Presentation at LAP, Montréal, Canada, July 21-22, 2001:

# From Database to Utterance Base:

## Envisioning Automated Business Communications[a]

by

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[a] File: lap-2001-flbc-slides.tex.

## (Some) 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

## Keynote opportunity

- Invitation to envision

  Where the rubber meets the clouds?

- Mark of progress: expanding the realm of the automated

  Important aim, and test.

- Envisioning: Where we'll go and how we might get there

  At least I aim to do this.

- Also, invitation to recall

  Motivating idea for FLBC: Bypass natural language, figure out the underlying structures

- Here: vision & recall, summary & review, prospects & challenges

## Outline

- Keynote challenge
- Visions & recall (page 5)
- Summary & review of FLBC
  - Presuppositions (page 7)
  - ESΘ theory (page 14)
  - Disquotation theory, (page 41)
- Prospects & challenges (page 59)
  - Basic English (page 62)

## "The Vision Thing" for electronic commerce

- 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

But how do you do it, exactly?

## Vision

- Machine-to-machine, formal language communication, widely applied
- From database to utterance base

  Querying, managing message traffic
- MOM++
- Language translation for people, automated reasoning by machine
- . . . and in general, nifty new applications.

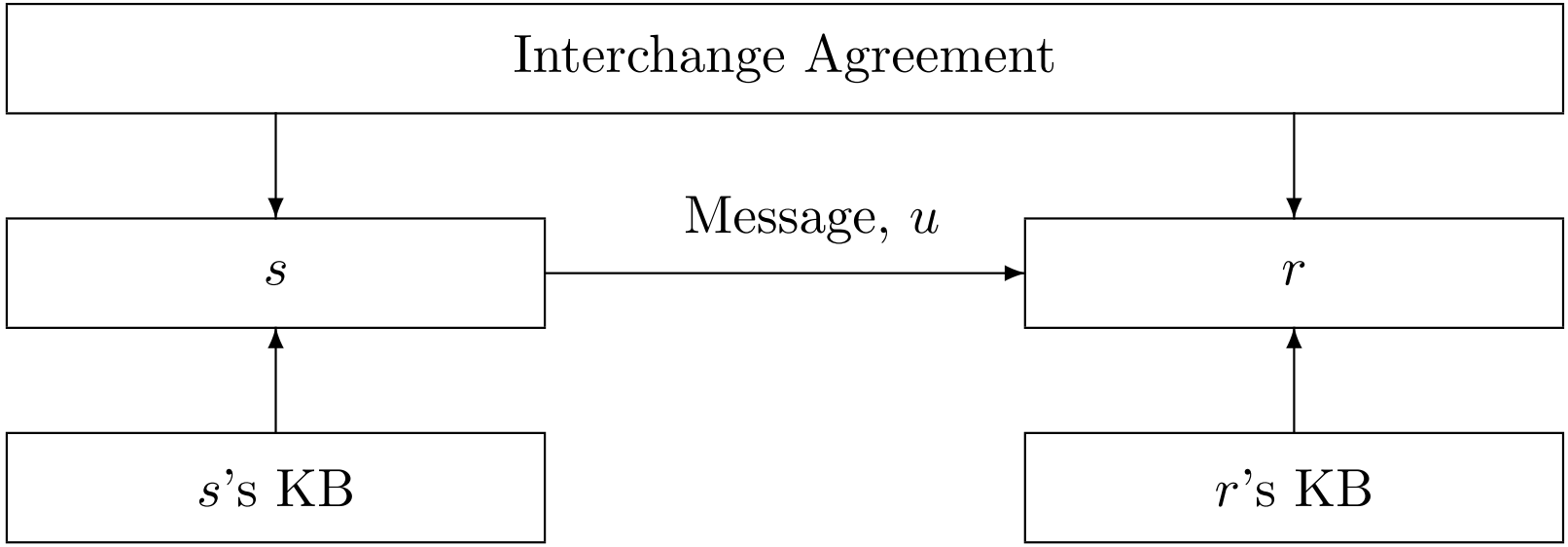
# Presuppositions

## Presuppositions

1. Permanent need for expressively-powerful means of machine-to-machine communication.
2. The template approach to message design, embodied in all EDI schemes, is fundamentally unrobust.
3. The language approach is highly desirable, in principle and in practice, providing its grammar can be made sufficiently general and expressive.
4. Importance of speech acts; real and ubiquitous

   Convention, not intention (Searle, Grice).
5. Applications in mind. Origin of work in problems of EDI: no compositional semantics $\rightsquigarrow$ expensive kludges.
6. Big issues: (a) intensionality, (b) getting the inferences right (inclusion, exclusion)

## EDI messaging schema: leanness

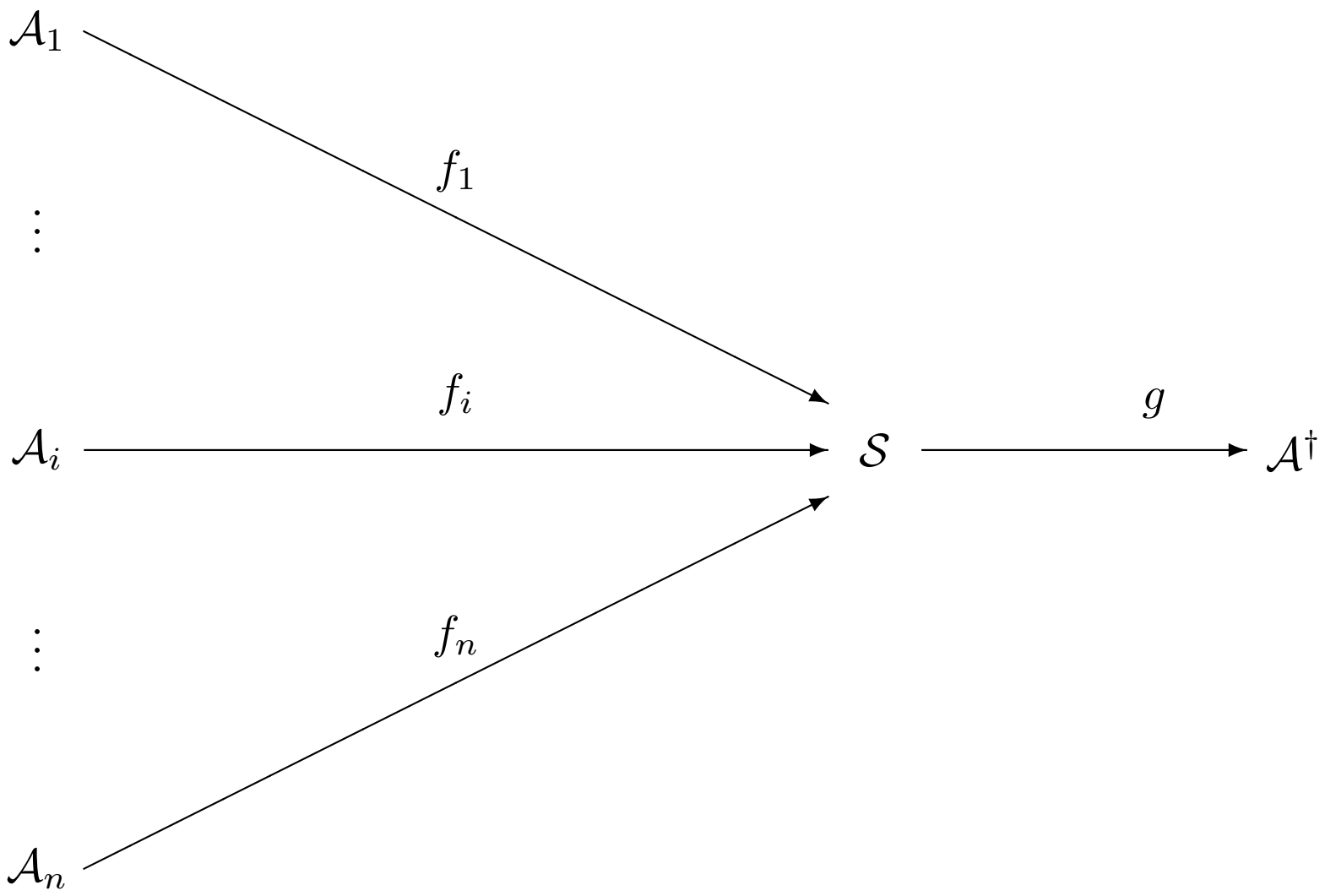



A message $u$ from speaker $s$ to addressee $r$.

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

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

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 and automated reasoning?

## 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 further) 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

# ESΘ Theory

Event (Subatomic) Semantics with Thematic Rôles

## 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

## 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."

Thematic rôles (con't.) Notice:

- (1) → (2)
- (1) → (3)
- (2) → (4)
- (3) → (4)
- (1) → (5)

&c. (and lots of it!)

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!)

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."

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

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)?

## 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."

$$\begin{aligned} &\exists e(speak(e) \wedge SUBJECT(e,\ Bob) \wedge \\ &\quad DIRECT\text{-}OBECT(e,\ Ted) \wedge \\ &\quad INDIRECT\text{-}OBJECT(e,\ Carol)) \end{aligned} \tag{1}$$

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

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

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

$$\begin{aligned}\exists e(&speak(e) \wedge SUBJECT(e,\ Bob) \wedge \\ &DIRECT\text{-}OBECT(e,\ Ted) \wedge \\ &INDIRECT\text{-}OBJECT(e,\ Carol) \\ &Cul(e,\ t) \wedge t < now)\end{aligned} \tag{2}$$

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

## 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."

$$\begin{aligned}\exists e(&\mathit{speak}(e) \wedge \mathit{SUBJECT}(e,\ \mathit{Bob}) \wedge \\ &\mathit{DIRECT\text{-}OBECT}(e,\ \mathit{Ted}) \wedge \\ &\mathit{INDIRECT\text{-}OBJECT}(e,\ \mathit{Carol}) \\ &\mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{3}$$

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

$$\begin{aligned}\exists e(&\mathit{speak}(e) \wedge \mathit{SUBJECT}(e,\ \mathit{Bob}) \wedge \\ &\mathit{DIRECT\text{-}OBECT}(e,\ \mathit{Ted}) \wedge \\ &\mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{4}$$

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

Our previous implication relationships go through naturally:

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

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

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

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \mathit{SUBJECT}(e,\ \mathit{Bob}) \wedge \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{6}$$

## 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."

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \\ &\quad \mathit{DIRECT\text{-}OBECT}(e,\ \mathit{Ted}) \wedge \\ &\quad \mathit{INDIRECT\text{-}OBJECT}(e,\ \mathit{Carol}) \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now}) \end{aligned} \tag{7}$$

And all the (right) implications go through!

## 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.

## 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.

## 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*)

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

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

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \\ &\quad \mathit{Theme}(e,\ \mathit{Ted}) \wedge \\ &\quad \mathit{Goal}(e,\ \mathit{Carol}) \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{8}$$

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

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \\ &\quad \mathit{Theme}(e,\ \mathit{Ted}) \wedge \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{9}$$

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

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

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \\ &\quad \mathit{Goal}(e,\ \mathit{Carol}) \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{10}$$

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

$$\begin{aligned}&\exists e(\mathit{speak}(e) \wedge \mathit{Agent}(e,\ \mathit{Bob}) \wedge \\ &\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})\end{aligned} \tag{11}$$

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

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

$$\begin{aligned}
&\exists e(\mathit{speak}(e) \wedge \\
&\quad \mathit{Theme}(e,\ \mathit{Ted}) \wedge \\
&\quad \mathit{Goal}(e,\ \mathit{Carol}) \\
&\quad \mathit{Cul}(e,\ t) \wedge t < \mathit{now})
\end{aligned} \tag{12}$$

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

## Event semantics with thematic rôles: Extensions

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

$$\begin{aligned}
&\exists e(stab(e) \wedge Agent(e,\ Brutus) \wedge \\
&\quad Theme(e,\ Cæsar) \wedge \\
&\quad Performer(e,\ knife) \wedge \\
&\quad violent(e) \wedge \\
&\quad in(e,\ the\text{-}back) \wedge \\
&\quad Cul(e,\ t) \wedge t < now) \qquad (13)
\end{aligned}$$

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*

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

Note that *bill* (a kind of request) is a speech act. Note that *confirm* (a kind of assertive) is a speech act, so the treament on this slide has to be modified. See below.

Also, the theme of the bill, $e'$, is going to be a payment in response to the bill, which is warranted by event $z$, something which presumably

produced the goods.

## 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*

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

Note that *forecast* is a speech act, so the treament on this slide has to be modified. See below.

Also, *Sake* is something I've introduced. It's an auxiliary, like *Cul*, and is needed at time. Short for $x$ *is for the sake of* $y$.

## 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 $x\ orders\ z\ from\ y\ on\ d$

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

Note that *invoice* is a speech act, a request to pay, so the treament on this slide has to be modified. See below.

Also, *Sake* is something I've introduced. It's an auxiliary, like *Cul*, and is needed at time. Short for *x is for the sake of y*. Note how *Sake* is useful here. Still, I wonder if it is really needed. Why shouldn't it be handled by the *Theme*? Well, I think the Theme, z, is the delivery event, say, and r is the, say, purchase order. I'll stick with it for now, for the sake of... This is an example of practice informing or constraining theory. Fine!

*order* is also a speech act, a kind of request. See below.

## 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*

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

Note the similarity between *ownershipChange* and *move*.

Note again that *ownershipChange* may or may not have a natural language corresponding verb. But we need it for the application. Cool.

## 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 $x\ ships\ items\ z\ to\ y\ on\ d$

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

## A worry, on account of speech acts.

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 $Agent$.

# Disquotation Theory

## Sentences with propositional content

Examples (with content $P$): *S believes that P*, *S promises that P*, *S says that P*, etc.

- Saying that (indirect discourse):
  - *Galileo said that the earth moves*
  - *Bush said that the U.S. economy was in deep trouble and only massive tax reductions, especially for the wealthy, could save the day.*

- Propositional attitude descriptions (aka: clausal complements) such as:
  - *Jane believes that Tom loves Mary*
  - *Jane desires that Tom does not love Mary*
  - *Jane intends that Tom will marry Susan*

  and their stylistic equivalents. For example, *Tom intends to marry Mary* is arguably a variant of the more stilted *Tom intends that he (Tom) will marry Mary.*
- Speech act descriptions, such as:
  - *Tom promised that he will marry Mary.*
  - *Sam promised Sue a diamond.*[a]
  - *Bush asserted that his administration would operate on a bipartisan basis.*

[a] I take this kind of construction as shorthand for, here, something akin to *Sam promised Sue that she (Sue) will get a diamond.*

- *The Supreme Court declared that the ballots will not be counted.*

- Modal descriptions, such as:
  - *It is impossible that Gore can appeal a Supreme Court decision.*
  - *Necessarily, it is raining or not*

- Deontic descriptions, such as:
  - *Jake is obliged to Tom that Jake read(s) the letter.*
  - *Parking is not permitted here.*

- Perceiving-that descriptions, such as:
  - *Jane saw that Tom kissed Mary*
    (as distinguised from *Jane saw Tom kiss Mary.*)

- Others, e.g.,
  - *Gore needs it to be the case that a miracle occurs.*

## Comments

1. Most of these examples and other cases involve some degree of inten[st]ionality.

   Here: focus on intensionality ("s-ality"). Roughly: linguistic description of intentionality. Diagnostic: failure of substitution of equivalents (identicals) can fail to preserve truth. "S believes that P, P if and only if Q, therefore S believes that Q" is surely invalid, as is "S knows that a robbed the bank, a = b, therefore S knowls that b robbed the bank." Aside: degrees or levels of inten[st]ionality.

2. Here: a sketch of a theory (or approach)

3. Definition versus description. Here: description. (Baseball)

## More on inten[st]ionality

Puzzling. Thought to challenge naturalism, materialism. The "mark of the mental"? Intentionality: directed, aspectual.

$f(x) = z, x = y \models f(y) = z$

$P, P \leftrightarrow Q \models Q$

$P \rightarrow R, P \leftrightarrow Q \models Q \rightarrow R$

Examples of intentionality: Oedipus, Juliet, police knowing the bank robber, BDI, etc.

Levels of inten[st]ionality, include: equivalences: extensional (Batman and Bruce Wayne), nomic (laws of nature), alethic (ordinary necessity), analytic (triangles, bachelors), synonymy (?)

## Modal approaches (to intensionality)

Standardly:

Modal logic, e.g., $\Box P, P \leftrightarrow Q \not\models \Box Q$ but $\Box P, \Box(P \leftrightarrow Q) \models \Box Q$

Logics of belief, of knowledge, etc.

Speech act analysis pushed by sok:

$promise(\mathrm{P}) \approx \exists e(promise(e) \wedge \Box(K(e) \leftrightarrow P))$

What's wrong with this? (a) Does there have to be something wrong to consider an alternative? (b) In my own case, I've been bothered by the lack of principled motivation for a modal approach. It's there for intensionality (only?).

## Disquotation theory/approach: core idea

Propositional content has (at least) two important aspects. First, it is about something, that is to say it is true-or-false or rather it is a description, accurate or not, of something. Second, it is itself something about which we attribute certain properties, e.g., that Mary believes it or hopes it or asserts it or promises it.

Summarizing (perhaps sloganizing), we might put the point by saying that the sentences of interest here large have the structure: content + comment (on the content). The core idea I wish to develop involves directly recognizing and representing these two aspects (content, comment) of sentences with propositional content.

## 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** $\exists e'(arrive(e') \wedge Subject(e', Sam) \wedge Cul(e', yesterday))$

Let $\phi$ represent Expression 2.

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

**Expression 3** $\exists e(assert(e) \wedge Subject(e,\ Mary) \wedge Obj(e,\ \lceil \phi \rceil))$

or fully written out:

**Expression 4** $\exists e(assert(e) \wedge Subject(e,\ Mary) \wedge Obj(e,\ \lceil \exists e'(arrive(e') \wedge Subject(e',\ Sam) \wedge Cul(e',\ yesterday)) \rceil))$

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)** $\forall e((assert(e) \wedge Obj(e, \lceil\phi\rceil)) \rightarrow (Veridical(e) \leftrightarrow \phi))$

Axiom Schema 1 should be thought of as a rule into which we may substitute uniformly for $\phi$ 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 $\phi$" we have $\Box(\neg\phi \rightarrow V)$ where $V$ is the bad (violation) condition. That is, "$\phi$ ought to be true" is unpacked as "Necessarily, if $\phi$ isn't true, then the bad happens" (and that's not good!).

Then...Suppose that a delivery is obligated:

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

## Disquotation theory: Deontic reasoning

Our fundamental schema for *ought* follows the usual form

**Fundamental Schema 1 (Ought)** $\exists e(ought(e) \wedge Obj(e, \ulcorner \phi \urcorner) \wedge \Gamma)$

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

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

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

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

## 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 $\phi$, we then have:

**Fundamental Schema 2 (Directed Obligation)** $\exists e(ought(e) \wedge Subject(e,\ a) \wedge IndObj(e,\ b) \wedge IsUnderNSystem(e,\ n) \wedge Obj(e,\ \ulcorner \phi \urcorner) \wedge \Gamma)$

Note: Error in paper. Instead of $V(e)$ we need $V(e, n)$.

## Summary & Discussion

For each type of expression (focused on intensional verbs) we have:

- a fundamental schema (with quotation)
- one or more axiom schemas (quantified, with disquotation)

with indexing on eventualities.

## Summary & Discussion

With quotation, the fundamental schema expressions are maximally intensional. Even to synonymy.

With disquotation, the axiom schemas allow degrees of relaxation (among other things) of the intensionality.

Claim: a nice property. Pretty obvious: a means to handle degrees of intensionality.

## Summary & Discussion

Another example: blocking deductive closure. Hard(er) to do in a modal system. $S$ *knows that* $P \wedge Q \not\models S$ *knows that* $P$. OK with the disquotation theory.

Also OK with the disquotation theory:

$S$ *knows directly and immediately that* $P \wedge Q \models S$ *knows indirectly and mediately that* $P$.

Note: can be generalized quantitatively.

Conclusion: Add the fact that this representation is friendly for logic programming and for RDBMS, and we have something well worth further investigation.

# Prospects & Challenges

Much remains to be done. Some examples.

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- Conceptual analysis and application

  Does it really work? The PO looks good (I think), as do other EDI examples, but reality has to be probed further. EDI systematically? Other locutions?

- Conceiving of new message-oriented applications.

  OK, so we've got toasters on the network, now what?

  One concept: Ready Archivist. Use the Internet to send messages to yourself, your group, etc. in FLBC. Then process and support recall. A PDA on steroids. Easy capture of formalized information.

- Elementary, formalized "natural" language

  Can we use these tools and concepts to formalize a significant fragment of a natural language, significant enough to be interesting?

  Applications: language translation (Ronald Lee's earlier work); Ready Archivist; office automation uses; and more.

# Basic English

British American Scientific International Commercial English

## Background: C.K. Ogen, 1930s

- English as a universal "auxiliary language"
- KISS. 850 words. 16 verbs.
- Demonstrated to be easy to learn.
- Much activity in 1930s, why halted?

  Churchill and beaucracy, but why not revival?
- Intriguing, especially in the current context

## Basic English: Concept

- Define a simple variant of English that is easy to learn, that is expressive enough for everday purposes, and that can be expanded as needed for particular domains.

  Ogden: add 150 words and you get your favorite branch of science.

  NB: Not rigid, not dogmatic; very practical.

- Fascinating, since it's pre-Austin (speech acts) and pre-ESΘ theory.

- How does it work?

  Observation: You can often reduce a vocabulary by careful reëxpression.

  Thus, 4,000 verbs $\longrightarrow$ 16 verbs.

## The verbs

| | | | |
|---|---|---|---|
| come | get | give | go |
| keep | let | make | put |
| seem | take | be | do |
| have | say | see | send |

Plus 836 common words, plus various extensions (-ing, -er), and multiple senses.

## Examples

- "Fred climbs a tree" $\longrightarrow$ "Fred goes up a tree."

  $\exists e \exists x(go(e) \wedge Agent(e,\ Fred) \wedge up(e) \wedge Theme(e,x) \wedge tree(x))$

- "Fred is a cook."

  NB: "be" of predication, not identity. "Fred is a cook-being" or "There is a state of being a cook and Fred is in it."

  $\exists s(cook(s) \wedge In(Fred,\ s))$

  What Ogden sees as things—cook, country, etc.—I see as states.

- "Fred is a good cook."

  $\exists s \exists s1(cook(s) \wedge In(Fred,\ s) \wedge good(s1) \wedge In(s,\ s1))$

## Comment

- Much more to say, examine about Basic English
- Very intriguing

Further examples of issues and prospects.

- Utterance management systems. Design? Uses? Business case?
- Description of complex objects, other than utterances.

  Mathematical models. Contracts and other financial instruments. Reasoning about, formulating.
- Message generation

  Goals and reasoning vs fixed templates.
- Message interpretation

  Beyond templates and rules?
- Understanding autonomy of agents

  How to create it. When and when not to rely on it.

Extra slides, if needed.

Consider. . .

1. Brutus stabbed Cæsar violently in the back.
2. Brutus stabbed Cæsar violently.
3. Brutus stabbed Cæsar in the back.
4. Brutus stabbed Cæsar.
5. Brutus stabbed violently.
6. Brutus stabbed in the back.
7. Cæsar was stabbed violently.
8. Cæsar was stabbed in the back.
9. Brutus stabbed.
10. Cæsar was stabbed.

Normally, we symbolize this with ten predicates...

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$S_1$ "... stabbed ... violently in the back"

$S_2$ "... stabbed ... violently,"

...

$S_{10}$ "... was stabbed"

But this seems, at the least, quite strange. Notice especially that this symbolization entirely misses out on a great deal of logical structure. For example, $(1) \rightarrow (2)$, but it is not true that $S_1(b, c) \rightarrow S_2(b, c)$. Also, $(1) \rightarrow (2) \wedge (3)$ but not $(2) \wedge (3) \rightarrow (1)$, yet the $S_i$ representation is irrelevant to this logical structure. Nor are any of very many other logical relations among (1) ... (10) captured. In short, something is wrong with the standard representation if we cannot infer a stabbing from a stabbing violently in the back.

T. Parsons, *Events in the Semantics of English*

The thesis ... is that semantics of simple sentences of English require logical forms that are somewhat more complex than is normally assumed in investigations of natural language semantics. In particular, the semantics of a simple sentence such as 'Brutus stabbed Cæsar' requires a form of at least the following complexity:

> For some event e, e is a stabbing, and the agent of e is Brutus, and the object of e is Cæsar, and e culminated at some time in the past.

This form, which is typical, is dominated by an existential quantification over events. Since no such quantification is explicitly indicated in the sense 'Brutus stabbed Cæsar', I call it an "underlying" quantification. A main theme of the theory I investigate is that such underlying quantification over events (and states) is ubiquitous in natural language.

## Example

In the underlying event theory, 'Brutus stabbed Cæsar' goes into first-order logic as:

$$\exists I \exists e \exists t(before(t, now) \wedge t \in I \wedge stab(e) \wedge$$
$$Subject(e, Brutus) \wedge Obj(e, Caesar) \wedge Cul(e, t)) \qquad (14)$$

(Our representation assumes a typed variable regime. $I$ is a temporal (or spatio-temporal) interval, $e$ is an eventuality, and $t$ is a time.)

## Example

Similarly, 'Brutus stabbed Cæsar in the back with a knife violently' goes into first-order logic as:

$$\begin{aligned} \exists I \exists e \exists t (before(t, now) \wedge t \in I \wedge stab(e) \wedge \\ Subject(e, Brutus) \wedge Obj(e, Caesar) \wedge \\ in(e, the\text{-}back) \wedge with(e, knife) \wedge \\ violent(e) \wedge Cul(e, t)) \end{aligned} \tag{15}$$

(The analysis is not complete, since *the-back* remains not fully articulated. Doing that is more or less a straightforward matter, but it is one that digresses from the issues at hand.)

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