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Sandra K. Dewitz
The University of Texas, Austin

Ronald M. Lee
The University of Texas, Austin

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Sandra K. Dewitz
Ronald M. Lee
Graduate School of Business
The University of Texas, Austin

ABSTRACT

Electronic Data Interchange (EDI) is a telecommunications format that many view as the next major productivity gain made possible by information technology. This paper discusses how our semantic, procedure-oriented view of business transactions leads to a different kind of telecommunications system -- a **performative network**. Viewing procedures as **formal conversations**, we present a representation schema and grammar to model these conversations and initiate the development of a formal language by which users can cooperate, negotiate, and make commitments over a performative network. Our approach complements and extends EDI's syntactic, record-format orientation, seeking to express not only the data transmitted through these transactions but also the semantics of the procedures themselves.

1. INTRODUCTION

Electronic Data Interchange (EDI) is changing the way many businesses interact by speeding and simplifying the exchange of common business documents (e.g., invoices, purchase orders). Through EDI, businesses such as IBM and General Motors have established links with their suppliers and dealers whereby raw materials are ordered and product shipments are invoiced through electronic networks. These networks instantly transmit information from computer to computer in standardized digital formats, allowing orders to be placed, confirmed, and billed in moments rather than days. In addition to saving time, companies that use EDI also make money by reducing their paperwork and by processing orders more quickly. The advantages of EDI have led one IBM marketing vice president to say "Doing business without EDI will soon be like trying to do business without the telephone" (Schatz 1988).

As attractive as EDI is, we feel that its approach is inherently limited -- limited primarily by its emphasis on automating forms instead of automating the procedures that use the forms. EDI developers start with a common business document, for example, a purchase order; then they establish low-level machine protocols -- in essence, a syntax -- that will allow the data in the forms to be processed by the receiving computer. We contend that development should begin with an understanding of the procedures to be automated, with the purpose and meaning of these transactions. By adopting a more procedural, semantic orientation, we hope to complement and extend the promise of EDI and to address some of the problems that arise when computers are used to perform social acts (see Auramaki, Lehtinen and Lyytinen 1988; Lehtinen and Lyytinen 1986; and Stamper and Lee, forthcoming, for a discussion of information systems as social systems).

We propose a formal language for business communication (FLBC) that gives a formal semantics for the procedures. A formal language employs a restricted vocabulary and explicit rules to convey meaning; predicate logic and programming languages such as COBOL and Pascal are examples of formal languages. Statements in a programming language are imperative (i.e., commands that describe actions for the computer to execute); statements in predicate logic are declarative (i.e., assertions that can be evaluated as true or false). The formal language presented here includes both declarative statements, which describe states and individuals, and performative statements, which are linguistic actions performed by agents negotiating and executing contracts. The development of a FLBC makes feasible what we call a **performative network** -- an electronic network over which organizations can transact business through repeated and enduring communication.

This paper defines our approach. Examining a small fragment of contract law, we explain how legal procedures can be modeled and begin to identify the syntax, semantics, and inference rules of the formal language. Section 2 discusses performatives -- words that perform actions -- and places procedures in formal conversations in which agents use language to make commitments and to transact business. Section 3 illustrates the use of performatives to conduct formal conversations over a performative network. Section 4 details our method of modeling formal conversations, and Section 5 presents a logic model of three contracts under a fragment of the Uniform Commercial Code (UCC). Section 6 discusses the implications of this approach and future research.

2. PERFORMATIVES, DEONTIC STATES, AND FORMAL CONVERSATIONS

2.1 Performatives Defined

Several authors have suggested that illocutionary logic[1] can serve as the basis of a formal language for business communication (see McCarthy 1982; Kimbrough and Lee 1986). Illocutionary logic (Searle and Vanderveken 1985) is an extension of Austin's (1975) speech act theory, which contends that words can do more than just describe the world. Words can be used to perform acts that change the state of the world. Thus, a witness's uttering the words "I swear to tell the whole truth and nothing but the truth" in a court of law is the act of swearing that the testimony about to be given is truthful. Similarly, using the words "XYZ Inc. offers to pay $56 per share of stock" performs the legal act of offering to purchase stock. These words -- whether spoken or written -- constitute **performative speech acts**, which can be distinguished from **informative speech acts**, or declarative statements, that only convey information about the world (e.g., the words "Last week XYZ Inc. offered to pay $56" describe but do not perform a speech act).

Informative speech acts, being state descriptions, are evaluated as true or false. Performative speech acts, being actions, are evaluated as successful or unsuccessful. Austin (1975) described a performative speech act as being "happily, successfully performed" if the speaker "secures uptake" -- that is, if the speaker brings about an understanding of his intent in the mind of the hearer. Strawson (1964) qualified this requirement somewhat when he argued that the intent to achieve the hearer's understanding may be sufficient to perform a speech act, whether the desired effect is achieved or not. The requirement for a successful performative speech act in commercial sales law is that a reasonable person in the hearer's position would have understood the language as expressing the intent claimed for it.

The law has long recognized that performative speech acts are actions, not merely statements. For example, an objective third party who witnesses the formation of an oral agreement can testify that a contract was formed. In fact, Tiersma (1986) points out that such evidence would stand up in court because the law recognizes that uttering a performative verb is a deed. Testifying what someone **said** is inadmissible, being hearsay evidence; however, testifying what someone **did** in making a performative utterance is admissible as evidence.

Many of the words in legal procedures perform legal acts, such as **offering** to sell goods, **licensing** someone to distribute a product, or **accepting** an offer. We call these **legal speech acts**. A legal speech act differs from an ordinary speech act in that it invokes the rules and conventions of the law and carries with it a certain legal force. That is, legal speech acts create obligations, permissions, and prohibitions -- deontic states that are enforceable by law.

2.2 Deontic States Created by Legal Speech Acts

One of the characteristics that distinguish performative speech acts from informative speech acts is the ability of performative speech acts to change the state of the world. Legal speech acts in commercial sales contracts obligate the contractual parties to perform the acts specified in their agreement. Thus, if a merchant offers to sell goods at a certain price, the buyer's acceptance of this offer obligates the merchant to perform a sales transaction. Obligations, permissions, and prohibitions are **deontic states**, derived from deontic logic, a form of predicate logic concerned with normative concepts (see Allen 1982; Casteneda 1982; von Wright 1968). These norms are performative prescriptions that change the state of affairs: what was prohibited may now be permitted, or what was discretionary may now be obligatory.

A change in state has three components: an initial state, an intentional action that triggers a transition from one state to another, and an end state, as shown in the state-transition diagram in Figure 1 (a). The initial state (State 1) is that party Y is prohibited from driving a car (deontic state is prohibition). When party X performs the legal speech act of licensing Y to drive, that action marks the transition to the end state (State 2) in which party Y now has permission to drive (deontic state is permission). Similarly, in a contracting procedure, the legal speech acts of offering and accepting create a deontic state of obligation between the parties to the agreement, as shown in Figure 1 (b). At State 1, no obligations exist between X and Y. X's legal speech act of offering creates a deontic state (State 2) in which X is obligated to accept Y's acceptance. Y's legal speech act of accepting creates a deontic state (State 3) in which both parties are obligated to perform future actions, Act1 and Act2. This ability to use words to form commitments is a major component of our definition of a formal conversation.

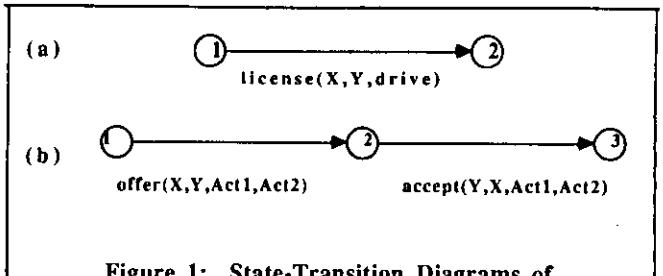

Figure 1: State-Transition Diagrams of Legal Speech Acts

2.3 Legal Procedures as Formal Conversations

When business people cooperate to perform procedures, the actions of each agent trigger and restrict the actions of the other agents, each action creating a new state in which a limited set of subsequent actions is appropriate (Searle

and Vanderveken 1985; Winograd and Flores 1986). When rules and conventions govern the actions of agents who use words to form commitments, the procedures in this largely linguistic interaction constitute a **formal conversation.**

Our concept of a formal conversation brings together several views of linguistic interaction. From Searle and Vanderveken (1985), we derive the notion of a conversation as "ordered speech act sequences that constitute arguments, discussions, buying and selling." From Maturana (1978), we adopt the idea of a "consensual domain" in which agents share a common language that evolves through their activities in that domain. Few professions or trades have evolved a more elaborate language than the legal profession; legal language is, in essence, a quasi-formal language whose word meanings are fixed by common use among participants in the legal consensual domain. Formal conversations also emphasize "conversations for action" (Flores and Ludlow 1981; Winograd and Flores 1986) in which agents use language to form commitments.

Formal conversations may be viewed as a kind of "language game" (Wittgenstein 1963).[2] A language game is a special context in which the use of language is governed by conventions. To understand the meaning of words in a language game, one must first understand the rules and conventions that determine how the "game" is played. In fact, the context or language game often provides the criteria for using a word; it defines "the normative aspects of certain linguistic conventions" (Fodor 1967) that determine what an expression denotes in that game. For example, in contract law, different terms share a common meaning: *convey, transfer, negotiate, assign,* and *delegate* are legal speech acts that bring about a change in ownership. The attribute that distinguishes one of these legal speech acts from another is the object of the ownership change, in essence, the context of the use of the word. Thus, one *conveys* real estate, *transfers* tangible personal property, *negotiates* commercial paper, *assigns* contractual rights, and *delegates* contractual duties.

With this background we can now give a full definition of **formal conversation:** an ordered sequence of speech acts performed by agents who share a common language and follow prescribed rules and conventions in order to form commitments. As this definition suggests, the timing and sequencing of speech acts matter. Each speech act is an event that must occur in a prescribed order or on, by, or within a certain time. For example, in the legal procedure of forming a sales contract, an offer must precede an acceptance. Similarly, the time frame of the acceptance may be restricted: the terms of the offer may stipulate that it will expire if not accepted within ten days.

Because timing and sequencing matter, our formal language must employ aspects of temporal logic to represent and reason about time. Both absolute time (e.g., January 1, 1999) and relative time (e.g., event A precedes event B) must be represented so that we can infer the status of the formal conversation. That is, we must be able to determine if a contract has been successfully completed, if it is pending, or if one of the parties has failed to fulfill a legal obligation within the allotted time.

A second issue in formal conversations is the competence of the participants. Because the expressions used in formal conversations are speech acts, they presuppose "the mastery of a certain game in which the expression...has a role" (Hintikka 1979); they presuppose that each participant in the formal conversation understands the rules and conventions that determine how the procedure is enacted. The rules governing legal procedures include stipulations about the capacity and intent of the parties involved, the purpose of the conversation, and the meaning of words within the conversation.

For example, if Alpha says to Beta that he will pay $5000 for Delta's car, has Alpha offered to buy Delta's car? No, because the rules governing the "game" of contract negotiation dictate that the offerer (Alpha) must make the offer to the offeree (Delta), the legal owner of the car. However, if Beta is the legally appointed agent of Delta (for example, if Beta is a car dealer or a friend whom Delta has appointed to sell his car), then Alpha has made an offer and is bound to buy Delta's car if Beta accepts the offer. But, if Alpha is a legal minor or is legally insane, Alpha's offer is voidable at his option since, according to legal rules and conventions, Alpha does not have the capacity to form a contract.

In essence, the law requires that participants in legal procedures have some degree of what Hintikka called "mastery of...[the] game" they are playing. Not only does contract law stipulate that contracts made by legal minors and by the legally insane are voidable, it also protects poorly informed consumers by rendering unenforceable a contract that takes advantage of a consumer's inability to understand the language of the agreement (what the law calls an unconscionable contract; see e.g., UCC, Section 2-302). Thus, formal conversations in contract law are governed by rules and conventions about how the parties should conduct themselves and about what constitutes an enforceable legal speech act.

Offering and counter-offering, accepting and rejecting are all rule-governed legal speech acts within the formal conversation of contracting. When one uses these words in other conversations, their effect may not be the same. When a motorist whose car has stalled in rush-hour traffic says, "I'll sell this car to the first person who offers me a nickel for it," his words are not to be construed as a binding offer. The circumstance of being stranded on a freeway and the role of irate motorist are not an adequate enabling context for a formal conversation! Thus, the

words alone are not binding; only in their "role within a certain set of social conventions or rules" (Kimbrough, Lee, and Ness 1984) -- within a well-defined formal conversation -- do these words constitute a legal speech act capable of obligating the parties.

In fact, in a well-defined context where the roles of the parties are clearly delineated, the parties can form a commitment even by using an indirect speech act, one which contains no performative verb but which implies a performative utterance. Tiersma provides an excellent example of the cruciality of the context in which a performative speech act occurs:

> There are numerous cases in which the word "offer" was not used, but courts nonetheless found a binding commitment. *Embry v. Hargadine, McKittrick Dry Goods Co.* involved a worker whose employment contract expired at the end of the year. On December 23, he went to his boss to ask for a renewal of the contract. His employer replied, "Go ahead, you're all right; get your men out and don't let that worry you." The court held that the employer had assented to the terms of a bargain. (Tiersma 1986, p. 192)

In this case, the roles of employer and employee and the circumstance of forming an employment contract are very clearly defined; any reasonable person in the employee's position would have assumed that the employer intended to renew the contract.

What this tells us about the performative network is that it must be governed by explicit rules stipulating when and how words from the formal language can be used and what meaning the legal speech acts convey in that context. An umbrella contract, which all participants on the network would be required to sign, could define the rules for conducting conversations on the network, thereby defining the conventions that govern how the legal speech acts are interpreted.

3. CONDUCTING FORMAL CONVERSATIONS ON A PERFORMATIVE NETWORK

Given the framework provided by Section 2, we can now describe a performative network more fully. A **performative network** is a telecommunications system that supports the formation of commitments between agents by providing a formal language by which they can perform legal speech acts. What makes a network performative is a set of assumptions about its use. For example, an ATM (automatic teller machine) network is performative in the sense that it provides a formal system whereby users perform the legal speech acts of withdrawing and depositing money. In other applications, a performative network may provide a meeting place, a kind of trading room floor or market place, that imposes certain rules of discourse on its members: for example, electronic shopping (see Lee and Widmeyer 1986) and electronic contracting (see Lee 1988). The performative network that we envision for electronic contracting can also monitor the fulfillment of agents' commitments. An example of a contracting procedure executed over a performative network will clarify how the network would work.

3.1 A Contracting Scenario

Our example describes a sale on approval in which a merchant allows a customer to examine and to "try out" goods during a trial period. Assume that Smith, a merchant, and Jones, a customer, are both subscribers on the network. Smith, who develops and sells small business software, logs on the network and places an ad that describes the programs currently available, giving their price and the terms of sale. The terms of sale stipulate that a customer may copy the software to his file space on the network and try it at no charge for 48 hours.

While browsing through the "For Sale" ads on the network, Jones reads Smith's ad and decides to try one of Smith's accounting packages. Jones executes the appropriate command to indicate that he wishes to enter a sale on approval with Smith. The network records this transaction by posting a record to its database, noting that Smith has bailed (given temporary possession of) an accounting software package to Jones. Then the network copies the accounting program to Jones' file space.

If Jones decides to buy the software, he signals his acceptance by remitting payment to Smith through an electronic funds transfer within the 48-hour trial period. The network, acting as monitor, records this transaction and completes the sale by authorizing Jones to download the software program to his own system and by issuing a registration number for Jones' copy (that registration number being the equivalent of a document of title or license). The network may also notify Smith to send Jones backup copies of the program diskette(s) and a hardcopy of the user manual through express mail delivery.

If Jones decides not to buy the software, he is obligated to log on the network and execute a statement signalling his rejection before the 48-hour trial period has elapsed. Executing the rejection command causes the network to erase the accounting program from Jones' network file space. If Jones does nothing (i.e., neither remits payment nor signals his rejection), the system infers that he has accepted the software by default and posts a record of Jones' payment obligation to Smith's transaction file.

3.2 Informative versus Performative Networks: Legal Issues

From this example, one sees that both Electronic Data Interchange and the performative network support the transmission of data from computer to computer. Howev-

er, what makes our approach different is its focus on procedures and its performative framework. Unlike EDI, in which the "negotiation of terms and conditions should be resolved prior to" logging on a network to transmit the "highly formatted, standardized, and automated" data (Baum, Boss and Fry 1988, p. 18), the performative network can support human agents as they form agreements. For example, Jones could reject Smith's price term and offer to pay $250 for the software instead of the $295 that Smith is asking. Then Smith could accept or reject Jones' offer, acceptance leading to the transaction described above.

An informative network (e.g., the Dow-Jones News Retrieval service or any other application that provides information to subscribers) merely describes the states of participants and objects. In contrast, a performative network actually supports the performance of acts that change the status of the participants. On an informative network, unauthorized access is the primary security concern; third parties must be prevented from accessing or altering the information on the network, data integrity being the paramount concern. In contrast, on a performative network, forgery and fraud pose the greatest security risks. Verifying the legitimacy of the acts requires verification of the agent's identity: that it was Smith who made the offer and Jones who accepted the goods. It also requires irrefutable evidence that the act itself was performed: that Smith tendered delivery of the accounting software or that Jones signalled his rejection within the trial period. These security issues have been addressed elsewhere (see Baum, Boss and Fry 1988; Kahn, Vezza and Roth 1981) in discussions of authenticity guarantees such as time stamping, receipt verification, and encryption.

Nonetheless, a major barrier to developing a performative network is satisfying the Uniform Commercial Code's requirement that, to be enforceable, a sales contract for goods in excess of $500 must be evidenced by a signed writing. A writing can be "any...intentional reduction to tangible form" (UCC, Section 1-201 (46)); a signature can be any symbol used by a party "with the present intention to authenticate" (UCC, Section 1-201 (39)) the form to which it is applied. Although neither a paper document nor a hand-written signature is specifically required under the UCC, it is unclear just how electronic technology can satisfy the requirement of a "signed writing." A task force on electronic messaging services, commissioned by the American Bar Association, has recommended that this requirement be dropped or that the UCC be supplemented with explicit statements approving an electronic equivalent of a signed writing (Baum, Boss and Fry 1988). Since the UCC already recognizes the legal force of a telegram and of a telex, designating rules for satisfying the signed writing requirement on a performative network is entirely feasible.

One way to overcome this impediment is to construe the execution of a performative statement on the network as an "affirmative act" (Baum, Boss and Fry 1988) similar to the act of signing a document or mailing a letter containing an offer or acceptance. Just as an offer to buy conveyed in a letter is activated at the moment the letter is placed in a mailbox (the "mailbox rule"), a legal speech act could be seen as activated the moment the appropriate command is executed on the network. Thus, in our scenario, Jones' executing the command for entering a sale on approval is an affirmative act that signals his acceptance of the terms of the sale and that commits him to either accept and pay for the software or explicitly reject it within the 48-hour trial period.

4. MODELING FORMAL CONVERSATIONS

Developing a performative network requires an in-depth understanding of the formal conversations to be conducted on the network. We must understand both the sequence of actions within these conversations and the obligations they create. In this section we give a representation schema for modeling the events in formal conversations (see Lee and Ryu 1989 for a fuller discussion). The events are performative (legal) speech acts that bring about commitments. In all cases, the timing and the sequencing of events are crucial to the satisfactory completion of the formal conversation. We represent these temporal aspects in two formal notations: an event grammar that provides a linear model of the formal conversation and an event net that models the conversation graphically.

4.1 Predicate Logic and Temporality

In predicate logic, problem domains are modeled using predicates denoted as predicate constants followed by an argument list: for example, $(\alpha_1,\alpha_2,\alpha_3,...\alpha_n)$. The arguments may be simple variables or constants representing individuals, or they may be complex structures called functions. This predicate represents a static relationship; however, because we are modeling procedures, we must assume that a relationship is not permanent, that it may change as the procedure progresses. Typically we will be most concerned with the moment when a predicate commences, that commencement signalling what we call an event. (We refer to the moment when a predicate ceases to be true as the commencement of its negation.)

To model procedures more fully, we add two components to the standard predicate notation.[3] First, we distinguish event predicates from ordinary predicates by prefixing a colon (:) to the event predicate: for example,

$$: \phi(\alpha_1,\alpha_2,\alpha_3,...\alpha_n)$$

The colon signifies that the state described by the predicate "occurs" or "is brought about." A second concept that our notation must capture is that of an agent responsible for the occurrence of the event. Although agency could be

represented as an additional argument within the predicate, its importance to organizational modeling requires that we explicitly identify the agent: for example, β : ϕ, where β identifies the person, role, or department responsible for bringing about the event ϕ. In this notation, ':' is, in effect, a higher order predicate that associates an agent with an event; thus, jones : payment(smith, $ 295) indicates that Jones brings about a payment to Smith of $295. Generic actions may be described using variables; X : A indicates that party X brings about event A.

Events will normally be regarded as occurring at a point in time. If the process that brings about an event is an activity having duration (e.g., building a house), the point event is the completion of the activity. We use an elementary form of temporal logic to reason about the occurrence of events in time and about deadlines for actions.[4] Since the calendar is the principal framework for temporal references, we adopt calendar dates as the basic temporal entity. The notation for dates is **<day>-<month>-<year>**, for example, 6-feb-1989. An action is associated with a particular date by means of temporal operators:

<action> **on** <date> =
an action performed on a certain date

<action> **by** <date> =
an action performed on or before a certain date

Relative times can be specified by using <action> **within** <integer> **days,** indicating that the action is to be performed within the specified number of days from the preceding state. In addition, our notation can indicate that a deadline has not been met; this involves a special form of negation that we call **temporal negation**: ~X:A by D. We use the negation sign (~) to indicate that an agent X fails to bring about an event A by the deadline D. Similar usage applies to the **on** and **within** constructs. Temporal negation differs from ordinary negation in that it refers to the non-fulfillment of a deadline. A promised action has a threefold status: completed (on time), pending (not completed, but deadline has not yet passed), or breached (not completed and deadline has passed). Temporal negation is a test used to identify when a breach has occurred.

We represent the relative sequencing of events as event grammars, which have both a graphical and a linear notation. Event grammars are so named because their linear notation is much like the definite clause grammars used to parse natural language. However, rather than parsing sequences of words, event grammars parse (historical) sequences of events. In our applications, these events are typically linguistic events involving performative speech acts. Thus, event grammars describe the permissible sequence of speech acts in a formal conversation. Section 4.2 discusses how these sequences are represented as **event nets**; Section 4.3 gives the linear **event grammar** notation.

4.2 Event Nets

An event net is a modification of a state-transition network extended to incorporate limited types of concurrency between events. This notation is somewhat less versatile than a Petri Net, but its notation is much more compact. An event net consists of nodes, drawn as circles, and directed arcs, drawn as arrows. Arcs are labelled with event predicates or the name of a subgraph in subroutine fashion. Each subgraph may have only one starting node, the starting node's label serving as the name of the subgraph. Concurrent events are represented as parallel arcs enclosed by vertical bars: the first bar indicates the beginning of the concurrent events, and the second indicates their completion, as shown in Figure 2.

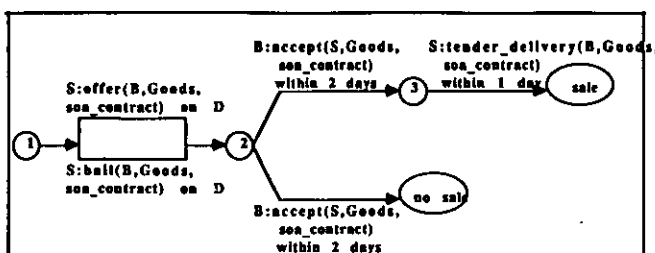

Figure 2: Event Net of a Sale on Approval Contract

This event net represents a contracting procedure that begins with two concurrent activities: a seller S brings about an offer to sell goods to a buyer B by creating a bailment (giving temporary possession of) the goods to the buyer. At State 2, the buyer B can either accept the goods by paying for them or reject the goods by returning them to the seller. If the buyer accepts the goods, a third state (State 3) arises in which the seller is obligated to tender delivery of the goods by giving the seller a document of title. In this situation, the procedure culminates in a completed sales transaction. If the buyer rejects the goods, the procedure ends with no sale.

4.3 Event Grammars

Like event nets, event grammars are intermediate to state-transition diagrams and Petri nets in their expressiveness, again in an effort to economize on notation while representing concurrency where necessary. In fact, event grammar rules are compiled into Petri net transition rules of the form

trans([<input places>], [<output places>], <action>).

Thus, the procedural reasoning is done within conventional predicate logic using predicates of this form.

The linear notation of event grammars is a series of rules having the general form ϕ = = > $y_1, y_2, y_3, ...y_n$. Each y_i is

an event predicate, which may be an atomic action, as in the notation described earlier, or a non-atomic action that is further defined by subsequent rules. The comma between event predicates indicates temporal sequence, not logical conjunction. An event grammar rule is read "Event ϕ is recognized if event y_1 is recognized, and next event y_2 is recognized, and next ..., and next event y_n is recognized." Event grammars can express limited concurrency. Corresponding to the vertical bars of the event net are the square brackets used in event grammars; for example, [A,B] indicates that A precedes B or vice-versa. Thus, the expression P = = > [A,B] is equivalent to P = = > A,B and P = = > B,A. Using this notation, the event net of Figure 2 can be represented by the following event grammar rule:[5]

```
sale_on_approval = = >
    [S:offer(B,Goods,soa_contract-1) on D,
    S:bail(B,Goods,soa_contract-1) on D],
    B:accept(S,Goods,soa_contract-1) within 2 days.
    S:tender_delivery(S,Goods,soa_contract-1) within 1 day
```

5. A FORMAL LANGUAGE FOR CONTRACTING

The previous section explained our notation for representing events in formal conversations. In this section we build on the event grammar notation to develop a logic model of formal conversations under a fragment of the Uniform Commercial Code. We also outline the syntax and semantics of a formal language that can be used to conduct and to monitor these conversations.

We use the framework of denotational semantics in which a formal language is defined by identifying its ontology (the primitive entities in the domain being modeled) and by specifying a vocabulary and formation rules for building complex structures from these entities.[6] The meaning of every well-formed sentence is given in the semantics, which describes the way the world would have to be for each sentence to be true. Because our model must support inferencing about the status of the formal conversation, we also provide inference rules to evaluate and to monitor that status.

5.1 A Fragment of Commercial Sales Contract Law

Our logic model describes formal conversations conducted to form and to execute three relatively simple sales contracts.

> **Shipment contract**: a contract in which the seller tenders delivery of goods by bailing them to a carrier who, in turn, transports them to a place specified by the buyer.
>
> **Destination contract**: a contract in which the seller bails goods to a carrier and tenders delivery of those goods at a place specified by the buyer.
>
> **Sale on approval**: a contract in which the seller bails goods to the potential buyer with the understanding that the buyer must accept (i.e., pay for) the goods or reject them within a certain time period.

As the explanations of these contracts suggest, the vocabulary of our formal language must correctly denote the precise meaning of several legal terms and concepts. A major task in developing a formal language is identifying the ontology of the discourse domain in which the language is to be used. The ontology describes the entities that exist in the domain being modeled. The ontology for this fragment of commercial sales law includes the entities shown in Figure 3.

PLAYERS are the participants in the formal conversation, the parties involved in the contract. In the contracts modeled here, the players include a merchant, a carrier (a delivery service, whether Federal Express, Union Pacific Railroad, or Bob's Trucking), and a customer. In other kinds of contracts, the players might include a cosigner, a financing institution, a notary, witnesses, and others. Players fill the agent role described in our event grammar notation. They are entities in the domain of discourse as well as users of the performative network; that is, these players use the formal language provided by the performative network to form commitments.

ACTS are the linguistic actions the players perform in order to conduct a formal conversation. Some of these legal speech acts are performed on paper. For example, a tender of delivery involves providing the buyer with a document of title that gives the buyer legal ownership of the contractual goods. Documents of title include a **bill of lading** (used when the merchant arranges delivery of goods through a carrier) and a **warehouse receipt** (used when the customer picks up the goods from a warehouse). One of the legal speech acts, **accept**, can be realized by the absence of action. By not explicitly rejecting goods in a sale on approval, a customer accepts them, his silence obligating him to pay the merchant the full price of the goods. Our earlier scenario of Jones' accepting the accounting software by failing to reject it within the 48-hour trial period is an example of silence being construed as a legal speech act in the appropriate context.

GOODS are the contractual objects of interest. Under the Uniform Commercial Code, goods include "all things... which are movable at the time of identification to the contract for sale other than the money in which the price is to be paid, investment securities...and things in action" (Section 2-105(1)). More specifically, the contracts modeled here cover only those goods purchased for personal or business use (i.e., real estate transactions, which involve real property, not goods, are outside the scope of the UCC).

DOMAIN = **PLAYERS U ACTS U GOODS U DATES U CONTRACTS** where

PLAYERS = {X: X is a merchant} U {X: X is a carrier} U {X: X is a customer}

ACTS = {offer, accept, tender_delivery, bail, reject} where

offer: A merchant (customer) offers to sell (buy) goods at a certain price. The offeree's acceptance obligates the offerer to perform the act offered.

accept: An offeree accepts an offer by agreeing to its terms, thereby being obligated to perform certain acts. In a sale on approval, a customer accepts goods either by failing to reject them within the trial period or by remitting payment to the merchant within the trial period.

tender_delivery: A merchant tenders delivery of goods to a customer by giving the customer a document of title to those goods.

bail: A merchant bails goods by giving temporary possession of those goods to
-a carrier for delivery to a customer or
-a customer in a sale on approval.

reject: A customer rejects goods in a sale on approval by returning them to the merchant within the trial period; an offeree rejects an offer by refusing to accept the offerer's terms.

GOODS = {X: X is a tangible, movable object}

DATES = {X-Y-Z : X-Y-Z is a calendar date where X is an integer 1-31, Y is an element in {jan, feb, mar, ..., dec}, and Z is a four-digit integer}

CONTRACTS = {X : X is a contract}

Figure 3: Ontology of a Fragment of Commercial Sales Law

When contracts refer to specific times for action, DATES are an important entity. The UCC adheres to the concept of "reasonable definiteness," which requires only that a contract "possess sufficient certainty to enable a court to determine the rights and obligations of the parties" (Howell, Allison, and Prentice 1988, p. 1400). When a date or time period for action is not specified in the contract, a "reasonable time" is inferred by studying the circumstances of the current and other similar agreements. Our model assumes that specific dates or relative times for performance are given so that we can avoid this fuzziness as we evaluate the status of the contract. Future research will add the features necessary to support inferences about "reasonable time."

CONTRACTS are the agreements formed by the Players. Each is uniquely identified by its contract type (**s_contract**, **d_contract**, or **soa_contract**) and by an index on each type; for example, **d_contract**-1 individuates a particular destination contract. Individuation becomes especially important when there is no physical document to provide a permanent, tangible record of the agreement. Lee (1984) describes the role of a neutral third party -- in our scenario, the performative network itself -- which individuates the agreements and guards against illegal reproduction.

5.2 Formation Rules

The entities defined in Figure 3 combine to form the sentences of the formal language. The formal language contains two kinds of statements: performative statements and declarative statements. Performative statements consist of the legal speech acts that players use to engage in formal conversations. Performative statements are events that succeed (are realized and become part of a database of historical events) or fail (are not performed

<formal_conversation> ::= <performative_statement> | <performative_statement>, <formal_conversation>

<performative_statement> ::= <player_name> : <action> <temporal_expression>

(Each performative_statement is an event. Realized events are given as facts in the data base;generic events that contain variables are used to infer states.)

<action> ::= <act>(<player_name>, <goods>, <contract_id>)

<act> ::= **offer** | **tender_delivery** | **bail** | **accept** | **reject**

<player_name> ::= <atom>

<goods> ::= <atom>

<contract_id> ::= <contract_type> - <contract_index>

<contract_type> ::= **d_contract** | **s_contract** | **soa_contract**

<contract_index> ::= <integer>

<temporal_expression> ::= **on** <date> | **by** <date> | **within** <integer> **days**

<date> ::= <day>-<month>-<year>

(The following expressions are declarative statements used to describe the status of a contract and of the parties to the contract.)

<obligation_expression> ::= **obligation**(<performative_statement>)

<pending_expression> ::= **pending**(<contract_id>, <date>)

<breach_expression> ::= **breach**(<contract_id>, <date>)

<completed_expression> ::= **completed**(<contract_id>, <date>)

<title_expression> ::= **has_title**(<player_name>, <contract_id>, <date>).

<risk_expression> ::= **bears_risk**(<player_name>, <contract_id>, <date>).

Figure 4: Formation Rules of the Formal Language

correctly and therefore do not become part of the data base). The formation rules for formal conversations and performative statements are given in BNF notation:

<formal_conversation> ::= <performative_statement> | <performative_statement>, <formal_conversation>

<performative_statement> ::= <player_name> : <action> <temporal_expression>

Thus, a formal conversation is defined recursively as consisting of a performative statement, or a performative statement followed by a formal conversation. Our formation rule for a performative statement is the event grammar notation wherein an agent (<player_name>) brings about (:) an event (<action>) **on**, **within**, or **by** a certain time (<temporal_expression>). This notation was discussed in detail in Section 4, so we will not elaborate on it here.

Declarative statements describe the status of the formal conversation and the players within the conversation. States are inferred by applying inference rules (discussed in Section 5.3) to the database of events. Figure 4 gives the formation rules for this fragment of a formal language for contracting.

5.3 Semantics and Inference Rules

The semantics of a formal language describes the conditions under which each well-formed sentence is true. The complete semantics for this fragment of our formal language is given in Appendix 1. Here we discuss a segment of that semantics only to explain the methodology. For example, the semantics of the well-formed sentence describing a performative speech act is:

If α is a <performative_statement> where β is in ACTS, σ and δ are in PLAYERS, e is in GOODS, ϕ is in DATES, and w is in CONTRACTS,then [α] = true iff [σ] performs the act [β] according to contract [w] regarding goods [e] on behalf of [δ] on [ϕ].

The square brackets [ ] are interpreted as "denotes"; thus, [α] means "the semantic value of α" or "the denotation of α." The semantics defines the conventions for interpreting performative and declarative statements on the network.

In order to monitor the status of conversations and the fulfillment of obligations, our formal language must also provide inference rules. The possible states to be inferred include:

obligation: a player has a contractual commitment to perform a certain act within a specified time

pending: a player has not performed an obligation, but the deadline for performance has not elapsed

completed: all obligations have been performed within the deadline

breach: an obligation has not been performed within the deadline

has_title: a player has legal ownership of goods

bears_risk: a player bears risk of loss for goods should they be damaged, lost, or stolen.

The first four states (**obligation, pending, completed**, and **breach**) are common to all contractual situations. These states are inferred from the database of events. For example, a contract is pending on Date1 if there is an obligation to be performed by Date2, but Date1 precedes Date2. In Prolog notation, this inference rule is expressed as[7]

```
pending(Contract, Date1) :-
    obligation(X: Act(Y,Goods, Contract) by Date2),
    not (X : Act(Y,Goods, Contract) on Date1,
    Date1 .<. Date2.
```

The state **obligation** refers to individual acts, not contracts. Thus, an inference rule giving the deadline for each obligatory act is needed. The inference rule for the obligation to tender delivery within 24 hours of acceptance under a sale on approval is expressed as:

```
obligation(X : tender_delivery(Y,Goods,Contract_id) by Date) :-
    Y : accept(X,Goods,Contract_id) on Date1,
    Date is Date1 + 1.
```

The last two states, **has_title** and **bears_risk**, are vital sales contracting concepts. Usually the two go hand-in-hand; that is, when title to goods passes from seller to buyer, risk of loss accompanies it. The basic tenet is that he who owns the goods must bear the loss if those goods are damaged, stolen, etc. In a shipment contract, title and risk of loss pass from the seller to the buyer upon the seller's turning the goods over to a carrier for delivery; in a destination contract, title and risk of loss pass to the buyer when the merchant tenders delivery of goods at a place specified by the buyer. In a sale on approval, the merchant holds title and bears risk until the buyer accepts the goods, as shown in the following inference rule:

```
has_title(X, Goods, Contract_id Date) :-
    merchant(X),
    soa(Contract-id),
    pending(Contract_id, Date1),
    Date .=<. Date1.
```

6. DISCUSSION AND CONCLUDING REMARKS

The aim of this paper has been to discuss commercial sales contracting procedures as formal conversations that can be conducted over a performative network. Viewing legal procedures from a linguistic perspective, we have identified some of the legal speech acts performed in formal conversations and have shown how these conversations can be modeled. We have also begun to outline a formal language through which these conversations can be conducted and monitored.

The formal language discussed here captures only a simplified view of the three sales contracts. Our future research will focus on modeling the complexity of contract formation and execution; for example, the variations that arise depending on the classification of the parties (merchant versus consumer, buyer in the ordinary course of business, etc.) and the type of title document used (negotiable versus non-negotiable documents of title). Our goal is to develop a system that supports the performance of business procedures as well as EDI supports the transmission of standard business forms.

We foresee that EDI formats can be used to represent and to transmit any legal documents required to complete the procedures our network hopes to support. Thus, future research will also investigate EDI and its role in conducting formal conversations on a performative network. Currently, it is not clear whether EDI transmissions are informative or performative. In fact, the American Bar Association has commissioned a special task force to study

legal issues raised by electronic messaging. A report of this task force notes that "businesses using electronic messaging systems [e.g., EDI] may...face unacceptable risks that their transactions may be unenforceable" and that "electronic messaging systems do not necessarily provide the requisite legal certainty to support unfettered use in business transactions" (Baum, Boss and Fry 1988). These problems arise because it is not clear that EDI transmissions constitute the legal speech acts discussed earlier in this paper.

The performative framework in which formal conversations are conducted in our approach seeks to avoid these problems by making explicit the meaning and effects of the agents' acts. Ultimately, we hope to complement EDI by using information technology both to support business people as they conduct formal conversations and to monitor the fulfillment of their commitments.

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9. ENDNOTES

1. Illocutionary logic is a form of predicate logic used to formally represent illocutionary acts, which include asking a question, giving a command, and making a promise. Each illocutionary act consists of an illocutionary force (i.e., "What's for dinner?" and "Who's on first?" have the same illocutionary force, that of a question) and a propositional content (i.e., these two questions have different propositional content, one asking about the menu for tonight's dinner, the other asking the identity of the player on first base). See Kimbrough and Lee (1986) for a brief overview or Searle and Vanderveken (1985) for a complete discussion.

2. The notion of a language game was originally proposed as a conceptual framework for organizing the contexts of usage in natural language. Our usage here is narrower, focusing on formal languages to capture the language game of legal communication. The reader should note that the language used in contract law and other legal specialties is not **ordinary** natural language but a form of specialized jargon, a kind of quasi-formal language. It is this formalized use that qualifies legal language as one of Wittgenstein's "language games."

3. This discussion proposes an application of predicate logic, rather than extensions to it. The notations introduced are modifications to the conventional syntax of logical functions and predicates designed to aid readability and to emphasize our particular interpretation.

4. See Lee, Coelho, and Cotta (1985) for a more complete discussion of this notation. See Rescher and Urquhart (1971) for a more general discussion of temporal logic.

5. Note: Terms from the formal language are indicated in boldface.

6. Logics, in particular predicate logic, are generally developed as uninterpreted frameworks. Thus, predicate logic may be used to model a wide variety of subject domains. Here we are developing a specially interpreted (applied) form of predicate logic, customized to legal procedures. Denotational semantics is used to explicate this interpretation.

7. The symbol ".<." indicates temporal precedence; for example, "Date1 .<. Date2" indicates that Date1 precedes Date2.

APPENDIX 1

SEMANTICS

If α is an <performative_statement> where β is in ACTS, χ and δ are in PLAYERS, ϵ is in GOODS, ϕ is in DATES, and γ is in CONTRACTS,
then[α] = true
iff [χ] performs the act [β] according to [γ] regarding goods [ϵ] on behalf of [δ] on [ϕ].

If α is a <pending_expression> where β is in ACTS, χ and δ are in PLAYERS, ϵ is in GOODS, ϕ is in DATES, and γ is in CONTRACTS,
then[α] = true
iff [χ] has not fulfilled his obligation according to [γ] to perform act [β] regarding goods [ϵ] on behalf of [δ] on or before date [ϕ] and date [ϕ] has not yet elapsed.

If α is a <completed_expression> where β is in ACTS, χ and δ are in PLAYERS, ϵ is in GOODS, ϕ is in DATES, and γ is in CONTRACTS,
then[α] = true
iff [χ] has fulfilled his obligation according to [γ] to perform act [β] regarding goods [ϵ] on behalf of [δ] on or before date [ϕ].

If α is a <breach_expression> where β is in ACTS, χ and δ are in PLAYERS, ϵ is in GOODS, ϕ is in DATES, and γ is in CONTRACTS,
then[α] = true
iff [χ] has an obligation according to [γ] to perform act [β] regarding goods [ϵ] on behalf of [δ] on or before date [ϕ], and date [ϕ] has elapsed.

If α is an <obligation_expression> where β is in ACTS, χ and δ are in PLAYERS, ϵ is in GOODS, ϕ is in DATES, and γ is in CONTRACTS,
then[α] = true
iff [χ] has an obligation according to [γ] to perform act [β] regarding goods [ϵ] on behalf of [δ] on or before date [ϕ].

If α is a <title_expression> where β is in PLAYERS, χ is in GOODS, δ is in CONTRACTS and ϵ is in DATES,
then [α] = true
iff [β] has legal ownership of [χ] under [δ] on date [ϵ].

If α is a <risk_expression> where β is in PLAYERS, χ is in GOODS, δ is in CONTRACTS, and ϵ is in DATES,
then [α] = true
iff [β] incurs the loss under [δ] if [χ] are lost or damaged on date [ϵ].

If α is a <date>, then [α] is an element in DATES.