Financial Reporting by a Shared Ledger

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Abstract. Among models and information about economic phenomena which help to understand how enterprises produce value, Accounting and Financial Reporting still play a leading and regulative role. The regulative role is established by enforceable International Financial Reporting Standards (IFRS). Ontology engineering methods, which have proven to cope with difficult standardization issues, are seldom used in developing the abovementioned standards. Furthermore, the standard setting should more increasingly account for the influence of advanced information technologies for capturing and reporting financial information, such as [blockchain-based] shared ledgers and data analytics. This paper proposes an initial version of the Core Ontology of Financial Reporting Information Systems for a Shared Ledger Environment (COFRIS) grounded on the Unified Foundational Ontology (UFO) network, and a preliminary analysis of the IFRS.

Keywords. UFO, REA, IASB, IFRS, COFRIS, Shared Ledger

1. Introduction

Ontology engineering methods, which have proven to cope with difficult standardization issues [14], are seldom used in developing standards of international financial reporting (IFRS). Consistency, completeness and clarity of recent editions of Conceptual Framework (CF) for Financial Reporting (FR) [1] and reworked standards [2] by the International Accounting Standards Board (IASB) still need to be improved [6]. We see the following areas of improvement of this framework and standards:

- usage of the ontology engineering tools for standard setting, grounding on upper level ontologies;
- elimination of the repetitions and inconsistencies among IFRS standards;
- elimination of the inconsistencies with other enterprise standards and enterprise ontologies;
- generalization of the conceptualization of economic contracts and their progression events [12];
- accounting of the impact of modern information technologies, such as data analytics and shared ledger [11].

Our research attempts to contribute to these improvements by using and extending the general patterns of upper ontologies and by extracting patterns common to all standards. These patterns facilitate the reuse, understanding and precision of IFRS standards and their accompanying documents, which now comprise thousands of pages.

The main contribution of this paper is an initial version of the Core Ontology of Financial Reporting Information Systems for a Shared Ledger Environment (COFRIS)

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grounded on the Unified Foundational Ontology (UFO) [3] network. The proposed ontology is partially extracted and validated analyzing the Financial Reporting Conceptual Framework, Standards and Illustrative examples. Such an analysis should lay the groundwork for a modern Ontology driven IS environment including data analytics, a shared ledger and smart contracts. The results are OntoUML [15] supported financial reporting information systems conceptual model development principles and Conceptual Framework for Financial Reporting improvement suggestions.

This paper is structured as follows: Section 2 reviews UFO foundational and domain related patterns and other previous work. Section 3 introduces the main economic phenomena used in financial reporting, and their presentation in OntoUML [15]. Section 4 outlines a possible information processing in a shared ledger environment for financial reporting. As a partial validation, Section 5 makes a preliminary ontological analysis of Conceptual Framework for Financial Reporting. Conclusions finalize the paper.

2. UFO Grounded Ontology Engineering and Other Previous work.

Our approach [12] is grounded on the Unified Foundational Ontology (UFO) network because of its comprehensive coverage of enterprise and FR relevant social concepts and cases that exceeds other foundation ontologies, and availability of the OntoUML ontology engineering tools and methodology.

UFO Foundational Ontology Patterns (FOP) [19] distinguishes types and individuals. *Individuals* are specialized in endurant FOP and event FOP. *Endurants* are entities that, whenever they exist, they are wholly present, i.e., whenever they are present, they are present with all their parts, i.e., they persist in time during their *life*. Endurants are further specialized in objects and modes (moments). *Objects* are *non-agentive objects*, agents and situations. *Modes* are intrinsic and relational (called relators). *Relator* FOP is existentially dependent on two or more endurants. *Agent* FOP represents an object that can bear intentional modes, such as beliefs, desires, and intentions.

In UFO-B [16]*, Events* are individuals composed of temporal parts, they happen in time, in the sense that they extend in time and accumulate temporal parts. *Actions* are intentional events with the specific purpose of satisfying a goal. An action achieves a goal if the action brings about a situation in the world which satisfies that goal. *Disposition* FOP represents modes that are only manifested in particular situations, but that can also fail to be manifested. When manifested, they are manifested through an occurrence of events. Dispositions are described by reference to the types of processes which would realize them under certain conditions, e.g., fragility, and *liability* [16].

Types in UFO are [sub]kinds, roles[mixin] and phases[mixin], categories, and collectives. *Phase* FOP is the extension of the endurant type due to a change in intrinsic properties. When mediated by a relator, an endurant plays a *Role* FOP in a certain context. *Rolemixin* FOP, is used for roles of different kinds.

In UFO-C [4], *Social relator* FOP is a relator composed of one or more pairs of social commitments and social claims among social agents. UFO *Pattern for Representing Events in Structural Business Models* [16] is used in COFRIS in combination with disposition and social relator, employed for modeling economic phenomena. Social relators are founded by events. As other events, creation events begin and end at certain time points. The creation moment of a relator, and objects in general, is derived from the termination time point of its creation event (e.g. in FR domain: initial recognition of an asset, contract inception, incorporation).

Objects have a causally active phase (e.g., a contract, an acquired property, an accrued liability, an going-concern enterprise) during which the qualities and dispositions of the, e.g., relator are manifested through several *life events* (e.g., a fulfillment of an obligation, a depreciation of a property, a revaluation of a foreign currency liability) that accumulate to constitute, at each point, a different process that represents the *current life of the relator* (e.g., the performance of an enterprise during the reporting period). Relators have a causally inactive phase (e.g., a sold property, a settled liability). In this latter phase, the properties of that relator can no longer be manifested, its qualities are immutable regarding their values and we can refer to the *final life of the relator* as the total accumulation of all *events in the life of the relator*. OntoUML gives us a support for deciding for which types in a model of endurants we should specify a behavioral model of changes [16], depicting its phases (e.g., an *offering* phase, a *fulfilment* phase of a contract) and including temporal OCL constraints prescribing the phase transitions, at the same time having possibility to specify all the structural details.

Within the UFO ontology network, UFO-S is a *core reference ontology on services* [13, 5], which characterizes the service phenomena by considering service commitments and claims established between service provider and customer along the service life-cycle phases: offering, negotiation/agreement and delivery. UFO-S presents general concepts spanning across several applications domains so that its conceptualization can be broadly reused. The service concept in UFO-S is rather broad, allowing the use of concepts and relations of this ontology as a base for a generic economic agent interaction life-cycle [12]. Resource exchanges can be added. However, the concepts defined in UFO-S sometimes have a different meaning as those from the financial reporting domain. For instance, car rental is a *service* as illustrated by UFO-S [13], but it is a *right to use* per [2], a Netflix subscription is a right to use per [5], but is a service per [2].

Legal aspects of service contracts are further elaborated in [18] within the UFO-L Legal ontology, that is based on Hohfeld's theory of fundamental legal concepts. The *legal positions* of UFO-L include not only those corresponding to commitments and claims from UFO-S (i.e., right and duty), but also other elements: no-right, permission, power, subjection, disability and immunity). All these legal relators are from two classes of *entitlement* and *burden/lack*, that we refer further as rights and obligations respectively.

Concerning FR related, but not UFO grounded ontologies, the Resource–Event–Agent ontology (REA) was originally formulated in [8] and announced as an Accounting ontology in [9]. REA is based on the core concepts of [physical] resources and *duality* of their transfer actions, performed by the economical parties, fulfilling commitment *reciprocity* within contracts. REA approach is different from FR primarily because it tries to conceptualize events, while FR accounts for the effects of the events. We support this aspect of REA, but otherwise we find its entities insufficient for conceptualizing FR. Primarily, the resource concept lacks consistent approach of presenting rights and obligations, leading to conceptualizing liabilities and assets as formal relations. Essential concepts of roles, such as of owners, and phases of objects, resource/obligation disposition, timing, uncertainty, impairment and value, as well as contract manipulation and revaluation/reclassification economic events are not elaborated in REA. UFO-S and REA include only "Happy Path"; contract and delivery phases in their models, while "Expired/Violated" phases are relevant for the FR.

Two others, not UFO grounded ontologies are OWL based. The Financial Industry Business Ontology (FIBO) [17] covers concepts and relations in a particular industry, relevant for important part of FR, regulated by IFRS 7 and 9 *Financial instruments* [2]. FIBO is grounded on semantic web principles and, in a sense, its own foundational

ontology. While many FIBO concepts overlap with COFRIS, their alignment is planned at the stage of developing a reference ontology for IFRS standard. The domain ontology of Conceptual Framework for Financial Reporting [6] is a fundamental transliteration of the part of the Conceptual Framework for FR concepts in OWL, using Protégé tools. It differs from our approach that ultimately aims at the whole set of the IFRS standards.

3. Economic Phenomena Depicted in COFRIS.

Financial reporting (FR) provides information relevant to investors and lenders about the *reporting enterprise*'s *economic situation - economic relationships* with *economic agents* and the *changes* of those relationships. *Reporting period* is used to decompose the changes of the whole as separate one-period flows. FR may be divided into *operating segments* of an enterprise, and comprises of several *financial statements,* such as balance sheet and income statement*,* in *functional currency* (see Fig. 1).

    Economic agent is a category of *persons* and *enterprises*, *contractual groups* of people and enterprises, or the *society at large* (see Fig. 1 in yellow). Economic agents are capable of [self] committing and fulfilling economic actions. According to UFO-C [4] communicative acts, of *incorporation* in our case, are used to distinguish between physical agents (e.g., a person) and social agents (e.g., an organization, a society). At this stage we model society and groups as collectives, but not functional complexes.
Society at large forms *economic environment* that is the context for economic agents and is represented in a *shared ledger*. Economic agents in a shared ledger are represented by accounts.

    Reporting enterprise (subject of FR and an institutional agent per UFO [4]), is an *incorporated* contractual group with some inherent goals. An *enterprise* has *control* to *allowed* and *intended actions* upon *economic resources* to attain its goals and fulfill its obligations for the benefit of its owners and other related agents. The *Enterprise owner controls* or *has a non-controlling interest* in an enterprise as per the *articles* contract. FR normally assumes that the reporting enterprise is a going concern. An enterprise itself is a resource/obligation and a prototype of any resource/obligation, in a sense that it comprises mediating agents, an internal or external input, a process and an output, as described in IFRS 3 [2].

    Economic relationship is a UFO social relator [4] existentially dependent on involved economic agents playing the roles of the *party* (e.g., by the reporting enterprise) and the *counterparty* and having two or more pairs of mutually dependent commitments/claims quantified in monetary terms, regarding some *underlying object*.

    Economic contract represents intended, suspended or recognized economic relationships and establishes a right and an obligation to exchange economic resources/obligations. In other words, a party has a commitment to transfer some resource/obligation to the counterparty in exchange for a claim to receive another resource/obligation. In the *smart contracts* commitments may be fulfilled automatically [11]. We distinguish *contract phases* progressed by *economic events.* These events and their effects become parts of the contract. Normally a contract in FR has no exchange value at inception. For economic contract conceptualization, we ground on UFO-S and UFO-L. We refine exchange pattern of [12], extracting common concepts of IFRS 9, 15-17 [2].
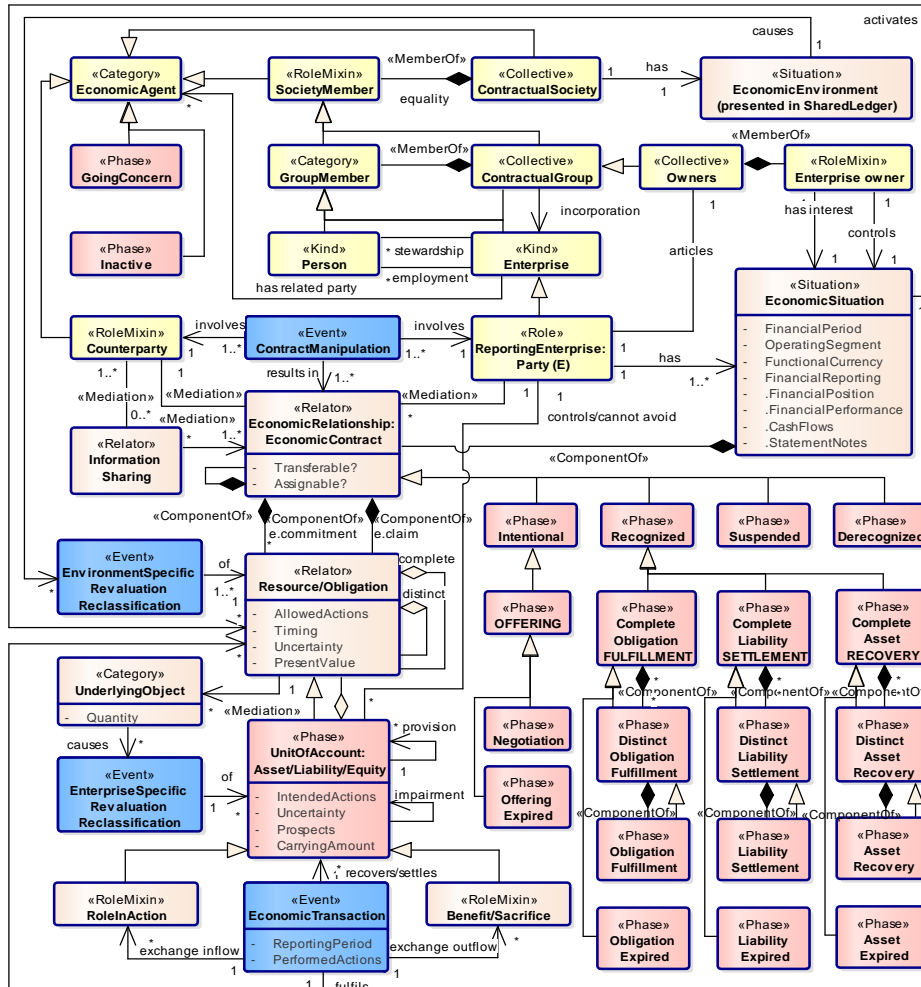
Figure 1. A fragment of the OntoUML diagram of COFRIS.

Resource is a right that has the disposition to produce [possibly in conjunction with other resources] *economic benefits*. It is an economic relationship of a party including, at a minimum, enforceable permissions against all economic agents for some underlying object. In [14] UFO regards the rights aspect of resources that is understood "as being available for the organization, e.g., by an employment contract between employers and employees, or by having the right/ownership over a certain object", i.e., the rights are contractual or are permissions [18]. Our comment is that contractual rights are also permissions, because they may be transferred. The *allowed actions,* by law, contract or nature rights, prescribe permissions of economic agents to use economic resources. The prescription includes: *exchange action type; role of the object* in this action; resulting *benefits/sacrifice* objects; *prospects* - potential or contracted counterparties and their roles; *timing*; and *uncertainty* of the actions and *present value* of the resources. Exchanges, which types are not within the allowed actions, should be prohibited in a smart contract system. An example of such violation would be a sale of a leased object by a leasee. *Timing* is a condition indicating when the resources are to be used/obligations

fulfilled, such as: on condition or triggering event; on fixed or determinable dates or on demand; at the end of the process or useful life of a resource; on default (expiration, violation); at will or a changed economic situation (dividends, put, call); at liquidation. Timing also broadly classifies relationships into current and noncurrent; together with economic events, it determines the transition of the phases of the economic relationships; characterizes the priority of the exchange relative to other exchanges. Timing is essential for all IFRS standards. *Present (exchange) value* is a price that exists independent from the enterprise, and is used as a measurement unit for FR.

Underlying object is a physical or intellectual object; or amount of matter, including human and natural environment energy; or an obligation/right for another underlying object. The *quantity* of an underlying object or its characteristic is used to depict resources required/available for exchange (e.g. currency units, commodity units, or a share of the net assets of the enterprise). Quantity is absent from the concepts of Conceptual Framework for FR, but is present in most IFRS standards.

Obligation is a resource transfer action to which an economic agent is legally or constructively bound. Obligations and resources may be complex objects – bundles combined from several separate parts, for transfer/use we distinguish *complete* and *distinct* obligations and resources. *Distinct obligation* fulfillment creates a usable resource for a counterparty and its distinct liability and allows for the enterprise to recognize revenue. *Complete obligation* fulfillment creates an unconditional right for the enterprise to receive and a complete liability for the counterparty.

Unit of account: is a group, and a phase - a result of past events, of enforceable/ constructive rights/obligations, presently recognized by an enterprise, classified by their intended use and valuation, with assessed uncertainty and impairment. A unit of account represents a stock *of* resource/obligation objects.

Asset is a resource controlled by the enterprise. As defined above an asset is a subtype of a resource. This is in contrast with other sources, e.g., mentioned in [11,14] where the resources could be understood as subtypes of "assets that can be drawn on by" the enterprise. In COFRIS, a resource has the general potential to produce economic benefits, while an asset has the potential to be realized by the enterprise who controls the resource. In other words, a resource is transferable, while an asset is a controlled resource. *Intended actions* refer to the primary actions, and assets/liabilities used in those actions in which an enterprise is engaged and capable, e.g., selling goods/services (via a specified distribution *channel*; for a specified *region*), manufacturing, or administration.

Carrying amount (*use value*) depicts the account value after deducting any accumulated depreciation and impairment losses. *Uncertainty* of receiving economic benefits. Assessed through *provisions* and mitigated by hedging. Valuation and uncertainty also include methods, assumptions and judgements used for their ascription.

Impairment is a condition that exists when the carrying amount exceeds the present value. IAS 36 [2].

Role in an action refers to the economic characteristics that distinguish assets and liabilities used in actions that do not respond similarly to alike economic events, such as materials, labor. For example, flour, owned by E, is intended as a raw material [role] for baking [action]. In the case of a sale of that flour, the exchange could be classified as *unordinary*. It is compliant with a general concept of resource modeling in UFO: "resource models both the role [mixin] an object plays in a particular context of usage as well as its allowed type" [14]. The context of usage, in UFO is defined "in the scope of a material relation (or in the scope of an event)", i.e., in economic relationship or exchange respectively. *Benefit/Sacrifice* refers to the outcome of the intended or

performed action, which increases/decreases equity. Additional identification of a portion of a resource may be required by the economic event affecting the resource/obligation; or location of the resource.

Liability/Equity is an obligation of the enterprise that cannot be avoided, to transfer a resource. Per UFO-L [18], legal modes are related to each other by a *correlation* association and are essential and inseparable parts of a legal relator. We assume the same association for the economic relator.

Economic event: is an UFO-B: Event that affects economic relationship characteristics relevant for FR (see Fig. 1 in blue).

Contract manipulation is a communicative act [4] (special kind of action) that can be used to create social modes. In COFRIS it includes contract *offer*, *inception*, *modification*, [un]*suspension* and *cancellation* events [10], performed by consensus or power.

Revaluation of economic relationships due to the changes in the environment or underlying object impairment.

Reclassification of economic relationships due to changes in the environment or in the allowed or intended actions of the enterprise.

Economic transaction is an exchange whereby an economic agent *transfers* one resource/obligation to obtain another for a gain in use value. Contains two opposite processes of partial, distinct and complete transfer, usually between the provider, that fulfills its contract obligations and the customer who settles its liabilities – customer's obligations enforced by provider's transfer. Generally, it is impossible to precisely allocate all the input and output resources/obligations for the exchange, therefore, only direct flows are accounted for within the exchange hierarchy, the upper level of which is the exchange activities of an enterprise with society in large for a reporting period. Particular exchange either *fulfils* an obligation, *settles* a liability or *recovers* an asset in either the planned or an alternative way. The agents of the parties of exchange are those of the contract or their assigned agents who act in planned or alternative roles, such as debtor and creditor.

Example 1. Flour owned by an economic agent C1, has an exchange value, and is transferable. That constitutes a disposition for the exchange manifested by a purchase by enterprise E. The exchange fulfills C1's contractual obligation to deliver and E's obligation to pay. The purchase creates a resource for E, with a new disposition for usage in the baking activity, and this resource, in the *role* of a raw material, is consumed in exchange for producing a pizza, that is then in turn sold to the economic agent C2, manifesting the sale disposition. Here the purchase, production and sale are exchange events, while flour and pizza are endurants – underlying objects of other endurants – economic relators representing ownership and contractual rights and potential economic benefits.

Relator Phases are listed in Fig. 1 in pink. In accordance with [7] status classes modeling constrains the evolution of an instance's membership in a type along its lifecycle and generally includes four phases: *intended* (scheduled), *recognized* (active), *suspended*, *derecognized* (disabled/inactive).

Contract phases: The reciprocity economic relationship in its lifecycle progresses through phases by exchange events as depicted in Fig. 1. Neither UFO-S, nor REA regard liabilities as separate objects as required by FR. Our model of commitments/claims initially [12] was grounded on the service lifecycle model in UFO-S [13], adapting UFO-S patterns and including the partial and complete (realization) transfer phases. However, our interpretation of [economic] commitment is different from that in UFO-S and REA.

We regard commitment as a reciprocity and a disposition of exchange, but not as a separate promise of a standalone transfer. While the later are possible (as e.g., altruism), in the economical realm they are regarded as exceptional. The economic actions are motivated not by standalone commitments as stated in UFO-S and REA, but by the expected result of future exchanges. A further distinction from REA is that the liabilities or REA: Claims are not "imbalances of a duality" [9], but separate objects that may be revaluated or reclassified for FR. Phase dispositions describe all further phases, e.g., the offerings describe not only delivery, but also negotiation.

Offering phase is formed by a contract offer event as a meta-commitment by a provider to a customer, to exchange. The offering may further enter into the *negotiation* phase or become *expired*. Offerings are also a source of market valuation (prices) and should be part of [often public] smart contract offerings in the shared ledger.

Fulfillment phase begins with the contract inception event and persists while the partial provider and customer obligation fulfillment events reach *distinct obligation fulfillment* and ends when the provider reaches *complete obligation fulfillment* specified by the contract. Per IFRS, a provider may recognize *revenue* for transferring distinct resources. To illustrate, we will use the example from IFRS 15 [2] with some modification:

Example 2. E, a software developer, contracts with a C to transfer a *complete* bundle that comprises: a software licence; an installation service; updates and technical support for a one-year period. E sells the licence, installation service and technical support separately. The software remains functional without the updates and the technical support. Per [2], E determines that the obligation to transfer the licence is not separately identifiable from the customized installation service. Thus, the software licence transfer only partially fulfils the obligation and forms a contract asset, but not an unconditional liability of the customer (receivable); and the payment for the licence only partially fulfills the customer's obligation and forms a contract liability, but not a payable. The license and the customized installation service are not *distinct*. At the same time, E concludes that the software updates and technical support are *distinct* from the other obligations in the contract, because they may be performed by other enterprises.

Settlement phase begins when the provider has accomplished complete fulfillment of its contract obligations and an unconditional *complete customer liability* is accrued. This phase is exemplified by accounts "Payables for purchase of energy", "Receivables from the rental of properties". Liabilities may also arise without the preceding phases (e.g. by statutory or court decisions). Liability accrued is settled in the *Liability settlement* phase; and occasionally may have a *Distinct liability settlement* phase. Customer liability usually refers to the most homogeneous resource - cash. The determination of liabilities can be subtle. as laid out in [2]. The *Obligation or Liability expired phase* occurs when those are not fulfilled/settled at a specified timing.

Recovery phase begins with the obtaining of control of the received asset by the customer. Within a complete asset lifetime, the distinct parts that have their own lifetime may be recognized with particular recovery plan as e.g. property, plant and equipment that needs to be reported per IAS 16 [2].

4. Shared Ledger and the Financial Reporting Process

In a **Shared ledger**, [multiple copies of] the economic contract and transaction ledgers are held by different parties, with data being added by consensus. As a result, a shared

ledger can provide gains in efficiency, trust and data reconciliation across all ledger participants. The shared ledger is a part of a common ledger, where data may be added by power or for information. In [11] the Essential business ontology for Blockchain (shared ledger) was developed, that is further extended for financial reporting purposes and grounded on COFRIS in this article. *Disintermediation*: Economic agents, can interact directly, without the need for an intermediary, including the ability to initiate direct transactions on digitized resources, which may be a cryptocurrency or a digital representation of real-world resources, such as land titles and collaterals.

Information sharing in the ledger is selective, ranging from global, i.e., among all members of society in large, to particular – among contractual group members, or a party and a counterparty, or participants within an enterprise. Sharing may be informative, i.e., unilaterally disclosed by an economic agent, or obtained in consensus. Sharing may be enabled on the type or instance level. Parties may have unshared sensitive or subjective information. *A* [*Digitized*] *resource or token*: represent the valued rights of an agent (for an underlying object) which can be transferred to a counterparty by simply transferring the token. For referenced [not Digitized] resource the transfer can be a representation of another action of rights transfer or it can effectuate the rights transfer itself (depending on legal context). Digitized resources and consensus are eliminating the need for reconciliation. Economic relationships are represented by referenced or digitized resources, and reciprocities by smart contracts or their offerings in a shared ledger.

The accounting interpretation of the contracts may be different for each party. The goal should be to obtain more consensus for assets/liabilities and resource/obligation interpretation in the contracts. Accounting in many cases does not directly capture the counterparty as the transferee/transferor of resources, but only as the debtor/creditor of the reciprocal liabilities. In a shared ledger, the requirements are stricter – the captured exchanges and reciprocities should be in mutual and possibly - public consensus.

We outline the process of FR in a shared ledger environment for a participating enterprise as consisting of the following activities:

1. Smart contracts (and contract offerings) of economic agents, containing mutual (unilateral) commitments, including information sharing specification, and IFRS relevant characteristics are added to a shared ledger by consensus of the parties.
2. Transactions of digitized resources/obligations are unchangeably recorded by consensus in a shared ledger, completely or partially fulfilling the smart contracts. Transfers together with accrual of liabilities caused by transfers, are accounted within smart contracts, including information sharing and IFRS relevant characteristics.
3. The effects of transactions involving resources/obligations are [de]recognized as assets/liabilities per IFRS requirements and enterprise policies in the shared or in the individual ledger part, according to information sharing specification.
4. FR relevant information gathered in activities 1 through 3 is abstracted to the type level, hiding sensitive instance details and forming an enterprise's multi-dimensional cube within global FR system.
5. The multi-dimensional cube is then aggregated, calculated, viewed, and mined per the IFRS Taxonomy requirements and financial reports are issued.

Example 3. E, a construction company, enters into a cost-plus smart contract with a customer D to build an object. D reimburses E for all its *allowed* expenses plus an additional variable payment that allows E to make a profit. E contracts with the subcontractors and vendors Ss and allows these contracts and contract transactions [complying to IFRS requirements] to serve as inputs to the contract with D, sharing with

D [and the global FR system] all the required details in consensus with Ss, possibly omitting the names of Ss. Furthermore, in consensus with D, shares all the required and non-sensitive details of the contract with D with the FR system. During the warranty period, D shares all relevant transactions involving the built object with E. This set-up benefits from having a single source of truth, simplifying administrative and control procedures, and the possibility of semi-automated execution of the smart contract.

5. Preliminary Ontological Analysis of the IASB Conceptual Framework for Financial Reporting

Based on the ontology defined above, we can make some preliminary analysis of the paragraphs of Conceptual Framework for Financial Reporting.

Objective and Usefulness of FR. Elements of Financial Statements. While FR is based on transactions and other events, the concepts (e.g., elements) and standards are defined about presentation and the disclosure of information in specific locations of financial reports. In a shared ledger, to improve the qualitative characteristics of FR, *financial meaning* for the transactions should be captured, reconciled and validated mostly automatically and at the time when this meaning is created, i.e., starting at intentional phases of reciprocity. Thus, the concepts should primarily concern offerings, contracts, transactions and other events (all qualitative characteristics of FR [1]), regarding aggregation and location as important for perception, but as secondary issues. If financial information is to be useful, it must be relevant and faithfully represent what it purports to represent. The usefulness of financial information is enhanced if it is comparable, verifiable, timely and understandable and will improve by having upper level explanations and a shared ledger. Digitized rights/obligations, smart contracts and transactions bear a qualitative difference for FR, similar to *audited* information, thus it is relevant to classify the shared ledger supported objects separately from each other.

Economic resources, Assets and Liabilities. CF, with whom we mostly agree for basic definitions of assets and liabilities, defines classification as the sorting of assets, liabilities, equity, income and expenses on the basis of shared characteristics. Such characteristics include the nature of the item, its role (function) within the business activities and how it is measured. These characteristics overlap with ours, but lack *timing, prospects, impairment, provision, quantity etc.* as a first-class concepts.

The *correlation* association in para 4.25 of [1] is expressed as: If one party has an obligation to transfer an economic resource (a liability), it follows that another party (or parties) have the right to receive that economic resource (an asset). but in para 4.26: A requirement for one party to recognise a liability (or asset) and measure it at a specified amount does not imply that the other party must recognise the corresponding asset (or liability) or measure it at the same amount.

In the context of a shared ledger, we will name the principle in para 4.25 as the *correlative principle*. Para 4.26 substantially undermines it, making it generally impossible to regard one economic relationship as common to all mediating parties. Having obtained consensus on relationships is an important feature which greatly improves FR faithfulness and reasoning and should be enforced by standards. Of course, after initial recognition and measurement, that relationship may gain specific internal features, however, the mutual relationship should be immutable. E.g., the new Lease standard IFRS 16 [2] states that "it is not essential that the lessee and lessor accounting models are symmetrical", noting the costs of lessor's accounting as the primary reason.

Such costs are not incurred when using a shared ledger, in which the lessor may see the lessee's information, while the benefits are in observing the state and changes of the lessor's resources.

FR requires individually valuating and classifying the economic relationships. If these relationships are initially in consensus in the shared ledger, the only way to ensure further consensus is for both parties to revalue based on the same market price, or to coordinate their reclassification based on a smart contract or regulation by IFRS.

Example 4. In a shared ledger environment, an EU resident E has a USD debt to the U.S. company C, the debt value in USD doesn't change, but E revaluates it periodically to EUR for FR, using an E specific exchange rate from a bank. Furthermore, C may reclassify this debt as an *overdue* receivable, this fact should possibly be reconcilable with the E. Valuation is forward-looking while the transaction captures historical information.

Executory contract. The definitions of executory contracts in [1] roughly conform to our contract fulfillment model in Section 3, but lack concrete disclosure/recognition requirements, precise patterns and phases of contract and liability fulfillment that are common to several contract standards.

Equity, income and expenses in Conceptual Framework for FR are defined in paragraphs 4.44-49: *Equity claims* are claims on the residual interest in the assets of the entity after deducting all its liabilities. *Income* is increases in assets or decreases in liabilities that result in increases in equity, other than those relating to contributions from the holders of equity claims. *Expenses* are decreases in assets or increases in liabilities that result in decreases in equity, other than those relating to distributions to holders of equity claims. Per these definitions, each economic event that changes the value of an asset or a liability, simultaneously changes the value of another economic relationship - the equity claim of the owners. The equity claim, thus, is *an endurant* and has the disposition of exchanging the value of this claim against dividends, residual assets after liquidation etc. per articles of incorporation, or other agreements or instruments. These claims may form a base for further income tax obligations; or serve for intended purposes, e.g., some will be shared and some will be reinvested or reserved, i.e., different types of endurants may be specified for different types of dispositions to future exchanges.

Meanwhile, equity claims are further classified by the type of economic event that caused the change of the asset or liability, e.g., "Fuel expenses", i.e., the event types are used as accounts. These classifications depict past performance of the enterprise and thus are *current life* or *final life events* as described in [16]. Thus, we argue that the Income and Expenses elements as changes in Equity and *endurants* are semantically overloaded by depicting economic performance events. Furthermore, economic event and disposition types are depicted in other Financial Statements [2] (Cash flow and Equity flow) and Statement Notes, but are not introduced as concepts (elements).

6. Conclusions

Financial reporting standard setting, implementation and the corresponding information system development, is at present a partially informal and long process and as exemplified by other domains, may be improved using ontological conceptual modeling approaches. That in turn may improve financial reporting information systems models.

Existing foundational and core ontologies, as exemplified by UFO ontology network usage, provide upper level patterns for representing FR concepts and

relationships. Existing domain ontologies such as the REA Accounting ontology do not provide sufficient and complying concepts for modeling FR. This paper has shown how COFRIS is addressing this research gap. Our analysis of economic relationships shows the benefits of this ontology, not only on the conceptual level but also with respect to the use of new (shared ledger) technology.

Contract economic relationship as a disposition of economic exchange events, creating new or progressing existing reciprocity lifecycle, is a fundamental and reusable pattern for capturing economic phenomena for FR. Ontological analysis allows for the explication of the core reciprocity phases and exchange types to capture full partition of the economic phenomena usable for FR. Introducing event reification per [16] should prevent income/expenses elements from semantic overloading and unify FR concepts for performance statements and statement notes. Aligning FR concepts with UFO allows for the understanding of FR concepts meaning and classification in the enterprise domain, as for instance, economic resource and assets definitions. Elaboration of correlative relations between enterprise and counterparty should lay a foundation for consensus based accounting in a shared ledger environment. As a further work, a full validation of COFRIS by modeling all IFRS standards is needed, including solving the ontology version transition problem.

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