sometimes we had the project almost done and **had to go back and adapt to attend law**” [Interviewee S10].

The analysis of this excerpt with the other interviews, using the constant comparison method, can create a factor that negatively impacts a category. In this case, Figure 2 (d) shows the process for identifying the negative factor (2) **Constant changes in the law make legal compliance difficult**. Similarly, a factor with positive influence appears.

Lastly, in selective coding, these codes, from axial coding, were related in categories. The goal of selective coding is to integrate the different categories that have been developed, elaborated, and mutually related during axial coding into one cohesive theory [Vollstedt and Rezat, 2019]. Thus, selective coding chooses the core category and relates it with the other categories from axial coding. The core category described “the central phenomenon around which all the other categories are integrated” [Corbin and Strauss, 2014].

The core is the category that accounts for a large portion of the variation in a pattern of behavior and is considered the central theme or main concern or problem for the participants [Glaser, 1978]. Some criteria for choosing a category as the core: it must be central and related to several other categories and their properties; it must frequently reoccur in the data; it relates meaningfully and quickly with other categories [Glaser, 1978]. Having detected the core category, the researcher knows the central phenomenon of his/her research and can finally answer the research question.

We found the two categories that passed all the criteria for the core: “**Specialized support area**,” and a “**Communication between development team members**.” Figure 3 illustrates the core categories and their relationship.

3.1 Threats to validity

We classify the threats according to the categories defined by Runeson and Höst [2009]. For the **Construct Validity**, we established rigorous planning and protocols for data collection and analysis, as suggested by Runeson and Höst [2009]. Additionally, we carefully designed the interview script and performed a pilot interview with a public company professional with extensive software development experience, whose answers were later discarded. Besides, it is essential to mention that we carried out this study with Brazilian software companies, where Portuguese is the first language. We translated the participants’ quotes that were reproduced in this document.

Also, the Consent Term informs the subjects that participation should be voluntary and withdrawal is possible at any time. The data they provided is confidential, anonymized, and aggregated with the other interviews, i.e., they will not be analyzed individually, not allowing the identification of research participants so that the subjects could freely share their practical experiences.

Concerning **Internal Validity**, we used maximum variation sampling to have good coverage, background, and different views regarding the requirements elicitation and specification activities for legal requirements. The interviewees were utterly free to present a project, and the interviewer did not influence this decision. Finally, the presented projects were of different sizes and types, and the interviewees had different backgrounds (see Table 1). All the interviews were analyzed independently to avoid researchers' bias in the coding process. Following this individual analysis, the two researchers discussed each code and its content and refined the coding structure to reduce overlaps. Moreover, they refined aspects to identify and eliminate any individual biases. Furthermore, we check the categories from the data gathered to confirm that none of them refuted any conclusions.

External Validity. Due to interviews carried out in Brazilian software companies with different interviewees' backgrounds, company size, and characteristics, interviewed could have used certain practices in a specific company and not in others. Therefore, it will not be easy to replicate the study. Considering the number of interviewees (with different expertise) and companies that operate in diversified domains, the study results can be generalized with a certain degree of confidence.

Reliability. In qualitative research, the data analysis consists of interpretation and coding of excerpts from the interviews. Therefore, the codes would probably be partly different with a different set of interviewees. To increase the reliability, we realized a review of the findings by another researcher, maximum variation sampling to have good coverage [Robson, 2002], and get different views regarding the ambiguity in privacy requirements specification. We use a non-probabilistic sample to increase the potential for generalization of the findings and reduce bias in selection. Conducted the interviews at different companies, and each interview happened in only one work session, thus avoiding bias through subjects discussing the interview amongst themselves.

When conducting sufficient interviews, one criterion is "saturation", i.e., when no new information or viewpoint is gained from new subjects [Corbin and Strauss, 2014]. Dey [1999b] states that instead of theoretical saturation, it is better to guarantee that categories are consistently built from the data. Therefore, saturation is closely related to the notion of theoretical sampling — the idea that sampling is guided by the necessary similarities and contrasts required by the emerging theory [Dey, 1999a]. At least two researchers analyzed all the interviews and the coding process in this research. Therefore, although theoretical saturation was not tested, we are confident that we achieve the theoretical sufficiency to apply the findings to other situations.

4 Results and Analysis

We have followed a narrative style integrating quasi-quotes from the interviewees in the general explanations to present the results. These quasi-quotes mean syntactical adaptations of the sentences to make them fit the story (e.g., including the missing context in the sentence, aligning verb tenses, and

others) [Franch *et al.*, 2020]. These quasi-quotes include the identifier of the subjects between curly braces.

The models for public and private companies presented in Figure 3 show the categories (represented by rectangles) and explains the factors that affect positively (+), i.e., corroborate, or negatively (-), i.e., oppose the factors, influence how Brazilian IT companies address ambiguity in privacy requirements specification. Figure 3 is divided into two parts to improve readability. Figure 3 – Part 1 presents the categories related to Requirements Elicitation and the communication dynamics among development team members. Figure 3 – Part 2 presents the categories related to Requirements Specification, the role of the Specialized Support Area, and the mechanisms used to reduce ambiguity in legal requirements. In addition to the categories related to Requirements Elicitation and Requirements Specification, the model includes two core categories that cut across these activities: Communication between Development Team Members and Specialized Support Area. These core categories support both phases and contribute to reducing ambiguity in legal requirements. To facilitate their location and reference in Figure 3, they are bold and numbered. The larger arrows connecting only categories represent that the related categories can influence each other. The rectangle with the red border highlights the core categories. We found the two categories that passed all the criteria for the core were "**Specialized support area**" and a "**Communication between development team members.**"

The "**Specialized support area**" assists both in **Requirements Elicitation** and **Requirements Specification**. The Company has professionals with specialized skills that support projects, **Reducing Ambiguity**. "**Communication between development team members**" assists both in **Requirements Elicitation** and **Requirements Specification**, and helps in **Reducing Ambiguity**.

Brazilian IT public companies have certain peculiarities because their units are spread over several cities or states. These companies serve public customers, have their own data center infrastructure, use a consolidated development process based on SCRUM to develop new products, or carry out major evolutionary maintenance, which has a durability of more than three months. Own separate development units and technology standards to ensure software developed at any development unit has the same quality. Eight interviewees from six different companies are from public companies (see Table 1).

In this context, in general, all projects are aligned with legislation, provisional measure¹, or the law. Thus the company's software development processes are published for society as a whole, and there is a repository internally with standards, laws, articles, or any artifact related to customer demand. Articles 23 to 27 of the LGPD [Brasil, 2018] deal with the processing of personal data by the Public Authorities.

IT private companies have certain peculiarities. These companies have several customers (tax, health, legal, education, among others domains), their development processes are based on agile methods. All companies adhere to Agile

¹A provisional measure is a legal act in Brazil through which the President of Brazil can enact laws without approval by the National Congress. There are two requirements for a provisional measure to be used: urgency and relevance of the matter regulated.

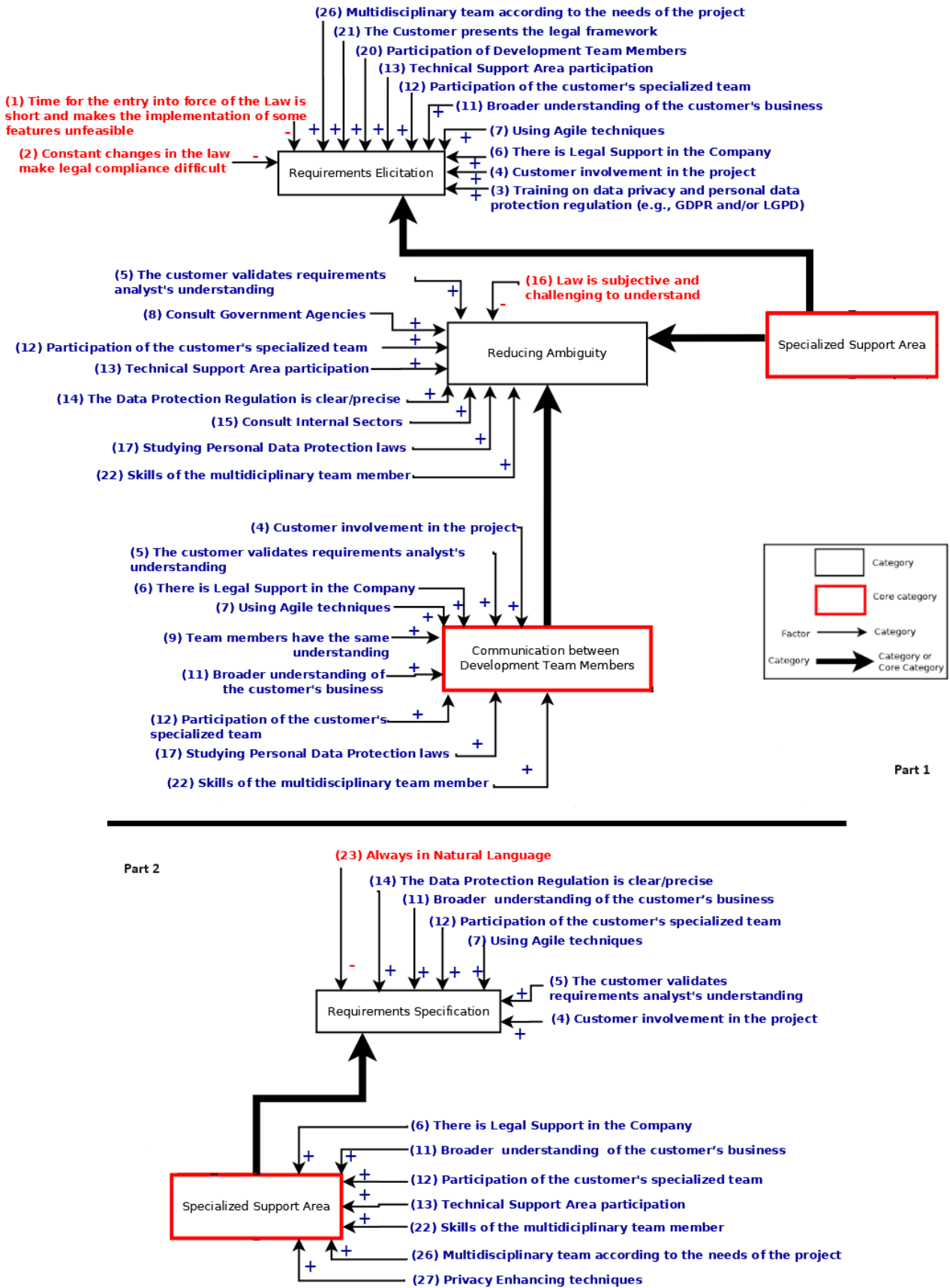


Figure 3. Model explaining how Brazilian IT companies address ambiguity in privacy requirements specification. (Part 1) Requirements elicitation and communication factors. (Part 2) Requirements specification and specialized support areas.

Scrum for large-scope projects or new systems development. Correction demands projects adhere to the waterfall method.

Fourteen interviewees from twelve different companies are from private companies (see Table 1).

According to the interviewees, legal requirements are those that the legislation discusses and states how to treat information and the functional requirements that the system must have.

4.1 Core Category - Communication between Development Team Members

Communication between all project members is one of the most cited factors to understand ambiguous legal requirements and better specify legal requirements (see Figure 3 - Part 1). The **(12) Participation of the customer's specialized team** or **(5) The customer validates the requirements analyst's understanding**. Another factor that positively influences **Communication between development team members** category are **(11) Broader understanding of the customer's business**, and **(22) Skills of the multidisciplinary team member**.

Nevertheless, the Requirements Analyst and team member first meet to discuss and develop a shared understanding inside the team. It is essential that **(9) Team members have the same understanding**. If it is impossible to understand within the team or between teams working on similar needs to mature the understanding, but if the decision still seems ambiguous, the Project Manager or Business Analyst will contact the customer (**(4) customer involvement in the project**), or customer's specialized team (**(12) Participation of customer's specialized team**), or **(6) There is legal support in the company** to clarify the doubt.

In most interviewed companies, the software development process follows agile methods (**(7) Using agile techniques**). Teams typically hold weekly meetings and maintain close interaction with the company's legal department to support compliance-related activities.

Nevertheless, agile methods also encourage customers to participate more actively in the development process. In this context, the customer plays an important role in **(5) validating the understanding of the requirement analyst** of the requested functionality. If the customer reviews what was delivered and realizes that it does not correspond to what was expected, the feature is not accepted. Instead, the ambiguity in the requirement must first be clarified. After the issue is resolved, the feature is re-estimated and scheduled again as a task for a future sprint. The following quote exemplifies this: *"The origin was a very high-level legal requirement, and I think there was a natural maturation of the understanding on the part of the client; at the time, however, we were not following agile methods; as the client refined the idea, we did not interact much with him; we delivered a solution, but the solution was not adequate"* [Interviewee S15].

During the development, if any doubts arise because the information is ambiguous or makes impossible to follow the functionality flow, the first thing to do is to talk to an experienced team member to get a better understanding. Usually, some people have contacted the customer during the survey of the product's first view within the team. These people remain as a specific reference to answer questions about that business. This strategy is similar to that presented by Berry and Kamsties [2004] *"is communicating an interpretation*

back to the author of the requirements, after which she can easily point out misinterpretations".

Usually, when team project members need some understanding from the legal text, the people involved read the law itself and talk with the customer. They deepen their understanding by **(17) Studying personal data protection laws**. The best way to remedy ambiguity is to communicate with someone knowledgeable in the business, between team members, a team that works on similar demands, or the client himself. Thus, **(12) Participation of the customer's specialized team** positively influences the reduction of ambiguity in specifying requirements. These findings are evidenced by the following quotes: (i) *"Moreover, ask him about some points of the law that are ambiguous, or difficult to understand, or know in the IT area"* [Interviewee S18]; and (ii) *"The best way for us to overcome this problem of knowing if it is aligned with the Client's needs is to have the most frequent contact with him"* [Interviewee S05].

4.2 How do Companies Perform Legal Requirements Elicitation?

The software development project starts when the client sends a demand to the Company. Then, the Business Analyst raises the Client's needs at a very high level. Many interviewees reported that the source of legal requirements is legislation, manuals, and regulations that determine the mechanics of operation, interpretation of specific legislation for each domain, and interaction with the customer.

The requirements elicitation session occurs, in all interviewed companies, through interviews with customers to identify needs and understand the Company or department's routines that the software product to be developed will be executed. Wagner *et al.* [2019] indicate the interview as the most popular approach to capture requirements. In addition to interviews, Company C03 carries out some ethnographic activities.

The creation of prototypes is a strategy widely used, and its validation by the customer. We cannot affirm that using these techniques positively or negatively influences legal requirements' elicitation, as we do not verify if the techniques are used correctly. We only present the techniques mentioned by the interviewees. Some companies use other techniques, such as workshops, document analysis and meeting records. We depict the practices for requirements elicitation found in this study in Figure 4.

Most interviewees' companies work **(7) Using agile techniques**. Roles on the agile team (Product Owner (PO), Development Team, Team Lead) plan the sprints for each set of items in the product backlog that will be developed. Therefore, closer contact with the Client (**(4) customer involvement in the project**) is necessary because **(21) The customer presents the legal framework** related to its area of activity (laws, norms, standards, among others), and there is the breakdown of the requirements for the sprint.

The elicitation of legal requirements has its particularities to software requirements. It demands knowledge of those involved in the project concerning the laws that regulate the software's domain to be developed. Thus, the Company must provide **(3) Training on data privacy and personal data**

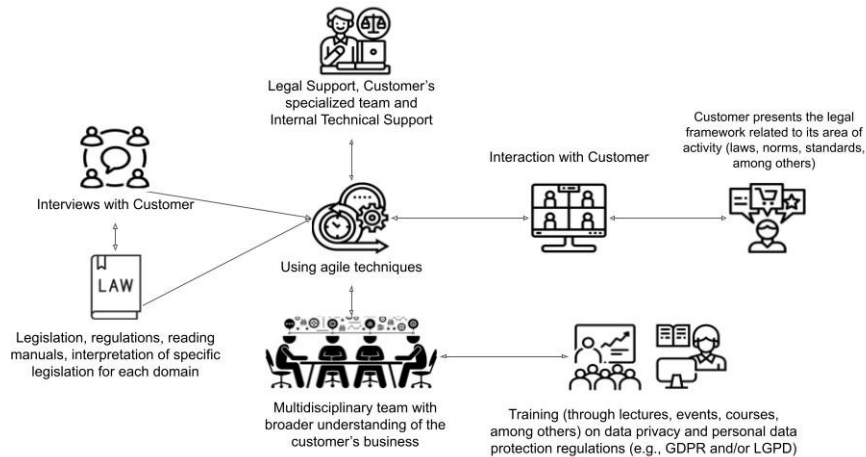


Figure 4. How do Companies perform Legal Requirements Elicitation?

protection regulations (e.g., GDPR and/or LGPD), to stimulate the requirements analyst, business analyst, or other participants in the elicitation session about privacy and personal data protection (through lectures, events, courses, among others). (3) **Training on data privacy and personal data protection regulation** is also a personal factor, as the initiative to take courses related to privacy and data protection may come from the employee. Training on data privacy or personal data protection is essential to assist the customer identify the software's legal requirements.

Another factor that positively influences the **Requirements Elicitation** category has (26) **Multidisciplinary team according to the project's needs** with members with (11) **Broader understanding of the customer's business**. The requirements elicitation and specification steps make it easy when the domain is known.

Conversely, an unknown customer domain negatively influences the requirements elicitation category, and it can cause interpretation difficulties. However, this negative factor can be resolved if there is the support of team members from the specialized support areas in the requirements elicitation sections ((6) **There is legal support in the company**, (12) **Participation of the customer's specialized team**, and (13) **Technical support area participation**), which positively influence the **Requirements Elicitation** category.

Analyzing these excerpts from the interviews, we identified that no support from the specialized legal area at the company could negatively influence eliciting legal requirements. As such, (6) **There is a legal support in the company** helps understand and interpret specific legal terms, reducing ambiguous software requirements specifications.

The (20) **Participation of development team members** in the requirements elicitation session positively influences the category **Requirements Elicitation** because they give examples and, based on practical cases, raise business rules and the first needs. Also, (4) **customer involvement in the project** is a facilitator and success criterion for carrying out **Requirements Elicitation** of legal requirements for employees **Working with Data Protection Regulations** in regulated project environments. And, (1) **the time to entry into force of the law is short and makes the implementation of some features unfeasible** influences the **Requirements Elicitation**

negatively, as quoted by a participant: "sometimes the law has a concise date to come into force, some requirements should be in the software do not go because of the development time" [Interviewee S04].

Another factor that negatively influences the elicitation of requirements is the (2) **Constant changes in the law make legal compliance difficult**. According to Interviewee S06 "if I develop software for six months, this law can change. Can happen. We read, scrutinized, detailed, studied a lot, understood several things, and finished the development. The legislation is changing". Figure 3 - Part 1 presents the factors that influence the Requirements Elicitation category.

4.3 Core Category - Specialized Support Area

This section explains this category influences the Reducing Ambiguity, Requirements Elicitation and Requirements Specification categories. The legal requirements have a particular characteristic: they demand in-depth knowledge of the domain. All interviewed subjects reported that clients usually allocate a specialist or a specialized team to accompany the project (that we call the (12) **Participation of the customer's specialized team**). The team members are Legal Experts, Business Analysts, Domain Experts, Auditors, and other stakeholders. Customer's specialized team functions as a facilitator for understanding the client's domain, mediating the discussion with the Business Analyst and Requirements Analyst. The customer's specialized team present the legal basis, assisting in interpreting the legal privacy requirements, monitoring the software development life cycle as a whole, conducting the legal compliance analysis, and certifying that the software complied with the legislation and was delivered as specified. Some companies reaffirmed the importance of (12) **Participation of the customer's specialized team**: "The customer's team has to be responsible for giving us regulations and standards that regulate his business area, the data flow that they will use. Furthermore, after that, we go through an analysis stage; the development team consults the sources on GDPR and takes internal notes and starts the discussion" [Interviewee S03].

The first thing to meet a legal requirement is to map the Data Flow Diagram (DFD) to understand what will happen to people's data. Detailed mapping of this data is required to

identify which sectors can access this data. Data flow mapping was vital in any compliance attempt. As states Sirur *et al.* [2018] without understanding where their data was transmitted and stored, organizations felt they could not hope to have enough control over their data to protect it. While this was feasible for more essential or more data protection-focused companies, this was a highly challenging task due to the overhead involved in mapping out complex webs of data networks. The following quote exemplifies this: *“To analyze that a given data passes through several sectors of the Company. In this process, we need to integrate Legal, IT, and Governance. Legal gives the legal interpretation, Governance explains what the internal procedures (business rules) are and, then IT translates into the computational language”* [Interviewee S07].

Although privacy and security issues are often treated as responsibilities of specific sectors, respondents emphasized that compliance affects the entire organization. Interviewee S22 stated that **“(24) Privacy Culture in the Company is essential for compliance with data protection laws and should be aligned with Privacy by Design (PbD)”**. Participants also highlighted that **(18) Compliance improves Company image**, reinforcing that privacy culture and organization-wide awareness are fundamental for legally compliant software.

Despite the growing discussion around GDPR and LGPD, some respondents reported **(10) Lack of awareness about Data Protection Regulations**, while others highlighted that **(19) The Company is not concerned about legal compliance**. These factors negatively affect compliance efforts and reveal limited knowledge about personal data protection laws. Therefore, organizations should promote training initiatives on privacy and legal requirements.

The formation of **(26) Multidisciplinary team according to the project’s needs** is crucial for eliciting legal requirements. The **(22) Skills of the multidisciplinary team member**, diverse knowledge, and versatile characteristics (specify, code, testing, database, and user interface skills). The roles participating are the most diverse: Client Project Management, Technical Leader (also named, Focal Point), Service Management Analyst (from the perspective of the development company is the person who best knows that service), Product Owner (PO), Scrum Master, developers, analysts (requirements, integration, and testing), software designers, and architects. In addition to these roles, Business Analysts specialized in the field (tax, health, education, among others).

In the software development Company, the **(13) Technical support area participation** is not part of the development team but provides consultancy (software architects, information security, project managers, lawyers, among others). Its role is to help the team overcome a complex problem and transfer their skills to one or more developers on the team. One Public Company has specialists identifying and treating ambiguity, and one Private Company has specialists in data anonymity. Support from technical experts has a compliance characteristic regarding team members’ work, project adherence, and execution against established company standards, identifies vulnerabilities, points that may violate the law, protects sensitive personal data, or any other identified risk.

In all Public Companies **(6) There is legal support in the company** that guides the project involved regarding the

developed software’s security and legal privacy requirements. However, this support is not within the development team, as stated by Interviewee S18. The business analyst, along with the legal support area, will make a deep understanding of this legislation and support the requirements analyst and development team in discussion with the customer about how these legal requirements translate into technical solutions. Together, they will understand the law and extract the details that need to be in the system, both functional software and work process requirements: *“We take this law, do the first job of reading, and, together with the client, we identify in the system what these points are, which must be changed and by our law’s understanding”* [Interviewee S05].

We identified two scenarios in these private companies related to factor **(6) There is legal support in the company**. The legal sector is part of the software project team [Interviewee S12] or working together only in specific situations [Interviewee S10]. One of the companies has a legal person dedicated to privacy, bringing the development team and the legal sector closer. We believe that this is the ideal composition of a team when it comes to Legal Requirements. The following quotes exemplify this: [1] *“Today, there is a person in the Legal sector dedicated to privacy. We hope that he will read and understand the law, explain and pass on this knowledge to people who need to act on the adequacy part, and that act as a consultant to help us get into compliance”* [Interviewee S12]; and [2] *“We have a person of legal support, a lawyer, that is when it is very critical, and there is a very high risk of us doing something, not in compliance. We trigger it much more as support”* [Interviewee S10].

Moreover, the second scenario in private companies, is when there is no support from the Company’s specialized legal area [Interviewees S07 and S16], illustrated by the following quotes: [1] *“There is no independent sector for legal software compliance, and there is a legal sector responsible for the compliance. This means that the focus is not 100% on software compliance because of several other day-to-day demands”* [Interviewee S07]; and [2] *“Today, the Legal department is more focused on another activity line. It turns out that people in the IT technical area have to interpret everything we already seek legal support, but it is never satisfactory”* [Interviewee S16].

The company of interviewees S12 and S13 has an anonymization sector. This sector is responsible for ensuring the user’s privacy, and one of the ways to achieve it is to have the data anonymized. LGPD [Brasil, 2018] article 5th indent III defines *anonymized data* as those related to the holder that cannot be identified or by whoever performed the collection or any other person, considering reasonable and available use of technical means at the time of treatment. Some **(27) Privacy-enhancing techniques** mentioned by the interviewees are encryption, hash, differential privacy, among others. The following quote exemplifies this: *“We are trying to anonymize all products, and we are doing privacy weeks, which is, like, every quarter, we take a week for everyone to focus on privacy, try to find privacy solutions for the company”* [Interviewee S12].

Having a **(11) Broader understanding of the customer’s business**, the **(12) Participation of the customer’s specialized team** and **(13) Technical support area participation**

(anonymization team, compliance area, and has a legal person dedicated to privacy) positively influences the Specialized Support Area category (see Figure 3 - Part 2).

4.4 How do companies perform legal requirements specification?

In Brazil, public companies must comply with the Open Data Policy [Brasil, 2011], which aims to improve the culture of public transparency. Interviewee S22 states that *“Our main challenge here at the Company is to specify the legal requirements for the data to be public without violating the fundamental right of staff because as a public institution, we have to comply with open data laws”*. Therefore, in addition to complying with LGPD, it is necessary to consider other laws that regulate access to information.

Techniques for requirements specification in public Companies include describing use case, user stories, requirements documents, personas, IEEE requirements specification template, the requirement recorded in their tools, but **(23) always in natural language**. The practices for Requirements Specification are depicted in Figure 5.

A company specifies requirements in its own template and registers them in an issue tracking tool. The customer approves the requirements specification before starting the development.

The process of extracting the legal requirements from the law is manual, when **(14) The data protection regulation is clear/precise**, as quoted by a participant: *“when the legislation is well written, it has entirely drawn the flow data, enters such data, and information processed in such a way, it says the processing rule and will come out in the end. So this will become a likely software requirement”* [Interviewee S05].

Another factor contributing to a precise specification and ambiguity reduction is when we have the **(11) Broader understanding of the customer’s business** i.e., context is not entirely new.

The legal snippet in the requirements specification document is used to perform traceability among the legal snippet and the requirements, as quoted in the following: *“For each specified legal requirement, there will be a section in the document that says “to meet the requirement of Law X,” and it wrote the full reference of the law”* [Interviewee S04].

If there is a disagreement between what is stated in the law with the stakeholder requirements, communication and trust are essential pillars. If something has come into conflict or a question has arisen, the customer has to decide. The law needs to be followed as it is written. Then, the Requirements Analyst records what the customer has requested and is aware. If the legal requirement conflicts with other requirements, then *“the whole scenario must be analyzed, the representative stakeholders must be identified to analyze the law, identify the particularities and verify the feasibility of the specification of the legal requirement”* [Interviewee S08].

(5) The customer validates requirement analyst understanding or **(12) Participation of the customer’s specialized team** continuously validates the interpretation of Requirements Analyst or others involved in the project for requirements specification. **(7) Using agile techniques** favors verifying and validating the requirements specification during

the product development until the final approval, as the following quote exemplifies: *“Sprint validations are essential to escape surprises and much rework”* [Interviewee S18].

Interviewees from two private companies (C02 e C07) cited that they do not specify requirements, as they receive the requirements already specified or don’t use any document to specify them, only tools such as issue tracking systems.

Some projects are based on the waterfall model. In these cases, the requirements are specified and documented in a spreadsheet or the Jira software Atlassian [2025]. Finally, the specifications’ doubts are resolved with the customer (**(4) customer involvement in the project**), and the customer validates the requirements. Then, the requirements are divided into sub-requirements and assigned to the development team members. Other techniques used in Waterfall projects are use cases and a few high and low-fidelity prototypes. The factors that influence the Requirements Specification category are shown in Figure 3 - Part 2.

4.5 How do Companies deal with inherent Legal Requirements ambiguity?

Figure 3 - Part 2 presents the factors that influence the Reducing Ambiguity category. The practices adopted to reduce ambiguity are summarized in Figure 6. Interviewees cite that when **(16) Law is subjective and challenging to understand**, the procedures for reducing ambiguity in legal requirements vary among Companies: consult the customer, **(8) Consult Government Agencies** and **(15) Consult internal sectors**, case law, request the **(12) Participation of the customer’s specialized team** to try to resolve the identified ambiguity, and cases of penalties for companies that failed to comply with the GDPR, for example. Others bring together the **(13) Technical support area participation** or experienced team members to reach a consensus on understanding the identified ambiguity (**(22) Skills of the multidisciplinary team member**).

In two Public Companies and one Private Company, three areas discuss the interpretation of a legal requirement (IT, Business/Governance, and Legal). The Legal (which interprets the law) and Business/Governance (which explains what the procedures are and how to operate them) need to reach an understanding and, therefore, present to the IT sector to “translate” the legal requirement into computational language. The different points of view are presented, how this legal requirement will impact each area, a risk assessment and analysis of the state of the art techniques is carried out. The articulation of actions will give more protection to the customer product development.

The **Reducing Ambiguity** category presents considerable divergences between public and private companies when it comes to LGPD, for example. Analyzing the excerpts of Interviewee S22, from a Public Company, he/she mentions that *“the law is extremely generalist, it does not objectively say what the requirements are”*. We analyzed excerpts similar to this one and categorized them in the factor **(16) Law is subjective and challenging to understand**. Already, interviewee S21, an employee of a private company, cites *“LGPD is very didactic. I think of it as a step-by-step”*. Similar excerpts were categorized under the factor **(14) Data protection**

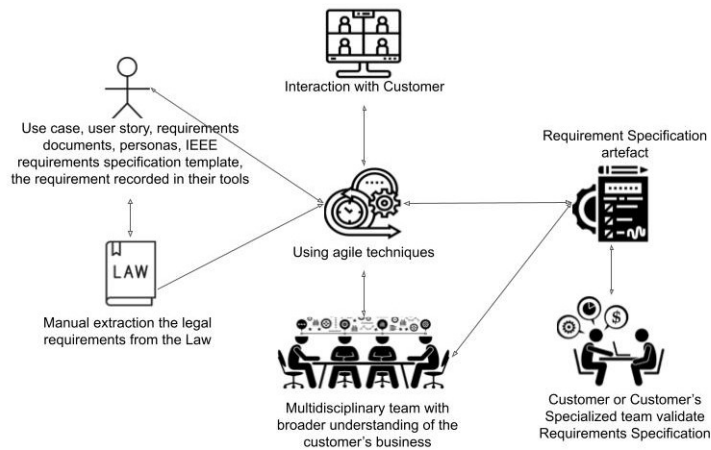


Figure 5. How do companies perform legal requirements specification?

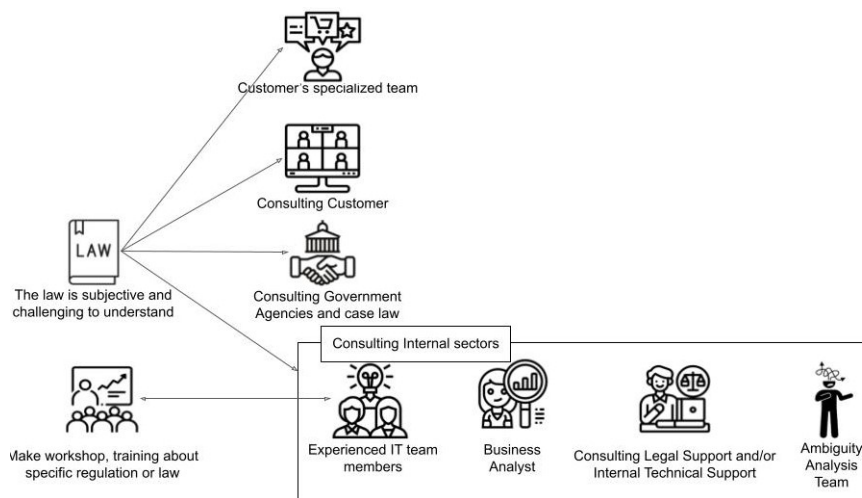


Figure 6. How do Companies deal with inherent Legal Requirements ambiguity?

regulation is clear/precise. Such divergences are due to several factors such as a background in the law, position at the company, experience in projects related to legal requirements and the interpretation of the law may be different for each individual. Therefore, we have two factors that influence the Reducing Ambiguity category: one positively (14), and the other negatively (16).

When team members are unfamiliar with the law, they start by (17) **Studying personal data protection laws**, organizing workshops, and sometimes participating in specific training sessions to develop a shared understanding. As the following quote shows: “The customer presents the Laws and standards that regulate your business area. We read the laws, do the workshop, sometimes, specific training. Sometimes, we have to specialize in legal language to collect laws for that particular business.” [Interviewee S04].

Moreover, only adopting (25) **Verification and Validation techniques for legal requirements** is not sufficient to ensure compliance. Companies also need a (11) **Broader understanding of the customer’s business**, the adoption of (27) **Privacy-enhancing techniques**, and formal education on privacy practices.

When the law comes from a Federal Agency, for example, which is much larger than the Company, the customer does not feel comfortable giving an understanding of the law and the company decides to (8) **Consult Government Agencies**

and (15) **Consult internal sectors.**

LGPD [Brasil, 2018] defines the Brazilian National Data Protection Authority (in Portuguese, Autoridade Nacional de Proteção de Dados - ANPD), which until the date of realization of these interviews is not acting. One interviewee pointed out that he could consult the ANPD to obtain guidance for the interpretation of ambiguity. The ANPD will function as an Information Commissioner’s Office [2025], for example, is the UK’s independent authority, set up to uphold information rights in the public interest, promoting openness by public bodies and data privacy for individuals.

The public Company C01 has a team for Ambiguity Analysis. That is not involved in demand, does not interact with the customer, does not engage with the context. This team analyzes the description of the requirements produced to identify if it is objective, precise, and does not give rise to double interpretation. If it is not satisfactory, ask the responsible for making the necessary corrections. Thus, software documentation produces better quality and decreases rework and risks not correctly meeting what the customer requests- contributing to strengthening the Company’s image (i.e., gaining credibility with your customers, competitive advantage over the competition, attracting investors, and investments).

The participation of the company’s (13) **Technical support area** in the development process positively influences the reduction of ambiguity in the specification of require-

ments and the achievement of legal compliance, as stated by the interviewee S01: “*We have an area not related to my Department, which guides us in Data Protection*”.

In private companies, interviewees cite that support for the technical area for reducing ambiguity occurs in several ways during the software development process: (i) “*Although I work very hard in this field, I have people on my team responsible for making all this interpretation and translating what the legislation requires into a requirement for developers to code*” [Interviewee S20]; (ii) “*There is a second team, besides mine, specialized in scoring the security of applications within the company*” [Interviewee S03]; and (iii) “*Currently, we have this anonymization team and the Legal team. So, together we define these privacy parameters*” [Interviewee S12].

The legal sector members act as consultants. So whenever there is a failure to understand a particular item, and it has a legal or operational nature, usually hold a meeting. This legal sector positions itself on ambiguity or difficulty and presents its understanding.

Interviewee 21 cited cases where the interpretation of ambiguous sections of the legislation caused sensitive personal data from users to be collected and sent to partners for marketing purposes. These facts were analyzed by the Legal sector, which suggested changes in collecting and sharing with partners based on LGPD. Furthermore, notified the partner Company to send its commitment to safeguarding the data, which is the motivation for using all the guiding principles that must be observed as a minimum requirement for an excellent personal data processing activity, as established in I to the X items of LGPD Section 6 [Brasil, 2018].

Interviewees S14 and S19 act as consultants in IT projects supporting the Requirements Analysts. They cite the following procedures for reducing ambiguity in legal requirements: “*Usually, I try to know the real impact that ambiguity can cause to the Client. I try much more to understand the context of ambiguity to know the possible interpretations. Moreover, together with the Client, measure the level of risk he is exposed to*” [Interviewee S14].

To summarize the findings and provide practical guidance for practitioners, we derived a checklist of practices for addressing ambiguity in legal requirements (Table 2). The checklist is grounded in the factors identified in Figure 3 and in the practices reported by the interviewees. Each practice is associated with the phase of the RE process in which it is most relevant.

5 Final Remarks and Future Directions

Ambiguity in legal and software requirements specification is a well-known problem in academic and industry communities. Privacy is a matter that deserves attention from everyone within the company because it is a point of vulnerability in the actions that it performs in the company. Thus, this paper presented a qualitative study on how Brazilian IT companies (public and private) deal with the inherent ambiguity in legal requirements specification.

We present 27 factors that affect positively or negatively the categories (Requirements Elicitation, Requirements Specification, Communication between development team members, Reducing ambiguity, Specialized support area). Moreover, these factors can be recommendations considered during the privacy requirements specification with reduced ambiguity when developing software systems that must comply with data protection laws.

The requirements elicitation session occurs through interviews. Therefore, closer contact with the client is necessary because the customer presents the legal framework (laws, norms, standards, among others) related to its activity area. Training on data privacy and personal data protection regulation helps the requirements analyst to identify software requirements. The requirements analyst needs to count on a multidisciplinary team. According to the project needs, the analyst may require the participation of members with a broader understanding of the customer’s business, as well as professionals from the company’s legal support area, the customer’s specialized team, and the technical support area.

The procedures adopted to reduce ambiguity in legal requirements vary among companies. These procedures may include consulting customers, government agencies, or internal sectors, analyzing case law, and requesting the participation of the customer’s specialized team. In addition, the customer or the customer’s specialized team continuously validates the analyst’s interpretation of the requirements.

As ongoing research, we aim to conduct a cross-sectional survey through a self-administered questionnaire online to reach participants from different countries and states in Brazil. The survey aims to collect the software practitioners’ perceptions regarding the factors and actions to achieve ambiguity resolution, presented in this paper, and complement these findings. The goal is to create consolidated guidelines based on best practices to promote compliance of software requirements specifications with data protection laws.

Declarations

Authors’ Contributions

Netto and Silva contributed to the conception of this study. Netto, Silva and Araújo designed the methodology. Netto performed the interviews and analyzed the data. Santos, Silva and Araújo reviewed the analysis result. Netto is the main contributor and writer of this manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Table 2. Checklist of Practices for Addressing Ambiguity in Legal Requirements

#	Practice	Phase	Description	Related Factors (Figure 3)
1	Involve legal and domain experts	Elicitation / Specification	Ensure the participation of legal specialists or domain experts to interpret legislation and support requirements analysis.	(6), (12), (13)
2	Maintain frequent communication with the customer	Elicitation / Specification	Interact regularly with the customer to clarify ambiguities and validate the interpretation of legal requirements.	(4), (5), (12)
3	Promote multidisciplinary collaboration	Elicitation / Specification	Form teams composed of professionals with diverse expertise (e.g., developers, analysts, legal experts, governance).	(22), (26)
4	Establish shared understanding within the team	Elicitation	Encourage discussions among team members to ensure a common understanding of legal requirements.	(9)
5	Study relevant legislation and regulatory frameworks	Elicitation / Ambiguity Reduction	Analyze laws and regulatory documents related to the system's domain to improve interpretation of legal requirements.	(17), (21)
6	Provide training on data protection and privacy regulations	Elicitation	Offer training sessions, workshops, or courses on regulations such as GDPR or LGPD.	(3)
7	Use agile practices for iterative validation	Specification	Apply agile practices (e.g., sprint reviews, regular meetings) to validate requirements continuously and detect ambiguities early.	(7)
8	Maintain traceability between legal texts and requirements	Specification	Explicitly reference legal provisions in requirements documentation to support compliance verification.	(14), (23)
9	Consult government agencies when interpretation is unclear	Ambiguity Reduction	Seek guidance from regulatory agencies when legal requirements are difficult to interpret.	(8)
10	Consult internal sectors for legal interpretation	Ambiguity Reduction	Engage internal departments such as legal, governance, or compliance to clarify ambiguous legal requirements.	(15)

Availability of data and materials

In [Netto et al., 2026], we disclose the instruments used in this study. The collected data can be provided under request.

References

- Abualhaija, S., Ceci, M., Sannier, N., Bianculli, D., Lanier, S., Siclari, M., Voordeckers, O., and Tosza, S. (2025). LLM-assisted Extraction of Regulatory Requirements: A Case Study on the GDPR. In *2025 IEEE 33rd International Requirements Engineering Conference (RE)*, pages 142–154. DOI: 10.1109/RE63999.2025.00023.
- Akhigbe, O., Amyot, D., and Richards, G. (2019). A systematic literature mapping of goal and non-goal modelling methods for legal and regulatory compliance. *Requir. Eng.*, 24(4):459–481. DOI: 10.1007/s00766-018-0294-1.
- Andrade, V., Gomes, R., Reinehr, S., Freitas, C., and Malucelli, A. (2023). Privacy by design and software engineering: a systematic literature review. In *Proceedings of the XXI Brazilian Symposium on Software Quality, SBQS '22*. Association for Computing Machinery. DOI: 10.1145/3571473.3571480.
- Atlassian (2025). Jira software. Available at: <https://www.atlassian.com/software/jira>. Acesso em: 12 mar. 2025.
- Ayala-Rivera, V. and Pasquale, L. (2018). The grace period has ended: An approach to operationalize GDPR requirements. In *26th IEEE Intl. Requirements Engineering Conference, RE 2018*, pages 136–146. IEEE Computer Society. DOI: 10.1109/RE.2018.00023.
- Baldassarre, M. T., Santa Barletta, V., Caivano, D., and Scalera, M. (2020). Integrating security and privacy in software development. *Software Quality Journal*, 28(3):987–1018. DOI: 10.1007/s11219-020-09501-6.
- Berry, D. M. and Kamsties, E. (2004). *Ambiguity in Requirements Specification*, pages 7–44. Springer US, Boston, MA. DOI: 10.1007/978-1-4615-0465-8_2.
- Berry, D. M., Kamsties, E., Ribeiro, C., and Tjong, S. F. (2025). *Detecting Defects in Natural Language Require-*

- ments Specifications, pages 117–151. Springer Nature Switzerland, Cham. DOI: 10.1007/978-3-031-73143-3_5.
- Bhatia, J., Breaux, T. D., Reidenberg, J. R., and Norton, T. B. (2016). A theory of vagueness and privacy risk perception. In *24th IEEE International Requirements Engineering Conference, RE 2016*, pages 26–35. IEEE Computer Society. DOI: 10.1109/RE.2016.20.
- Blix, F., Elshekeil, S. A., and Laoyookhong, S. (2017). Data protection by design in systems development: From legal requirements to technical solutions. In *12th Intl. Conference for Internet Technology and Secured Transactions, ICITST 2017*, pages 98–103. IEEE. DOI: 10.23919/ICITST.2017.8356355.
- Boella, G., Humphreys, L., Muthuri, R., Rossi, P., and van der Torre, L. W. N. (2014). A critical analysis of legal requirements engineering from the perspective of legal practice. In *IEEE 7th Intl. Workshop on Requirements Engineering and Law, RELAW 2014*, pages 14–21. IEEE Computer Society. DOI: 10.1109/RELAW.2014.6893476.
- Brasil (2011). Lei nº 12.527, de 18 de novembro de 2011. Available at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/lei/112527.html.
- Brasil (2018). LGPD - lei geral de proteção de dados pessoais. DOI: 10.47385/simpdir.2024.1647.
- Canedo, E., Calazans, A., Bandeira, I., Costa, P., and Masson, E. (2022). Guidelines adopted by agile teams in privacy requirements elicitation after the brazilian general data protection law (LGPD) implementation. *Requir. Eng.*, 27(4):545–567. DOI: 10.1007/s00766-022-00391-7.
- Canedo, E., Calazans, A., Masson, E., Costa, P., and Lima, F. (2020). Perceptions of ICT practitioners regarding software privacy. *Entropy*, 22(4):429. DOI: 10.3390/e22040429.
- Cerqueira, D., de Mello, R., da Costa, J., and Travassos, G. H. (2025). Experimental evaluation of a checklist-based inspection technique to verify the compliance of software systems with the brazilian general data protection law. *Empir Software Eng*, 30(5). DOI: 10.1007/s10664-025-10681-7.
- Corbin, J. and Strauss, A. (2014). *Basics of qualitative research*. Thousand Oaks, California, CA. sage.. DOI: 10.2307/3172751.
- Deng, M., Wuyts, K., Scandariato, R., Preneel, B., and Joosen, W. (2011). A privacy threat analysis framework: Supporting the elicitation and fulfillment of privacy requirements. *Requir. Eng.*, 16(1):3–32. DOI: 10.1007/s00766-010-0115-7.
- Dey, I. (1999a). *Grounding Grounded Theory: Guidelines for Qualitative Inquiry*. Academic Press, San Diego. Book.
- Dey, I. (1999b). *Qualitative data analysis: A user friendly guide for social scientists*. Routledge. DOI: 10.4324/9780203412497.
- Ellen Renner Ferrão, S., Ramos Sousa Silva, G., Dias Canedo, E., and Freitas Mendes, F. (2024). Towards a taxonomy of privacy requirements based on the LGPD and ISO/IEC 29100. *Information and Software Technology*, 168:107396. DOI: 10.1016/j.infsof.2024.107396.
- European-Union (2018). GDPR - general data protection regulation. <https://eugdpr.org/>.
- Franch, X., Palomares, C., and Quer, C. (2020). Industrial practices on requirements reuse: An interview-based study. In *Requirements Engineering: Foundation for Software Quality*, pages 78–94, Cham. Springer Intl. Publishing. DOI: 10.1007/978-3-030-44429-7_6.
- Ghanavati, S., Amyot, D., and Rifaut, A. (2014). Legal goal-oriented requirement language (legal grl) for modeling regulations. In *Proceedings of the 6th International Workshop on Modeling in Software Engineering, MiSE 2014*, page 1–6. ACM. DOI: 10.1145/2593770.2593780.
- Gharib, M., Mylopoulos, J., and Giorgini, P. (2020). Copri-a core ontology for privacy requirements engineering. In *International Conference on Research Challenges in Information Science*, pages 472–489. Springer. DOI: 10.1007/978-3-030-50316-1_28.
- Glaser, B. (1978). Theoretical sensitivity. *Advances in the Methodology of Grounded Theory*. Book.
- Information Commissioner’s Office (2025). Information commissioner’s office (ico). Available at: <https://ico.org.uk/>.
- Kempe, E., Massey, A., Seaman, C., Sampath, S., and Semsar, S. (2024). Modeling, analyzing and communicating regulatory ambiguity: An empirical study. *MO2RE 2024*, page 28–34. Association for Computing Machinery. DOI: 10.1145/3643666.3648576.
- Kitchenham, B. A., Pfleeger, S. L., Pickard, L., Jones, P. W., Hoaglin, D. C., Emam, K. E., and Rosenberg, J. (2002). Preliminary guidelines for empirical research in software engineering. *IEEE Trans. Software Eng.*, 28(8):721–734. DOI: 10.1109/TSE.2002.1027796.
- Klymenko, O., Kosenkov, O., Meisenbacher, S., Elahidoost, P., Mendez, D., and Matthes, F. (2022). Understanding the implementation of technical measures in the process of data privacy compliance: A qualitative study. In *Proc. of the 16th ACM / IEEE Intl. Symposium on Empirical Software Engineering and Measurement, ESEM ’22*, page 261–271. Association for Computing Machinery. DOI: 10.1145/3544902.3546234.
- Kosenkov, O., Elahidoost, P., Gorschek, T., Fischbach, J., Méndez, D., Unterkalmsteiner, M., Fucci, D., and Mohanani, R. (2025). Systematic mapping study on requirements engineering for regulatory compliance of software systems. *Inf. Softw. Technol.*, 178:107622. DOI: 10.1016/J.INFSOF.2024.107622.
- Li, Z. S., Werner, C., Ernst, N., and Damian, D. (2022). Towards privacy compliance: A design science study in a small organization. *Information and Software Technology*, 146:106868. DOI: 10.1016/j.infsof.2022.106868.
- López, H. A., Debois, S., Slaats, T., and Hildebrandt, T. T. (2020). Business process compliance using reference models of law. In *Fundamental Approaches to Software Engineering*, pages 378–399, Cham. Springer International Publishing. DOI: 10.1007/978-3-030-45234-6_19.
- Massey, A. K., Rutledge, R., Antón, A. I., and Swire, P. P. (2014). Identifying and classifying ambiguity for regulatory requirements. In *IEEE 22nd Intl. Requirements Engineering Conference, RE 2014*, pages 83–92. IEEE Computer Society. DOI: 10.1109/RE.2014.6912250.
- Massey, A. K., Rutledge, R. L., Antón, A. I., Hemmings, J. D., and Swire, P. P. (2015). A strategy for addressing ambiguity in regulatory requirements.

- Technical report, Georgia Institute of Technology. Available at: <https://www.semanticscholar.org/paper/A-Strategy-for-Addressing-Ambiguity-in-Regulatory-Massey-Rutledge/2414cdfcbc8b43137ef80ead0e7575cdd0ec46d2>.
- Netto, D., Peixoto, M. M., and Silva, C. (2019a). Privacy and security in requirements engineering: Results from a systematic literature mapping. In *Anais do WER19 - Workshop em Engenharia de Requisitos*. Editora PUC-Rio. DOI: 10.29327/1298731.22-5.
- Netto, D., Silva, C., and Araújo, J. (2019b). Identifying how the Brazilian software industry specifies legal requirements. In *Proceedings of the XXXIII Brazilian Symposium on Software Engineering, SBES 2019*, pages 181–186. ACM. DOI: 10.1145/3350768.3352730.
- Netto, D., Silva, C., Araújo, J., and Santos, M. (2026). Supplementary material. <https://dorgivalnetto.github.io/journal2026/>. Available at: <https://dorgivalnetto.github.io/journal2026/>.
- Otto, P. N. (2009). Reasonableness meets requirements: Regulating security and privacy in software. *DUKE LAW JOURNAL*, 59:309–342. Available at: <https://scholarship.law.duke.edu/dlj/vol159/iss2/3>.
- Otto, P. N. and Antón, A. I. (2007). Addressing legal requirements in requirements engineering. In *15th IEEE Intl. Requirements Engineering Conference, RE 2007, October 15-19th, 2007, New Delhi, India*, pages 5–14. IEEE Computer Society. DOI: 10.1109/RE.2007.65.
- Pandit, N. R. (1996). The creation of theory: A recent application of the grounded theory method. *The qualitative report*, 2(4):1–15. DOI: 10.46743/2160-3715/1996.2054.
- Peixoto, M., Silva, C., Araújo, J., Gorschek, T., Vasconcelos, A., and Vilela, J. (2022). Evaluating a privacy requirements specification method by using a mixed-method approach: Results and lessons learned. *Requir. Eng.*, 28(2):229–255. DOI: 10.1007/s00766-022-00388-2.
- Provalis Research (2024). Qda miner: Qualitative data analysis software. Available at: <https://provalisresearch.com/products/qualitative-data-analysis-software/>. Accessed: 2026-03-25.
- Raj, A., Basit Ur Rahim, M. A., Hussain, S., and Zia, I. (2025). Enhancing software requirements quality: Ambiguity detection and resolution using large language models. In Arabnia, H. R., Deligiannidis, L., Shenavarmasouleh, F., Amirian, S., and Ghareh Mohammadi, F., editors, *Computational Science and Computational Intelligence*, pages 340–355, Cham. Springer Nature Switzerland. DOI: 10.1007/978-3-031-95127-5_25.
- Robson, C. (2002). *Real world research: A resource for social scientists and practitioner-researchers*. Blackwell Publishing. numb. 2. vol. 2nd. pg. 587. Book.
- Runeson, P. and Höst, M. (2009). Guidelines for conducting and reporting case study research in software engineering. *Empir Software Eng.*, 14:131–164. DOI: 10.1007/s10664-008-9102-8.
- Runeson, P., Host, M., Rainer, A., and Regnell, B. (2012). *Case study research in software engineering: Guidelines and examples*. John Wiley & Sons. DOI: 10.1002/9781118181034.
- Saraiva, J. and Soares, S. (2023). Privacy and security documents for agile software engineering: An experiment of Igd inventory adoption. In *2023 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, pages 1–9. DOI: 10.1109/ESEM56168.2023.10304806.
- Singhal, A. and Breaux, T. (2025). Legal requirements translation from law. In *2025 IEEE 33rd International Requirements Engineering Conference (RE)*, pages 205–217. DOI: 10.1109/RE63999.2025.00028.
- Sirur, S., Nurse, J. R. C., and Webb, H. (2018). Are we there yet?: Understanding the challenges faced in complying with the general data protection regulation (GDPR). In *Proceedings of the 2nd International Workshop on Multimedia Privacy and Security, MPS@CCS 2018*, pages 88–95. ACM. DOI: 10.1145/3267357.3267368.
- Spósito, S. L., Targino, J. F. G., Silva, G. R. S., Peotta, L., Porto, D. d. P., Mendonça, F. L. L., and Canedo, E. D. (2025). A comprehensive review of techniques, methods, processes, frameworks, and tools for privacy requirements. *Journal of Internet Services and Applications*, 16(1):508–529. DOI: 10.5753/jisa.2025.5252.
- Strandberg, P. E. (2019). Ethical interviews in software engineering. In *2019 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, pages 1–11. DOI: 10.1109/ESEM.2019.8870192.
- Swire, P. and Anton, A. (2014). Engineers and lawyers in privacy protection: Can we all just get along? *IAPP Privacy Perspectives*. Available at: <https://iapp.org/news/a/engineers-and-lawyers-in-privacy-protection-can-we-all-just-get-along>.
- Tankard, C. (2016). What the GDPR means for businesses. *Netw. Secur.*, 2016(6):5–8. DOI: 10.1016/S1353-4858(16)30056-3.
- Tsohou, A., Magkos, E., Mouratidis, H., Chrysoloras, G., Piras, L., Pavlidis, M., Debussche, J., Rotoloni, M., and Gallego-Nicasio Crespo, B. (2020). Privacy, security, legal and technology acceptance elicited and consolidated requirements for a GDPR compliance platform. *Information and Computer Security*, 28(4):531–553. DOI: 10.1108/ICS-01-2020-0002.
- Vollstedt, M. and Rezat, S. (2019). *An Introduction to Grounded Theory with a Special Focus on Axial Coding and the Coding Paradigm*, pages 81–100. Springer International Publishing, Cham. DOI: 10.1007/978-3-030-15636-7_4.
- Väyrynen, K., Lanamäki, A., Laari-Salmela, S., Iivari, N., and Kinnula, M. (2025). Unpacking the regulatory ambiguity mechanism: Implications for industry-level digital transformation. *Information Systems Journal*, 35(6):1528–1564. DOI: 10.1111/isj.12595.
- Wagner, S., Fernández, D., Felderer, M., Vetrò, A., Kalinowski, M., Wieringa, R., Pfahl, D., Conte, T., Christiansson, M.-T., Greer, D., Lassenius, C., Männistö, T., Nayebi, M., Oivo, M., Penzenstadler, B., Prikladnicki, R., Ruhe, G., Schekelmann, A., Sen, S., Spinola, R., Tuzcu, A., de la Vara, J. L., and Winkler, D. (2019). Status quo in requirements engineering: A theory and a global family of surveys. *ACM Trans. Softw. Eng. Methodol.*, 28(2). DOI: 10.1145/3306607.