



A Bridge not too far

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Cuil, Inc.

+ A Bridge?

culum adveniente inu-
incrabiliuulnueru
mozum multitudine
quibus a sumo capite
usq; ad imum pedie-
unieratus fuisti et
ab impissime carn
fiabue lacratue et sa-
cissimo sanguine tuo
rubricatus quā ma-
ritudinem doloe in-
magna carne tua
pro nobis pertulisti
Die ussu quid ultra de-
bueris facere quod non

Translation



+ Why do we want this bridge?

- Want our computer to understand us
- Want to ask questions
 - large-scale intelligent information access
- Want to search for content on the web
 - exploiting the large amounts of textual data on the web
- Want automatic, high quality translation into other languages
- Etc...



+ A bridge between language and logic

Wish List:

- translation compositional and principled,
- meaning preserving, at least truth value preserving...
- a reasonable fragment of all language
- generic texts
- “logical forms” obtained are useful for reasoning.

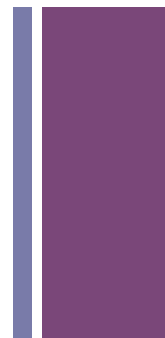
Questions:

- which kind of logic on the target?
- how do we know when we're done?
- how do we measure quality of results?



+ Dead simple?

- Isn't this what every undergraduate logic text deals with in its first chapter?...
- It was Russell's belief that by using the new logic of his day, philosophers would be able to exhibit the underlying "logical form" of natural language statements. SEP
- Long before that, it was Leibniz's idea *Calculus*
- ...problems with 'the present king of France' and his hair.
"On Denoting", 1905



+ Not so simple?

- A natural reaction:
- “Natural language, states Carnap, is misleading because it is not sharply defined and because it is not systematic enough. The syntactic rules governing natural language sentences do not enable us to distinguish between assertions and pseudo-assertions.”

Gamut on R. Carnap's “The elimination of metaphysics through logical analysis of language”, 1932.

- Carnap suggested: Instead do artificial languages.
- And logicians did: philosophical and mathematical logicians studied artificial languages





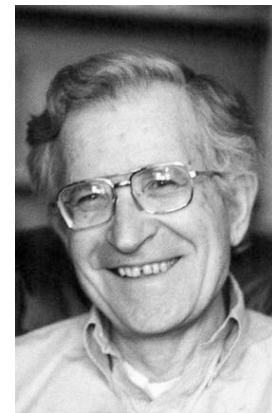
Is it too hard?

- “The skepticism in logical circles about the possibility of describing natural language with logical methods is similar to that in logical positivism.”
- Tarski thought that applying the semantics he developed for logical languages to natural languages would be problematic[...] any such semantics assumes a precisely formulated syntax,[..] out of the question that such could be found for natural languages.
- “The conviction that there is no exact logic of natural language, and that language therefore does not lend itself to an analysis in terms of precise logical notions and rules, is common to just about all analytic philosophers, even those that were most interested in language”
Gamuth, 1990



+ Not for every one...

- Davidson “Recent work by Chomsky and others is doing much to bring the complexities of natural language within the scope of serious semantic theory.” 1967
- Montague “I reject the contention that an important theoretical difference exists between formal and natural languages” - English as a formal language, 1970
- Both a translation from English to a formal system and a model theory for the system
- Since then a body of work on Formal Semantics of natural language concentrating on model theory
- fragments, pen and paper calculations, interesting phenomena. ..But also lots of computer systems, eg GUS





HANG ON A MINUTE...

30-odd years of solid work on NL semantics doesn't solve my BRIDGE problem...

Need to deal with huge amounts of text

Need to be robust

Need to move easily between genres, subject domains



+ The problem: between a rock and a hard place

- Knowledge-based representations of meaning
- Deep/logical representations allow high precision and recall, but
- Typically on restricted domains
- Hard for users to read/interpret output of the system
- **Very hard for system to build up knowledge**
- Shallow, open-domain representations
- Broad-coverage
- Fails “gracefully”
- Lower precision and recall
- Hard to compare systems
- Too sensitive to form of

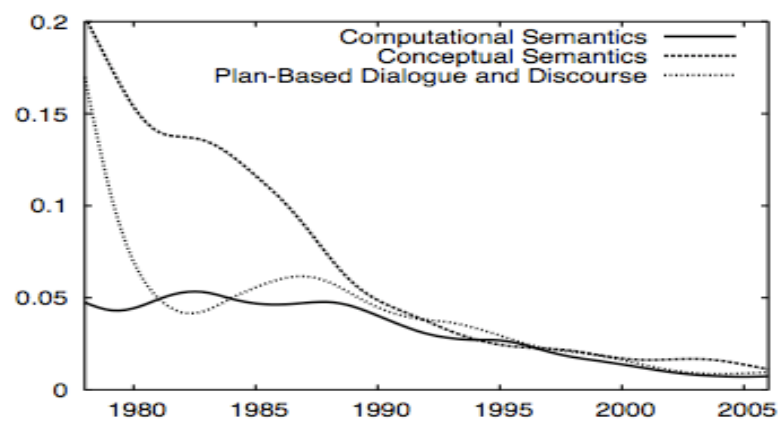


Figure 2: Topics in the ACL Anthology that show a strong decline from 1978 to 2006.

+ Which hard place?

- Whether you're fond of symbolic methods or of machine learning, the following are contradictory:
- No civilians were killed in the Najaf suicide bombing.

Two civilians died in the Najaf suicide bombing.

- Detecting whether one piece of text entails another or contradicts it is a **necessary** condition for text understanding.

- PASCAL (an EU-funded network of excellence), decided to organize a series of challenges benchmarking the task of Recognizing Textual Entailment (RTE) in 2004. This has been continued by TAC (Text analysis conference) supported by NIST.
- RTE Challenges promoted textual entailment recognition as a generic task capturing semantic inference needs across applications such as QA, Info Retrieval, Info Extraction and doc summarization,
- RTE-5 last year.

+ What makes language hard?

Not only semanticists seeking unicorns or non-existing kings...

“Negotiations prevented a strike”

- Claims that no strike came into being, but true and false assertions can be made about the non-existent strike.

- Bad idea:

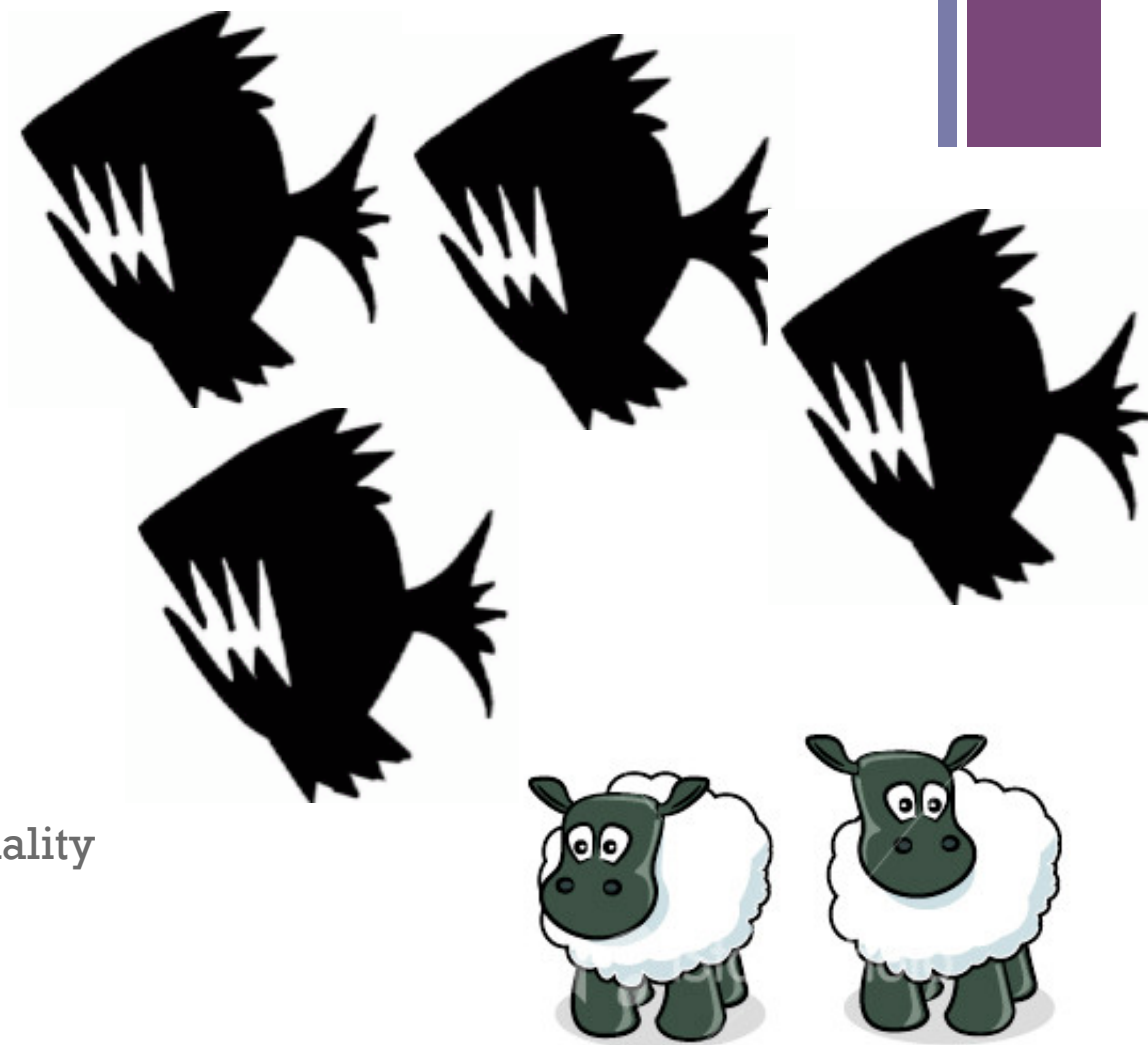
$\exists x \exists y \text{ Strike}(x) \text{ Negotiations } (y) \text{ prevented}(x,y)$

- Could do existence predicates, but entailments don't work.
- Instead do **concepts** see “Preventing Existence”, Crouch et al, FOIS2001



+ What is Hard?

- Many problems, besides (non-)existence
- intensionality
- ambiguity
- reference resolution,
- conditionals,
- presuppositions, etc...
- See “Entailment, Intensionality and Text Understanding”, Condoravdi et al, 2003



+ Pervasive Intensionality

- Intensionality is widespread in natural language
- Raises detection issues that cannot be brushed aside:

H: The US sought the release of hostages.

T: Hostages were released.

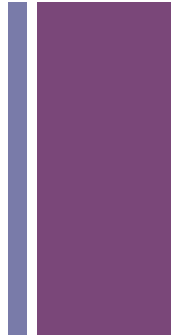
H→T?

People know that propositional attitudes (knowing, believing, seeking, etc..) introduce intensionality. Can we avoid them?

- Anecdotal evidence at least 453 sentences out of 1586 on 100 tips photocopier repair will have a prop complement
- Clearly it would be desirable to cope with intensionality.
- Proposal underspecified CONTEXTS
- Feasible?...



Scalability of Symbolic Methods



- From “Scalability of redundancy detection in Focused Document collections”, Crouch et al, 2002

“Symbolic parsing scales well, both in coverage and in dealing with the proliferation of ambiguity that arises out of broad coverage.” This is the XLE system, based on LFG grammar.

- Scalability/feasibility proven by doing it. It’s relative to what others are doing and how fast. Claim above based on Riezler et al “Parsing the Wall Street Journal using a lexical functional grammar and discriminative estimation techniques”, 2002. Parsing performance comparable with Collins

(More problematic is the series of canonicalizations of meaning necessary to take language-based representations to tractable conceptual representations.)

+ Scalability of Symbolic Methods?

- Measuring different parsers is not easy.
- But has been done for quite a while.
- Translating between outputs by different parsers is hard, lots of scope for messing the results.
- But there are gold standards, e.g. Penn TreeBank
- Semantic representations are harder to compare. No gold standard, no vast collection of annotated data. Not even a consensus on what annotations should look like
- Still the case in 2010...



+ Is it too hard?

- By late 2005 I was ready to throw in the towel.
- We had a beautiful layered architecture
- Processing sentences was fast and high-quality
- But big bottleneck when mapping to KR.
- Then TWO big changes:
 - Instead of the ideal golden standard, concentrate on how representations relate to each other, entailment and contradiction detection ECD
 - Instead of KR concepts from Cyc, fluid, wordy concepts from WordNet/VerbNet

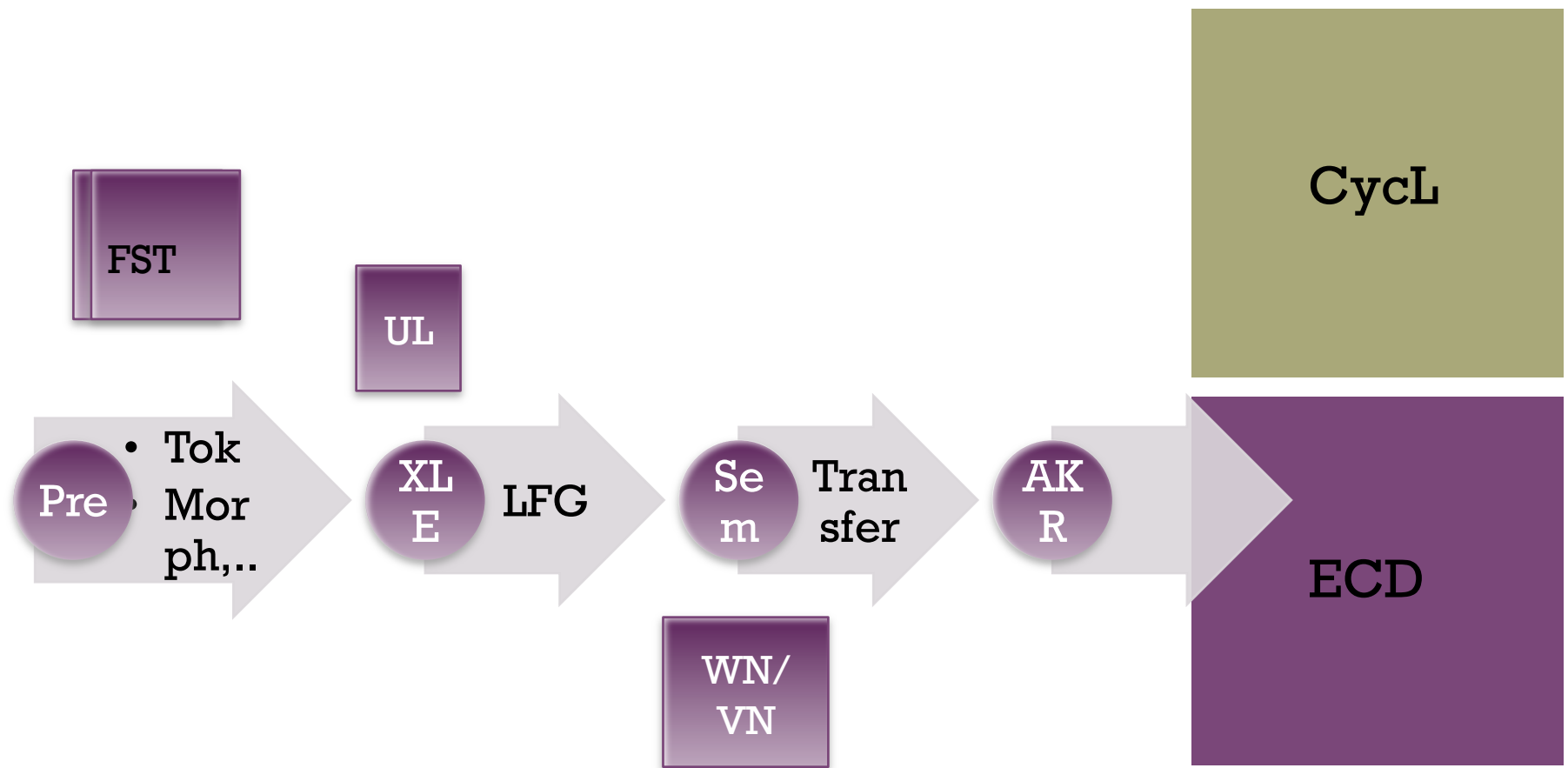


We can do
it!



How much of it?
How do we improve?

Architectures for Text Understanding



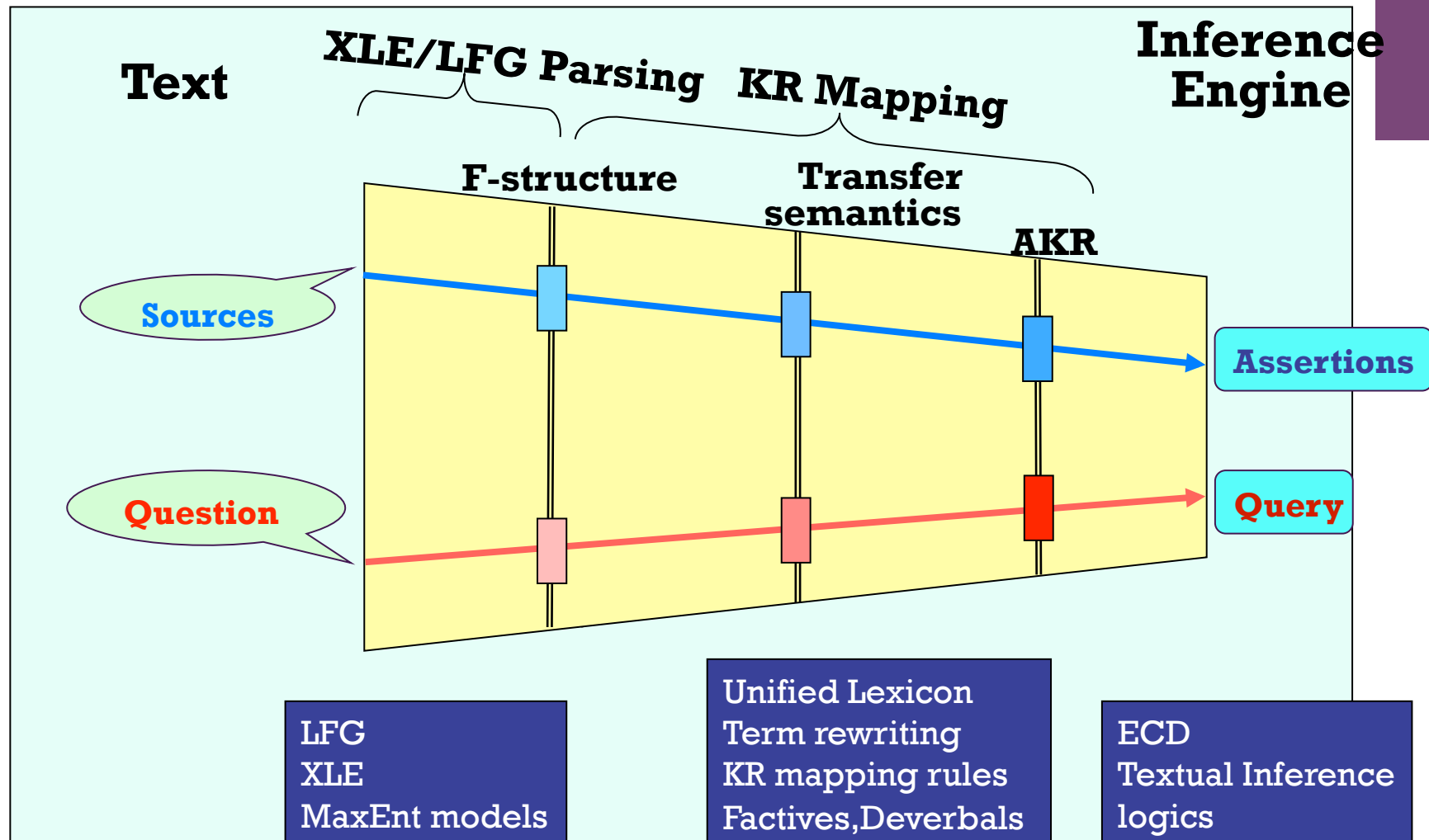
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Kaplan, Bobrow et al

PARC Pipeline

+

PARC Layered Architecture

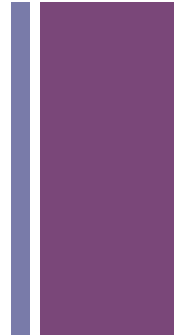


Basic idea: canonicalization of meanings

+ Key Process: Canonicalization of representations

- Sentences are parsed into f(unctional)-structures using XLE
- F-structures are (somewhat) semantic representations
- Transform f-structures into (flat and contexted) transfer semantic structures
(inspired by Glue and need to 'pack' semantics)
- Transform transfer sem-structures into (flat and contexted) AKR structures
- what do these layers of representation buy you?

+Language/KR misalignments:



■ Language

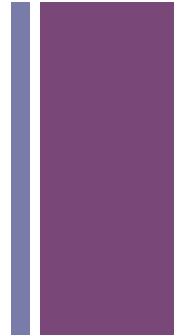
- Generalizations come from the structure of the language
- Representations compositionally derived from sentence structure

■ Knowledge representation

- Generalizations come from the structure of the world
- Representations to support reasoning
- Maintain multiple interpretations

■ Layered bridge helps with the different constraints

+ Semantics and AKR?



- Conceptual structure
 - concepts and roles as in a Description Logic
 - concepts as WordNet synsets
 - deverbal normalization
 - example: destruction of the building -> destroy the building
- Temporal structure (extracted from linguistic analysis)
 - relate time periods, events, states (a hook)
- Contextual structure
 - for negation, propositional attitudes, modals, ...
 - context-lifting rules
- Packed ambiguity encoding

+

Abstract KR: “Ed fired the boy.” (Cyc version)

$$\left[\begin{array}{ll} \text{PRED} & \text{fire<Ed, boy>} \\ \text{TENSE} & \text{past} \\ \text{SUBJ} & [\text{PRED Ed}] \\ \text{OBJ} & \left[\begin{array}{ll} \text{PRED} & \text{boy} \\ \text{DEF} & + \end{array} \right] \end{array} \right]$$

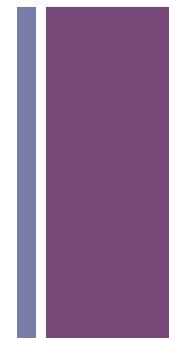
- (subconcept Ed3 Person)
 - (subconcept boy2 MaleChild)
 - (subconcept fire_ev1 DischargeWithPrejudice)
 - (role fire_ev1 performedBy Ed3)
 - (role fire_ev1 objectActedOn boy2)
- }
- Conceptual
-
- (context t)
 - (instantiable Ed3 t)
 - (instantiable boy2 t)
 - (instantiable fire_ev1 t)
- }
- Contextual
-
- (temporalRel startsAfterEndingOf Now
fire_ev1)
- }
- Temporal

+ Abstract KR: “Ed fired the boy.” (WN/ VN version)

- `cf(1, context(t)),`
- `cf(1, instantiable('Ed0',t)),`
- `cf(1, instantiable('boy3',t)),`
- `cf(1, instantiable('fire1',t)),`
- `cf(1, role('Agent','fire1','Ed0')),`
- `cf(1, role('Theme','fire1','boy3')),`
- `cf(1, subconcept('Ed0',[[7626,4576]])),`
- `cf(1, subconcept('boy3',[[10131706],[9725282],[10464570],`
`[9500236]),),`
- `cf(A1, subconcept('fire1',[[1124984],[1123061],[1123474]])),`
- `cf(A2, subconcept('fire1',[[2379472]])),`
- `cf(1, temporalRel(startsAfterEndingOf,'Now','fire1'))`

+ Are we there yet?

- NO! Challenges abound.
- Make translation better (“Deverbal Nouns in Knowledge Representation”, “Context Inducing nouns”, 2008)
- Named Entities, measures phrases, gazetteers
- Deal with anaphora and discourse (DRS?)
- Improve sense clustering
- Treatment of copula





A generic Architecture?

Semantics in Text Processing, 2008

Eds. Johan Bos, Rodolfo Demonte

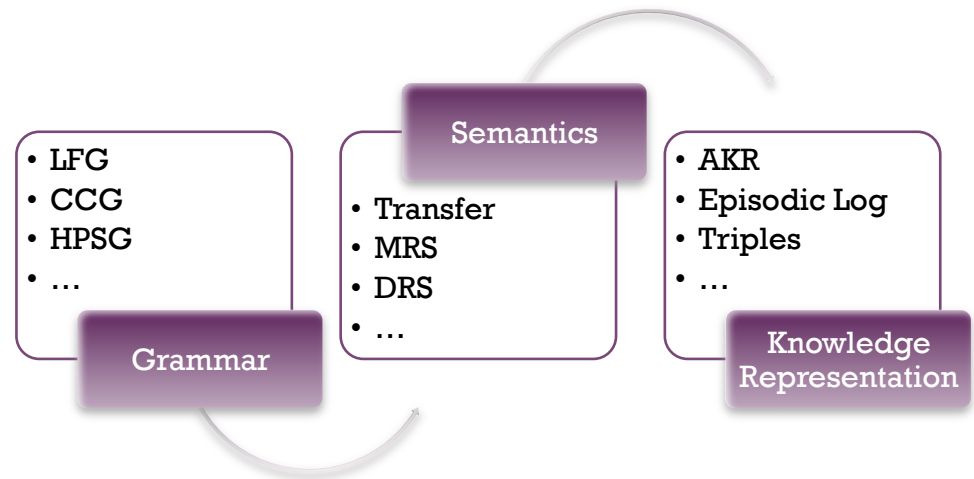
At least 8 systems doing similar work:

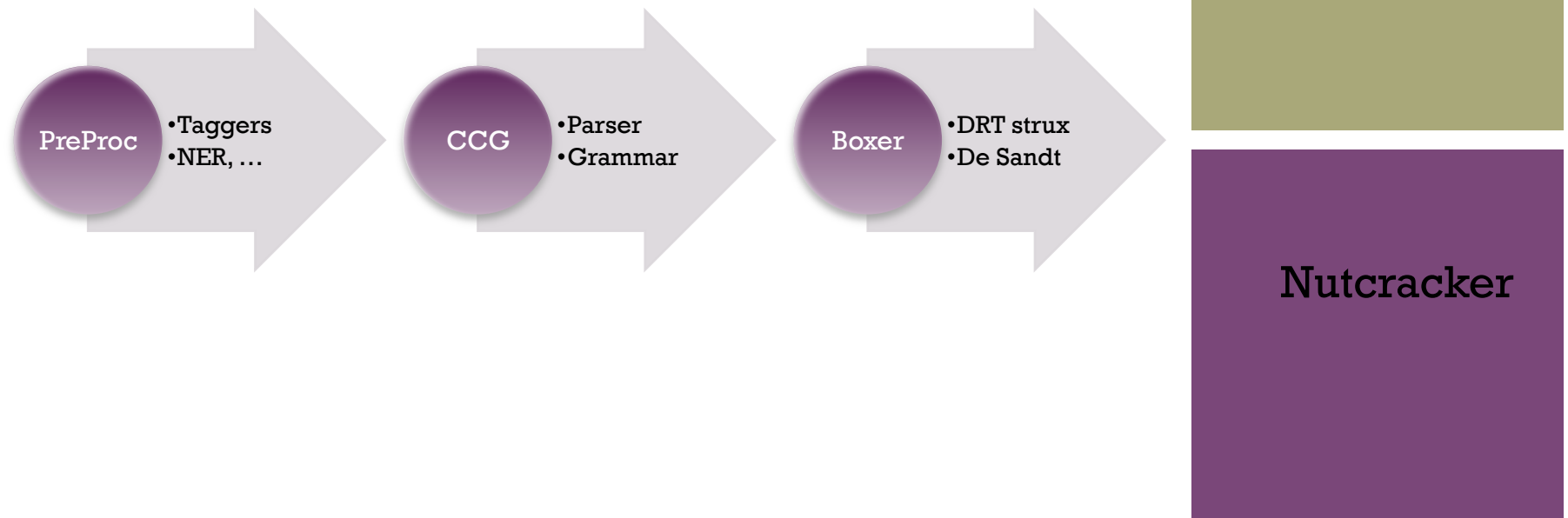
- Boing BLUE
- BOXER
- Ontosem
- Open Knowledge, Schubert
- Trips, Allan
- Getaruns
- TextCap
- LXGram



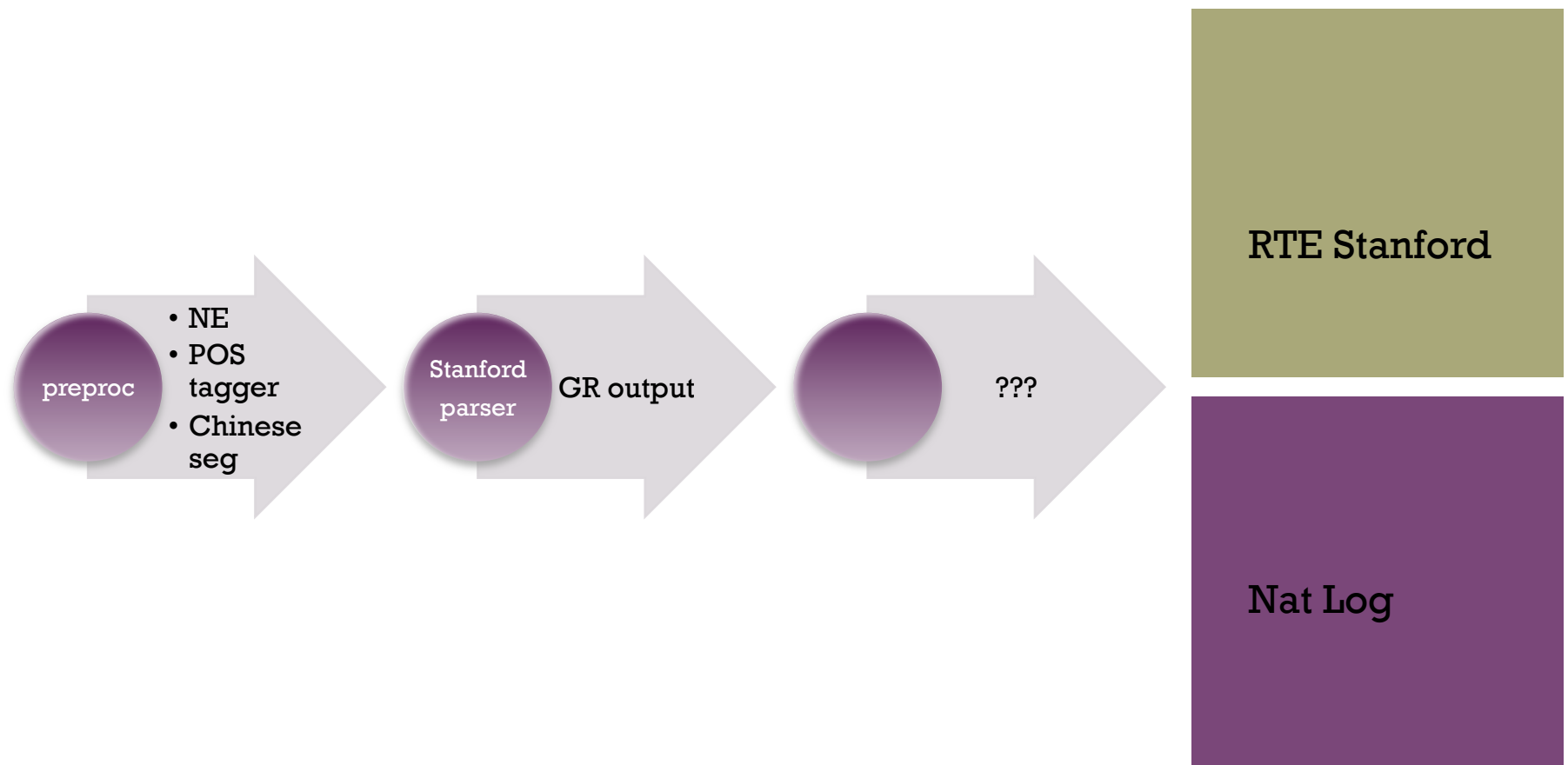
A Generic Architecture

All require a host of pre & post-processing: text segmenters, POS taggers, Lexica, Named Entity Recognizers, Gazetteers, Temporal Modules, Coreference Resolution, WSD, etc



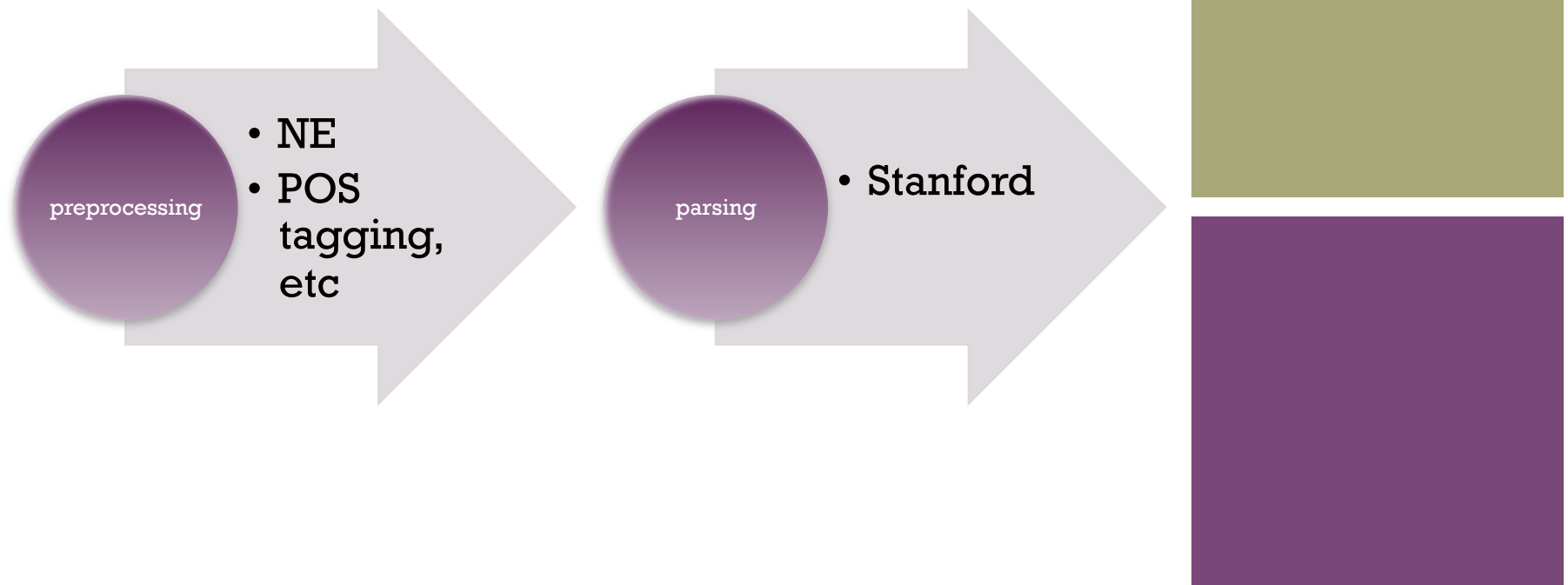


+ C&C Tools
Clark, Curran & Bos



+ Stanford NLP

Manning et al



+ GATE, EDITS

Cunningham et al, Nagnani et al



How do we got about it?

Totally unbaked ideas...

- The future seems easier if it's Open Source (see Ann Copestake's page)
- And collaborative (that too!)
- Translation and comparison of results is necessary
- Many more lexical resources need to be created and shared
- Machine learning of semantics/kr is required
- Logics, building up from ECD, using probabilistic component need to be in place
- Looking on the bright side... LOTS of FUN WORK!



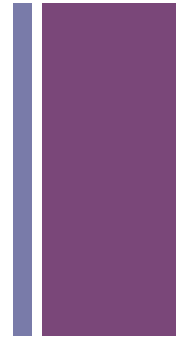
Elaborating a little...

- Borrowing from Ann Copestake Slacker Semantics:
- High-throughput parser with semantic output
- Effective statistical technique for syntactic parse ranking
- No underlying knowledge base for disambiguation
- Underspecification is good
- Support inter-sentential anaphora, text structure
- Robust inference and semantic pattern matching
- (pay attention to ease of use, notations that help..)

+ Is it too hard?

“Our language shows a tiresome bias in its treatment of time. Relations of date are exalted grammatically as relations of position, weight and color are not. This bias is of itself an inelegance, or breach of theoretical simplicity. Moreover, the form that it takes – that of requiring every verb form to show a tense – is peculiarly productive of needless complications, since it demands lip service to be paid to time even when time is farthest from our thoughts.”

Quine 1960





Thanks!

+ References

- ``Preventing Existence'', FOIS 2001.
- ``Making Ontologies Work for Resolving Redundancies Across documents'', Communications of the ACM, 2002.
- ``Scalability of redundancy detection in focused document collections'', ScaNaLU, Heidelberg, 2002
- ``Entailment, Intensionality and Text Understanding'', Workshop on Text Meaning, Edmonton, Canada, May 2003.
- ``Natural Deduction and Context as (Constructive) Modality'', CONTEXT 2003
- ``A Basic Logic for Textual inference'', AAI Workshop on Inference for Textual Question Answering, 2005.
- ``Textual Inference Logic: Take Two'', CONTEXT 2007.
- ``Precision-focused Textual Inference'', Workshop on Textual Entailment and Paraphrasing, 2007
- ``Deverbal Nouns in Knowledge Representation'', 2008
- ``Context Inducing Nouns'', 2008

+ Until The winter of our discontent

- The Winter of semantics
- As told by Hall, Juravsky and Manning in “Studying the History of Ideas Using Topic Models”, 2008
- Jokes apart, computational semantics seemed a thriving subject (to me) until around 1995, when it fell out of favor.
- Completely
- During the same time huge progress on statistics based methods for language

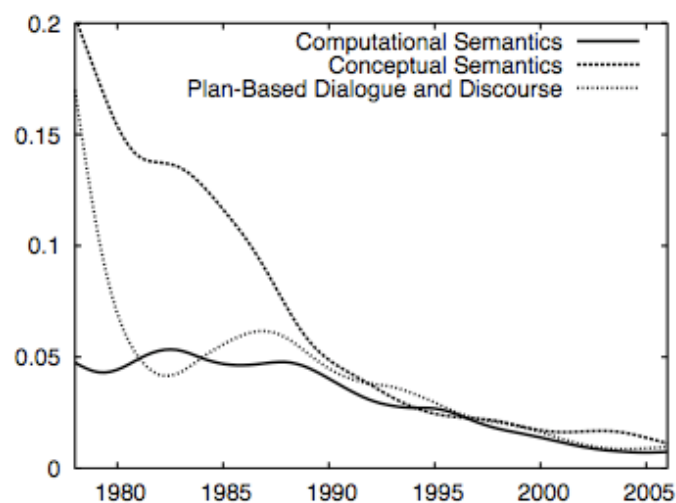


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