may be composite software entities is left out of this figure as being less relevant to the user, but is of course relevant to the software developer.

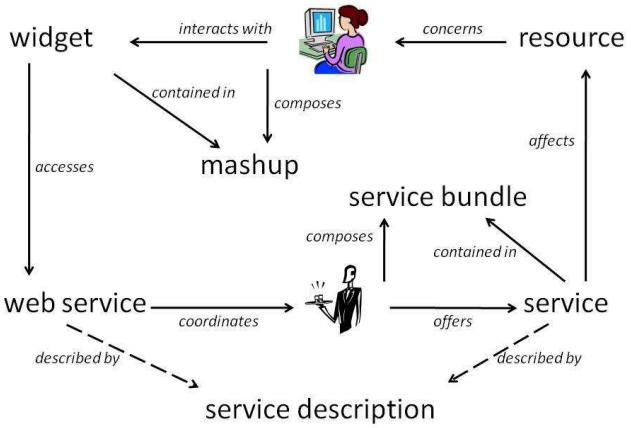

Fig. 1 User-centric service coordination cycle

Both web services and services need a description, but what should be in this description? In composing web services, a major challenge is to reconcile incompatible data representations. The *availability* of the data is not a problem, as data can be copied without virtually any limit. In composing services in the real world, a major challenge is to meet the constraints imposed by the fact that resources are scarce, can only be in one place at a time and often cannot be shared. For that reason, [16] argues convincingly that "asset-driven" service modeling will be a central concern in developing an Internet of Services and claims that "novel methodologies and tools are needed to support the modeling of the key assets of services". In our view, this modeling should be guided by at least two objectives: conflict prevention and conflict detection.

In order to make conflict prevention and conflict detection possible at all, we need a generic language to describe services, the resources they use, as well as planned and actual events on the type level, Web services can use this language to represent the preconditions and effects of the real services they connect to as well as their own semantics. A mashup environment can collect and combine this information, integrate it with other sources such as the user's agenda (that should be represented in the same format) in order to provide the user with the conflict prevention and conflict detection functionality described above.

In this paper, we propose to ground the service description language in the REA ontology [11] where we concentrate on coordination services. A coordination service is a service that supports an exchange of a good or a service [WJ09]. The use of REA has two advantages: first of all, we believe it can be a basis for user-based service composition as it is "as simple as possible, but not simpler than that". There is evidence that REA is easy to understand both for the users and for consultants and application developers [10]. Secondly, resources ("assets") are its core concept. In

actions, but of a coordination process made up by communicative actions, and information systems are well-suited to support the latter. What remains a bit out of the OASIS picture is that these social facts refer to physical world events, such as the delivery of a product. For a full account of service effects, this relationship between social facts and the real world must be made explicit (Fig. 2).

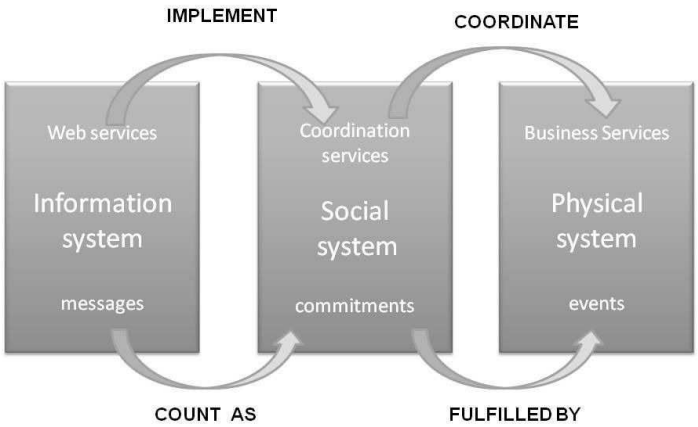

Fig. 2 Coordination services are the glue between web services and business services

In two kinds of situations, the "social effect semantics" are not relevant, or less so. First, in so-called pervasive environments, the system may contain devices that have a direct physical effect such as switching on the light [18]. This interaction is a case of instrumental rather than communicative action. Secondly, certain business transactions are fully automated, such as electronic payment, or digital music provisioning. They do involve a coordination process including a contract between service provider and customer, but the normal execution does not involve human or other non-digital resources anymore. In this case, the social effect semantics are still relevant for explaining what happens on the business level, but the social facts do not play a coordinating role operationally.

It is widely recognized that input and output descriptions of web services, or its operations, are not sufficient for capturing the semantics that users need. Precondition and Effect descriptions have been added. Although WSDL-S provides a mechanism to include these attributes, it does not give guidance on how to do specify their contents. The OASIS reference model views web services as coordination mechanisms and emphasizes the social effects. How these are to be represented, and how these social facts relate to real-world business events is still to be worked out. In the following, we address this research gap by proposing the REA ontology for coordination service description.

3.2 Commitments in REA

Commitments were added to the REA ontology in [7] as "important economic phenomena", and modeled as the pair-wise connection of requited commitments. The pair-wise connection is similar to the *duality* relationship between actual exchanges or conversions but as it is not between events, REA calls it a *reciprocal* relationship. In the following, we refine and extend the commitment concept of REA by adding explicit commitment events and by rethinking the "reserve" relationship. Starting point is that we consider a commitment as a special type of resource, so that it can be handled in the same way, that is, by manipulated and used in exchange and conversion events using stockflow relationships. One consequence of this approach is that the "resource" becomes equivalent to the FASB notion of "asset" and it is not necessary to make the exception anymore that McCarthy made in [11:562].

As discussed in section 2, a commitment is a promise regarding the future. Commitments are formalized as clauses in contracts and those commitments are subsequently fulfilled through economic events. A distinction can be made between increment commitments (assets in the agent's perspective) and decrement commitments (liabilities in the agent's perspective) [10].

Depending on the commitment type (decrement vs. increment) the relationship of the provider to the commitment is characterized as a give or take stockflow (Fig.4). When the customer promises to pay, this means that the provider receives an i-commitment. A customer can, in a *decommit* event, take a d-commitment that is received by a provider in the same event. This represents an absolving of a commitment. Similarly, the provider can give back a previously received i-commitment.

A structure involving increment commitments can be constructed as well (not illustrated here) for the customer's part of the contract, but still from the provider's point of view. In a commit event a provider becomes the receiver of an i-commitment (increment) through a take stockflow. The customer owes the provider. The provider can, in a decommit event, give the customer an i-commitment back, thereby cancelling the debt. Note that the customer cannot cancel this debt himself, but he can request for it. The exchange reciprocity between commitments reflects an exchange duality between commitment events.

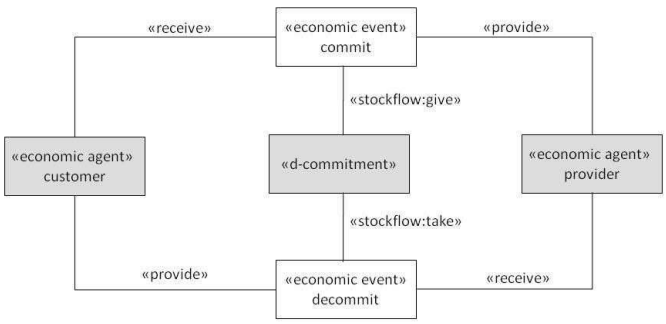

Fig. 4 REA commitment pattern for decrement commitment

intensional logics, we propose to draw on the notion of resource group [8]. Let the object of the commitment be a resource group of a certain resource type. Cardinality of the set/quantity of the resource is the most important attribute of resource group, and additional constraints can be specified. The relationship between resource group and resource type is a *policy* relationship [8]. It specifies the type of resources that may go into the resource group. In the case that a particular resource is to be reserved, the *grouping* relationship is already made at commitment time. In all other cases, it is specified later when the purchase contract is being executed. Fig. 5 presents the revised "reserve" relationship.

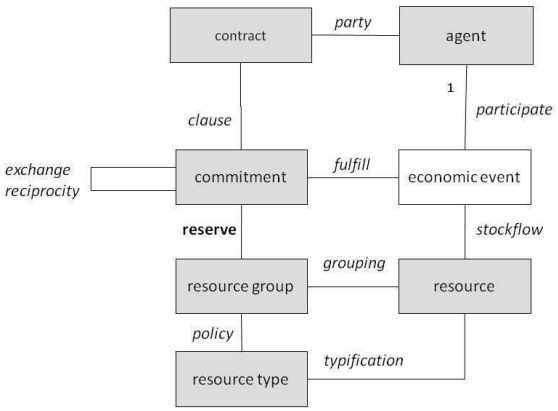

Fig. 5 REA relationship "reserve" revisited

For example, a reservation of two hotel rooms is formalized as a commitment being a clause in a contract. The object of the commitment is a group. The policy for this group says that it must contain "double non-smoking rooms", and 2 of these. In the economic event that fulfills the commitment two double rooms (resources of the specified type) are allocated to this group.

3.3 Services in REA

In REA, a service is a resource as it is viewed as valuable by some agent and can be transferred between agents [20]. As such, it inherits all features of resources, in particular that it can be exchanged between agents, that it is governed by a contract and that it is part of a conversion process chain. Although a service cannot be owned – the customer cannot resell it, only the right on a service may be resalable, as in the case of a hotel coupon – he does have a certain control over it and has a right to make use of it for some time. A service is produced by one agent for another agent using certain resources or capabilities. The production and consumption of the service are not independent events, as in the case of goods, but occur simultaneously. As a consequence, the customer participates in the service execution and a service is a typical example of co-creation of value.

active in the case of an emergency, as stipulated in the service contract. This is service use. The effect of service use is a particular house (resource) being rescued, whereas the effect of the service consumption is the increased security of all houses in town (resource). Security of the resource in this case does not mean that no accident could happen but that the damage will be limited.

If we want the rescuing to be modeled as a service (e.g. because it can occur independently from the overall fire brigade service), this can be represented by coupling the service use to an event that creates a right on such a rescuing service. So then the service goal is no longer "rescue", but "create right on a rescuing service".

For the user-centric description of a service, the "*goal"* is important [WJ09]. A service aims to produce an effect on resources of the customer in such a way that the value increases. If the effect is not reached, this may cause the transaction to fail. Formally, the goal relationship can be seen as an extension of the REA meta-model. However, as it can also be seen as a derived relationship, since it is defined as "the production events at the customer' side that stands in conversion duality with the service use and consumption". When also the *consumption* events at the customer and provider side are relevant, we could add a "source" relationship, analogous to the "goal" relationship. Together, source and goal provide a reference to all resources affected by the service execution. As the description of all kinds of failures and exceptions is never exhaustive, we refrain from including that in the effect. It can be specified in the contract.

For web services and similar software artifacts to deserve the label "service", the service model elements should be clear. What is the goal of the web service, that is, what resources does it create or affect that have value to the client? Who are the actors involved in the exchange process? In the next section, we will consider coordination services as one important subclass of web services.

4. Coordination services

Coordination services are defined in [20] as services supporting an exchange process (a set of events) for a good or a service alike. Processes like identification, negotiation, order execution and after-sales take place in both cases. We introduce the notion of coordination object for the object of these processes: what *is* negotiated and executed? Well, the central coordination object in an exchange process is the purchase order, not in the sense of a document, but as the commitment to deliver, to be fulfilled by the exchange event. Complex processes can include more coordination objects. Reservation and appointment are two coordination objects that reoccur often, especially when services are concerned. The reason for that is simply that the delivery of a service affecting resources from both the provider and customer to be present at the same time and place requires more coordination than the delivery of a good.

In terms of REA all coordination objects can be specified in terms of commitments. Therefore, another way of characterizing coordination services is to say that these services manipulate commitments (their goal is to give, take and fulfill commitments). We assume that for all coordination objects there is a negotiation and contracting process first followed by an execution and evaluation process, that is, the

It should be noted that although the meaning of reservation and purchase order is quite stable over different domains, these two coordination objects are not always applied in the same way. In the case of a hotel, the purchase order is made when the customer checks in. At that moment, the reservation, if any, is fulfilled. In the case of a flight ticket, the purchase order is made when the ticket is sold, typically long before the check-in at the airport. What happens at the check-in is the allocation of a specific resource (a chair with a number). Sometimes, it is possible to take an option on a flight ticket for a few days before buying it. That is a case of reservation.

The complete reservation pattern is represented in Fig. 8 It shows the reciprocity relationships with other commitments that are grouped together in a contract.

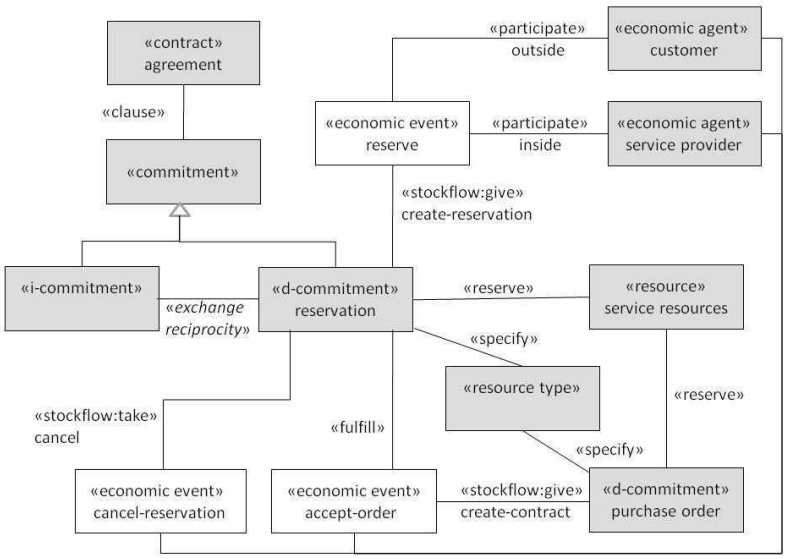

Fig. 8 REA Application Model for Reservation

An *appointment pattern* is used when two or more agents want to meet at a specific location. Appointments can be made for their own sake, but can also be part of a purchase contract, for example, when customer and provider have to agree on where to deliver the service or good. Fig. 9 shows an application model for show-up appointments where the commitment is from the side of the customer (so it is an i-commitment), typically reciprocal to an appointment of the other party to be there as well. Since the appointment includes at least a resource (the customer himself, or some resource related to the customer; and the location) there are two "reserve" links. In accordance with our "reserve" ontology, these links point to groups that specify the reservation on an abstract level and that are populated at some time with specific instances.

We have described three coordination objects, corresponding to three coordination services. Although they capture perhaps 80% of business coordination, the question

The focus of this paper has been on the description of coordination services which are the services that support an exchange process (a set of events) of a resource. Creating, executing and evaluating commitments is done in a combination of informational and material processes (in the sense of [12]). The Language/Action Perspective ([3, 9]) has explored a couple of standard micro-patterns on which the informational processes can be based. However, in this paper we have focused on the essential business level that abstracts from process and implementation aspects.

Although we adhere to the REA way of denoting the "fulfill" relationship, we have argued that it can be interpreted in terms of stockflow relationships when we distinguish a "take" commitment event that stands in exchange duality with the economic event that executes the commitment. At first sight, this event may seem superfluous, but what it expresses is that for the fulfillment of a commitment it is not only necessary that the commitment is executed, but also that the customer accepts this as execution of the fulfillment – and therefore absolves the claim. At this point we do not agree with [11] who interprets claims in terms of imbalances in the economic exchange only, for instance, when money has been received but the goods have not been shipped. When there is a contract, the other party has a claim independent of the time of payment. It is possible that a party balances one duality (e.g. shipping a good for which a corresponding payment was made) without balancing the other (e.g. because the shipping is not according to contract).

We see at least two directions for future research; the first line involves a deeper investigation of our proposed extension of the REA ontology regarding the 'resource-resource group-resource type' construct. The main rationale for this construct was to understand and model the notion of reservation while reconciling some previous proposals of solutions for the same problem.

The second line of research concerns the relationship between coordination objects and rights. The business scenario that we have described in section 4 assumes that first a commitment to reserve some resource is created (a hotel room, say). At the same time, a commitment to show-up is created. Subsequently, upon arrival the reserve commitment is returned and a new commitment, involving a specific hotel room is created. This second commitment is returned when the guest is satisfied with the hotel service having being delivered. What is interesting to explore is the interpretation of the commitments in terms of rights. When an agent commits (d-commitment), he gives away some right on the resources involved, which assumes that he did hold that right before. REA posits a "control" relationship between agents and resources. This control can be made more precise in terms of rights (ownership, custody, discretion). Viewed in this way, an economic exchange event represents not so much a change in the value of the resources but a change in the rights of the enterprise on the resources.

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