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Title: Information technology — Business Agreement Semantic Descriptive Techniques
Part 4: Business Transactional Scenarios -- Accounting and Economic Ontology

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Project Editor's Notes

Coordination of this work with evolving ontology work and evolving standards in ebXML and UN/CEFACT

The contents of this work are being governed and aligned with work in both the academic and the standards community.

- The primary academic standards for this document are the series of REA Model papers contained on the following website:

  http://www.msu.edu/user/mccarth4/rea-ontology

  These papers are individually referenced in an informative annex that describes the REA model.

- The primary standards documents are:

  - **ebXML Business Process Overview**
  - **ebXML Business Process Worksheets**
  - **ebXML Catalog of Common Business Processes**
  - **UN CEFACT Common Business Process Catalog Specification**
  - **UN CEFACT UMM User Guide**

2. Work Plan

Stage	Date
WD	2002-09
CD	2004-01-29
FCD	2005-07-13
FDIS	
IS	

3. Standard ISO/IEC Presentation Format

Time/resource constraints did not permit the addition of standard ISO/IEC presentation of this draft. This work will be completed as part of further document preparation.

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Contents

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 15944-4 was prepared by Joint Technical Committee ISO/IEC JTC JTC1, *Information Technology*, Subcommittee SC 32, *Data Management and Interchange*.

ISO/IEC 15944 consists of the following parts, under the general title *Information Technology — Business agreement semantic descriptive techniques*:

Part 1: Operational aspects of Open-edi for implementation

Part 2: Registration of scenarios and their components as business objects

Part 3 : Open-edi description techniques

Part 4 : Open-edi business transaction ontology

Part 5: Identification and mapping of various categories of jurisdictional domains as external constraints

0. Introduction

0.1 Purpose and Overview

This work is motivated with important ideas from the ISO Open-edi specifications as represented in ISO/IEC 15944-1: *Information technology -- Business agreement semantic descriptive techniques - Part 1: Operational aspects of Open-edi for implementation.* In that document and in some of its earlier foundational expositions – such as ISO/IEC 14662: *Information technology – Open-edi reference model* -- there were important concepts defined and interrelated such as business transaction, fundamental activities of a business transaction, commitment, Person, role, scenario, and others. A need for relating all of these concepts in a formal framework for the Open-edi work is apparent.

This is a question of ***ontology*** -- a formal specification of the concepts that exist in some domain of interest and the relationships that hold among them.[1] In this case, the domains of interest are those that encompass Open-edi activities; that is: law, economics and accounting in an extended sense – not the internal accounting of one particular firm, but the accountabilities of each of the participants in an external business transaction.

Ontologies are generally classified as either *upper-level ontologies* -- dealing with generalized phenomena like time, space, and causality -- or domain ontologies – dealing with phenomena in a specific field like military operations, manufacturing, medical practice, or business. The economic and accounting ontology being used in ebXML, in the UN/CEFACT modelling methodology, and ECIMF work is entitled the ***Resource-Event-Agent Ontology***, or ***REA***[2]. REA is used here as an ontological framework for specifying the concepts and relationships involved in business transactions and scenarios in the Open-edi sense of those terms. The resulting framework is titled the Open-edi business transaction ontology (OeBTO).

The REA ontology is actually an elementary set of concepts derived from basic definitions in accounting and economics. These concepts are illustrated most simply with a UML class diagram in Figure 1 which illustrates the simple Resource-Event-Agent structure that gives REA its name. A business transaction or exchange has two REA constellations joined together, noting that the two parties to a simple market transfer expect to receive something of value in return when they trade. For example, a seller, who delivers a product to a buyer, expects a requiting cash payment in return.

There are some specific points of synergy between the REA ontology and the ISO Open-edi specifications as represented in ISO/IEC 15944-1 *Information technology -- Business agreement semantic descriptive techniques - Part 1: Operational*

1 Thomas Gruber (1993) "A Translation Approach to Portable Ontologies," Knowledge Acquisition, pp. 199-220

2 Elements of the REA ontology as they are used in other standards work are explained in Informative Annex 8 in this document.

aspects of Open-edi for Implementation.

> *Term 3.9: Commitment – The making or accepting of a right, obligation, liability, or responsibility by a person.*
> Commitment is a central concept in REA. Commitments are promises to execute future economic events -- for example to fulfil an order by executing a delivery event.
>
> *Rule 1: Business transactions require both information exchange and commitment exchange.*
> REA firmly agrees with and helps give definition to this assertion. Reciprocal commitments are exchanged in REA via economic contracts that govern exchanges, while information exchange is tracked via business events that govern the state transitions of business transaction entities that represent various economic phenomena.
>
> *Rule 39: Conceptually a business transaction can be considered to be constructed from a set of fundamental activities. They are planning, identification, negotiation, actualization and post-actualization.* For REA, actualization is the execution of economic events that fulfil commitments. Planning and identification involve business partners with types of economic resources, events, and persons, while negotiation is finalized by an economic contract which is a bundle of commitments. The UN/CEFACT Business Process Group has also defined negotiation protocols that assist in forming commitments. The Open-edi set of activities and the REA economic concepts will help each other tie together all the activities into a cohesive business transaction, and then unite that transaction definition with its related information models.

Finally with regard to the preliminary agreement between Open-edi and REA, the two major sets of ideas that characterize the Open-edi work – the specification of Business Transactions and the configuration of Scenarios – correspond well at the aggregate level to what the REA ontology calls the accountability infrastructure and the policy infrastructure. A business transaction specifies in a descriptive sense actual business events: what has occurred or has been committed to. Conversely, a scenario is more prescriptive. It configures what could be or should be. The realm of both descriptions and prescriptions is important to Open-edi and to REA, and they can work well in developing standards for each.

0.2 Ontology Definition

According to the most widely accepted definition from Tom Gruber "An ontology is a formal, explicit specification of a shared conceptualisation." [3] The individual

3 Thomas Gruber (1993) "A Translation Approach to Portable Ontologies," Knowledge Acquisition, pp. 199-220

components of this meaning are each worth examining.

- *formal* = machine-readable
- *explicit specification* = concepts, properties, relations, constraints, and axioms are explicitly defined
- *of a shared* = consensual knowledge
- *conceptualization* = abstract model of some phenomenon in the real world

At present, the REA model is certainly an explicit specification of a shared conceptualization of economic phenomena in the accounting community. A formal, machine-readable specification is not proposed in this document; however, such extensions may follow in other standards work.

0.3 Use of the "Independent" and "Trading Partner" Perspective in the Open-edi Ontology Work

In normal business use, the naming perspective for the ontological primitives would be that of the entrepreneur of one of the two trading partners engaged in collaborative commerce. The other trading partner would ordinarily have a mirror-image view. Thus a sale, a cash receipt, or a resource inflow for a particular entrepreneur would become a purchase, a cash disbursement, or a resource outflow for a corresponding trading partner. From this perspective, business events and their accompanying economic phenomena would be modelled twice, once in the database of each trading partner. However, for Open-edi purposes, or for that matter for any other independent modelling of business collaborations like the BRV level of the UN/CEFACT modelling methodology, this redundancy is not acceptable, because it allows the states of the two representations to become inconsistent. This difference in naming perspective is explained below and illustrated in Figure 2.[4]

Figure 2 illustrates three independent value chains for three different enterprises. Each company has a connected network of business processes that takes its initial input of resources (called factor inputs for their production functions) and transforms them via cumulative flows of goods, services, and cash into an output for that firm's downstream customers. For Open-edi collaboration modelling, these internal processes are not relevant until a resource flow crosses enterprise boundaries as is illustrated for Enterprise #2 which accepts materials from Enterprise #1 and which delivers materials to Enterprise #3 (most probably in both cases for cash payments in return). The two dotted lines with double-headed arrows show these inter-enterprise events.

The independent or collaboration perspective of resource flows is anchored on the view of the eye outside of Enterprise #2. This view sees both exchanges as conceptually similar with flows of materials being requited by flows of funds. Such a

4 Figures 2 and 3 were contributed by the Japanese delegation to SC 32, led by Katsuhiro Morita.

perspective is quite different than that of the eye inside of Enterprise #2 which sees the flow between Enterprise #1 to Enterprise #2 as a "purchase" and the flow between Enterprise #2 and Enterprise #3 as a "sale." Note that an eye inside of Enterprise #1 (not shown on diagram) would have modelled the "purchase" of Enterprise #2 as a "sale" of Enterprise #1, hence the redundancy and the inevitable inconsistency.

Business process modeling can take either of the perspectives shown by the eyes of Figure 2, but the independent perspective is clearly the choice for Open-edi. This leads to the concept of a business collaboration that is illustrated in Figure 3. Most generally, there is a value exchange between two Persons, with one assuming the role of a "buyer" (has money, wishes goods or services) and the other assuming the role of a seller (has goods or services, wishes money). It is also possible to anchor the independent view on time, with one event being the initiating flow and the requiting event being the responding flow. In either case, there is a possibility of having a third party in on the collaboration such as a shipment provider or an escrow agent. For internal database purposes of corporate accountability, "trading partner perspective" terms are directly derivable from "independent perspective" terms.

0.3 The "Open-edi Business Transaction Ontology" (OeBTO)

The prior two sections have suggested :

- That the components of the REA domain ontology model are sufficiently well-defined, stable, and well-known that they can clearly serve as the basis for an ontological specification of the concepts involved in collaborative exchanges between trading partners; and
- That the components of that model must be viewed from the outside perspective of a modeller viewing the economic phenomena independently.

Because the primitive economic terms are being adopted here for use with the operational aspects of Open-edi from ISO/IEC 15944-1, the ontology to be defined will be termed the "Open-edi Business Transaction Ontology" (OeBTO). Its definition is:

> A formal specification and definition of the concepts pertaining to business transactions and scenarios and the relationships that hold among these concepts.

From the definitional foundations of both ISO/IEC 15944-1and the REA model, it follows that the OeBTO will follow these principles:

- As a business transaction ontology, a distinguishing characteristic of OeBTO is that in addition to information exchange, it incorporates commitment exchange among autonomous Persons.

- An OeBTO requires the use of clear and pre-defined rules, principles, and guidelines (see Clause 5.1 of 15944-1).
- An OeBTO is neutral in terms of technology, representation, and application.
- The scope of OeBTO covers all areas of business transactions (e.g., public/private, industry sectors, international, regional, etc.).
- The semantics of the concepts represented in the OeBTO are explicitly specified and constrained.

Clause 1and Clause 2 provide scope and normative references for OeBTO. The basic OeBTO definitions are first enumerated in Clause 3, while Clause 4 provides a table of symbols and abbreviations. Clause 5 provides the *declarative* substance for this document – a set of UML class diagrams and conceptual explanations that circumscribe the Open-edi Business Transaction Ontology. Clause 6 explains the mechanics of a business transaction state machine – the procedural component of an OeBTO – while Clause 7 explains the constraint component of OeBTO – its repository for business rules. Clause 8 and Clause 9 provide an informative annex on REA model background and a set of references.

1. Scope

This Business Operational View (BOV) related standard addresses collaborations among independent trading partners as defined in ISO/IEC specification 15944-1. It applies to both binary collaborations (buyer and seller) and mediated collaborations (buyer, seller, third-party).

2. Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 14662: 2004 Information Technology - Open-edi reference model

IEC/ISO 15944-1: 2002 Information technology- Business agreement semantic descriptive techniques Part 1: Business operational aspects of Open-edi for implementation

3. Definitions

3.1
agent
a *Person* acting for another *Person* in a clearly specified capacity in the context of a *business transaction*
[ISO/IEC 15944-1:2002 (3.1)]

3.2
agreement
an arrangement of reciprocated *economic commitments* between two partners where the abstract specification of terms of trade is incomplete and not subject to legal enforcement

3.3
attribute
data representing properties of objects

NOTE: For example, a *Person* might have a name attribute, a date-of-birth attribute, and a national-identifying-number attribute.

3.4
bilateral transaction
a subtype of a *business transaction* where the Persons include only the *buyer* and the *seller*, or alternatively other *Persons* acting as *agents* for the *buyer* or *seller*

3.5
business event
an occurrence in time that partners to a *business transaction* wish to monitor or control

NOTE: *Business events* are the workflow tasks that business partners need to accomplish to complete a *business transaction*. As *business events* occur, they cause a *business transaction* to move through its various phases of planning , identification, negotiation, actualization, and post-actualization.

3.6
business location
the geographic site where an *economic event* is deemed to occur with its attendant transfer of an *economic resource* from one *Person* to another.

3.7
Business Operational View (BOV)
A perspective of *business transactions* limited to those aspects regarding the making of business decisions and *commitments* among organizations, which

are needed for the description of a *business transaction*
[ISO/ FDIS 14662:2003]

3.8
business transaction
a predefined set of activities and/or processes of *Persons* which is which is initiated by an *organization* to accomplish an explicitly shared business goal and terminated upon recognition of one of the agreed conclusions by all the involved *organizations* although some of the recognition may be implicit
[ISO/ IEC 14662:1997 (3.1.4)]

NOTE: *Business transactions* may normally proceed through five process phases: Planning, identification, negotiation, actualization, and post-actualization.

3.9
business transaction entity
the computable representation of any real world entity that participates, occurs, or is materialized during a *business transaction*

3.10
business transaction entity type
the abstract specification of a *business transaction entity*, detailing its recommended characteristics, its recommended methods, and its recommended life-cycle states

NOTE: A business transaction entity type will usually specify the types of business events that cause a business transaction entity of this type to proceed through its different states as the business transaction itself progresses through its phases of planning, identification, negotiation, actualization, and post-actualization.

3.11
buyer
a *Person* who aims to get possession of a good, service, and/or right through providing an acceptable equivalent value, usually in money, to the *Person* providing such a good, service, and/or right
[ISO/IEC 15944-1:2002 (3.8)]

3.12
collaboration space
the business activity space where an *economic exchange* of valued resources is viewed independently and not from the perspective of any business partner

NOTE: In collaboration space, an individual partner's view of economic phenomena is de-emphasized. Thus, the use common business and

accounting terms like purchase, sale, cash receipt, cash disbursement, raw materials, and finished goods is not allowed because they view resource flows from a participant's perspective.

3.13
commitment
the making or accepting of a right, obligation, liability, or responsibility by a *Person* that is capable of enforcement in the jurisdiction in which the *commitment* is made
[ISO/IEC 15944-1:2002 (3.9)]

3.14
constraint
a rule, explicitly stated, that prescribes, limits, governs, or specifies any aspect of a *business transaction*
[ISO/IEC 15944-1:2002 (3.11)]

3.15
custody
an association between a *Person* and an *economic resource* where the *Person* has physical control over the resource or controls access

3.16
data
a reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing
[ISO/IEC 15944-1:2002 (3.13)]

3.17
defined market model
a trade model where the buyer and seller accept the entry terms of market in advance and where that market has an accepted and recognized source for business rules and conventions

NOTE: In a defined market, the phases of a business transaction –planning, identification, negotiation, actualization, and post-actualization – are governed by the rules and conventions of the particular defined market.

3.18
duality
an association between *economic events* where one is the legal or economic consideration for the other in an exchange

3.19
economic bundle
an association between economic commitments and the economic contract

that legally bundles those promises and binds them to the two partners who negotiated them

3.20
economic claim
the expectation of one *Person* to receive a future inflow of *economic resources* from another *Person* because of an *economic exchange* which is presently incomplete

3.21
economic commitment
a type of *commitmen*t by one *Perso*n to transfer *economic resources* to another *Person* at some specified point in the future

3.22
economic contract
a bundling of reciprocated *economic commitments* between two partners where the abstract specification of the *economic resource* transfers between the two parties is deemed legally complete and enforceable

3.23
economic control
an association between a *Person* and an *economic resource* where the Person either owns the resource or is otherwise able to derive economic benefit (utility) from it

3.24
economic event
an occurrence in time wherein ownership of an *economic resource* is transferred from one *Person* to another *Person*

3.25
economic event type
the abstract specification of an *economic event* where its grouped properties can be designated without attachment to an actual, specific occurrence in time

NOTE: Example of attributes at the type level for events might be expected-duration or standard-pricing-percentage.

3.26
economic exchange
an *economic exchange* is a type of a business transaction where the goal is an exchange of *economic resources* between two *Person*s where both parties derive higher utility after the completed transaction

NOTE: An *economic exchange* usually involves two *economic events* with different types of *economic resources* flowing in opposite directions. For example, an exchange of cash for a good involves a shipment with a requited payment following.

3.27
economic resource
a good, right, or service of value, under the control of a Person

3.28
economic resource type
the abstract specification of an *economic resource* where its grouped properties can be designated without attachment to an actual, specific resource

NOTE: Example of attributes at the type level for a resource like an automobile might include its designated fuel capacity or its maximum expected range.

3.29
economic role

the abstract specification of a *Person* for economic purposes where its grouped properties can be designated without attachment to an actual Person

NOTE: An example economic role might be qualified buyer or approved shipper

3.30
entity
any concrete or abstract thing that exists, did exist, or might exist, including associations among these things
[ISO/IEC 15944-1:2002 (3.20)]

3.31
external constraint
a constraint which takes precedence over *internal constraints* in a *business transaction,* i.e., is external to those agreed upon by the parties to a *business transaction*
[ISO/IEC 15944-1:2002 (3.23)]

3.32
fulfillment
an association between an *economic commitment* and an *economic event* where the event executes the promised resource flow from one *Person* to another

NOTE: For example, a delivery to a customer would fulfill that customer's sale order.

3.33
governed
the association between an *agreement* and the *business transaction* whose conduct and phases are subject to that *agreement*

3.34
individual
a *Person* who is a human being , i.e., a natural *Person*, who acts as a distinct indivisible entity or is considered as such
[ISO/IEC 15944-1:2002 (3.28)]

3.35
information
knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts that within a certain context have a particular meaning
[ISO/IEC 15944-1:2002 (3.29)]

3.36
information bundle
the formal description of the semantics of the information to be exchanged by *Open-edi Parties* playing *roles* in an *Open-edi scenario*
[ISO/IEC 15944-1:2002 (3.30)]

3.37
internal constraint
a constraint which forms part of the *commitment(s)* mutually agreed to among the parties to a *business transaction*
[ISO/IEC 15944-1:2002 (3.33)]

3.38
location type
the abstract specification of an *economic location* where its grouped properties can be designated without attachment to an actual place

NOTE: An example location type might be accepted shipping facility or approved hospital location.

3.39
materialized
an association between an *economic event* and an *economic clai*m where the occurrence of the event causes the claim to come into existence

3.40
mediated transaction
a subtype of a *business transaction* where a third partiy mediates between the *partners*

3.41
object
any part of the perceivable or conceivable world
[ISO/IEC 15944-1:2002 (3.36)]

3.42
Open-edi
electronic data interchange among multiple autonomous *organizations* to accomplish an explicit shared business goal according to Open-edi standards
[ISO/IEC 14662:1997 (3.1.9)]

3.43
Open-edi Party (OeP)
an *organization* that participates in Open-edi
[ISO/IEC 14662:1997 (3.1.11)]

3.44
Open-edi scenario
a formal specification of a class of *business transactions* having the same business goal
[ISO/IEC 14662:1997 (3.1.12)]

3.45
organization
a unique framework of authority within which a *Person* or *Persons* act, or are designated to act, towards some purpose
[ISO/IEC 15944-1:2002 (3.44)]

3.46
participates
the association between an *economic event* and each of the two *Persons* participating in the event

NOTE: Usually there is a “from” association and a “to” association, depending upon the direction of the flow of the economic resource.

3.47
partner
a subtype of *Person* that includes *buyer* and *seller*

3.48

Person

an entity,i.e., a natural or legal person, recognized by law as having legal rights and duties, able to make *commitment(s)*, assume and fulfill resulting obligations(s), and able of being held accountable for its action(s)
[ISO/IEC 15944-1:2002 (3.47)]

3.49

process

a series of actions or events taking place in a defined manner leading to the accomplishment of an expected result
[ISO/IEC 15944-1:2002 (3.53)]

3.50

reciprocal

an association between *economic commitments* where the promise by one *partner* to execute an *economic resource* transfer in the future is reciprocated by the other *partner* promising a requited transfer in the opposite direction

3.51

regulator

a *Person* who has the authority to prescribe *external constraints* which serve as principles, policies, or rules governing or prescribing the behavior of *Persons* involved in a *business transaction* as well as the provisioning of goods, services, and/or rights interchanged
[ISO/IEC 15944-1:2002 (3.59)]

3.52

resource-flow

the association between an *economic event* and an *economic resource*

NOTE: A common example would be a resource-flow between some inventory and the shipment that caused control of that inventory to flow from one *Person* to another.

3.53

responsibility

an association between *Persons* where one is responsible to the other or between a *Person* and an *organization* where that *Person* is assigned

NOTE: Subtypes of Persons include *individuals* and *organizations*, so an *individual* may be responsible to another *individual* or an *individual* may be responsible to an *organization.*

3.54

seller
a *Person* who aims to hand over voluntarily or in response to a demand or a request, a good, service, and/or right to another *Person* and in return receives an acceptable equivalent value, usually in money, for the good, service, or right provided
[ISO/IEC 15944-1:2002 (3.62)]

3.55
Semantic Component (SC)
a unit of *information* unambiguously defined in the context of the business goal of the *business transaction*
[ISO/IEC 14662:1997 (4.1.2.2)]

3.56
settlement
an association between a requiting *economic event* and an *economic claim* where the occurrence of the event causes the claim to expire

3.57
site
the association between an *economic event* and the *location* where the transfer of *economic resources* involved in that event is deemed to have occurred

3.58
specification
the association between an *economic commitment* and the abstract properties of an *economic event*, an *economic resource*, a *partner*, or a *location*

3.59
third party
a *Person* besides the two primarily concerned in a *business transaction* who is agent of neither and who fulfills a specified role or function as mutually agreed to by the two primary *Persons* or as a result of *external constraints*
[ISO/IEC 15944-1:2002 (3.65)]

3.60
typification
the association between a concrete *entity* and the abstract specification of its grouped properties

3.61
undefined market model
a trade model where participants are not registered in advance and where all phases of a business transaction (planning, identification, negotiation,

761 actualization, and post-actualization) must be performed
762
763 **3.62**
764 **vendor**
765 a *seller* on whom consumer protection requirements are applied as a set of
766 *external constraints* on a *business transaction*
767 [ISO/IEC 15944-1:2002 (3.67)]
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4. Symbols and Abbreviations

Acronym	Description
BOV	Business Operational View
BTE	Business Transaction Entity
BTET	Business Transaction Entity Type
ebXML	electronic business eXtended Markup Language
ECIMF	E-Commerce Integration Meta-Framework
EDI	Electronic Data Interchange
ISO	International Standards Organization
OCL	Object Constraint Language
OeBTO	Open-edi Business Transaction Ontology
OeP	Open-edi Party
REA	Resource-Event-Agent
SC	Semantic Component
UML	Unified Modelling Language
UN	United Nations
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business

5. The Declarative Component of an OeBTO – Primitive and Derived Data Classes

5.1 Persons and Economic Resources

One of the most fundamental ideas in Open-edi is the category of *Person* as an entity recognized as having legal rights and duties, able to make commitments, and fulfill resulting obligations. Person can be decomposed into three separate subclasses based on identity as indicated into 15944-1: individual, organization, and public administration. These subclasses are illustrated in Figure 4.

A second very important notion in the OeBTO is the concept of an *Economic Resource* which is something of value under the control of a *Person*. These two fundamental categories appear on the left of Figure 5, connected by an *economic control* relationship which indicates that the Person either owns the resource or is otherwise able to derive economic value (utility) from it.

Onto the right side of Figure 5 is now added an additional Person and economic resource association, thus setting the stage for a possible exchange where both parties might view control of the other Person's resource as a means of deriving higher utility than present circumstances render. This "value exchange" as it is titled in the collaboration space of Figure 3 is the basis for what Open-edi calls a *business transaction* between the two persons. When those business transaction occur, Persons are able to play roles as indicated the different subtyping shown in Figure 6.

- *Partner* which itself further specializes to *Buyer* (has money, desires goods) and *Seller* (has goods, desires money).
- *Regulator* which represents Persons who impose external constraints on Business Transactions.
- *Third Party* which specializes to a number of other classes such as Escrow, Mediator, Guarantor, and Notary.

Agents are a special subtype in Open-edi who can act for any Person.

Figure 7 illustrates some of the possible subtyping for the economic resource primitive into these classes.

- *Goods* which are tangible resources to include:
    - *Materials* including capital assets (like trucks), basic raw materials and natural resources (like steel or petroleum) plus sub-components of a larger assembled product (like seats for an automobile).
    - *Real Estate* like office buildings or warehouses.
    - *Funds* like money or marketable securities.

- *Services* which are the provision of value-adding activities by a provider to a consumer to include:
    - *Human Services* like temporary workers or consultants.
    - *Transportation Services* like packing/picking or actual shipments.
    - *Regulatory Services* such as the right to import/export or the right to do business in a certain segment or area.
    - *Warranty Services* such as the automatic provision of replacement goods under faulty judgments.
    - *Insurance Services* such as guaranteed payment under exigent circumstances.

- *Rights* which are intangible resources to include examples like *Intellectual Products (IPR)* and *Rights-of-way*.

Figure 7 also shows a recursive association that is especially important in ontological terms because it reflects an important aspect of economic reality -- that economic resources often have component structures. This means that their value is often derived from an assembly of other resources. For a product example, those components could be the physical material, its advertised cache, its delivered-to-the-door-status, and its warranty.

In Open-edi, a business transaction usually involves an economic exchange of resources between Persons with competing economic interests, each attempting to maximize his or her own economic utility. As portrayed in 15944-1 and shown in Figure 8, there are two additional fundamental elements of a Business Transaction Model besides PERSON (discussed amply above). The first of these is the DATA involved in the transaction, and the ontological categories for capturing that data will be the topic for the rest of this Clause 5. The other fundamental element is the PROCESS involved in a business transaction and that will be the main topic for the following Clause 6. Clause 7 illustrates the constraint component where the business rules concerning both data and processes are enumerated.

5.2 The Normative Data Categories for a Business Transaction Involving an Economic Exchange: Resources, Events, and Persons Plus Their Fundamental Relationships

The UML class diagram of Figure 9 illustrates the high level semantic view of the essentials of an economic exchange. In Open-edi, the full details of this exchange are effected within the scope of a single business transaction as trading partners identify each other, negotiate commitments, and engage in the actual exchange of resources with value.

As a starting point for ontological definition, this collaboration space diagram concentrates on the object answers to four fundamental questions:

- **Who** is involved in the collaboration (Persons)?
- **What** is being exchanged in the collaboration (Economic Resources)?
- **When** (and under what trading conditions) do the components of the exchange occur (Economic Events)?
- **Why** are the trading partners engaged in the collaboration (duality relationships between resource flows)?

The normative infrastructure of the Open-edi Business Transaction Ontology (OeBTO) encompasses these essential question components, as explained in section 5.2 that follows. Section 5.3 illustrates the ontological components that result from typifying the OeBTO normative infrastructure, while section 5.4 deals with the non-normative extensions of claims and locations. Section 5.5 discusses the elaborate commitment structures of the OeBTO, and section 5.6 finishes this chapter by accounting for the extended ontology objects of scenarios and markets.

Figure 9 illustrates the basic economic primitives of OeBTO. An actual value exchange in the collaboration space of Open-edi between a buyer and a seller would involve two instances of this object pattern. A full example of this is shown in Figure 10 with a delivery of product followed by a payment of cash. In very general terms, a full economic exchange of value in collaboration space is defined as a *Business Transaction* in the Open-edi ontology. It is important to remember that *Bilateral Transactions* between a buyer and a seller constitute the basic collaborative unit in Open-edi. These bilateral transactions may be aggregated to *Mediated Transactions* involving more than two *Persons*. However, these mediated transactions may always be decomposed into binary components.

5.2.1 Entity Definitions:

- A *Person* is a natural or legal person or organizational unit empowered to control the flow of economic resources (including his or her own labor) by engaging in economic events. Persons are also empowered to make commitments or promises to execute resource flows in the future. The *Person* class may also include persons and agencies that are responsible for subordinates' participation in economic events. A subset of *Person* is *Partner;* partners are Persons who play the leading roles in business transactions as sellers and buyers (or alternatively, as producers and consumers of services).
- An *Economic Resource* is a scarce good, right, or service that possesses utility (economic value) and that is presently under the identifiable control of a particular Person.
- An *Economic Event* most simply is an inflow or outflow of an economic resource. Economic events reflect changes in economic resources resulting from exchanges, conversions, or transportation.

Relationship Definitions:

- A *resource-flow* relationship is an association between an economic resource and an economic event. From the independent perspective, *resource-flow* instances are matched in bi-directional fashion with each party both giving and taking in the same exchange.
- An *accountability* relationship is an association between a Person and an economic event. Economic events normally have two accountability relationships with independent parties who have competing economic interests (that is, they are said to have an "arm's length relationship with each other). One of these is specialized on the class diagram of Figure 6 as *from* and the other as *to,* indicating again the independent perspective of collaboration.
- *A duality* relationship is an association between two (or more) economic events where one is the economic or legal consideration for the other in an economic exchange. Dualities are needed for every binary component of mediated transactions.
- A *custody* relationship is an association between a Person and an economic resource where physical control or access to physical control possession is indicated.
- *Responsibility* is a relationship between (among) two or more Persons. These r*esponsibility* associations indicate hierarchical orderings within an enterprise that are necessarily revealed to trading partners in a collaboration model.

Addition of *Business Event* to Basic Pattern:

In Figure 11, the primitive *Business Event* has been added to the basic OeBT ontology pattern. A *business event* is an occurrence in time in collaboration space that Persons wish to plan, control, monitor, or evaluate. To bring about the occurrence of an economic event, it is often necessary to perform multiple business events. Additionally, business events may also be aggregates of other, finer-grained business events, so the UML component structure shown is possible. In a state machine sense where many elements of the OeBT ontology become *business transaction entities* (representing *business transaction entity types* as explained in Clause 6)) with defined object states and defined object lifecycles, a business event can be defined more precisely as an occurrence that causes a state change in one or more business transaction entities.

5.3 Extension Of The Ontology Into Types

Abstract concepts are information structures used to describe the intangible

components of actual phenomena. For ontologists, this is an important distinction. In the OeBT ontology, “type images” are used to represent the abstract structure of economic phenomena. For the construction of abstract concepts, the common abstraction mechanism of typification is used.

Typification captures descriptions that apply to a group of actual phenomena. For instance with two 15944-1 examples, the definition of “goods” as an economic resource might involve some notion of “consumption” while “rights” as an economic resource might not. Also important is that the definition of a “right” is preserved even when no actual rights exist in the universe of discourse. In Figure 12, the grouping and abstraction involved with these two examples is illustrated. The group “goods” would have “consumability” as part of its definition, and it could also have differential group operations as part of its definition (for example, the valuation of goods might involve depreciation while that of rights might involve amortization).

When type images are connected with each other as illustrated in the dotted associations of Figure 13, policy and planning artifacts often emerge, so this abstraction mechanism is especially important to the pre-actualization components (planning, identification, and negotiation) of an Open-edi Business Transaction. For example, parties often specify in advance the types of goods they desire to be shipped under different delivery categories by different types of shipping agencies. Under Open-edi, typification is strongly linked to the concept of *Scenarios* which are formal specifications of specific classes of business transactions designed for reusability. As discussed in Clause 6, connected type images also result many times in control artifacts such as the rules embodied in internal and external Open-edi constraints. Such constraints supply pre- and post-conditions on state machine transitions.

5.4 Locations and Claims

Figure 14 illustrates two non-normative additions to the basic Open-edi ontological framework.

- A *Business Location* designates the place where an Economic Event occurs if such information is needed. Locations also indicate the targeted delivery points for Economic Commitments. *Location Types* indicate instances like an approved kind of delivery warehouse or loading dock.
- An *Economic Claim* is an optional materialization of a temporal imbalance in a duality relationship where an Economic Event has occurred without its requited correspondence to another Economic Event. An initial Economic Event *materializes* the claim, while the requiting Economic Event *settles* it. A common EDI document example of a claim is an invoice.

5.5 Adding Commitments to Economic Exchanges

In the Open-edi ontology, a Business Transaction pertains to the exchange of something of value as illustrated in the delivery-payment example of Figure 7. An additional key property of an Open-edi Business Transaction is that it involves commitment exchange, a circumstance modelled on top of the delivery-payment example in Figure 10. In economic terms however, commitments do not occur in isolation because partners simply do not agree to value exchanges without reciprocation. As illustrated at the top of Figure 15, commitments are bundled in contracts between persons where, for example, a commitment to deliver some product is reciprocated by a commitment to pay cash.

In Figure 16, the ex ante nature of commitments is illustrated further. At a minimum, an Open-edi economic commitment should specify the type of economic resource expected in the fulfilling economic event. For example, a catalog order chooses from a product list for delivery. Additionally, the economic commitment often will specify:

- the type of event to fulfil it (such as an expedited delivery or a purchase under wholesale pricing), and
- the economic roles needed in the eventual exchange (such as a buyer, a seller, a seller agent, and a third-party escrow).

Economic Commitments may less commonly specify location types like an approved class of warehouse.

5.6 Business Transactions with Contracts

Figure 17 adds Economic Commitment structures to the basic notion of an economic exchange. As mentioned previously, commitment is one of the defining features of Open-edi, so these structures are extremely important ontological components.

- An *Economic Commitment* is a promise to execute an Economic Event at some point in the future. The specification of an Economic Commitment may involve relationships with four type-level classes: Economic Resource Type, Location Type, Economic Event Type, and Economic Role. Economic Commitments may also have relationships with Economic Resource (*reserves*), Person (*involves*), and Business Location (*targe*t).
- A *fulfills* relationship is an association between an Economic Commitment and the Economic Event that executes that commitment.
- *A reciprocal* relationship is an association between Economic

Commitments that each in turn individually fulfills compensating Economic Events.

- An *Economic Contract* is a bundle of reciprocating Commitments wherein two Parties agree to a future schedule of exchanges with compensating Economic Events. An *Agreement* is similar to a Contract, but it is not legally enforceable.
- An *establishment* relationship is an association between an Economic Contract and its pair of reciprocal Commitments.

Figure 18 illustrates the full addition of the "commitments to type specification" by combining Figures 16 and 17. Additionally, it extends the concept of a *Bilateral Transaction* to that of a *Mediated Transaction* by including the previously-defined *Third Party* subtype of *Person* as an essential ingredient of mediated collaborations. Figure 18 also indicates the essential roles of *Regulators* who are Persons who constrain business transactions.

5.7 Typifying Agreements and Business Transactions

Figure 19 and Figure 20 illustrate typification of Agreements and Business Transactions.

- All Business Transactions are set in both *Defined Markets* and *Undefined Markets,* both of which are *overseen* by various *Jurisdictions.*
- Business Transactions are classed in different kinds of *Scenarios* such as the 2x2x2 factoring shown in the cloud at the bottom of Figure 19.
- An *Agreement* can be decomposed into classes like *Leases/Rentals*, *Service Agreements*, *Consignments*, and *Purchases.* Agreements have *Pricing Methods* like reverse auctions, open and closed bids, and individual quotes. These methods can in turn be typified into classes (Pricing) like bid, auction, or matching. These are all illustrated in Figure 20.

The modelling specifications illustrated in Figure 4 through Figure 20 give specific conceptual definition to many of the Open-edi Business Transaction terms used in part 1 of 15944. In the following clause, the behavioural use of these components is explained with explicit reference to the Open-edi notion of Business Transaction *phases*. According to 15944-1, a collaboration proceeds through the stages of planning, identification, negotiation, actualization, and post-actualization, and an ontologically-based state machine model of this progress is explained there.

6. The Procedural Component of an OeBTO – Business Transaction State Machines

An ontology has a declarative component – which specifies the categories into which collaboration data exchanged among Persons in a business transaction may be slotted – a procedural component – which specifies how that data is to be used in deriving conclusions -- and a constraint component – which specifies the business rules for both data and procedures. In an operational Open-edi business transaction ontology, the various declarative components specified in Clause 5 – for example all of the classes illustrated in Figure 18 – become defined as *Business Transaction Entity Types (BTET).* BTETs represent the abstract specification of *Business Transaction Entities (BTE)*, detailing their recommended characteristics, their recommended methods, and their recommended life-cycle states. Additionally, a business transaction entity type will usually specify the types of business events that cause a BTE of this type to proceed through its different states as the business transaction itself progresses through its own phases of planning, identification, negotiation, actualization, and post-actualization. A *BTE* thus is a particular real instance of a *business transaction entity type*. For procedural materialization of conclusions, a BTE is the computable representation of any real world *entity* that participates, occurs, or is materialized during a particular *business transaction.*

6.1 Relating Ontological Components to the Open-edi Business Transaction Phases

From Open-edi 15944-1, Figure 21 enumerates the five identified phases of an Open-edi *Business Transaction*. This phase specification is one of the major contributions of that standard. Figure 22 adds the definition of Business Transaction Phases to the OeBTO declarative primitives for a bilateral collaboration as specified in Clause 5. This figure also specifies that these phases have *Business Events* as components, illustrating the behavioural progress through each phase as marked by collaborative activities. A Business Event is defined as *an occurrence in time in collaboration space that persons wish to plan, control, monitor, or evaluate*. Business Events are the fuel that drives a business transaction state machine, as they progress that dynamic representation through its five phases by changing the states of the ontological components illustrated in Figure 22. Additionally, Business Events have component structures as illustrated by the recursive relationships in Figure 22, and this facilitates the modeling of actions in business collaboration space at whatever level of granularity is needed. Business Event components can drive the state of a higher-level Business Event to completion, and that higher level component may then effect a state change in one of the business transaction entities for a particular transaction. Figure 22 illustrates the addition of Business Transaction Phases and Business Events to the basic Open-edi collaboration ontology.

Figure 23 illustrates the approximate correspondence of the Open-edi Business

Transaction phases with the categories of ontological components defined in Clause 5.

- Planning and Identification involve Business Events wherein potential buyers and sellers identify each other by matching on proposed types of resources to be exchanged and their actual trading partners.
- Negotiation involves Business Events wherein linked business partners cooperate on the abstract specification of their proposed exchange (its type of resources, events, and roles as stipulated in a contract).
- Actualization and Post-Actualization involve Business Events that aggregate to the performance of actual resource transfers (Economic Events) between the buyer and seller.

Business Events are the specific activities that mark the explicit states that trading partners expose to each other as they complete an exchange. For example, supplying a quote on a listed product during negotiation may progress an Economic Commitment from status (or state) "unspecified" to "proposed" while simultaneously marking a Resource-Type and an Event-Type as "specified." If this Business Event of supplying a quote was followed by a quote acceptance and then a payment terms acceptance, an Economic Contract might move into status "in-force" and then the entire Negotiation Phase might move into state "completed." This completed negotiation would keep the entire Business Transaction in state "in progress," whereas an unsuccessful negotiation might have moved the overall Business Transaction into state "aborted" or state "suspended."

Figure 24 portrays the individual phases of a Business Transaction and the targeted object states that would signal to each business partner that a particular phase was now complete.

- Planning is complete when both trading partners have formulated an abstract vision of an exchange. This involves moving certain Economic Resource Types into an identified state.
- Identification is complete when the corresponding partners have been identified along with the planned resource types. This establishes a 1-to-1 linkage.
- Negotiation is complete when the abstract specification of Economic Commitments in a full contract is complete.
- Actualization is complete when the requiting Economic Events are both complete, thus marking the full exchange.
- Post-Actualization is complete when the possible warranty (or similar post-exchange exception condition) component of an Economic Resource is invoked, and the conditions of the exchange reach their final values.

Figure 25 illustrates how the declarative ontological components of Open-edi (referred to here as Business Transaction Entity Types) can be augmented to

account for state machine mechanics. Each ontological component is envisioned as a possible Business Transaction Entity with a defined Business Transaction Entity Lifecycle consisting of multiple Business Transaction Entity States. The transition to these states is effected by the occurrence of a Business Event.

6.2 An Example State Machine

Figure 26 illustrates some example states that could be defined for some of the Open-edi Ontology components defined thus far. In a full ontological specification, all of the business transaction entity types defined in this document would be given fully-enumerated lifecycles of object states (as specified in Figure 25). However, these would change from one business context to another, so the exposition here is limited to this non-normative example.

Figure 27 shows the ontology components of a Business Transaction, as augmented to include the example states from Figure 26 for four of the business objects: Business Transaction, Economic Claim, Business Transaction Phase (e.g., Negotiation), and Economic Resource Type. A full state machine representation would have these cycles defined for every object on the diagram.

Figure 28 lists an example set of business events involved in an example business transaction. These 13 Business Events represent a full collaboration between an example buyer and seller, as it proceeds through the Open-edi phases. Again, each Business Event might cause multiple state changes. For example, the tenth action -- Buyer sends *ReceivingReport* to Seller when inspected goods are accepted – would cause the Economic Event of *Shipment* to move into its *Completed* state, and the Economic Resource of *Inventory* to move into its *Transferred* state.

A UML state machine diagram is the best formal specification of dynamic object behavior with state changes. Such a specification is illustrated in Figure 29 for the *Business Entity Type* “Economic Resource Type” as it moves through the example collaboration.

- The Economic Resource Type (for example a type of inventory) would become a *Candidate* when the Publish-Catalog business event occurs, moving from its initial undefined state (black dot).
- The Send-Catalog-Request event would then move the inventory into state *Planned.*
- The Accept-Availabity-And-Price-Request would cause the inventory to become *Identified.* This same event would move the Partners into state *Identified* and the Identification Phase of the Business Transaction into state *Complete* (not shown in Figure 29).
- The Send-Offer event would shift the example inventory into its *Proposed* state.
- The Accept-Offer would cause the Economic Resource Type to become

Specified.

- And finally, , a Send-Shipping-Notice action would cause the resource type to move to an *Actualization* state (end of object life cycle).[5]

To summarize the state machine presentation, it is necessary to understand how the definitions of Clause 5 and Clause 6 work together.

- Clause 4 defined the *declarative* components of the Open-edi ontology. This is a specification of the primitive classes as they model the components of a business transaction. These primitive classes become candidates for *business transaction entity types*.
- Clause 6 defined the *procedural* components of the Open-edi ontology. This illustrated the dynamic mechanics of tracking a business collaboration through each of its five phases using state machine mechanics.

[5] In actuality, this state machine example for Economic Inventory Type is slightly more complicated as the individual state changes would need to be tracked through a UML association class between the Economic Inventory Type and the Business Transaction.

7. The Constraint Component of an OeBTO – Incorporating Business Rules into Business Transactions

7.1 Business Rules and Open-edi Constraints

Business rules specifying computational procedures, approved sequences of actions, valid inferences, and effective control monitoring govern the day-to-day operations of business enterprises. A useful definition of a "business rule" from Eriksson and Penker is:

> … a statement that can control or affect the execution of a business process as well as the structure of the resources in a business. The statement specifies a condition that must be upheld, or a condition that controls which activity should follow next. It can express a business goal, specify the way a process should execute, detail the conditions of a relationship, or constrain the behavior of a resource.[6]

In the database world somewhat synonymously,"constraints" are defined as rules governing the integrity of data that prevent a database from moving from one representation state to another without proper validation, and in the most simple ontological case, their function is exactly congruous with the business rules definition given above. Database integrity constraints are also commonly referred to as assertions.[7]

In *Operational aspects of Open-edi for implementation* (part 1 of 15944), a **constraint** is defined as "a rule, explicitly stated, that prescribes, limits, governs, or specifies any aspect of a *business transaction*." That same standard differentiates those constraints that are self imposed by the trading parties (internal) from those constraints created by law, regulation, orders, treaties, conventions, or similar instruments (external):

> **internal constraint:** a constraint which forms part of the *commitment(s)* mutually agreed to among the parties to a *business transaction*
>
> **external constraint:** a constraint which takes precedence over *internal constraints* in a *business transaction,* i.e., is external to those agreed upon by the parties to a *business transaction*

Open-edi further divides the category of external constraints into (1) those that are common and horizontal in nature as introduced by the additional presence in a business transaction of a "regulator" as a third subtype of Person representing "public administration," and (2) those that are more sectorial in nature (involving standard rules both across many sectors and across just one sector). Open-edi

6 Hans-Erik Eriksson and Magnus Penker (2000*) Business Modeling with UML*, John Wiley & Sons, New York, p. 81.

7 D.C. Tsichritzis and F.H. Lochovsky (1982). *Data Models*, Prentice-Hall, Englewood Cliffs, NJ., chap. 3.

differentiates these classes of constraints in order to provide summaries of complex bundles of rules for scenario registration. For example, the simplest constraint bundle for a scenario could aggregate only internal constraints, the next most complex could add horizontal external constraints, etc.

In the OeBTO, constraints encapsulating business rules constitute the third major representation component. The first component was the declarative specification of domain classes and associations in Clause 5, while the second component was the procedural aspects associated with business transaction state machines explained in Clause 6.

7.2 OeBTO Constraint Examples

Constraints may be expressed informally in natural language, such as the following accounting rule for separation of duties as applied to the class diagram of Figure 9:

> *"the Person who fills the accountability role in an Economic Event that involves a certain Economic Resource should not be the same Person who has a custody relationship with that Economic Resource"*

The need for this constraint to a business transaction could be derived for example from a sectorial application (an OeBTO external constraint) of the 2002 USA Sarbanes-Oxley internal control legislation.

Constraints may also be expressed more formally with the Object Constraint Language (OCL) of the UML. For example, a state sales tax rule for Michigan (another sectorial external constraint) on merchandise orders (a subtype of Economic Contract) could be specified as 6% of the gross amount of the order:

```
context Order inv michiganSalesTaxCalculation
salesTax = grossAmount * .06
```

Such a constraint could be placed in curly brackets on a UML class diagram next to the class definition for order (for example, a more specific form of Figure 18), and it then becomes an invariant (inv) or a condition that must be true for all objects of that class.

According to both Odell (1998) and Eriksson and Penker (2000), constraints may be of two general behavioral kinds[8]:

8 James Odell (1998) *Advanced Object-Oriented Analysis and Design Using UML*. Sigs Books, New York, and Hans-Erik Eriksson and Magnus Penker (2000) *Business Modeling with UML,* John Wiley & Sons, New York

- Those that define how knowledge in one form may be inferred or derived from another form. Examples of this constraint category might be the Michigan sales tax calculation shown above. Another example might be a constraint that designates a scheduled shipment as ”hazardous” if it exceeds a designated weight threshold of goods (economic resources) typed as “dangerous if unpackaged” in an inheritance taxonomy.
- Those that “constrain either the possible structure or the behavior of objects or processes, that is, the way objects are related to each other or the way objects or process state changes may occur.”[9] An especially prominent illustration for the OeBTo of this class of constraints are rules that define pre- and postconditions for the types of state changes described in Clause 6. For example in Figure 29, the state machine diagram makes it clear that for EconomicResourceType to achieve its “proposed” state, it has a precondition of being in state “identified” and a postcondition of state “specified” and that these transitions are effected by the business events shown. These same types of rules can be specified as constraints in OCL and portrayed on UML class diagrams.

Both derivation business rules and constraint business rules are important to effective business operation in collaboration space, so their characterization in the Open-edi Business Transaction Ontology is an important third step in insuring interoperability and semantic integrity. To the extent that the declarative and procedural components of an ontology are specified correctly, the parties to a business transaction are given computable methods for ensuring compliance with both internal and external constraints.

7.3 Summary

There is certainly now a critical opportunity for developing coherence in worldwide standards for business level definitions of economic phenomena. Open-edi, especially in its prior work of 15944-1, has standardized much of the technical and economic environment for economic exchanges, and the field of ontology provides an extended opportunity for unifying and coordinationg that work. Part 4 of 15944 aims to provide that unity with an ontological analysis of the declarative, procedural, and constraint components of Open-edi. Certainly, the majority of the work in this document concentrates on the declarative components of the OeBTO – those data classes that model the fundamental categories of economic endeavors in collaboration space and the relationships that exist among those categories. This declarative emphasis is reasoned and deliberate. As noted by John Sowa[10], conceptual progress in a specialized domain is usually marked by an increasing percentage of the knowledge in that

9 -Erik Eriksson and Magnus Penker (2000) *Business Modeling with UML,* John Wiley & Sons, New York, p. 154.

10 John Sowa (1984). *Conceptual structures: Information Processing in Mind and Machine*. Addisson-Wesley, Reading, MA. P. 24.

field being embedded in its declarative components. As ad hoc procedures and constraints become more structured and predictable, they lead naturally to better theoretical and conceptual structures.

In concert, the declarative, procedural, and constraint components of the Open-edi ontology provide a definitive specification that is formal, explicit, and conceptual. An ontological foundation is one of the key components of that coherence.

8.0 Informative Annex – REA model background[11]

8.1 REA (Resource-Event-Agent) Ontology Introduction

Ontology, according to the most generally accepted e-commerce definition of that word, is a "specification of a conceptualization." [12] The REA (Resource-Event-Agent) ontology is a specification of the declarative semantics involved in a business process. The theory behind REA came initially from the field of accounting where REA was first introduced, but its components clearly have microeconomic origins with specific ties in many instances to the use of economic definitions in the practice of building enterprise-wide information systems. In UN/CEFACT work, all of the REA ontology definitions are applied to the collaborative space between enterprises where market exchanges occur in closely synchronized fashion among two or more trading partners.

In its most simple form without a high degree of precision, REA can be portrayed as a UML class diagram with associations and generalizations relating the object classes. The intent of this appendix is to display REA simply and to explain its basic rationale. To do so, the appendix will use a set of figures labeled A-1 through A-5. The most advanced of the UML diagrams (A-3) is a good overall guide to the BRV semantics, given both here and in the Unified Modeling Methodology (UMM) of UN/CEFACT. This appendix will also list a series of archival publications that are freely available at the following website for readers who desire more detailed explanations (http://www.msu.edu/user/mccarth4/rea-ontology/index.htm).

8.2 The Basic REA Ontology

The basic REA model was first published in the July 1982 issue of *The Accounting Review*[13], the most prominent, most reliable, and most tightly controlled outlet for theoretical-based accounting work in the world. Its basic premises have withstood all theoretical challenges in the 20 years since, and its components are used extensively in a variety of educational, practical, and theoretical contexts. The REA model work was given the first (and thus far only) *Seminal Contribution to the Accounting Information Systems Literature Award* in 1996 by the American Accounting Association (AAA), and in 2003, its use as a model for teaching enterprise information systems was awarded the *Innovation in Accounting Education Award*, also from the AAA. There are a number of textbooks in worldwide use that feature REA as a pattern-oriented teaching framework, the most prominent of which is the 2004 Dunn, Hollander, and

11 This Annex with some modifications has been adapted from the *UN/CEFACT Simple Guide to the UMM*

12 Thomas Gruber (1993) "A Translation Approach to Portable Ontologies," *Knowledge Acquisition*, pp. 199-220.

13 William E. McCarthy (1982.) "The REA Accounting Model: A Generalized Framework for Accounting Systems in A Shared Data Environment." The Accounting Review (July), pp. 554-578

Cherrington book[14].

Figure A-1**Error! Reference source not found.** illustrates the basic class structure of REA ontology. The left-to-right configuration of economic Resources, economic Events, and economic Agents (renamed in UMM as "Partner") in a typical business collaboration pattern is the source of the model's REA name.

A successful business collaboration involves first and foremost two types of Economic Events, each of which details the Economic Resources involved in an exchange between two Trading Partners. For example, a Supplier (Trading Partner) transfers ownership of an Automobile (Economic Resource) to a Customer (Trading Partner) in return for which (duality association) the Customer will provide Money (Economic Resource) to the Supplier. There are two mirror-image instantiations of the object pattern shown in Figure A-1 where one transfer represents the legal or economic consideration given for the other.

The declarative semantics shown here are central to all trading relationships. Economic Resources are objects that have value and are under the control of one of the two collaborative agents. Trading partners always expect requited transfers of resources when they engage in commerce. Hence, **Error! Reference source not found.** Figure A-1is a pattern for all economic exchanges.[15]

8.3 Adding Commitments to the Basic Exchange Ontology

In electronic commerce, the actual trading phase of an exchange is accommodated well by the object structure shown in Figure A-1 **Error! Reference source not found.**. However, trading partners in long-term relationships need more trusted and predictable structures where both parties contract for their exchange behavior in advance. The REA ontology accommodates this expansion with the addition of the classes shown as Economic Commitments, Economic Contract, and Agreement in Figure A-2.

A Commitment is a promise by a Trading Partner to initiate an Economic Event in the future. Performing the Economic Events fulfills that Commitment. Commitments should always be reciprocated by the other Trading Partner who commits to initiate another type of Economic Event in return. An Economic Contract is a bundle of reciprocating commitments between Trading Partners who bind themselves to one or more economic exchanges in the future. A contract is a subtype of the more general object class called Agreement, and Agreements can regulate other Agreements.

14 C. Dunn, J.O. Cherrington, and A.S. Hollander (2005) *Enterprise Information Systems: A Pattern-Based Approach*, McGraw-Hill Irwin, Boston, MA

15 G. Geerts and W.E. McCarthy (1999). "An Accounting Object Infrastructure For Knowledge-Based Enterprise Models." IEEE Intelligent Systems & Their Applications (July August 1999), pp. 89-94

In the case of the automobile-for-money exchanges discussed in the prior section, Commitments would involve the Customer agreeing to accept delivery of an Automobile on a certain date in return for which he or she would be contractually obligated to making a series of Cash payments to the Supplier for that purchase.

In the bottom part of Figure A-2, two additional objects of the REA ontology are illustrated: Claims and Locations.

- 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.
- A Location is another object that is sometimes needed to fill out the specification for a full economic transfer. Locations simply identify the place where Economic Events take place.

The economic and ontological foundations of commitments are explained more completely by Geerts and McCarthy.[16]

8.4 Adding Types to the Basic REA Exchange Ontology

The object pattern portrayed in Figure A-2 is primarily descriptive in the sense that it illustrates what actually occurred in an economic exchange or what has been committed to. In the UMM, these descriptive components have been augmented by prescriptive components that allow the specification of control policies or collaboration patterns. These prescriptive components are enabled by the inclusion of type images of the basic descriptive objects[17]. The class diagram of Figure A-3 shows these additions.

The addition of Types to the REA model proceeds in two stages:

- The three base descriptive classes – Economic Resource, Economic Event, and Partner (Economic Agent) – have classes added for their types. These new classes are connected to the descriptive objects by *typifies* associations. An example of a Resource Type could be different models of

16 G. Geerts and W.E. McCarthy (2000) “The Ontological Foundation of REA Enterprise Information Systems, “ paper presented to the Annual Meeting of The American Accounting Association, August 2000.

17 G. Geerts and W.E. McCarthy (2002) “An Ontological Analysis of the Primitives of the Extended-REA Enterprise Information Architecture,” The International Journal of Accounting Information Systems (Vol. 3), pp. 1-16.

automobiles. An example of Economic Event Type could be the classes of retail transaction and wholesale transactions, each with different pricing structures. An example of Partner Type could be different classes of employees, each type with separate training requirements. Additionally, the class Location is also typified. An example of Location Type might be different types of loading docks with different sizes and stress capability levels.

- The full design of the Economic Commitment would necessitate associations between the commitment and each of the new type-level objects. These are illustrated in the figure with *specifies* associations.

In addition to these two groups of additions, there are other REA associations in the UMM that are not illustrated here in an effort to minimize diagram complexity. These include:

- Contract – responsible -- Partner
- Partner -- participates – Agreement
- Economic Commitment – reserves – Economic Resource

And finally with regard to Figure A-3, the partial integration of the elements of the REA ontology with the components of the UMM business collaboration framework is illustrated by showing the class for Business Collaboration (with dotted lines) and some of its associations with REA classes (also illustrated with dotted lines). Outside of its use with the UMM and the attendant specifications, the REA ontology has a three-level architecture that is explained by Geerts and McCarthy.[18] In the UMM, this three-level architecture is effected by the integration of REA components within the business collaboration framework and by the connection of the Business Requirements View (BRV) to the Business Domain View (BDV) above it and the Business Transactions View (BTV) below it.

8.5 The Suitability of the REA Ontology within the Open-edi Model

The REA ontology is well known and well used throughout the field of accounting and to a lesser extent throughout the field of enterprise computing in general. It is the best example of a business domain ontology in existence today, and its measures well against the most commonly cited "ontology quality" criteria as proposed by Gomez-Perez.[19] Her functional criteria and the REA explanation of

18 G. Geerts and W.E. McCarthy (2001)."Using Object Templates from the REA Accounting Model to Engineer Business Processes and Tasks," The Review of Business Information Systems, vol. 5, no. 4, pp. 89-108.

19 Gomez-Perez, A. 1998. "Knowledge sharing and reuse," in J. Liebowitz, ed., The Handbook of Applied Expert Systems, CRC Press.

their applicability are portrayed in Figure A-4.

REA and Open-edi also fit very well together, as do REA and the Business Requirements View of the UN/CEFACT metamodel. Figure A-5 illustrates how these three systems correspond to each other on some very important points of emphasis.

It is also the case that many of the best-developed ideas of Open-edi have themselves led to improvements in the published presentations of the REA ontology. For example:

- The extremely well-developed logic of Persons and its subtypes in Open-edi has led to significant additions in the REA ontology to the concepts of Economic Agent and (especially) Economic Agent Type.
- The concepts of binary and mediated collaborations in Open-edi has led to much closer examination in REA work to the notion that all multi-party transactions can, under conditions of general equilibrium, perfect knowledge, and monetary liquidity, be decomposed into binary transactions.
- The notion of the independent view of business collaborations has confirmed ontological input from UN/CEFACT and other groups concerning this important distinction.
- The incorporation of business rules as Open-edi constraints has enabled the inclusion of important inferencing and control mechanisms within an REA-typed collaboration.
- And finally and clearly most significant of all, the 5-phase process model of Open-edi has been adopted directly within REA to solve the business process state machine problems within that ontology. Previously, REA had no criteria to serialize the occurrence of business events or workflow. The state machine model of Open-edi, illustrated in this document in Clause 6, has solved this problem in an elegant fashion.

9.0 REFERENCES

Geerts, G. and W.E. McCarthy. 1999. "An Accounting Object Infrastructure For Knowledge-Based Enterprise Models." *IEEE Intelligent Systems & Their Applications* (July August 1999), pp. 89-94.

Geerts, G. and W.E. McCarthy. 2001. "An Ontological Analysis of the Primitives of the Extended-REA Enterprise Information Architecture," *The International Journal of Accounting Information Systems*

Geerts, G. and W.E. McCarthy. 2005. "The Ontological Foundation of REA Enterprise Information Systems"

Gomez-Perez, A. 1998. "Knowledge sharing and reuse," in J. Liebowitz, ed., *The Handbook of Applied Expert Systems*, CRC Press.

Gruber, T. 1993. "A Translation Approach to Portable Ontologies," *Knowledge Acquisition*, pp. 199-220.

Ijiri,Y. 1975. *Theory of Accounting Measurement*, American Accounting Association.

McCarthy, W.E. 1979. An Entity-Relationship View Of Accounting Models. *The Accounting Review* (October): 667-86.

McCarthy, W.E. 1982. "The REA Accounting Model: A Generalized Framework for Accounting Systems in A Shared Data Environment." *The Accounting Review* (July), pp. 554-578.

Odell,J.J. 1998. *Advanced Object-Oriented Analysis & Design Using UM*L, Cambridge University Press.

Porter, M.E. 1985. *Competitive Advantage.* The Free Press.

Sakai, H. 1981. "A Method for Defining Information Structures and Transactions In Conceptual Schema Design," *Proceedings of the Seventh International Conference on Very Large Data Bases*, pp. 225-34.

Smith, J.M. and D.C.P. Smith. 1977. "Database abstractions: Aggregation and Generalization," ACM *Transactions on Database Systems* (June): 105-133.

Sowa, J. 1999. *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, Brooks/Cole Publishing, Pacific Grove, CA.

Tsichritzis, D.C. and F.H. Lochovsky. 1982. *Data Models*, Prentice-Hall, Englewood Cliffs, NJ.

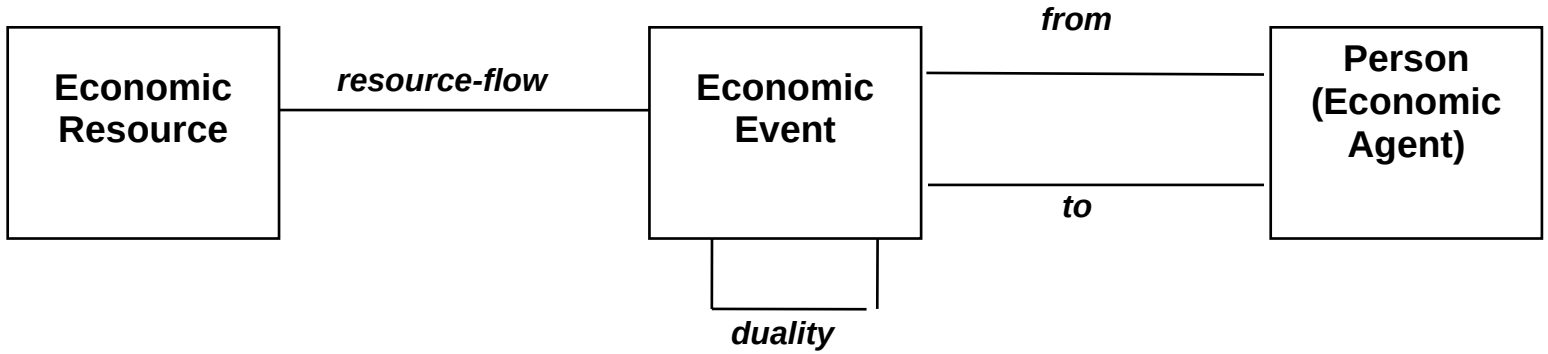

Figure 1 – Basic Economic Primitives of the ISO Open-edi Ontology

Collaboration Perspective: Trading Partner vs. Independent

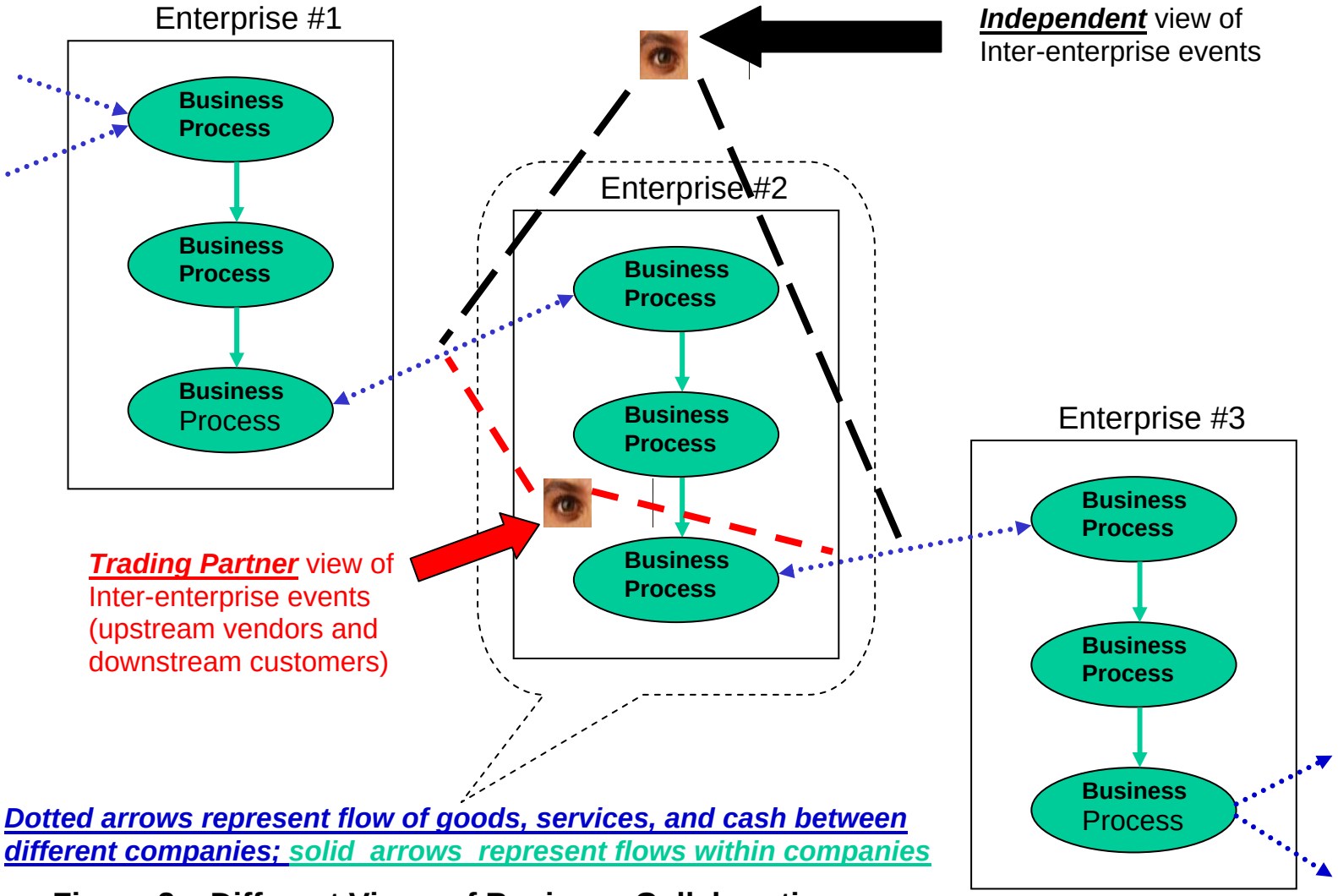

Figure 2 – Different Views of Business Collaboration

1647 Japan expert contribution to 15944-4, 22 Oct 2001, Victoria BC ,

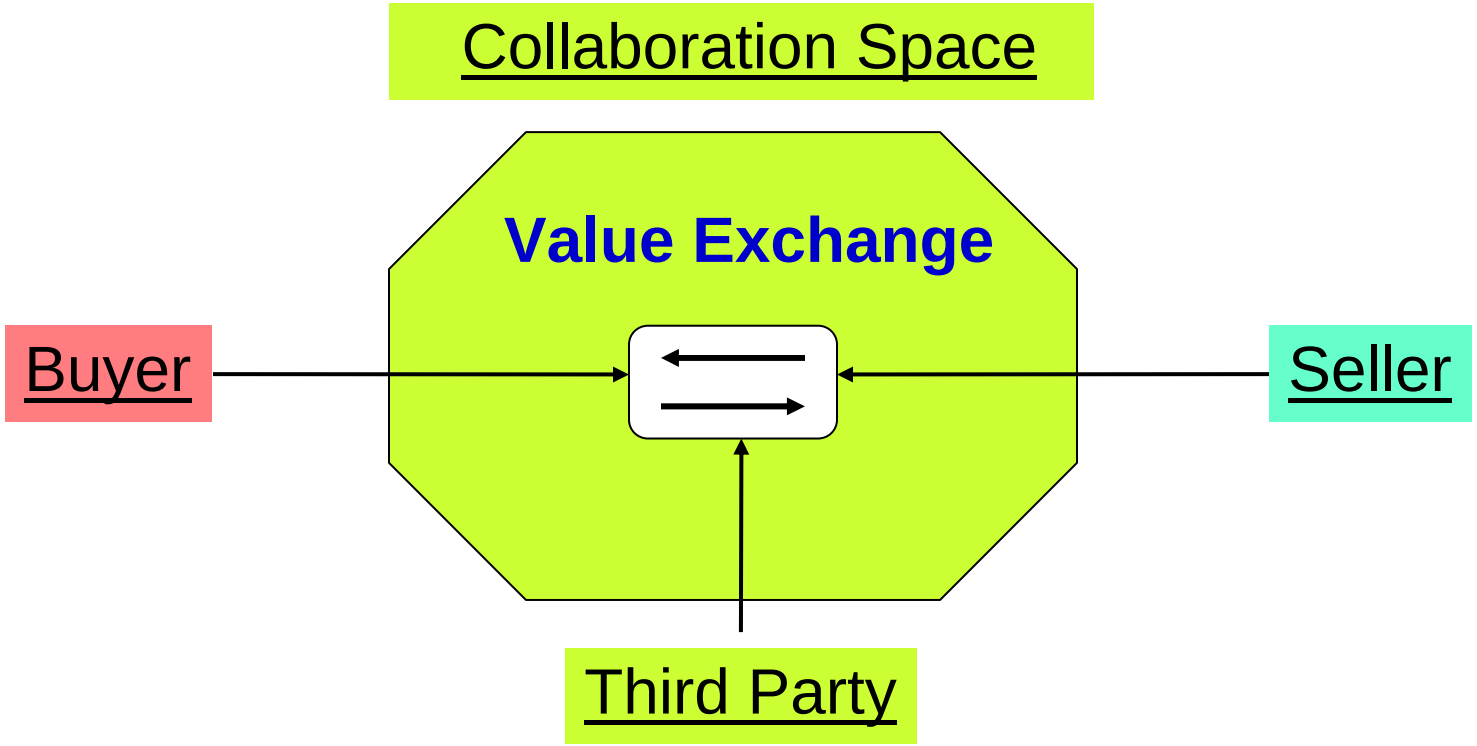

Figure 3 – Concept of a Business Collaboration

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Japan expert contribution to 15944-4, 9 May 2002, Seoul Korea

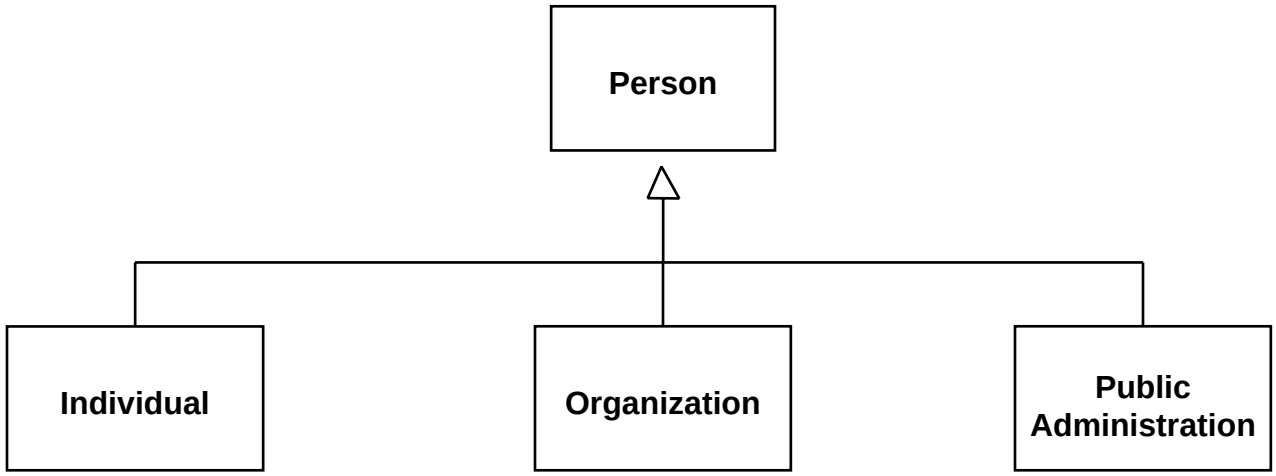

Figure 4 -- Subtypes of Person Based on Identity

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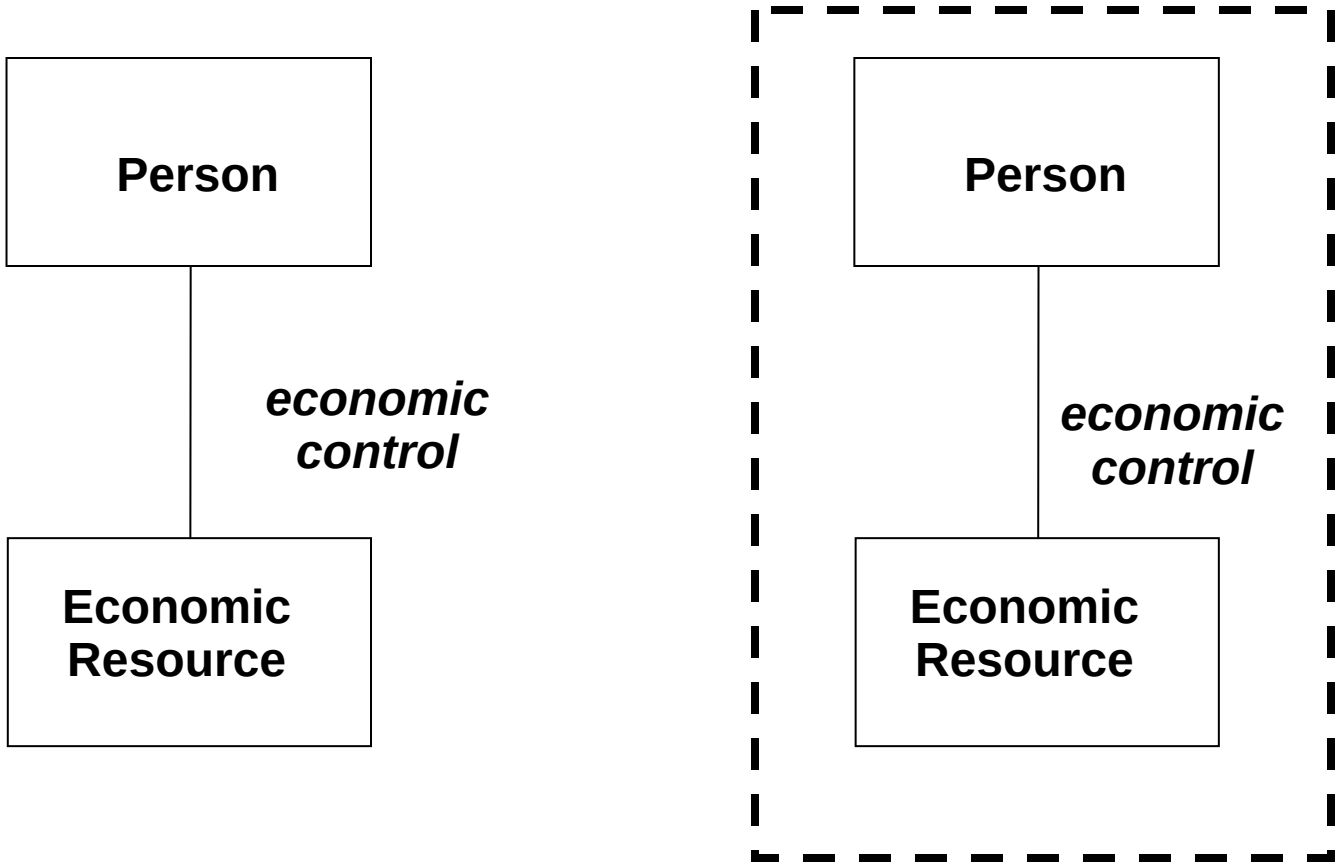

Figure 5 – Person and Economic Resource as the Basis for Exchange

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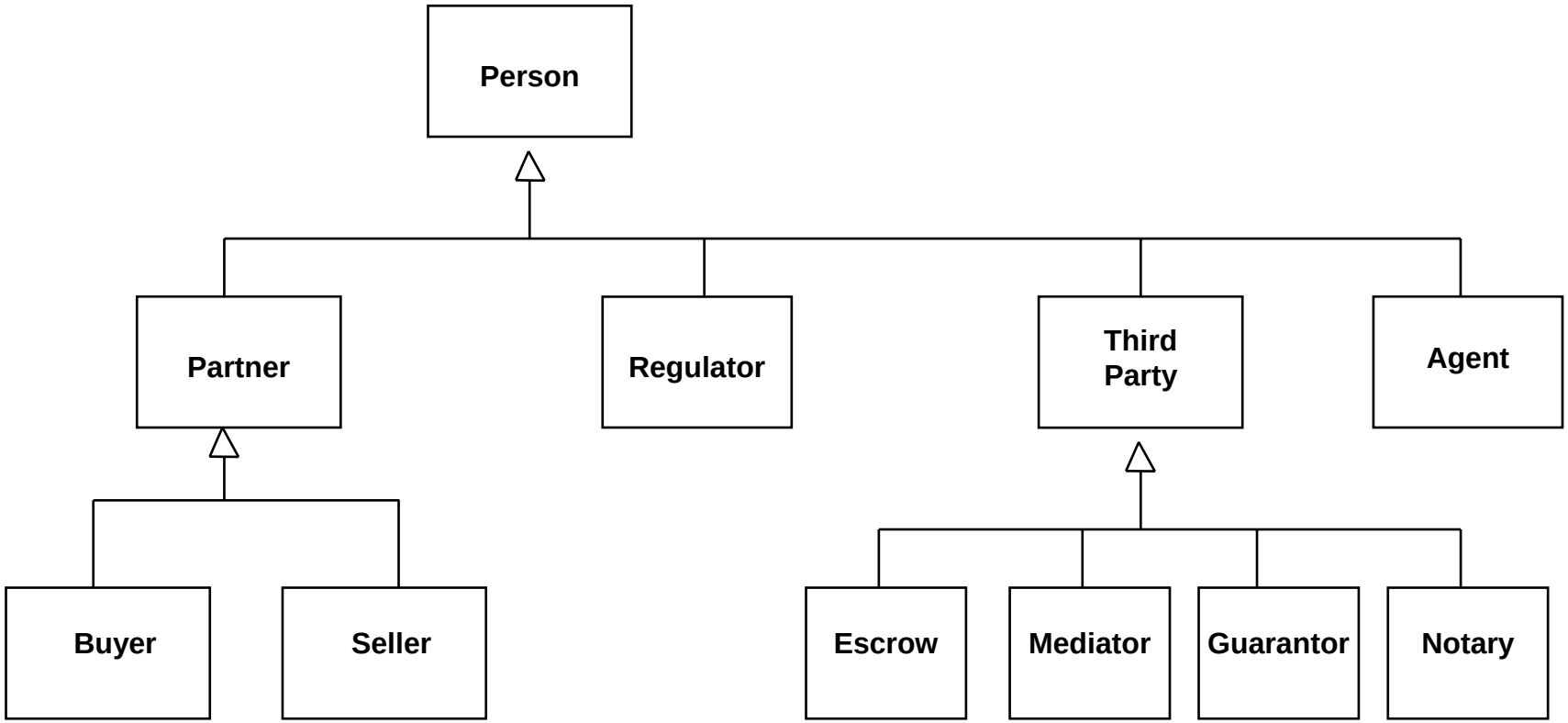

Figure 6 -- Subtypes of *Person* based on roles in a business transaction

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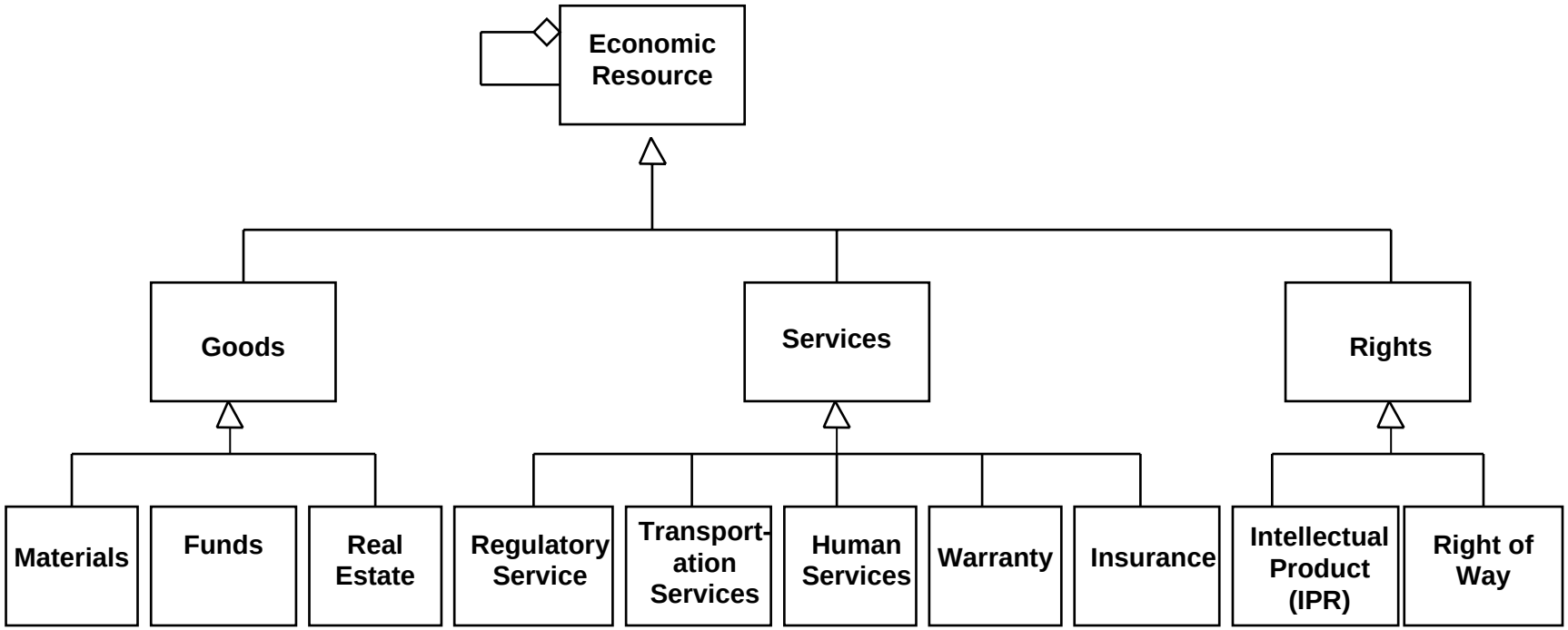

Figure 7 -- Subtypes (possible) for ECONOMIC RESOURCE

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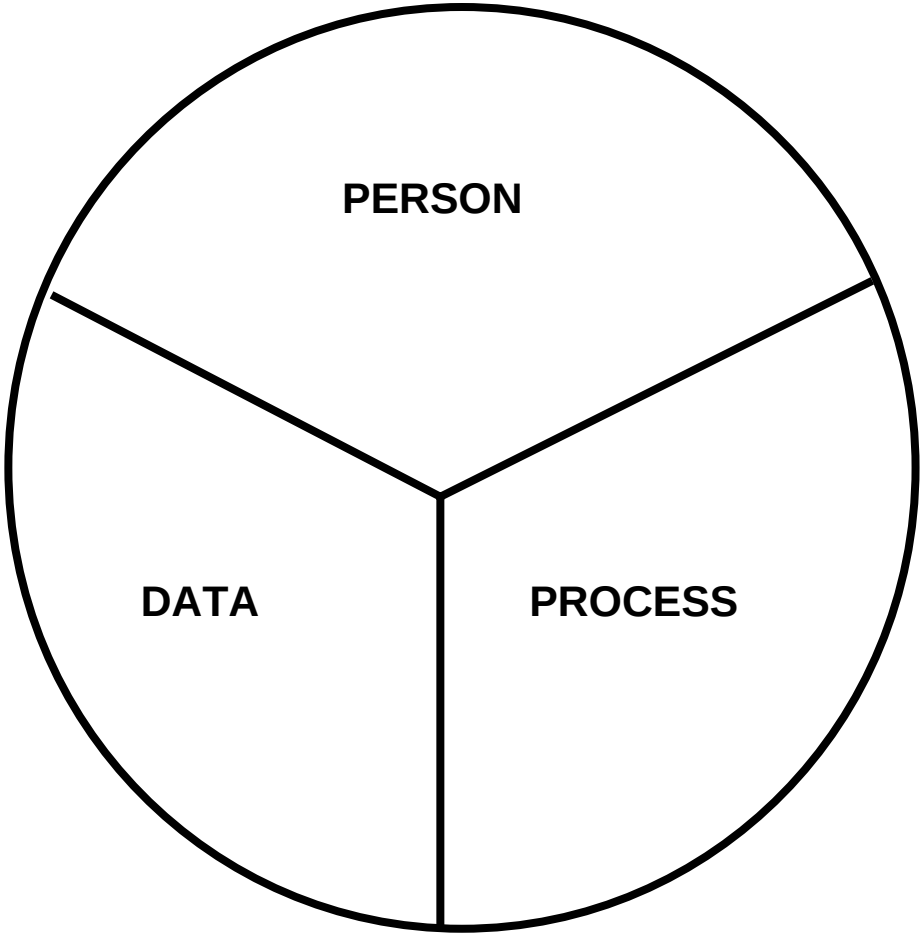

Figure 8 -- Fundamental Parts of a Business Transaction

1653

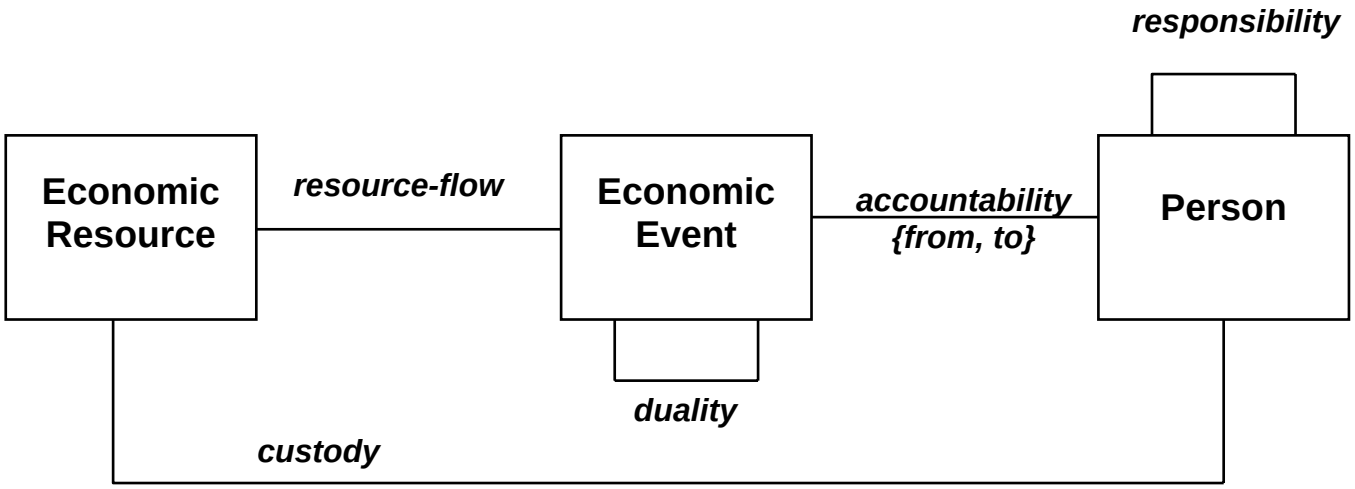

Figure 9 – Basic Exchange Primitives of the Open-edi Ontology

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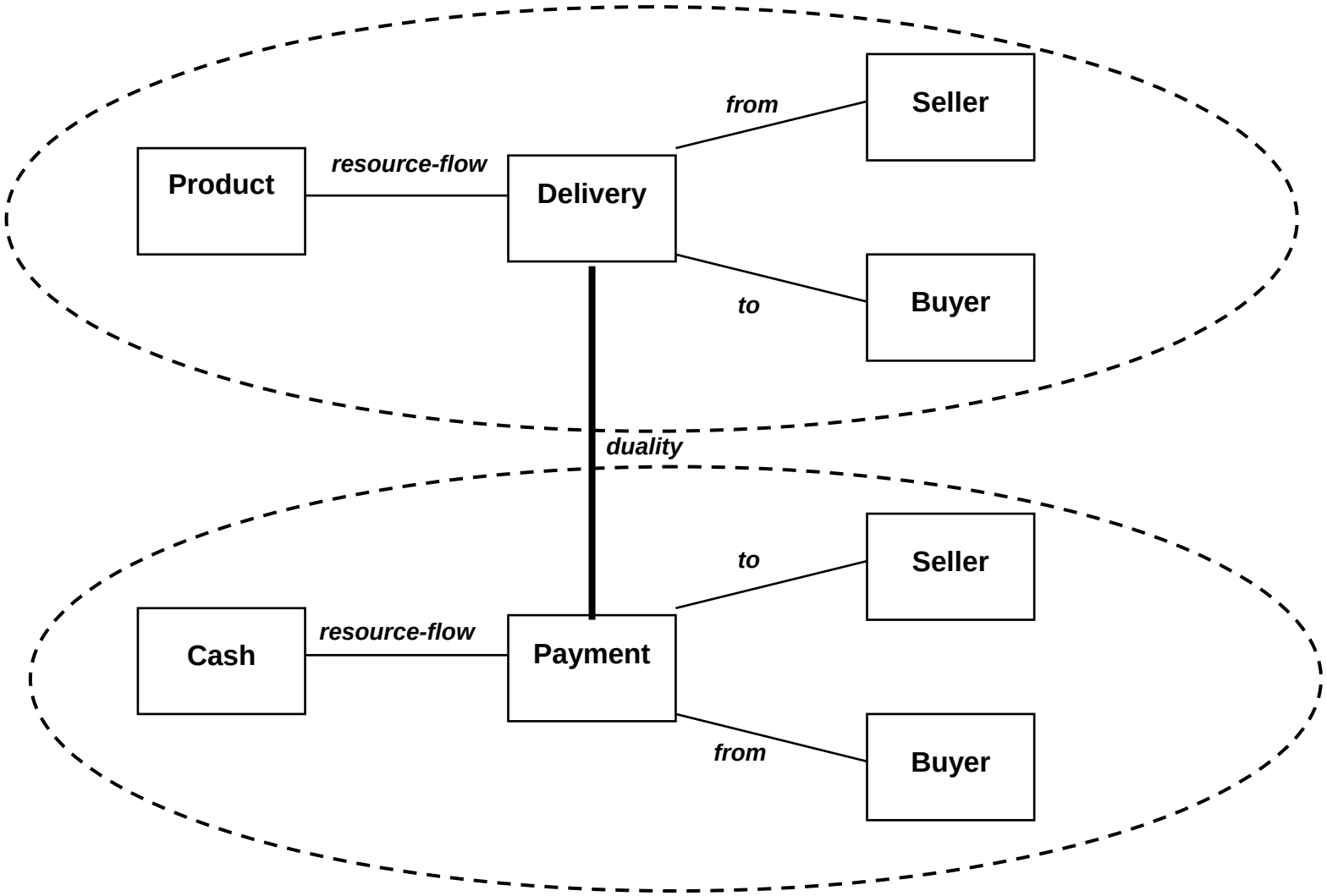

Figure 10 – Exchange of Value in Collaboration Space Involves Two Symmetrical Resource-Event-Person Clusters

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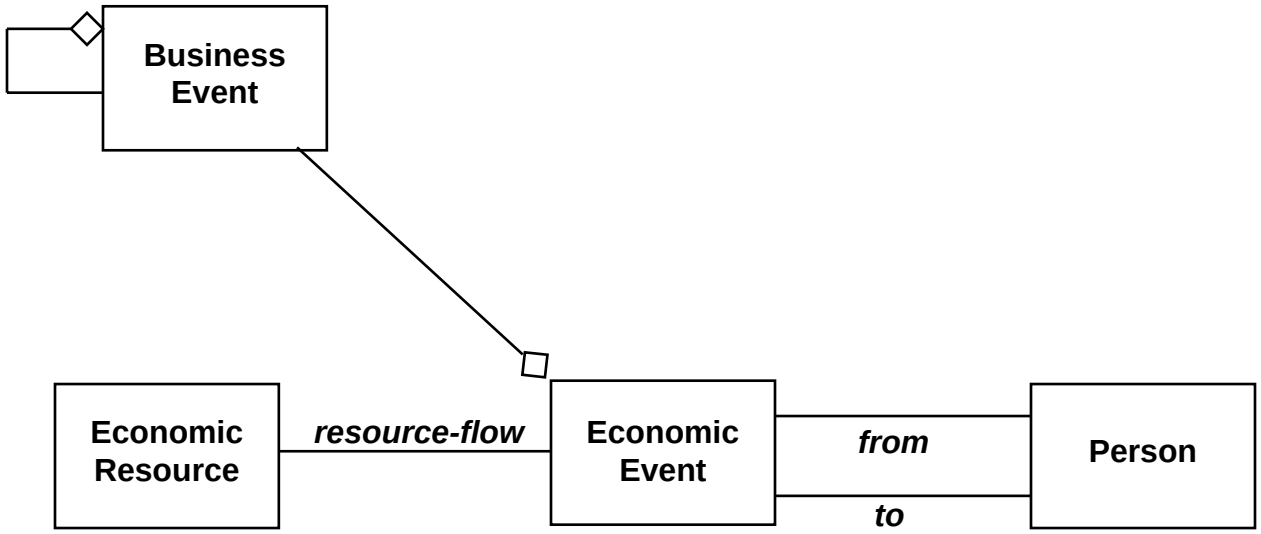

Figure 11 -- Addition of Business Event to Basic Business Transaction Pattern

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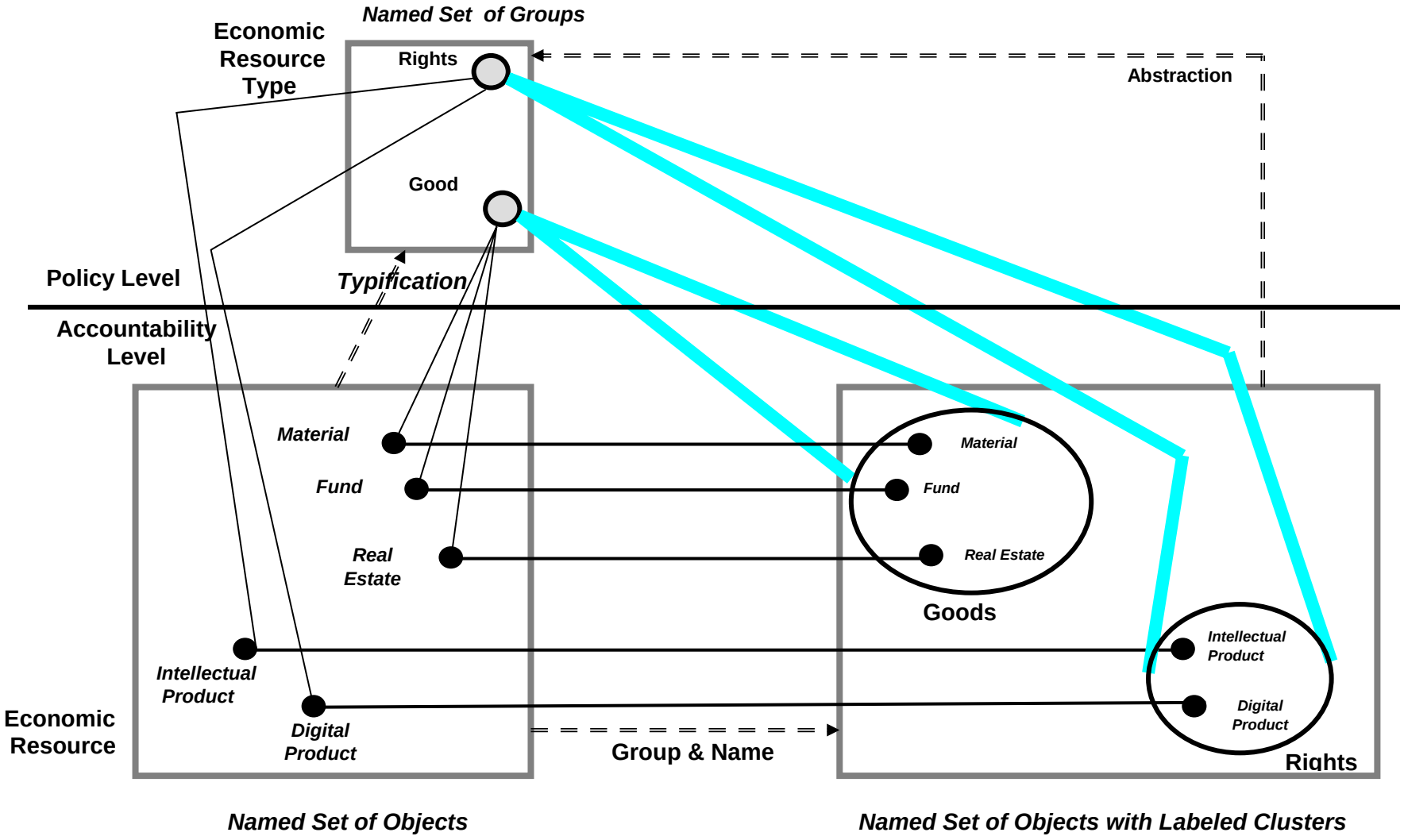

Figure 12 – Abstract Specification with Typification

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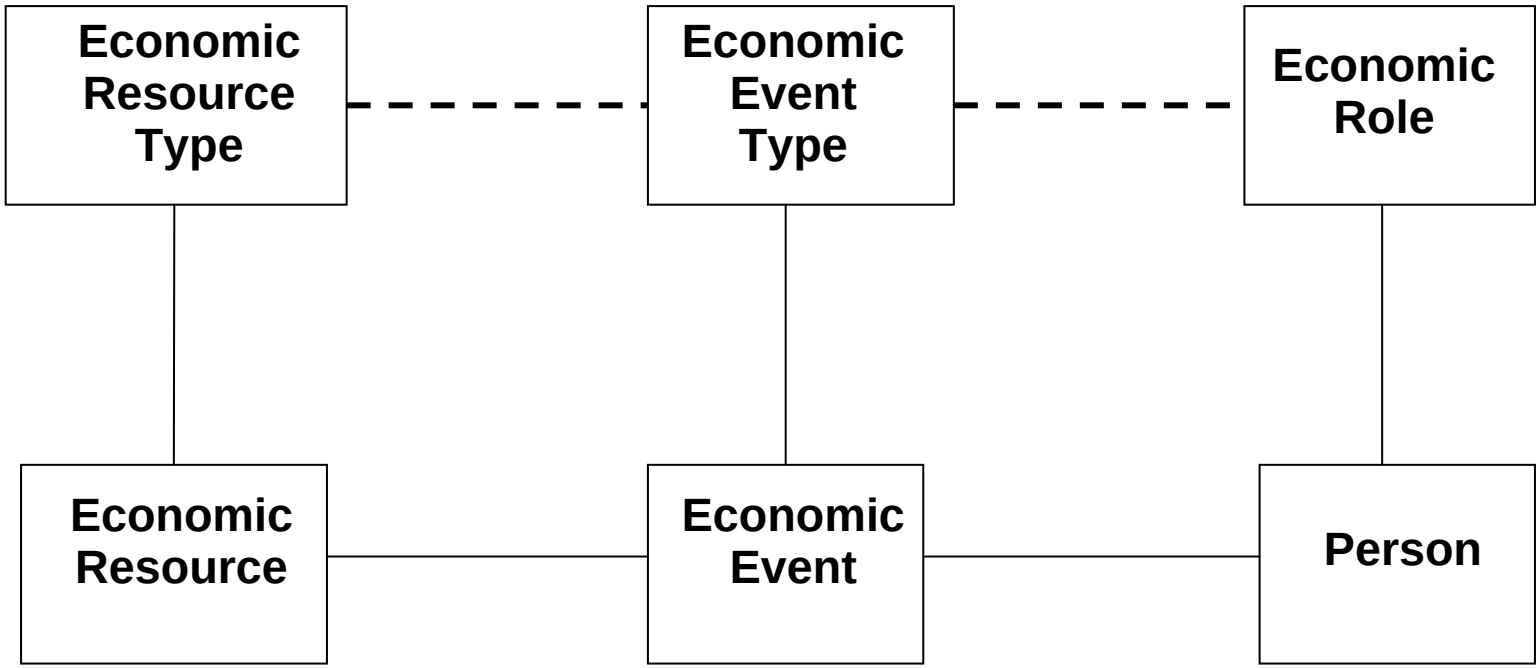

Figure 13 – Type Connections for Policy and Planning

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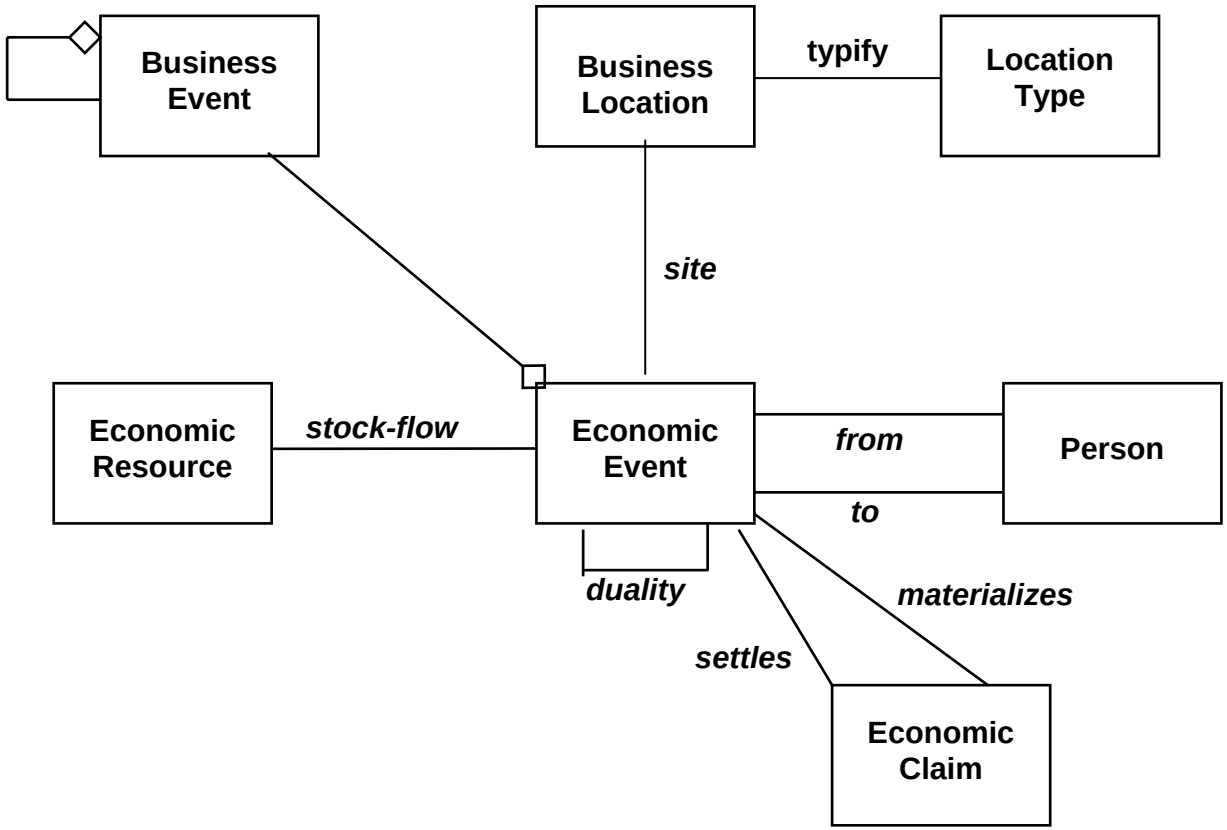

Figure 14 -- Addition of Location and Economic Claim

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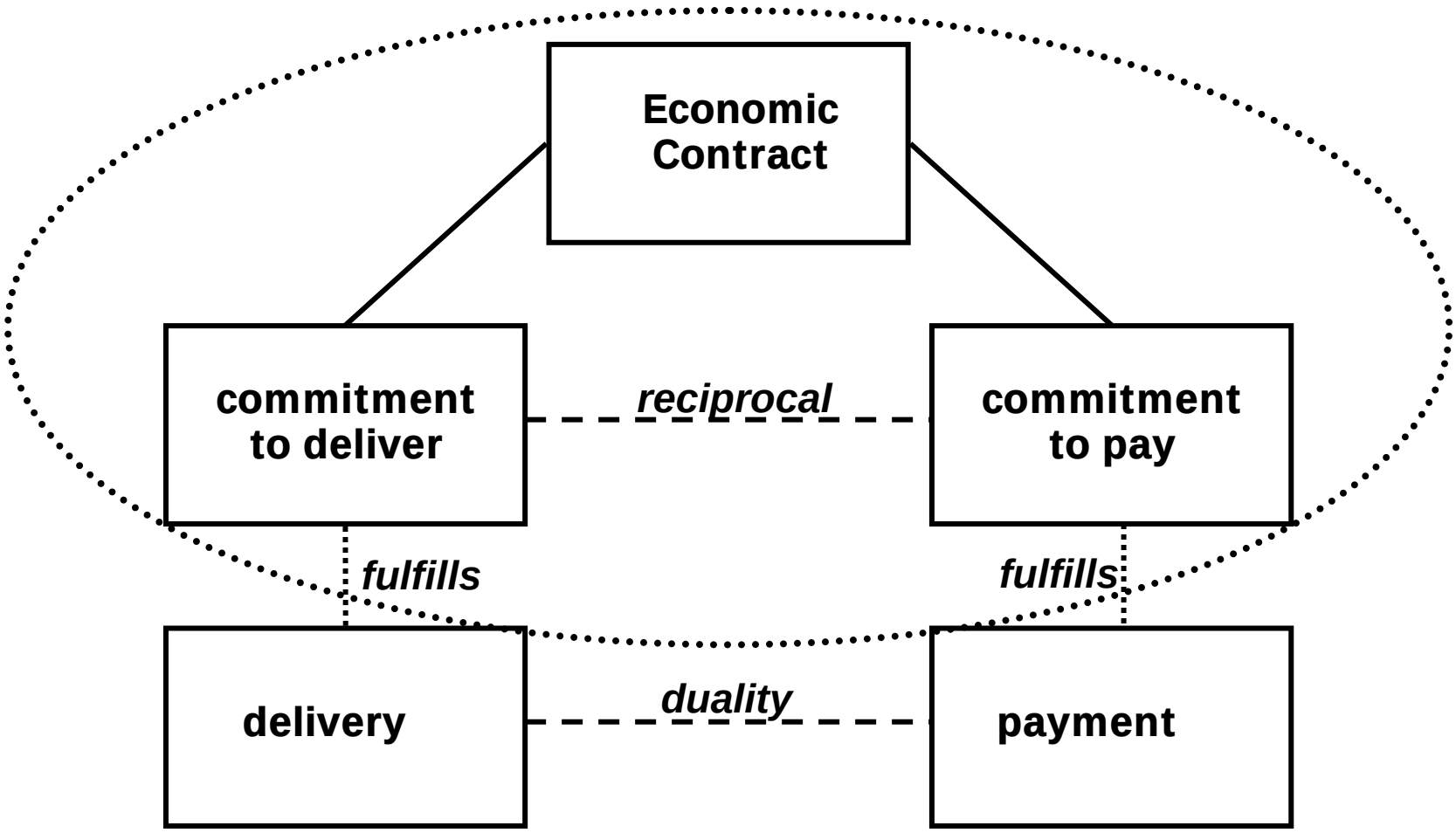

Figure 15 -- Contract as a Bundle of Commitments

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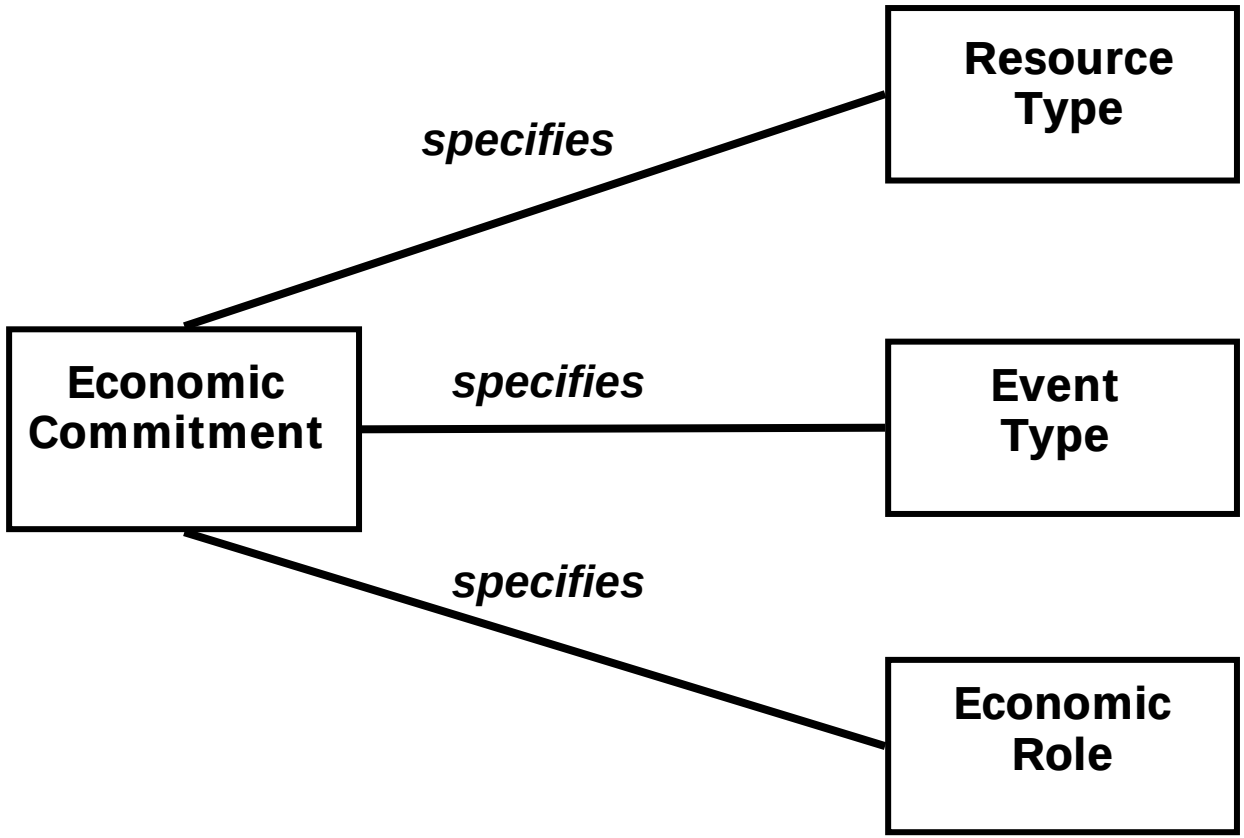

Figure 16 – Abstract Specification of Commitments

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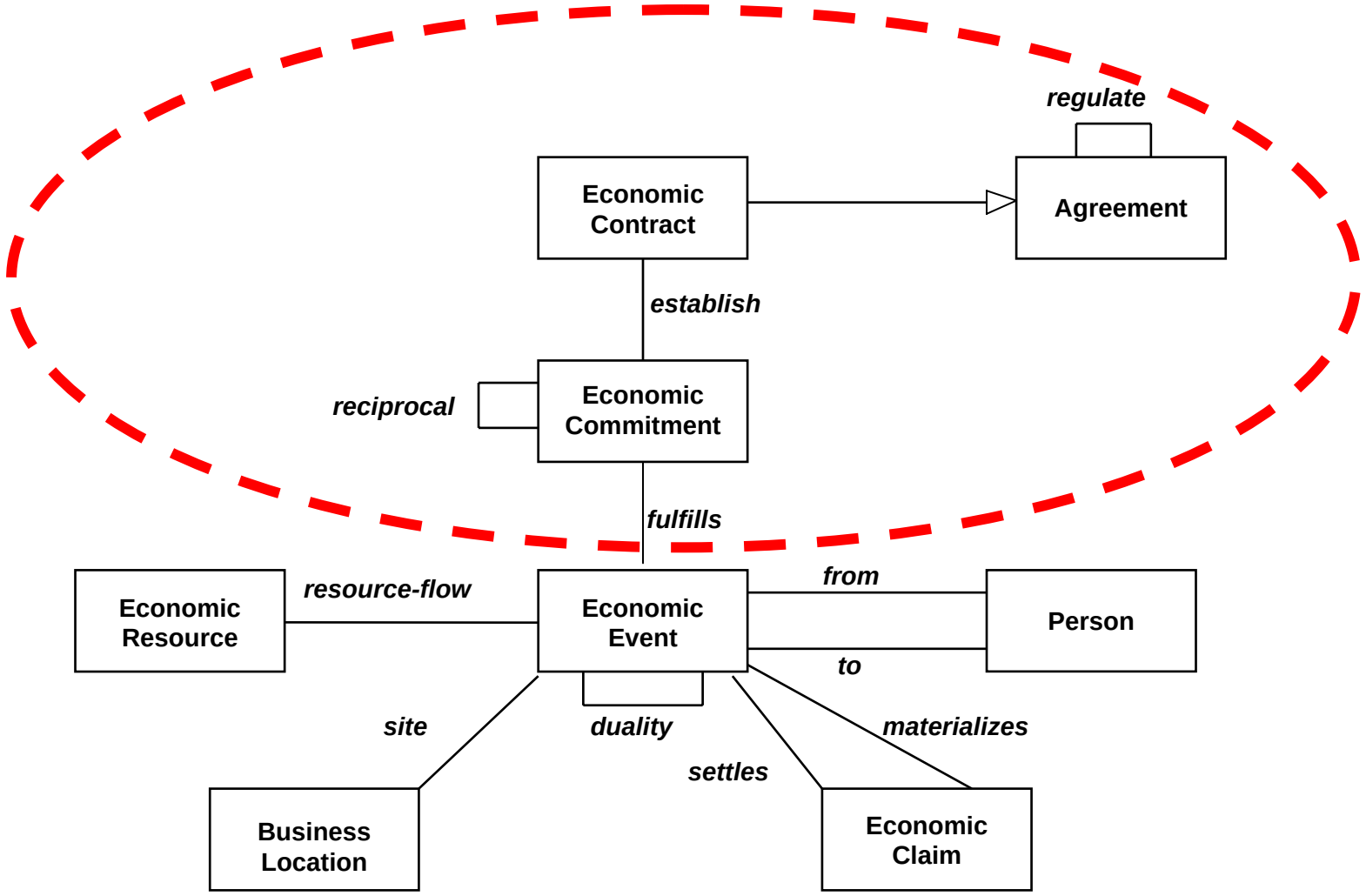

Figure 17 – Business Transaction Model with Bundled Commitments

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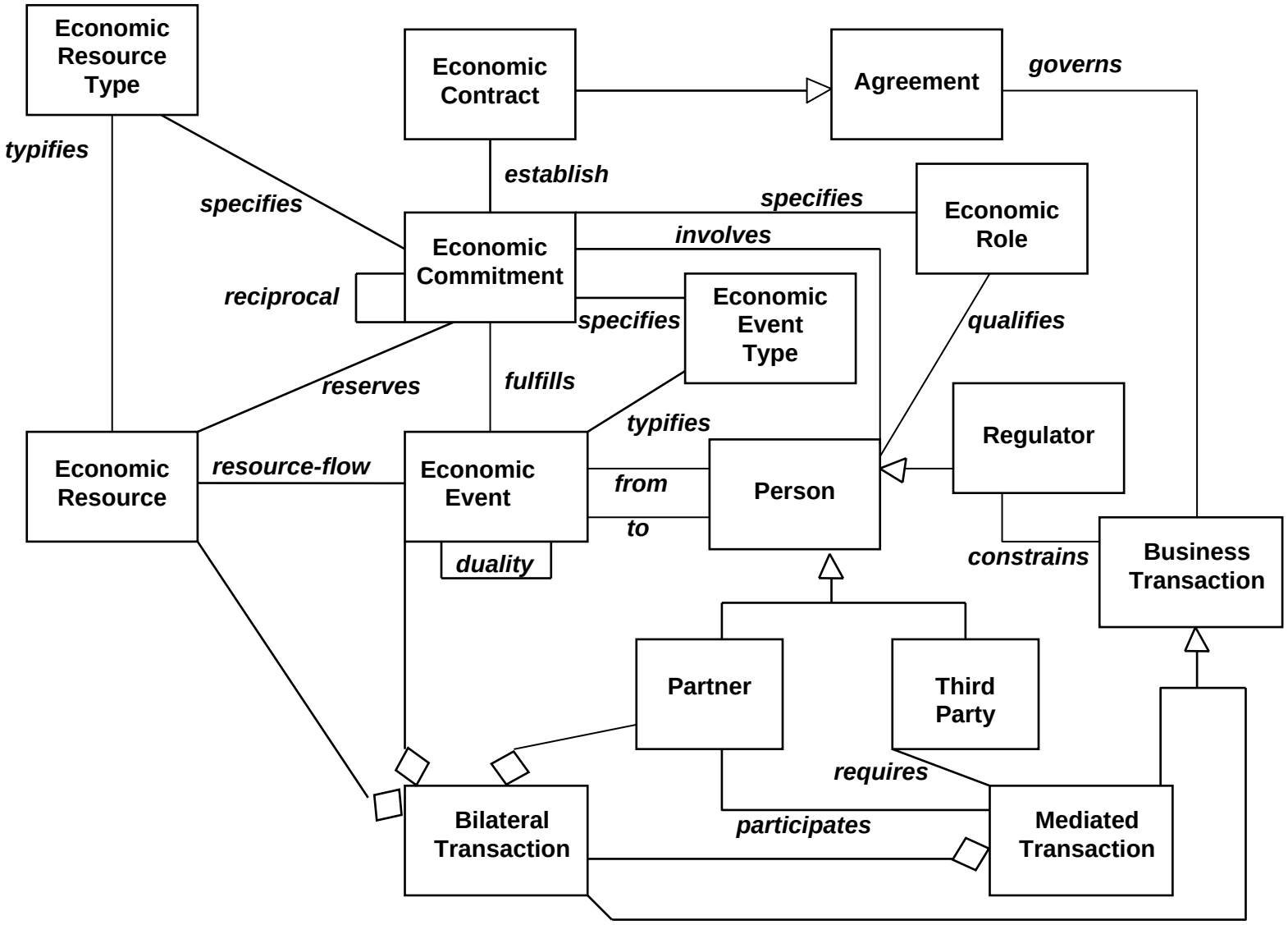

Figure 18 -- Collaboration with Commitment Structures

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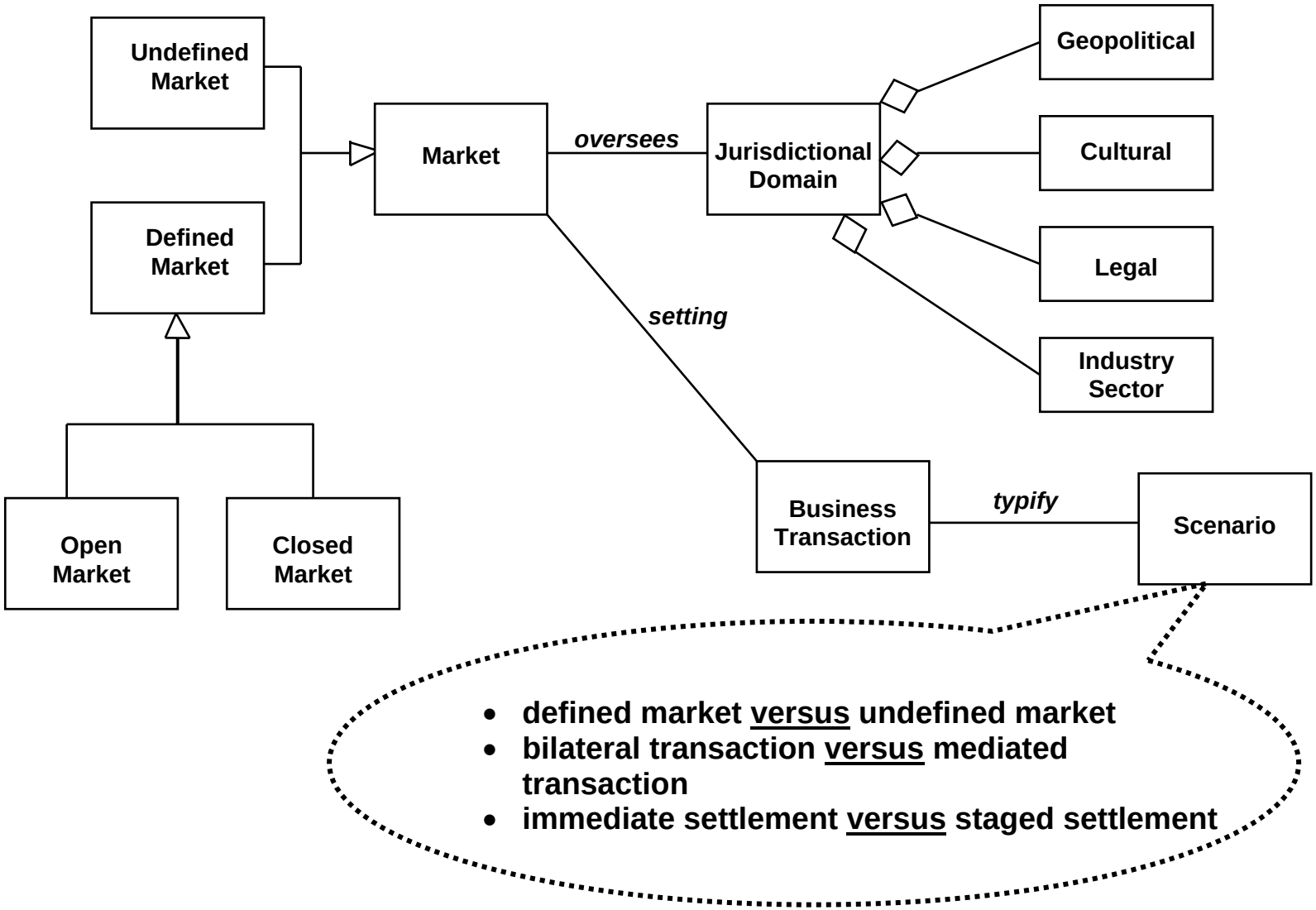

Figure 19 -- Addition of Markets and Scenarios for Business Transactions

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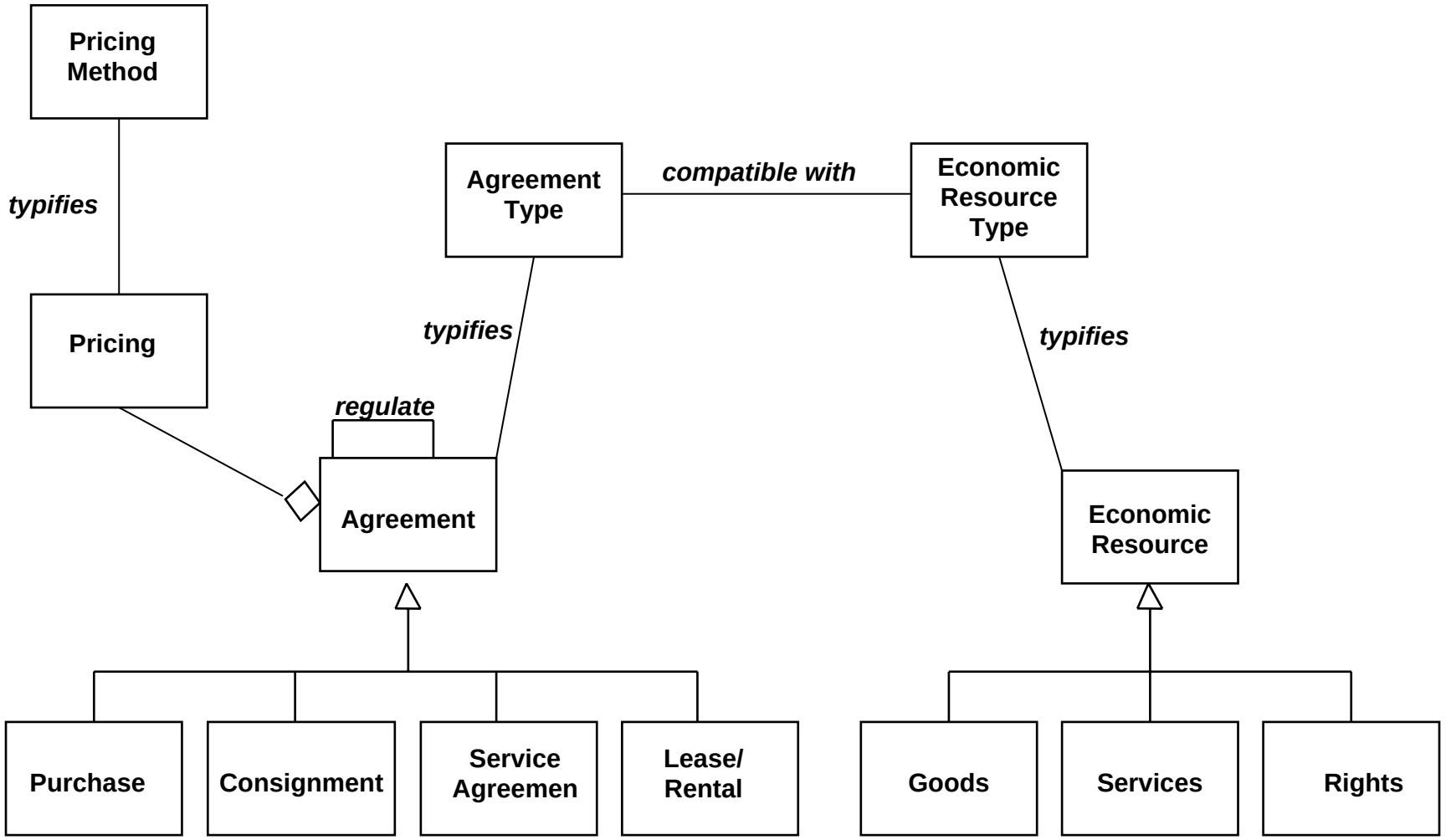

Figure 20 -- Agreement Types with Pricing Methods

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- Planning: In the Planning Phase, both the buyer and seller are engaged in activities to decide what action to take for acquiring or selling a good, service, and/or right.
- Identification: The Identification Phase pertains to all those actions or events whereby data is interchanged among potential buyers and sellers in order to establish a one-to-one linkage.
- Negotiation: The Negotiation Phase pertains to all those actions and events involving the exchange of information following the Identification Phase where a potential buyer and seller have (1) identified the nature of good(s) and/or service(s) to be provided; and, (2) identified each other at a level of certainty. The process of negotiation is directed at achieving an explicit, mutually understood, and agreed upon goal of a business collaboration and associated terms and conditions. This may include such things as the detailed specification of the good, service, and/or right, quantity, pricing, after sales servicing, delivery requirements, financing, use of agents and/or third parties, etc.
- Actualization: The Actualization Phase pertains to all activities or events necessary for the execution of the results of the negotiation for an actual business transaction. Normally the seller produces or assembles the goods, starts providing the services, prepares and completes the delivery of good, service, and/or right, etc., to the buyer as agreed according to the terms and conditions agreed upon at the termination of the Negotiation Phase. Likewise, the buyer begins the transfer of acceptable equivalent value, usually in money, to the seller providing the good, service, and/or right.
- Post-Actualization: The Post-Actualization Phase includes all of the activities or events and associated exchanges of information that occur between the buyer and the seller after the agreed upon good, service, and/or right is deemed to have been delivered. These can be activities pertaining to warranty coverage, service after sales, post-sales financing such as monthly payments or other financial arrangements, consumer complaint handling and redress or some general post-actualization relationships between buyer and seller.

SOURCE: ISO FDIS 15944-1 – *Operational Aspects of Open-edi for implementation*

Figure 21 -- ISO Open-edi Phases of a Business Transaction

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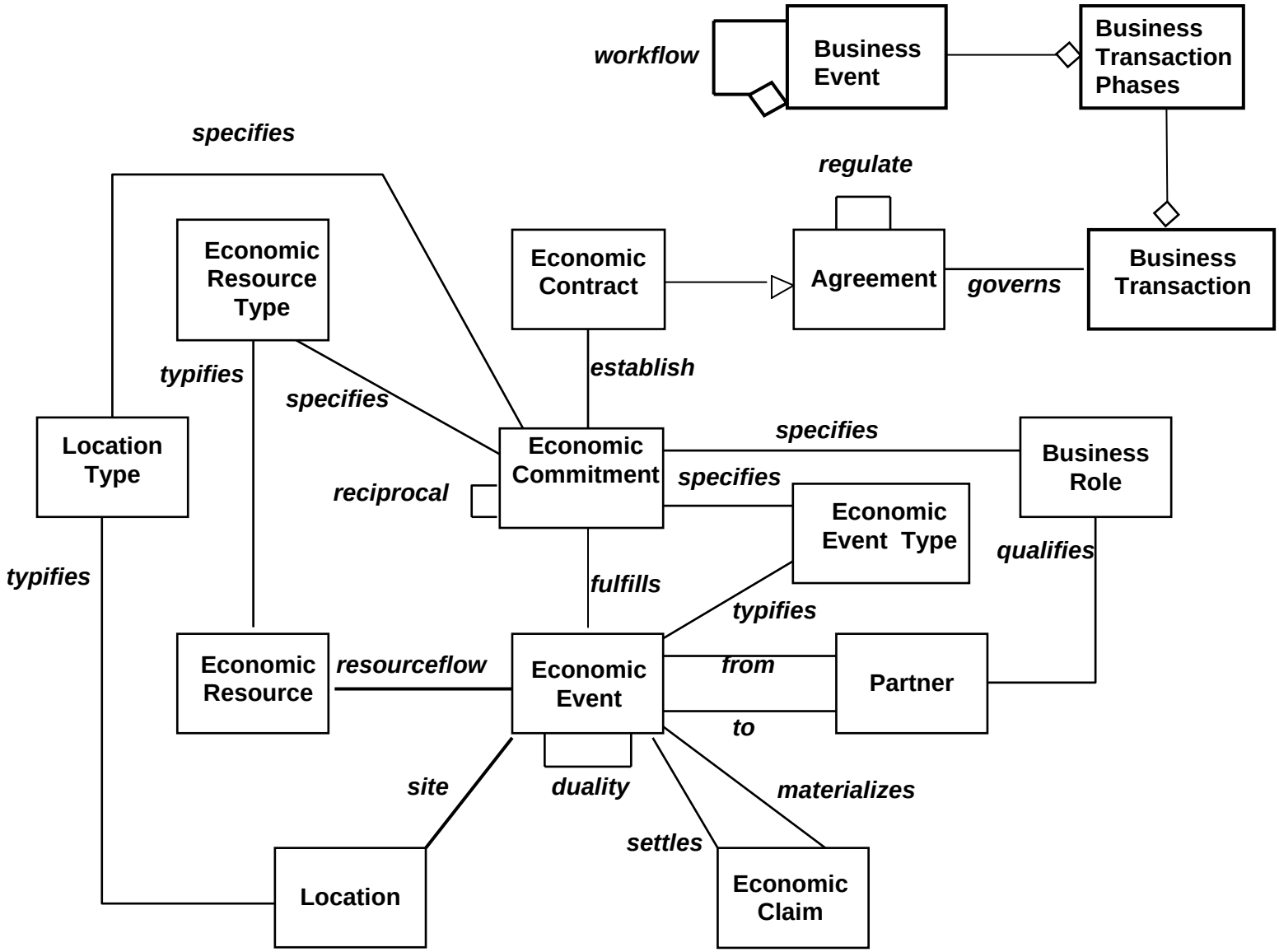

Figure 22 -- Open-edi Ontology with Business Events

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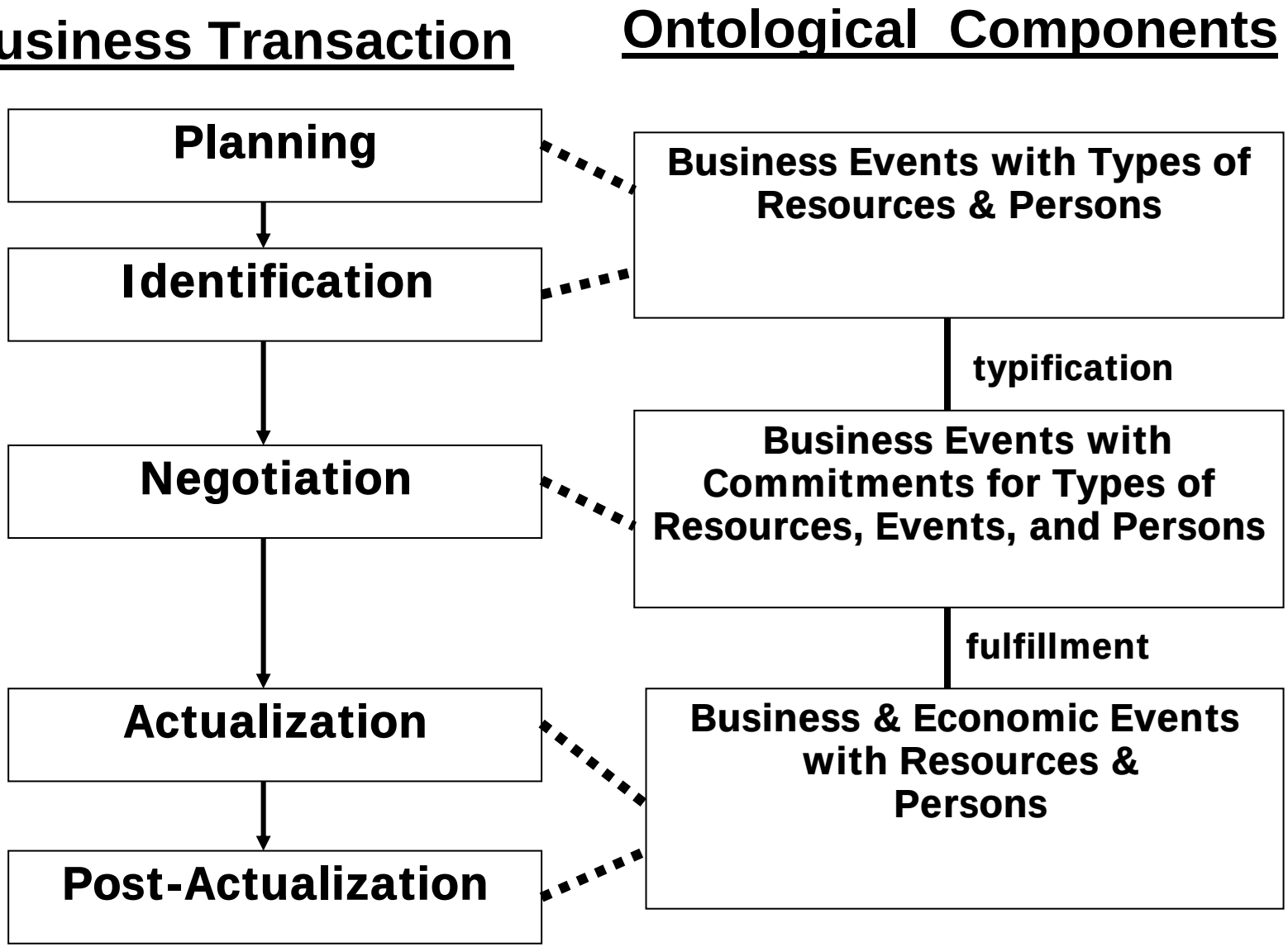

Figure 23 -- ISO Open-edi Phases with Components

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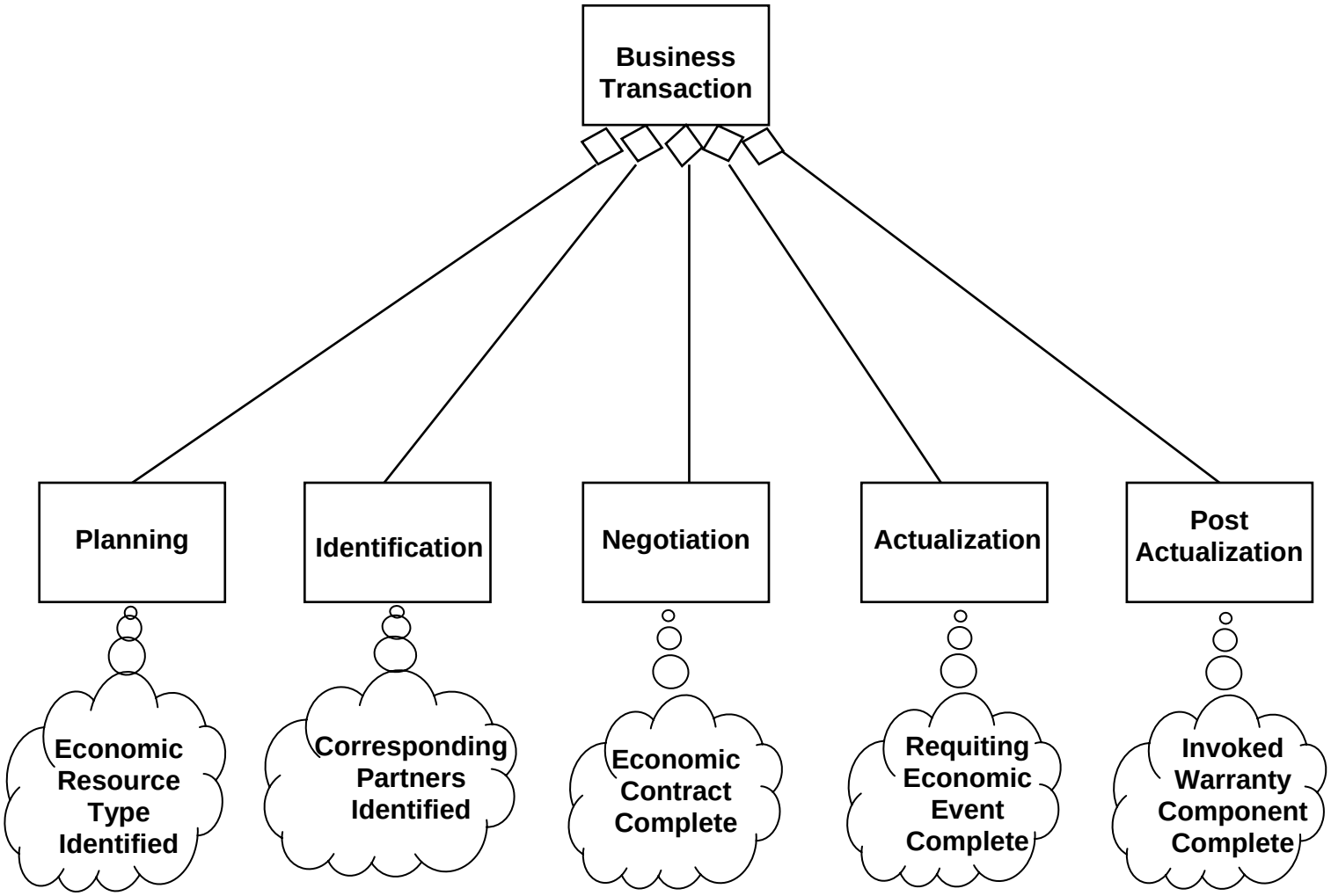

Figure 24 -- Phases of a Business Transaction and Object States for Completion

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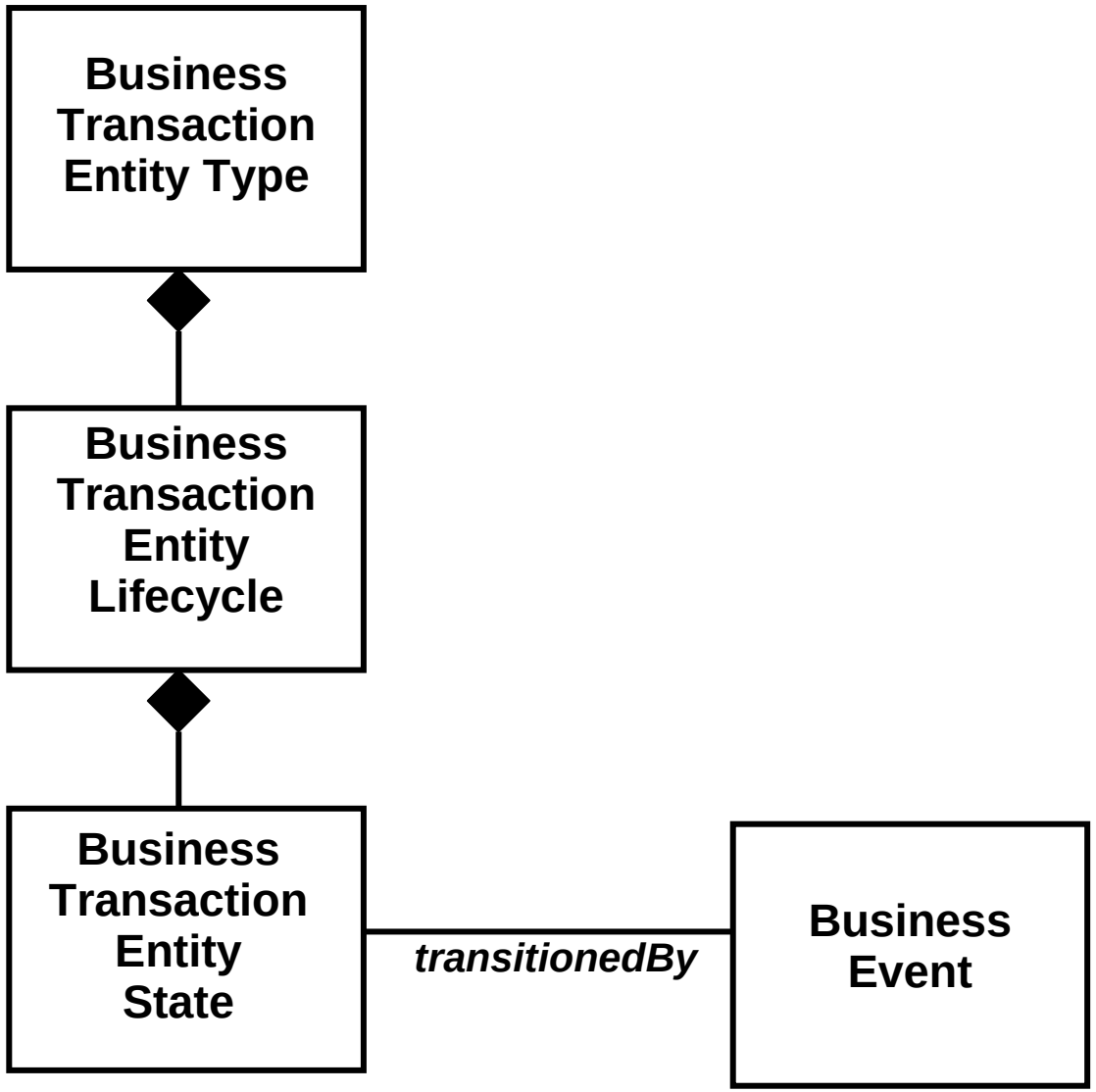

Figure 25 – Business Objects, Lifecycles, States, and Events

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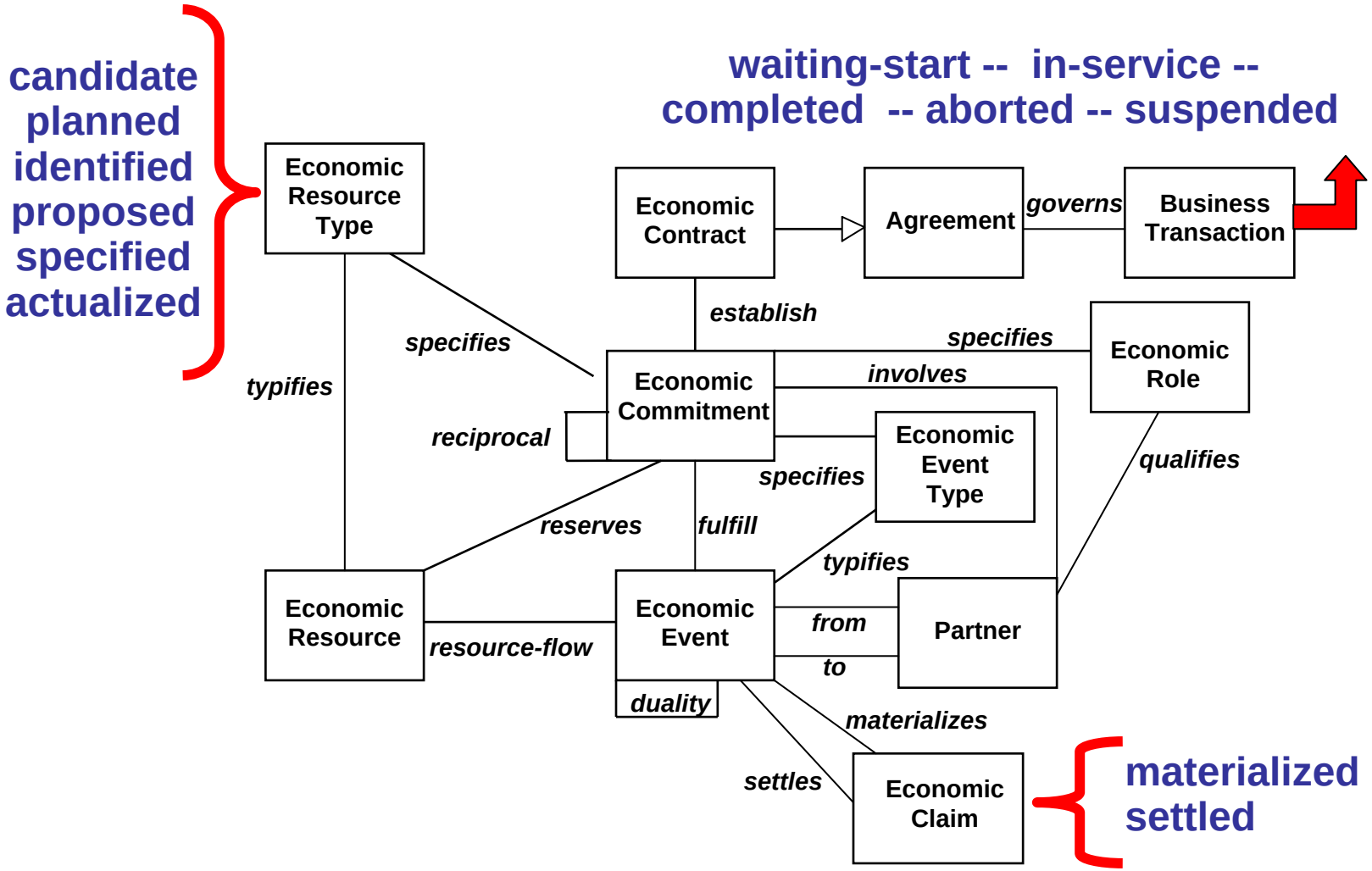
Sample Business Transaction Entity	Example States (Lifecycles) for Business Transaction Entity
Business Transaction	• Waiting-Start • In-Service • Completed • Aborted • Suspended
Economic Claim	• Materialized • Settled
Economic Resource Type	• Candidate • Planned • Identified • Proposed • Specified • Actualized
Business Transaction Phase	• Pending • In-Service • Complete

Figure 26 – Sample States for Business Transaction Entities



negotiation-pending → negotiation-in-service → negotiation-complete

Figure 27 -- Sample Business Objects with State Life Cycles

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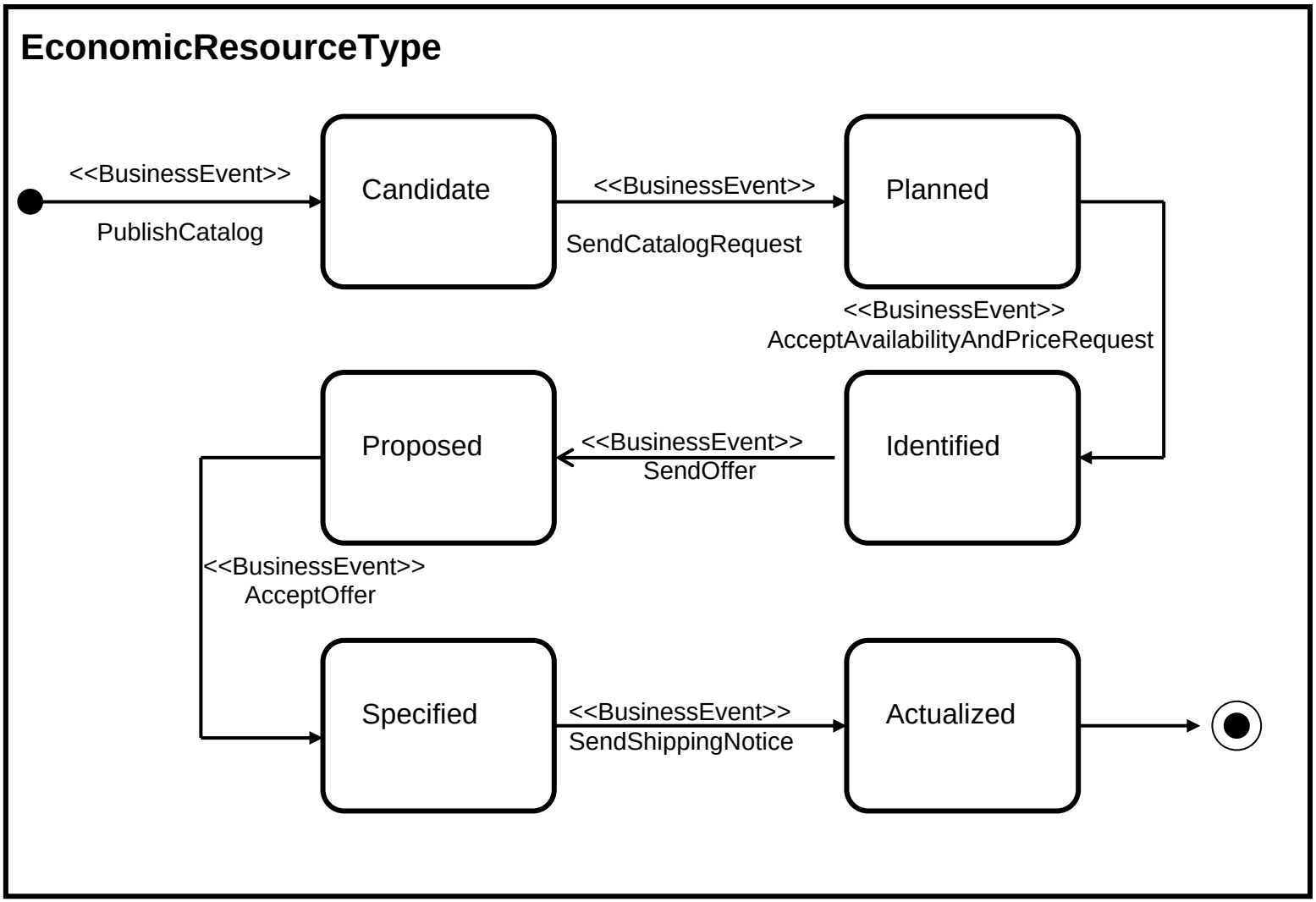

Figure 29 – State Machine Diagram for Economic Resource Type

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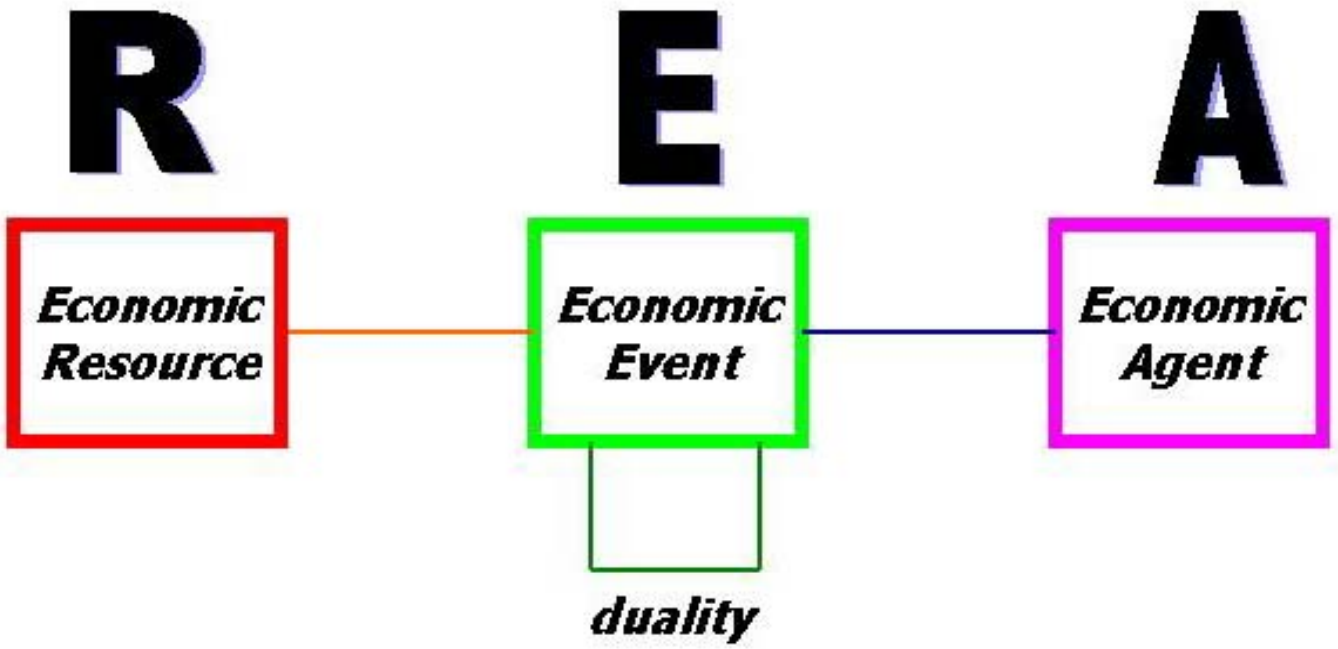

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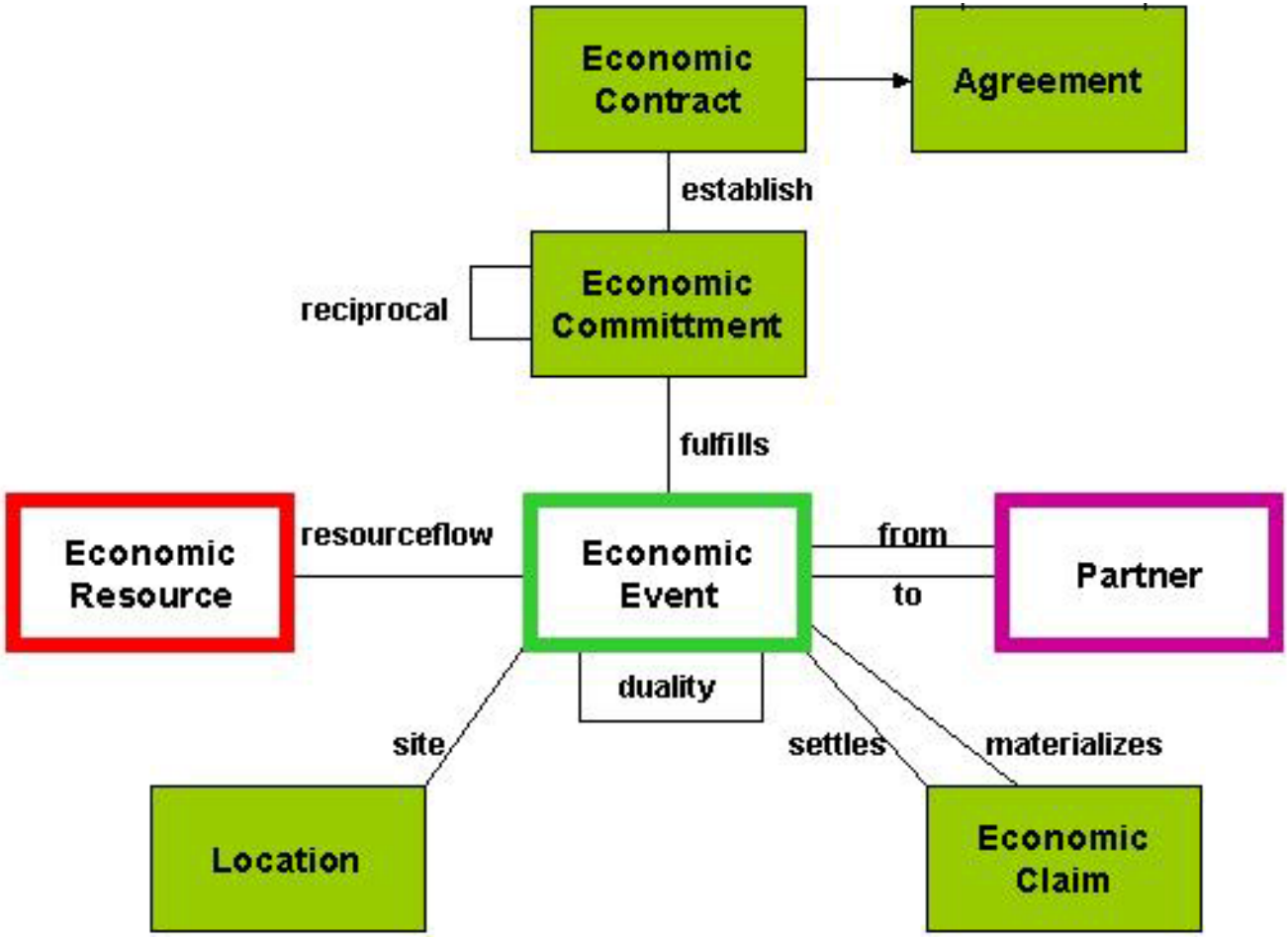
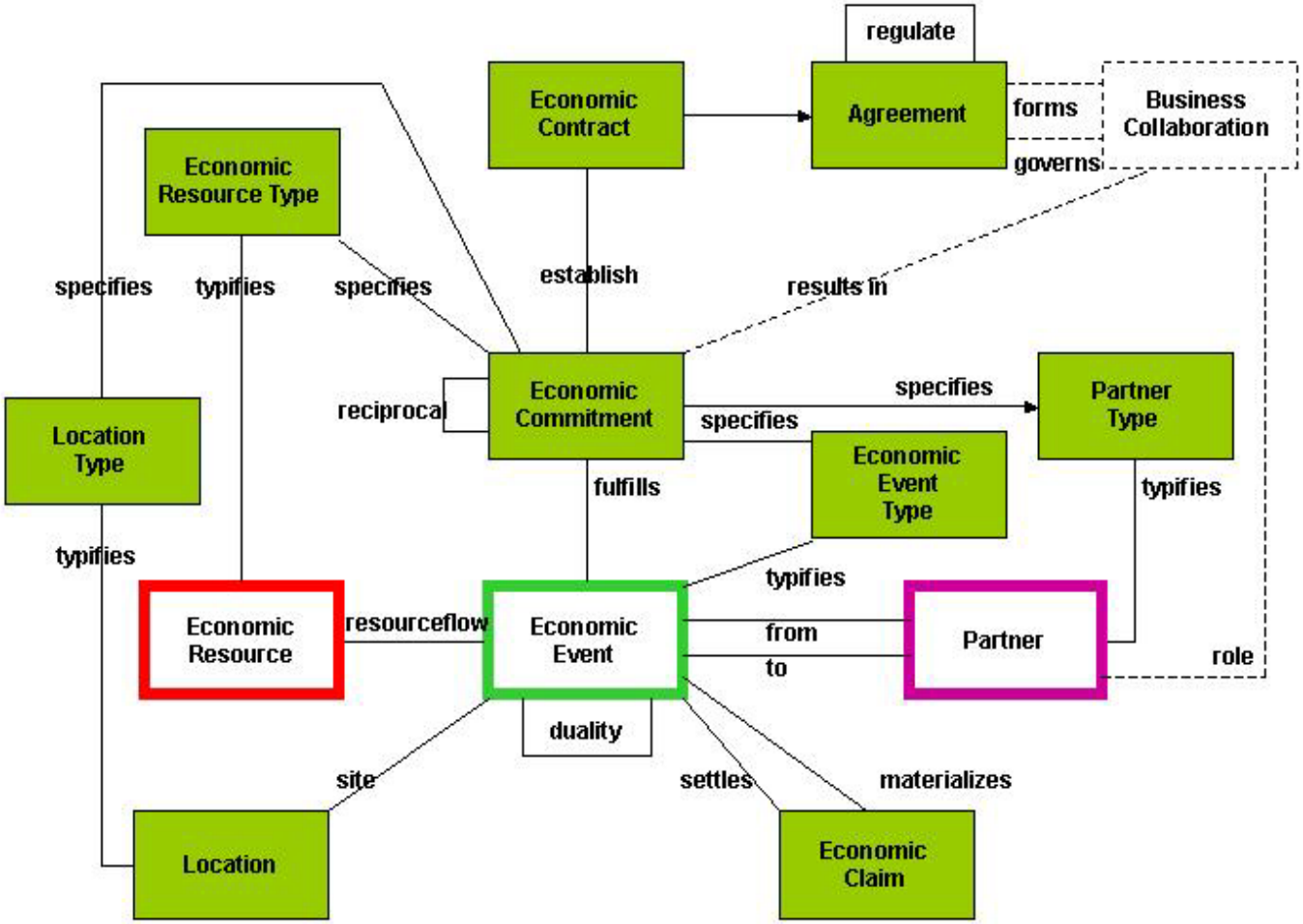
1676 **Appendix Figure A-1-- Basic REA Ontology**



Appendix Figure A-2 -- REA Ontology with Commitments



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1683 **Appendix Figure A-3 -- REA Ontology with Types**

Functional criteria	REA explanation
Does it express the consensus knowledge of a community of people?	The original paper and all extensions since have been published in high quality refereed journals (*The Accounting Review, IEEE Intelligent Systems*, etc.) where its components are open to constant review and criticism. In 1996, the original paper was given the first *Seminal Contribution to the Accounting Information Systems Literature Award* by the American Accounting Association. The Work was most recently awarded the *2003 Innovations in Accounting Education Award* by the AAA.
Do people use it as a reference of precisely defined terms?	The three leading textbooks on accounting systems analysis and design all use REA extensively to define system primitives and to explain modeling of accounting phenomena.
Is the language used expressive enough for people to say what they want to say?	The REA primitives may be used to model any of the economic dealings of an enterprise. The actual chain of entrepreneurial logic might itself be hard to explicate in a minority of cases (why for instance do firms support public charities or why is training important for employees ?), but once those links are made at some level of granularity, REA primitives are able to document them.
Is it stable?	The original paper was published in the top accounting journal in the world (*The Accounting Review*) in 1982. No substantive criticisms of its features have been published in the intervening 20 years.
Can it be used to solve a variety of different sorts of problems or as a starting point to construct multiple sorts of applications?	REA can be used to model and design the accounting components of software systems. It has also been used to model external business processes or business collaborations for ebXML and TMWG of UN/CEFACT. It has also been used to model inter-firm phenomena such as supply chains and to analyze the efficacy of a variety of enterprise software systems. Moreover, this documentation can be expressed at multiple levels of granularity, ranging from high level value chains and supply chains all the way down to the level of workflow tasks (see Figure 2). The original model covered both inter- and intra-enterprise transactions, but its use can be specialized for either case.

Appendix Figure A-4 – Ontology Criteria and REA

OVERALL CONCEPT	ISO OPEN-EDI	REA ONTOLOGY	UN/CEFACT TMG, ebXML & eBTWG
Emphasis on "economic value" as foundation for business process and business collaboration definitions	A *business transaction* pertains to the exchange of something of value	An exchange involves requited *economic events* wherein one *economic resource* – which is something of value under the control of an enterprise – is exchanged for another *economic resource*	A business collaboration is an activity where "one thing of measurable value is created, either as a service performed or as a product created
Designated "actors" or agents who participate in the economic activities within or between business enterprises or who are responsible for the participation of others	*Person* is a legal or human entity having the ability to make commitments and to fulfill resulting obligations, and to be held accountable for those obligations	*Economic Agents* include persons and agencies who participate in the economic events of the enterprise or who are responsible for subordinates' participation	*Partner* is an actor in a business collaboration
The ability to make and impart information about *commitments* as a critical component of e-commerce	A key property of a business transaction is that it involves *commitment exchange* among persons	A *commitment* is 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	An economic commitment is an obligation to perform an economic event (that is, transfer ownership of a specified quantity of a specified resource type) at some future point in time
Pre-established patterns for different classes of e-commerce collaboration at the business or economic level	An *Open-edi Scenario* is a formal specification of a class of business transactions having the same business goal	A Scenario is a configuration of event types, resource types, commitment types, and agent types aggregated together to illustrate prototypical behavior	Run-time *Declarative Collaboration Patterns* are work items being developed based on the BRV components of the UMM meta-model

Appendix Figure A-5 – Correspondence of ISO, REA, and UN/CEFACT