

On The Specification Of Payment Requirements For Collaborative Services

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Abstract

Payment arrangement is one of the vital issues in a B2B setting. For example, failing to accurately specify and communicate payment details such as the method of the payment, whether payment is refundable and negotiable, and what settlement model is used, can lead to serious disputes between the provider and requester of a service. However current development and solutions in service description, e.g., WSDL, do not cater for the specification and negotiation of payment related requirements for services. In this paper we present a comprehensive modeling approach for capturing and specifying payment requirements in the context of business collaboration. It will lay a foundation for service providers and requesters to explicitly define and adjust their business and technical requirements for payment in an adaptive and verifiable way. Furthermore, it provides support for terms of payment to be negotiated effectively to reach service provisioning agreements.

1 Introduction

In today's business climate organizations are increasingly utilizing existing business services cross organizational boundaries. Such business collaboration is about cooperation between services offered by organizations, where a service provider delivers a service to a service requester. One of the key issues that must be addressed in the environment of service provisioning and consumption is payment, as most services in a business-to-business setting require some form of payment or compensation. For example, it should be made clear to both sides whether payment is refundable for a service, what type of payment settlement model is adopted, whether cancellation is acceptable (and if so whether it involves a cancellation fee), and what type of compensation is desired (like financial or natural means). Therefore it is necessary for providers and requesters to specify their service payment related preferences in an ex-

PLICIT and unambiguous manner so that they can be reasoned about during negotiation.

Current work in the area of payment specification, like [4] and [10], does not address all the issues of payment in the context of collaborative services due to their technological focus. Typically, the technology underlying service provisioning is usually secondary to the business requirements applicable to these services. Without a proper method to capture the relation between business requirements and the technical implementation in which service providers and requesters expect the payment for services to occur, it is very difficult for them to assess to what degree their respective payment terms are consistent. Moreover, in case changes are required and an agreement needs to be reached, it is hard for requesters and providers to assess the impact of changes to business requirements on technical requirements (and vice versa). Without knowing the impact of changes, it becomes a tedious affair to (re-)negotiate the terms to reach a service provisioning agreement.

In order to remedy this situation, in this paper we present a comprehensive approach for specifying payment requirements for collaborative services by integrating them into basic service descriptions. We first explore service description in general in section 2. Next, in section 3 we identify payment related characteristics that are needed to complement service descriptions. Then, in section 4 we define a mechanism for consistency verification of the different payment requirements of service providers and requesters. Resulting we show how service providers and requesters are supported in specifying and adjusting their business and technical requirements for payment during the development of service description and service agreement negotiation by using this mechanism. Finally, we discuss related work and give conclusions in section 5.

2 Service Description

In general, in order for the negotiation of service agreements to be successful organizations must have a clear idea

of their respective requirements for service provisioning. This requires that organizations have the means to capture these requirements in an explicit and unambiguous manner. Typically this is done through the process of service description, where service providers define the exhibited behavior of their provisioned service and service requesters specify the desired behavior of this requested service. Current work on service description like WSDL [1] focuses mainly on the technical dimension of services, and important elements that related to the high level business objectives are missing. Therefore, we adopt a multi-layered view on service description in this paper, which let service providers and requesters to express different concerns during service description development and negotiation.

Particularly, we adopt three different but interrelated levels for service description following the work in [7]: the *strategic*, *operational* and *technical* level. To illustrate the purpose of having these different, levels let us take look at an example from the AGFIL case study [3]. In this case study, the insurance company AGFIL makes (among others) use of a claim management service provided by management firm Lee C.S. This service entails the handling of car damage claims that have been reported to AGFIL. In a nutshell AGFIL provides Lee C.S with all the information concerning a claim. Lee C.S manages the claim from that point on and reports back to AGFIL with the final invoice details as reported by the garage responsible for the car repair. In the following we shall illustrate how the description of this service is developed. For a complete discussion we refer the reader to [8].

Firstly, Lee C.S's and AGFIL's service descriptions capture their respective purpose and high level requirements for claim management service at strategic level. On the basis of these two descriptions they can reason about and negotiate an abstract service agreement. Strategic service descriptions are expressed in terms of organizations, services, resources, steps and schedules. For example, AGFIL's description will contain an organization to describe Lee C.S. It also includes the claim management service that provides high level functions captured in steps such as manage claim. AGFIL will also define that it wishes to use this functionality by providing the informational resource claim information when issuing a claim handling request. Lastly, for this step AGFIL will define a schedule stating that it expects Lee C.S to carry out manage claim in one week.

Secondly, at operational level the service descriptions of both organizations portray their requirements for communicating information. These descriptions are useful during negotiation as it allows them to talk about how information is to be exchanged (without being abstract in nature or having to include technological details). Operational service

descriptions are defined in terms of units, services, documents, tasks and events, and concretizes its strategic counterpart. For example, Lee C.S's description of claim management service will convey that it is provided by the claim handling unit within Lee C.S. It will also provide details on how tasks like receive claim file and receive customer file are carried out to realize step manage claim. Moreover, it will inform that in order to access these functions AGFIL is required to provide Lee C.S with documents claim file and customer file respectively. Finally, it will give details about milestones in its schedule for manage claim, e.g. the event claim file received.

Thirdly, at technical level Lee C.S's and AGFIL's descriptions of claim management service have the purpose of letting the other party know how they wish to exchange electronic messages to implement the communication of information. During negotiation they can then discuss the technological realization of their communication without mixing these with higher level business requirements. A technical service description is defined in terms of endpoints, services, messages, operations and triggers. For example, Lee C.S will offer claim storage service as one of the technical services to implement the communication from and to its claim management service. This service will have endpoint claim storage endpoint depicting its network location. The description will also state that operation store claim info implements task receive claim file. It will also convey that AGFIL must sent message claim storage request to deliver document claim file. Finally, it will define trigger claim storage request received as a technological indicator that event claim file received has transpired.

3 Payment Characteristics Of Services

In the previous section we explained how services can be described at different, yet interrelated levels. Can we specify payment requirements in the same fashion? In general, at strategic level specification of payment requirements is concerned with the *criteria* of the payment required by the high level functionality of a service. Including such criteria makes it possible for organizations to discuss and negotiate payment objectives at high level without concerning themselves with how to realize these objectives. If agreement can be reached, then based on the payment criteria usage of particular *mechanisms* can be negotiated. Defining these mechanisms allows service providers and requesters to determine during negotiation whether they have a shared common view on when payment should occur and what payment mechanisms should be adopted, etc, without having to

consider specific technological solutions.

When consensus has been achieved on the mechanisms to be used, then lastly negotiation of specific payment *measures* can take place. In order facilitate this goal, at technical level organizations can specify concrete payment measures that realize their supported payment mechanisms. They can then use this information during negotiation to assess whether their expectations regarding the employed technological solutions are compatible. Moreover, they can do so without considering higher level business and strategic requirements. In this way the multi-level service description approach helps organizations to structure the specification and negotiation of their payment requirements for service provisioning and consumption in a consistent and coherent manner. In the remainder of this section we shall explore in detail which criteria, mechanisms and measures are of relevance to service description.

3.1 Payment At Strategic Level

As observed, at the strategic level service providers and requesters define abstract criteria for the high level functionalities offered by services. We identify eleven payment criteria based on an analysis of current literature on the characteristics of payment protocols (such as [4] and [10]). The first criteria is the *value* of the strategic service being provided, that is, what is actually to be paid. We feel that this needs to be vague in nature indicating merely for each individual step whether payment is low, normal or high; where this is of course relative to the particular service being offered (e.g. in relation to pricing benchmarks for particular industries). Lee C.S may want to promote its `claim management service` as a high quality product, therefore indicating that its price is 'high'.

Related to the value of the performance of a step is whether this value is *negotiable* or not. Standard services will likely have default prices, but in customized situations the price might not be fixed. AGFIL may feel that the price of the `claim management service` should be negotiable, e.g. depending on the volume of claims that Lee C.S is to manage. The things with which payment is to occur is defined in the *means* characteristic. We identify three generic types of means that can be used for payment, being financial (like money), informational and natural (like land, products) means. A side issue of importance with the selection of a particular payment means is whether it should be easily exchangeable or not. Obviously financial means can be exchanged for other means rather straightforwardly using well established mechanisms. In contrast, natural means like land are not so easily transferred into for example money. Here Lee C.S and AGFIL will prefer some form of financial payment.

The *settlement* criteria deals with the manner in which

payment is to occur. Is payment done for example on a rental, subscription, metered, facilitated, escrow or swap basis? As Lee C.S will want to work with AGFIL on a long term basis, it seems reasonable to expect that it will adopt a settlement scheme, e.g., a 'metered' scheme in which the amount to be paid is determined based on the number and type of claims managed (naturally Lee C.S may depict that it supports multiple schemes). Another aspect of payment is what occurs when the service requester attempts to undo the transaction. Whether payment is *annulable* at all is the first criteria in this regard. If payment is annulable, then even after a requester has paid for a business service he/she can still undo the transaction. For the `claim management service` AGFIL may want Lee C.S to allow withdrawal of individual claim management requests depending on the circumstances.

Closely related to annullability is whether payment is *refundable*. That is, upon undoing the transaction can the service requester get some sort of refund? In case that AGFIL withdraws a claim management request (for valid reasons), it may expect a (partial) refund from Lee C.S as a courtesy. Also related to the previous two criteria is the question of whether payment can be *refutable*. That is, is it possible for a service provider to deny payment has occurred when in fact this is not the case? Alternatively, can the service requester deny that the to-be-delivered functionality has not been performed yet to avoid payment? Lee C.S will likely want to ensure that delivery of the `claim management service` is not refutable. Vice versa, AGFIL will want to be sure that Lee C.S can not refute fulfilled payments.

An additional interesting question for a payment transaction relates to how quickly the paid amount is to be received. *Immediacy* is one dimension of this issue, expressing how long it takes before payment is received after the requested functionality has been performed. For example, a bank transfer will take several days to complete, whereas cash payment has no such delay. Possible values here are immediate and delayed. As most likely Lee C.S will charge for its services on a monthly (or longer) basis, a delayed payment should not be a problem. An issue related to immediacy is whether a payment is *re-spendable* after receipt. After payment has been done, does the service provider have to take intermediate steps before it can be used in other transactions? Is this possible at all? Lee C.S will prefer that its payments for `claim management service` are re-spendable, e.g. to use for personnel costs, building rent, electricity, etc.

Continuing with this example, is the payment specific to the service provider or can it be used by others as well? That is, is the payment *transferable* to other parties? Named bonds for example are not transferable, but cash obviously is. Given the arguments just listed for re-spendability Lee

C.S will prefer its payment to be transferable. It seems improbable that AGFIL should object to this. A last criteria concerns the *traceability* of the payment. Is it necessary for example that the identity of both service provider and requester are known? Or the exact amount paid, at what time? This is captured in the traceable requirement. Since the business collaboration between Lee C.S and AGFIL will be long term in nature with regular payments, it will probably be preferred by both parties that the different payment details are traceable.

3.2 Payment At Operational Level

Based on the criteria analysis at the strategic level, service providers and requesters will specify payment mechanisms for all the tasks requiring payment at the operational level. As discussed before, at this level a service description constitutes defining the exchange of appropriate information in order to deliver a business service. For example, in order to make the value of a step at strategic level concrete, we can define the *amount* to be paid for one or more of its task. Interestingly, there need not be consensus on which task requires payment. For example, Lee C.S may want to charge the management costs when the claim information is received (that is, payment is due for *receive claim*); while in contrast, AGFIL might prefer to delay payment until *report invoice* has been carried out.

Additionally, the way in which the amount is specified, is captured in the *price style*. If the amount of a payment is negotiable for a task, then the price style must be 'ranged'. Otherwise, it can be 'absolute' or 'proportional'. Lastly, since usually tax must be paid whenever business services are paid for, the tax style must be depicted. The style can be equal to 'inclusive' or 'exclusive'. This information is naturally important for service requesters to determine the real cost of a business function. Given that AGFIL wants the 'price' to be negotiable, its price style for *report invoice* will be 'ranged'. It may also include tax in order to have a clear idea of the cost of *manage claim*.

The type of means selected at strategic level falls into two dimensions at operational level: *tangibility* and *channel*. Tangibility reflects whether the payment instrument that will be used at service level must be tangible (i.e. can be touched) or intangible. Natural means will always require a tangible instrument; whereas informational ones use intangible instrument. Financial means can be both tangible or intangible. Related to the previous is the question of what type of payment channel is used, choices can be either online or offline. Tangible payments can only be made offline naturally, intangible ones can be made via online channel. Since financial compensation is desired, Lee C.S and AGFIL have the option of both tangible and intangible payment. As the amount involved will be high, an intangible

payment via an online channel seems prudent.

The settlement category chosen for a payment is concretized in the form of *mediation*, *model* and *charging style*; where these are associated with individual tasks (involving payment). Mediation may be direct, i.e. no mediation, or indirect in which a third party is involved in establishment of the payment. Possible payment models include account based and token based payment, whereas charging can be done on a per request, per unit, or a percentage basis. Lee C.S will likely offer an 'account based' payment which is charged for every claim management request made with no mediation. AGFIL's views on this can be expected to be similar. If payment for a step is annulable, then its related tasks (requiring payment) at operational level must depict what *cancellation style* is supported. Annulment may be done for free, or be accompanied by a penalty. Lee C.S may allow cancellation of *claim management requests*, but impose a 'penalty' whenever this is done. Needless to say AGFIL will not necessarily share this view.

When a step's payment is refundable, for each task to which it is mapped and for which payment is required the *refund style* must be depicted. Possible styles that currently have been identified are 'return with money', 'return for voucher' and 'trade'. AGFIL might prefer 'return with money', where the to-be-refunded amount is deducted from its account. In contrast, if Lee C.S supports refunds at all it may only allow this via 'trade' for another *claim management request*. The refutability of a step, when set to 'false', requires that for each task involving payment the *type of repudiation* (that is to be prevented) must be depicted. Lee C.S will indicate that payment and delivery must be non-refutable *receive claim*.

In case payment for a step is not immediate, i.e. there is a delay, then it must be indicated for each task to-be-paid how 'short' or 'long' the *delay* will be. Naturally if a service provider immediately wishes control over the payment, then at operational level there must be no delay. It is unlikely that Lee C.S will mind a delay if it is not for too long. If the means with which a payment is made are re-spendable. then at operational level the *expiration style* and *usable* property must be specified. Possible values for the expiration style are 'indefinite' and 'limited'. Usage may be 'immediate' or 'postponed'. However it is possible that if the means will expiry and they can not be immediately used, Lee C.S could receive a payment but by the time it can spend the money, it may no longer be valid. This is something that Lee C.S would wish to prevent of course.

Continuing, many times payment of a step is transferable from the service provider to others. If this is the case, at operational level the ways in which this can be done must be specified for each payment-related task. This is depicted in the *transfer style*; where transfer can be 'direct' or 'in-

direct'. Lee C.S will want its payments to be transferable, preferable in an indirect manner (like paying personnel costs via a bank). Lastly, when a payment should not be traceable, the properties of anonymity and privacy are used at operational level. Anonymity pertains to the issue of whether the service provider and requester involved are to be anonymous or not. Privacy is concerned with keeping the details of the payment a secret in terms of the amount of the payment, time of payment, and so on. Traceability is desirable for both Lee C.S and AGFIL, therefore anonymity and privacy should not be preserved.

3.3 Payment At Technical Level

In order to concretize the payment mechanisms defined at the operational level, service providers and requesters add concrete payment details to their technical service descriptions. First of all, the amount to be paid and the price style are reflected in the *absolute*, *proportional*, *minimum* and *maximum price*. For example, since the pricing style preferred by AGFIL is 'ranged', a minimum and maximum price for the implementing operation `notify invoice` must be specified. When it comes to the price of an operation realizing a task, the sum of the operations' prices involving payment must be equal to the total cost of this task. This means, for example, for Lee C.S that its price for `store claim info` must match the amount of task `receive claim`. If tax was exclusive, the *tax rate* or *taxes amount* must be defined for each chargeable operation. The prices including taxes of all chargeable operations summed must equal the total amount of the task. For `notify invoice` a tax rate/taxes amount does not have to be specified by AGFIL given that its tax style for `report invoice` was 'inclusive'.

Tangibility, type of channel, payment model and privacy determine the *payment instrument* used in every chargeable operation. Supporting instruments are 'cash', 'cheque', 'directFundTransfer', 'creditcard', 'travellersCheque', 'wireTransfer', 'moneyOrder', 'bankBill', 'voucher', 'stored-ValueCard', 'digitalCash' and 'anonymousCash' depending on whether the instrument is tangible or intangible, exchanged online or off line, and account or token based. In case a credit card is used, the *surcharge* must be specified. If a money order or bank bill is accepted, then bank details like *account number* and *bank name* of the service provider must be provided. If the payment model used for a task is 'account based', then for each chargeable operation the requester must provide its account number, name, etc. Based on this information, we can say a suitable instrument for `store claim info` is a direct fund transfer (also given Lee C.S's privacy requirements). Note: Lee C.S may support multiple instruments based on its requirements (like 'wireTransfer').

If there is a third party mediating in the payment transaction, then at service level we must specify what *broker* is to be used for each operation. This is not the case for Lee C.S and AGFIL as they do not use mediation for their payable task. For the same reason Lee C.S does not need to specify the *unit* and *granularity* of the payment, because it charges its service per request (i.e. per invocation of `store claim info`). In contrast, if the charging style is 'per unit', then we must define unit and granularity for each chargeable operation. Possible values for unit include 'time', 'weight', 'volume', 'area', 'length', 'watt', 'byte', 'person', 'event', and 'permit'. Depending on the chosen unit granularity could then be one of the values 'hour', 'minute', 'second', 'day', 'month', 'year', 'gram', 'kilogram', 'tonne', 'cubicMetre', 'squareMetres', 'millimetre', 'centimetre', 'metre', 'kilometre', 'kilowatt', 'megawatt', 'kilobyte', 'megabyte', 'gigabyte', 'adult', 'child', 'infant', 'pensioner', 'senior', 'mouseClick' or 'ticket'.

With regard to cancelation, if this can be done for free, then no additional information is required. If cancelation comes with a penalty, then for any chargeable operation a *cancelation fee* must be defined. Lee C.S may indicate that for `store claim info` cancelation can be done at a certain cost. Similar as for cancelation, if a refund is offered in the form of money back, then the *refund amount* must be specified. This can be absolute or proportional to the paid price. AGFIL might wish a refund that is 100% of the made payment; whereas Lee C.S wants to withhold 10% for incurred administrative costs. When the payment is not refundable, then each operation involving payment must indicate whether *delivery repudiation* and/or *payment repudiation* must be prevented. In the case of Lee C.S and AGFIL both types of repudiation will be specified. Delay at operational level of a task must also be concretized for each chargeable operation by depicting the exact *delay period*. Lee C.S may accept a delay of payment of at most 14 days for `store claim info`.

Next, if the payment means can expire, the *expiry period* of each payment instrument must be specified. For the `claim management service` this is not needed, since for `receive claim` payment is set not to expire. The transfer style of a task translates itself in the *transfer period* of each chargeable operation. If transfer is 'direct', then this period will be zero. Given that Lee C.S prefers that the transfer style of `receive claim` is 'indirect', it will depict a transfer period for `store claim info`. Lastly, the anonymity required for a task is refined for its chargeable operations in *anonymous buyer* and *anonymous seller*. For `store claim info` this will not be the case, since `receive claim` requires no anonymity. On the other hand, the privacy guarantees defined for a task must be refined to indicate whether payment details should be kept private. These are captured in boolean indicators *private*

price, private time, and private place. AGFIL will specify all these indicators as 'false' for its chargeable operation notify invoice.

4 Consistency Verification for Payment Requirements

In the previous section we presented an extensive classification of payment criteria, mechanisms and measures. The challenge for organizations when specifying and negotiating these different payment requirements is to ensure that the requirements are and remain consistent. To address this challenge we develop a *payment consistency verification mechanism* that offers two types of verification: firstly, *horizontal verification* allows organizations to assess the consistency of their payment requirements at a particular level with those of another party. This is useful during service agreement negotiation to find discrepancies between their respective payment criteria. Secondly, *vertical verification* makes it possible for organizations to detect inconsistencies between payment requirements in their service descriptions at different levels. This allows them to define their payment criteria, mechanisms and measures in a consistent manner; and moreover analyze the impact of changes from one level of abstraction to another during service provisioning negotiation.

The mechanism is based on the idea of using generically applicable *consistency rules* to detect inconsistencies. These consistency rules can be horizontal in nature, e.g. to detect that Lee C.S adopts only 'digital cash' as a payment instrument, whereas AGFIL only supports 'bank transfers'. They can also be vertical in nature for example to help Lee C.S realize that if it changes its payment instrument to 'cash', its higher level requirement for using an intangible means of payment is violated. In the following we will first discuss how such payment related consistency rules can be specified and applied. Then in subsection 4.2 we exemplify the benefits of applying formal consistency checking in both service description development and service agreement negotiation.

4.1 Defining And Applying Payment Consistency Rules

In order to specify consistency rules we adopt the Business Collaboration Rule Language (BCRL) developed in [8]. In BCRL rules are specified on top of the four so-called *modeling description atoms* forming the constructs with which models and relationships between models are defined: *element*, *property*, *link*, and *attribution*. An element represents a building block of a service description, e.g. `element(manage claim, step, lee-stp)` expresses the step manage

claim in the strategic service description. A *property* defines the property of an element. For example, `property(negotiable, false, manage claim, lee-stp)` reflects that payment for manage claim is not negotiable. A *link* expresses a connection with another element. `link(manage claim, offered by, claim management service, offers, lee-stp)` conveys that service claim management service offers the functionality manage claim. Finally, an *attribution* defines a connection between elements from different models, e.g. `attribution(manage claim, divided into, receive claim, divides)` indicates that step manage claim is (in part) sub divided in the task receive claim. Rules in the BCRL are defined on top of these modeling description atoms. Several examples of payment consistency rules in BCRL customized for the AGFIL case study are provided in Fig. 1.

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Horizontal payment consistency rules

CR1
if property(negotiable, V1, S, M1) AND property(negotiable, V2, S, M2)
then equalsIgnoreCase(V1, V2)

CR2
if property(instrument, V1, O, M1) AND property(instrument, V2, O, M2)
then subList(V2, V1)

Vertical payment consistency rules

CR3
if property(negotiable, true, S, M) AND attribution(S, divided into, T, divides)
AND property(pricing style, V, T, M)
then equalsIgnoreCase(V, ranged)

CR4
if property(payment instrument, digital cash, T, M) AND attribution(T1, realized by, O, realizes)
AND property(tangibility, V, T, M)
then equalsIgnoreCase(V, intangible)

```

Figure 1. Example Payment Consistency Rules

Now, let us have look at horizontal payment consistency rule CR₂ stating that the payment instrument requirements of Lee C.S and AGFIL for an operation 'O' (e.g. `store claim info`) is consistent if the instruments supported by AGFIL are a subset of those offered by Lee C.S (since both organizations can potentially support multiple payment instruments). This rule is useful during negotiation to find discrepancies between different parties support for particular payment instruments. An example of a vertical payment consistency rule is CR₃ stipulating that if the payment amount for a step 'S' (like `manage claim`) is negotiable, it is mapped to a task T like `receive claim`) and this task has a pricing style, then the style value must

be 'ranged'. This rule is important during service description development to ensure that the payment mechanism for payment criteria 'negotiable' is properly defined. It is also of use when it is necessary during negotiation to alter the price style, as it allows to detect that the support for the higher level criteria is diminished.

It is important to realize that the rules in Fig. 1 reflect generically applicable payment consistency patterns, as exhibited by the usage of variables (denoted by capital letters) in the rules. For example, CR_1 can be applied to any pair of high level steps in the service descriptions of Lee C.S and AGFIL (or any other arbitrary organizations negotiating service provisioning agreements). Similarly, any organization can employ the rules with the pattern in CR_4 to verify the consistency between payment requirements for their tasks and the operations realising these tasks. We have identified an extensive set of such patterns, enabling organizations to fast-track the development and application of payment consistency rules to verify the consistency of their payment requirements both during service description development and service provisioning negotiation.

In order to support both service providers and requesters to perform such verification in a formal way we adopt the notion of *satisfaction* in [8] based on Datalog semantics [11]. In Datalog rules are expressed as so-called definite clauses in the form "head \leftarrow body"; where the body consists of one or more conjunctive literals and the head of a single, non-negated literal. An atomic sentence is a relation of arity 'n' applied to 'n' terms, for example `element(manage claim, step, lee-stp)`. A literal is an atomic sentence or the negation of an atomic sentence, such as `\neg property(myProp, negotiable, false, manage claim, lee-stp)`. Therefore a collection of service description models and the mappings between them then becomes set of ground atomic sentences M. Subsequently, satisfaction of a payment consistency rule R in relation to M can be formally specified as:

1. $M \models t_1 = t_2$ if and only if t_1 and t_2 are the same term, syntactically.
2. $M \models p(t_1, \dots, t_n)$ if and only if $p(t_1, \dots, t_n) \in M$.
3. $M \models \neg\theta$ if and only if it is not the case that $M \models \theta$, where ' θ ' is an atomic sentence in the body B of rule R.
4. $M \models \theta_0 \wedge \dots \wedge \theta_n$ if and only if $M \models \theta_i$ for every i, where ' θ_0 ' to ' θ_n ' are atomic sentences.
5. $M \models h \leftarrow b_1 \wedge \dots \wedge b_n$ if and only if either it is not the case that $M \models b_1 \wedge \dots \wedge b_n$ or $M \models h$ or both, where ' b_1 ' to ' b_n ' are literals and ' h ' is a non-negated literal.
6. $M \models \forall X.\theta(X)$ if and only if $M \models \theta(t)$ for every ground term 't'.

In the next subsection we will see how the above definition of satisfaction can be used to verify consistency of payment requirements. Note that due to space limit we do not provide detailed definitions here about the formal specification and the semantics of payment consistency rules.

4.2 Example Use Cases

In the previous subsection we explained how consistency rules can be defined and applied to detect inconsistencies in the payment requirements of organizations. To illustrate this, let us assume that Lee C.S is developing its payment related requirements for claim management service taking the payment capabilities of its technical services as a starting point. The consistency rules are of use in this regard in order to ensure that Lee C.S defines proper requirements at the operational and strategic level. For example, suppose we have operation `store claim info` with payment instrument 'digital cash' captured as `property(payment instrument, digital cash, receive claim, lee-opp)`. Also suppose this operation is mapped to task `receive claim`, constituting the fact `attribution(receive claim, realized by, store claim info, realizes)`. Then it follows from CR_4 that Lee C.S can only depict that the task `receive claim` has an 'intangible' payment. Otherwise, the conditions of consistency rule CR_4 would be satisfied, but its conclusion would not be (and thus there would be an inconsistency).

In another example, suppose that AGFIL is drafting its payment related requirements in preparation for its negotiation with Lee C.S. Since AGFIL is not bound by any existing constraints, it starts by first defining that payment for the main functionality `manage claim` must be negotiable. Next, it specifies the price style of the task `report invoice` (which operationalizes `manage claim`) as 'absolute'. Subsequently, the consistency rules can be automatically enforced to ensure that a proper style is chosen. Concretely, what happens is that we have `property(negotiable, true, manage claim, agfil-stp)`, `property(pricing style, absolute, report invoice, agfil-opp)` and `attribution(manage claim, divided in, report invoice, divides)` as facts. These facts instantiate the conditions in CR_3 implying that `equalsIgnoreCase(absolute, ranged)` is also true. However, this is clearly not the case and as such the consistency rule is violated.

Finally, let us envision for a moment that Lee C.S and AGFIL come together in order to work out a service provisioning agreement. Besides the obvious difference that Lee

C.S could prefer upfront payment and AGFIL payment upon completion, other points of disagreement can also exist. For example, suppose that Lee C.S prefers 'digital cash' as its sole payment instrument for operation store claim info, while AGFIL only wants to pay via a 'bank transfer'. Thus we have the facts `property(payment instrument,digital cash,store claim info,lee-sep)` and `property(payment instrument,bank transfer,store claim info,agfil-sep)`. These facts satisfy the conditions of CR₂ but not its conclusion, and thus an inconsistency is detected.

Now, a possible response could be that Lee C.S explores the consequences of adopting AGFIL's payment instrument. To this end it first determines that its current requirements are consistent. It does so by applying the consistency rules to its facts `property(payment instrument,digital cash,store claim info,lee-sep)` and `property(payment instrument,digital cash,receive claim,lee-opp)`, which does not result in any inconsistencies. Lee C.S then makes the change by replacing the first fact with `property(payment instrument,bank transfer,store claim info,lee-sep)`. It then performs forward reasoning using a consistency rule CR₅ that informally states that "if the payment instrument is equal to 'bank transfer', tangibility is equal to 'intangible'". Application of this rule tells Lee C.S that its requirements are still consistent. We leave it to the reader to work out that if AGFIL wishes to pay in cash, and we have a rule of the form 'if payment instrument is cash, then tangibility is tangible', the change would lead to an inconsistency.

5 Related Work And Conclusions

In this paper we addressed the issue in service payment requirements modeling and specification in order to better facilitate payment negotiation motivated by the lack of support thereof in the current research. [10] introduces several price and payment models, but its focus is limited to the specification of low level characteristics such as payment instrument. Other relevant proposals focus on establishing comparisons criteria for digital payment mechanism selection (like [6], [5] and [4]), and/or development of a generic payment service by defining payment models [9]. Unfortunately, these works do not consider payment in context of service description. In contrast, the presented work in provides a comprehensive approach for payment specification in service description that enables service providers and requesters to define and subsequently reason about their payment requirements during service provisioning agreement negotiation. Future work entails foremost the expansion and

validation of the identified payment characteristics and the relations between them. Furthermore, we plan to investigate a way to express dependencies among payment properties at the same level, e.g. the tax amount should never exceed a certain percentage of the price. Finally, it will be interesting to apply the presented ideas also in service based private business processes and publicly agreed business agreements.

References

- [1] R. Chinnici, J. Moreau, A. Ryman, S. Weerawarana. Web Service Description Language 2.0. <http://www.w3.org/TR/wsdl20/>, June 2007.
- [2] M. Fischer, H. Gall, M. Hauswirth. Towards a Generalized Payment Model for Internet Services. *Technical Report TUV-1841-2002-53*, Distributed Systems Group, Technical University of Vienna, Austria, 2002.
- [3] P. Grefen, K. Aberer, Y. Hoffner, H. Ludwig. Cross-Flow: Cross-Organizational Workflow Management in Dynamic Virtual Enterprises. *International Journal of Computer Systems Science & Engineering*, 15(5):277-290, 2000.
- [4] J. Mackie-Mason, K. White. Evaluating and Selecting Digital Payment Mechanisms. *G. Rosston and D. Waterman, editors, Interconnection and the Internet*, 113-134, Lawrence Erlbaum, 1997.
- [5] G. Medvinsky, B. Neuman. NetCash: A design for practical electronic currency on the Internet. *Proceedings of the First ACM Conference on Computer and Communications Security*, Fairfax, Virginia, USA, November 1993.
- [6] B. Neuman, G. Medvinsky. Requirements for Network Payment: The NetCheque Perspective. *Proceedings of the IEEE Computer Society International Conference*, San Francisco, USA, March 1995.
- [7] B. Orriens, J. Yang. Bridging the Gap between Business and IT in Service Oriented Business Collaboration. *Proceedings of the IEEE International Conference on Services Computing*, Orlando, Florida, USA, July 2005.
- [8] B. Orriens. On the Adaptive Development and Management of Business Collaborations. *CentER Dissertation Series*, No. 194, Tilburg, The Netherlands, September 12, 2007.
- [9] J. Peiro, N. Asokan, M. Steiner, M. Waidner. Designing a generic payment service. *IBM Systems Journal*, 37(1):72-88, 1998.
- [10] J. O'Sullivan, D. Edmond, A. ter Hofstede. What's in a Service? Towards Accurate Description of Non-Functional Service Properties. *Distributed and Parallel Databases*, 12(2-3):117-133, 2002.
- [11] J. Ullman, J. Widom. A First Course in Database Systems. *Addison-Wesley*, 1997.