XLE:
Grammar Development Platform Parser/Generator

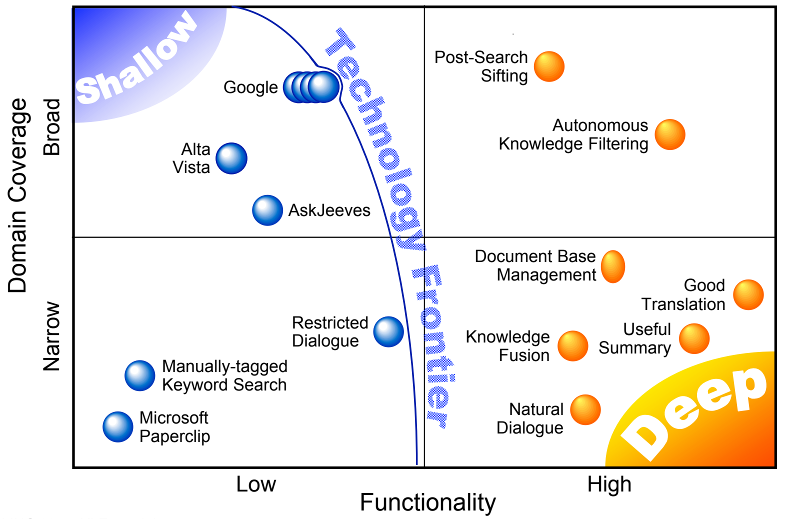
Miriam Butt (Universität Konstanz)
Tracy Holloway King (PARC)

COLING 2004 Tutorial

Tutorial Outline

- What is a deep grammar and why would you want one?
- XLE: A First Walkthrough
- Robustness techniques
- Generation
- Disambiguation
- Applications:
  - Machine Translation
  - Sentence Condensation
  - Computer Assisted Language Learning (CALL)
  - Knowledge Representation

Applications of Language Engineering



Deep grammars

- Provide detailed syntactic/semantic analyses
  - HPSG (LinGO, Matrix), LFG (ParGram)
  - Grammatical functions, tense, number, etc.

    Mary wants to leave.

    subj(want~1,Mary~3)
    comp(want~1,leave~2)
    subj(leave~2,Mary~3)
    tense(leave~2,present)
- Usually manually constructed

Why would you want one?

- Meaning sensitive applications
  - overkill for many NLP applications
- Applications which use shallow methods for English may not be able to for "free" word order languages
  - can read many functions off of trees in English
    - » subj: NP sister to VP
    - » obj: first NP sister to V
  - need other information in German, Japanese, etc.

Deep analysis matters… if you care about the answer

Example:

A delegation led by Vice President Philips, head of the chemical division, flew to Chicago a week after the incident.

Question: Who flew to Chicago?

Candidate answers:

~~*division*~~	~~closest noun~~	shallow but wrong
~~*head*~~	~~next closest~~	
~~*V.P. Philips*~~	~~next~~	
delegation	furthest away but Subject of *flew*	deep and right

Why don't people use them?

- Time consuming and expensive to write
  - shallow parsers can be induced automatically from a training set
- Brittle
  - shallow parsers produce something for everything
- Ambiguous
  - shallow parsers rank the outputs
- Slow
  - shallow parsers are very fast (real time)
- Other gating items for applications that need deep grammars

Why should one pay attention now?

New Generation of Large-Scale Grammars:

- Robustness:
  - Integrated Chunk Parsers
  - Bad input always results in some (possibly good) output
- Ambiguity:
  - Integration of stochastic methods
  - Optimality Theory used to rank/pick alternatives
- Speed: comparable to shallow parsers
- Accuracy and information content:
  - far beyond the capabilities of shallow parsers.

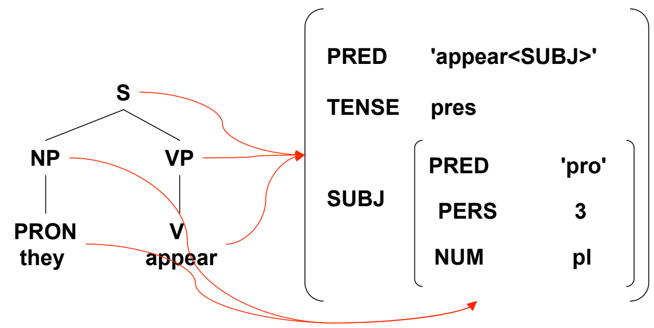
XLE at PARC

- Platform for Developing Large-Scale LFG Grammars
- LFG (Lexical-Functional Grammar)
  - Invented in the 1980s
    (Joan Bresnan and Ronald Kaplan)
  - Theoretically stable ⇔ Solid Implementation
- XLE is implemented in C, used with emacs, tcl/tk
- XLE includes a **parser**, **generator** and **transfer** component.

Basic LFG

- Constituent-Structure: tree
- Functional-Structure: Attribute Value Matrix

universal



Grammar components

- Configuration: links components
- Annotated phrase structure rules
- Lexicon
- Templates
- Other possible components
  - Finite State (FST) morphology
  - disambiguation feature file

Basic configuration file

```
TOY ENGLISH CONFIG (1.0)
ROOTCAT S.
FILES .
LEXENTRIES (TOY ENGLISH).
RULES (TOY ENGLISH).
TEMPLATES (TOY ENGLISH).
GOVERNABLERELATIONS SUBJ OBJ OBJ2 OBL COMP XCOMP.
SEMANTICFUNCTIONS ADJUNCT TOPIC.
NONDISTRIBUTIVES NUM PERS.
EPSILON e.
OPTIMALITYORDER
    NOGOOD.
----
```

Grammar sections

- Rules, templates, lexicons
- Each has:
  - version ID
  - component ID
  - XLE version number (1.0)
  - terminated by four dashes ----
- Example

```
STANDARD ENGLISH   RULES   (1.0)

----
```


Syntactic rules

- Annotated phrase structure rules

```
Category --> Cat1: Schemata1;
             Cat2: Schemata2;
             Cat3: Schemata3.

S --> NP: (^ SUBJ)=!
          (! CASE)=NOM;
      VP: ^=!.
```


Another sample rule

```
                               "indicate comments"
VP --> V: ^=!;                 "head"
       (NP: (^ OBJ)=!          "() = optionality"
            (! CASE)=ACC)
       PP*: ! $ (^ ADJUNCT).   "$ = set"
```

VP consists of:
- a head verb
- an optional object
- zero or more PP adjuncts

Lexicon

- Basic form for lexical entries:

```
word Category1 Morphcode1 Schemata1;
     Category2 Morphcode2 Schemata2.

walk V * (^ PRED)='WALK<(^ SUBJ)>';
     N * (^ PRED) = 'A-WALK' .

girl  N * (^ PRED) = 'A-GIRL'.

kick  V * { (^ PRED)='KICK<(^ SUBJ)(^ OBJ)>'
           |(^ PRED)='KICK<(^ SUBJ)>'}.

the   D * (^ DEF)=+.
```

Templates

- Express generalizations
  – in the lexicon
  – in the grammar
  – within the template space

No Template

```
girl N * (^ PRED)='GIRL'
         { (^ NUM)=SG
           (^ DEF)
          |(^ NUM)=PL}.
```

With Template

```
TEMPLATE: CN = { (^ NUM)=SG
                 (^ DEF)
                |(^ NUM)=PL}.
girl N * (^ PRED)='GIRL' @CN.
boy N * (^ PRED)='BOY' @CN.
```


Template example cont.

- Parameterize template to pass in values

```
CN(P) = (^ PRED)='P'
        { (^ NUM)=SG
          (^ DEF)
         |(^ NUM)=PL}.
```

```
girl N * @(CN GIRL).
boy N * @(CN BOY).
```

- Template can call other templates

```
INTRANS(P) = (^ PRED)='P<(^ SUBJ)>'.
TRANS(P) = (^ PRED)='P<(^ SUBJ)(^ OBJ)>'.
OPT-TRANS(P) = { @(INTRANS P) | @(TRANS P) }.
```


Parsing a string

- create-parser demo-eng.lfg
- parse "the girl walks"

Walkthrough Demo

Outline: Robustness

Dealing with brittleness

- Missing vocabulary
  – you can't list all the proper names in the world
- Missing constructions
  – there are many constructions theoretical linguistics rarely considers (e.g. dates, company names)
- Ungrammatical input
  – real world text is not always perfect
  – sometimes it is really horrendous

Dealing with Missing Vocabulary

- Build vocabulary based on the input of shallow methods
  - fast
  - extensive
  - accurate
- Finite-state morphologies

  falls -> fall +Noun +Pl

  fall +Verb +Pres +3sg
- Build lexical entry on-the-fly from the morphological information

Building lexical entries

- Lexical entries

```
-unknown  N      XLE   @(COMMON-NOUN %stem).
+Noun     N-SFX  XLE   @(PERS 3).
+Pl       N-NUM  XLE   @(NUM pl).
```

- Rule

```
Noun -> N  N-SFX  N-NUM.
```

- Structure

```
[ PRED  'fall'
  NTYPE common
  PERS  3
  NUM   pl ]
```


Guessing words

- Use FST guesser if the morphology doesn't know the word
  - Capitalized words can be proper nouns

    Saakashvili -> Saakashvili +Noun +Proper +Guessed
  - *ed* words can be past tense verbs or adjectives

    fumped -> fump +Verb +Past +Guessed

    fumped +Adj +Deverbal +Guessed

Using the lexicons

- Rank the lexical lookup
  1. overt entry in lexicon
  2. entry built from information from morphology
  3. entry built from information from guesser
     - » quality will depend on language type
- Use the most reliable information
- Fall back only as necessary

Missing constructions

- Even large hand-written grammars are not complete
  - new constructions, especially with new corpora
  - unusual constructions
- Generally longer sentences fail

Solution: Fragment and Chunk Parsing

- Build up as much as you can; stitch together the pieces

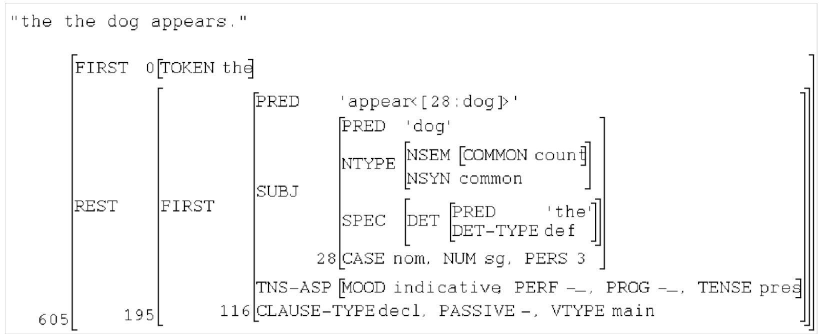
Grammar engineering approach

- First try to get a complete parse
- If fail, build up chunks that get complete parses
- Have a fall-back for things without even chunk parses
- Link these chunks and fall-backs together in a single structure

Fragment Chunks: Sample output

- the the dog appears.
- Split into:
  - "token" *the*
  - sentence "*the dog appears*"
  - ignore the period

F-structure



Ungrammatical input

- Real world text contains ungrammatical input
  - typos
  - run ons
  - cut and paste errors
- Deep grammars tend to only cover grammatical input
- Two strategies
  - robustness techniques: guesser/fragments
  - disprefered rules for ungrammatical structures

Harnessing Optimality Theory

- Optimality Theory (OT) allows the statement of preferences and dispreferences.
- In XLE, OT-Marks (annotations) can be added to rules or lexical entries to either prefer or disprefer a certain structure/item.

  +Mark = preference

  Mark = dispreference
- The strength of (dis)preference can be set variably.

OT Ranking

- **Order of Marks**: Mark3 is preferred to Mark4

  OPTIMALITYORDER Mark4 Mark3 +Mark2 +Mark1.

- **NOGOOD Mark:** Marks to the left are always bad. Useful for parametrizing grammar with respect to certain domains

  OPTIMALITYORDER Mark4 NOGOOD Mark3 +Mark2 +Mark1.

- **STOPPOINT Mark:** slowly increases the search space of the grammar if no good solution can be found (multipass grammar)

  OPTIMALITYORDER Mark4 NOGOOD Mark3 STOPPOINT Mark2 STOPPOINT Mark1.

Rule Annotation (O-Projection)

- Common errors can be coded in the rules

  mismatched subject-verb agreement

  ```
  Verb3Sg = { (^ SUBJ PERS) = 3
              (^ SUBJ  NUM) = sg
            | @(OTMARK BadVAgr) }
  ```
- Disprefer parses of ungrammatical structure
  - tools for grammar writer to rank rules
  - two+ pass system

Robustness via Optimality Marks

Demo
Ungrammatical Sentences

english.lfg (Tokenizer, FST Morphology)

The girls walks.
The the dog appears.

Robustness Summary

- Integrate shallow methods
  - morphologies (finite state)
  - guessers
- Fall back techniques
  - fragment grammar (chunks)
  - disprefered rules (OT)

Generation Outline

- Why generate?
- Generation as the reverse of parsing
- Constraining generation (OT)
- The generator as a debugging tool
- Generation from underspecified structures

Why generate?

- Machine translation
  Lang1 string -> Lang1 fstr -> Lang2 fstr -> Lang2 string
- Sentence condensation
  Long string -> fstr -> smaller fstr -> new string
- Question answering
- Grammar debugging

Generation: just reverse the parser

- XLE uses the same basic grammar to parse and generate
  - Parsing: string to analysis
  - Generation: analysis to string
- Input to Generator is the f-structure analysis
- Formal Properties of LFG Generation:
  - Generation produces Context Free Languages
  - LFG generation is a well-understood formal system (decidability, closure).

Generation: just reverse the parser

- Advantages
  - maintainability
  - write rules and lexicons once
- But
  - special generation tokenizer
  - different OT ranking

Restricting Generation

- Do not always want to generate all the possibilities that can be parsed
- Put in special OT marks for generation to block or prefer certain strings
  - fix up bad subject-verb agreement
  - only allow certain adverb placements
  - control punctuation options
- GENOPTIMALITYORDER
  - special ordering for OT generation marks that is kept separate from the parsing marks
  - serves to parametrize the grammar (parsing vs. generation)

Generation tokenizer

- White space
  - Parsing: multiple white space becomes a single TB

    John   appears. -> John TB appears TB . TB

  - Generation: single TB becomes a single space (or nothing)

    John TB appears TB . TB -> John appears.

    *John   appears   .

Generation tokenizer

- Capitalization
  - Parsing: optionally decap initially
    They came -> they came
    Mary came -> Mary came
  - Generation: always capitalize initially
    they came -> They came
    *they came
- May regularize other options
  - quotes, dashes, etc.

Generation morphology

- Suppress variant forms
  - Parse both *favor* and *favour*
  - Generate only one

Morphconfig for parsing & generation

STANDARD ENGLISH MOPRHOLOGY (1.0)

TOKENIZE:
P!eng.tok.parse.fst G!eng.tok.gen.fst

ANALYZE:
eng.infl-morph.fst G!amerbritfilter.fst
G!amergen.fst

Reversing the parsing grammar

- The parsing grammar rules can be used directly as a generator
- Adapt the grammar rule set with a special OT ranking GENOPTIMALITYORDER
- Why do this?
  - parse ungrammatical input
  - have too many options: one f-structure corresponds to many surface strings

Ungrammatical input

- Linguistically ungrammatical
  - They walks.
  - They ate banana.
- Stylistically ungrammatical
  - No ending punctuation: They appear
  - Superfluous commas: John, and Mary appear.
  - Shallow markup: [NP John and Mary] appear.

Too many options

- All the generated options can be linguistically valid, but too many for applications
- Occurs when more than one string has the same, legitimate f-structure
- PP placement:
  - In the morning I left. I left in the morning.

Using the Gen OT ranking

- Generally much simpler than in the parsing direction
  - Usually only use standard marks and NOGOOD
    no STOPPOINT
  - Can have a few marks that are shared by several constructions
    one or two for disprefered
    one or two for prefered

Example: Comma in coord

```
COORD(_CAT) = _CAT: @CONJUNCT;
              (COMMA: @(OTMARK GenBadPunct))
              CONJ
              _CAT: @CONJUNCT.
```

GENOPTIMALITYORDER GenBadPunct NOGOOD.

parse:		They appear, and disappear.
generate:	without OT:	They appear(,) and disappear.
	with OT:	They appear and disappear.

Example: Prefer initial PP

```
S --> (PP: @ADJUNCT @(OT-MARK GenGood))
      NP: @SUBJ;
      VP.
VP --> V
       (NP: @OBJ)
       (PP: @ADJUNCT).
GENOPTIMALITYORDER NOGOOD +GenGood.
```

parse: they appear in the morning.

generate: without OT: In the morning they appear.
They appear in the morning.

with OT: In the morning they appear.

Generation commands

- XLE command line:
  - regenerate "They appear."
  - generate-from-file my-file.pl
  - (regenerate-from-directory, regenerate-testfile)
- F-structure window:
  - commands: generate from this fs
- Debugging commands
  - regenerate-morphemes

Debugging the generator

- When generating from an f-structure produced by the same grammar, XLE should always generate
- Unless:
  - OT marks block the only possible string
  - something is wrong with the tokenizer/morphology

    regenerate-morphemes: if this gets a string

    the tokenizer/morphology is not the problem
- XLE has generation robustness features
  - seeing what is added/removed helps with debugging

Underspecified Input

- F-structures provided by applications are not perfect
  - may be missing features
  - may have extra features
  - may simply not match the grammar coverage
- Missing and extra features are often systematic
  - specify in XLE which features can be added and deleted
- Not matching the grammar is a more serious problem

Creating Paradigms

- Deleting and adding features within one grammar can produce paradigms
- Specifiers:
  - set-gen-adds remove "SPEC"
    set-gen-adds add "SPEC DET DEMON"
  - regenerate "NP: boys"

{ the | those | these | } boys

etc.

Generation for Debugging

- Checking for grammar and lexicon errors
  - **create-generator english.lfg**
  - reports ill-formed rules, templates, feature declarations, lexical entries
- Checking for ill-formed sentences that can be parsed
  - parse a sentence
  - see if all the results are legitimate strings
  - **regenerate "they appear."**

Regeneration example

% regenerate "In the park they often see the boy with the telescope."

parsing {In the park they often see the boy with the telescope.}

4 solutions, 0.39 CPU seconds, 178 subtrees unified

{They see the boy in the park|In the park they see the boy} often with the telescope.

regeneration took 0.87 CPU seconds.

Regenerate testfile

- regenerate-testfile
- produces new file: testfile.regen
  - sentences with parses and generated strings
  - lists sentences with no strings
  - if have no Gen OT marks, everything should generate back to itself

Summary: Generation and Reversibility

- XLE parses and generates on the same grammar
  - faster development time
  - easier maintenance
- Minor differences controlled by:
  - OT marks
  - FST tokenizers

Demo Generator

Ambiguity Outline

- Sources of Ambiguity:
  - Alternative c-structure rules
  - Disjunctions in f-structure description
  - Lexical categories
- XLE's display/computation of ambiguity
  - Packed representations
  - Dependent choices
- Dealing with ambiguity
  - Recognize legitimate ambiguity
  - OT marks for preferences
  - Shallow Markup/Tagging
  - Stochastic disambiguation

Ambiguity

- Deep grammars are massively ambiguous
- Use packing to parse and manipulate the ambiguities efficiently
- Trim early with shallow markup
  - fewer parses to choose from
  - faster parse time
- Choose most probable parse for applications that need a single input

Syntactic Ambiguity

- Lexical
  - part of speech
  - subcategorization frames
- Syntactic
  - attachments
  - coordination
- Implemented system highlights interactions

Lexical Ambiguity: POS

- verb-noun
  I saw her duck.
  I saw [NP her duck].
  I saw [NP her] [VP duck].
- noun-adjective
  the [N/A mean] rule
  that child is [A mean].
  he calculated the [N mean].

Morphology and POS ambiguity

- English has impoverished morphology and hence extreme POS ambiguity
  - leaves: leave +Verb +Pres +3sg
    leaf +Noun +Pl
    leave +Noun +Pl
  - will: +Noun +Sg
    +Aux
    +Verb +base
- Even languages with extensive morphology have ambiguities

Lexical ambiguity: Subcat frames

- Words often have more than one subcategorization frame
  - transitive/intransitive
    I broke it./It broke.
  - intransitive/oblique
    He went./He went to London.
  - transitive/transitive with infinitive
    I want it./I want it to leave.

Subcat-Rule interactions

- OBL vs. ADJUNCT with intransitive/oblique
  - He went to London.

```
 [ PRED 'go<(^ SUBJ)(^ OBL)>'
   SUBJ [PRED 'he']
   OBL   [PRED 'to<(^ OBJ)>'
          OBJ   [ PRED 'London']]]
[ PRED 'go<(^ SUBJ)>'
   SUBJ [PRED 'he']
   ADJUNCT  { [PRED 'to<(^ OBJ)>'
               OBJ   [ PRED 'London']]}]
```

OBL-ADJUNCT cont.

- Passive *by* phrase
  - It was eaten by the boys.

```
[ PRED    'eat<(^ OBL-AG)(^ SUBJ)>'
  SUBJ    [PRED 'it']
  OBL-AG  [PRED 'by<(^ OBJ)>'
           OBJ    [PRED 'boy']]]
```

  - It was eaten by the window.

```
[ PRED      'eat<NULL(^ SUBJ)>'
  SUBJ      [PRED 'it']
  ADJUNCT { [PRED 'by<(^ OBJ)>'
             OBJ    [PRED 'boy']]}]
```


OBJ-TH and Noun-Noun compounds

- Many OBJ-TH verbs are also transitive
  - **I took the cake. I took Mary the cake.**
- The grammar needs a rule for noun-noun compounds
  - **the tractor trailer, a grammar rule**
- These can interact
  - I took the grammar rules
  - **I took [NP the grammar rules]**
  - **I took [NP the grammar] [NP rules]**

Syntactic Ambiguities

- Even without lexical ambiguity, there is legitimate syntactic ambiguity
  - PP attachment
  - Coordination
- Want to:
  - constrain these to legitimate cases
  - make sure they are processed efficiently

PP Attachment

- PP adjuncts can attach to VPs and NPs
- Strings of PPs in the VP are ambiguous
  - **I see the girl with the telescope.**

    I see [the girl with the telescope].

    I see [the girl] [with the telescope].
- This ambiguity is reflected in:
  - the c-structure (constituency)
  - the f-structure (ADJUNCT attachment)

PP attachment cont.

- This ambiguity multiplies with more PPs
  - **I saw the girl with the telescope**
  - **I saw the girl with the telescope in the garden**
  - **I saw the girl with the telescope in the garden on the lawn**
- The syntax has no way to determine the attachment, even if humans can.

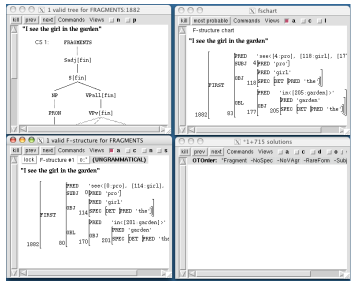
Ambiguity in coordination

- Vacuous ambiguity of non-branching trees
  - this can be avoided
- Legitimate ambiguity
  - old men and women
    old [N men and women]
    [NP old men] and [NP women]
  - I turned and pushed the cart
    I [V turned and pushed] the cart
    I [VP turned] and [VP pushed the cart]

Grammar Engineering and ambiguity

- Large-scale grammars will have lexical and syntactic ambiguities
- With real data they will interact resulting in many parses
  - these parses are legitimate
  - they are not intuitive to humans
- XLE provides tools to manage ambiguity
  - grammar writer interfaces
  - computation

XLE display

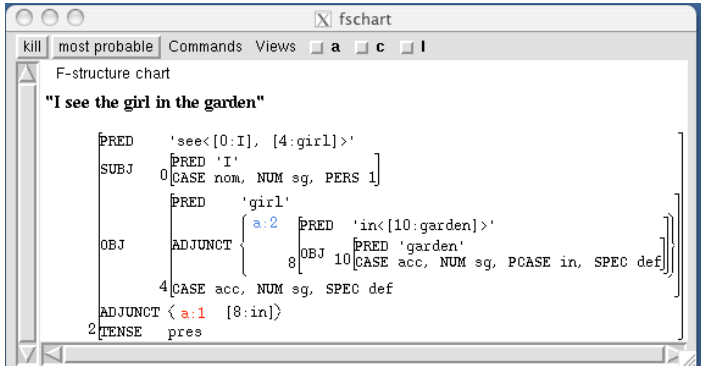


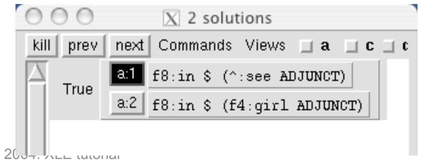
- Four windows
  - c-structure (top left)
  - f-structure (bottom left)
  - packed f-structure (top right)
  - choice space (bottom right)
- C-structure and f-structure “next” buttons
- Other two windows are packed representations of all the parses
  - clicking on a choice will display that choice in the left windows

Example

- I see the girl in the garden
- PP attachment ambiguity
  - both ADJUNCTS
  - difference in ADJUNCT-TYPE

Packed F-structure and Choice space





Sorting through the analyses

- "Next" button on c-structure and then f-structure windows
  - impractical with many choices
  - independent vs. interacting ambiguities
  - hard to detect spurious ambiguity
- The packed representations show all the analyses at once
  - (in)dependence more visible
  - click on choice to view
  - spurious ambiguities appear as blank choices
    - » but legitimate ambiguities may also do so

XLE Ambiguity Management

The sheep liked the fish.

How many sheep?
How many fish?

Options multiplied out

{ *The sheep-sg liked the fish-sg.*
The sheep-pl liked the fish-sg.
The sheep-sg liked the fish-pl.
The sheep-pl liked the fish-pl. }

Options packed

The sheep {*sg* / *pl*} *liked the fish* {*sg* / *pl*}

> Packed representation is a "free choice" system
> – Encodes all dependencies without loss of information
> – Common items represented, computed once
> – Key to practical efficiency

Dependent choices

Das Mädchen {*nom* / *acc*} *sah die Katze* {*nom* / *acc*}
The girl *saw the cat*

Again, packing avoids duplication … but it's wrong
It doesn't encode all dependencies, choices are not free.

~~*Das Mädchen-nom sah die Katze-nom*~~	*bad*
Das Mädchen-nom sah die Katze-acc	The girl saw the cat
Das Mädchen-acc sah die Katze-nom	The cat saw the girl
~~*Das Mädchen-acc sah die Katze-acc*~~	*bad*

Who do you want to succeed?

I want to succeed John	*want intrans, succeed trans*
I want John to succeed	*want trans, succeed intrans*

Solution: Label dependent choices

~~*Das Mädchen-nom sah die Katze-nom*~~	*bad*
Das Mädchen-nom sah die Katze-acc	The girl saw the cat
Das Mädchen-acc sah die Katze-nom	The cat saw the girl
~~*Das Mädchen-acc sah die Katze-acc*~~	*bad*

Das Mädchen {p:*nom* / ¬p:*acc*} *sah die Katze* {q:*nom* / ¬q:*acc*}

$$\varphi = (p \wedge \neg q) \vee (\neg p \wedge q)$$

- Label each choice with distinct Boolean variables p, q, etc.
- Record acceptable combinations as a Boolean expression φ
- Each analysis corresponds to a satisfying truth-value assignment
  (free choice from the true lines of φ's truth table)

Ambiguity management: Shallow markup

- Part of speech marking as filter
  I saw her duck/VB.
  – accuracy of tagger (very good for English)
  – can use partial tagging (verbs and nouns)
- Named entities
  – <company>Goldman, Sachs & Co.</company> bought IBM.
  – good for proper names and times
  – hard to parse internal structure
- Fall back technique if fail
  – slows parsing
  – accuracy vs. speed

Chosing the most probable parse

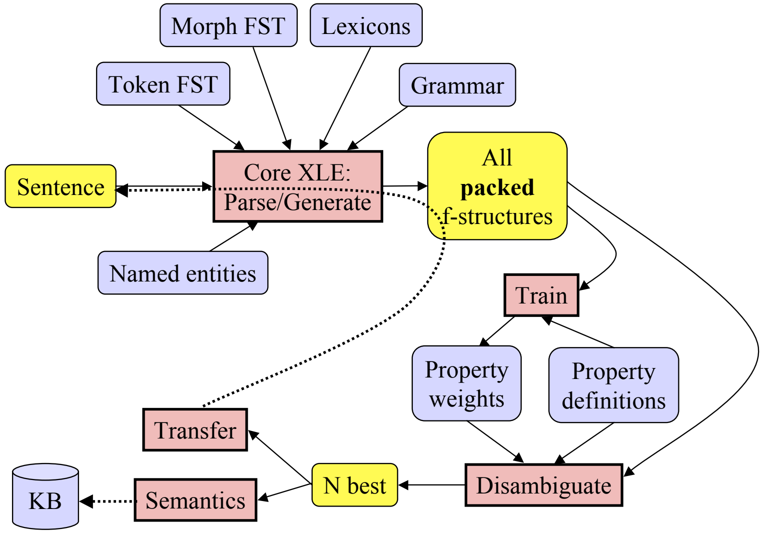
- Applications may want one input
- Use stochastic methods to choose
  – efficient (XLE English grammar: 5% of parse time)
- Need training data
  – partially labelled data ok
  [NP-SBJ They] see [NP-OBJ the girl with the telescope]

Demo
Stochastic Disambiguation

Applications — Beyond Parsing

- Machine translation
- Sentence condensation
- Computer Assisted Language Learning
- Knowledge representation

XLE related language components



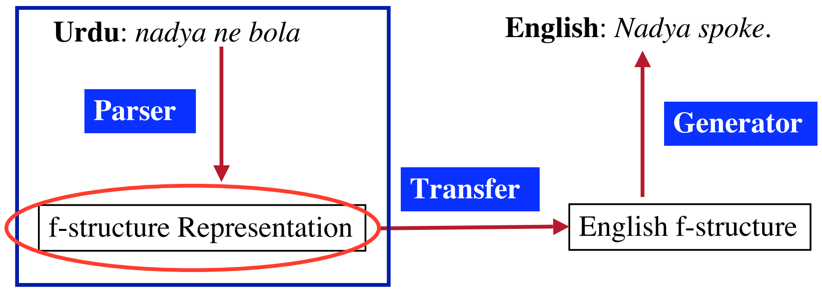
Machine Translation

- The Transfer Component
- Transferring features/F-structures
  - adding information
  - deleting information
- Examples

Basic Idea

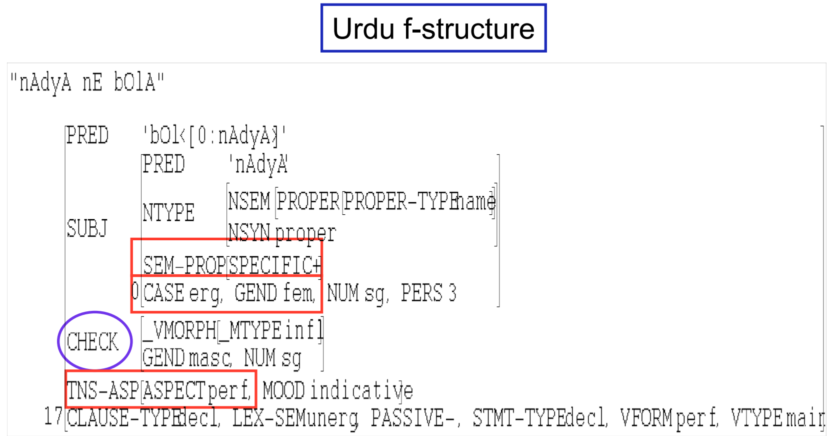
- Parse a string in the source language
- Rewrite/transfer the f-structure to that of the target language
- Generate the target string from the transferred f-structure

Urdu to English MT

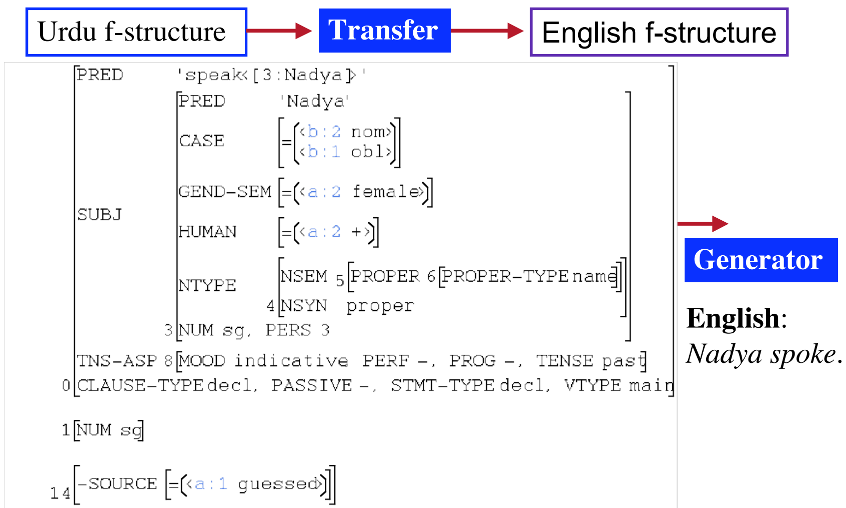


from Urdu structure …

parse: *nadya ne bola*



… to English structure



The Transfer Component

- Prolog based
- Small hand-written set of transfer rules
  - Obligatory and optional rules (possibly multiple output for single input)
  - Rules may add, delete, or change parts of *f*-structures
- Transfer operates on packed input and output
- Developer interface: Component adds new menu features to the output windows:
  - transfer this f-structure
  - translate this f-structure
  - reload rules

Sample Transfer Rules

Template

```
verb_verb(Urdu, English) ::
  pred(X, Urdu), +vtype(X,main) ==>  pred(X, English).
```

Rules

```
verb_verb(pI,drink).
verb_verb(dEkH,see).
verb_verb('A',come).
```

```
%perf plus past, get perfect past
  aspect(X,perf), +tense(X,past) ==>  perf(X,'+'), prog(X,'-').

%only perf, get past
  aspect(X,perf) ==> tense(X,past), perf(X,'-'), prog(X,'-').
```


Generation

- Use of *generator as filter* since transfer rules are independent of grammar
  - not constrained to preserve grammaticality
- Robustness techniques in generation:
  - Insertion/deletion of features to match lexicon
  - For fragmentary input from robust parser grammatical output guaranteed for separate fragments

Adding features

- English to French translation:
  - English nouns have no gender
  - French nouns need gender
  - Solution: have XLE add gender
    the French morphology will control the value
- Specify additions in configuration file (xlerc):
  - set-gen-adds add "GEND"
  - can add multiple features:
    set-gen-adds add "GEND CASE PCASE"
  - XLE will *optionally* insert the feature

Note: Unconstrained additions make generation undecidable

Example

The cat sleeps. -> Le chat dort.

```
[ PRED 'dormir<SUBJ>'
  SUBJ  [ PRED 'chat'
          NUM   sg
          SPEC  def ]
  TENSE present ]
```

```
[ PRED 'dormir<SUBJ>'
  SUBJ  [ PRED 'chat'
          NUM   sg
          GEND masc
          SPEC  def ]
  TENSE present ]
```

Deleting features

- French to English translation
  - delete the GEND feature
- Specify deletions in xlerc
  - set-gen-adds remove "GEND"
  - can remove multiple features
    set-gen-adds remove "GEND CASE PCASE"
  - XLE *obligatorily* removes the features
    no GEND feature will remain in the f-structure
  - if a feature takes an f-structure value, that f-structure is also removed

Changing values

- If values of a feature do not match between the input f-structure and the grammar:
  - delete the feature and then add it
- Example: case assignment in translation
  - set-gen-adds remove "CASE"
    set-gen-adds add "CASE"
  - allows dative case in input to become accusative
    e.g., exceptional case marking verb in input language but regular case in output language

Machine Translation

MT Demo

Sentence condensation

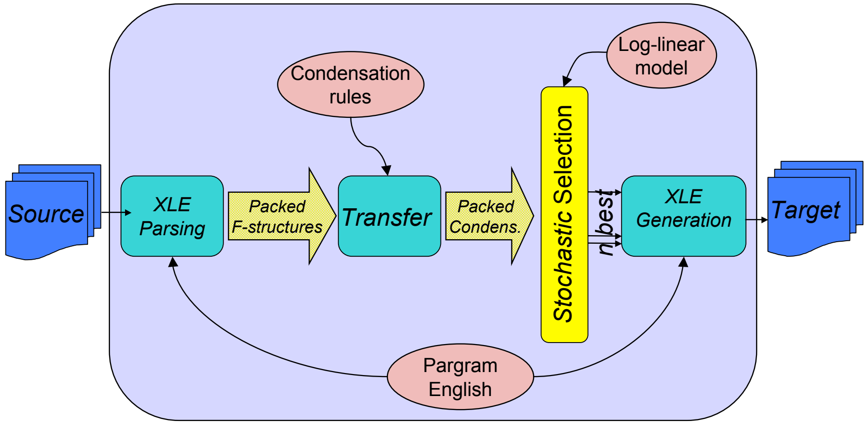
- Goal: Shrink sentences chosen for summary
- Challenges:
  1. Retain *most salient information* of input
  2. and *guarantee grammaticality* of output
- Example:
  Original uncondensed sentence
  A prototype is ready for testing, and Leary hopes to set requirements for a full system by the end of the year.

  One condensed version
  A prototype is ready for testing.

Sentence Condensation

- Use:
  - XLE's transfer component
  - generation
  - stochastic LFG parsing tools
  - ambiguity management via packed representations
- Condensation decisions made on *f-structure* instead of context-free trees or strings
- Generator guarantees grammatical well-formedness of output
- Powerful MaxEnt disambiguation model on transfer output

Condensation System



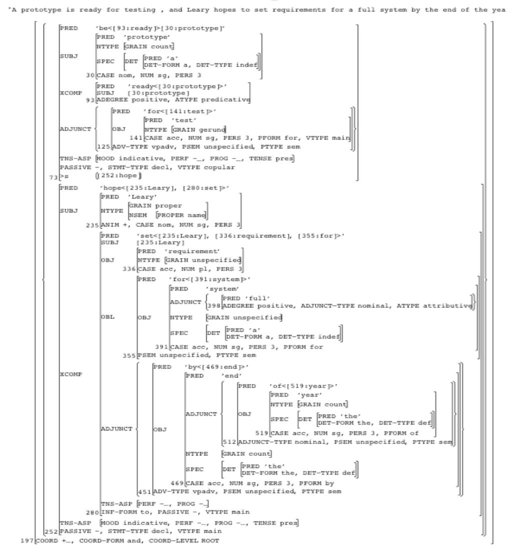
Simple combination of reusable system components

Sample Transfer Rules: sentence condensation

```
+adjunct(X,AdjSet), in-set(Adj,AdjSet),
  -adjunct_type(Adj,neg) ?=> del-node(Adj).
```

- Rule optionally removes a non-negative adjunct Adj by deleting the fact that Adj is contained within the set of adjuncts AdjSet associated with expression X.
- Rule-traces are added automatically to record relation of transfered *f*-structure to original *f*-structure for stochastic disambiguation.

One *f*-structure for Original Sentence



Packed alternatives after transfer condensation

```
PRED     'be<[93:ready]>[30:prototype]'
         PRED   'prototype'
         NTYPE  [GRAIN count]
SUBJ
         SPEC   [DET [PRED 'a'
                      DET-FORM a, DET-TYPE indef]]
       30 CASE nom, NUM sg, PERS 3
         PRED    'ready<[30:prototype]>'
XCOMP    SUBJ    [30:prototype]
       93 ADEGREE positive, ATYPE predicative
          a:1 PRED   'for<[141:test]>'
                     PRED   'test'
ADJUNCT {     OBJ    NTYPE  [GRAIN gerund]
                 141 CASE acc, NUM sg, PERS 3, PFORM for, VTYPE main
          125 ADV-TYPE [=<b:1 vp> <b:2 paren>], PSEM unspec, PTYPE sem }
TNS-ASP  [MOOD indicative, PERF -_, PROG -_, TENSE pres]
73 PASSIVE -, STMT-TYPE decl, VTYPE copular
```


Selection <a:1,b:1>

"A prototype is ready for testing."

```
PRED     'be<[93:ready]>[30:prototype]'
         PRED   'prototype'
         NTYPE  [GRAIN count]
SUBJ
         SPEC   [DET [PRED 'a'
                      DET-FORM a, DET-TYPE indef]]
       30 CASE nom, NUM sg, PERS 3
         PRED    'ready<[30:prototype]>'
XCOMP    SUBJ    [30:prototype]
       93 ADEGREE positive, ATYPE predicative
              PRED   'for<[141:test]>'
                     PRED   'test'
ADJUNCT {     OBJ    NTYPE  [GRAIN gerund]
                 141 CASE acc, NUM sg, PERS 3, PFORM for, VTYPE main
          125 ADV-TYPE vpadv, PSEM unspecified, PTYPE sem }
TNS-ASP  [MOOD indicative, PERF -_, PROG -_, TENSE pres]
73 PASSIVE -, STMT-TYPE decl, VTYPE copular
```


Selection <a:2>

"A prototype is ready."

```
PRED     'be<[93:ready]>[30:prototype]'
         PRED   'prototype'
         NTYPE  [GRAIN count]
SUBJ
         SPEC   [DET [PRED 'a'
                      DET-FORM a, DET-TYPE indef]]
       30 CASE nom, NUM sg, PERS 3
         PRED    'ready<[30:prototype]>'
XCOMP    SUBJ    [30:prototype]
       93 ADEGREE positive, ATYPE predicative
TNS-ASP  [MOOD indicative, PERF -_, PROG -_, TENSE pres]
73 PASSIVE -, STMT-TYPE decl, VTYPE copular
```


Generated condensed strings

All grammatical!

A prototype is ready.

A prototype is ready for testing.

Leary hopes to set requirements for a full system.

A prototype is ready and Leary hopes to set requirements for a full system.

A prototype is ready for testing and Leary hopes to set requirements for a full system.

Leary hopes to set requirements for a full system by the end of the year.

A prototype is ready and Leary hopes to set requirements for a full system by the end of the year.

A prototype is ready for testing and Leary hopes to set requirements for a full system by the end of the year.

Transfer Rules used in Most Probable Condensation <a:2>

- Rule-traces in order of application
  - r13: Keep of-phrases (*of the year*)
  - r161: Keep adjuncts for certain heads, specified elsewhere (*system*)
  - r1: Delete adjunct of first conjunct (*for testing*)
  - r1: Delete adjunct of second conjunct (*by the end of the year*)
  - r2: Delete (rest of) second conjunct (*Leary hopes to set requirements for a full system*),
  - r22: Delete conjunction itself (*and*).

Condensation discussion

- Ranking of system variants shows *close correlation between automatic and manual evaluation*.
- *Stochastic selection of transfer-output crucial*: 50% reduction in error rate relative to upper bound.
- *Selection of best parse for transfer-input less important*: Similar results for manual selection and transfer from all parses.
- *Compression rate around 60%:* less aggressive than human condensation, but shortest-string heuristic is worse.

Computer Assisted Language Learning (CALL) Outline

- Goals
- Method
- Augmenting the English ParGram Grammar via OT Marks
- Generating Correct Output

XLE and CALL

- Goal: Use large-scale intelligent grammars to assist in grammar checking
  - identify errors in text by language learners
  - provide feedback as to location and type of error
  - generate back correct example
- Method: Adapt English ParGram grammar to deal with errors in the learner corpus

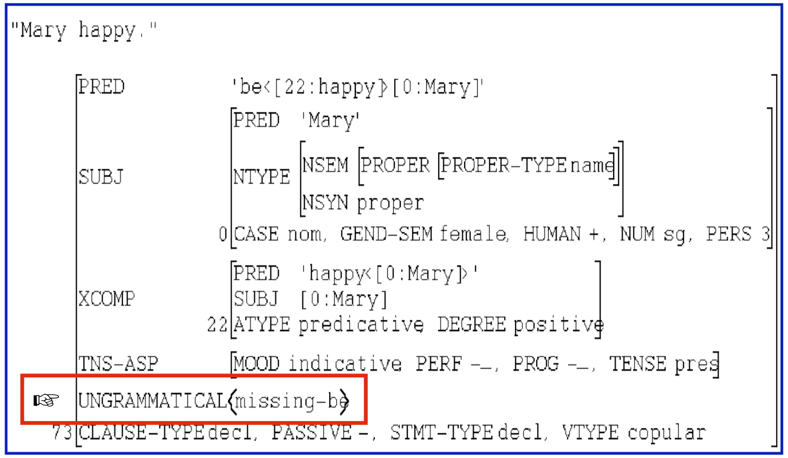
XLE CALL system method

- Grammar: Introduce special UNGRAMMATICAL feature at f-structure for feedback as to the type of error
- Parse CALL sentence
- Generate back possible corrections
- Evaluated on developed and unseen corpus
  i. accuracy of error detection
  ii. value of suggestions or possible feedback
  iii. range of language problems/errors covered
  iv. speed of operation

Adapting the English Grammar

- The standard ParGram English grammar was augmented with:
  – OT marks for ungrammatical constructions
  – Information for feedback: Example: Mary happy.
    UNGRAMMATICAL {missing-be}
    top level f-structure
- Parametrization of the generator to allow for corrections based on ungrammatical input.

F-structure: Mary happy.



Example modifications

- Missing copula (Mary happy.)
- No subj-verb agreement (The boys leaves.)
- Missing specifier on count noun (Boy leaves.)
- Missing punctuation (Mary is happy)
- Bad adverb placement (Mary quickly leaves.)
- Non-fronted wh-words (You saw who?)
- Missing *to* infinitive (I want disappear.)

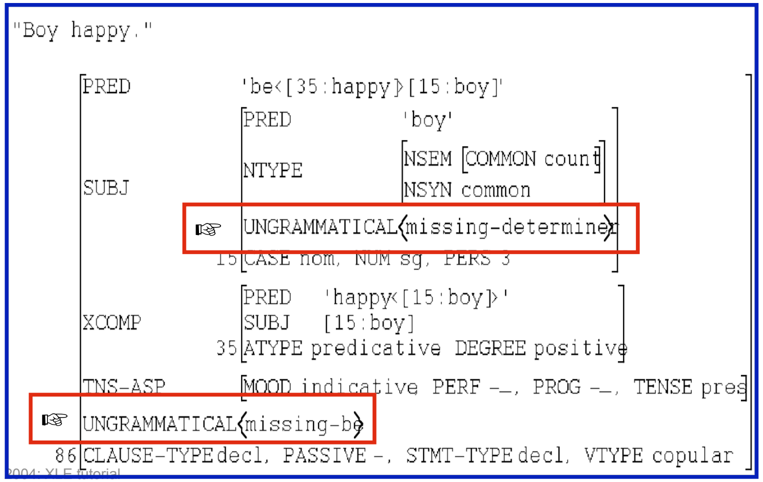
Using OT Marks

- OT marks allow one analysis to be prefered over another
- The marks are introduced in rules and lexical entries
  - @(OT-MARK ungrammatical)
- The parser is given a ranking of the marks
- Only the top ranked analyses appear

OT Marks in the CALL grammar

- A correct sentence triggers no marks
- A sentence with a known error triggers a mark ungrammatical
- A sentence with an unknown error triggers a mark fragment
- no mark < ungrammatical < fragment
  - the grammar first tries for no mark
  - then for a known error
  - then a fragment if all else fails

F-structure: Boy happy.



Generation of corrections

- Remember that XLE allows the generation of correct sentences from ungrammtical input.
- Method:
  - Parse ungrammatical sentence
  - Remove UNGRAMMATICAL feature for generation
  - Generate from stripped down ungrammatical f-structure

Underspecified Generation

- XLE generation from an underspecified f-structure (information has been removed).
- Example: generation from an f-structure without tense/aspect information.

John sleeps (w/o TNS-ASP)

→ All tense/aspect variations

```
John
 {  { will be
      |was
      |is
      |{has|had} been}
   sleeping
  |{{will have|has|had}|} slept
  |sleeps
  |will sleep}
```


CALL Generation example

- parse "Mary happy."
  generate back:
  Mary is happy.
- parse "boy arrives."
  generate back:
  { This | That | The | A } boy arrives.

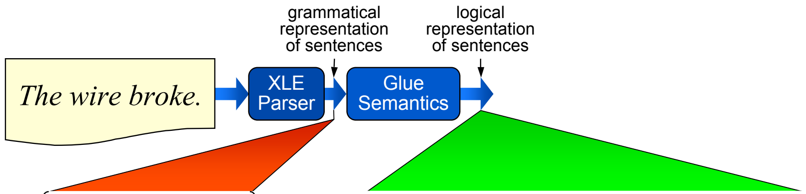
CALL evaluation and conclusions

- Preliminary Evaluation promising:
  - Word 10 out of 50=20% (bad user feedback)
  - XLE 29 out of 50=58% (better user feedback)
- Unseen real life student production
  - Word 5 out of 11 (bad user feedback)
  - XLE 6 out 11 (better user feedback)

Knowledge Representation

- From Syntax to Semantics
- From Semantics to Knowledge Representation
- Text Analysis
- Question/Answering

Glue: From Syntax to Semantics

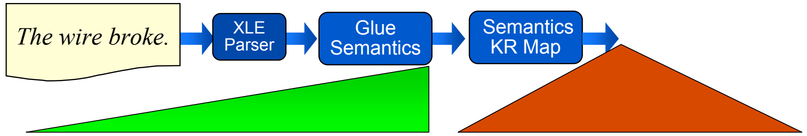


PRED	break<↑SUBJ>
SUBJ	[PRED wire, SPEC def, NUM sg]
TENSE	past

∃w. wire(w) & w=part25 &
  ∃t. interval(t) & t<now &
    ∃e. break_event(e) & occurs_during(e,t) &
      object_of_change(e,w) &
      ∃c. cause_of_change(e,c)

- Grammatical structure gives basic predicate-argument relations, but lacks additional semantic structure, such as:
  - Standard logical machinery *(variables, connectives, etc)*
  - Implicit arguments *(events, causes)*
  - Contextual dependencies *(the wire = part25)*
  - Non-syntactic ambiguities *(quantifier & modifier scope, etc)*
- Mapping systematically from language to logical form is non-trivial

From Semantics to KR



∃w. wire(w) & w=part25 &
  ∃t. interval(t) & t<now &
    ∃e. break_event(e) & occurs_during(e,t) &
      object_of_change(e,w) &
      ∃c. cause_of_change(e,c)

(isa part25 cableXeroxMachinePart)
(isa break43 DamageEvent)
(isa break43 StateChangeEvent)
(ObjectOfStateChange break43 part25)
(AgentOfStateChange break43 entity47)

- Semantics is of the traditional *"Every linguist seeks a unicorn"* variety
  - Needed to capture semantic entailment & contradiction relations
  - Reflects compositional structure of sentence (leads to expressive semantic rep'ns)
  - But unwieldy / intractable for practical knowledge representation & inference
- Mapping from semantics to KR
  - Canonicalize alternative linguistic structures to common content structures
  - Preserve semantic meanings / entailments within less expressive KRs
  - Introduce some domain/ontology knowledge *(wire is a XeroxMachinePart)*

Advancing Open Text Semantic Analysis

- Deeper, more detailed linguistic analysis
  - Functional structures, not just parse trees
  - Fully scoped, intensional semantic representations, not just predicate-argument structure.
- Canonicalization into tractable KR
  - Flat, contexted KR clauses reflecting intensional structure
  - Map alternative linguistic realizations of the same meanings onto common, canonical KR expressions
  - Employ constrained ontological reasoning to improve canonicalization
- Ambiguity enabled semantics and KR
  - Common packing mechanisms at all levels of representation
  - Avoid errors from premature disambiguation

Driving force: Entailment & Contradiction Detection (ECD)

ECD and Maintaining Text Databases

Tip 27057

Problem: Left cover damage

Cause: The left cover safety cable is breaking, allowing the left cover to pivot too far, breaking the cover.

Solution: Remove the plastic sleeve from around the cable. Cutting the plastic off of the cable makes the cable more flexible, which prevents cable breakage. Cable breakage is a major source of damage to the left cover.

Tip 27118

Problem: The current safety cable used in the 5100 Document Handler fails prematurely causing the Left Document Handler Cover to break.

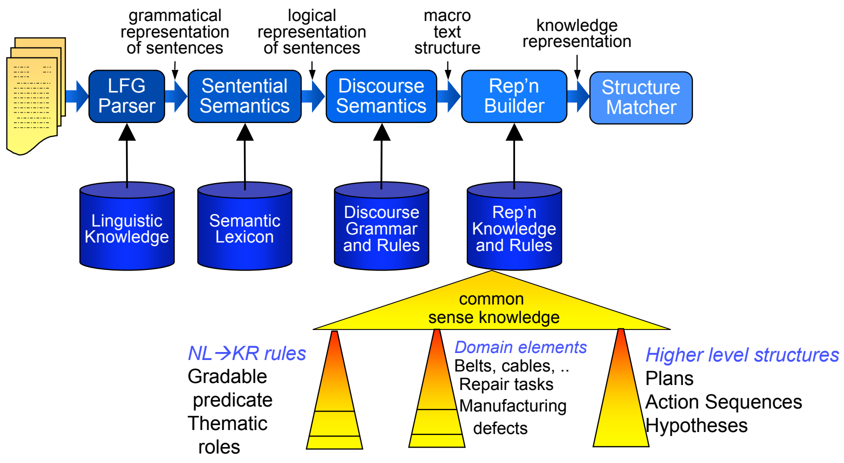
Cause: The plastic jacket made the cable too stiff. This causes stress to be concentrated on the cable ends, where it eventually fails.

Solution: When the old safety cable fails, replace it with the new one [12K1981], which has the plastic jacket shortened.

Maintain quality of text database by identifying areas of redundancy and conflict between documents

Deep, canonical, ambiguity-enabled semantic processing is needed to detect entailments & contradictions like these.

Architecture for Document ECD



Entailment, Contradiction & QA

- ECD is a necessary (but not sufficient) condition for language understanding
- ECD improves with increasing world & domain knowledge
  - But many EC relations derivable from purely linguistic knowledge
- QA can (conceptually) be viewed as ECD
  - Answers entail or contradict declarative content of question
    - » Human interpreter of text snippets currently has to decide which
- Yes/No QA: a more direct application of ECD
  - Automatically identify positive and negative answers to yes/no questions, e.g.
    - » *Is sickle cell anemia related to S-trait hemaglobin?*
      YES: …..
      NO: ….

XLE: Overall Conclusions

- Grammar engineering makes deep grammars feasible
  - robustness techniques
  - integration of shallow methods
- Many current applications can use shallow grammars
- Fast, accurate, broad-coverage deep grammars enable new applications

Contact information

- Miriam Butt
  miriam.butt@uni-konstanz.de
  http://ling.uni-konstanz.de/pages/home/butt
- Tracy Holloway King
  thking@parc.com
  http://www.parc.com/thking

- Many of the publications in the bibliography are available from our websites.
- Information about XLE:
  http://www.parc.com/istl/groups/nltt/xle/default.html

Bibliography

Butt, M., T.H. King, M.-E. Niño, and F. Segond. 1999. *A Grammar Writer's Cookbook*. Stanford University: CSLI Publications.

Butt, Miriam and Tracy Holloway King. 2003. Grammar Writing, Testing, and Evaluation. In A. Farghaly (ed.) *Handbook for Language Engineers*. CSLI Publications. pp. 129-179.

Butt, M., M. Forst, T.H. King, and J. Kuhn. 2003. The Feature Space in Parallel Grammar Writing. *ESSLLI 2003 Workshop on Ideas and Strategies for Multilingual Grammar Development*.

Butt, M., H. Dyvik, T.H. King, H. Masuichi, and C. Rohrer. 2002. The Parallel Grammar Project. *Proceedings of COLING2002, Workshop on Grammar Engineering and Evaluation* pp. 1-7.

Butt, M., T.H. King, and J. Maxwell. 2003. Productive encoding of Urdu complex predicates in the ParGram Project. In *Proceedings of the EACL03: Workshop on Computational Linguistics for South Asian Languages: Expanding Synergies with Europe*. pp. 9-13.

Butt, M. and T.H. King. 2003. Complex Predicates via Restriction. In *Proceedings of the LFG03 Conference*. CSLI On-line Publications. pp. 92-104.

Frank, A., T.H. King, J. Kuhn, and J. Maxwell. 1998. Optimality Theory Style Constraint Ranking in Large-Scale LFG Grammars *Proceedings of the LFG98 Conference*. CSLI Publications.

Kaplan, R., T.H. King, and J. Maxwell. 2002. Adapting Existing Grammars: The XLE Experience. *Proceedings of COLING2002, Workshop on Grammar Engineering and Evaluation,* pp. 29-35.

Kaplan, Ronald M. and Jürgen Wedekind. 2000. LFG generation produces context-free languages. In *Proceedings of the 18th International Conference on Computational Linguistics (COLING2000), Saarbrücken*.

Kaplan, R.M., S. Riezler, T. H. King, J. T. Maxwell III, A. Vasserman, R. Crouch. 2004. Speed and Accuracy in Shallow and Deep Stochastic Parsing. In *Proceedings of the Human Language Technology Conference and the 4th Annual Meeting of the North American Chapter of the Association for Computational Linguistics (HLT-NAACL'04), Boston, MA.*

Kaplan, R. M. and P. Newman. 1997. Lexical resource reconciliation in the Xerox Linguistic Environment. In *Computational environments for grammar development and linguistic engineering*, pp. 54-61. Proceedings of a workshop sponsored by the Association for Computational Linguistics, Madrid, Spain, July 1997.

Kaplan, R. M., K. Netter, J. Wedekind, and A. Zaenen. 1989. Translation by structural correspondences. In *Proceedings of the 4th Meeting of the EACL*, pp. 272-281. University of Manchester: European Chapter of the Association for Computational Linguistics. Reprinted in Dalrymple et al. (editors), *Formal Issues in Lexical-Functional Grammar*. CSLI, 1995.

Karttunen, L. and K. R. Beesley. 2003. *Finite-State Morphology*. CSLI Publications.

Kay, M. 1996. Chart Generation. *Proceedings of the ACL* 1996, 200-204.

Khader, R. 2003. *Evaluation of an English LFG-based Grammar as Error Checker*. UMIST MSc Thesis, Manchester.

Kim, R., M. Dalrymple, R. Kaplan, T.H. King, H. Masuichi, and T. Ohkuma. 2003. Multilingual Grammar Development via Grammar Porting. *ESSLLI 2003 Workshop on Ideas and Strategies for Multilingual Grammar Development*.

King, T.H. and R. Kaplan. 2003. Low-Level Mark-Up and Large-scale LFG Grammar Processing. *On-line Proceedings of the LFG03 Conference*.

King, T.H., S. Dipper, A. Frank, J. Kuhn, and J. Maxwell. 2000. Ambiguity Management in Grammar Writing. *Linguistic Theory and Grammar Implementation*Workshop at European Summer School in Logic, Language, and Information (ESSLLI-2000).

Masuichi, H., T. Ohkuma, H. Yoshimura and Y. Harada. 2003. Japanese parser on the basis of the Lexical-Functional Grammar Formalism and its Evaluation, *Proceedings of The 17th Pacific Asia Conference on Language, Information and Computation* (PACLIC17), pp. 298-309.

Maxwell, J. T., III and R. M. Kaplan. 1989. An overview of disjunctive constraint satisfaction. In *Proceedings of the International Workshop on Parsing Technologies*, pp. 18-27. Also published as `A Method for Disjunctive Constraint Satisfaction', M. Tomita, editor, *Current Issues in Parsing Technology*, Kluwer Academic Publishers, 1991.

Riezler, S., T.H. King, R. Kaplan, D. Crouch, J. Maxwell, and M. Johnson. 2002. Parsing the Wall Street Journal using a Lexical-Functional Grammar and Discriminative Estimation Techniques. *Proceedings of the Annual Meeting of the Association for Computational Linguistics, University of Pennsylvania*.

Riezler, S., T.H. King, R. Crouch, and A. Zaenen. 2003. Statistical sentence condensation using ambiguity packing and stochastic disambiguation methods for Lexical-Functional Grammar. *Proceedings of the Human Language Technology Conference and the 3rd Meeting of the North A merican Chapter of the Association for Computational Linguistics (HLT-NAACL'03)*.

Shemtov, H. 1996. Generation of Paraphrases from Ambiguous Logical Forms. *Proceedings of COLING* 1996, 919-924.

Shemtov, H. 1997. *Ambiguity Management in Natural Language Generation.* PhD thesis, Stanford University.