Automated Determination of Jurisdiction and Applicable Law for International Service Contracts: Modeling Method, Information Model, and Implementation

Martin Waldburger*, Marinos Charalambides†, Thomas Schaaf‡, Burkhard Stiller*

*University of Zürich, CH–8050 Zürich, Switzerland, [waldburger|stiller]@ifi.uzh.ch
†University College London, London WC1E 7JE, United Kingdom, M.Charalambides@ee.ucl.ac.uk
‡Ludwig-Maximilians-Universität Munich, DE–80538 München, Germany, schaaf@mnm-team.org

***Abstract*—Jurisdiction and applicable law constitute two parameters of international service contracts with a high potential impact on business risk. The legally compliant determination of jurisdiction and applicable law, however, is highly complex and costly as it must consider the case-specific connecting factor setting applicable to a given international contract relation. With the aim to support contract parties in concluding an international service contract, hence, a decision support tool to produce a list of recommended jurisdiction(s) and/or applicable law(s) in an automated and compliant manner is developed in this paper.**

This implies to address the following three challenges. First, in the light of a method lacking to identify, select, and formally model the relevant legal basis, such a method has to be developed. Second, a common information model basis has to be built in order to reflect and integrate different notions originating from different jurisdictions and their laws. Third, and in consideration of both, modeling method and information model, an implementation of those laws modeled becomes necessary. Therefore, this paper addresses these challenges and it shows for the example of the main European jurisdiction-oriented regulation modeled and implemented that an automated determination is feasible and fully operational.

I. Introduction and Motivation

Upon the conclusion of a contract between a service provider and a service customer for a commercially offered electronic service in the Internet, this contract is likely to have an international connection. Provider and customer might be related by means of, *e.g.*, residence or citizenship to different jurisdictions. Also, the contracted service might have to be provisioned internationally. In case an international service contract has to be concluded, contract parties are well advised to agree at the time of contract formation on two key contractual provisions, namely those of jurisdiction and applicable law. Jurisdiction indicates which nation's courts are authorized to hear and decide on a potential conflict arising from a concluded contract. Applicable law indicates under which nation's law a court decision shall be found. Jurisdiction and applicable law provisions, thus, might have a considerable impact on the risk assessment of an international service contract to be concluded.

The legal frame to be consistent with when determining jurisdiction and applicable law for an international contract of civil and commercial matters is laid out by Private International Law (PIL). PIL dictates to identify jurisdiction and applicable law according to the contract-specific set of relevant connecting factors. This, however, stands in contrast to the vast majority of international service contracts concluded in the Internet today. Such contracts usually cover provisions on jurisdiction and applicable law, which are static and unilaterally imposed in the sense that a relevant set of connecting factors is not considered at all. Given the importance of jurisdiction and applicable law, the often PIL-ignorant way international service contracts are concluded today needs to be overcome. To this aim, the value of a decision support tool to help a provider and customer determine recommendable jurisdiction(s) and applicable law(s) in a legally compliant and automated manner becomes apparent. Consequently, this paper addresses three challenges, all of which are embedded in the search of a methodology and a tool set to facilitate, ease, and automate the legally compliant determination of jurisdiction and applicable law based on the accordingly applicable set of connecting factors.

The first challenge tackled covers a method developed to identify, analyze, and formally model a single national or supra-national PIL. This includes in particular instructions to pre-select thematically relevant parts of the PIL considered, to assess and grade provisions of interest within a previously pre-selected law part, and to group similar provisions into thematic blocks. Moreover, this method provides guidelines to formally model identified thematic blocks and to inter-link these in a technically and legally correct manner—resulting in a formal model represented as a UML (Unified Modeling Language) activity diagram. Driven by this modeling method, the second challenge addressed is concerned with the development and documentation of a suitable information model reflecting key requirements of international contract and service management. This information model is derived from a comprehensive information model established in ITSM (IT Service Manage-

ment) and consists out of two components: a concept model and a model of the set of information artifacts—connecting factors—required to determine jurisdiction and applicable law in international service contracts. Both sub-models are represented as UML class diagrams. This information model serves as the solid basis for a successful implementation, which constitutes the third challenge addressed by this paper. For the concrete example of a modeled PIL, and in consideration of the relevant information model, this approach describes the design and a functional implementation achieved in logic programming (Prolog). Based on a configurable connecting factor input set this implementation generates, in an automated and legally compliant manner, a listing of recommendable jurisdictions and applicable laws to be written in an international service contract to be concluded.

In summary, the problem to be solved is to determine in an automated and PIL-conforming manner recommendations on suited jurisdiction(s) and/or applicable law(s) for an international service contract to be concluded. Those three identified challenges of a modeling method, information model, and implementation constitute necessary contributions to this problem.

Accordingly, the remainder of this paper is structured as follows: Section II provides background information relevant to these challenges listed and it gives an overview of related work in the area. Driven by the set of requirements determined at the end of Section II, Section III is concerned with developing and documenting the according modeling method addressing the first challenge mentioned. Moreover, the modeling method finds application to the concrete example of a European PIL regulation. In accordance with the respective resulting activity diagram, Section IV specifies the according information model covering both, service management and international contracting aspects. This information model bridges the modeling method determined with the design and implementation as documented in Section V. Obtained results are, finally, discussed in Section VI, whereas performed work is summarized and the set of overall conclusions is drawn in Section VII.

II. Background Information and Related Work

Based on the set of three challenges introduced and motivated, this section gives an overview of relevant background information and related work. This covers, in particular, a discussion of the respective applicable service and contract notions as well as of the procedure by which courts handle international contract claims (see Section II-A). Section II-B provides basic information in relation to information modeling as it presents an established ITSM information model contributing the starting point based on which this paper's information model is developed. Section II-C introduces rule-based systems and in what terms they are useful for an implementation as foreseen here. Out of these three background information areas, Section II-D lists gaps identified and accordingly derived requirements on the modeling method, the information model, and on the implementation.

A. PIL in International Service Contracts

Before going into details of international contract claims according to PIL, two fundamental notions have to introduced, namely the applicable understanding of the contract type focused in this paper as well as the underlying notion of a service. As for the former, contracts of electronic services are looked at exclusively. Services are assumed to be provided commercially, *i.e.*, for monetary compensation between a single service provider and a single service customer. For details of the envisioned contractual relationship and the related information model refer to Section IV-A.

Of note here is that, in general, the contractual relation focused is a bilateral (as opposed to a multilateral) one. Furthermore, relations are assumed to have an international (as opposed to intra-national) connection. The contract itself shall endorse a civil and commercial matter. Thus, a contract under private law is envisioned. Private law is typically differentiated from public law, including international public law (often referred to as international law), and from penal law (also referred to as criminal law). From a legal systematic perspective, the type of contract foreseen falls under PIL (also known as Conflicts of Laws). The requirement of an international relation may imply international service provision (*e.g.*, between two customer offices) or it may mean that contract parties have international connection (*e.g.*, by means of domicile in different nations).

With respect to the contractual object focused, services are envisioned to embrace electronic provisioning of the contracted object exclusively. Purely electronic provisioning of the contracted electronic service implies that a service performed does not include any physical or material good at all. Consequently, legal sources considering material goods are excluded. Most notably, this excludes application of the United Nations convention on contracts for the international sale of goods (CISG) [15]. Any considered PIL must be applicable to contracts covering the contractual object focused. The main reason for this selection is to narrow scope on to those services which are exclusively virtual in the sense of non-material, *i.e.*, services which are at the core of "Internet services". By this specific, narrowed service scope, an equally narrow scope is outlined for "Internet contracts".

With this contractual, service-related, and PIL-oriented scope introduced, this work looks at an automated, legally compliant determination of jurisdiction and applicable law. At the point of contract conclusion, both parameters are mainly important from a risk assessment point of view. Should a dispute arise from a concluded international service contract and should this dispute be brought into court, that court would then first assess whether it has authorization to hear the case and to decide about it. If that court sees itself responsible, then the law applicable to the case in question needs to be determined. This might be the law of the state in which that court is located, but it might also be the law of another, foreign state. Coming back to the moment of contract negotiations, service provider as well as service customer have an interest

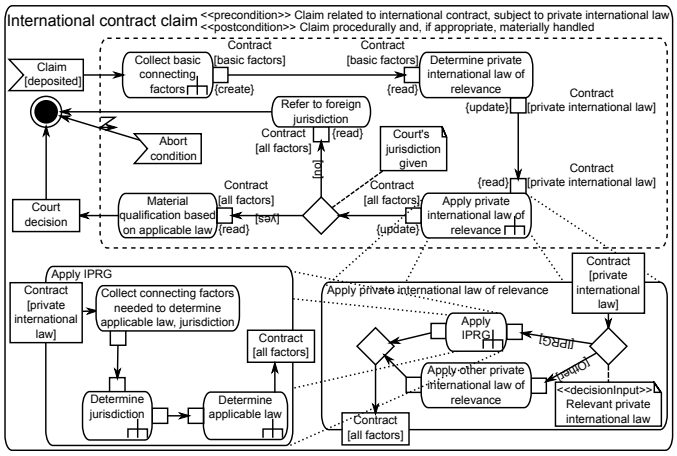


Fig. 1. International Contract Claim Procedure

to know about where to direct potential claims and under what law such claim shall be investigated. The problem, however, is that contract parties are not always and under all circumstances free to make a choice of jurisdiction or to make a choice of law. So, the meaning of risk assessment at contract conclusion is whether any jurisdiction-/applicable law-related provision included in a contract is valid (or voided) should a claim be deposited at a specific court.

In order to assess the impact of jurisdiction and applicable law better, Figure 1 models procedures by which a Swiss court would handle an international contract claim under the Swiss federal PIL (IPRG, [3]). At the event of an international contract claim being deposited at a Swiss court, that court would collect a basic set of connecting factors by which a contract with international relation is bound—connected—to the respective set of jurisdictions. By means of these jurisdictions supposedly showing a connection to the case, the respective applicable PIL or PILs is/are determined. For a case, in which a service provider has only connections to state X, and a service customer has connections to only Switzerland, the court would see whether there is a supra-national PIL to cover international relations between X and Switzerland or, if this is not the case, it would consider the IPRG as the applicable PIL (the applicable *procedural* law, that is). In this context, it is important to note about the difference between procedural and material law. At this point in the procedure, a court focuses only on which procedural law to apply. PIL is part of procedural law as it tells, in simplified terms, what procedure to follow, but it does not go into substantive matters (instead, it refers to material law).

Under the assumption that the IPRG is the PIL of relevance, the court would apply the IPRG in order to answer questions of jurisdiction and applicable (material) law. Both questions depend on the knowledge of the IPRG-specific set of connecting factors. Once these are collected, the court is enabled to decide whether it has jurisdiction and, if yes, under which applicable law a case shall be assessed. In case Swiss jurisdiction is given, the court would proceed with a material qualification of the international contract in question. In case Swiss jurisdiction is not substantiated by the IPRG, the court would deny a trial in this court and refer to foreign jurisdiction.

The decision support tool aimed at in this work is about an automated way to anticipate at the time of contract conclusion jurisdictions and applicable laws that have a good chance to "survive" the procedure described. In other words, recommendations on jurisdictions/applicable laws shall be determined and communicated to the contracting parties so that they can assess during negotiations where to reasonably attribute jurisdiction to and under what state's law. To this end, legal compliance is key. Thus, recommendations have to consider the relevant set of provisions originating from the respective PIL(s) applicable to a contract to be concluded.

Considering the inherent risk of long-arm jurisdiction, costly legal counsel, and complex decision processes in the conclusion of international service contracts, the need for a decision support system to produce recommendable jurisdiction(s) and/or applicable law(s) becomes apparent, especially for SMEs (Small and Medium-Sized Enterprise) that might not have strong legal workforce at hand. Such a system is expected to provide for increased legal certainty, *i.e.*, better expectations about a potential dispute, namely that such dispute would be settled by a court which is accepted and feasible, and under the laws of a nation which are accepted and feasible.

In the absence of directly related work, this paper endorses a real pioneering effort in modeling and implementing PIL(s) applicable to international service contracts. To the best of current knowledge, there is no comparable methodology or a tool set available or under development. The only albeit loosely related work consists of partial workflows modeled for, *e.g.*, the Swiss IPRG [12]. Books like this include tables and workflows reflecting major cases while covering the complete law. However, such sources do not necessarily constitute better suited basis than the actual law it is about for a number of reasons: First, these books embrace typically an entire law, whereas a single included workflow often is summarizing and abstracting away details. In contrast, as shown in Sections III-A and III-B, only an excerpt of law sections is of relevance to this work usually. The part of relevance, however, must be analyzed in great detail. Second, books addressing laws of different jurisdictions typically do not follow a common methodology to model workflows, nor is the modeling method documented in any way. Third, a PIL is by nature not written with automation in mind. It addresses experts in the field, not computer science. By that, human interpretation is expected instead of machine-execution. Workflows of such books imply the same audience of jurists as their main audience so that they do not offer any benefit with respect to automation purposes over a PIL source. In the same way, PILs (and workflow books about PILs) assume the existence of a dispute out of an international contract. This work, however, looks at the time of contract conclusion at which, by definition, neither contract party has knowledge about any potential dispute, about whether such dispute might end in court, and about who acts as a claimant and who is defendant. Accordingly, all PIL

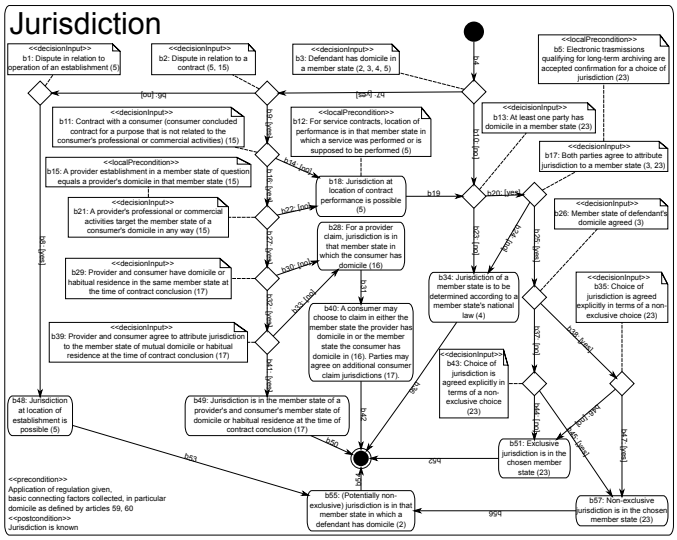


Fig. 2. Activity Diagram for Brussels I Under Application of the Preliminary Method [17]

provisions which base on the assumption of a dispute must be time-wise ported back to the respective knowledge of contract parties at contract conclusion.

In the light of a modeling and implementation methodology lacking, a preliminary modeling method has been determined and documented in [17]. This method was applied to the two major European regulations for jurisdiction and applicable law, the Brussels I [4] regulation and the Rome I [5] regulation, respectively. This led to two activity diagrams modeled, whereas Figure 2 shows the respective diagram for Brussels I. As can be seen in Figure 2, several actions and decisions have to me made in dependence of dispute-driven information. For instance, decision b26 is in relation to the role of a defendant. Hence, one of the primary modeling method requirements to be met in this paper is to develop a methodology which overcomes any dispute-related provision. Furthermore, the preliminary method determined in [17] apparently does not consider different notions of jurisdiction. As there is not only a single jurisdiction, but potentially multiple jurisdictions at different levels of content and relevant to either or both contract parties, the according concept of jurisdiction has to be strengthened in the methodology developed in this paper.

B. ITSM Information Model

As indicated in Section I, the second main challenge addressed by this paper consists of the development of an information model reflecting key requirements of international contract and service management. This information model links the analysis and modeling method (introduced in the previous section) with the rule-based implementation (described in the next section). It thus serves as an important basis for a successful implementation of a (prototypical) decision support tool for the determination of jurisdiction and applicable law in the context of international service contracts.

According to [14], having an information model generally provides—amongst others—the following benefits:

- It allows for simplification of information management by providing a common terminology and reducing unnecessary variation.
- It allows for unification of information both within an enterprise (provider) and between enterprises (providers).
- It provides a bridge between the business and information technology groups by providing definitions that are understandable by the business, but are rigorous enough to be used for software development.

In addition, with respect to the specific goal of developing automated decision support in the area of international contracts, the information model can be seen as a solution enabler. It clearly defines the required information objects, attributes and dependencies that are relevant for the information exchange between different components of the decision support system.

The starting point is a comprehensive information model [11] that focuses on *Service Level Management (SLM)*—an IT service management discipline dealing with different kinds of agreements and contracts between IT service providers and its customers and suppliers, as well as service catalogs and reports. SLM is not only considered one of the most important ITSM processes (in a process-oriented IT service management system), but it is also closely related to the topics covered by this paper.

This information model has been reused, adapted and extended in order to ensure that it reflects all relevant aspects mentioned in Section II-A. It consists out of two components: a concept model and a model of the set of information artifacts. Both sub-models are represented as UML class diagrams. The concept model can be seen as the result of a first, high-level approach in identifying the most important domains, objects and outputs of an SLM process. Both the concept model and artifact model are presented and explained, together with a set of necessary assumptions, in Section IV.

C. Rule-based Systems

Determining applicable law and jurisdiction for service contracts is not a trivial task mainly because of the various interconnected parameters that describe these contracts. This can be a cumbersome process when carried out manually by human experts, especially when constraints imposed by international law have to be taken into account. The design and implementation of an approach that automates such a process can provide substantial benefits not only in terms of efficiency, but also in terms of minimizing the potential of human error.

The approach proposed in this paper implements a rule-based system (RBS) for automating the decision making process when determining applicable law and jurisdiction. Rule-based systems, also know as expert systems [18][7], constitute a simple form of artificial intelligence in which the knowledge of human experts is encoded in the form of rules. These are conditional statements that link given conditions to

actions—if <condition(s)> then <action(s)>—where the left part is known as the premise and the right part as the outcome.

The two basic components of an RBS are the knowledge base and the inference engine [1]. The former stores specified rules and a set of facts (assertions about properties or relations), and the latter controls the application of the rules given the facts that hold at runtime, *i.e.*, determines when a particular rule should fire. In contrast to procedural programs, the control flow in RBSs is chosen by the runtime system and the facts that hold at a given point in time, instead of a predefined algorithm. Furthermore, knowledge in RBSs is not embedded in a program, but it is maintained separately in a knowledge base. The advantages of this approach are that knowledge can be maintained fairly easily by refining, or adding rules, and the core program does not require recompilation in the case of knowledge changes. The applications of RBSs vary from simple e-mail filtering, to diagnosing medical problems [13] and configuring network firewalls [2].

D. Preliminary Conclusions and Gap Analysis

Considering the lack of directly related work for an automated, PIL-conforming determination of recommendable jurisdiction(s) and/or applicable law(s) at the time of contract conclusion, the work focused in this paper constitutes a true pioneering effort. Given the inherent complexity of procedures in PIL, however, the set of three challenges identified in Section I has to be addressed in a comprehensive, most structured manner. In particular, the following requirements on models and implementation as determined throughout this section have to be met:

- *Applicable notion of service and contract*: The modeling method, the implementation, and especially the information model shall consider and reflect concepts as well as concrete information artifacts in relation to the type of service (purely electronic services for monetary compensation) and contract (bilateral international service contract under PIL) assumed here.
- *Consistency and compliance*: In particular the modeling method, but also the information model and the implementation, shall consider and reflect specifics of PIL procedures. This implies, for example, a time-wise back porting of dispute-dependent PIL provisions to the time of contract conclusion. Overall, legal compliance and content-wise consistency with a law to be modeled are key issues while interpretation, albeit not completely avoidable, shall be kept to a minimum.
- *Extension of the existing information model*: The information model is important to inter-link modeling method and implementation. As such, the existing SLM information model provides for a well-suited, established basis for model extensions. Model adaptations are mainly needed to reflect both, service and contract management dimensions.
- *RBS*: The implementation shall adopt an RBS-driven approach, as RBSs show advantages in building expert systems addressing decision-based procedures that are characterized by high complexity. Hence, with the help of a knowledge base, a modeling result consisting mainly of conditions and actions, and the interference engine, a decision support tool as introduced and motivated shall be implemented in logic programming.

III. PIL Modeling Method

Driven by the motivation outlined and the set of PIL modeling method requirements determined (*cf.* Section II-D), this section documents the accordingly developed PIL modeling method in full detail. This method is structured into three major thematic blocks, namely PIL identification and selection, PIL analysis, and activity diagram modeling—each of which are addressed in a dedicated sub-section. The first block, presented in Section III-A, is concerned with identifying and selecting relevant legal sources in PIL. Once identified, a selected PIL undergoes a thorough, multi-step analysis to assess modeling relevance of law sections and single provisions included in the PIL in question. Section III-B explains those various considerations made and in-/exclusion criteria are defined to facilitate such a relevance assessment. Those provisions which were found relevant are then considered for a formal PIL workflow modeling by means of UML2 activity diagrams (*cf.* Section III-C).

The modeling method developed and introduced takes input from a PIL modeling effort [17] in the sense that select methodological elements and lessons learned from [17] form the basis on what this modeling method is built upon. In particular, the main part of inclusion and exclusion criteria considered originates from [17]. While some parts of the modeling method presented here, thus, are reflected by [17], major modeling steps were so far either missing or only marginally addressed. For instance, good practice on how to model relevant PIL provisions as UML2 activity diagrams was lacking. Overall, the modeling method as presented here finds its roots in those selective procedures documented in [17], while it has stabilized over time and considerably widened in scope, so that it now represents a modeling method in an embracing and structured manner.

In analogy with [17], the modeling method is presented by means of a concrete PIL to be modeled. This example PIL is the European Union's (EU) regulation 44/2001 on "Jurisdiction and the Recognition and Enforcement of Judgments in Civil and Commercial Matters" [4] (Brussels I regulation hereafter). Brussels I represents the primary (supra-national) PIL in jurisdictional questions for most EU member states. Brussels I has a parallel convention, the Lugano Convention [8], which brings the directly comparable set of jurisdiction provisions to ratifying associated states. Even though Brussels I was the example PIL to be modeled in [17] as well as it is here, the resulting activity diagram in this paper is substantially different from the diagram drawn earlier (*cf.* Figure 2). This is due to methodological differences as previously explained. One major deviation of note is found in the fact that Figure 2 bases on the existence of a dispute and the according understanding of a defendant and claimant. The existence

of a dispute is a valid assumption for any PIL as a court would only become active after that a dispute-related claim was deposited. Figure 2 is modeled directly after the law and does not question the existence of a dispute. Since this work, however, aims at an automated determination of PIL-relevant contract parameters at the time of contract formation—when none of the involved contract parties have knowledge about any potential future dispute—, the modeling methodology presented here had to find a way around any dispute-driven clause. Disputes had to be handled in a pro-active way, so to say. This implies that any PIL provision that bases on a dispute and the respective role of a defendant or claimant had to be time-wise ported to the time of contract conclusion. Therefore, this modeling method foresees wherever needed parallel cases for a service provider and a service customer potentially being defendant and claimant, respectively.

Overall, the modeling method documented in this section contributes to this work in terms of a conceptual framework. This framework, thus, embraces a comprehensive and highly structured method to identify, analyze, formally model, and implement (covered in Section V) multiple PILs based on identified thematic topics as well as on an integrated information (covered in Section IV) and workflow model.

A. PIL Identification and Selection

This first step of identifying and selecting PILs for a subsequent modeling is a fundamental one. Only those PILs which were found, assessed relevant, modeled, and finally implemented may be used in order to determine lists of recommendable jurisdictions and/or of recommendable applicable laws. The set of considered PILs defines the overall system's geographical reach in terms of jurisdictions and international contractual relations covered. If, for instance, a contract between a service provider domiciled in the USA and a service customer domiciled in Switzerland shall be concluded and if the system lacks only one of the three relevant PIL perspectives here—the two national PILs as well as any potential supra-national PIL source applicable—, then there is a substantial chance any determined recommendation list misses important entries.

Despite the fact that the range of covered PILs defines the overall system's expressiveness, the procedure to identify PILs must be admitted to lack a fully satisfying method. This is mainly reasoned by an inherent territorial principle in law and the according principle of state sovereignty. Multiple legal traditions have emerged over time in different regions of the world [6]. Consequently, while one nation might have codified PIL provisions in the form of a dedicated national law, another nation might base completely on case law, build a collection of procedural rules, or might not even trade its law in written form. These are just a few examples mentioned. In addition to these legal tradition-driven obstacles, a number of more practical hurdles originating from international diversity has to be considered. In particular, PIL sources might be available, but in a language requiring translation services. The important conclusion here with respect to a structured method with reproducible results is that there is probably none, at least not a universally applicable one—in the same way there is probably "no such universalizable core" [6] among existing legal traditions.

On the other hand, general guidelines may be outlined to identify relevant PIL sources. The following short list has been compiled from experience made in the process. This list, which is not meant to be encyclopedic, shall help identify PIL sources more easily by means of commonly available sources:

- *National law compilations*: Many states and supra-national organizations nowadays keep an up-to-date compilation of national and international law, very often even in an on-line, searchable, and freely accessible manner. This is an excellent comprehensive source to identify potentially relevant PILs as these compilations typically include or refer to all national and supra-national laws, regulations, treaties, and conventions of relevance for a given single state or supra-national organization.
- *Court decisions and civil procedure rules*: Especially in those jurisdictions with a case based legal tradition, collections of key court decisions determining PIL-relevant precedence constitute a primary source of investigation. In some cases, conflicts of law provisions are even documented and updated in the respective set of civil procedure rules.
- *Books, articles, and commentaries in PIL*: PIL and conflicts of law is an area of law which imposes multifarious, considerable, and non-trivial challenges to be addressed. Consequently, this field attracts researchers to investigate these problems and publish results in terms of books, scientific articles, and legal commentaries. This type of PIL source is typically focusing on a specific issue within the domain and may cover (often compare) several PILs. Books, articles, and commentaries, thus, often contribute as meta sources, while the first two mentioned PIL sources are regarded as primary sources.
- *Specialized web sites*: As there is a wide variety of work done in PIL and PIL research by an equally wide range of different stakeholders, specialized web sites help collect and aggregate relevant information, actions, and trends for an interested audience.

Unlike the procedure to identify PILs of potential relevance, the method to select an identified PIL for further analysis, modeling, and implementation follows a specific set of selection criteria. These criteria are well-determined by virtue of the specific contractual object considered here. This contractual object is related to the type of service and, with that, the type of business transaction considered. Accordingly, the set of determined criteria is driven by an underlying question of whether or not a given PIL is applicable to the type of service and type of business transaction of relevance in this work. A PIL is selected if (and only if) all of the following selection criteria are met:

- *Provision of services*: This criterion is met if a PIL in question is applicable explicitly (by statement in the

law itself) or implicitly (by prevailing case law or by prevailing opinion) to business transactions consisting completely or predominantly in the provisioning of services (as opposed to production and/or delivery of goods). This work focuses on commercial electronic services in the Internet (*cf.* Section II-A). The provision of this particular type of service is assumed to be included in a general, non-specific definition of service provisioning.

- *Civil and commercial matters*: This criterion is met if a PIL in question is applicable to legal matters that fall under civil law (as opposed to penal or public law) and that embrace a commercial offering. In the current context, commercial offering implies a provisioning of services (as previously described) for compensation of some sort (primarily in monetary terms). Such commercial service provisioning is furthermore assumed to require a service contract to be concluded. This service contract is foreseen here to involve exactly one service provider and exactly one service customer (bilateral contract), whereas the respective service offering is expected to be endorsed by a service provider's professional or commercial activities. On the other hand, an involved service customer is expected to conclude such a service contract both, either within or outside his or her professional and commercial activities. In other words, a PIL must be applicable to service contracts that cover civil and commercial mattes reflecting electronic business in a Business-to-Business (B2B) or Business-to-Consumer (B2C) manner.
- *Connection to multiple jurisdictions*: This criterion is met if a PIL in question is applicable to a relation with a connection to multiple (at least two different) jurisdictions and/or their laws. It is within the considered PIL's scope to define connecting factors that may relate a service contract or the contracted service provisioning to multiple jurisdictions and/or their respective laws. Prominent examples of connecting factors are a contract party's presence in a jurisdiction (*e.g.*, domicile, habitual residence, market activities, property) and contractual obligation-related characteristics (*e.g.*, location of performance) as well as a contract party's explicit or supposed will (*e.g.*, choice of jurisdiction, choice of law).
- *International connection*: This criterion is met if a PIL in question is applicable to relations with international connection (as opposed to intra-national inter-state connection). Thus, touched jurisdictions must not relate to federated states (or comparable legal domains) of a single sovereign state. Touched jurisdictions must relate to different sovereign states—to different "nations" in informal terms. Accordingly, a considered PIL represents law on either national or supra-national level. Should a considered law cover provisions of intra-national inter-state and of international scope at the same time, the criterion is assessed met, but only with respect to those provisions that involve an international connection.
- *Hierarchy*: This criterion is met if a PIL in question can be attributed a distinctive place in a hierarchy of identified PILs of national and supra-national level. In the context of a sovereign state and all state-relevant PIL sources of national and supra-national level (*e.g.*, this state's national PIL and bi- or multilateral PIL-related conventions/regulations accessed and ratified), each single PIL source must be defined as to which other PILs this PIL is superior and inferior to. This means that for every considered jurisdiction, the set of relevant PILs must be built and equipped with the respective set of subsidiarity relations between those PIL instruments embraced by that set. Typically, national PIL sources are subordinate to supra-national PIL sources.
- *Validity*: This criterion is met if a PIL in question is in force, *i.e.*, it is valid at a given moment in time. In this context, that moment in time is related to the time of contract conclusion. Since this work includes a time-wise porting from a potential dispute arising from contract to the time that contract was concluded, PIL validity is—strictly seen—not fully satisfied when checking validity only at the time of contract conclusion. There is a chance that a list of recommended jurisdictions/applicable laws was determined at contract conclusion according to a PIL which was in force at that time, whereas that same PIL was not in force anymore at the time an actual dispute arose and was brought to court. In this case, it might be that a recommended jurisdiction could not be substantiated at the time of dispute as another PIL in force then might state conflicting provisions. This issue is well acknowledged here. It is seen as an eventual challenge which contract parties should be aware of. Since its existence is of systematic nature and since no obvious solution to it is available without substantial change to the overall methodology required, it cannot be easily overcome.
- *Ratification*: This criterion is met if a PIL in question is ratified by a sovereign state in question. In other terms, for a given PIL the respective set of member states that have ratified that PIL needs to be known at the time of contract conclusion. In principle, the same reservation with respect to validity is present with respect to the criterion of ratification. The chance, however, that (a) a PIL was ratified by a considered state before contract conclusion, that (b) this state had abandoned the PIL in question in the time span after contract conclusion and before a dispute was brought to court, while (c) this PIL is still in force at the time of dispute, is assessed rather low. Therefore, the reservation is seen here to be of a more theoretical nature.

For the given example of investigation here, the Brussels I regulation [4], all criteria are met. Accordingly, Brussels I is applicable to the provision of services. It is applicable to many other (non-considered) legal relations as well. Provisioning of services is explicitly mentioned in multiple Articles, *e.g.*, Article 5(1)(c). Brussels I is applicable to civil and commercial matters (prominently mentioned in the regulation's title as

well as in Article 1(1)). Furthermore, the regulation refers in the vast majority of included provisions to relations with connection to multiple jurisdictions, and the majority of these cases involves international connection between the regulation's member states which are sovereign states despite being member states of the EU. Finally, Brussels I's relation to other instruments has been clarified, the regulation is in force at the time of writing this paper, and the set of ratifying states has been determined.

B. PIL Analysis

After a PIL of interest was identified and successfully selected for modeling and implementation, the PIL in question undergoes a detailed analysis. This analysis follows a two-step approach. First, a thematic pre-selection is conducted. A PIL typically covers a wide area of legal transactions and/or contract types. Based on the respective contractual object notation adopted here (see, *e.g.*, selection criteria outlined in Section III-A), a considerable share of PIL sections addressing non-considered areas can be excluded *ex ante*, meaning without proceeding with step two, the detailed in-/exclusion assessment of single articles or parts of thereof. Thus, this two-step approach pre-selects in a first step PIL sections which seem worthwhile for detailed investigation as well as it unselects PIL sections which, for a documented reason, need not to be assessed in detail.

Table I lists the set of those reasons for inclusion or exclusion, including for each in-/exclusion criterion a three letter mnemonic code. The same list is equally used in the first and second PIL analysis step, in the coarse-granular pre-selection step as well as the detailed in-/exclusion assessment step, respectively. This list bases partly on those criteria introduced and reasoned in [17] (*cf.* pages 21-22). While those reasons given for a criterion in the original list are seen valid and, thus, unchanged as of today—the only exception being previously excluded annex sections—, the list shown in Table I has seen substantial extensions over the original list. These extensions are driven by a wider experience gained in analyzing further sources such as the Swiss federal PIL [3] (on jurisdiction and applicable law) and the EU's Rome I regulation [5] (on applicable law). In this context, the list in Table I shall be understood as a comprehensive list from a current perspective, however, with a reservation of potential future extensions being possible and foreseen when the need for new, so far not addressed, criteria might become apparent due to the study of further PILs. This list, thus, is seen generally stable, nevertheless extensible.

With regard to inclusion criteria, the original list covered provisions related to jurisdiction/applicable law for consumer contracts (CCO), connecting factor definitions (COF), general jurisdiction/applicable law (GEN), and special jurisdiction/applicable law (SPE). The new list addresses all of these criteria plus two new criteria: Choice of jurisdiction/applicable law (CHO) and foreign jurisdiction (FOR) provisions were added. The first was previously subsumed in SPE. As CHO gains typically as much attention as CCO—which can be seen as a prominent case of SPE, too—, CHO is introduced as a separate criterion. In the example of Brussels I, jurisdictional questions of CHO are even treated in a section of their own. The latter, FOR, is introduced as a new criterion to differentiate from (excluded) provisions related to recognition, enforcement, and judicial assistance (REC). This follows an understanding that only those inter-jurisdiction issues are perceived relevant that have an impact at the time of contract conclusion. Recognition of a (foreign) decision by a state's courts requires existence of a dispute in (another) court after conclusion of a contract. Accordingly, recognition is not considered. On the other hand, provisions in a PIL that attribute jurisdiction to a foreign court are relevant when a list of recommended jurisdictions at the time of contract conclusion based on a given PIL shall be determined.

With regard to exclusion criteria, the original list covered provisions related to admissibility (ADM), consent (CON), final provisions (FIN), incapacity (INC), liability (LIA), *lis pendens* (LPE), motives/recitals (MOT), non-considered contract types/legal actions (NCO), burden of proof (PRF), recognition, enforcement, and judicial assistance (REC), reservations (RES), PIL review (PIL), application scope and relations with other instruments (SCO), set-off (SET), subrogation (SUB), transitional provisions (TRA), and material and formal validity (VAL). In addition to these, the original list was extended by

TABLE I
OVERVIEW OF INCLUSION (+) AND EXCLUSION (–) CRITERIA WITH MNEMONIC

Mnemonic	Criterion
Inclusion criteria	
(+) CCO	Jurisdiction/applicable law for consumer contracts
(+) CHO	Choice of jurisdiction/applicable law
(+) COF	Relevant connecting factor definitions
(+) FOR	Foreign jurisdiction
(+) GEN	General provisions on jurisdiction/applicable law
(+) SPE	Special provisions on jurisdiction/applicable law
Exclusion criteria	
(–) ADM	Admissibility
(–) ARB	Arbitration
(–) AUT	Authentic instruments; court settlements
(–) COC	Counter claim
(–) CON	Consent
(–) FIN	Final provisions
(–) INC	Incapacity
(–) LIA	Liability
(–) LPE	Lis pendens
(–) MOD	Modalities of performance and investigation
(–) MOT	Motives/recitals
(–) NCO	Non-considered contract types/legal actions
(–) PRF	Burden of proof
(–) PRO	Provisional and protective measures
(–) REC	Recognition; enforcement; judicial assistance
(–) REG	Regress
(–) REN	Renvoi
(–) RES	Reservations
(–) REV	PIL review
(–) SCO	Application scope; relations with other instruments
(–) SET	Set-off
(–) SUB	Subrogation
(–) TIM	Time limit and prescription
(–) TRA	Transitional provisions
(–) VAL	Material and formal validity

the following new exclusion criteria: Arbitration (ARB), authentic instruments and court settlements (AUT), counter claim (COC), performance and investigation modalities (MOD), provisional and protective measures (PRO), regress (REG), renvoi (REN), and time limit and prescription (TIM).

The reason to exclude provisions related to these newly introduced criteria is the same as for most already existing exclusion criteria. These provisions are perceived to be out of scope when taking this work's focus outlined as a reference value.

Table II documents the respective results obtained by conducting a thematic pre-selection of provisions for the example of Brussels I. Based on those criteria listed in Table I, Table II lists these Brussels I sections and chapters which were not selected *ex ante* for a detailed assessment, *i.e.*, sections and chapters which were excluded. For each excluded part, a mnemonic is provided. This mnemonic indicates the primary reason for which a part was not considered. In case of Annex V, two (instead of one) mnemonics are given in order to emphasize that this Brussels I part addresses both inextricably.

On this coarse-granular level of thematic assessment it can be observed that Brussels I parts are excluded based on a limited number of reasons only. The most frequently given reason for exclusion is REC as a full Brussels I chapter and several annex sections deal with issues of recognition, enforcement, and judicial assistance. Furthermore, excluded Brussels I part cover recitals (MOT), scope definition (SCO), law parts relating to non-considered contract types or non-considered legal actions (*e.g.*, contracts of employment), special issues of admissibility (ADM) or *lis pendens* (LPE), provisional measures (PRO), final (FIN), or transitional provisions (TRA), and authentic instruments (AUT).

Table III visualizes why a two-step procedure as described and adopted here is meaningful when analyzing a given PIL. The second step, consisting of an in-depth analysis down to the detail of sub-paragraphs, parts of sentences and, sometimes, even single expressions, reflects a complex and time-consuming task. It is essential as it lays down the basis for any subsequent modeling and implementation, but due to its complexity it is feasible for a limited number of provisions only. Consequently, work load in this second PIL analysis step can be significantly lowered when it is conducted exclusively on a pre-selection of seemingly relevant provisions. On the other hand, it must be noted that a pre-selected provision is only a candidate for further analysis. Pre-selection alone does not imply a considered article is relevant in all parts. For instance, articles in Chapter II, Section 1 of Brussels I have been pre-selected. That section embraces three articles out of which one full article (Art. 4) and two single paragraphs of separate articles (Art. 2(2) and Art. 3(2)) have not been included for different reasons (see mnemonics in Table III).

The negative pre-selection (exclusion) as documented in Table II results in a pre-selection of Brussels I provisions out of Chapters II and V. The latter is concerned with general provisions, including a number of important connecting factor (COF) definitions. Art. 60 defines the respective applicable notion of domicile for a legal person—in this context applicable to a service provider and to a professional service customer, since B2B and B2C business relations are envisaged here.

Other relevant connecting factor definitions are found in Brussels I sections that address primarily issues of general or special jurisdiction. These definitions cover the notion of location of performance for service provisioning (Art. 5(1)(b)-(c)), the understanding of a consumer (Art. 15(1)), of service provider market activities constituting jurisdiction (Art. 15(1)(c)), and of service provider domicile in relation to consumer contracts and claims out of operation of a service provider establishment (Art. 15(2)).

TABLE II
NEGATIVE THEMATIC PRE-SELECTION ASSESSMENT (EXCLUSION) FOR BRUSSELS I PROVISIONS

Article	Mnemonic
MOTIVES	
Motives 1-29	(–) MOT
Chapter I, SCOPE	
1	(–) SCO
Chapter II, JURISDICTION	
Section 3, Jurisdiction in matters relating to insurance	
8-14	(–) NCO
Section 5, Jurisdiction over individual contracts of employment	
18-21	(–) NCO
Section 6, Exclusive jurisdiction	
22	(–) NCO
Section 8, Examination as to jurisdiction and admissibility	
25-26	(–) ADM
Section 9, Lis pendens — related actions	
27-30	(–) LPE
Section 10, Provisional, including protective, measures	
31	(–) PRO
Chapter III, RECOGNITION AND ENFORCEMENT	
32	(–) REC
Section 1, Recognition	
33-37	(–) REC
Section 2, Enforcement	
38-51	(–) REC
Section 3, Common provisions	
53-56	(–) REC
Chapter IV, AUTHENTIC INSTRUMENTS AND COURT SETTLEMENTS	
57-58	(–) AUT
Chapter VI, TRANSITIONAL PROVISIONS	
66	(–) TRA
Chapter VII, RELATIONS WITH OTHER INSTRUMENTS	
67-72	(–) SCO
Chapter VIII, FINAL PROVISIONS	
73-76	(–) FIN
ANNEX I, Rules of jurisdiction referred to in Article 3(2) and Article 4(2)	
Annex I	(–) SCO
ANNEX II	
Annex II	(–) REC
ANNEX III	
Annex III	(–) REC
ANNEX IV	
Annex IV	(–) REC
ANNEX V, Certificate referred to in Articles 54 and 58 of the Regulation on judgments and court settlements	
Annex V	(–) REC, AUT
ANNEX VI, Certificate referred to in Article 57(4) of the Regulation on authentic instruments	
Annex VI	(–) AUT

TABLE III
DETAILED IN-/EXCLUSION ASSESSMENT FOR PRE-SELECTED BRUSSELS I PROVISIONS

Article	Provision	Mnemonic
Chapter II, JURISDICTION		
Section 1, General Provisions		
2(1)	"Subject to this Regulation, persons domiciled in a Member State shall, whatever their nationality, be sued in the courts of that Member State."	(+) GEN
2(2)	not cited	(–) NCO
3(1)	"Persons domiciled in a Member State may be sued in the courts of another Member State only by virtue of the rules set out in Sections 2 to 7 of this Chapter."	(+) SPE
3(2)-4(1)	not cited	(–) SCO
4(2)	not cited	(–) NCO
Section 2, Special Jurisdiction		
5	"A person domiciled in a Member State may, in another Member State, be sued:"	(+) SPE
5(1)(a)	"in matters relating to a contract, in the courts for the place of performance of the obligation in question;"	(+) SPE
5(1)(b)	"for the purpose of this provision and unless otherwise agreed, the place of performance of the obligation in question shall be:"	(+) COF
5(1)(b)	"in the case of the sale of goods, the place in a Member State where, under the contract, the goods were delivered or should have been delivered,"	(–) NCO
5(1)(b)	"in the case of the provision of services, the place in a Member State where, under the contract, the services were provided or should have been provided,"	(+) COF
5(1)(c)	"if subparagraph (b) does not apply then subparagraph (a) applies;"	(+) COF
5(2)-5(4)	not cited	(–) NCO
5(5)	"as regards a dispute arising out of the operations of a branch, agency or other establishment, in the courts for the place in which the branch, agency or other establishment is situated;"	(+) SPE
5(6)-7	not cited	(–) NCO
Section 4, Jurisdiction over consumer contracts		
15(1)	"In matters relating to a contract concluded by a person, the consumer, [...], jurisdiction shall be determined by this Section, without prejudice to Article 4 and point 5 of Article 5, if:"	(+) CCO
15(1)	"[...], for a purpose which can be regarded as being outside his trade or profession, [...]"	(+) COF
15(1)(a)-(b)	not cited	(–) NCO
15(1)(c)	"in all other cases, the contract has been concluded with a person who pursues commercial or professional activities in the Member State of the consumer's domicile or, by any means, directs such activities to that Member State or to several States including that Member State, and the contract falls within the scope of such activities."	(+) CCO, COF
15(2)	"Where a consumer enters into a contract with a party who is not domiciled in the Member State but has a branch, agency or other establishment in one of the Member States, that party shall, in disputes arising out of the operations of the branch, agency or establishment, be deemed to be domiciled in that State."	(+) COF
15(3)	not cited	(–) NCO
16(1)	"A consumer may bring proceedings against the other party to a contract either in the courts of the Member State in which that party is domiciled or in the courts for the place where the consumer is domiciled."	(+) CCO
16(2)	"Proceedings may be brought against a consumer by the other party to the contract only in the courts of the Member State in which the consumer is domiciled."	(+) CCO
16(3)	not cited	(–) COC
17	"The provisions of this Section may be departed from only by an agreement:"	(+) CCO, CHO
17(1)	not cited	(–) NCO
17(2)	"which allows the consumer to bring proceedings in courts other than those indicated in this Section; or"	(+) CCO, CHO
17(3)	not cited	(–) NCO
Section 7, Prorogation of jurisdiction		
23(1)	"If the parties, one or more of whom is domiciled in a Member State, have agreed that a court or the courts of a Member State are to have jurisdiction to settle any disputes which have arisen or which may arise in connection with a particular legal relationship, that court or those courts shall have jurisdiction. Such jurisdiction shall be exclusive unless the parties have agreed otherwise. [...]"	(+) CHO
23(1)(a)-23(2)	not cited	(–) VAL
23(3)	"Where such an agreement is concluded by parties, none of whom is domiciled in a Member State, the courts of other Member States shall have no jurisdiction over their disputes [...]"	(+) CHO
23(3)	"[...] unless the court or courts chosen have declined jurisdiction."	(–) RES
23(4)-(5)	not cited	(–) NCO
24	not cited	(–) RES
Chapter V, GENERAL PROVISIONS		
59	not cited	(–) SCO
60(1)	"For the purposes of this Regulation, a company or other legal person or association of natural or legal persons is domiciled at the place where it has its: (a) statutory seat, or (b) central administration, or (c) principal place of business."	(+) COF
60(2)	"For the purposes of the United Kingdom and Ireland 'statutory seat' means the registered office or, where there is no such office anywhere, the place of incorporation or, where there is no such place anywhere, the place under the law of which the formation took place."	(+) COF
60(3)-62	not cited	(–) NCO
63	not cited	(–) TRA
64-65	not cited	(–) NCO

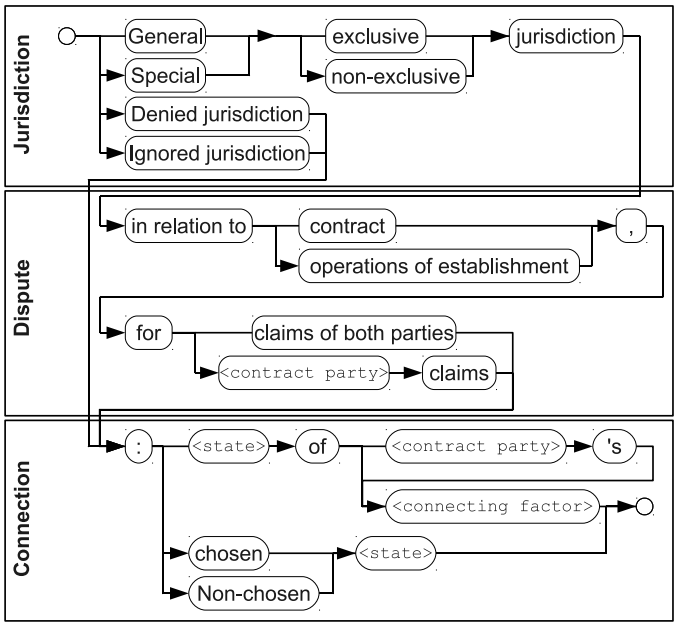


Fig. 3. Syntax Diagram for Jurisdiction-oriented Statements in Actions Nodes

C. Activity Diagram Modeling

Subsequent to the two-step PIL analysis procedure as shown in Section III-B, those provisions considered relevant are formally modeled in terms of a UML 2 activity diagram. Also this is done in a two-step manner in order to cope better with complexity. As PIL sources are usually structured thematically, a modeling of single thematic blocks is a considerably more straight forward task than modeling all selected provisions at once. Laws are by nature not meant to constitute technical specifications. Accordingly, a certain degree of interpretation due to lack of formal completeness is inherent. In this context, the adopted two-step approach of first modeling thematic blocks, and then modeling interdependencies between blocks helps address challenges appropriately. In the first step, the main challenge consists in reflecting a single thematic block in a most law-abiding way. Consistency, thus, is key here. In the second step, the main challenge consists in determining a hierarchy between modeled thematic blocks and to interlink them in a way that leads to an integrated activity.

Activity diagram models resulting from both steps have to satisfy a number of formal and procedural requirements determined:

- *OMG UML compliance*: All diagrams are compliant with version 2.1.2 of the OMG UML specification for activity diagrams [9]. Activity diagrams make use of the following language elements:
  - *Activity* ([9], Table 12.3): Each thematic block modeled (step 1) as well as the integrated activity diagram (step 2) constitutes an activity. Activities may contain nodes and flows (edges) as described subsequently.
  - ControlFlow ([9], Table 12.2): Directed (arrowed) transitions constitute control flows. Control flows must connect exactly two nodes in general. Diagrams of step 1 may have control flows that connect only one node (starting point of a flow), *i.e.*, control flows may be "open-ended". Control flows of diagrams of step 2 must always connect two nodes.
  - *InitialNode* ([9], Table 12.1): Each activity of step 1 disposes of exactly one initial node. This node references the start of an activity, *i.e.*, the control flow of an activity initially starts here. The same requirement applies for the integrated diagram of step 2, whereas such integrated diagram covers modeled provisions of multiple thematic blocks in a single activity and this activity disposes of exactly one initial node.
  - *ActivityFinal* ([9], Table 12.1): Each activity of step 1 disposes of exactly one final node. This node references the termination of an activity. If a control flow reaches a final node, any other potentially active control flow is terminated as well. The same requirement applies to the integrated diagram of step 2 in the same way as described for initial nodes.
  - *Action* ([9], Table 12.1): Actions represent those moments in an activity at which a statement about jurisdiction or applicable law is made. In order to facilitate an implementation in logic programming, statements in actions follow a regulated syntax as determined in Figure 3 for the case of Brussels I and the question of jurisdiction. Statements following this syntax cover three elements: First, the applicable type of jurisdiction is determined. There is not only a single type of jurisdiction, but a set of jurisdictions. Different jurisdictions may be brought into a hierarchy. For instance, special jurisdiction overrules general jurisdiction. Exclusive jurisdiction supersedes non-exclusive jurisdictions. Other PILs might know additional jurisdiction characteristics, such as unwaivable jurisdiction (*e.g.*, relevant to consumer contracts under [3]). Second, a statement about jurisdiction is characterized with respect to dispute. This includes a differentiation of contract-related disputes and disputes that originate from operating an establishment. While the former is obviously of interest here, the latter is as well as long as the operation of an establishment happens in the context of an international service contract. Furthermore, PIL provisions typically determine jurisdiction in dependence of which contract party is claimant and which party is defendant. Consequently, this aspect is reflected in the syntax diagram of Figure 3. Third, the syntax presented includes the actual statement about where—in which state—and possibly by means of which connecting factor jurisdiction is attributed.
    In addition to a regulated syntax, all activity diagrams of step 2 have to fulfill a requirement of central importance: Every distinct path between an initial node and a final node must pass at least once an action node. This guarantees that at least a single

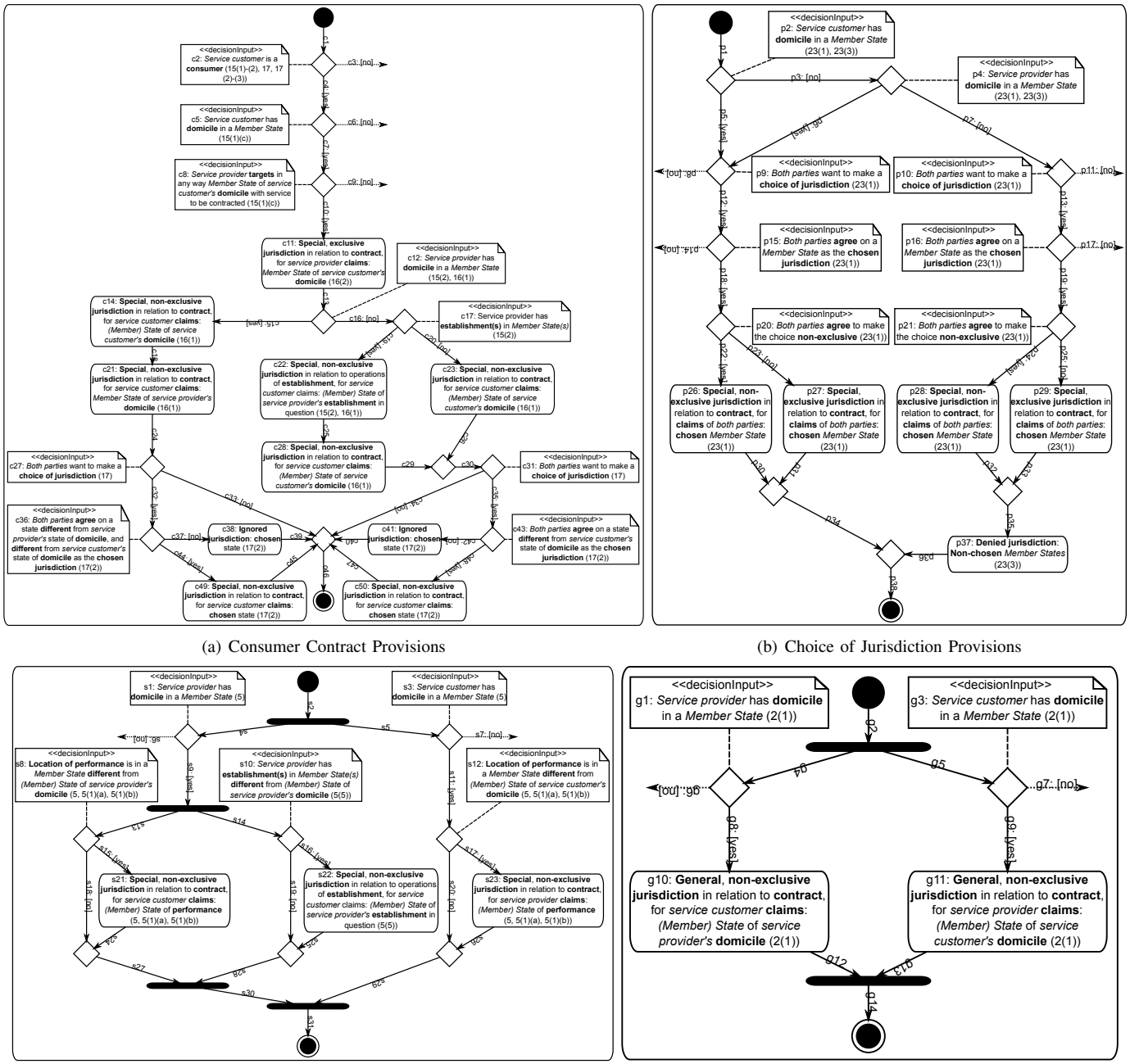
statement (in this context a statement about jurisdiction) is made. In order to fulfill this requirement and as an exception to the syntax diagram shown in Figure 3, diagrams of step 2 introduce actions that include void jurisdiction statements. These void statements are related to those "open-ended" control flows of step 1 diagrams that lead to an outcome in which the modeled PIL does not substantiate any jurisdiction/applicable law. Void jurisdiction statements are formulated as either "No jurisdiction for `<contract party>` claims by virtue of `<PIL>`" or "No jurisdiction by virtue of `<PIL>`".

- *DecisionNode* ([9], Table 12.1): Decision nodes follow a common syntax scheme similar to the syntax regulated for action nodes. Each decision node has exactly one input edge and exactly two output edges. The output edges are mutually exclusive from a control flow perspective. This means that according to the respective `<<decisionInput>>` statement of any given decision node (each decision node has exactly one `<<decisionInput>>`), control flows only along one of the two possible output edges. Output edges are always marked with yes and no, respectively. Accordingly, `<<decisionInput>>` statements reflect yes-no questions. These statements typically include a contract party (subject of statement), a verb, and a characteristic related to a connecting factor.
- *ForkNode, JoinNode, MergeNode* ([9], Table 12.1): A fork node has exactly one input edge and multiple (two to many) output edges. It multiplies any incoming control flow by as many output edges it has. This means that control flow tokens run in parallel on different paths. A fork node is complemented by its counterpart, a join node. Join nodes have multiple (two to many) input edges and exactly one output edge. Join nodes synchronize previously multiplied control flows. A join nodes outputs a single control flow if and only if all incoming control flow tokens have arrived. For every parallelization opened by a fork node (in diagrams of both steps), there must be a join node integrating parallel flows into a single flow synchronously. Merge nodes, finally, are similar to join nodes in behavior, but they are asynchronous. This means that a control flow is outputted every time a single input edge delivers an incoming control flow to the merge node irrespective of whether other incoming edges have delivered control flow tokens or not. As such, activity diagrams modeled make use of merge nodes in order to integrate mutually exclusive control flow paths opened by decision nodes.
- *Connector* ([9], Figure 12.40): When integrating modeled thematic blocks into a single consistent activity diagram (step 2) the use of connectors helps keep the resulting diagram remaining visually clear. Connectors are used to bridge visually control flows. Functionally, however, connectors do not have any meaning and, thus, they do not find representation in the implementation. Connectors consist of a circle-shaped node denoted by a character. A single connector is found always twice in a diagram. Once as an end node of a control flow to be bridged, once as the respective starting node of the same control flow.

- *Identifier*: Each control flow, `<<decisionInput>>`, and action in the activity diagrams modeled in both steps must have a unique identifier. This identifier consists of one character and a number. Numbers must be unique per character used. A character is typically used per thematic block modeled (step 1). The identifier has no deeper meaning beyond referencing items of an activity diagram in an unambiguous way. In the implementation, identifiers are used to represent predicates reflecting partial paths. Identifiers are placed before any statement and separated from the statement by means of a colon. Identifiers determine a feature added on top of the UML 2 activity diagram specification.
- *Reference*: Similar to identifiers, each `<<decisionInput>>` and each action in the activity diagrams modeled in both steps must have at least one reference to the respective modeled provision(s) of the PIL in question. For Brussels I, references reflect articles. A reference is placed after a statement. It is embraced by brackets. In case of void jurisdiction/applicable law statements "n/a" is used instead of a reference. Multiple references are comma-separated. References serve as assistance to track back a statement to the law modeled. References are not used in the implementation. References are a feature added on top of the UML 2 activity diagram specification.
- *Dotted control flows*: As described previously, diagrams resulting from modeling step 1 may be "open-ended", diagrams of step 2 must be fully integrated so that control flows cannot end in an undetermined manner. Integration bears a high amount of complexity due to an inherent degree of freedom in modeling and inter-relating thematic blocks. In order to express this openness explicitly, diagrams make use of dotted control flow representations whenever a transition is not substantiated directly and only by the respective law provisions modeled. Dotted control flows, thus, mark transitions which incorporate a higher degree of interpretation. This is a feature added on top of the UML 2 activity diagram specification.

In accordance with those requirements determined and listed, Figures 4(a), 4(b), 4(c), and 4(d) show the respective activity diagrams modeled for step 1. These figures, thus, cover four thematic blocks as identified in Section III-B. Figure 4(a) covers provisions in relation to consumer contracts (*cf.* provisions marked with CCO in Table III. Figure 4(b) covers provisions of choice of jurisdiction (CHO), while Figure 4(c) is about special jurisdiction (SPE), and Figure 4(d) models general jurisdiction provisions (GEN).

Each of these diagrams reflects a similar structuring ap-



(a) Consumer Contract Provisions

(b) Choice of Jurisdiction Provisions

(c) Special Jurisdiction Provisions

(d) General Jurisdiction Provisions

Fig. 4. Activity Diagrams for Thematic Blocks (Modeling Step 1)

proach. In the first decision nodes included after the initial node, fundamental pre-conditions for a thematic block to apply are modeled. For instance, the respective detailed provisions for consumer contracts apply only if a service customer is a consumer (c2 in Figure 4(a)), if that service customer has domicile in a member state of Brussels I (c5), and if the service provider in question targets the state in which the service customer is domiciled (c8). For the case of choice of jurisdiction, the respective pre-condition is found in that at least one contract party has domicile in a Brussels I member state (p2 and p4 in Figure 4(b) including the according case separation in p9, p15, p20 and p10, p16, p21, respectively).

For special and general jurisdiction, finally, pre-conditions are the same, namely whether a contract party has domicile in a Brussels I member state (s1, s3 in Figure 4(c) and g1, g3 in Figure 4(d)). The specific way these pre-conditions have been modeled here is reasoned by the needed time-wise porting of Brussels I provisions back to the moment of contract conclusion (*cf.* Sections II-A and III-A). Brussels I differentiates jurisdiction according to which contract party is defendant and claimant in a dispute brought to court. It assumes the existence of a concluded contract and that a dispute

has arisen and that a claim was deposited in a court. This is the case for most provisions modeled in relation to consumer contracts, special jurisdiction, and general jurisdiction. It is, however, not the case for choice of jurisdiction provisions. There, Brussels I attributes jurisdiction for (potential future) claims of both parties to the courts of the respective agreed and chosen state. For all other jurisdiction attributions, however, jurisdiction is assigned for the claims of a single contract party only. Since this paper looks at determining recommendable jurisdiction(s) and applicable law(s) at the time of contract conclusion, all provisions assuming a dispute in court have to be ported. In particular, this means that for the time of contract formation an equivalent to roles of a claimant and defendant needs to be found. This is achieved by means of a case differentiation introduced in Figures 4(c) and 4(d). This case differentiation leads to parallelization. In the first case, jurisdiction is determined according to the case that a service provider has domicile in a Brussels I member state. In the second case, the same is done for the case that a service customer has domicile in a Brussels I member state.

Of course, any specific modeling decision taken and described so far is valid for the investigated example PIL only. Nevertheless, from a methodological point of view, the introduced way to handle pre-conditions and a time-wise back-porting by means of a case differentiation constitute procedures of general validity. In addition to these general aspects, the set of Brussels I-specific connecting factors becomes apparent at this step of modeling. Connecting factors are represented in decision and action nodes. Domicile and consumer status have been mentioned already for several occasions, but there are multiple connecting factors more to be considered. A service provider's market activities (c8 in Figure 4(a)), a service provider's establishments (c17, c22; s10, s22 in Figure 4(c)), location of performance for a service (s8, s21, s12, s23), and choice of jurisdiction-related factors (most nodes in Figure 4(b); c27, c31, c36, c38, c41, c49, c50 in Figure 4(a)) denote the most important additional connecting factor dimensions for Brussels I. These factors are of key importance to the respective information model as determined and discussed in greater detail in Section IV.

As the main goal in activity diagram modeling is in an integrated functional model (modeling step 2), these four thematic blocks modeled in Figure 4 need to be brought into a single consistent, Brussels I-compliant activity diagram. The resulting integrated viewpoint is shown in Figure 5. In order to visualize changes made, added nodes are marked with a gray background. Those different steps needed to integrate models of Figure 4 into the activity diagram of Figure 5 are explained subsequently.

The most important question in integrating thematic blocks is about hierarchical inter-relations between blocks. For a law such as the investigated Brussels I, a reasonable approach to hierarchy is to separate according to the dimension of specificity. Brussels I knows provisions about general jurisdiction. General jurisdiction applies if there is not a more specific provision to apply. In other words, the more specific a provision is the higher this provision is ranked. Following this principle, provisions of general jurisdiction (Figure 4(d)) are ranked lowest. Next in hierarchy are provisions of special jurisdiction (Figure 4(c)), meaning special jurisdiction supersedes general jurisdiction. Provisions in relation to consumer contracts (Figure 4(a)) and to choice of jurisdiction (Figure 4(b)) rank on the top-most hierarchy level as those provisions may be seen as special cases of special jurisdiction.

This hierarchy is, in principle, in-line with the hierarchy determined in [16]: *"[...] have a particular hierarchical structure, which are determined by the following criteria:*

1) *Does the matter relate to an exclusive jurisdiction ground?*
2) *Has there been a tacit prorogation of the court according to Article 24?*
3) *Does the claim concern a protective jurisdiction rule?*
4) *Did the parties agree upon a court in particular as stipulated in Article 23?*
5) *Does the claim arise out of an action for which alternative jurisdiction rules provide for a forum that is different from the forum indicated in Article 2?*
6) *If the claim concerns a provisional protective matter, [...]."*

Out of this hierarchy list, criteria 2) and 6) are not relevant here. The latter is not considered as provisional matters are excluded (see Table I). The former is not considered as Article 24 is excluded (see Table III). As with respect to criterion 1), exclusive jurisdiction—which is assigned highest priority—is attributed in Figure 4(a) (c11) and Figure 4(b) (p27, p29). Accordingly, highest priority is assigned to consumer contract-related and to choice of jurisdiction-related provisions. For consumer contract provisions, additional importance is attributed by criterion 3), whereas choice of jurisdiction earns somewhat less weight by criterion 4). Criterion 5), finally, addresses hierarchical issues between special and general jurisdiction: Special jurisdiction gains preference over general jurisdiction. In consequence, the applicable hierarchy of modeled thematic blocks (using mnemonics of Table I) is substantiated as follows:

- *Top priority*: CCO and CHO, whereas CCO is slightly preferred over CHO
- *Middle priority*: SPE
- *Lowest priority*: GEN

This hierarchy is reflected by Figure 5. The integrated activity diagram checks first if pre-conditions for CCO are given. If yes, jurisdiction in relation to consumer contracts is determined and the activity is terminated eventually. If CCO does not apply, then CHO is checked next. Again, if choice of jurisdiction pre-conditions apply, jurisdiction is determined accordingly, and the overall activity is terminated eventually. If parties, however do not want to make a choice of jurisdiction or if they cannot agree on a choice, pre-conditions of SPE are checked, applied if applicable, and finally general jurisdiction is determined, whereupon the overall activity is terminated.

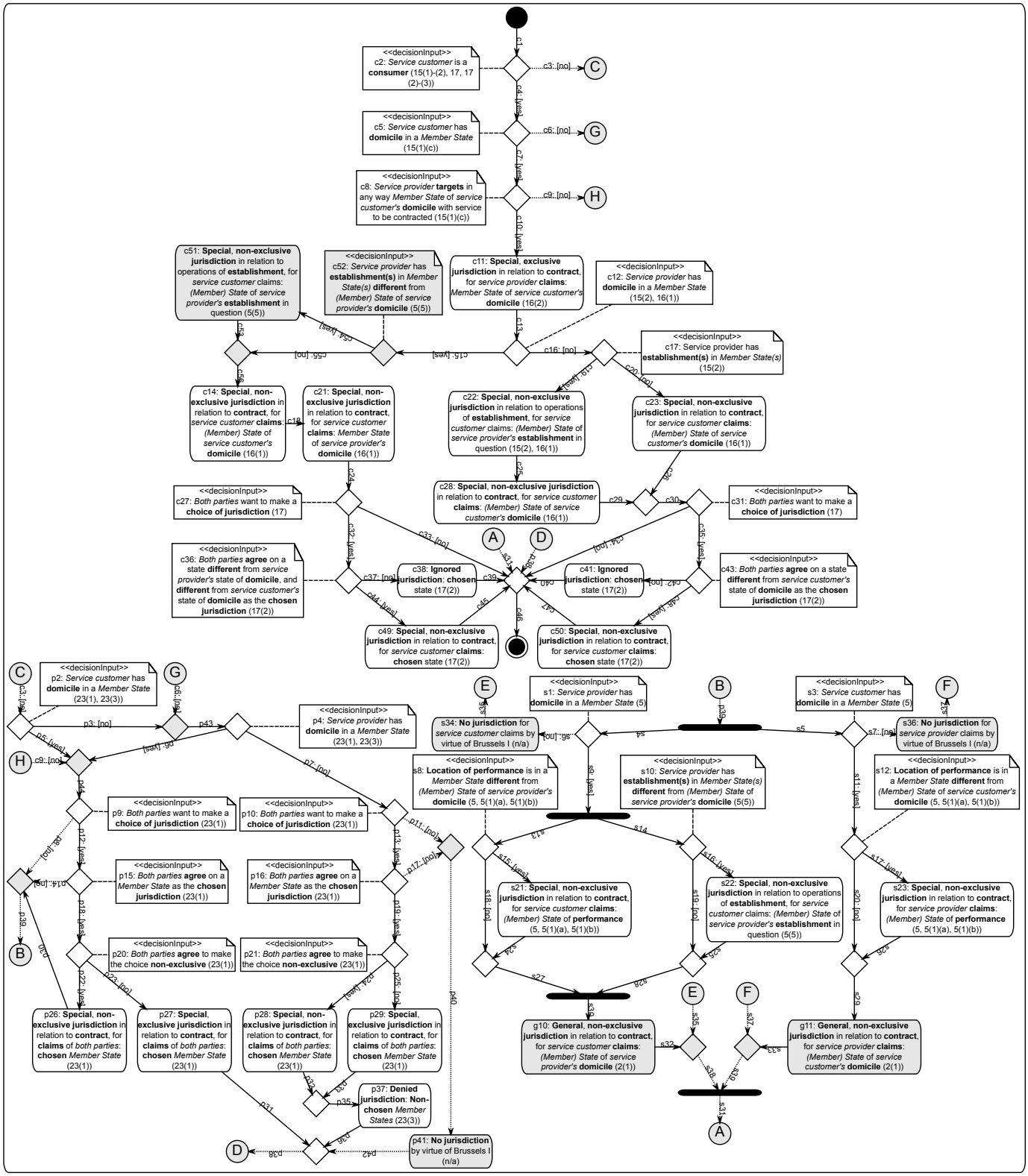


Fig. 5. Integrated Activity Diagram (Modeling Step 2)

In reversed order of hierarchy, the integration of thematic blocks into a single activity diagram was performed as follows: First of all, GEN (Figure 4(d)) and SPE (Figure 4(c)) were integrated. This is a straight forward task as these two blocks share the same pre-conditions and, thus, are structured equally. Therefore, action nodes g10 and g11 were moved to control flows s30 and s29, respectively. The terminal node connected to s31 was replaced by a connector (A) to c45 and, by that, to the remaining, single terminal node. For the two "open-ended" control flows of s6 and s7, void jurisdiction statements in two new action nodes (s34 and s36) were added and connected via s35 and s37 through connectors E and F to the activity's terminal node. Finally, the initial node of Figure 4(c) was replaced by connector B coming from a newly introduced control flow p39 out of CHO (Figure 4(b)).

Connector B, control flow p39 as well as a related merge node were added to address "open-ended" control flows of p8 and p14. These edges indicate situations in which pre-conditions for CHO are given, but contract parties either do not want to prorogate jurisdiction or they cannot agree on a choice. Figure 4(b) knows two other control flows which are "open-ended", namely p11 and p17. For these cases, in which neither of the involved contract parties has domicile in a Brussels I member state and in which parties do not want to make a choice or they cannot find an agreement, a merge node, control flow p40, void jurisdiction statement p41, and control flow p42 were added. It would not make sense to lead control via connector B to SPE and GEN in this case, since pre-conditions for neither SPE nor GEN would be given. Hence the void jurisdiction statement and the subsequent activity termination (through connector D which replaces the former terminal node of Figure 4(b)).

Newly added entry points for CHO are denoted by connectors C, G, and H. C replaces the former initial node. It connects from CCO via c3, implying that the contractual relationship considered is not a B2C, but a B2B one. G connects via c6 assuming that the involved service customer does not have domicile in a Brussels I member state. H connects via c9 which means that the involved service customer has domicile in a member state, but the involved service provider does not target that member state in any way. G and H both imply that the service customer in question is a consumer, thus, a B2C relationship is implied. Nevertheless, and while CCO provisions cannot apply as explained, control flow is handed over to CHO (and with that potentially to SPE and GEN) which might still apply. At this point, it becomes fully clear that integrating thematic blocks into a single activity is a highly complex task—and a task which requires a certain degree of interpretation even though the hierarchy between thematic blocks might seem clarified in general.

Similar considerations hold true for a final integration change made involving CCO (Figure 4(a)) and SPE (Figure 4(c)): In case pre-conditions for CCO are all fulfilled and the service provider in question has domicile in a Brussels I member state (c12, c15), jurisdiction statements in relation to contract would be made in action nodes c14, c21, and either c38 or c49 before the overall activity would be terminated. This would imply special jurisdiction in relation to operations of establishment (s22) would never be made. This is why decision node s10 and action node s22 were copied and inserted between control flow c15 and action node c14. Further copying is not needed as, on the one hand, the respective pre-conditions for application are not given in case of c16, while on the other hand, by means of connectors B, C, G, and H it is guaranteed that s22 is reachable in all relevant cases.

In conclusion, the integrated activity diagram represented by Figure 5 constitutes the second key contribution of this paper for the specific example PIL considered here. While the modeling methodology developed and discussed in Sections III-A, III-B and finally the sub-section at hand represents the first main contribution of this paper, the integrated activity diagram is the direct result of this methodology. It proves that a formal modeling according to the methodology introduced is feasible and and that this leads to the desired result. That is to say the resulting activity diagram determines fundamental input to both, the respective information modeling as investigated in Section IV and the subsequent implementation addressed in Section V.

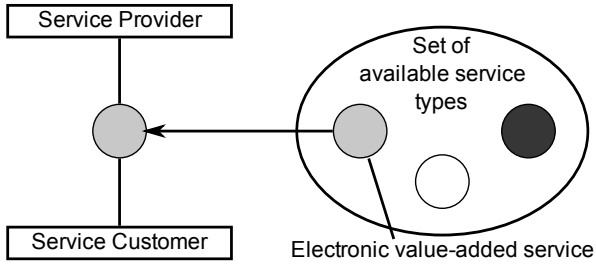


Fig. 6. Customer/provider Relationship

IV. Information Model

The motivation for and necessity of an information model—both in general as well as in the specific context of this work—have been clarified in Section II-B. It has also been stated that the information model presented here is an adaptation of an existing comprehensive SLM information model [11] that differentiates two abstraction layers: the basic concept model showing general information classes and high-level dependencies, and the artifact model breaking down class definitions to their attributes level and, thus, enabling data modeling and model-driven implementation. Accordingly, Section IV-A highlights some basic assumptions, followed by a presentation of the concept model in Section IV-B and an outline of the detailed artifact model in Section IV-C.

A. Basic Assumptions

Figure 6 shows the initial starting point for the information model with respect to the applicable business (and contractual) relationship considered. This relationship covers a service provider and a service customer, whereas it has to be noted that a service customer may or may not be the same entity

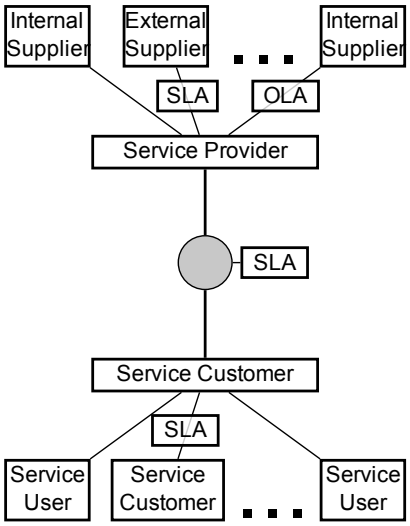


Fig. 7. Extended Customer/provider Relationship

as the service user. Within the scope of this work, thus, a differentiation between that party that uses and that pays for a service is made. Figure 6 also includes the object of such a customer/provider business relationship, namely the contracted service to be provided and consumed, respectively.

According to ITIL [10], a service can be regarded as a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks. As a specialization of this definition, an electronic service can be defined as a service that can be realized exclusively by means of electronic systems and information technology equipment as well as through aggregation and interconnection of such systems. In the context of this work, electronic services are focused exclusively (*cf.* Section II-A).

Figure 7 develops the previously introduced customer/provider business relationship further by including potential internal or external suppliers—parties which are possibly not known to a service customer—and potential service users as well as further service customers (when re-selling a service)—parties possibly not known to a service provider.

It is important to note that this paper focuses on the primary business relationship between (exactly) one service customer and (exactly) one service provider and, thus, abstracts away potential further business relations within the scope of a service provider or a service customer, respectively. This implies a bilateral contractual agreement for an electronic service as negotiated between the respectively involved service provider and service customer only. Such a contractual agreement may find a technically measurable representation in an associated service level agreement (SLA). The information model is concerned with those concepts and information artifacts that allow the legally compliant formation of an international service contract. In particular, concepts and artifacts are focused that help determining jurisdiction and applicable law.

B. Basic Concept Model

The following questions indicate the goals of the basic concept model:

- Which information needs to be processed and maintained in the context of SLM and its activities?
- Which information object (artifact) definitions can be used to bundle all relevant information in a clear set of object classes?
- What are the concrete informational requirements with respect to the identified information objects?
- What are the superior interrelations, dependencies and multiplicities between these artifacts?

Figure 8 shows accordingly the major concepts relevant to the existing ITSM model as documented in full detail in [11]. This model serves as a starting point to determine appropriate and necessary adaptations. The adopted focus on SLM-driven concepts requires extension towards an angle covering both, service management and contracting concepts. Contracting issues and provisioning/management aspects of contracted services are both of interest. As a contract is a mutual agreement, the inclusion of contracting concepts requires to reflect the respective involved contract parties equally. Considered contract parties embrace exactly one service provider and exactly one service customer (both being of type `ContractParty`). On the other hand, concepts of type `ServiceDeliveryParty` are not focused on here, so that these concepts can be neglected—which, however, does not imply that these concepts are not relevant.

Driven by existing model shown partially in Figure 8, a first set of adaptations for the extended concept model of relevance to this work is summarized as follows:

1) Concepts for both considered contracting parties are included. The existing `Customer` concept is renamed to `ServiceCustomer`, complemented by its counter-part concept, `ServiceProvider`. `ServiceCustomer` and `ServiceProvider` inherit from the (newly included) concept `ContractParty`.
2) `ServiceDeliveryParty` concepts (including concretized concepts of `InternalDeliveryParty` and `ExternalSupplier`) are abstracted away from the concept model.
3) The concept for `ServiceContract` is included as a central contracting concept.
4) `SupportiveAgreement` concepts (including concretized concepts of `OperationalLevelAgreement` and `UnderpinningContract`) are abstracted away from the concept model.
5) `Agreement` (including associated concept of `AgreementConflict`) is abstracted from the concept model due to a potentially misleading interpretation of the `ServiceContract` concept in the context of this paper.
6) Contract management and service management domains are included. Concepts are placed according to their relation to either one or both domains.

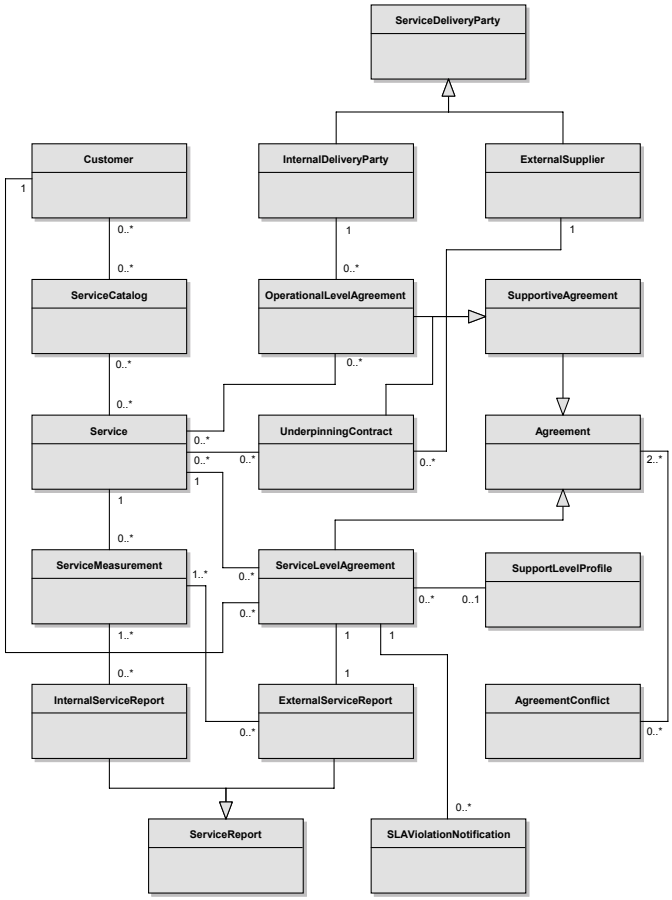


Fig. 8. Partial View on the Existing Concept Model [11]

7) Customer and provider domains included. Concepts placed according to relation on either one or both domains.
8) Typical contract-general concepts, such as `GeneralTermsAndConditions` and (the previously introduced) `ServiceContract`, are included. These concepts usually see a stronger relationship with the contract management domain than with the service management domain.
9) Typical service-specific concepts, such as `TermsAndConditions`, `AcceptableUsePolicy`, and `ServiceLevelAgreement`, are introduced.
10) Management-driven concepts of `ServiceUser` and `ServiceOperator` are included as a complement to their respective contract-driven concepts of `ServiceCustomer` and `ServiceProvider`.
11) `ServiceReport` concepts (including concretized concepts of `InternalServiceReport` and `ExternalServiceReport`) are abstracted away from the concept model. Accordingly, the `ServiceMeasurement` concept (basis to prepare `ServiceReport`) is abstracted away from the concept model.
12) Concepts related to `ServiceLevelAgreement` with a primary management focus—`SLAViolationNotification` and `SupportLevelProfile`—are abstracted away from the concept model.
13) Management-driven concepts of `Service` and `ServiceCatalog` are used from the existing model. `ServiceCatalog` is associated with the `ServiceContract` concept. The `Service` concept is associated with the service-specific contract part concepts.

The results of these adaptations are, in parts, outlined and visualized in Figure 9.

C. Artifact Model

Driven by the concept model adapted, this section is concerned with the modeling of concrete, related information objects (information artifacts) required for a PIL-conforming determination of jurisdiction and applicable law. Once the questions from the beginning of Section IV-B have been answered, a refinement of the concept model into concrete data models needs to be performed, addressing the following points:

- How can the informational requirements of the artifacts be refined and formalized as data models?
- What are the concrete data models resulting from the set of information object classes identified before?
- How can all data models be integrated into one single consistent information system for SLM?

Figure 10, as a partial information model emphasizing on contract parties, provides an elaborate overview of artifacts that reflect each contract party's characteristics and preferences, while it does not elaborate in full detail on artifacts telling about whether both parties actually find agreement according to their mutual preferences so that a contract might see a choice of jurisdiction and/or of applicable law (and if yes, which choice). Similarly, the partial model in Figure 10 includes a generic, *i.e.*, not further differentiated, artifact for jurisdiction(s) and applicable law(s).

In summary, both the adapted concept and the artifact model determined on the basis of the existing SLM information model cover by means of those extensions made dimensions of service as well as contract management. These models facilitate a bridging of the modeling method and, especially, the resulting activity diagram (Section III) with the design and implementation as detailed in Section V. In particular, in- and output variables used in the implementation (reflecting connecting factors or jurisdiction-oriented information) are in direct relation to the artifacts embraced by Figure 10. Sections V-B and V-C provide an in-depth discussion of these artifacts.

V. Design and Implementation

Having both function (*cf.* Section III) and information (*cf.* Section IV) models available, this section focuses on the implementation aspects of the approach for automatically determining jurisdiction. The implementation reflects a machine-executable representation of the activity diagram depicted in

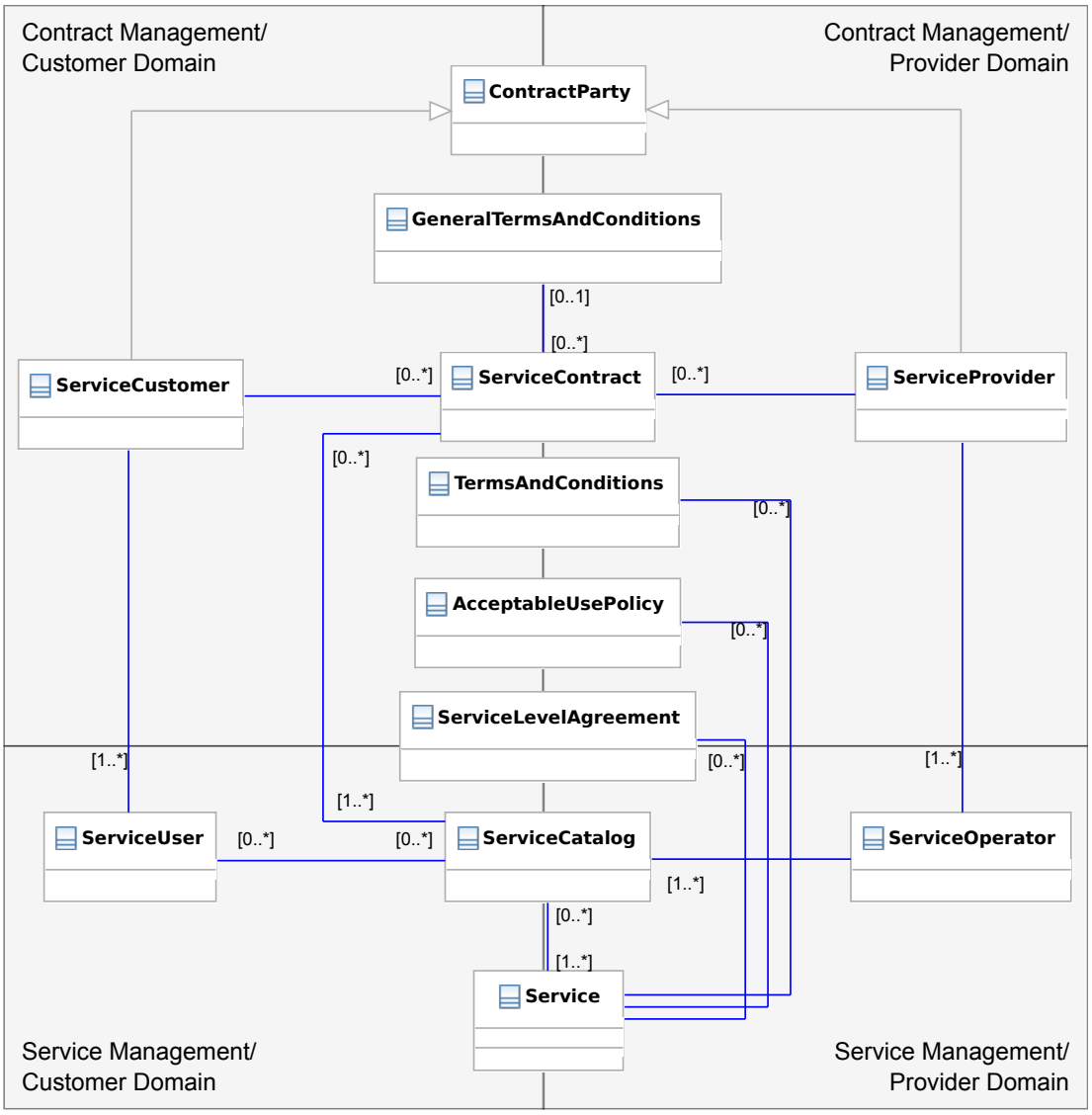


Fig. 9. Adapted Concept Model (Outline)

Figure 5, taking into consideration concepts and artifacts of relevance as determined in Figures 9 and 10.

From a design viewpoint, the implementation constitutes a rule-based system which follows a traditional input-processing-output model as shown in Figure 11. The processing part relates to decision making, which has been implemented using the Prolog programming language following the logic programming paradigm. Input to the decision engine is of two types: predetermined and interactive. The latter relates to jurisdiction queries, whereas the former constitutes the logic of the activity diagram for Brussels I and the set of connecting factor variations, in the form of logic predicates. A specific connecting factor variation and the respective path through the relevant activity diagram reflect a single test case to assess the implementation's functionality. The output of the decision engine is a set of jurisdictions determined by the Prolog interpreter applying to individual service contracts.

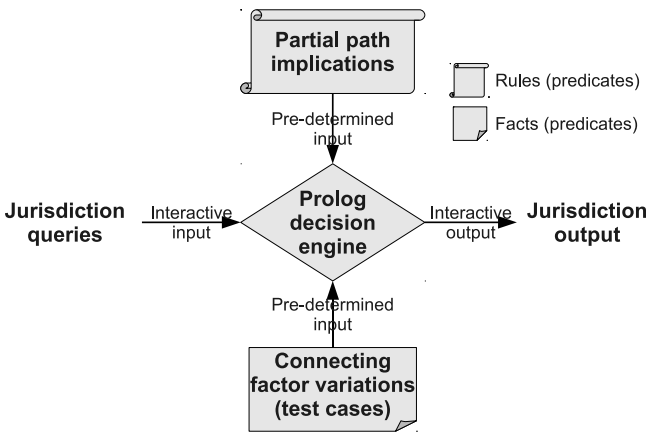


Fig. 11. High-level System Design

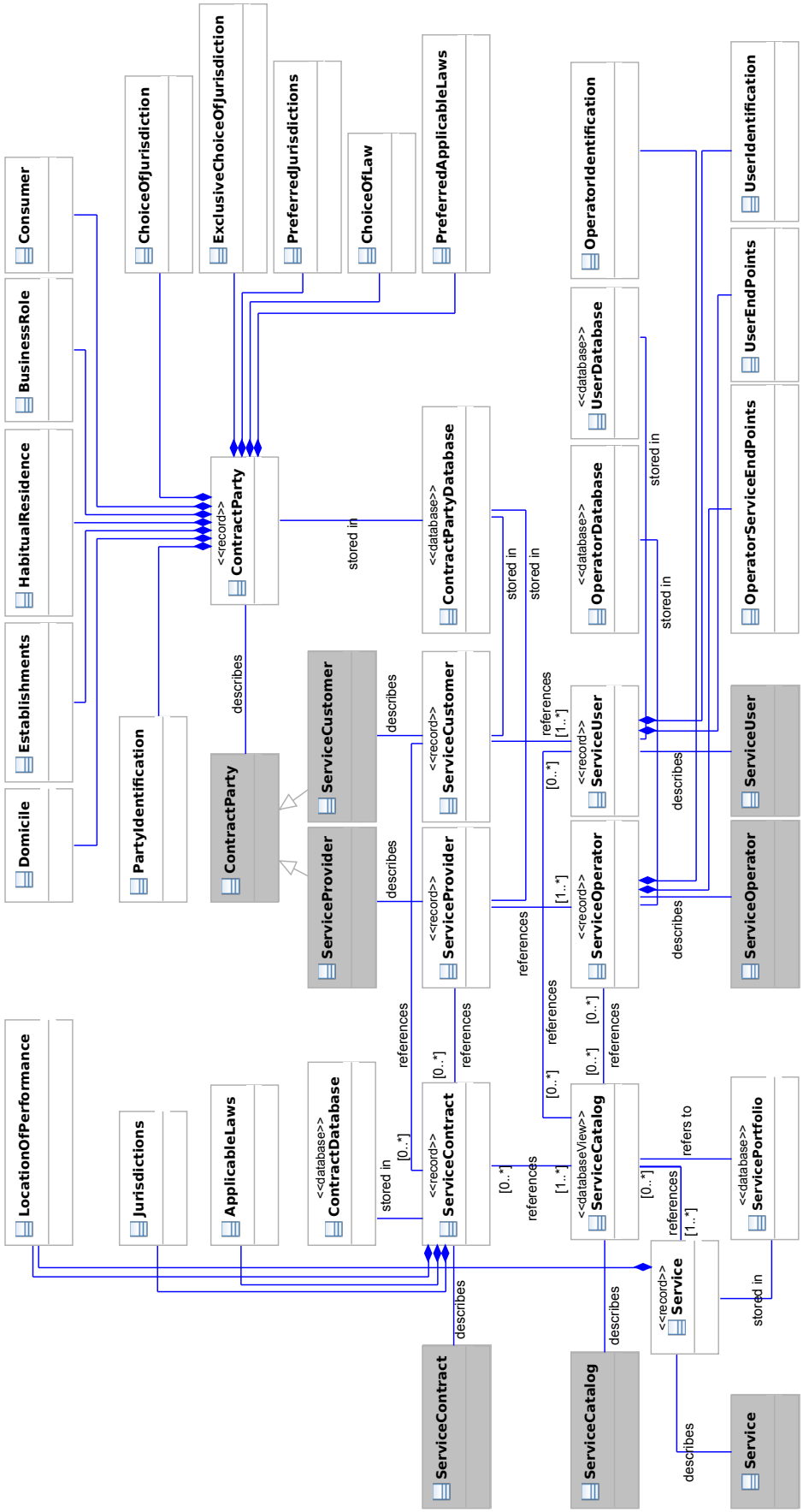


Fig. 10. Partial Artifact Model

Accordingly, Section V-A details on a splitting into partial path implications. Section V-B focuses on connecting factor variations, while Section V-C presents those Prolog predicates that specify decision rules for partial and complete paths in the Brussels I activity diagram, and Section V-D documents jurisdiction queries and functional verification.

A. Partial Path Implications

A complete, dedicated path from the initial to the terminal node of the Brussels I activity diagram (*cf.* Figure 5) constitutes a single test case as expressed by means of a given connecting factor variation. It would, thus, seem appropriate at first to follow an implementation approach which would directly reflect complete paths. Since the Brussels I activity diagram, however, shows a quite complex activity, the number of complete paths to be modeled in such an approach would be considerably large. Furthermore, several complete paths would have substantial overlaps as they would differ in a few decisions only. The implementation would consist largely of very lengthy predicates for complete paths that would be difficult to debug and that would share large code parts with other path predicates. For these reasons, a more structured implementation approach was chosen. Its main idea consists in complexity reduction and code re-use by means of splitting the Brussels I activity diagram into partial paths.

When starting from the activity diagram's terminal node and then going backwards, the first partial path definition is the one for control flow c46 in Figure 5. If c46 was taken, this implies that c45, c39, c33, s31, p38, c34, c40, or c47 was taken before. Similarly, c45 implies c49, c44, and c32, while c39 implies c38, c37, and c32. So, the next step in partial path definition is to determine implications of c32 and so on. This partial path implication procedure is repeated until all control flows are fully determined as being part of a partial path. Figure 17 included in Appendix A documents the resulting partial paths determined and expressed in terms of implications. In accordance with Prolog syntax, ";" stands for a logic OR connection and "," stands for a logic AND connection. Implication is expressed by "$\rightarrow$".

By following strict logic, any partial path in relation to a merge node would have to make use of a logic XOR operation (exclusive OR) instead of logic OR. However, by virtue of those formal activity diagram modeling requirements raised in Section III-C, activity diagrams guarantee that only one input edge carries a control flow token into a merge node. Consequently, logic OR can be used instead of the more complex logic XOR.

In a next step, these partial paths identified are directly implemented as Prolog predicates. Each predicate constitutes a decision rule expressed as an implication. Before defining this decision rule set, however, it is necessary to identify the parameters that need to be considered when making a decision. These parameters are connecting factors (*cf.* Figure 11) as determined subsequently.

B. Connecting Factor Variations

Connecting factors are reflected in the Prolog implementation by means of predicates representing facts. Each connecting factor predicate is supposed to make a statement about all facts necessary to make decisions. This implies that decision-relevant connecting factors need to be collected first. By going through the modeled Brussels I activity diagram of Figure 5 the set of 12 connecting factors is identified. Accordingly, the implementation defines a connecting factor predicate `input/13`. This predicate includes 13 variables—one for an identifier, 12 for connecting factors—, each of which can be assigned with a valid value. These variables are included in accordance with the information model specified in Section IV, and in particular with respect to the information artifacts described. The following list defines these variables along with the respective values that can be assigned to them.

- *ID*: ID is a unique number, a positive integer, serving as an identifier for a connecting factor variation.
- *CustomerDomicile*: ISO three-character, non-capitalized country code for the state in which a service customer has domicile.
- *ProviderDomicile*: *Cf.* `CustomerDomicile`.
- *CustomerConsumer*: Either a value of "consumer" or a value of "professional". The first means that a service customer is a consumer. This would imply a B2C case–a service provider is always assumed to be a professional/business.
- *CustomerChoice*: Either a value of "choice" or a value of "noChoice". The first means that a service customer wants to make a choice of jurisdiction.
- *CustomerExclusiveChoice*: This variable is only considered if `CustomerChoice` is "choice". Otherwise `CustomerExclusiveChoice` will see a value of "n/a". If choice, then `CustomerExclusiveChoice` can have a value of either "exclusive" or "nonExclusive". The first means that a service customer wants to make a choice of jurisdiction an exclusive one.
- *CustomerPreferred*: A list of ISO three-character, non-capitalized country codes determining a service customer's preferred states to attribute jurisdiction to. For instance, a list of [che, deu, fra] means that the service customer gives highest jurisdiction preference to Switzerland, followed by Germany, and then France. This is only considered if `CustomerChoice` has a value of "choice". Otherwise, CustomerPreferred sees an empty list ("[]").
- *ProviderChoice*: *Cf.* `CustomerChoice`.
- *ProviderExclusiveChoice*: *Cf.* `CustomerExclusiveChoice`.
- *ProviderPreferred*: *Cf.* `CustomerPreferred`.
- *ProviderEstablishments*: A list of ISO three-character, non-capitalized country codes determining states in which a service provider has establishments.
- *ProviderTargetStates*: A list of ISO three-character, non-capitalized country codes determining states that a service

provider targets with his service offerings.

- *LocationOfPerformance*: ISO three-character, non-capitalized country code for the state in which a service is supposed to be performed.

By means of value variations in `input/13`, a data base of test cases is built. For instance, "input(15, aut, aut, professional, choice, exclusive, [aut, deu, che], choice, exclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut)" stands for a complete path through the Brussels I activity diagram starting at c1, then leading through c3, p5, p44, p12, p18, p23, p27, p31, p38, and finally c46. This full path, thus, stands for a B2B case in which both parties have domicile in a Brussels I member state, both parties want to make an exclusive choice of law, and in which both parties agree to attribute jurisdiction to a Brussels I member state. In this case, a single action is performed (p27) in which a statement about jurisdiction is made. A specific connecting factor variation determining a full path—in other words, a given `input/13` predicate containing valid facts—constitutes a test case, since it defines an expected outcome. In the example case mentioned before, the expected outcome is that by action p27 special, exclusive jurisdiction in relation to contract and for claims of both parties is in Austria, the state mutually agreed through choice of jurisdiction.

Table IV in Appendix B lists a selection of 19 test cases with the corresponding complete paths through the Brussels I activity diagram modeled. The test cases are represented as variations of input variables (connecting factors) to the `input/13` predicate and serve as a basis for the functional evaluation of partial and complete paths as discussed subsequently.

C. Predicates Implementing Partial and Complete Paths

The main part of the implementation consists of the actual predicates for partial paths as listed in Section V-A. These predicates are implemented as Prolog rule predicates determining implications (*cf.* Figure 11). The primary predicate is `jurisdictions/16` which reflects c46. As c46 is the last edge before the terminal node is reached, `jurisdictions/16`, is the predicate to assess overall functionality. For its special impact, the predicate was not simply named c46 but it was given more visibility by the name of "jurisdictions". All other predicates in this implementation part are named as mentioned in the partial path description.

As partial paths may include both decisions (decision nodes and the according output edges) and statements about jurisdiction (action nodes), predicates may consider input and output variables. Input variables consist primarily of connecting factors and IDs for specific input variations as defined in `input/13` fact predicates (see Section V-B). Output variables consist primarily of IDs and jurisdiction-related output obtained in action nodes. The following list describes the 16 output variables for the implementation's core predicate `jurisdictions/16`. As this predicate carries along all possible jurisdiction-related output variables, this list is self-contained with respect to jurisdiction output. It must be noted that all jurisdiction-related output variables are either a ISO three-character, non-capitalized country code or a list thereof.

- *ID*: The identifier of a test case. *Cf.* `input/13` predicate description in Section V-B.
- *SNCCjurisdiction*: SNCC is a code (left-to-right): S=Special, N=Non-exclusive, C=Contract, C=Customer. This means that this output variable determines "Special, non-exclusive jurisdiction in relation to contract, for service customer claims". There is not only a single jurisdiction, but multiple jurisdictions that an activity diagram may identified. These jurisdictions must be differentiated from each other so that they can be brought into a hierarchy of jurisdictions (see Section III-C). `SNCCjurisdiction` is a single type of jurisdiction considered here as a possible jurisdiction output. The code SNCC is used as an abbreviation for the respective full syntax specified in Figure 3. This type of jurisdiction is determined in action nodes c14, c23, c28, and s21.
- *SNCCjurisdiction2*: *Cf.* `SNCCjurisdiction`. Regarding numbering: Non-exclusive jurisdiction is additive, meaning if there are two non-exclusive jurisdictions one does not supersede the other. In some paths, there are multiple non-exclusive jurisdictions possible (*e.g.*, [...], c14, c18, c21, c24, c32, c44, c49, c45, c46)—these are numbered and preserved along a path. This type of jurisdiction is determined in action nodes c21 and c50.
- *SNCCjurisdiction3*: *Cf.* `SNCCjurisdiction` and `SNCCjurisdiction2`. This type of jurisdiction is determined in action node c49.
- *SNECjurisdiction*. *Cf.* `SNCCjurisdiction`. SNEC means: S=Special, N=Non-exclusive, E=Establishment, C=Customer. This type of jurisdiction is determined in action nodes c22, c51, and s22.
- *SECPjurisdiction*: *Cf.* `SNCCjurisdiction`. SECP means: S=Special, E=Exclusive, C=Contract, P=Provider. This type of jurisdiction is determined in action node c11.
- IgnoredJurisdiction: In case contract parties want to make a choice of jurisdiction, and they actually come to a jurisdiction agreement, but this agreement cannot be accepted by law for this specific configuration, the chosen but ignored jurisdiction is listed. This type of jurisdiction is determined in action nodes c38 and c41.
- *SNCBjurisdiction*: *Cf.* `SNCCjurisdiction`. SNCB means: S=Special, N=Non-exclusive, C=Contract, B=Both. This type of jurisdiction is determined in action nodes p26 and p28.
- *SNCPjurisdiction*: *Cf.* `SNCCjurisdiction`. SNCP means: S=Special, N=Non-exclusive, C=Contract, P=Provider. This type of jurisdiction is determined in action node s23.
- *GNCCjurisdiction*: *Cf.* `SNCCjurisdiction`. GNCC means: G=General, N=Non-exclusive, C=Contract, C=Customer. This type of jurisdiction is determined in action node g10.
- *GNCPjurisdiction*: *Cf.* `SNCCjurisdiction`. GNCP

means: G=General, N=Non-exclusive, C=Contract, P=Provider. This type of jurisdiction is determined in action node g11.

- NoCjurisdiction: In some cases, no jurisdiction by virtue of the law—Brussels I—can be determined. Nevertheless, the formal requirements listed in Section III-C ask always for at least one jurisdiction-related statement to be run through. Hence, if such a case is hit, then this is mentioned in the output. NoC is a code and means: No=No jurisdiction, C=Customer. Accordingly, `NoCjurisdiction` stands for "No jurisdiction for service customer claims by virtue of Brussels I". This type of jurisdiction is determined in action node s34.
- *NoPjurisdiction*: *Cf.* `NoCjurisdiction`. NoP is a code and means: No=No jurisdiction, P=Provider. This type of jurisdiction is determined in action node s36
- *SECBjurisdiction*: *Cf.* `SNCCjurisdiction`. SECB means: S=Special, E=Exclusive, C=Customer, B=Both. This type of jurisdiction is determined in action nodes p27 and p29.
- *DeniedJurisdiction*: Brussels I mentions explicitly for specific cases that some of its member states cannot have jurisdiction. `DeniedJurisdiction` lists these states if such case applies. This type of jurisdiction is determined in action node p37.
- *NoJurisdiction*: *Cf.* `NoCjurisdiction`, except that, in this case, no jurisdiction can be determined by virtue of Brussels I for claims of both contract parties. This type of jurisdiction is determined in action node p41.

In addition to those predicates implementing partial paths a number of helper predicates, mainly for Prolog list operations, have been implemented. Of special note here is `memberStates/1`. This supporting predicate defines member states of Brussels I in terms of a Prolog list containing ISO three-character, non-capitalized country codes. Moreover, supporting predicates exist for the management of choice of jurisdiction (`disagreement/2`, `chosenJurisdiction/3`, `nonChosenMemberStates/2`) and to handle Brussels I member state status (`memberState/1`, `establishmentsInMemberStates/2`, `chosenStateIsMemberState/1`).

In order to show how predicates for partial paths are implemented an example case is presented. This case reflects test case 15 as outlined in Section V-B. For case 15, which is a very simple case, a path of c1, c3, p5, p44, p12, p18, p23, p27, p31, p38, c46 is expected as Table IV specifies. The implementation does not define a predicate for c1 since this control flow is taken with every path and it does not carry along any information nor does it require any input to make a decision. The first predicate defined in this example path implements c3. Figure 12 documents the set of predicates implemented in relation to this case, including the respective predicate for c3, (`c3/1`).

Predicate `c3/1` has one output variable (`ID`). It constitutes an implication which decides based on two variables (`ID` and `CustomerConsumer`) if a service customer is a consumer. Predicate `c3/1` implements an output edge of a decision node, that of c2. Similarly, predicate `p5/1` is "true" if the answer to decision node p2 is "yes". A value of "true" for `p5/1` implies that `c3/1` is "true" and that `CustomerDomicile` denotes a member state. Predicate `p44/1` implements a merge node implying that predicates `c9/1`, `p5/1`, or `p6/1` are true. Predicate `p12/1` implies `p44/1` to be "true" and that both contract parties want to make a choice of jurisdiction.

While all predicates introduced so far had a single output variable only, from predicate `p18/2` onwards, further information beyond the identifier of a test case is carried along a path. In case of `p18/2` this concerns the state which both contract parties are willing to assign jurisdiction to. This information is needed in other predicates so that it serves as decision making input there. In the example path shown, the case in predicate `p32/2` assigns the respective chosen state to its output variable of `SECBjurisdiction`, if neither contract party wants to make the choice of jurisdiction a non-exclusive one.

Since predicate `p38/5` implements a merge node with `p32/2` being only one out of three possible input edges, output variables of `p38/5` must consider all information carried along all inputs. Besides the two variables of relevance to `p32/2`, this includes three additional notions of jurisdiction output. Finally, after p38 was passed in the example path assessed, c46 is taken—which is reflected by `jurisdictions/16`.

D. Jurisdiction Queries and Functional Evaluation

Based on previous discussions about partial paths, connecting factor variations, and implication predicates, this section presents results obtainable when interacting with the Prolog decision engine. Queries for partial or full paths combined with the set of test cases specified makes a functional evaluation possible. In this context, the section at hand explains in what terms function is assessed for the implementation of Brussels I, whereas further evaluation dimensions such as security, scalability, and performance are not covered here. Similarly, aspects of deployment—*e.g.*, which component to run where/in which administrative domain—are not addressed at all. In non-technical terms, hence, to "make the implementation work" and to show feasibility of an automated determination of jurisdiction according to Brussels I constitute the key aspects of interest.

A key aspect of the partial path implementation approach is that function assessment is made available at all stages of development. This allows for immediate testing by debugging partial paths instead of complete paths. Since partial paths are considerably less complex to assess than complete ones, the development process is actively accelerated. This is illustrated by means of the same example used in Section V-C in relation to test case 15. After compiling the Prolog code, the Prolog interpreter may be queried about each predicate implemented. For instance, for `c3/1` the query "?- c3(ID)."+ lists all test case IDs which involve a consumer as a service customer. The output reads like:

```
c3(ID) :- input(ID, _, _, CustomerConsumer, _, _, _, _, _, _, _, _, _),
        CustomerConsumer\=consumer.

p5(ID) :- c3(ID),
        input(ID, CustomerDomicile, _, _, _, _, _, _, _, _, _, _, _),
        memberState(CustomerDomicile).

p44(ID) :- c9(ID);
        p5(ID);
        p6(ID).


p12(ID) :- p44(ID),
        input(ID, _, _, _, CustomerChoice, _, _, ProviderChoice, _, _, _, _, _),
        CustomerChoice==choice,
        ProviderChoice==choice.

p18(ID, Choice) :- p12(ID),
        input(ID, _, _, _, _, _, CustomerPreferred, _, _, ProviderPreferred, _, _, _),
        not(disagreement(CustomerPreferred, ProviderPreferred)),
        chosenJurisdiction(CustomerPreferred, ProviderPreferred, Choice),
        chosenStateIsMemberState(Choice).

p31(ID, SECBjurisdiction) :- p18(ID, Choice),
        input(ID, _, _, _, _, CustomerExclusiveChoice, _, _, ProviderExclusiveChoice, _, _, _, _),
        not(
                (
                        CustomerExclusiveChoice==nonExclusive,
                        ProviderExclusiveChoice==nonExclusive
                )
        ),
        SECBjurisdiction=Choice.

p38(ID, SECBjurisdiction, SNCBjurisdiction, DeniedJurisdiction, NoJurisdiction) :-
        p31(ID, SECBjurisdiction);
        p36(ID, SNCBjurisdiction, SECBjurisdiction, DeniedJurisdiction);
        p42(ID, NoJurisdiction).

jurisdictions(ID, SNCCjurisdiction, SNCCjurisdiction2, SNCCjurisdiction3, SNECjurisdiction,
        SECPjurisdiction, IgnoredJurisdiction, SNCBjurisdiction, SNCPjurisdiction, GNCCjurisdiction,
        GNCPjurisdiction, NoCjurisdiction, NoPjurisdiction, SECBjurisdiction, DeniedJurisdiction,
        NoJurisdiction) :-
        (
                c45(ID, SNCCjurisdiction, SNCCjurisdiction2, SNCCjurisdiction3, SNECjurisdiction,
                        SECPjurisdiction);
                c39(ID, SNCCjurisdiction, SNCCjurisdiction2, SNECjurisdiction, SECPjurisdiction,
                        IgnoredJurisdiction);
                c33(ID, SNCCjurisdiction, SNCCjurisdiction2, SNECjurisdiction, SECPjurisdiction);
                s31(ID, SNCBjurisdiction, SNCCjurisdiction, SNCPjurisdiction, GNCCjurisdiction,
                        GNCPjurisdiction, SNECjurisdiction, NoCjurisdiction, NoPjurisdiction);
                p38(ID, SECBjurisdiction, SNCBjurisdiction, DeniedJurisdiction, NoJurisdiction);
                c34(ID, SNECjurisdiction, SNCCjurisdiction, SECPjurisdiction);
                c40(ID, SNECjurisdiction, SNCCjurisdiction, SECPjurisdiction, IgnoredJurisdiction);
                c47(ID, SNECjurisdiction, SNCCjurisdiction, SNCCjurisdiction2, SECPjurisdiction)
        ).
```

Fig. 12. Implementation Excerpt Showing Predicate Definitions for Path in Relation to Test Case 15

```
ID = 1 ;
ID = 9 ;
ID = 10 ;
ID = 11 ;
ID = 14 ;
ID = 15 ;
false.
```

This means that the Prolog interpreter found connecting factor variations—test cases—with IDs 1, 9, 10, 11, 14, and 15 which satisfy the implication of `c3/1`. This outcome is in-line with the expected results documented in Table IV. The test cases mentioned represent those variations for which `CustomerConsumer` has a value of "consumer" and for which the corresponding path goes through c3. Analogously, the same testing procedure applies to more complicated predicates, *e.g.*, to `p38/5` as the query and output show in Figure 13.

This query asks about test cases for which all requirements to pass control flow p38 in the Brussels I activity diagram are given. Consequently, the Prolog interpreter searches for `input/13` facts which reflect possible partial paths arriving at p38. For the set of test cases determined in Table IV, preconditions to reach p38 are satisfied for connecting factor variations with IDs 7, 10, 11, 12, 13, 14, and 15. For each test

```
?- p38(ID, SECBjurisdiction, SNCBjurisdiction, DeniedJurisdiction,
|   NoJurisdiction).
ID = 15,
SECBjurisdiction = [aut] ;
ID = 11,
SNCBjurisdiction = [aut],
DeniedJurisdiction = [bel, bgr, cyp, cze, dnk, est, fin, fra, deu|...] ;
ID = 14,
SECBjurisdiction = [aut],
DeniedJurisdiction = [bel, bgr, cyp, cze, dnk, est, fin, fra, deu|...] ;
ID = 7,
SECBjurisdiction = [deu],
DeniedJurisdiction = [aut, bel, bgr, cyp, cze, dnk, est, fin, fra|...] ;
ID = 10,
NoJurisdiction = noJurisdictionByBrusselsI ;
ID = 12,
NoJurisdiction = noJurisdictionByBrusselsI ;
ID = 13,
NoJurisdiction = noJurisdictionByBrusselsI ;
false.
```

Fig. 13. Example Query and Obtained Output for Predicate p38/5

case found, case-specific jurisdiction output is listed. Case-specific means that the set of output variables returned by the Prolog interpreter for a given case identified contains only those variables (and the according values) for which a value was determined throughout a full path. For test case 12, for instance, a single output variable was attributed a value until control flow reached p38, namely that of `NoJurisdiction`. On the other hand, test case 11 reflects a path in which twice a statement about jurisdiction was made until p38 was reached. Special, non-exclusive jurisdiction in relation to contract, for service customer claims, was set to Austria, and `DeniedJurisdiction` was noted to embrace all Brussels I member states except for Austria. Again, these results obtained are fully in-line with the expected result documented in Table IV. Case 12 is expected to see only one jurisdiction statement to be made, namely in action node p41 where `Nojurisdiction` is attributed. Case 11 is expected to see two jurisdiction statements. The first is supposed to happen in activity node p28 where chosen jurisdiction is adopted as `SNCBjurisdiction`. Chosen jurisdiction is in this case—according to customer and provider preferences expressed—Austria (determined by predicate `p19/2`).

Finally, Figure 14 presents the implementation's main output when querying the Prolog interpreter for `jurisdictions/16`. The output obtained shows that for all 19 test cases used in this paper the respective case-specific set of jurisdiction variables is attributed the relevant values. By means of this output, the implementation proves to deliver results which are exactly those expected from test case definitions and when going through the Brussels I activity diagram accordingly. Therefore, the implementation is found to facilitate for the set of connecting factor variations tested a correct, automated determination of jurisdiction according to the PIL modeled, the Brussels I regulation.

In summary, a number of key conclusions with respect to the implementation are drawn as follows: First and foremost, the implementation has proven to be fully functional. It represents the first and only fully machine-executable implementation of the Brussels I regulation to date. Second, obtained results have been successfully tested by means of those 19 test cases documented in this paper as well as by further test

```
?- jurisdictions(ID, SNCCjurisdiction, SNCCjurisdiction2, SNCCjurisdiction3,
|    SNECjurisdiction, SECPjurisdiction, IgnoredJurisdiction,
|    SNCBjurisdiction, SNCPjurisdiction, GNCCjurisdiction,
|    GNCPjurisdiction, NoCjurisdiction, NoPjurisdiction, SECBjurisdiction,
|    DeniedJurisdiction, NoJurisdiction).
ID = 4,
SNCCjurisdiction = svk,
SNCCjurisdiction2 = aut,
SNCCjurisdiction3 = [hun],
SNECjurisdiction = [svk, svn],
SECPjurisdiction = svk ;
ID = 5,
SNCCjurisdiction = svk,
SNCCjurisdiction2 = aut,
SNCCjurisdiction3 = [ita],
SECPjurisdiction = svk ;
ID = 2,
SNCCjurisdiction = svk,
SNCCjurisdiction2 = aut,
SNECjurisdiction = [cze, hun, svk, svn],
SECPjurisdiction = svk ;
ID = 8,
SNCCjurisdiction = aut,
SNCCjurisdiction2 = aut,
SNECjurisdiction = [cze, hun, svk, svn],
SECPjurisdiction = aut ;
ID = 9,
SNECjurisdiction = [cze, hun, svk, svn],
GNCCjurisdiction = aut,
NoPjurisdiction = noJurisdictionByBrusselsI ;
ID = 1,
SNECjurisdiction = [cze, hun, svk, svn],
SNCBjurisdiction = [aut],
GNCCjurisdiction = aut,
GNCPjurisdiction = aut ;
ID = 3,
SNCCjurisdiction = svk,
GNCCjurisdiction = aut,
GNCPjurisdiction = svk ;
ID = 19,
SNCPjurisdiction = grc,
GNCPjurisdiction = cyp,
NoCjurisdiction = noJurisdictionByBrusselsI ;
ID = 15,
SECBjurisdiction = [aut] ;
ID = 11,
SNCBjurisdiction = [aut],
DeniedJurisdiction = [bel, bgr, cyp, cze, dnk, est, fin, fra, deu|...] ;
ID = 14,
SECBjurisdiction = [aut],
DeniedJurisdiction = [bel, bgr, cyp, cze, dnk, est, fin, fra, deu|...] ;
ID = 7,
SECBjurisdiction = [deu],
DeniedJurisdiction = [aut, bel, bgr, cyp, cze, dnk, est, fin, fra|...] ;
ID = 10,
NoJurisdiction = noJurisdictionByBrusselsI ;
ID = 12,
NoJurisdiction = noJurisdictionByBrusselsI ;
ID = 13,
NoJurisdiction = noJurisdictionByBrusselsI ;
ID = 16,
SNCCjurisdiction = aut,
SNECjurisdiction = [dnk],
SECPjurisdiction = aut ;
ID = 18,
SNCCjurisdiction = cyp,
SECPjurisdiction = cyp ;
ID = 6,
SNCCjurisdiction = aut,
SNECjurisdiction = [dnk],
SECPjurisdiction = aut ;
ID = 17,
SNCCjurisdiction = aut,
SNCCjurisdiction2 = [che],
SNECjurisdiction = [dnk],
SECPjurisdiction = aut ;
false.
```

Fig. 14. Query and Obtained Jurisdiction Output for Predicate jurisdictions/16

cases not explicitly mentioned here. Third, when comparing complexity levels of modeling a PIL and of implementing a modeled PIL in Prolog, the first bears clearly a higher complexity. The implementation, hence, is not the main driver for complexity. Nevertheless, implementation effort is not to be underestimated. Even though the inherent possibility to implement and test partial paths helps development, the implementation of a complex PIL is a time-consuming undertaking. This is mainly due to the fact that logic programming and the definition of predicates as shown ask for a strict,

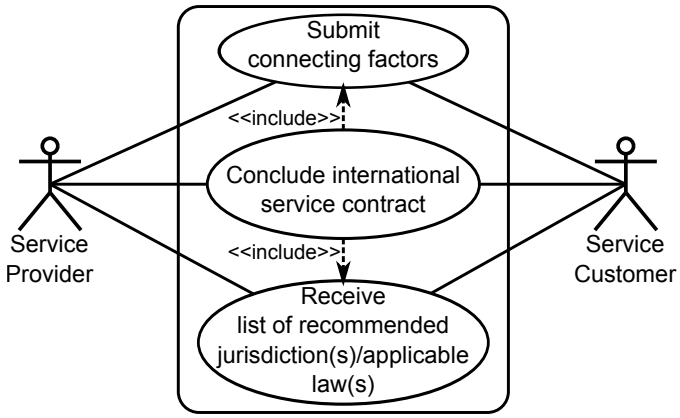


Fig. 15. High-level Scenario

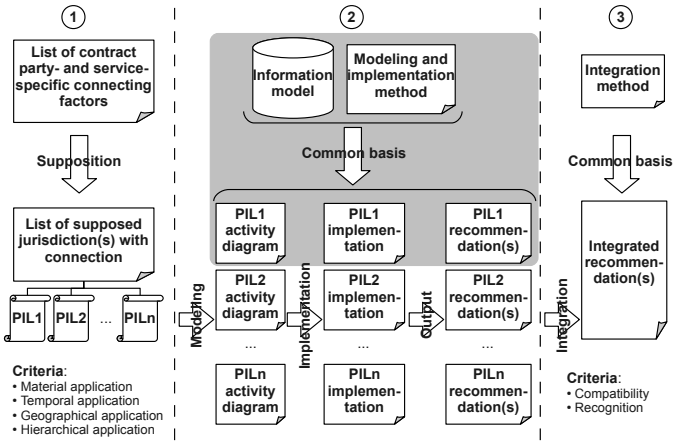


Fig. 16. Overall Three-step Procedure and Focus Area of This Paper (Grey Background)

diligent procedure. Accuracy is key to achieve compliance. For these considerations, this implementation demonstrates that, by application of the modeling method determined and the information model outlined, it is feasible in principle to bring a PIL into a machine-executable form.

VI. Discussion

The underlying scenario for this work as introduced and motivated in Section I covers a service provider and a service customer. Both parties are in the process to conclude a contract in relation to an electronic, commercial service as characterized in Section II-A. This service contract is supposed to show an international connection since contract parties are assumed to be connected to different jurisdictions and/or the respective service is assumed to be provided internationally. Figure 15 visualizes this scenario by means of two actors—service provider and service customer—taking part in the according use case for international service contract conclusion.

The scenario goes on to suppose that both parties would like to know about jurisdiction(s) and/or applicable law(s) that fit(s) the specific contractual agreement they are about to conclude. This is to inform and prepare for the case a dispute would arise from the contract concluded. In order to retrieve jurisdiction- and/or applicable law-related recommendations both sides submit the respective set of connecting factors, upon which they obtain a list of recommendations compiled according to the PIL(s) of supposed relevance. Figure 15 accordingly embraces two use cases which are both included in the overall contract conclusion use case.

Given this scenario as well as the PIL procedure explained in Section II-A, the overall target of automated jurisdiction/applicable law determination requires the set of the three steps presented in Figure 16 to be modeled and implemented. The first step consists in identifying potentially affected jurisdictions by an international service contract to be concluded. This should happen in the same way a court dealing with a PIL-oriented claim would proceed. A court would collect basic connecting factors and determine on this basis jurisdictions with potential connection. In the contract conclusion case, such procedure is to be reflected by the contract parties to submit the respective set of contract party- or service-specific connecting factors of interest. A complete implementation would take these factors in consideration and produce a list of supposedly connected jurisdictions. For each jurisdiction identified, the set of relevant PIL sources is determined. Criteria for PIL selection would be related to application of a PIL in question, namely whether a law applies to a case in question (material application), whether it is in force for the time frame in question (temporal application), whether it applies in the location or locations touched (geographical application), and whether it supersedes other PILs or is subsidiary to another PIL (hierarchical application).

In step 2, each PIL identified would need to be reflected by a formal model in terms of an activity diagram—one diagram per PIL, which would then each be implemented in order to produce jurisdiction/applicable law-related output. Modeling, implementation, and output generation all base on a common information model as well as a common modeling and implementation method. By every new PIL modeled, common parts might need to be altered in order to reflect so far non-covered aspects. Updates in the information model and the method are expected to tend less frequent with the number of already modeled PILs. Moreover, changes in the underlying information model might provoke an update in the set of basic connecting factors to be collected during step 1. Issues in this context concern the list of connecting factors to be covered. This is of utter importance since if an important connecting factor is missing in the first place, a relevant jurisdiction (and related PILs) might not be investigated at all.

A list—one list per PIL considered—of recommended jurisdiction(s) and/or applicable law(s) is produced in step 2. These lists constitute the main outcome of this step. The procedure, however, cannot end here. Contract parties should obtain additional information with respect to compatibility of the different recommendations. Due to a territorial principle in law (state sovereignty) there is no mechanism in place, *per se*, that guarantees consistency (in terms of compatibility) within jurisdiction/applicable law provisions originating from

different PILs. There are multiple scenarios to be assessed, and for each a mitigation strategy is to be developed. For instance, two lists reflecting two PILs might be overlap-free. In this case, it remains unclear which recommendation to choose over another. It is even unclear whether one may be ranked higher than another. In other scenarios, there might be partial overlaps of recommendations. Similar questions would apply here. Even a case which is probably less complex, such as the case where one list is completely embraced by another (sub-set of jurisdictions/applicable laws), is not completely deterministic. Only in cases where a single list of recommendations is produced—a case, however, which is rather unlikely as it is a very special case—or in case multiple lists are fully compatible (congruent lists) the mitigation strategy to adopt is clear.

At this point of discussion, contributions of this paper may be placed and valued in the context of the overall picture sketched in Figure 16. Focus in this paper is exclusively on the core of step 2, including several sub-steps (*cf.* area with gray background in Figure 16). In particular, a thorough investigation of how to reflect a PIL formally has led to substantial methodological contributions documented in Section III. Moreover, the methodology has been shown to be applicable to an example PIL modeled, the Brussels I regulation. The modeling method with respect to PIL identification (Section III-A was found to provide for general guidelines, while the procedure itself is, by definition, somewhat unstructured. Future work in this area includes an extension in coverage, implying a more complete coverage of PILs identified. For PIL selection (also addressed in Section III-A), concrete criteria were determined. These criteria are most direct in nature so that this modeling part's main challenge, law application, is well addressed. Similarly, the set of specific criteria for subsequent law analysis in a direct manner was defined (Section III-B). Focus in this context is put on major cases meaning that the law analysis method includes aspects assumed to reflect typical circumstances while aspects such as reservations are not considered. With respect to activity diagram modeling (Section III-C), finally, the modeling method contributes both guidelines and specific criteria. While a modeling of thematic blocks is comparably straight forward, the integration of thematic blocks is considerably less deterministic and less structured. A certain degree of interpretation must be acknowledged here. Consequently, compliance constitutes the main challenge in activity diagram modeling.

In addition to the modeling method developed and documented as well as the modeling example of Brussels I, this paper has seen a major methodological contribution with regard to implementation. Section V denoted those guidelines and the set of specific criteria determined for a successful implementation of a previously modeled activity diagram by means of logic programming in Prolog. Even though an implementation is not fully deterministic, *i.e.*, it is dependent on a certain degree of interpretation, this paper has proven by means of the concrete example of Brussels I that an implementation is feasible. Furthermore, this part's main challenge of verification was proven successful by means of a functional evaluation. Finally, both the implementation and modeling steps were in-line with the common information model developed and specified in Section IV.

In summary, thus, the results achieved within this paper are found to be substantial in the sense of Figure 16. With those results obtained, the range of covered PILs may be extended in future work, whereas generalizable aspects of modeling method, information model, and implementation technique shall result in an update of the existing methods and information model. At the current state of work, it is suited to provide a preliminary decision support tool resulting in PIL-specific, non-integrated recommendations of jurisdiction(s) and/or applicable law(s). Even though specific expressiveness is currently limited to cases involving European connection, the common basis to extended application range considerably in the future is made available.

Despite these overall positive achievements, steps 1 and 3 as of Figure 16 have to be addressed in future when aiming at a productive solution. Furthermore, all obtained jurisdiction recommendations directly reflect the expressiveness of the methodology applied. Its current focus on "standard" cases appears satisfactory for the time being, but again, it might be necessary to be extended when aiming at a productive solution. In this case, it is expected that support from jurists is required, since legal interpretation gains considerably more weight.

VII. Summary and Conclusions

The international provision of commercially offered electronic services is a common scenario in the Internet. Service customer and service provider may be domiciled in different states, or service performance may be in a foreign state. From a contractual point of view, such scenario results in the conclusion of an international service contract. Despite the fact that international service contracts are concluded often in the Internet, two contractual parameters of key importance—jurisdiction and applicable law—are typically addressed in a static, provider-imposed manner abstracting away any specifics of both contract parties involved as well as service provisioning characteristics. Such procedure may be even against the according applicable PIL so that there is a risk jurisdiction/applicable law provisions endorsed in an international service contract are nil should a dispute arise and should a claim be deposited in court. This situation is clearly non-satisfactory for either contract party. Hence, in order to increase legal certainty and with regard to increased trust in electronic business in the Internet, this paper has investigated an automated way to determine recommended jurisdictions in a legally compliant manner. To this aim, this paper has contributed results in terms of a modeling and implementation method, an information model, and it has shown feasibility for a concrete European PIL modeled, implemented, and evaluated.

In this light, Section I introduced the scenario of a service provider and a service customer wanting to conclude an international service contract. It also motivated the need for a decision support tool helping contract parties identify recommended jurisdictions and applicable laws according to PIL,

which was translated into this paper's three main challenges of (a) a method to be developed to identify, analyze, and formally model a single national or supra-national PIL, (b) the development and documentation of a suitable information model reflecting key requirements of international contract and service management, and (c) a successful implementation.

According to these challenges outlined, Section II provided for the relevant background information and related work overview in the areas of PIL and international service contracts, the existing ITSM information model, and rule-based systems. In the first, the very type of contracts and services envisaged here was defined as contracts of electronic, commercially provided services in the Internet—contracts with an international connection, under civil law and applicable to civil and commercial matters. These definitions were complemented by valuing the importance of jurisdiction and applicable law as important parameters in an international contract as well as by an introduction to procedural law in relation to international contract claims. The latter resulted in a number of requirements raised on modeling and implementation, such as that PIL provisions must be ported back to the time and knowledge of contract conclusion from the time and knowledge of a dispute in court. Similarly, sub-sections on the existing ITSM information model and on rule-based system resulted in information modeling- and implementation-oriented requirements. In particular, the ITSM information model was assessed to provide for a solid, established starting point which needed extension in internationalization, and rule-based systems were found to qualify for the implementation.

Driven by those requirements determined, Section III contributed extensively in several dimensions to develop and document an appropriate modeling method. This method was in all sub-steps—that of PIL identification and selection, PIL analysis, and activity diagram modeling—accompanied by application to the concrete example of the Brussels I regulation. In PIL identification and selection, sources for law identification were determined to include law compilations, court decisions, books, articles, commentaries and specialized web sites. In order to select a PIL identified, the respective set of selection criteria was compiled. A PIL in question may be selected if it applies to the provision of services and to civil and commercial matters, if it makes connection to more than one jurisdiction, if it applies to relations with international connection, and if geographical, time-wise, and hierarchical application is given. In PIL analysis, a list of specific in- and exclusion criteria as presented in Table I was introduced. These criteria find application when a selected law is assessed in a two-step procedure—first a high-level pre-selection on section level, then a detailed provision-by-provision selection. Tables II and III document detailed results and the accordingly conducted discussion for Brussels I. In activity diagram modeling, finally, detailed instructions with respect to formal requirements on activity diagrams were presented. These embrace UML activity diagram standard compliance in the sense that all used model elements were listed including specific requirements like the number of incoming and outgoing control flows. Furthermore, standard extensions made (node and edge identifiers, references to law articles, and dotted control flows to indicate a higher degree of interpretation) were listed and explained. Driven by these requirements and in accordance with the action node syntax specification outlined in Figure 3, Brussels I was modeled in a two-step procedure. First, thematic blocks in the law were identified as to cover consumer contracts, choice of jurisdiction, special jurisdiction, and general jurisdiction. These thematic blocks were modeled as single activity diagrams in Figures 4(a), 4(b), 4(c), and 4(d), respectively. Subsequent to this, thematic blocks were brought into a hierarchy and integrated into a single, consistent activity diagram (*cf.* Figure 5).

With the aim to inter-relate the functional modeling of Section III with the implementation of Section V, Section IV started with an established information model in SLM and extended this model so that the adapted information model covers equally aspects of service and contract management. This was achieved on the basis of the respective customer/provider relationship to be assumed in this paper. This relationship, which finds expression in the according contractual relationship to be expected, focuses on a bilateral relationship in which a single service customer and a single service provider agree on a (potentially) international service contract. Both developed models, incorporate the according set of service management- and service contract-related concepts and artifacts, respectively. For instance, artifacts cover important connecting factors in international service contracts (contracting perspective) and concepts differentiate between a service user entity (service management perspective) and a service customer entity (both perspectives).

Based on the modeling output obtained and in consideration of the information model determined, Section V sketched a system design with two pre-determined inputs—Prolog decision rules and facts to include test cases—, interactive input in terms of jurisdiction queries, and interactive jurisdiction output delivered by the Prolog decision engine (*cf.* Figure 11). In compliance with this design, the first step in implementing consisted in splitting the activity diagram for Brussels I into partial paths. Partial paths show advantages in functionality reuse, partial testing, and they serve as direct templates for an implementation of Prolog decision rules. Before these rules were implemented, the full set of 12 connecting factors for the Brussels I case was compiled and explained. Connecting factors include information about contract party domiciles, whether a service customer is a consumer, will and preferences to make a choice of jurisdiction, locations of provider establishments, a provider's target markets, and location of performance of a service in question. The implementation was concluded by considerations of jurisdiction queries and functional evaluation conducted. The first was explained exemplary by means of the implementation covering a complete path through the diagram of Brussels I. The latter was discussed by comparing results obtained from different predicate queries with the respective expected result according to a matching test

case.

Results and paper contributions were assessed from an overall perspective. The overall three-step procedure as shown in Figure 16 was developed according to procedures applicable to international contract claims. In this context, this paper's contributions were related to core contributions in a common basis for a PIL-specific, successful modeling, implementation, and output generation, whereas wider extension in PIL coverage, supposition of potentially connected jurisdictions, and integration of different jurisdiction/applicable law recommendations were identified to be fields of interest for future work.

Out of this work, a number of key conclusions with respect to multiple dimensions is drawn. This embraces the following dimensions:

- Challenges addressed and results obtained
- Feasibility shown
- Functionality assessed
- Overall expressiveness and significance valued
- Complexity faced and potential mitigation strategies to adopt

Challenges addressed and results obtained: The paper contributed with a digest of generalizable aspects out of experience gained with modeling a law as a UML activity diagram—covering the full process from law identification through law selection and analysis to actual modeling—into a multi-step, detailed modeling method. Furthermore, the information model developed and documented provides for a common base for future efforts in widening PIL coverage, as the model is found to bridge successfully the analysis and modeling method with the rule-based implementation. The implementation addressed the example of Brussels I and contributed with a digest of generalizable aspects. Consequently, when further PILs are envisaged to be modeled and implemented, the same structured approach documented here may be taken as a method for implementation.

Feasibility shown: This paper shows by means of a complete and concrete case—that of the Brussels I regulation, which is the primary PIL source in Europe—that an automated determination of jurisdiction recommendations at the time of contract conclusion is feasible. Feasibility has been proven on all levels of challenges addressed and procedures performed.

Functionality assessed: The concrete example of Brussels I and in particular the implementation thereof has shown fully functional. By help of the set of determined test cases, a functional evaluation of partial as well as complete paths through the Brussels I activity diagram was shown. By that, it can be concluded that the implementation is able to deliver meaningful jurisdiction recommendations, whereas meaningful means here that recommended jurisdictions may be of actual help for a service provider and service customer to conclude an international service contract which sees increased legal certainty.

Overall expressiveness and significance valued: When adopting a fully comprehensive perspective, it shall be noted that this paper's results need extension in future work in a more wide PIL coverage, and an effort towards steps 1 (supposition of potentially affected jurisdictions) and 3 (integration of PIL-specific recommendations into a single list of recommendations) shown in Figure 16. While the first is achieved by making use of the modeling and implementation method as well as by the information model developed and documented here, supposition and integration are considerably more challenging, since both bear a high level of complexity and uncertainty. When aiming at a comprehensive, potentially even productive solution, however, the complete set of supposition (step 1), PIL modeling, implementation, and output production (step 2), as well as integration of recommendations (step3) has to be endorsed.

Complexity faced and potential mitigation strategies: All three challenges addressed in this paper have proven to be highly complex. In general, the way complexity was addressed in developing the modeling method, the information model, and in the implementation method reflects a "divide-and-conquer" approach. In modeling, the overall procedure was split into distinct steps for which each either guidelines or criteria could be determined. For instance, law selection was split into a pre-selection and detailed in-/exclusion sub-procedure so that complexity was better handled. In the information model part, the starting point was found in an existing ITSM model which was extended step-by-step. Again, this happened in order to accomplish a complex procedure. In the implementation, finally, a multi-step procedure focusing on different in- and output variables and predicates implementing partial paths (instead of complete paths) was adopted. The latter facilitates a partial debugging—reducing complexity considerably.

These complexity issues lead to the question of how to mitigate such challenges. Three basic directions have been identified as follows:

- *Status quo*: One way to handle complexity is to not do anything *fundamental* about it, but to cope with it as good as it gets. Coping means to, *e.g.*, extend both, modeling method and PIL coverage range, possibly with the help of jurists in order to lower potential for misinterpretation. In fact, this strategy is perceived as a pragmatic albeit inefficient and probably only symptomatic approach. Given the fact that territoriality and the respective political implications that come with it are not expected to diminish any time soon, a status quo approach constitutes a realistic option.
- *Arbitration*: There are alternatives to judicial arbitration. Arbitration is a possible approach to so-called alternative dispute resolution. While alternative dispute resolution shows typically advantages in terms of flexibility and choice over judicial jurisdiction, it may as well turn out as complex as PIL, and enforcement might be a real problem in some cases. In conclusion, arbitration (and other alternative means) is difficult to assess with respect to trade-offs.
- *PIL for international service business*: The Internet is one of the few truly global infrastructures. Electronic business in the Internet is happening now, and so are international service contracts concluded every day. The existence of a

harmonized, widely accepted PIL specific to international service contracts in the Internet would mark a corner stone towards making contracts in the Internet less of a "second-class" type of contract. Harmonization in PIL is perceived as the only way to address issues with the current approach at the root and in a sustainable manner. Therefore, it must be envisaged as a long-term objective.

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APPENDIX

A Partial Path Implications

As discussed in Section V-A, Figure 17 lists the complete set of partial path implications for the Brussels I activity diagram (Figure 5).

```
c46 → c45; c39; c33; s31; p38;
      c34; c40; c47
c45 → c49, c44, c32
c32 → c24
c24 → c21, c18, c14, c56
c56 → c53; c55
c53 → c51, c54, c15
c15 → c13
c13 → c11, c10, c7
c7 → c4
c4 → c1
c55 → c15
c39 → c38, c37, c32
c33 → c24
s31 → s38, s39
s38 → s32; s35
s32 → g10, s30
s30 → s27, s28
s27 → s18; s24
s18 → s13, s9
s9 → s4
s4 → p39
p39 → p8; p14; p30
p8 → p44
p44 → c9; p5; p6
c9 → c7
p5 → c3
c3 → c1
p6 → p43
p43 → p3; c6
p3 → c3
c6 → c4
p14 → p12
p12 → p44
p30 → p26, p22, p18
p18 → p12
s24 → s21, s13, s9
s28 → s19; s25
s19 → s14
s14 → s9
s25 → s22, s16, s14
s35 → s34, s6, s4
s39 → s37; s33
s37 → s36, s7, s5
s5 → p39
s33 → g11, s29
s29 → s20; s26
s20 → s11
s11 → s5
s26 → s23, s17, s11
p38 → p31; p36; p42
p31 → p27, p23, p18
p36 → p37, p35
p35 → p32; p33
p32 → p28, p24, p19
p19 → p13
p13 → p7
p7 → p43
p33 → p29, p25, p19
p42 → p41, p40
p40 → p17; p11
p17 → p13
p11 → p7
c34 → c30
c30 → c29; c26
c29 → c28, c25, c22, c19, c16
c16 → c13
c26 → c23, c20, c16
c40 → c41, c42, c35
c35 → c30
c47 → c50, c48, c35
```

Fig. 17. Partial Paths for Brussels I Expressed as Implications

B Test Cases and Expected Paths

Table IV documents a selection of 19 test cases with the corresponding complete path through the Brussels I activity diagram (Figure 5). The functional evaluation as presented in Section V-D bases primarily on these test cases.

TABLE IV
SELECTION OF TEST CASES WITH CORRESPONDING COMPLETE PATHS

ID	Test Case (`input/13`)	Complete Path (action nodes in bold face)
1	input(1, aut, aut, professional, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c3, p5, p44, p12, p18, p22, **p26**, p30, p39, in parallel: (s4, s9, in parallel: (s13, s18, s27) and (s14, s16, **s22**, s25, s28), s30, **g10**, s32, s38) and (s5, s11, s20, s29, **g11**, s33, s39), s31, c46
2	input(2, svk, aut, consumer, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], svk).	c1, c4, c7, c10, **c11**, c13, c15, c54, **c51**, c53, c56, **c14**, c18, **c21**, c24, c32, c37, **c38**, c39, c46
3	input(3, svk, aut, consumer, noChoice, n/a, [], choice, nonExclusive, [aut, cze, hun], [aut], [aut, cze, hun, svn], svk).	c1, c4, c7, c9, p44, p8, p39, in parallel: (s4, s9, in parallel: (s13, s15, **s21**, s24, s27) and (s14, s19, s28), s30, **g10**, s32, s38) and (s5, s11, s20, s29, **g11**, s33, s39), s31, c46
4	input(4, svk, aut, consumer, choice, nonExclusive, [hun, deu, che], choice, nonExclusive, [aut, cze, hun], [aut, nor, lie, svk, svn], [aut, cze, hun, svk, svn], svk).	c1, c4, c7, c10, **c11**, c13, c15, c54, **c51**, c53, c56, **c14**, c18, **c21**, c24, c32, c44, **c49**, c45
5	input(5, svk, aut, consumer, choice, nonExclusive, [fra, deu, ita], choice, nonExclusive, [aut, ita, hun], [aut, nor, lie, che], [aut, cze, hun, svk, svn], svk).	c1, c4, c7, c10, **c11**, c15, c55, c56, **c14**, c18, **c21**, c24, c32, c44, **c49**, c45, c46
6	input(6, aut, nor, consumer, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [nor, dnk, swe], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], aut).	c1, c4, c7, c10, **c11**, c16, c19, **c22**, c25, **c28**, c29, c30, c35, c42, **c41**, c40, c46
7	input(7, isl, nor, consumer, choice, nonExclusive, [aut, deu, che], choice, exclusive, [deu, dnk, swe], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], isl).	c1, c4, c6, p43, p7, p13, p19, p25, **p29**, p33, p35, **p37**, p36, p38, c46
8	input(8, aut, aut, consumer, choice, nonExclusive, [aut, deu, che], noChoice, n/a, [], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c4, c7, c10, **c11**, c15, c54, **c51**, c53, c56, **c14**, c18, **c21**, c24, c33, c46
9	input(9, lie, aut, professional, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [svn, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], lie).	c1, c3, p3, p43, p6, p44, p12, p14, p39, in parallel: (s4, s9, in parallel: (s13, s15, **s21**, s24, s27) and (s14, s16, **s22**, s25, s28), s30, **g10**, s32, s38) and (s5, s7, **s36**, s37, s39), s31, c46
10	input(10, lie, nor, professional, noChoice, n/a, [], choice, nonExclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c3, p3, p43, p7, p11, p40, **p41**, p42, p38, c46
11	input(11, lie, nor, professional, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c3, p3, p43, p7, p13, p19, p24, **p28**, p32, p35, **p37**, p36, p38, c46
12	input(12, isl, nor, consumer, choice, nonExclusive, [nor, deu, swe], choice, nonExclusive, [nor, dnk, swe], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], isl).	c1, c4, c6, p43, p7, p13, p17, p40, **p41**, p42, p38, c46
13	input(13, isl, nor, consumer, choice, nonExclusive, [nor, deu, swe], choice, nonExclusive, [che, dnk, bgr], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], isl).	c1, c4, c6, p43, p7, p13, p17, p40, **p41**, p42, p38, c46
14	input(14, lie, nor, professional, choice, exclusive, [aut, hun, che], choice, exclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c3, p3, p43, p7, p13, p19, p25, **p29**, p33, p35, **p37**, p36, p38, c46
15	input(15, aut, aut, professional, choice, exclusive, [aut, deu, che], choice, exclusive, [aut, cze, hun], [aut, cze, hun, svk, svn], [aut, cze, hun, svk, svn], aut).	c1, c3, p5, p44, p12, p18, p23, **p27**, p31, p38, c46
16	input(16, aut, nor, consumer, noChoice, n/a, [], noChoice, n/a, [], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], aut).	c1, c4, c7, c10, **c11**, c13, c16, c19, **c22**, c25, **c28**, c29, c30, c34, c46
17	input(17, aut, nor, consumer, choice, nonExclusive, [aut, deu, che], choice, nonExclusive, [che, dnk, swe], [nor, dnk], [aut, bel, bgr, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, nor, isl, che, lie], aut).	c1, c4, c7, c10, **c11**, c16, c19, **c22**, c25, **c28**, c29, c30, c35, c48, **c50**, c47, c46
18	input(18, cyp, nor, consumer, noChoice, n/a, [], choice, nonExclusive, [nor, dnk, try], [nor, try], [cyp, dnk, gbr, grc, nor, pol, try], cyp).	c1, c4, c7, c10, c11, c13, c16, c20, **c23**, c26, c30, c34, c46
19	input(19, cyp, nor, consumer, noChoice, n/a, [], choice, nonExclusive, [nor, aut, cze, hun], [nor, aut], [nor, aut, cze, hun, svn], grc).	c1, c4, c7, c9, p44, p8, p39, in parallel: (s4, s6, **s34**, s35, s38) and (s5, s11, s17, **s23**, s26, s29, **g11**, s33, s39), s31, c46