1. Introduction

Anchoring the AIS in a well-defined ontology enhances an integrated approach and efficient implementation. This presupposes that the ontology chosen as a base is well-suited for domains such as business models and accounting systems. One alternative is to use a top level ontology which classifies the whole world, often starting with the abstract notion of a thing which encompasses everything [10]. So, for example, the upper level ontology of BFO is used by more than 130 ontology-driven endeavors throughout the world [15]. While top-level ontologies provide a general scope they have the drawback that they demand mappings between the top-level ontology and the domain at hand. A solution is to choose a core ontology aimed at describing/ prescribing domains such as business models and service systems [10].

According to Wikipedia an accounting information system (AIS) is a system of collecting, storing and processing financial and accounting data that is used by decision makers. Concerning AIS, scholars in [11] conclude the absence of a widely adopted conceptualization: “What are the concepts covered by AIS? Given the diversity of approaches and elements adopted and used by various AIS professors, this is not an easy question to answer. Some adopt an internal control perspective, others an REA approach, and still others a fraud prevention angle.” It seems logical that the AIS conceptualization should start with Financial and Management Accounting Conceptual Framework, both for reporting and operational use, grounded in upper ontology. We follow Yuji Ijiri [1] who claims that accountability is the foundation and the goal of accounting.

The [Financial] Accounting at present is undergoing a substantial change with introduction of new Conceptual Framework (CF) [4] and number of worldwide standards jointly developed by IASB and FASB, such as Revenue from contracts with customers [5]. Some of the problems that still remain are the verbal form of the CF and standards, as well as the limited coverage of the economic exchange lifecycle, that leads to usage of the commitment and agreement concepts not integrated into the framework and being at best disclosed versus recognized; and lead to statements that e.g. IFRS guidance on disclosure are inconsistent, complex and difficult to understand.

Previously our AIS research approach was based on the REA ontology [3], but due to slow practical acceptance and pragmatic difficulties, we have decided to alternate our research grounding it in UFO-S core ontology [6], present state of international accounting standards (IAS) conceptualization [4, 5] and other works, including REA extensions. The goal of our research is the development a modeling and recording notation for AIS, with evaluation in modeling and verifying the new IAS and cases, as well as several ERP systems and practical cases. The particular goal for this paper is UFO-S grounded conceptual model of complex (process oriented) exchange lifecycle, economic commitments and agreements and their conversion to the enforceable obligations and intermediate or final delivery with relation to the IAS, with respect to the SDL [9].

Section 2, describes the background of the research, section 3 introduces the overall exchange model, section 4 compares with the other work, while section 5 concludes with a discussion and future directions.

2. Background

Yuji Ijiri's works and REA Ontology

Ijiri [1] introduces Economic exchange as “an action whereby the entity [“Enterprise] gives up control over some resources in order to obtain control over other resources”, with the enterprise’s Economic goal “to increase the monetary resources under its control”. He also postulates that the coordinated chain of economic exchanges comprises the operations of the firm. Ijiri regards two kinds of economic exchanges – the Exchanges in a market and Exchanges in production (Conversions) which may be considered exchanges between the enterprise and nature. Ijiri axiomatizes exchange, control, quantities and historical value of economic resources. He defines:

- **Economic entities (agents)** as “identifiable parties with discretionary power to use or dispose of economic resources”;
- **Economic resources** as “objects that the entity intends to place under its control, they must have utility and must be scarce”;
- **Economic control** as “discretionary power to utilize or dispose of resources”;
- **Accountability** as “a demand to account for the resources under entity's control provided by some other economic agent”;
- **Economic event** as: “identified by economic resources controlled by the entity and their changes”

with the assumption that the resource set of an entity at a time t is described by history of all economic events of the entity affecting this resource. The principal enhancement (that allows for accounting of all phases of an exchange) to the initial Ijiri's “Accounting measurement theory” was the addition in [1] of the concept of Economic commitment as “an agreement to execute an economic event in a well-defined future that will result in either an increase of resources or a decrease of resources”. Further Ijiri suggests to extend resource control recognition criteria to commitments and even forecasting and budgeting, explore ideas similar to 400 years old assumptions, when the promises in the agreements were legal obligations. He also adds commitment accounts and proposes to use the existing accounting notation for recording and manipulating commitments, but that does not
specify the fact that reciprocal commitments are linked and interdependent, neither demonstrate how to overcome open-ended and cost-plus agreement and other reciprocity depicting difficulties using traditional accounting.

Ijiri analyzes the exchange delivery process, he writes [1]:

"The axiom of exchanges requires that all changes in the resource set R be partitioned into a set of exchanges \( r = r', r' \) which relates an increment \( r' \) and a decrement \( r \). Let us call that part of the transaction, either \( r' \) or \( r \), which occurs first the initiator of the exchange and the other the terminator of the exchange. If the change is an initiator of a new change, its likely terminator must be estimated in order to enter the transaction in the record... In order to fill the gap between the time of the initiator and the time of the terminator, an account (e.g., accounts receivable) is created so that the outstanding terminator is matched properly when that part of the transaction actually occurs. Thus, when the exchange is concluded, the terminator is matched with the original estimate".

(Quotation 1)

The accounting theory, developed by Ijiri was used by William McCarthy to develop an Entity-Relationship framework for economic exchange [2] called REA framework, with the goal to unify views of different classes of EIS users in a database environment. Additional concepts of External and Internal agents; give, take, consume, use and produce resource flow types were introduced, the event accounting approach maintained. The conventional accounting artifacts such as debits, credits, accounts and double entry were declared redundant. The reciprocal commitments were also added to the REA ontology in [12], that later resulted in the ISO 2007 standard [3], where REA is positioned as accounting ontology. While analyzing the exchange delivery processes [13] REA didn’t detail any new concepts and had approximately the same process view as Ijiri (Quotation 1) and the duality concept expressed in [3] (i.e. the claims are dependent, because they can be calculated and are not resources):

"Materialization of Claims is sometimes needed when Trading Partners insist on documentation of partially completed exchanges (for example, when a Customer takes possession of an Automobile before paying for it in full). If needed, Claims can be instantiated by documents like invoices or by accounting artifacts like accounts receivable. Their inclusion here is more a matter of business custom than ontological completeness."

(Quotation 2)

For further analysis, it is important to notice that Ijiri and REA treat Resources as Goods, Services or Rights, where the later doesn’t include Claims, mentioned in the above quotation.

We have the following alternative views concerning the abovementioned process descriptions, claims and event approach.

1. The initiators and terminators generally are separate processes – complex events, where each part may be performed over time or even separated in time (by events of delays) and change the resource set, but only partially fulfill the commitment, so the initiator is not the one who starts first, but the one who finishes first. The intermediate states need separate concepts, matched with commitments and obligations.

2. “To fill the gap between the time of the initiator and terminator an account is created” and thus accountability for this now independent object – receivable or providable is required - an obligation which is enforced by natural or jurisdiction laws, of a greater binding power than the initial commitment.

3. The original estimate of the terminator, at the time of finishing of the initiator is the exchange value (or transaction price [5]). The terminator’s value after the “time gap” (of sometimes many years) may change its exchange value, as an object (e.g. market price change or price concession), so matching of fulfillment is done not with the “original estimate”, but with the current value, and not with the commitment, but obligation.

4. As an object, the terminator may undergo different transformations and transfers, such as factoring, integration in portfolios and separation (e.g. an agent retains the rights for the principal amount receivable, but sells the rights for the interest receivables); and different ways of fulfillment, such as netting or forgiving; which constitute an exchange per se, not connected to the original exchange. The tracking of the original exchange may be useful in cash basis of accounting. The possible advantages of such approach and the specific usefulness of activity accounts [1] and claims as event imbalances [3] concepts should be researched further, but they don’t constitute a general institutional solution today.

5. The obligations are created not only by contracts, but also from delicts, court decisions and tax laws, i.e. they are separate objects, possibly without explicit duality origin.

6. The problem with the pure event approach is that the events describe the history of resources, while accounting is also interested in resource as a base for future economic events and benefits, that leads us to conclusion that conceptually economic event forms a relationship object, that after receiving event, may evolve, change purpose, valuation, be suspended, insured etc. and finally given up. The neutral events proposed to “unify views of different classes of users” often don’t have enough meaning to be registered in an accounting system, the state change needs to be fulfilled (allocated to the commitment/obligation), recognized, valued and classified, i.e., the control, hold (delegated to an agent) and the purpose needs to be specified and measured and possibly re-measured later; while contrary to the conventional accounting, much of these may be inferred by AIS from the planning level relationships. So the system registers relationships representing history, evolution and disposition of future changes, not only the foundation events. The unify views goal may be achieved through upper ontologies.

New International Accounting Standards (IAS) and the Conceptual Framework (CF).

The current state of the economic exchange conceptualization is represented by the new IAS [e.g. 5] and CF [4]. The later defines resource as a right that has potential to produce benefits [4, para. 4.5]. We understand to produce benefits as an
permitted action types to exchange a present resource to another with an increased value for the enterprise; and the rights definition in [4, para. 4.6-4.39] as the specification of permitted actions, namely:

1. actions with the rights themselves;
2. actions with the underlying object or
3. actions that another party has a present obligation to perform for the benefit of the enterprise. [according to the term]

The later resource is called a receivable, while the resource controlled by the enterprise is called an asset. A liability is a present obligation of the enterprise to perform actions for the benefit of another party. An enterprise controls a resource if it has the present rights and [cap]ability to direct the use [enable actions] of the resource and obtain the benefits that flow from it.

A contract asset is the enterprise’s right to contribution for resources that the enterprise has transferred to a counterparty when that right is conditioned on something other than the passage of time (e.g., the future performance). A contract liability is the enterprise’s obligation to transfer resources to a counterparty for which the enterprise has received contribution (or the amount is due) from the counterparty. These resources defined in [5] are similar to work in process asset in conversion, and represent the intermediate states for representing processes, the definitions should be improved, but an important point for us is that these delivery in process obligations (enforced e.g. in case of the breach of the contract) are in 1:1 relation with current partial commitment fulfilments and also may represent momentarily assets until they will be represented by their results.

The party (or parties) could be a specific person or enterprise, a group of people or enterprises, or society at large [community]. An agent is a party that is primarily engaged to act [committed] on behalf of, and for the benefit of, another party (the principal). If an enterprise holds a resource as an agent, the benefits arising from the resource flow to the principal instead of the agent. Consequently, the enterprise does not control the resource and it does not have an asset, nor does it have a liability because it has no obligation to transfer any resource that it controls or will control. This is different as in [2], where the agent also could have control, whereby here it has a hold.

Services are regarded by [4, para. 4.9] as momentarily rights to obtain benefits until they are consumed - thus as resources. Lease is regarded as right to use, but not a service. In [4] service is described as a resource whose control could be obtained by the enterprise, its use may be directed to obtain the benefits from this momentarily asset. From our standpoint, if a service is an event then it could not be transferred, but the rights may be directed in the form of in-process assets and the benefits obtained as objects created or changed as result, and should be separately regarded for the enterprise and the counterparty.

A contract is defined as an agreement between two or more parties that creates enforceable rights and obligations, so generally before delivery neither agreements (commitments) nor offerings are recognized (but may or should be disclosed).

In our research we follow and analyze the IAS and CF. As mentioned before, we find the need for explicit commitment concepts. While we agree and emphasize that the enforcement of the commitments are of a much different nature as the ones of obligations enforced by law, we introduce the commitments as intentions and claims to them, giving them also a resource state in a sense of transferable rights. As in [14] we will call them intentional resources. We provide a definition for commitment:

An Economic commitment is the enterprise’s voluntary promise to guarantee to perform economic actions, on the occurrence of a certain triggering event [according to the terms and conditions], voluntary agreed with and for the benefit of the counterparty. An Economic claim is a counterparty’s voluntary promise to guarantee to perform economic actions, on the occurrence of a certain triggering event, voluntary agreed with and for the benefit of the enterprise.

UFO and UFO-S

In search of an upper ontology for our framework, we were looking at one that includes event and social oriented concepts as well as provides tools for a substantial ontology engineering support, and have choosen the UFO [8] with the OntoUML tool, while several BFO [15] concepts will also be used. In UFO [8], the Agent concept, is defined as a concrete Endurant (i.e. an entity that endures in time while maintaining its identity) which can bear certain Intentional States. These intentional states include Beliefs, Desires and Intentions. Intentions are mental states of Agents which refer to (are about) certain Situations in reality. Situations are snapshots of reality. The propositional-content (i.e., proposition) of an Intention is termed a Goal. In contrast to Endurants, Events are perduring entities, i.e., entities that occur in time accumulating their temporal parts. Events are triggered by certain Situations in reality (termed their pre-situations) and they change the world by producing a different post-situation. Actions are deliberate Events, i.e., Events deliberately performed by Agents in order to fulfill their Intentions. An Action achieves a Goal if the Action brings about a Situation in the world that satisfies that Goal. In contrast with an Agent, an Object is a concrete Endurant that does not bear intentional states or perform actions. An Object participating in an Action is termed a Resource. [in our framework – a right]. A distinguishing concept in UFO is a Relator [7], which can be seen as reified relationship. More exactly, relators, can be seen as aggregations of qualities (modes, in UFO) inhering in related entities, accounting for the way the related entities are involved in the relationship. Commitments (intentions and social commitments) can be closed commitments (commitments to achieve goals by causing the occurrence of events - actions - of a certain type).

A core ontology of services UFO-S [6] was developed based on the UFO. It includes the lifecycle of an exchange and was chosen as core ontology for our framework. Other frameworks were available such as [1], [16], but they lacked the foundational base or
core concepts, the detailed comparison is out of the scope of this paper. The existing ERP systems though are overloaded with pragmatic details, concerned about technical efficiency and legacy, and the concepts are often buried in the code.

### 3. Complex economic exchange model description.

We’ve learned previously that Economic exchange as an agreement and an interaction whereby, based on commitment, the enterprise provides control over some resources in order to receive control over other resources, based on reciprocal claim. Now let’s start a more detailed analysis, applying UFO-S to construct our framework. Concerning the resources and “providing” and “receiving”, there are two possibilities:

1. The services as actions are being provided (consumed) in the process and the (rights for) results of the services in receiver’s objects transferred to the receiver.
2. The rights, including obligations and permissions to perform future actions, for underlying objects and services are transferred to the receiver.

The second delivery type is more and more involving services, in fact goods may be regarded as postponed potential services – appliances for receiver self-service, and the exchange scope enlarged to the full value creation - as proposed in Service-Dominant-Logic (SDL) [9] that states that the “exchange of service is the fundamental basis of all social and economic exchange” and “services as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself” [9]. While we will not explore all the findings of this theory, mainly in the marketing field, we will accept this approach as unifying the view of exchange under a sdl service concept, which covers services a) in accounting sense, b) goods, and c) benefits – receiver’s self sdl service. Under this assumption we have chosen the UFO-S as a core ontology for the economic exchange, where we do not find any contradictions to such treatment. Moreover, we think that UFO-S may benefit from our application, further called EXT, and introducing processes and goods as intermediates, because of comprehensive and symmetrical approach. In fact all the examples that are used in the UFO-S description [6] are not services in the accounting sense, but leases or sales of goods; e.g., the main case of the car rental is a lease, because the car (good) is temporarily transferred to the customer, but organizing a possibility of car rental for the customer could be regarded as a service, but implicitly; also in the practical applications of the UFO-S, the resource concept emerges.

In analogy with UFO-S, EXT is a commitment-based economic exchange framework whose conceptualization, is based on the establishment and fulfillment of reciprocal commitments and claims between exchange participants (enterprise and counterparty) along the exchange life-cycle. In this paper, in analogy to [6] and other approaches [3] we start with the three main phases of the exchange life-cycle, namely: exchange offer, negotiation, and delivery, but with enterprise and reciprocity as well as delivery process focus. The UML diagram in Fig. 1 is an abbreviated version of the OntoUML diagram, due to space and clarity limitations and forthcoming event and relator support. The OntoUML stereotypes used in this paper represent Universals.

We make the following modifications of the UFO-S model, because of AIS and enterprise centric orientation: We omit “service” for offer, offering, negotiation, agreement, provider, customer, delivery; due to different usage of service term in accounting and imply rights and control. We call: the enterprise in the role of provider - a provider and counterparty in the role of provider - counter provider; and enterprise in the role of customer - a receiver and counterparty in the role of customer - a counter receiver; and we use commitment/claim and obligation/right for the enterprise modes and counter commitment/claim and counter obligation/right for the counterparty modes, due to the fact that enterprise can be in both roles – of a provider or a customer. We use [counter] committer, provider, creditor, instead of hired service provider and [counter] committer, receiver, debtor, instead of service customer, because we will differ roles for different modes; and differ event and relationship roles of the agents and regard them for accountability. We use provide for enterprise actions towards the benefit of counterparty and receive for counterparty actions towards the benefit of the enterprise.

We will detail both the service offering and service agreement normative descriptions into separate provide plan and receive plan and further for these plans we introduce provide and receive event specifications respectively; and further develop the model to include resources, quantification and valuation. For the plans of commitments and obligations, based on analysis of agreement texts and [4], we will use action-based logic, meaning that modalities are applied to actions (e.g. “the customer must transfer”) as opposed to situations (e.g. “the customer deposit should reach”), so the commitments are closed, but we allow for refinement during fulfillment (e.g. the customer may choose a method of payment) and so the commitment may become open. Complex actions can be expressed using operators for choice, sequence, concurrency and repetition. Plan clauses (event specifications) in agreements/obligations can also have sanctions — sub-clauses which are applied as a penalty when the primary commitment/obligation or prohibition is violated. These are respectively referred to as contrary-to-duties and contrary-to-prohibitions, but are not further regarded in this article.

### An Offering

In analogy with UFO-S, at the beginning of an exchange relation there is a promise of the enterprise, a speech act that establishes a pattern of commitments and corresponding counter[party]-claims, that is called enterprise offer, and the resulting pattern of commitments and counter-claims enterprise offering relationship, that constitutes a document act [15]. First section of the Fig. 1 shows an UFO stereotyped UML class diagram with the main concepts and relations involved in enterprise and counter-party offerings. In analogy to UFO-S, an enterprise offer event results in the establishment of an offering between the enterprise as offerer [provider] and a target receiver community. An offering relationship is composed of offering commitments...
from the offerer towards the target receiver community and the corresponding offering counter-claims from the target community towards the offerer. The actual content of offering commitments (and corresponding claims) is described in offering descriptions i.e., normative descriptions in UFO and in our framework contains the provide meta-plans, that include:

- Types, terms and conditions of the actions to be performed in the scope of providing,
- Required type and location of resources to be transferred,
- Required types and locations of provider and counter receiver.

Fig. 1. Complex economic exchange lifecycle pattern UML class diagram (Events in blue).
and required receiver’s counter-commitment meta-plans (such as consideration), of the following:

- Types, terms and conditions of the actions to be performed in the scope of receiving,
- Required type and location of resources to be received,
- Required type and location of counter provider and receiver.

So enterprise’s commitment is conditional – it is committing, if the counterparty will counter-commit.

What is established in the offering commitments also determines the level of flexibility for a subsequent service negotiation phase, in which a particular receiver and a provider establish a particular agreement. Because of that, offering commitments are in fact meta-commitments [6] (i.e., they are commitments to accept commitments), because they refer to commitments that can be established later during the negotiation phase and that do not yet exist as a result of an offer alone.

Meta-committer is the role played by agents when these agents commit themselves to a target receiver community by an offer event. In terms of UFO, the roles are role mixin, since it can be instantiated by agents of different kinds, e.g., persons and organizations. According to [6], Target receiver community is a collective that refers to the loosely coupled group of agents that constitute the community to which the exchange is being offered.

An offering is the social relator that arises from the offer event, and is the aggregate of offering commitments and the corresponding counter-claims. Offering commitments and counter-claims are social moments (in the sense of UFO-C), i.e., offering commitments are intrinsic moments, which inhere in the meta-committed agent and are externally-dependent on the target receiver community. Offering counter-claims, in turn, are intrinsic moments that inhere in the target receiver community and are externally-dependent on the meta-committed agent.

The following [adapted] axioms of UFO-S ensure that the decomposition of an offering relator into offering commitments and counter-claims is valid:

1. Enterprise offering commitments and counter-claims, which are counterparts, are part of the same offering.
2. Each enterprise offering commitment that is part of an offering, which involves an agent called meta-committer and a target receiver community, inhere in such agent and is externally dependent on this target receiver community.
3. Each offering counter-claim that is part of an offering, which involves an agent called meta-committer and a target receiver community, inhere in this target receiver community and is externally-dependent on such agent.

We will add constrains that are relevant for reciprocity and exchange values – transaction prices:

4. Each offering includes a provide plan and receive plan
5. For each offering, the transaction price of the provide meta-plan is equal to the transaction-price of its receive meta-plan at specified time t.

Since we take an enterprise centric view, as in accounting, we must regard the enterprise also as a receiver [customer] and the counterparty offer and offering. The diagram in this case is similar to the provider case and shown in the Fig. 1. The major difference is that the target community is not modeled in this case, because the enterprise is the target receiver. The delivery phase of UFO-S and EXT may consist of actions of provider, provider-receiver interactions and receiver actions. Thus the offer and agreement phases, in addition to external plan specifications should include internal [meta] self-commitments for actions of the enterprise in the roles of provider and receiver (not depicted in Fig 1).

An Agreement

According to UFO-S, an offering is a base for agreement negotiation event. During negotiation, the enterprise and counterparty interact in order to establish an agreement regarding their reciprocal commitments and claims with respect to an eventual delivery. If the negotiation succeeds, an exchange agreement is established, and the enterprise starts to play the role of committer, while the counterparty starts to play the role of counter committer. Like an offering, an agreement is composed of commitments and counter-claims. However, in an agreement, counterparty establishes counter commitments to the enterprise e.g., the commitment to pay, and the enterprise has a claim towards counterparty. (The counter claims and counter commitments are not shown in Fig.1 for the agreement and obligations, the principle is similar as for offerings.)

As in the case of an offer, what is agreed between the parties (reciprocal commitments and counter-claims of both enterprise and counterparty) are described in agreement descriptions (such as a service contract), that in our model are specializations/updates of offer descriptions and consist of provide and receive plans, that include event specifications. In terms of UFO-C, a negotiation is an interaction involving the participations of the exchange - enterprise and the counterparty. When a negotiation (an event) succeeds, this event is the foundation for an agreement (a relator). Enterprise’s and counterparty’s commitments and claims are social moments. Enterprise’s commitments and claims are intrinsic moments that inhere in the enterprise and are externally-dependent on a counterparty. Counterparty’s commitments and claims are intrinsic moments that inhere in a counterparty and are externally-dependent on the enterprise. We have to note, that meta-agreements may also result from negotiation, as offering may be commitments for concrete resources and not meta-commitments, and the differentor is unilatery versus dydatic, but it may be easy added to our model.

The axioms for agreements: (For brevity, we as in [6] omit here the axioms that constrain the decompositions of agreements).

1. When a negotiation results in an agreement, that agreement must conform to the offering to which the negotiation refers.
2. An agent cannot simultaneously play the roles of provider and target receiver in the same service negotiation.
3. The provider that participates in an service negotiation is involved in the offering to which the negotiation refers.
4. Every target receiver that participates in a negotiation is a member of the target receiver community involved in the offering to which the negotiation refers.
5. The agents that are bound to a agreement as commiter and counter-committer, have acted, respectively, as provider and target receiver in the negotiation that resulted in this agreement.
6. Each agreement includes a provide plan and receive plan.
7. For each agreement the transaction price of a commitment is equal to the transaction price of a claim (counter commitment) at specified time t.

A Delivery

Delivery is the execution of actions aimed at fulfilling the commitments established in the agreement. Fig. 1, Factual level shows an OntoUML class diagram presenting the main concepts and relations involved in delivery phase according to our model. Delivery is composed by several actions, including actions performed only by the provider, actions performed only by the receiver, and actions performed by both in an interaction. All of these actions are motivated by the commitments established in the agreement, between the enterprise and the counterpart. The UFO-S axioms for the delivery are:

1. Every delivery has at least one part that is a provider action, a receiver action, or a provider-receiver interaction
2. The commitments that motivate a provider action inhere in the provider that performs the action.
3. The commitments that motivate receiver action inhere in the receiver that performs the action.
4. Each provider-receiver interaction is motivated by at least one commitment (a provider commitment or a receiver commitment).
5. The provider commitments that motivate a provider-receiver interaction inhere in the provider that participates in the interaction.
6. The receiver commitments that motivate a provider-receiver interaction inhere in a receiver that participates in the interaction.
7. Each provider action that is part of a delivery related to an agreement is performed by the provider bound to that agreement.
8. Each receiver action that is part of a delivery related to an agreement is performed by the receiver bound to that agreement.
9. Each provider-receiver interaction that is part of the delivery related to an agreement, has the participation of the provider and some receivers bound to that agreement.

Now we will apply the UFO-S model to have a more details of the delivery processes and its relation with accounting concepts:

1. The delivery actions are economic events that fulfill commitments described by certain plans, that happen over time, possibly separately. The provide actions decrease assets or increase liabilities, the receive – increase assets or decrease liabilities.
2. Each delivery action changes the enterprise’s resource set – an account and simultaneously create a temporary delivery in process claim, to the counteragent of this action, so the action represents a part-exchange or consumption. In accountig delivery in process is represented by accounts like work in process, contract assets, contract liabilities. The provide in process changes the income by the standalone selling price [5].
3. The delivery actions fulfill a delivery plan and hence the commitment, that, when fulfilled, triggers the rights-exchange or production, that exchanges the delivery in process claims to enforceable obligations of reciprocal delivery, by creating a new object that inherits the unfulfilled process plan. The fulfillimg of provide plan recognizes revenue at transaction price [5].
4. Generally, the exchange model does not determine which delivery action – provide or receive will be executed first, also an interaction may occur motivated either by agreement conditions, or by agent’s autonomy [17].
5. When the reciprocal obligation is fulfilled again as a process, such an exchange combined with preceeding rights-exchange, may be called an object-exchange.
6. The transaction price equality is in force only for (or till) the moment of the rights-exchange, the remaining obligation may be revalued at a present value.
7. When commitment/claim of an agreement is fulfilled the respective reciprocal mode changes to the obligation/right, the agreement ceases to exist, but the contract of unfulfilled provide/receive plan (with all the sanctions) continues to exist.
8. When the beneficiaries have finally benefited from the exchage such an exchange may be called a service-exchange.

The part exchanges may be planned, but also emerge during delivery as partial fulfillments of a different aspects of the transferred control e.g.:
- The required combination of goods and services is not transferred fully as e.g. some provided mechanism may be useless without proper training; or
- the control of a resource is not transferred fully as e.g. only use rights, but not ownership; or
- the title is transferred, but the possession or access not provided or vice versa; or
- only part of the object, function, quantity, location or duration required is delivered; or
- an excess resource is transferred; etc.

Example 1. Electricity supply offer to the enterprise for a current year,
2. Four options (a need for a choice operator):
   a. An option for monthly measuring and payment at fixed rate.
   b. An option for monthly measuring and payment at market rate.
   c. An option for a balanced payment:
      i. An object exchange processes during the year (part-exchanges):
         1. balanced monthly payments provide process; versus
         2. electricity receive process upon request,
      ii. A reconciliation of the meter and payments at the end of the year at fixed rate – a rights exchange – either there is payable to the supplier or receivable from him.
   d. An option to accumulate electricity to Tesla’s battery at lower rate during the night hours – a postponed service.
4. Related work

Recent VDML standard [18] provides value and exchange concepts even beyond economic, generalizes and explains many other important concepts for value modeling, that overlap with our analysis, their planning level though is restricted to valueProposal is that roughly similar to the Offering concept, the further details of agreements, commitments and obligations and their fulfillment are not regarded. The resource concept is regarded outside any deontic aspects, also their ontology is not grounded in any upper ontology, except for SSM[Measurement], and is not directly applicable to accounting, PPS 1.0 or UBL 2.1 standards.

Fundamental work in commitment area is provided by Singh et al. [17], while many concepts are directly comparable in commitment area we differ from Singh in elaboration of reciprocity and economic resources, value, economic or accounting view; while we currently lack true MAS approach, primarily because of the focal enterprise view.

REA-DSL [19] that was a fundamental step forward for REA notation, unfortunately has not received any traction as a notation. The advanced REA concepts though are being realized in a practical system [20]. The differences previously mentioned between REA and our model have not received any substantial progress yet, while they should appear during practical use of the system in future as well as a new version of REA notation.

The POA framework [21] distinguishes possession and ownership delivery as separate delivery events based on availability, showing that the resource transfer is a process important for the AIS to detail, but doesn’t explore on other constituents of such process.

5. Conclusions and future work

An economic exchange was analyzed from a standpoint of UFO-S core ontology [6], the existing approaches of conceptual frameworks of IAS [4,5], Ijiri [1] and REA [2] were regarded, a conceptual model for exchange were proposed that includes planned, agreed, partial, control and object exchanges, offerings, commitments and obligations and delivery events. It was shown that building a realistic AIS model is impossible without introduction of reciprocal commitment, delivery in process and obligation concepts as resource modes.

While the number of regarded concepts is quite large and the associations complex, hopefully they reflect the existing practice, which is important for the realistic models, that is today a concern in several domains including MAS, see e.g. [17, 22], where recently a serious attention was drawn toward timing and partial and aggregated fulfillment and delegation aspects.

Due to partitioning and integration of exchanges and resources, it may be costly and probably unnecessary to track their identity through object-exchange, and it is necessary and advantageous to allocate the fulfillment of the commitments in rights exchange.

The future directions involve elaborating the framework toward formalization, exchanges with owners, community as well as conversion aspects and relation to other standards; further development of a textual, graphical and table oriented notation.

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