

# Formalizing Dynamics of Service Engagements: A Commitments-Based Approach

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## Abstract

*A service engagement brings together two or more parties in a contractual arrangement. This paper considers a commitments-based approach for modeling and enacting service engagements. We model a service engagement as arising within a dynamic service organization or Org. The members of an Org create commitments toward each other. The proposed approach places Orgs within institutions, themselves modeled as specialized Orgs that provide a social or legal environment for service engagements. Commitments form the basis of the interactions among the participants of an Org. This paper provides an agent-based conceptual model for Orgs and addresses the dynamic aspects of the enactment of service engagements.*

## 1 Introduction

A service engagement brings together two or more parties in a contractual arrangement. Let us consider an example scenario involving service engagements occurring in an online marketplace such as eBay. eBay regulates how members can join eBay. eBay supports creation of an indefinite number of auctions, each bringing buyers and sellers together. Consider an auction for an item created by a seller. Several bidders participate in the auction and when the auction ends, the highest bidder is chosen as the buyer. The buyer and the seller now enter into a service engagement, where the seller promises to ship the won auction item to the buyer once he receives the payment from the buyer. Although simple, the above is a useful example of a service engagement because it involves the parties committing to each other. Unlike a one-shot transaction that ends immediately, an engagement may last a long time, e.g., until the buyer receives the item and has no complaints about it. The service engagement is usually fulfilled outside eBay,

as it normally involves other parties that are not necessarily members of eBay. The buyer would send the payment to the seller via a credit card or a payment service provider such as PayPal (which only incidentally happens to be associated with eBay). The seller would use one of the shipping service providers such as DHL. The service engagement thus extends beyond the direct control of eBay. The key processes of a service engagement run across multiple organizations involving different administrative domains. Current approaches do not account for multiple autonomous parties and thus cannot model even such simple engagements adequately.

We model a service engagement as arising within an Org, which is our formalization of a dynamic service organization. An Org is a computational virtual organization that comes into existence when a group of autonomous parties or agents come together in a contractual arrangement. In the above example, the service engagement resulting from the won auction can be modeled using an Org. Sellers and buyers are the agents involved in this Org. An Org itself can be modeled as an agent, and it encloses other agents (individuals or Orgs). An Org created for a service engagement lasts only until the service engagement is fulfilled. A service engagement is characterized by a set of related *commitments* created by the participating agents toward each other.

To naturally model and enact real-life engagements, it is helpful to introduce the notion of an *institution*. An institution is an Org that has an identity of its own. Its life time may exceed that of its members. Universities and markets such as eBay are examples of institutions. Several service Orgs arise within institutions. An institution provides a (social or legal) environment for the dynamic service Orgs that come into existence within its scope. An institution provides the entry and exit policies and may specify certain restrictions on the service engagements occurring within it. For example, in eBay, each auction must have exactly one (registered) seller and as many (registered) bidders as hap-

pen to participate in the auction. The highest bidder is selected as the buyer. The Orgs representing won auctions exist temporarily within the eBay institution, and are subject to eBay’s requirements.

Modeling service engagements using Orgs identifies the various stakeholders, their relationships, and the various interactions among them. Business service contracts from business organizations to consumers are the other examples of service engagements where Orgs are applicable. For example, when a business organization that is accredited with BBB (Better Business Bureau) [1] creates a contract with a consumer, we can model this engagement using a service Org that arises within BBB. Here, BBB acts an institution within which several Orgs may arise.

Service engagements often result in violations, delays, or cancellations. The parties involved should be able to seek recourse under such circumstances. For example, eBay provides a feedback and rating mechanism, where buyers or sellers can post any grievances about the auction they participated in. eBay may step in to determine if any member has to be penalized, based on the feedback received. BBB offers *dispute resolution services* to mediate in a dispute between a business organization and the consumer [1]. Current mechanisms mostly rely on human intervention and do not have a proper model of the dynamics of a service engagement. The proposed approach models the enactment of service engagements occurring within Orgs.

Our recent work studies the enactment of commitments-based service engagements formed within (virtual) organizations and proposes an agent-based conceptual model to model such engagements [10]. This paper extends the above model with *institutions*. An institution helps us model real-life service engagements more naturally, and acts as a context to the several Orgs arising within it. The proposed model also includes templates within an institution for specifying different classes of service engagements.

**Contributions.** This paper’s contribution is a conceptual model for the dynamics of commitment-based service organizations. It (1) formalizes Orgs and institutions, (2) provides the dynamics of enactment using life cycle analyses of commitments and Orgs, and (3) establishes useful properties on the enactment of commitments and the Org life cycle.

## 2 Conceptual Model

Our conceptual model is based on agents, where each agent represents a stakeholder in a service engagement. When two or more agents form commitments toward each other in a service engagement, an Org is dynamically created as a context for the corresponding commitments. Such an Org lasts only until the service engagement ceases to exist. A real-life organization can be involved in any service

engagement, and at the same time can host several other service engagements to solve more specific problems for their members. Hence an Org, either a virtual computational organization or representing a real-life organization, is recursively formulated as an agent that has member agents, who are either individual agents, or Orgs.

An institution is a real-life Org providing a social or legal environment for any service engagements created among its members, and thus forming the context for the resulting Orgs. Figure 1 illustrates our extended conceptual

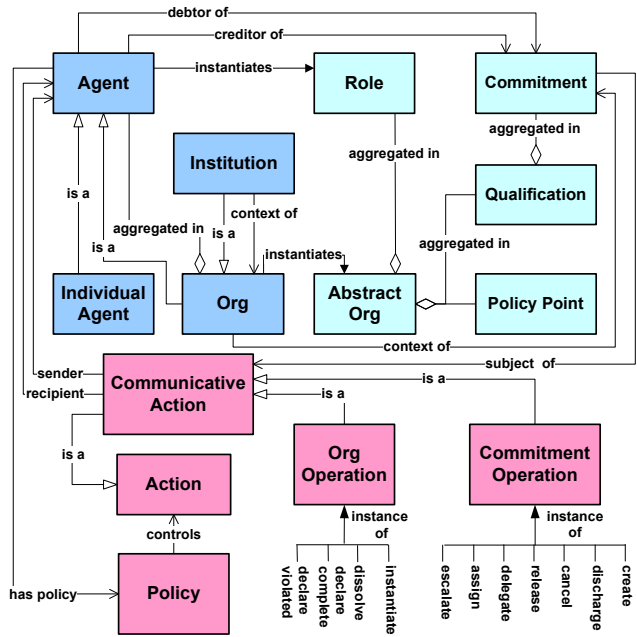


Figure 1. The conceptual model

model. It captures the operations that characterize the interactions among the agents, and thus forms the basis for a rich, domain-independent vocabulary for specifying Orgs, including the creation of new Orgs and the enactment of the associated commitments. The main concepts are formalized below:

**Commitments.** A service engagement created among two or more agents results in a set of commitments. Commitments are the key abstraction for expressing organizational interactions among agents [9]. A commitment is a directed obligation from a *debtor* agent to a *creditor* agent, but arising within the scope of a context Org. Commitments are first-class entities, and can be manipulated through several operations [9]. A commitment can be *created*, *discharged* (by bringing about the stated condition), or *canceled* by its debtor. Sometimes, the context Org or the creditor of a commitment may *release* it relieving the debtor. The debtor may *delegate* a commitment, and the creditor may *assign* a commitment to another agent. The creditor or the debtor may

*escalate* a commitment to the context *Org*, indicating any violations or cancellations. The context of a commitment provides the means to handle exceptions and opportunities by providing an organizational basis for revoking or otherwise manipulating commitments.

**Definition 1** A *commitment* is defined as  $C(D, Cr, \phi, O)$ , where *D* is the *debtor*, *Cr* the *creditor*,  $\phi$  the *discharge condition*, and *O* the *context*.

**Definition 2** An *Org*  $A_O$  is an agent that encloses a set of zero or more member agents ( $M = \{A_1 \dots A_n\}$ ).

It forms the context for a set of commitments, each of which has a creditor and a debtor drawn from *M*.

**Definition 3** An *individual agent*  $A_I$  specifies a set of policies *P* and a set of commitments *S*, each of which includes  $A_I$  as either the debtor or the creditor.

The policies of an agent control its actions. An *Org* agent may specify certain policies that are inherited by its member agents. Policies play a key role in the enactment of service engagements and become important in administering *Orgs*. For example, an eBay seller agent may apply a shipping policy to decide how to enact its shipping commitment to the buyer. For example, a shipping policy might determine whether to delegate the shipping commitment to FedEx or UPS. An auction *Org* in eBay might include policies (inherited from eBay’s policies) that restrict kinds of items that can be sold on eBay. We recently proposed a policy-based governance architecture for *Orgs*, which emphasizes the importance of policies in *Orgs* [11]. Due to the lack of space, the present paper treats policies quite narrowly.

**Definition 4** An *institution* (*I*) is a kind of an *Org*. An institution may enclose zero or more member agents (*M*), one or more *abstract Orgs* (*AOrgs*), and forms the context for zero or more (instantiated) *Orgs*. It includes a set of *institutional policies* (*P*).

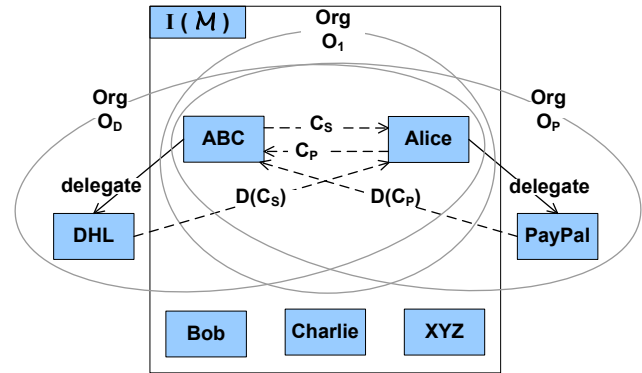
The policies of an institution address the administration of an institution but not the (domain-level) operations of its members. The policies determine agents joining and exiting the institution, the life cycles of the *Orgs* in the institution, their functioning, penalties, rewards, and so on. For example, eBay’s membership policies are entry and exit policies. An *abstract Org* is defined below.

**Definition 5** An *abstract Org* (*AOrg*) is a template of an *Org* and is represented by the tuple  $AOrg: \langle R, Q, Pp \rangle$ . It encapsulates a set of member roles *R*, a set of *qualifications* (*Q*), which specify constraints on the roles and include the relevant commitments, and a set of *policy points* (*P*), indicating where and what kinds of policies relevant to the specific commitment scenario being modeled apply.

*AOrgs* are designed for an institution to support classes of service engagements with associated commitments formed among the members of an institution. *AOrgs* are stored as templates in repositories and may be instantiated as needed. For example, eBay acting as an institution may define how a won auction may be settled using an *AOrg* that specifies: the roles in such a transaction, constraints on such roles in terms of the applicable commitments, and a set of *policy points*, indicating the kinds of policies that apply for specific roles. The actual policies are authored by the agents adopting the roles when an instantiated *Org* is created. This way an institution provides certain institutional policies and abstract *Org* templates for creating service contracts, but the agents have the autonomy to specify the actual policies of the contract.

Agents in an institution choose an *AOrg* and instantiate the roles specified, which results in the creation of an *Org*. Within an institution, an *AOrg* may be instantiated by different sets of agents to form separate *Orgs*. For example, an *Org* for the service engagement resulting from a won auction is created in eBay when a suitable auction *AOrg* is instantiated. Here, the seller and buyer roles are instantiated by the agents by participating in the auction. In the eBay institution, several auction *Orgs* may exist simultaneously.

**Exogenous Orgs.** Agents outside the institution may be involved in the enactment of the associated commitments. For example, a won auction arising within the eBay institution is fulfilled outside eBay when an auction item is shipped to a buyer after the seller receives the payment. Such *Orgs* with some members within and some members outside an institution are called *exogenous Orgs* of that institution.



**Figure 2. An example auction Org in eBay**

Let us apply the above ideas to model a simplified online Marketplace  $\mathcal{M}$  as an institution. Table 1 shows how  $\mathcal{M}$  includes an abstract *Org* for the settlement of a won auction. Here, the example policies are stated in English, but can be easily implemented using a rule-based policy language such as Jess.

Institution Name: $\mathcal{M}$ ( $I$ )
Policies: Example policies of $\mathcal{M}$ include: <i>P1</i> : (Entry policy:) Members need to be at least 18 years of age and have a valid email address <i>P2</i> : (Exit policy:) A <i>seller</i> not paying the listing fee may be suspended from eBay
Abstract Orgs: An example AOrg $\Theta$ specified in $\mathcal{M}$ for the settlement of a won auction is described below: Roles: <i>Seller, Buyer</i> Qualifications: Example qualifications are listed below: <i>Q1</i> : $C_S: C(\text{Seller}, \text{Buyer}, \phi_S, \Theta)$ exists, where $\phi_S$ means the <i>buyer</i> receives the item <i>Q2</i> : $C_P: C(\text{Buyer}, \text{Seller}, \phi_P, \Theta)$ exists, where $\phi_P$ means the <i>seller</i> receives the payment Policy Points: Examples include: <i>Pp1</i> : <i>Seller</i> may specify a <i>shipping delegation</i> policy to delegate $C_S$ to a shipper <i>Pp2</i> : <i>Buyer</i> may specify a policy for delegating $C_P$ to a payment service provider
Member Agents (M): ABC, XYZ, Alice, Bob, Charlie.
Instantiated Orgs: The instantiated Org $O_1$ in the institution $\mathcal{M}$ is created with the role instantiations: <i>Seller</i> : ABC and <i>Buyer</i> : Alice

**Table 1.** An example institution specification

Figure 2 illustrates an enactment scenario based on this example. Solid arrows indicate the delegations of the service commitments. Dashed arrows indicate the commitments with the arrow pointing from the debtor to the creditor. An oval indicates an Org. Agents Alice, Bob, Charlie, ABC, and XYZ meet the entry policies and join  $\mathcal{M}$ . Say, Alice wins an auction created by the *seller* ABC and instantiates the role of a *buyer*. Alice and ABC create commitments toward each other by instantiating the roles of the AOrg  $\Theta$  and create an instantiated Org  $O_1$ . Here, Alice commits ( $C_P$ ) to make the bid payment to ABC and ABC commits ( $C_S$ ) to ship the auction item to Alice, both within a time specified in the contract. Alice makes the payment via PayPal by delegating  $C_P$  to PayPal, which creates a commitment  $D(C_P)$  to ABC within the context of an exogenous Org  $O_P$ . ABC ships the book using DHL by delegating  $C_S$  to DHL, which creates a commitment  $D(C_S)$  to Alice within another exogenous context Org  $O_D$ .

Service Orgs are formed within this institution among the members when auctions created by the *sellers* are won by the *buyers*. In simple terms, this means that agents must first find their way into an institution. Once there they have established the credentials needed to create service engagements with their peers, the institution provides the necessary policies and the contexts for the enactment of the commit-

ments formed among the agents.

### 3 Dynamics of Orgs

The enactment of a service engagement is carried out by manipulating the associated commitments. We present the dynamics of the enactment of service engagements by describing the life cycles of commitments and their context Orgs arising within an institution.

#### 3.1 Enactment of Commitments

We describe how the commitments are enacted by describing their life cycle. We extend and simplify the life cycle for commitments proposed by Verdicchio and Colombetti [14] and provide four states for commitments: *active* ( $A$ ), *done* ( $D$ ), *violated* ( $V$ ), and *pending* ( $P$ ). However, our life cycle model includes transitions such as *delegate*, *assign*, and *escalate* across commitments which enables us to address organizational considerations more naturally. The following describe the commitment operations.

**Create.** A newly created commitment is *active*.

**Discharge.** An *active* commitment changes to *done* when its condition is brought about.

**Release.** A commitment is *done* when it is released by the creditor or the context Org.

**Cancel.** A commitment is *violated* when it is canceled.

**Assign and Delegate.** A commitment being delegated by the debtor (assigned by the creditor) results in a new commitment in the *active* state with a new debtor (creditor) and the same creditor (debtor). The original commitment becomes *pending*.

**Escalate.** A delegated or assigned commitment that is *violated* results in an escalate. An escalate moves the original commitment from *pending* back to *active*.

Figure 3 shows the commitments operations and the corresponding state transitions. Here, when a commitment  $C_i$  in *active* state is delegated or assigned,  $C_{i+1}$  is the new commitment created, and similarly the delegate or assign of  $C_{i-1}$  results in the creation of  $C_i$ .  $D$ ,  $Cr$ , and  $O$  are the debtor, creditor, and context of  $C_i$  respectively. The nodes indicate the states of commitments. Labels of the edges indicate the commitment operations. For example, the label  $D$ : cancel indicates that the debtor  $D$  canceled the commitment  $C_i$  resulting in it becoming *violated*.

**Chain of commitments** A *chain of commitments* is created due to a series of delegate and assign operations on a commitment, resulting in the formation of new commitments, each with a new debtor or a new creditor. The discharge condition of the commitment remains the same. However, the new commitment can be formed within the context of a

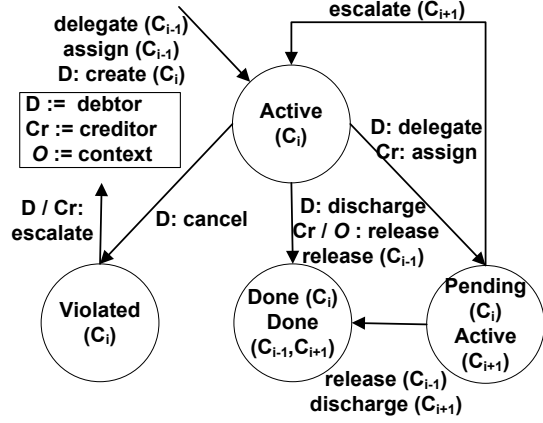


Figure 3. The life cycle of commitments

new dynamic Org that is created within the context Org of the original commitment. This simplifies computation with the new Org scoping the new commitment. This chain completes when the last commitment becomes *done* or *violated*.

**Definition 6** A *chain of commitments* is a nonempty, finite sequence of commitments  $H_n = \langle C_1, \dots, C_i, \dots, C_n \rangle$ , where  $C_1$  is the original commitment and  $C_{i+1}$  is formed by a delegate or assign operation on  $C_i$ .

A new commitment is appended to the chain every time the final active commitment is assigned or delegated. The new final commitment in the chain is the current *active* commitment, while the preceding commitments are *pending*.

**Definition 7** A chain of commitments  $H_n$  is *active*, when some  $C_i \in H_n$  is *active*; *complete*, when some  $C_i \in H_n$  is *done*; and *violated*, when  $C_1 \in H_n$  is *violated*.

For the completion of the enactment of a service contract that includes the commitment  $C_1$  from  $H_n$ , it is essential for the chain  $H_n$  to be finite and complete.

Figure 4 illustrates the enactment of a commitment in the example scenario of Figure 2.  $C_S$ , from ABC to Alice, is formed within the context Org  $O_1$ . ABC delegates  $C_S$  to DHL, which results in the creation of a commitment  $C_2$  with DHL as the new debtor, and  $O_2$  as the new context Org, but with the same creditor Alice. The new Org  $O_2$  is formed within  $O_1$  to enable the correct treatment of escalations and releases. Similarly  $O_3$  is the new Org created within  $O_1$ , when DHL delegate  $C_2$  to DHL-USA resulting in a commitment  $C_3$ . Here, please note that all the context Orgs  $O_i$  are generated at runtime. Here the resulting chain of commitments is  $H_3 = \langle C_1, C_2, C_3 \rangle$ .

The following describe the state transitions of a commitment that occur due to the operations occurring in a chain

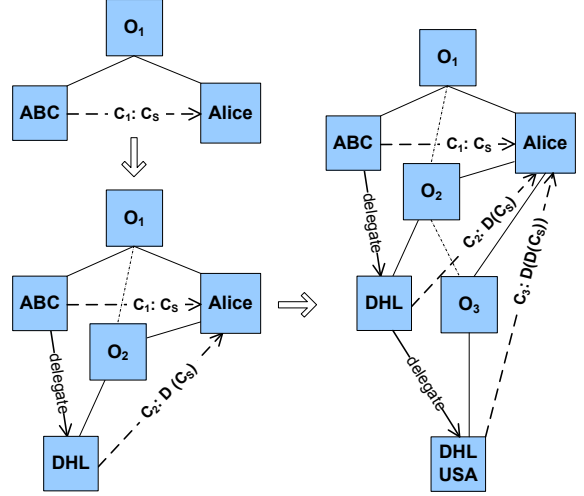


Figure 4. Creating a chain of commitments  $\langle C_1, C_2, C_3 \rangle$

of commitments.

**Release ( $C_{i-1}$ ).** When a commitment ( $C_{i-1}$ ) is released, any delegated or assigned commitment ( $C_i$ ) next in the chain of commitments is also released. Hence  $C_i$  in *active* or *pending* state changes to *done*.

**Discharge ( $C_{i+1}$ ).** When a delegated or an assigned commitment ( $C_{i+1}$ ) discharges, the commitment above it in the chain of commitments ( $C_i$ ) is also discharged. Hence  $C_i$  in *pending* state changes to *done*.

The following postulates formally present the state transitions described in Figure 3.

$$\text{P 1 } \overline{\text{create}(C_1)} C_1:\text{active}$$

$$\text{P 2 } C_i:\text{active} \overline{\text{delegate}/\text{assign}(C_i)} C_i:\text{pending} \text{ and } C_{i+1}:\text{active}$$

$$\text{P 3 } C_i:\text{pending} \overline{\text{escalate}(C_{i+1})} C_i:\text{active}$$

$$\text{P 4 } C_i:\text{active} \overline{\text{cancel}(C_i)} C_i:\text{violated}$$

$$\text{P 5 } C_i:\text{active} \overline{\text{discharge}/\text{release}(C_i)} C_i:\text{done}$$

$$\text{P 6 } C_i:\text{pending} \overline{\text{release}(C_i)} C_i:\text{done}$$

$$\text{P 7 } C_{i+1}:\text{pending}/\text{active} \overline{C_i : \text{done}} C_{i+1}:\text{done}$$

$$\text{P 8 } C_{i-1}:\text{pending} \overline{C_i : \text{done}} C_{i-1}:\text{done}$$

### 3.2 Life Cycle of Orgs

We consider an institution as a kind of an Org that has a longer lifetime than its member Orgs. An institution continues to exist even if it has no instantiated Orgs. The institution itself may dissolve due to factors such as change or inapplicability of its policies, especially if its entry policies are no longer viable within the institution to which this institution belongs. An Org may dissolve when all of its commitments are *done* or *violated*. An institution may dissolve an Org within it if it violates any of the institution's policies.

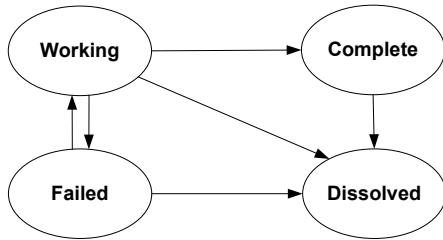


Figure 5. The life cycle of an Org

We consider four states of an Org, starting from where an abstract Org is instantiated, resulting in an Org in a *working* state, until the *working* Org is *dissolved*. Assuming an institution already exists, we elaborate on the state transitions in an Org that is created for enacting its contract. Figure 5 illustrates the state transitions in an Org.

- An abstract Org is instantiated within an institution to form a *working* Org, which forms the context of the commitments specified in the contract.
- A *working* Org *completes* when the associated service engagement completes, i.e., when all of its commitments are *done*.
- A *working* Org becomes *failed* when an Org is unable to resolve any escalate received because of a violated commitment.
- A *failed* Org may be revived back to being *working* by a higher level Org or the institution in which it occurs. This is made possible either by compensatory actions such as forming new commitments, or by replacing those members responsible for the violation with new members.
- A *complete* Org can be *dissolved*, with all of its commitments *done* and hence removed. A *failed* Org may be *dissolved*, when it cannot be revived back to being *working*. A *working* Org may sometimes be directly

*dissolved* by the institution, if it decides based on its policies.

### 3.3 Completeness of Chain of Commitments and Orgs

We present results on state transitions in a chain of commitments. We describe some important properties of Orgs regarding the completeness and soundness of Orgs.

**Early release of commitments.** Sometimes, a commitment may be dropped due to various reasons (legal, business, or economic). For example, a commitment may be deemed illegal by a higher level Org or a policy violation may happen. Under such situations, the creditors of the commitment or the higher-level Org may release the debtors of the commitment. The following theorem generalizes the effect of release on the lower commitments in the chain.

**Theorem 1** If  $C_i \in H_n$  is released, then  $H_n$  *completes* with all commitments subsequent to  $C_i$  that are not priorly *violated* being *done*.

**Proof sketch.** From Definition 6 and postulates P 5, P 6, and P 7.

For example, in the scenario illustrated by Figure 4, if the commitment  $C_1$  is deemed invalid by Org  $O_1$  due to an institutional policy of  $\mathcal{M}$  that restricts the auction of the item being sold by ABC,  $O_1$  may release the commitment  $C_1$ . Now the subsequent commitments ( $C_2$  and  $C_3$ ) in the chain are released and hence become *done*.

**Successful discharge of delegated commitments.** The motivation for the following theorem is that, when an agent discharges a delegated or an assigned commitment, it solves the requirements of the higher-level Org that had transferred the responsibility to the agent. Hence the corresponding top-level commitment is also discharged.

**Theorem 2** If a commitment  $C_i \in H_n$  is *done*, then all  $C_j \in \{C_1, \dots, C_{i-1}\}$  are *done*.

**Proof sketch.** It follows from postulate P 8.

For example, in the example of Figure 4, if the DHL-USA discharges the delegated commitment  $C_3$  by shipping the auction item to Alice, the commitments  $C_2$  and  $C_1$  are also discharged and hence become *done*.

**Propagation of Escalations.** The following theorem combines the above situations, considering the cases of violations in the delegated or assigned commitments among the lower-level Orgs. An escalation propagates up bringing back the upper commitment to *active*. An escalate is forwarded up until an agent can potentially discharge the commitment. If no agent can discharge the commitment, the first commitment in the chain is *violated*.

**Theorem 3** If a commitment  $C_i \in H_n$  ( $i < n$ ) is *done*, then each  $C_j \in \{C_{i+1}, \dots, C_n\}$  is *done* or *violated*.

**Proof sketch.** This follows from the state transitions defined by our life cycle model. If  $C_{i+1}$  is *violated*, then  $C_i$  would have become *active* and then become *done* (P 3). We use the fact that only an *active* commitment can ever become *violated* (P 4). Hence,  $C_{i+1}$  being *violated* implies each  $C_k \in \{C_{i+2}, \dots, C_n\}$  is *violated*. If  $C_{i+1}$  is previously *done*, then  $C_i$  is also *done* (P 8).

In Figure 4, if  $C_1$  is *done*, that implies  $C_2$  and  $C_3$  are either *done* or *violated*. If both  $C_2$  and  $C_3$  are *violated*, then ABC would have directly discharged  $C_1$ . But if either of  $C_2$  or  $C_3$  is *done*, then that would have made  $C_1$  *done* as well.

**Properties of Orgs.** The life cycle of an Org depends on the enactment of commitments formed within the Org. An Org *completes* only when the commitments created within it are *done*. An Org is in a *failed* state when any of the commitments created within it is *violated*. Ensuring that the chains of commitments are finite is necessary for the *completion* of Orgs. One way to ensure the above is to not allow for any delegates and assigns to happen to (1) a higher Org (one of the delegaters or assigners), or (2) an escalating debtor or creditor, respectively. The correct treatment of state transitions and the existence of necessary policies to take care of any violations ensures the soundness of Orgs arising within institutions. A *sound* Org ensures that each action undertaken by a member agent does not violate any of the institutional policies.

**Pr 1** In a *complete* Org, all the chains of commitments are *complete*.

**Pr 2** A *failed* Org has at least one chain of commitments  $H_n$ , where  $C_1 \in H_n$  is *violated*.

**Pr 3** In a *sound* Org, every state transition occurring in every chain of commitments is compliant with the policies of the institution, within which it is instantiated.

**Pr 4** A *sound* Org that includes chains of commitments with at least one delegation or assignment of the original commitments should necessarily specify *escalation handling policies* that handle escalates received from delegated or assigned commitments.

## 4 Discussion

This paper develops a commitments-based “institutional” model for service organizations. The *raison d’être* for an Org is the service engagement created among its members. A service engagement arises from a service contract among an Org’s members. The proposed approach simplifies the specification and handling of service engagements by providing a conceptual model for the static and

dynamic aspects that capture intuitions about real-life service engagements.

The above model treats Orgs as consisting of agents, which themselves might be other Orgs. The nesting structure of Orgs provides the necessary scoping of service engagements among the members and enables the proper handling of escalations. The key advantages of the institutional approach are as follows. It naturally supports complex organizational structures via an application of commitments. Orgs arising within an institution might be linked to parties outside the institution but remain subject to their commitments within the institution. An institution provides the necessary policies that ensure proper enactment of service engagements and correct handling of escalations caught within.

We have implemented a prototype system that realizes our distributed agent-based model for service organizations and incorporates a policy engine based on Jess. This prototype demonstrates the enactment of commitments within service organizations.

**Future work.** This paper opens up several directions for future research. The proposed approach emphasizes hierarchical Orgs. But an agent can simultaneously be involved in multiple service contracts, and hence participate in multiple Orgs. Such a case suggests overlapping Orgs. The dynamics of enactment of commitments depend on the overlap and structure of the Orgs. The service engagements created in such overlapping Orgs may potentially conflict. We defer analyzing the dynamics of enactment of service engagements in overlapping Orgs including handling specific cases of conflicts in Orgs to future work.

### 4.1 Related Work

We study some relevant work and provide a comparative evaluation of the present approach.

**Electronic contracts.** A contract binds different parties in an agreement specifying certain terms and conditions of a service engagement among the contracting parties. Electronic contract systems automate manual paper-based contract processes. Karlapalem *et al.* present ER<sup>EC</sup>, an entity-relationship (ER) model extended to model electronic contracts, which includes the core constructs of *contracts*, *clauses*, *activities*, *parties*, and *exceptions* [5]. By contrast, our approach develops an agent-based model for enacting service engagements based on contracts. Karlapalem *et al.*’s notion of a clause is comparable to a commitment in our approach, and activities to agent actions. Any exceptions and conditions of a contract can be specified as policies and enforced by the participating agents.

Chieu *et al.* present an electronic contract management system that supports initiating and terminating contract workflow, tracking different contract life cycle stages,

and organizing and controlling access to the various contract documents [4]. By contrast, our approach includes a nested Org model which scopes the service engagements appropriately. The institutional model provides a social and legal environment within which service engagements can be monitored and escalations allow for handling any exceptions.

**Contracts in organizations.** Boella *et al.* [2] discuss contracts in the context of multiagent organizations. They formalize contracts as having constitutive rules that demonstrate how the creation of a contract relates to the mental attitudes (beliefs, desires, and goals) of an organization. In our approach, the commitments created among agents can be considered as a contract, and the enactment of the contracts involves various operations on commitments. Commitments are similar to Boella *et al.*'s notion of obligations. However, our approach considers various operations on commitments and provides the dynamics of commitments, thus yielding a more precise model of the enactment of service Orgs.

**Organizations and institutions.** Pacheco and Carmo provide a role-based model to specify an organized collective agency [7], where a group of agents acting together give rise to a new agent, termed the institutionalized agent. This institutionalized agent is characterized by a set of roles, and its behavior is determined by the agent actions. The proposed approach is similar to the way an abstract Org is instantiated within an institution, but offers a study of the dynamics of Orgs. Cardoso and Oliveira describe institutions that facilitate both the creation and the enforcement of contracts among agents [3]. Contracts are formalized using norms, which are used by an institution while monitoring the contracts, thus making the institution a dynamic normative environment. In contrast, our approach considers an institution to host several Orgs that form the contexts of the commitments created among agents.

The existing literature on institutions treats them as *normative systems* that can be modeled using agent-based organizational structures. An agent's behavior is constrained by the norms set by the organization. Noriega uses a fishmarket metaphor to describe an *agent-mediated electronic institution* as a computational entity that imposes restrictions on the agents' behaviors [6]. A Fish Market is an auction house that is modeled as an agent-mediated institution in [8]. Vázquez & López y López describe agent-based hierarchical organizations modeled using a normative multiagent framework [12]. Vázquez-Salceda *et al.* propose an organizational model for normative institutions [13]. Their framework models organizational structure, agent interactions, and the normative structure separately from the agents. Our approach places organizations within an institution, acting as a normative system, and modeled as special organization. Institutions can specify policies stating the norms for

its members.

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