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Business by Machine: Design of Application Languages for Conducting Electronic Commerce*

by

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*File: usc-20010126-flbc-slides.tex.

Related papers

"EDI, XML, and the Transparency Problem in Electronic Commerce," (Steven O. Kimbrough) http://grace.wharton.upenn.edu/∼sok/sokpapers/1999-0/indiana-transparency/flbc-transparency.pdf

Kimbrough, Steven Orla, "Reasoning about the Objects of Attitudes and Operators: Towards a Disquotation Theory for Representation of Propositional Content," working paper, January 6, 2001. http://grace.wharton.upenn.edu/ sok/sokpapers/2000-1/flbc-disquotation-sketch.pdf

Kimbrough, Steven Orla and Tan Yao-Hua, "On Lean Messaging with Unfolding and Unwrapping for Electronic Commerce," similar version published in International Journal of Electronic Commerce, 5, no. 1 (Fall 2000), pp. 83-108. http://grace.wharton.

upenn.edu/ sok/sokpapers/1999-0/lean-tan-20000412/lean-sok-tan-si.pdf

"The Vision Thing"

- AAA communication infrastructure, operating cheaply
- Ubiquitous, semi-autonomous, plug-and-talk artificial agents, on the Net, constantly alert, doing business for us
- Transaction costs head towards 0
- Transaction delays head towards 0
- Transaction quality heads towards perfection

Note: Both for inter- and for intra-organizational transactions

"The Vision Thing" Vision: This is achieved based in (significant) part on an

- Expressively powerful,
- Open,
- Generic,
- Entirely formal,
- Semantically sound

Formal Language for Business Communication (FLBC)

Lots of questions on the details

How to

- minimize cost
- maximize speed
- maximize reliability
- maximize expressive power (and felicity)
- maximize the realm of effective applicability

of computer-to-computer message-based transactions?

How to get there from here?

Substantial problems today with e-contracting. Related problems:

- The "first trade" problem

  Like the "last mile" problem: labor intensive.

- The standards problem

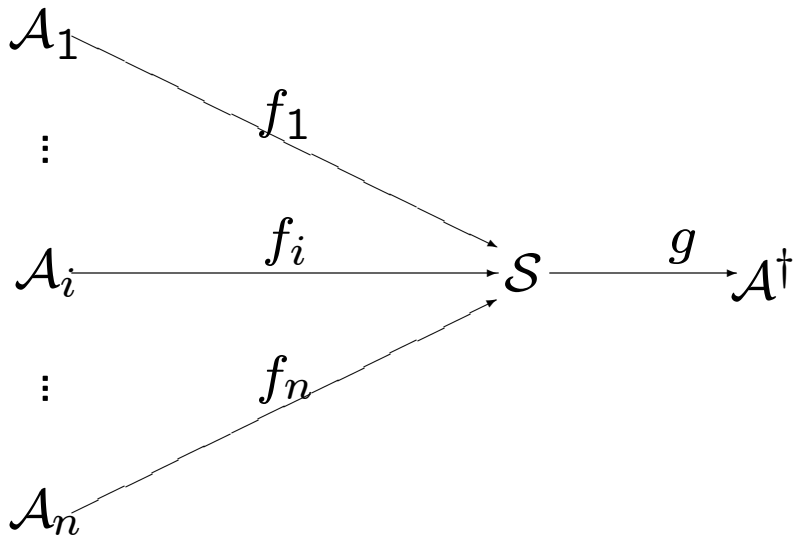
  "The nice thing about EDI standards is that you have so many to choose from."

- The mapping problem

  Organization's view vs message view

And more. Today EDI is expensive to own and operate, and the notion of AAA-EDI is only a distant vision. . . . despite claims by XML enthusiasts.

Schematic for the FLBC program (in part):



$\mathcal{S}$ as FOL (insofar as $\diamond$). $\mathcal{A}^\dagger$ as Prolog, Java, XML, etc.

The GP-FLBC problem:

How can we develop a usable, general-purpose formal language (and logic) for business communication?

Goals/requirements

- $\mathcal{S}$ ($\mathcal{A}^{\dagger}$) sufficiently and felicitously expressive
- FOL for $\mathcal{S}$
- General grammar for $\mathcal{S}$
- Public-only lexicons (required for commencement of business)
- $\mathcal{S}$ has public grammar, controlled lexicon, open lexicon.
- Controlled lexicon is small.
- Open lexicon is large but semantically limited (noun phrases).

Emphasize: speech acts, and "good enough" semantics.

(Some) Puzzles, issues & challenges

1. Accounting for speech acts

   Semantics of actions? Intensionality (opacity; s-ality)? Intentionality?

2. Compositionality and exploiting it

   What are the atomic (or sub-atomic) elements?

3. Spanning domains with a limited vocabulary

   Ontology?

4. Maximizing (correct) inferential capabilities

   Adverbial, adjectival &c. modification

Three levels of representation:

1. Informal: Typically in natural language.

   Example:

   "All politicians are liars." (1)

2. Formal: Syntactically formal, but not fully logical (e.g., without formal rules of inference, or a formal semantics).

   Example (for representing "All politicians are liars," i.e., (1) $\mapsto$ (2)):

   `(politician and liar)(x)` (2)

Three levels (con't.)

3. Logical: Syntactically and semantically formal, i.e., in a logic and with a formal semantics. Example (for representing "All politicians are liars," i.e., (1) $\mapsto$ (3) and (2) $\mapsto$ (3)):

$$\forall x(P(x) \rightarrow L(x)) \tag{3}$$

Required for practice: level 3. EDI so far: level 2.

Keep in mind, focus on:

- First-trade problem

  Semantic transparency

- Reduction to practice

- End-to-end view of transactions

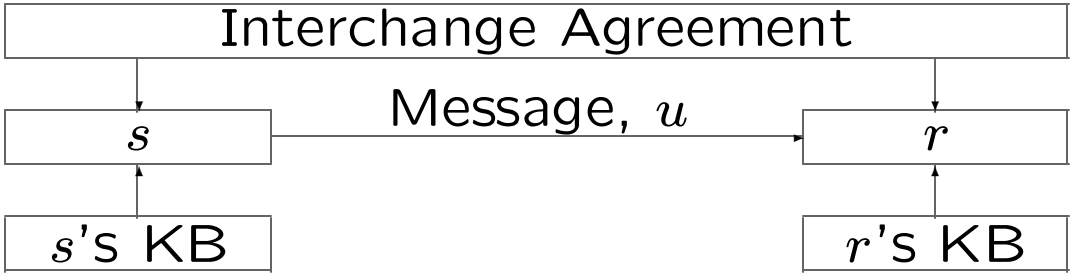
Our point (Kimbrough & Tan, IJEC)

- There is something *right* about EDI standards and practices (which has not been generally noted and which we essay to note).

- Names/principles for this: lean messaging, wrapping, unfolding, and unwrapping.

- These principles should (will? must?) be preserved in future standards and systems (we think).

EDI messaging schema



A message u from speaker s to addressee r.

Sender: s. Addressee: r. knowledge base: KB.

X's wrapper: Interchange Agreement + X's KB

Summary comments on the EDI messaging schema

"... we should think of the interchange agreement as a sort of (static) wrapper .... Communication is effected by sending a particular message *in the context of the wrapper* (i.e., interchange agreement), which is itself communicated only once. The message is lean in the sense that only a minimal, or core meaning, is expressed. The larger, or extended, meaning of the message can only be determined in light of the governing interchange agreement. Thus, to interpret a message, a recipient will unpack (or unfold) its core meaning then use the interchange agreement (and other knowledge as appropriate) to make action–relevant inferences. We mean this as a *descriptively* accurate (albeit abstract) account of how things are now done (cf., [EDI messaging schema]). The *prescriptive* element in our story concerns the need for a good semantic theory ...covering all EDI messages. Again, the received view (with which we agree) holds that having a proper semantics for EDI messages would be a very good thing. Our account helps us see why: a good semantics would provide the basis for enriching and validating wrappers and unfolding."

Example of a ‘conversation’ between two computers.

1. Computer A: `1, 360`
2. Computer B: `6, 350`
3. Computer A: `3, 1, 1, 2`
4. Computer B: `5, 1, 1`
5. Computer A: `3, 1, 1, 3`
6. Computer B: `5, 1, 1`
7. Computer A: `3, 1, 1, 1`
8. Computer B: `4, 1, 1`
9. Computer A: `3, 2, 1, 150`

10. Computer B: `4, 2, 150`

11. Computer A: `6`

12. Computer A: `8`

13. Computer B: `6`

Translation of the conversation

1. Computer A: Please talk to me on lines 360/361.
2. Computer B: OK. You can talk to me on 350/351.
3. Computer A: Can you do CVSD?
4. Computer B: No, but I can do LPC.
5. Computer A: Can you do RELP?
6. Computer B: No, but I can do LPC.
7. Computer A: How about LPC?
8. Computer B: LPC is fine with me.
9. Computer A: Can you use 150 microsecond sampling?

10. Computer B: I can use 150 microsecond sampling.

11. Computer A: I am ready.

12. Computer A: Are you ready?

13. Computer B: I am ready.

EDI exampe: RFQ in X12

```
[1] ST*840*159
[2] BQT*00*Q47391*820430
[3] N1*SE*X, Inc.
[4] N1*BY*Y Co.
[5] P01*1*30000*EA*0.42*PN*747355*PD*Circuit Network
[6] SCH*10000*EA****002*820604
[7] SCH*20000*EA****002*820709
[8] CCT*1*30000
[9] SE*9*159
```

EDI (X.12) Request for Quotation (line numbers added).

EDI exampe: RFQ in X12, translated

```
[1] This is an RFQ Message * Message Number 159
[2] An Original Document * RFQ #Q47391 * Date: April 30, 1982
[3] Seller of item is X, Inc.
[4] Purchaser of item is Y Co.
[5] First Item: 30000 of part 747355 (a Circuit Network)
    at $0.42/item.
[6] Request that 10000 of the first item be delivered
    after June 4, 1982.
[7] Request that 20000 of the first item be delivered after
    July 9,1982.
[8] A total of 30000 items have been requested.
[9] There are 9 lines in this message.
    This is the end of message 159.
```

Elements of (my) solution

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure

2. Speech act theory

3. Qualifier abstractions

4. Event semantics

5. Thematic rôles

Will skip details; go to examples (mostly); try to give intuitions.

5. Thematic rôles

- Verbs typically allow some of: SUBJECT, DIRECT-OBJECT, and INDIRECT-OBJECT.

- Consider:

  "Bob spoke to Carol about Ted."

- SUBJECT = Bob

- DIRECT-OBJECT = Ted

- INDIRECT-OBJECT = Carol

5. Thematic rôles (con't.)

Consider:

1. "Bob spoke to Carol about Ted."
2. "Bob spoke about Ted."
3. "Bob spoke to Carol."
4. "Bob spoke."
5. "Someone spoke to Carol about Ted."

5. Thematic rôles (con't.) Notice:

- (1) $\rightarrow$ (2)
- (1) $\rightarrow$ (3)
- (2) $\rightarrow$ (4)
- (3) $\rightarrow$ (4)
- (1) $\rightarrow$ (5)

&c. (and lots of it!)

5. Thematic rôles (con't.) So, this symbolization does't work:

---

1. *Spoke1(Bob, Carol, Ted)*: "Bob spoke to Carol about Ted."
2. *Spoke2(Bob, Ted)*: "Bob spoke about Ted."
3. *Spoke3(Bob, Carol)*: "Bob spoke to Carol."
4. *Spoke4(Bob)*: "Bob spoke."
5. *Spoke5(Carol, Ted)*: "Someone spoke to Carol about Ted."

(unless we add lots of meaning postulates). (And besides, it's a kludge!)

5. Thematic rôles (con't.) Better is something like this:

---

1. "Bob spoke to Carol about Ted."

   $Speak \wedge SUBJECT(Bob) \wedge DIRECT\text{-}OBECT(Ted) \wedge INDIRECT\text{-}OBJECT(Carol)$

2. "Bob spoke about Ted."

   $Speak \wedge SUBJECT(Bob) \wedge DIRECT\text{-}OBECT(Ted)$

3. "Bob spoke to Carol."

   $Speak \wedge SUBJECT(Bob) \wedge INDIRECT\text{-}OBJECT(Carol)$

4. "Bob spoke."

   $Speak \wedge SUBJECT(Bob)$

5. "Someone spoke to Carol about Ted."

   $Speak \wedge DIRECT\text{-}OBECT(Ted) \wedge INDIRECT\text{-}OBJECT(Carol)$

5. Thematic rôles (con't.) Problem:

Linking together the verb, the SUBJECT, the DIRECT-OBJECT, the INDIRECT-OBJECT.

E.g., in

1. "Bob spoke to Carol about Ted."

   $Speak \wedge SUBJECT(Bob) \wedge DIRECT\text{-}OBECT(Ted) \wedge INDIRECT\text{-}OBJECT(Carol)$

what makes *Bob* the subject of *this* speaking (event)?

4. Event (aka: subatomic) semantics

Link together the verb, the SUBJECT, the DIRECT-OBJECT, the INDIRECT-OBJECT &c. via an *eventuality* (event, process, or state).

"Bob spoke to Carol about Ted."

$$\begin{aligned}\exists e(&\textit{speak(e)} \wedge \textit{SUBJECT(e, Bob)} \wedge \\ &\textit{DIRECT-OBECT(e, Ted)} \wedge \\ &\textit{INDIRECT-OBJECT(e, Carol)})\end{aligned} \tag{4}$$

Event e makes *Bob* the subject of *this* speaking (event).

4. Event (aka: subatomic) semantics (con't.). Even better:

"Bob spoke [in the past] to Carol about Ted."

$$\begin{aligned}\exists e(&\mathit{speak}(e) \wedge \mathit{SUBJECT}(e,\ \mathit{Bob}) \wedge \\ &\mathit{DIRECT\text{-}OBECT}(e,\ \mathit{Ted}) \wedge \\ &\mathit{INDIRECT\text{-}OBJECT}(e,\ \mathit{Carol}) \\ &\mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{5}$$

The speaking event e culminated at time t, which was before the present.

4. Event (aka: subatomic) semantics (con't.). More better yet:

Our previous implication relationships go through naturally:

1. "Bob spoke [in the past] to Carol about Ted."

$$\begin{aligned}&\exists e(\textit{speak(e)} \wedge \textit{SUBJECT(e, Bob)} \wedge \\ &\quad \textit{DIRECT-OBECT(e, Ted)} \wedge \\ &\quad \textit{INDIRECT-OBJECT(e, Carol)} \\ &\quad \textit{Cul(e, t)} \wedge t < \textit{now})\end{aligned} \tag{6}$$

2. "Bob spoke [in the past] about Ted."

$$\begin{aligned}&\exists e(\textit{speak(e)} \wedge \textit{SUBJECT(e, Bob)} \wedge \\ &\quad \textit{DIRECT-OBECT(e, Ted)} \wedge \\ &\quad \textit{Cul(e, t)} \wedge t < \textit{now})\end{aligned} \tag{7}$$

4. Event (aka: subatomic) semantics (con't.). More better yet:

Our previous implication relationships go through naturally:

3. "Bob spoke [in the past] to Carol."

$$\exists e(\mathit{speak}(e) \wedge \mathit{SUBJECT}(e, \mathit{Bob}) \wedge \mathit{INDIRECT\text{-}OBJECT}(e, \mathit{Carol}) \mathit{Cul}(e, t) \wedge t < \mathit{now}) \quad (8)$$

4. "Bob spoke [in the past]."

$$\exists e(\mathit{speak}(e) \wedge \mathit{SUBJECT}(e, \mathit{Bob}) \wedge \mathit{Cul}(e, t) \wedge t < \mathit{now}) \quad (9)$$

4. Event (aka: subatomic) semantics (con't.). More better yet:

Our previous implication relationships go through naturally:

5. "Someone spoke [in the past] to Carol about Ted."

$$\begin{aligned}&\exists e(\textit{speak(e)} \wedge \\ &\quad \textit{DIRECT-OBECT(e, Ted)} \wedge \\ &\quad \textit{INDIRECT-OBJECT(e, Carol)} \\ &\quad \textit{Cul(e, t)} \wedge t < \textit{now})\end{aligned} \tag{10}$$

And all the (right) implications go through!

5. Thematic rôles (again!) Thematic rôles:

- Generalize, and improve upon, SUBJECT, DIRECT-OBJECT, INDIRECT-OBJECT (and more).

- Can be used to characterize / classify verbs.

- Are instrumental in exploiting compositionality.

5. Thematic rôles (again!) SUBJECT:

- *Agent* (a person in the broad sense, who does something)

  Includes corporations and possibly animals.

- *Performer* (if not a person)

  In *The knife pierced his arm*, the performer rôle is played by *the knife*.

- *Experiencer* (used less often; person (or sentient being), but sometimes institutions or mechanisms; subject of the sentence but not an agent in the action)

  Agents make actions happen; experiencers have things happen to them. *Bob fell* is an example; the sense is this happened to Bob.

5. Thematic rôles (again!)

DIRECT-OBJECT:

- *Theme* (e.g., the *what* in *who does what to whom*)

INDIRECT-OBJECT:

- *Goal* (and/or indicated by *to*)
- *Benefactive* (and/or indicated by *for*)

4. Event semantics (con't.). With thematic rôles:

---

1. "Bob spoke [in the past] to Carol about Ted."

$$\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \mathit{Theme}(e,\ \mathit{Ted}) \wedge \mathit{Goal}(e,\ \mathit{Carol}) \wedge \mathit{Cul}(e,\ t) \wedge t < \mathit{now}) \quad (11)$$

2. "Bob spoke [in the past] about Ted."

$$\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \mathit{Theme}(e,\ \mathit{Ted}) \wedge \mathit{Cul}(e,\ t) \wedge t < \mathit{now}) \quad (12)$$

4. Event semantics (con't.). With thematic rôles (con't.):

3. "Bob spoke [in the past] to Carol."

$$\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \mathit{Goal}(e,\ \mathit{Carol}) \wedge \mathit{Cul}(e,\ t) \wedge t < \mathit{now}) \quad (13)$$

4. "Bob spoke [in the past]."

$$\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \mathit{Cul}(e,\ t) \wedge t < \mathit{now}) \quad (14)$$

4. Event semantics (con't.). With thematic rôles (con't.):

---

5. "Someone spoke [in the past] to Carol about Ted."

$$\begin{aligned}&\exists e(\textit{speak(e)} \wedge \\ &\quad \textit{Theme(e, Ted)} \wedge \\ &\quad \textit{Goal(e, Carol)} \\ &\quad \textit{Cul(e, t)} \wedge t < \textit{now})\end{aligned} \tag{15}$$

And all the (right) implications continue to go through!

4. Event semantics with thematic rôles: Extensions

Consider: *Brutus stabbed Cæsar violently in the back with a knife.*

$$\begin{aligned}\exists e(&\mathit{stab}(e) \wedge \mathit{Agent}(e,\ \mathit{Brutus}) \wedge \\ &\mathit{Theme}(e,\ \mathit{Cæsar}) \wedge \\ &\mathit{Performer}(e,\ \mathit{knife}) \wedge \\ &\mathit{violent}(e) \wedge \\ &\mathit{in}(e,\ \mathit{the\text{-}back}) \wedge \\ &\mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{16}$$

Variations possible, but a good way to handle adverbs and prepositions. Note: handling of implications, exploitation of compositionality.

Event semantics & thematic rôles: Applications

Some verbs of commerce:

1. bill *x bills y for (goods) z on (date) d*

   $\exists e(bill(e) \wedge Agent(e, x) \wedge Theme(e, e') \wedge Goal(e, y) \wedge Sake(e,z) \wedge Cul(e, d))$

2. debit *x debits (y's account) z on d*

   $\exists e(debit(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Cul(e, d))$

3. confirm *x confirms to y that z occurred on d*

   $\exists e(confirm(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

Event semantics & thematic rôles: Applications (con't.)

4. credit *x credits y's account for z on d*

   $\exists e(credit(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

5. deliver *x delivers z to y on d because of r*

   $\exists e(deliver(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge$

   $Sake(e,r) \wedge Cul(e, now))$

6. forecast *x forecasts to y that z will occur*

   $\exists e(forecast(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, now))$

Event semantics & thematic rôles: Applications (con't.)

7. invoice *x invoices y on d because of r*

   $\exists e(invoice(e) \wedge Agent(e, x) \wedge Theme(e, e') \wedge$

   $Sake(e, r) \wedge Goal(e, y) \wedge Cul(e, d))$

   (cf., *bill*)

8. move *x moves items z from a to b on d*

   $\exists e(move(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, b) \wedge$

   $from(e, a) \wedge Cul(e, d))$

9. order *x orders z from y on d*

   $\exists e(order(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

Event semantics & thematic rôles: Applications (con't.)

10. ownershipChange *ownership of item z transfers from x to y on d*

    $\exists e(ownershipChange(e) \wedge Theme(e, z) \wedge$

    $from(e, x) \wedge Goal(e, y) \wedge Cul(e, d))$

11. purchase *x purchases z from y on d*

    $\exists e(purchase(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

12. pay *x pays z to y on d*

    $\exists e(pay(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

Event semantics & thematic rôles: Applications (con't.)

13. receive *x receives items z from y on d*

$\exists e(receive(e) Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

14. ship *x ships items z to y on d*

$\exists e(ship(e) \wedge Agent(e, x) \wedge Theme(e, z) \wedge Goal(e, y) \wedge Cul(e, d))$

3. Qualifier abstraction

Briefly, since this is less important.

Contrast

Sentence Complex 1 *x is a big red ball*

with

Sentence Complex 2 *x is a light brown desk*

The big red ball is big and red, but the light brown desk is heavy and dark.

3. Qualifier abstraction: solution

Sentence Complex 3 $brown(s) \wedge light(s') \wedge In(s, s') \wedge In(x, s) \wedge desk(x)$

Paraphrased: "The desk is brown and the brown is light."

More generally:

Sentence Complex 4 $StateType(s, big) \wedge StateType(s', red) \wedge In(x, s) \wedge In(x, s') \wedge ball(x)$

More generally, the pattern is this: adjectives and other modifiers—including modifier modifiers such as "light" in "light brown" above—refer to underlying states for which the objects of the modifiers participate.

3. Qualifier abstraction: application to a PO

3. `REF*DP*10`

(a) DP is the Reference Number Qualifier which indicates the Reference Number that follows is a Department Number.

(b) 10 is the department number assigned by the buyer.

/* Together, these yield: */

PO Line Symbolization 3 $\exists s \exists s' (StateType(s, REF) \wedge In(005001234500, s) \wedge StateType(s', DN) \wedge Value(s', 10) \wedge In(s, s'))$

2. Speech act theory

- $F(P)$ hypothesis for *all possible* utterances
- F: illocutionary force
- P: propositional content (true-or-false)
- $F(P)$: not true-or-false
- Many illocutionary forces; modifications of a few fundamental illocutionary points.

2. Speech act theory (con't.)

Fundamental illocutionary points (*à la* Searle)

1. assertives
2. directives
3. commissives
4. requestives
5. emotives

2. Speech act theory (con't.)

Puzzles and challenges

1. Speech acts are actions and hence not true-or-false. Do we need an action logic, or can standard FOL help us?

2. Intensionality (opacity) of speech act talk.

   $F(P), P \leftrightarrow Q \not\models F(Q)$

3. Intentionality. What must the speaker intend for there to be a speech act?

2. Speech act theory (con't.)

Example speech act predicates (from above):

1. bill (a request that payment be made)

2. confirm (a form of assertive)

3. forecast (an assertive concerning the future)

4. invoice (a request for payment)

5. order (a request)

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (sok's theory (blame him!))

Do examples and see pattern. Begin with assertives.

Example: *Bob asserts to Carol that goods g are to be delivered before noon.*

$$\begin{aligned}
&\exists e \exists e' \exists t \exists t' (\mathit{assert(e)} \wedge \mathit{Agent(e,\ Bob)} \wedge \\
&\quad \mathit{Theme(e,\ e')} \wedge \\
&\quad \mathit{Goal(e,\ Carol)} \wedge \\
&\quad \mathit{Cul(e,\ t)} \wedge \\
&\quad \Box\ (V(e) \leftrightarrow \\
&\quad (deliver(e') \wedge \mathit{Theme(e',\ g)} \wedge \\
&\quad \mathit{Cul(e',\ t')} \wedge t' < \mathit{noon})))
\end{aligned} \tag{17}$$

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Extensional approximation (change at line 18):

$$\begin{aligned}
&\exists e \exists e' \exists t \exists t' (\mathit{assert(e)} \wedge \mathit{Agent(e,\ Bob)} \wedge \\
&\quad \mathit{Theme(e,\ e')} \wedge \\
&\quad \mathit{Goal(e,\ Carol)} \wedge \\
&\quad \mathit{Cul(e,\ t)} \wedge \\
&\quad (V(e) \leftrightarrow \\
&\quad (\mathit{deliver}(e') \wedge \mathit{Theme(e',\ g)} \wedge \\
&\quad \mathit{Cul(e',\ t')} \wedge t' < \mathit{noon})))
\end{aligned} \tag{18}$$

β: line 18. α: stuff before line 18. γ: stuff after line 18.

$V(e)$: Event e is veridical.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example directive: *Carol requests to Bob that goods g be delivered before noon.*

$$\begin{aligned}
&\exists e \exists e' \exists t \exists t' (\mathit{request(e)} \wedge \mathit{Agent(e,\ Carol)} \wedge \\
&\quad \mathit{Theme(e,\ e')} \wedge \\
&\quad \mathit{Goal(e,\ Bob)} \wedge \\
&\quad \mathit{Cul(e,\ t)} \wedge \\
&\quad \Box\ (H(e) \leftrightarrow \\
&\quad (\mathit{deliver}(e') \wedge \mathit{Theme(e',\ g)} \wedge \\
&\quad \mathit{Cul(e',\ t')} \wedge t' < \mathit{noon}))) \qquad (19)
\end{aligned}$$

$H(e)$: Event e is honored. Issue: Does Bob have to have something to do with e'? $\ldots \wedge$ *CAUSE(Bob, e')*? or $\ldots \wedge$ *Sake(e', e)*?

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example declarative: *Ted declares that goods g have cleared customs.*

$$\begin{aligned}
&\exists e \exists t(\mathit{declare(e)} \wedge \mathit{Agent(e,\ Ted)} \wedge \\
&\quad \mathit{Theme(e,\ e)} \wedge \\
&\quad \mathit{CuI(e,\ t)} \wedge \\
&\quad \Box\,(\mathit{Auth}(e) \leftrightarrow \\
&\quad (\mathit{clearCustoms}(e) \wedge \mathit{Theme(e,\ g)})))
\end{aligned} \tag{20}$$

Auth(e): Event e is done with sufficient authority. When you declare it, it's done. Saying so makes it so (provided you have the authority).

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example promise: *Bob promises to Carol that goods g are to be delivered before noon.*

$$\begin{aligned}
&\exists e \exists e' \exists t \exists t' (\textit{promise(e)} \wedge \textit{Agent(e, Bob)} \wedge \\
&\quad \textit{Theme(e, e')} \wedge \\
&\quad \textit{Goal(e, Carol)} \wedge \\
&\quad \textit{Cul(e, t)} \wedge \\
&\quad \Box\,(K(e) \leftrightarrow \\
&\quad (deliver(e') \wedge \textit{Theme(e', g)} \wedge \\
&\quad \textit{Cul(e', t')} \wedge t' < \textit{noon} \wedge \textit{Sake(e',e)})))
\end{aligned} \tag{21}$$

$K(e)$: Event e, a promise, is kept. Issue: Does Bob have to have something to do with e'? . . . $\wedge$ *CAUSE(Bob, e')*? or . . . $\wedge$ *Sake(e', e)*? Yes! Promises are not (here) just solemn assertions.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example directive: *x bills y for (goods) z on (date) d.* A bill is a request for payment.

$$\exists e \exists e' \exists t' (\mathit{bill(e)} \wedge \mathit{Agent(e,\ x)} \wedge$$
$$\mathit{Theme(e,\ e')} \wedge$$
$$\mathit{Goal(e,\ y)} \wedge \mathit{Sake(e,\ z)} \wedge$$
$$\mathit{Cul(e,\ d)} \wedge$$
$$\Box\ (H(e) \leftrightarrow (\mathit{pay(e')} \wedge$$
$$\mathit{Agent(e',\ y)} \wedge \mathit{Theme(e',\ m)} \wedge \mathit{Goal(e',\ x)} \wedge$$
$$\mathit{Cul(e',\ t')} \wedge \mathit{Sake(e',\ e)}))) \qquad (22)$$

$\ldots \wedge$ *Sake(e', e)*? Yes, to keep payments straight. Note: the theme of the billing is not (money) m, but e', a paying event whose theme is m. The currency used and amount for m can be supplied conjunctively.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example assertive: *x confirms to y that z occurred on (date) d.* A confirmation is an assertion, typically in response to a request, r.

$$\begin{aligned}
&\exists e \exists t (\mathit{confirm}(e) \wedge \mathit{Agent}(e, x) \wedge \\
&\quad \mathit{Theme}(e, z) \wedge \\
&\quad \mathit{Goal}(e, y) \wedge \mathit{Sake}(e, r) \wedge \\
&\quad \mathit{Cul}(e, t) \wedge \\
&\quad \Box\,(V(e) \leftrightarrow (\mathit{Event}(z) \wedge \\
&\quad \mathit{Theme}(z, r) \wedge \\
&\quad \mathit{Cul}(z, d))))
\end{aligned} \tag{23}$$

Note: The request r is convenient here, but not necessary since z is a constant (a name referring to something definite).

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example assertive: *x forecasts to y that z will occur.*. A forecast is an assertion, typically about an event in the future.

$$\begin{aligned}
&\exists e \exists t' (\textit{forecast(e)} \wedge \textit{Agent(e, x)} \wedge \\
&\quad \textit{Theme(e, z)} \wedge \\
&\quad \textit{Goal(e, y)} \wedge \\
&\quad \textit{Cul(e, now)} \wedge \\
&\quad \Box\,(V(e) \leftrightarrow (\textit{Event(z)} \wedge \\
&\quad \textit{Cul(z, t')} \wedge now < t'))) \qquad (24)
\end{aligned}$$

And (as in the previous example) we could get along without *Event(z)*, letting *Cul(z, t')* do the job.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example directive: *x invoices y on d because of r.* An invoice, like a bill, is a request for payment. Here, the two are the same.

$$\begin{aligned}
&\exists e \exists e' \exists t' (\mathit{invoice(e)} \wedge \mathit{Agent(e,\ x)} \wedge \\
&\quad \mathit{Theme(e,\ e')} \wedge \\
&\quad \mathit{Goal(e,\ y)} \wedge \mathit{Sake(e,\ r)} \wedge \\
&\quad \mathit{Cul(e,\ d)} \wedge \\
&\quad \Box\,(H(e) \leftrightarrow (\mathit{pay(e')} \wedge \\
&\quad \mathit{Agent(e',\ y)} \wedge \mathit{Theme(e',\ m)} \wedge \mathit{Goal(e',\ x)} \wedge \\
&\quad \mathit{Cul(e',\ t')} \wedge \mathit{Sake(e',\ e)}))) \qquad (25)
\end{aligned}$$

$\ldots \wedge$ *Sake(e', e)*? Yes, to keep payments straight. Note: the theme of the billing is not (money) m, but e', a paying event whose theme is m. The currency used and amount for m can be supplied conjunctively.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.)

Example directive: *x orders z from y on d.* An order is a request, here to take possession of something, but it could be other things, e.g., to sell, to move, etc.

$$\begin{aligned}
&\exists e \exists e' \exists t' (\mathit{order(e)} \wedge \mathit{Agent(e,\ x)} \wedge \\
&\quad \mathit{Theme(e,\ e')} \wedge \\
&\quad \mathit{Goal(e,\ y)} \wedge \mathit{Sake(e,\ r)} \wedge \\
&\quad \mathit{Cul(e,\ d)} \wedge \\
&\quad \Box\,(H(e) \leftrightarrow (\mathit{ownershipChange(e')} \wedge \\
&\quad \mathit{Theme(e',\ z)} \wedge \mathit{Goal(e',\ x)} \wedge \\
&\quad \mathit{Cul(e',\ t')}))) \qquad (26)
\end{aligned}$$

The units, type, and amount for z can be supplied conjunctively.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

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1. Speech acts are actions and hence not true-or-false. How can this non-action-logic approach be at all plausible?

   Answer: The Bob Dole principle.

   The first-person "I promise . . ." is not true-or-false. The third-person "Ted promises . . ." *is* true-or-false. We have here (above) a theory for third-person utterances. I say you make a promise (assertion, etc.) by making the third-person utterance with you as the speech act *Agent*.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

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2. Intensionality (opacity) of speech act talk.

   $F(P), P \leftrightarrow Q \not\models F(Q)$

   Answer: Everything's fine with the $(\alpha \wedge \Box (\beta \leftrightarrow \gamma))$ structure. With the extensional approximation, $(\alpha \wedge (\beta \leftrightarrow \gamma))$, we lose intensionality, but in most applications this doesn't matter.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

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3. Intentionality. What must the speaker intend for there to be a speech act?

   Or: Hey, I thought if you made a promise you were obligated to keep it?

   Answer: People associate all sorts of things with speech acts, and they are right in a way. But, with Grice, we need to distinguish *core meaning* and *extended meaning* (implicature for Grice). This is a theory of core meaning, a *lean* theory as opposed to a *fat* theory.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

See Searle for an extremely fat theory. To promise with the utterance U, e.g., you must:

1. Say you will perform a future action.

2. Intend to do that action.

3. Believe you can do it.

4. Believe you wouldn't do it anyway (without promising), in the normal course of action.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

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5. Believe that the person to whom you made the utterance wants you to do what you uttered.

6. Intend to place yourself under an obligation to do what you uttered.

7. Must understand U, as must the person to whom it was addressed.

8. Be a conscious, normal human, as must the addressee.

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

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9. Be in normal circumstances as must your addressee (e.g., not play acting).

10. Have in U some illocutionary force indicator, which is only properly uttered if all these conditions obtain.

Comment: Too mucking fuch! Not possible for electronic commerce (or in normal life).

See: Kimbrough & Tan paper, IJEC 2000

1. $(\alpha \wedge (\beta \leftrightarrow \gamma))$ structure (con't.) Worries and objections.

Better to stick with a lean theory and add meaning postulates as needed and appropriate for the application to hand.

Example: obligations.

Disquotation theory: altenative to the modal theory ($\Box$)

Consider the simple propositional content (and speech act) sentence:

Expression 1 *Mary asserts that Sam arrived yesterday.*

My idea is to represent this (and similar) sentence(s) with two kinds of expression: (a) a fundamental expression and (b) one or more axiom schemas, used to articulate meaning for the fundamental expressions. First, we can represent *Sam arrived yesterday* in what is more or less standard event semantics:

Expression 2 $\exists e'(\mathit{arrive}(e') \wedge \mathit{Subject}(e', \mathit{Sam}) \wedge \mathit{Cul}(e', \mathit{yesterday}))$

Let ϕ represent Expression 2.

The fundamental expression for the sentence (in Expression 1) becomes, in shorthand:

Expression 3 $\exists e(\mathit{assert}(e) \wedge \mathit{Subject}(e, \mathit{Mary}) \wedge \mathit{Obj}(e, \ulcorner\phi\urcorner))$

or fully written out:

Expression 4 $\exists e(\mathit{assert}(e) \wedge \mathit{Subject}(e, \mathit{Mary}) \wedge \mathit{Obj}(e, \ulcorner\exists e'(\mathit{arrive}(e') \wedge \mathit{Subject}(e', \mathit{Sam}) \wedge \mathit{Cul}(e', \mathit{yesterday}))\urcorner))$

Thus, the main idea in the fundamental expressions is to treat a quoted sentence (the propositional content) as an object or individual about which a comment is made. In particular, the

quoted sentence is the direct object of an event (or eventuality). Moreover, a special form of quotation is used: $\lceil \cdot \rceil$. By quoting an expression in this way—as in 3 and 4—we treat it as an individual and so capture (I argue) the second aspect noted about it.

Disquotation theory: altenative to the modal theory ($\Box$)

Formally we have the following rule:

Axiom Schema 1 (Assert Rule) $\forall e((\mathit{assert}(e) \wedge \mathit{Obj}(e, \lceil\phi\rceil)) \rightarrow (\mathit{Veridical}(e) \leftrightarrow \phi))$

Axiom Schema 1 should be thought of as a rule into which we may substitute uniformly for ϕ any well-formed formula in the current language.

Note: This generalizes to all the speech acts.

Disquotation theory: Extension to deontic reasoning

Obligations and permissions. Problems with the standard logic. Now an alternative.

The Anderson reduction: Instead of $\mathcal{O}\phi$ for "It ought to be the case that ϕ" we have $\Box\,(\neg\phi \rightarrow V)$ where V is the bad (violation) condition. That is, "ϕ ought to be true" is unpacked as "Necessarily, if ϕ isn't true, then the bad happens" (and that's not good!).

Then... Suppose that a delivery is obligated:

Expression 5 $\mathcal{O}\exists e_1(\mathit{deliver}(e_1) \wedge \mathit{Sub}(e_1, a) \wedge \mathit{Obj}(e_1,g) \wedge \mathit{IndObj}(e_1, s) \wedge \mathit{Sake}(e_1, e))$

Disquotation theory: Deontic reasoning

Our fundamental schema for *ought* follows the usual form

Fundamental Schema 1 (Ought) $\exists e(ought(e) \wedge Obj(e, \lceil \phi \rceil) \wedge \Gamma)$

and our example (Expression 5) instantiates in the predictable fashion:

Expression 6 $\exists e(ought(e) \wedge Obj(e, \lceil \exists e_1(deliver(e_1) \wedge Sub(e_1, a) \wedge Obj(e_1, g) \wedge IndObj(e_1, s) \wedge Sake(e_1, \boxed{e}) \rceil))$

Corresponding closely to the spirit of the Anderson reduction gives us the *weak* ought rule:

Axiom Schema 2 (Weak Ought Rule)
$\forall e((ought(e) \wedge Obj(e, \lceil \phi \rceil)) \rightarrow (\neg \phi \rightarrow V(e)))$

Disquotation theory: Deontic reasoning

My theory allows us to employ the *strong* ought rule:

Axiom Schema 3 (Strong Ought Rule)
$\forall e((ought(e) \wedge Obj(e, \ulcorner\phi\urcorner)) \rightarrow (\neg\phi \leftrightarrow V(e)))$

Permission works similarly.

Expression 7 (Permission) $\exists e(permit(e) \wedge Obj(e, \ulcorner \exists e_1(deliver(e_1) \wedge Sub(e_1, a) \wedge Obj(e_1,g) \wedge IndObj(e_1, s) \wedge Sake(e_1, \boxed{e})\urcorner))$

Disquotation theory: Deontic reasoning, directed obligation

The move here is the same as in systems of obligation and permission: add predicates to qualify the underlying event. If a has an obligation to b under system of norms n that ϕ, we then have:

Fundamental Schema 2 (Directed Obligation) $\exists e(\mathit{ought}(e) \wedge \mathit{Subject}(e, a) \wedge \mathit{IndObj}(e, b) \wedge \mathit{IsUnderNSys\text{-}tem}(e, n) \wedge \mathit{Obj}(e, \ulcorner \phi \urcorner) \wedge \Gamma)$

Concluding remarks: Recall: Goals/requirements

- $\mathcal{S}$ ($\mathcal{A}^\dagger$) sufficiently and felicitously expressive
- FOL for $\mathcal{S}$
- General grammar for $\mathcal{S}$
- Public-only lexicons (required for commencement of business)
- $\mathcal{S}$ has public grammar, controlled lexicon, open lexicon.
- Controlled lexicon is small.
- Open lexicon is large but semantically limited (noun phrases).

Emphasize: speech acts, and "good enough" semantics.

Concluding remarks

- Level 3 representation is possible. What follows, does; what doesn't doesn't.

- Key elements for a (GP)-FLBC: event semantics, disquotation theory for propositional content (including speech acts).

- Spanning vocabulary: small number of basic predicates; tables of names (catalogs).

- How to say what you need to say.

But does it work?

- Yes: Real examples yield nicely (so far!)

- Is it practicable?

  I believe so: Reduction to RDBMS schema. Predicates $\approx$ Tables.

- The PostScript argument and message management systems

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/* $Header$ */
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