Toward an Ontology of Commercial Exchange

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Abstract. In this paper we propose an Ontology of Commercial Exchange (OCE) based on Basic Formal Ontology. OCE is designed for re-use in the Industrial Ontologies Foundry (IOF) and in other ontologies addressing different aspects of human social behavior involving purchasing, selling, marketing, and so forth. We first evaluate some of the design patterns used in the Financial Industry Business Ontology (FIBO) and Product Types Ontology (PTO). We then propose terms and definitions that we believe will improve the representation of contractual obligations, sales processes, and their associated documents. A commercial exchange, for instance, involves mutual agreement to reciprocate actions, such as transferring money, performing a service, or transferring goods.

Keywords. Commerce, Sale, Contract, Basic Formal Ontology

1. Introduction

The proposed Ontology of Commercial Exchange (OCE) is a mid-level reference ontology built in conformity with Basic Formal Ontology (BFO) and with an initial use case of providing support for the Industrial Ontology Foundry (IOF). Our ontology relies also on the Information Artifact Ontology (IAO), and the Document-Acts Ontology (D-Acts). BFO is a top-level ontology, designed to be used as a starting point for building domain ontologies. As such, using BFO to create the commerce ontology will help to make data tagged with OCE interoperable with other bodies of data using a BFO-based ontology. The Industrial Ontologies Foundry (IOF) is a resource initiated by ontology developers and domain experts with the goal of creating, maintaining, and implementing ontologies for use in manufacturing and engineering industries [1]. The IOF project is analogous to the Open Biomedical Ontologies (OBO) Foundry, which involves some scores of ontologies guided by principles that promote interoperability [2]. Since the IOF needs to represent, for example, classes of products and services across their life cycle, including the point of sale, it requires an account of commercial entities. The aim of this paper is to provide such an account in the form of an initial delineation of the domain of the OCE.

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2. Background

Some ontologies that handle commercial entities have already been developed. Their quality and usefulness, however, vary dramatically. We briefly describe two examples.

2.1. Financial Industry Business Ontology (FIBO)

The Financial Industry Business Ontology (FIBO) is a collection of interrelated ontologies covering business and financial entities (Business Processes, Business Entities, Securities, Loans, Market Data, and others). FIBO is strictly speaking not one ontology, but rather a suite of ontologies which share no common top-level ontology but instead draw on over 40 mid-level root terms, such as 'capability', 'convention', 'occurrence', 'ownership', and so on. FIBO sees all such classes as concepts which represent "things in the world" [3].

FIBO is expressed in the web ontology language (OWL). Its main strength as an ontology is the breadth of its vocabulary relevant to the domain (broadly: the domain of financial services). FIBO describes a broad spectrum of entities. It includes low-level terms used in different fields of finance, such as 'trust', 'loan', 'futures', and so on. It also includes high-level terms such as 'role', 'relation', and 'quantity', and mid-level entities such as 'corporation', 'legal entity', 'transaction', some of which are general terms which are not unique to the field of financial services. However, FIBO was not constructed on the basis of a top-level ontology in a way that would have provided formal treatments of many of these terms. A version of FIBO exists that is aligned with BFO, but we were not able to consult this version when writing this paper.

Definitions in FIBO are provided both in natural language and by means of OWL axioms. Terms in the OWL file have subclass relations and axioms but precise differentiae are not always provided. For example, a 'service' in FIBO is defined as: 'a type of economic activity that is intangible, is not stored and does not result in ownership; a service is consumed at the point of sale' (we note the slight problem of mismatch here between instance and type – types are not consumed at the point of sale). Service also has associated axioms, as for example

> 'is provided by' only 'service provider'
>
> 'is provisioned by' only 'service provider'
>
> 'provides' some 'capability'

Unfortunately, FIBO does not assert the parent class "economic activity" anywhere in the OWL representation and it does not supply a definition. There is a term 'commercial activity' but this is defined, oddly, as "the context of carrying out trade", rather than as the activity itself that occurs in such a context.

Another FIBO term is 'product', defined as:

> a commercially distributed good that is (1) tangible property, (2) the output or result of a fabrication, manufacturing, or production process, or (3) something that passes through a distribution channel before being consumed or used.

'Product' in FIBO thus excludes information artifacts (such as commercial software or mutual funds created by the financial services industry) because they are intangible. It would thus be difficult to apply FIBO to the music, book, or film industries.

Axioms in FIBO pertaining to the class 'product' include:

'is produced by' some 'producer'

'has lifecycle' minimum 0 'product life cycle'

There is also an assertion of the disjointness of 'product' and 'service'.

Not all FIBO classes have OWL axioms indicating hierarchy or relations between instances of classes. The term 'role' has a definition, but without any associated axioms. A role is defined as: 'a set of connected behaviours, rights, obligations, beliefs, and norms as conceptualised by actors in the context of some situation'. The terms invoked in the definition, for example, 'obligation', 'behaviour', 'belief'. 'norm', 'situation', are not defined elsewhere in the OWL file. The parent term 'collection' is defined circularly as 'a meaningful collection of concepts'.

One good practice in ontology development is the provision of Aristotelian definitions, which are definitions in which a term 'A' is defined in terms of its immediate parent term 'B' within the salient ontology. The definition is then formulated according to the schema: an A is a B which Cs, where C is the relevant specific difference. Definitions of this sort have the advantage of helping the user to determine whether a given entity is an instance of a class while also explicitly indicating the position of the class within the ontology hierarchy. It also helps the ontology to remain stable as new sorts of entities of a given type are discovered, since these can be dealt with by adding further differentia.

FIBO does indeed use Aristotelian definitions. But it does not do so systematically. This means that it may be less useful for both expanding representation and promoting interoperability for example with ontologies in the Industrial Ontologies Foundry [4]. Nevertheless, FIBO brings considerable benefits by making available an open formal treatment, using OWL, of some hundreds of financial terms.

2.2. Product Types Ontology (PTO)

The Product Types Ontology is an OWL ontology, constructed with the support of the German Federal Ministry of Research (BMBF), representing the domain of products and services [5]. PTO utilizes the GoodRelations ontology, which serves as a common e-commerce schema for major websites, providing terms such as 'make', 'model', and relations such as 'offers' [6]. The developers of PTO have designed the ontology so that it will grow in a way analogous to Wikipedia. Terms are added to the ontology directly from Wikipedia pages on the basis of requests by users. This design is motivated by the idea that included terms should be relevant (popular enough to be represented) and refer to real entities (rather than fictions) [7]. The ontology was developed with a sensitivity to the distinction between universals and particulars (or more generally: classes and their members), and account for the fact that product databases released to the public often do not incorporate such a distinction when they are compiled.

For all its benefits, however, the chosen strategy is problematic, because the resultant vocabulary is not controlled either by ontology experts or by domain experts. The result is

that its taxonomies are messy, which contributes to its weak formal semantics. One of the highest nodes in the ontology is labelled "ProductOrService" [8]. While a disjunction in itself is not necessarily problematic, to use a disjunctive term such as this will make it difficult for PTO to be aligned to domain ontologies using a top-level ontology such as BFO or DOLCE, both of which take the distinction between continuants and occurrents to be foundational. Similar problems arise because PTO makes reference to qualities, roles, dates, data strings, and so forth, but does not capture the meanings of these terms systematically.

PTO brings the benefit of providing synonyms across multiple languages, and it is motivated by the goal of being widely used by having a wide scope. Terms in PTO relevant to our purposes here include some of the processes involved in an exchange, such as making an offer to sell some object. But the ontology does not itself provide any systematic set of definitions covering the commercial process domain.

3. Using BFO and BFO-conformant ontologies

OCE relies on Basic Formal Ontology (BFO), the Information Artifact Ontology (IAO), and the Document Acts Ontology (D-Acts), together with other and frequently utilized ontologies from the Open Biological and Biomedical Ontology (OBO) Foundry [9], through an ontology lookup service such as OntoBee [10] [11]. Having a commerce ontology that can easily interoperate with other domain ontologies is of particular benefit, since all commercial entities exist in elaborate networks involving also non-commercial entities (such as persons, preferences, desires, needs, activities of work and leisure, and so forth).

BFO is a realist ontology, which attempts to represent reality at the most general level [12]. Its root node 'entity' captures anything that exists. The BFO term independent continuant entity covers sub-universals such as person and planet; BFO dependent continuant entities include sub-universals such as qualities, roles, and dispositions. The latter are *specifically* dependent continuants (SDCs), which means that they do not exist apart from their independent continuant bearers.

Roles and dispositions are realizable entities, which means that they are associated with instances of processes which realize the role or disposition. Roles are realizable entities which are externally grounded. For example, the role of being a president is grounded in certain social acts and associated documents, and is realized in performing processes such as writing executive orders or vetoing bills. By contrast, a disposition is internally grounded. For example, a vase has a disposition to shatter, which is realized when the vase cracks into pieces. One commercially important type of disposition are capabilities, dispositions that provide a gradable benefit to some organism. For example the capability of your car to play music, the capability of the seeds you buy to germinate, or the capabilities of the staff in your company to do the work you hired them for [13].

The information Artifact Ontology (IAO) is a reference ontology that imports BFO. It represents the domain of information content entities, such as documents, data, symbols, and so on [14]. These entities are *generically* dependent continuants (GDCs) in BFO. Each GDC depends for its existence on some independent entity (a bearer) which bears a pattern of qualities that is copyable to other independent continuants. The pattern then concretizes the

GDC, as a document, for example, is concretized in a pattern formed out of ink on paper. Accordingly, the document's existence is not tied to any particular copy, and it exists as long as at least one copy exists. Other examples of information content entities relevant to commerce include receipts, pieces of software, lending agreement documents, and account ledgers.

BFO also represents occurrents, such as processes, which include as sub-types signing, buying, selling, manufacturing, and so on [15]. One important class of processes represented in the Ontology of Biomedical Investigation (OBI) is 'planned process', wherein some agent consciously intends to perform some activity, for example, by following some documented plan specification.

More specific to the domain of commerce are those kinds of planned processes which form what the Document Acts Ontology (D-Acts) calls 'social acts', which they define as follows:

> **Social act** =def. planned process that is carried out by a conscious being or an organization, and is self-generated, directed towards another conscious being or an aggregate of conscious beings, an organization or an aggregate of organizations, and that needs to be perceived.

For example, when someone communicates their interest in an object available for purchase, they have a self-directed goal of communicating their desire to make an exchange. This exchange will occur only if certain conditions are satisfied, including that the offer was acknowledged and its terms were found acceptable. The information entities involved in these social and legal contexts are represented in the Information Artifact Ontology (IAO), which includes terms representing entities such as documents, data, graphs, symbols, and so forth.

The D-Acts ontology is designed to deal with those cases where information is communicated via social acts in order to change social expectations. The ontology extends IAO's representation of social and legal entities to those created and regulated through acts of using documents. Consider for example writing and signing a document that lays out the terms and conditions for living in an apartment (a lease). This creates an *obligation* between the renters and the landlord. The renters and the landlord have their respective roles because the signing of the document resulted in a change in social reality. Contracts, bills, invoices, and currency are all examples of documents that can be used to bring about changes of this sort, and document acts will accordingly play an important role in OCE.

4. Towards an Ontology of Commercial Exchange

Central to commercial exchanges are labor and ownership, the activities of obligating and performing labor, the activities of acquiring or transferring properties, and the dynamic social arrangements that are either presupposed or generated by these activities. All of these entities figure in a variety of contexts, whether in the finance, real estate, or retail industries, in economic theories, or in commercially relevant events in the lives of individuals and households. The basic activity we will focus on here is the act of trading, which is to say the exchanging of goods (including money) and services.

Many consider the exchange of tangible goods to be the paradigmatic case of trading [16, p. 3]. For example, one person may prefer some apple over some amount of money which he currently possesses, where another may prefer some amount of money over an apple. The parties come to an exchange when they voluntarily give up their respective possessions to acquire new ones. Some think that all other commercial exchanges can be analyzed with reference to this common case, including commercial exchanges involving intangible goods such as property rights and software, or involving services such as teaching or hairdressing.

The trading of material objects may be the more common example of exchange, but there are problems with the assumption that all exchanges involve the exchange of material objects. Indeed the exchange of instances of action types (transferring, serving, and so forth) is for some purposes a better contender specification of what is common to all exchanges [16, p. 20]. On any view, an act of trading is a *social act* since it involves (1) conscious processes on the part of individuals and (2) a component of registration or acknowledgment (acts of trading are contrasted in this respect with, for example, social acts of cursing or forgiving) [17].

OCE focuses on modern commerce based on acts of trade using currency, while still aiming to capture the entities and relations that are present within any kind of commerce whatsoever. It is a mid-level ontology, which means that it will not include domain specific terms for use in particular industries or branches of industry, for example, marketing or real estate, which will be dealt with at a later stage.

There are different kinds of continuant entities which can be exchanged in an act of commercial exchange. First, there are two kinds of products: material products, on the one hand, such as laptops and loaves of bread; and GDC (immaterial, intangible) products, on the other hand, such as software, data files (for example a file capturing your genome), and digital images. Second, there are two kinds of money: material money, on the one hand, such as the coins in your pocket and the banknotes in your wallet; and GDC money on the other hand, such as the money in your computerized bank account [18].

When money of either kind is exchanged for services, then this can be either after the service has been provided – when the money is transferred in direct payment for the service; or it can be transferred in advance of the service provision – when what is being paid for are in effect certain rights to have the service provided at some time in the future. Close inspection of those cases where a GDC product is purchased show that it is rights (for example the right to make copies, the right to use a certain concretization of the GDC product in one's computer) that are being purchased in this case also. This brings a certain unity in the account since, as pointed out by Massin and Tieffenbach [16], all acts of commercial exchange involve the provision of services (the buyer, for instance, performs the service to the benefit of the seller of *giving him money*) and all involve transfers of rights.

4.1. Document Acts and Deontic Roles

Commerce is a social phenomenon, whose activities both create new entities and change the relationships between existing entities. As an agent contracts with an employer to perform valuable labor, he acquires a new role and becomes an employee. As a customer purchases a

good, she becomes an owner. As an aggregate of agents comes together to create a corporation the latter may itself enter into various contracts. Our proposed ontology will cover all entities of these sorts, including the processes which account for their creation, their persistence, their ceasing to exist, and (for example) their possession of ownership and other commercially relevant rights.

As an outgrowth of speech act theory, the Document Acts Ontology (D-Acts) is a social ontology that represents those aspects of social reality and those social interactions which involve documents. Speech acts are acts performed through speech, such as promising, nominating, pronouncing, declaring war, and so on [19] [20] [21]. For a speech act of a given type to occur, certain success criteria, also known as felicity conditions, must be satisfied. For example, a promise to return borrowed money to occur requires communication with the promisee (the lender), and that the speaker (the borrower) be sincere.

Document acts are analogues of speech acts, and often involve a speech act component, but they essentially involve also one or more documents [22] [23]. Examples are: issuing a receipt, signing a delivery note, posting a list of prices. The D-Acts ontology covers (i) those scenarios in which documents provide the ground for claims and entitlements; (ii) how the latter are created and maintained, and (iii) the entities involved in the associated social networks. A 'deontic role' is defined in D-Acts as follows:

> **Deontic role** =def. role that inheres in an agent and which is externally grounded in the normative expectations that other agents within a social context have concerning how that agent should behave.

Roles as thus defined are grounded in something outside the continuant that bears the role. (In this they are contrasted with dispositions – for example your disposition to sleep, to go bald, to speak English.) Thus, a role may change without any physical change in the bearer, unlike a disposition or a quality, as for instance where an employee has been fired but has not yet been informed of this fact. The role depends on the specific bearer, but the realization of the role involves the wider context in which the role and its bearer exist. Typically, such realization also involves some sort of trigger (another process, like the realization itself, of a type associated with the type of role in question). The use of 'expectation' in the definition is not descriptive – for example a matter of statistics – but normative or prescriptive. When an agent is expected to behave one way or another, this means that there are norms that determine the realization conditions of the role that the agent bears [24].

If an agent has an obligation, according to the D-Acts approach, then this is to say that the agent bears an obligor-role. To realize this role – and thus to fulfil the obligation – is to instantiate the action type that is normatively expected to occur for an obligation of the corresponding type, to do this in the appropriate circumstances, with the appropriate intentions, and so forth. Failing or refraining from performing the relevant action type generates a reason to sanction the agent.

The key difference between speech acts and document acts rests on the fact that, while documents are the instruments of communication, they persist beyond their initial use, where speech is in the normal case merely remembered in the minds of the hearers [25]. (If the audio is recorded, then the resulting audio file has the properties of a document.) This difference between speech acts and document acts is significant because a document will have many other uses after its initial creation, for example as an authoritative record of what occurred.

Documents are critical to the flourishing of a society [26] [27], not only because managing obligations and ownership are difficult when relying solely on speech and memory, but also because successive layers of documents – for example mortgage contracts, insurance policies – can bring into being new avenues for the creation of wealth.

Since speech acts *occur* (they are occurrent entities in BFO terminology), they are evanescent. They do not undergo change but are rather themselves a form of change. Documents, in contrast, persist through time and can undergo different sorts of changes, being signed, stamped, registered, stored, amended, attached to other documents, held as security on a loan, serving as means of payment, and so forth. Speech acts and document acts also admit of different felicity conditions; a document, for example, may be forged; speech can be clarified by questions at the moment when negotiations occur; the formulations used in documents are stable; speech requires the audience to be present at the moment of utterance; a document may be widely distributed and include many people who are able to vouch for its authenticity. Even with all of these differences, however, documents may be used to perform many of the same actions as were in earlier times performed by speech – proposals for terms of sale, confirmation of acceptability of terms, requests for payments, confirmation of received payment, warnings of sanctions on insufficient payment, and so on. This broad repertoire will only become broader as paper documents progressively give way to digital documents, and in some cases to dynamic digital documents which – like your on-line tax form – have inbuilt software layers.

Examples of definitions in the D-Acts ontology are:

Deontic declaration =def. social act that creates or revokes a deontic role

Deontic document act =def. deontic declaration creating or revoking a deontic role by lawfully manipulating (signing, stamping, publishing) a document

Deontic power role =def. deontic role that, if realized, is realized in the creation, modification, or revoking of other deontic roles.

4.2. Ownership

Ownership is normally presented as a kind of relationship between a conscious being and an independent continuant entity such as a car or a house. The conscious being, i.e., an agent, is an owner of some piece of property if and only if the agent bears a certain kind of role, namely an owner role. Similarly, a valuable good might bear a 'property role' when it is owned by some owner. When 'role' is understood in BFO terms, the *owner role* entity is a specifically dependent continuant that is realized in one or other of the processes typical of ownership, such as accessing, using, consuming, sharing, storing, destroying, renting, bequeathing, gifting, and so forth.

This view must account for the fact that dependent continuants, such as pieces of software, or shares of stock, are also capable of being owned, and thus also of being purchased, sold, and so forth. Matters here are not entirely clear, however. For normally we do not own the specifically dependent continuant (SDC) that is the pattern of qualities on a CD or hard drive, but rather the GDC that this SDC concretizes. Thus we may be able to make copies of our software, providing these are for personal use, and this in turn suggests

that what we do not own the GDC either, in such a case, but rather that we have purchased a certain set of associated rights.

Otte et al. [28] propose that ownership in general and ownership of digital goods in particular can be represented utilizing what in the Common Core Ontologies is called a "stasis" [29], defined as an occurrent which exists/occurs during a certain period of time in which it does not change for a duration of time, for example the process of an apple's being on a table for a certain period. A song may be owned, for example, when it participates in a stasis of ownership, which occurs at a location and for a certain time.

4.3. Contractual Obligations

Contracts are deontic agreements. When agents make agreements together about certain obligations the parties have in relation to each other, we say that they place themselves in a contractual relationship. This relationship is then a relational quality, in BFO terms, with the parties to the contract as its bearers. The parties also bear corresponding deontic roles. The process of creating a contract may involve sub-processes such as negotiating the terms of the contract, stipulating expectations on the part of either party, acts of consenting to these terms, and so forth. Outputs of the contracting process then include not only the contract itself (and often an associated document), but also deontic roles regarding the time when each party is to behave and how they are to behave, together with certain relational qualities – such as marriage bonds – which join them together socially.

While handshakes and other gestures were historically sufficient for a contractual relationship to obtain, in modern contracts documents and signatures (including digital signatures) are typically used. The documents used are often based on prior documents, which serve as templates, thereby allowing terms of each contract to be spelled out more fully and reliably by incorporating lessons learned from the consequences of the shortcomings of previous contracts. The document used in a contractual agreement and the contract itself are now so tightly associated that in common parlance 'contract' often refers to the document which was used in the deontic act of contracting (and now serves as a record thereof). In a commerce ontology, clearly, terms are needed for both, for example because the document may outlast the agreement itself, and because the document may need to be preserved for historical purposes.

A core term in OCE is that activity of commerce in which parties mutually agree to perform some respective actions.

> **Act of commercial exchange** =def. social act involving two parties in which each party transfers something of value to the other party, either a good or a service, and in which relevant deontic roles begin to inhere in one party or the other.

The notion of transfer or exchange may be taken as a primitive in that it cannot be defined into other, logically simpler terms, since it is neither reducible to movement of goods nor committed to a specific sequence (or simultaneity) of actions involved. The notion of exchange can include such cases as performing an action on behalf of a party in return for the performance of some other action by another party. For simplicity's sake we here confine our attention to cases involving only two parties, which may be individuals or organizations.

4.4. Acts of Buying and Selling

When an act of commercial exchange occurs, even one involving the exchange of some material good for some amount of money, then certain processes take place – acts of transferring, buying, selling, confirming, and so forth. The latter are all occurrents and they may be understood in terms of the provision of services. For example, if Jones and Smith agree to exchange an apple for an orange, then Jones is obligating himself to perform a service (the act of transferring the apple to Smith) where Smith is obligating himself to perform an equal and reciprocal service (the act of transferring the orange to Jones). According to this scheme, they each acquire deontic roles whose realizations are determined by the agreements made. The result of both parties fulfilling their obligations is a new arrangement of ownership, such that Jones now owns this orange and no longer owns that apple.

Trades need not require such symmetry of exchanging one material object for another material object, because one party may trade their object for another party's services. Both parties acquire an obligation to perform a service within an appointed time frame (even if this time frame is left vague within the contractual arrangement of the exchange) – again, to be understood in terms of a deontic role). Where the former party gives up ownership, the latter relinquishes time and effort which could have been spent on some other activity. (Performing the service has what is called an opportunity cost.)

The basis for OCE will then be terms such as:

> **Act of payment** =def. social act in which one party transfers an amount of money to another party, wherein the agent relinquishes ownership thereof and the other party acquires ownership thereof.

> **Act of buying** =def. act of payment that is a part of an act of commercial exchange in which the complementary part is an act of selling

> **Act of selling** =def. social act involving the transfer of some good that is part of an act of commercial exchange in which the complementary part is an act of buying

Here act of buying and act of selling are provided with definitions, but they nonetheless must be treated as complementary (taken together the definitions are circular). It should be emphasized that not all commercial exchanges involve acts of payment. For example, an act of bartering is one such act which involves no money as intermediary, and thus involves no act of buying and selling.

When a customer buys some object offered for sale, she makes a payment in order to acquire the object offered. Characteristic of any act of buying is that the agent who makes the payment acquires a new ownership role as a result of the act of buying and the result can be explained partially in terms of the sub-process which is an act of payment. For example, if Jones gives Smith a dollar for the apple, Jones makes a payment of one dollar, and since Jones is the agent of that act of payment Jones is now the owner of the apple. If, in contrast, Jones pays for Smith's meal at a restaurant, then even though this involves an *act of payment* on Jones' behalf, this is not an *act of buying*, since (assuming that Smith finished his meal before Jones pays) neither Jones nor Smith is an owner of that which was paid for.

Acts of buying and selling are temporally coinciding sub-processes in acts of commercial exchange. The act of selling merits separate treatment, since some acts of buying result in agents sharing the object in question and some acts of selling need no act of payment. When agents share the object bought, the process merely modifies the ownership relational quality (and the expectations associated with the owner role) rather than destroying it. Since selling does not always involve the revocation of the owner role of the one who makes the sale, the definition is uncommitted as to whether the owner's relationship to the object owned changes or is lost.

In modern commerce, the transfer of ownership is frequently assisted with instruments of payment such as cash, check, or electronic transfer. Such instruments are documents (a subclass of IAO:*information content entity*) which are specified as having some monetary value relative to some unit of currency. These documents can be concretized in metal (coins), on paper, or in computer systems. In the metal and paper (money) cases there is an independent document entity which is an amount of money which can be used to buy things with (can be transferred in an act of commercial exchange). In the computer system case the pixels on a screen or the electromagnetic excitations on a server merely *represent* money [18]. They are thus information entities that are associated with deontic (socio-legal) powers (rights) wielded by their bearers analogous to those associated with owning metal or paper money.

Even the latter are used as medium of exchange, there are still certain felicity conditions that must be satisfied. For example, if Jones offers a dollar bill as payment for an apple, this presupposes certain entitlements on the side of the parties involved; it presupposes also that the context is one in which the metal or paper items are accepted as legal tender.

4.5. Documents Regulating the Rendering of Services and Transferring of Goods

In virtue of their status as social acts, acts of commercial exchange require processes of communication in order to take place. These may be speech or document acts in which one human intentionally communicates some information content to another human. But they may also be purely digital transfers of information in which no human is involved.

Acts of trading, price quoting, and invoicing are often communicated by means of documents of various types. Just as contracts facilitate negotiation of agreements, so there are supporting documents that facilitate a variety of other commercial processes. Here we enumerate some common activities and associated documents to be included in the ontology of commercial exchange.

> **Price quote document** =def. document that has as part some plan specification for some planned process which is a sub-process of some act of commercial exchange and prescribes some act of payment for performance of that process

> **Act of price quoting** =def. social act which has output some price quote document

> **Invoice document** =def. document about some planned process that has part some plan specification and which prescribes some act of payment for a past realization of that planned process

Act of invoicing =def. social act which has output some invoice document

Whereas price quoting is typically forward looking, anticipating the performance of actions according to a plan specification, invoicing is typically retrospective in that it refers to specific instances of planned processes which have occurred already. The invoice document that results from an act of invoicing prescribes normative expectations of payment on the part of the addressee of the invoice.

Receipt document =def. document which asserts in the name of the recipient that some entity has been received

Payment confirmation document =def. receipt document which asserts that the output of some act of payment has been received

Finally, communication of successful transfer is common in commerce. The most generic confirmation document merely confirms that a good or commodity has arrived or been accepted. For example, an email stating that a package has arrived and has been signed for by the recipient is one such receipt document. One critical subclass of such documents is a document of payment confirmation, which states that an act of payment has occurred. This document may be used in a document act to release of the party of some obligation. For example, a credit card company may send an SMS notification that the amount the customer paid was posted.

5. Conclusion

The above represents a first draft in the development of a future Ontology of Commercial Exchange, further parts of which will be built in tandem with on-going ontology work within the framework of the Industrial Ontologies Foundry and related initiatives.

References

[1] "Industrial Ontologies Foundry," Available at: https://www.industrialontologies.org. [Accessed 14 August 2019].

[2] B. Smith and e. al., "The OBO Foundry: Coordinated Evolution of Ontologies to Support Biomedical Data," *Nature Biotechnology,* vol. 25, p. 1251, 2007.

[3] "EDM Council - FIBO Specifications," Available at: https://spec.edmcouncil.org/fibo/. [Accessed 14 June 2019].

[4] "Industrial Ontologies Foundry," Available at: https://www.industrialontologies.org/. [Accessed 14 June 2019].

[5] "The Product Types Ontology: Class Definition for 'Retail'," Available at: http://www.productontology.org/doc/Retail. [Accessed 14 June 2019].

[6] M. Hepp, "GoodRelations: The Professional Web Vocabulary for E-Commerce," Available at: http://www.heppnetz.de/projects/goodrelations/. [Accessed 14 June 2019].

[7] M. Hepp, K. Siorpaes and D. Bachlechner, "Harvesting Wiki Consensus: Using Wikipedia Entries as Vocabulary for Knowledge Management," *IEEE Internet Computing,* vol. 11, no. 5, pp. 54-65, 2007.

[8] M. Hepp, "GoodRelations: An Ontology for Describing Products and Services Offers on the Web," *Proceedings of the 16th International Conference on Knowledge Engineering and Knowledge Management (EKAW2008),* vol. 5268, pp. 332-347, 2008.

[9] "The OBO Foundry," Available at: http://www.obofoundry.org/. [Accessed 14 June 2019].

[10] E. Ong, Z. Xiang, B. Zhao, Y. Liu, J. Zheng, C. Mungall, M. Courtot, A. Ruttenberg and Y. He, "Ontobee: A linked ontology data server to support ontology term dereferencing, linkage, query, and integration," *Nucleic Acid Research,* vol. 45, no. D1, pp. D347-D352, 2017.

[11] "Ontobee," Available at: http://www.ontobee.org/. [Accessed 14 June 2019].

[12] R. Arp, B. Smith and A. D. Spear, *Building ontologies with Basic Formal Ontology*, Cambridge: MIT Press, 2015.

[13] E. Merrell, D. Limbaugh, A. Anderson and B. Smith, "Mental Capabilities," in *Proceedings of the International Conference on Biomedical Ontology (ICBO)*, Buffalo, NY, 2019.

[14] B. Smith, T. Malyuta, R. Rudnicki, W. Mandrick, D. Salmen, P. Morosoff, D. Duff, J. Schoening and K. Parent, "IAO-Intel: An Ontology of Information Artifacts in the Intelligence Domain," in *Proceedings of teh Eighth International Conference on Semantic Technologies for Intelligence, Defense, and Security (STIDS 2013)*, Fairfax, VA, 2013.

[15] P. Grenon and B. Smith, "SNAP: and SPAN: Towards Dynamic Spatial Ontology," *Spatial Cognition and Computation,* vol. 4, no. 1, pp. 69-104, 2004.

[16] O. Massin and E. Tieffenbach, "The Metaphysics of Economic Exchanges," *Journal of Social Ontology,* vol. 1, no. 2, pp. 167-205, 2017.

[17] K. Mulligan, "Promisings and other Social Acts: Their Constituents and Structure," in *Speech Act and Sachverhalt: Reinach and the Foundations of Realist Phenomenology*, Dordrecht, Nijhoff, 1987, pp. 29-90.

[18] B. Smith and J. Searle, "The Construction of Social Reality: An Exchange," *American Journal of Economics and Sociology,* vol. 62, no. 2, pp. 285-309, 2003.

[19] J. L. Austin, *How to Do Things with Words,* Cambridge: Harvard University Press, 1962.

[20] J. Searle, *Speech Acts: An Essay in the Philosophy of Language*, London: Cambridge University Press, 1969.

[21] J. Searle, *The Construction of Social Reality*, New York: Free Press, 1995.

[22] B. Smith, "How to Do Things with Documents," *Rivista di Estetica,* vol. 50, pp. 179-198, 2012.

[23] M. Brochhausen, M. B. Almeida and L. Slaughter, "Towards a Formal Representation of Document Acts and the Resulting Legal Entities," in *Johanssonian Investigations: Essays in Honour of Ingvar Johansson on His Seventieth Birthday*, De Gruyter, 2013, pp. 120-139.

[24] B. Donohue, "Toward a BFO-Based Deontic Ontology," in *International Conference on Biomedical Ontology (ICBO)*, Newcastle upon Tyne, UK, 2017.

[25] B. Smith, "Document Acts," in *Institutions, Emotions, and Group Agents: Contributions to Social Ontology*, Dordrecht, Springer, 2014, pp. 19-31.

[26] H. de Soto, *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*, New York: Basic Books, 2000.

[27] B. Smith, D. M. Mark and I. Ehrlich, Eds., *The Mystery of Capital and the Construction of Social Reality*, Chicago: Open Court, 2008.

[28] J. N. Otte, D. Kiritsi, M. M. Ali, R. Yang, B. Zhang, R. Rudnicki, R. Rai and B. Smith, "An Ontological Approach to Representing the Product Life Cycle," *Applied Ontology,* vol. 14, no. 2, pp. 1-19, 2019.

[29] "The Common Core Ontology (CCO) Repository," Available at: https://github.com/CommonCoreOntology/CommonCoreOntologies. [Accessed 14 June 2019].

[30] B. Smith and e. al., "BFO 2.0 Reference Manual," Available at: https://raw.githubusercontent.com/BFO-ontology/BFO/v2.0/BFO2-Reference.docx. [Accessed 14 June 2019].