

# Designing Abstract Meaning Representations for Machine Translation

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July 11, 2014

2014 JHU/CLSP Fred Jelinek Memorial PIRE Workshop

# What is meaning?

... just piling up words, one after the other, won't do much of anything until something else has been added.

*Stanley Fish, How to Write a Sentence, 2011*

- *And the words slide into the slots ordained by syntax, and glitter as with atmospheric dust with those impurities which we call meaning.*

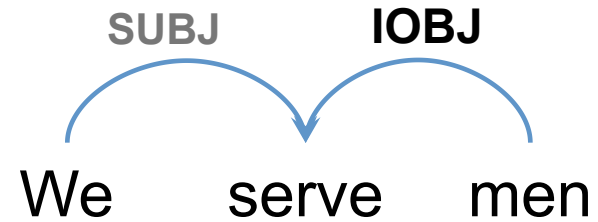
*Anthony Burgess, Enderby Outside, 1968*

# How do we sprinkle atmospheric dust?

- Some of the challenges
- AMR
- Challenges it addresses
- Challenges it doesn't

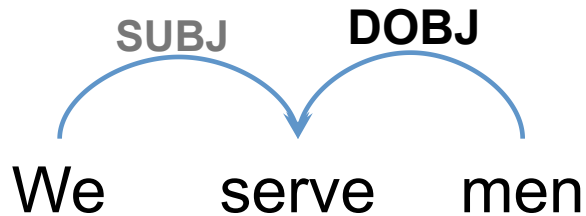
# Challenges

- Sense distinctions
- Semantic similarity
- World knowledge
- Metaphors
- Constructions
- Coercion, metonymy, implicit arguments, ...



We serve food to men.  
We serve our community.  
serve —IndirectObject→ men

## Sense Distinctions



We serve organic food.  
We serve coffee to connoisseurs.  
serve —DirectObject→ men



# Sense distinctions

## MT can already handle

Iraq lost the battle.

*Ilakuka centwey ciessta.*

[Iraq] [battle] [lost].

John lost his computer.

*John-i computer-lul ilepelyessta.*

[John] [computer] [misplaced].

# Sense Distinctions AMR makes

- call.02 *He calls me every day at 8am and 5pm.*
- call.03 *Secretary of State Baker , in a foreign policy speech , called for the reunification of Germany.*
- AMR makes the same distinctions PropBank makes.

# Trickier distinctions...

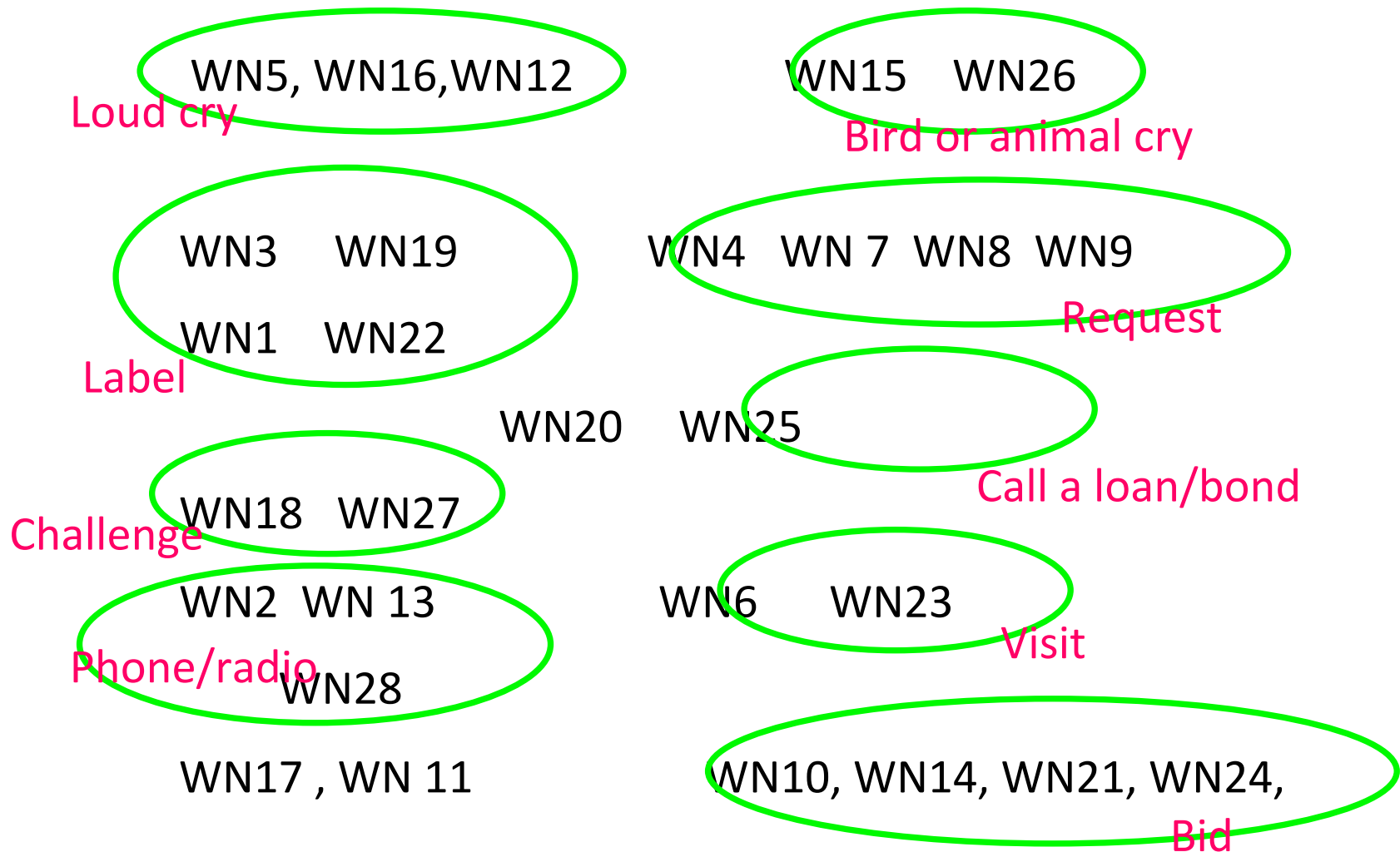
- *take-vpc-v*
  - take.11: *obtain* (“take out a pencil, take out an ad”)
  - **take.26: *project anger*** (“take it out on her”)
  - take.27: *kill* (“take out the enemy”)
  - take.28: *vacation* (“take out a year”)
- *take* has 256 multi-word expressions
- WordNet verb senses - ~65% accuracy



# 39 more MWE's

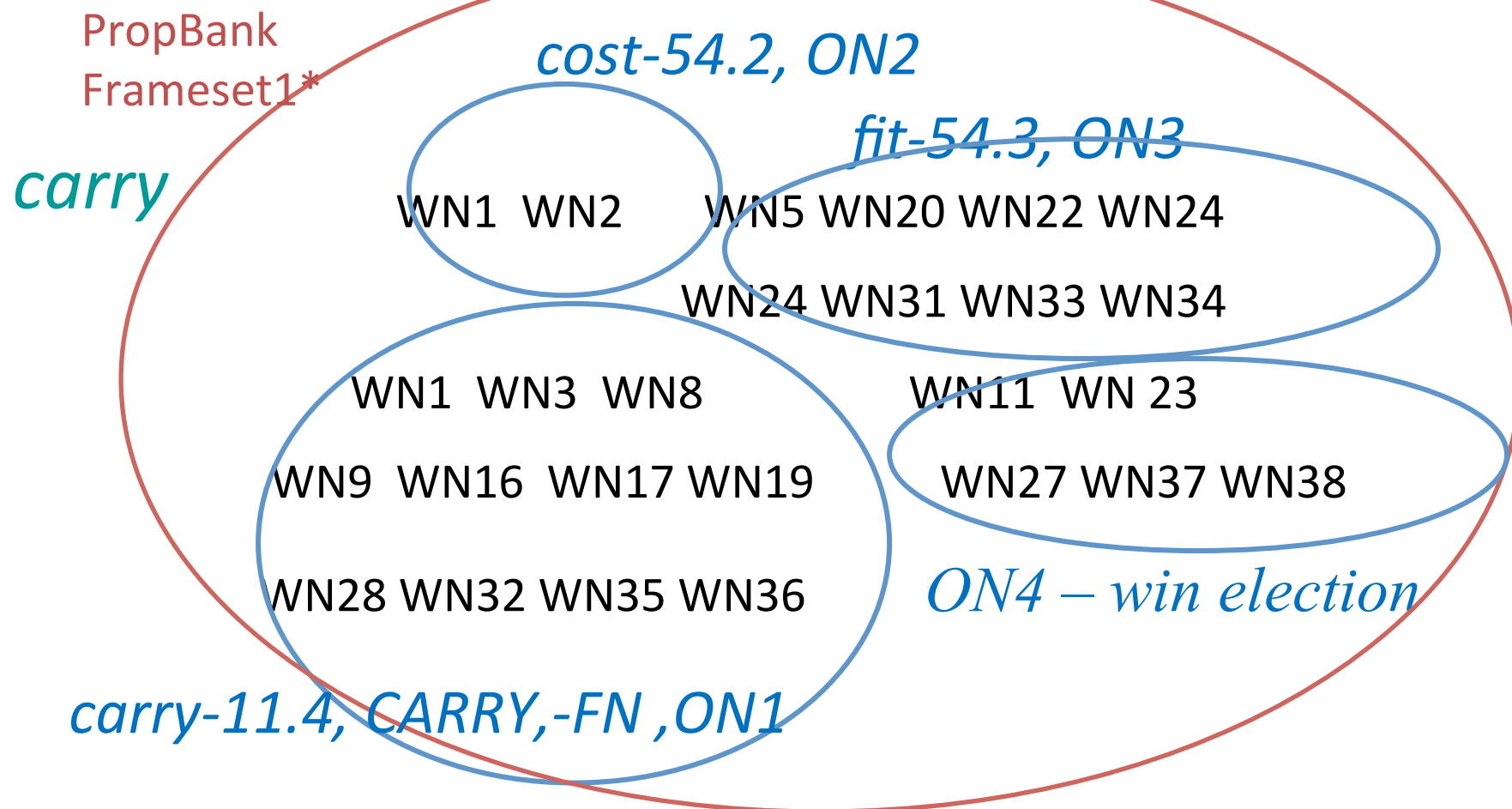
- TAKE A CHILL  
TAKE A HIT  
TAKE A POWDER  
TAKE ABACK  
TAKE ADVANTAGE  
TAKE AFTER  
TAKE BACK  
TAKE CARE  
TAKE DOWN  
TAKE FOR GRANTED  
TAKE HOME  
TAKE IN VAIN  
TAKE IN CHARGE  
TAKE ISSUE  
TAKE IT EASY  
TAKE ITS/HIS/HER TOLL

# WordNet: - call, 28 senses, 9 groups



# SEMLINK-PropBank, VerbNet, FrameNet, WordNet, OntoNotes

*Palmer, Dang & Fellbaum, NLE 2000*



*\*ON5-ON11 carry oneself, carried away/out/off, carry to term*

# Sense Hierarchy

- PropBank Framesets – ITA >90%  
coarse grained distinctions  
20 Senseval2 verbs w/ > 1 Frameset  
Maxent WSD system, 73.5% baseline, 90%
- Sense Groups (Senseval-2/OntoNotes) - ITA 89%  
Intermediate level  
(includes Verbnet/some FrameNet) – SVM, 88+%
- WordNet – ITA 73%  
fine grained distinctions, 64%

*Dligach & Palmer, ACL2011*

# SEMLINK

- Extended VerbNet: 6,340 senses
  - 92% PB tokens (8114 verb senses/12,646 all)
- Type-type mapping PB/VN, VN/FN, VN/WN
- Semi-automatic mapping of WSJ PropBank instances to VerbNet classes and thematic roles, hand-corrected. (*now FrameNet also*)
- VerbNet class tagging as automatic WSD

*Brown, Dligach, Palmer, IWCS 2011; Croce, et. al., ACL2012*
- Run SRL, map Arg2 to VerbNet roles, Brown performance improves

*Yi, Loper, Palmer, NAACL07*

# AMR development

- ISI, Colorado, LDC, SDL
  - creating large-scale semantics bank
- Simple structures, like PTB
- Goal is supporting research in:
  - semantic parsing
  - natural language generation
  - machine translation

## Meaning-based MT



- What content goes into the meaning representation?
  - Linguistic annotation

today's focus

A yellow rectangular box with a black arrow pointing to the left, towards the 'Linguistic annotation' sub-point of the list.

# Semantic Representation

## LOGICAL FORM

$\exists w, b, g : \text{instance}(w, \text{WANT}) \wedge$   
 $\text{instance}(g, \text{GO}) \wedge$   
 $\text{instance}(b, \text{BOY}) \wedge$   
 $\text{agent}(w, b) \wedge$   
 $\text{patient}(w, g) \wedge$   
 $\text{agent}(g, b)$

"The boy wants to go."

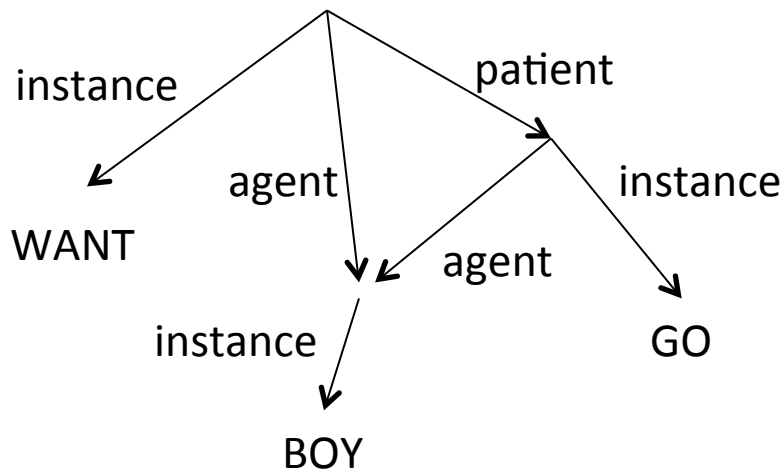
## PENMAN

$(w / \text{WANT}$   
 $\quad : \text{agent } (b / \text{BOY})$   
 $\quad : \text{patient } (g / \text{GO}$   
 $\quad \quad : \text{agent } b)))$

## PATH EQUATIONS

$((x0 \text{ instance}) = \text{WANT})$   
 $((x1 \text{ instance}) = \text{BOY})$   
 $((x2 \text{ instance}) = \text{GO})$   
 $((x0 \text{ agent}) = x1)$   
 $((x0 \text{ patient}) = x2)$   
 $((x2 \text{ agent}) = x1)$

## DIRECTED ACYCLIC GRAPH



## FEATURE STRUCTURE

$\left( \begin{array}{l} \text{instance: WANT} \\ \text{agent: } \boxed{1} \left( \text{instance: BOY} \right) \\ \text{patient: } \left( \begin{array}{l} \text{instance: GO} \\ \text{agent: } \boxed{1} \end{array} \right) \end{array} \right)$



# Semantic Representation

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"The boy wants to go."

PE human friendly  
(AMR)

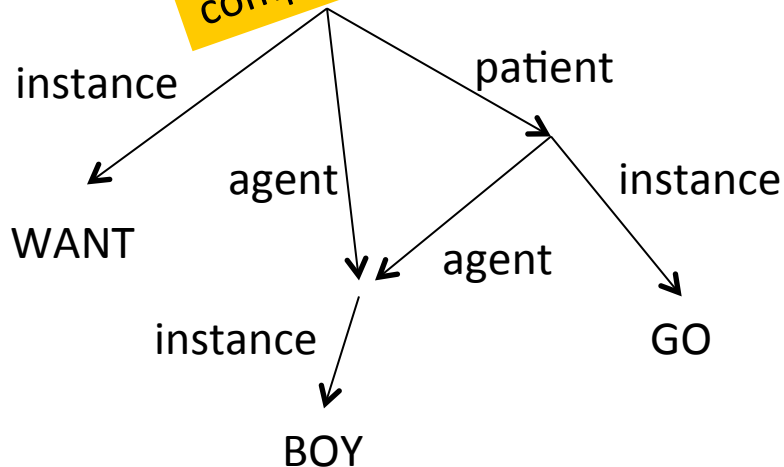
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 $((x0 \text{ patient}) = x2)$   
 $((x2 \text{ agent}) = x1)$

## DIRECTED ACYC

computer friendly



## FEATURE STRUCTURE

instance: WANT  
 agent: 1 { instance: BOY }  
 patient: { instance: GO }  
 agent: 1

# Abstract Meaning Representation (AMR)

- How to represent the meanings of sentences?
  - Which concepts and relations?
  - How to put them together?
- 
- First guidelines released April 24, 2012
  - 100 sentences from WSJ
  - 244 sentences from webtext, 80 with consensus agreement
  - The Little Prince, etc.

# Abstract Meaning Representation (AMR)

- Basic “who-is-doing-what-to-whom”
- Cover all sentence content in single, rooted structure
- Builds upon PropBank
  - Uses PB rolesets: e.g. describe.01
    - Arg0: describer
    - Arg1: thing described
    - Arg2: secondary attribute, described-as
  - <http://verbs.colorado.edu/propbank/framesets-english/>
  - Uses existing PB annotations as “dummy elements”

# Abstract Meaning Representation (AMR)

- AMR composed of concepts and relations, not nouns and verbs
  - Currently ~100 relations, plus inverses
- AMR is not enslaved to syntax, or even mildly indentured:

He described her as a genius.	(d / describe-01
As he described her, she is a genius.	:ARG0 (h / he)
His description of her: a genius.	:ARG1 (s / she)
	:ARG2 (g / genius))

# AMR vs. PB

He described her as a genius.	(d / describe-01
As he described her, she is a genius.	:ARG0 (h / he)
His description of her: a genius.	:ARG1 (s / she)
	:ARG2 (g / genius))

Describe-01: same

Be-01: she-ARG1, genius-ARG2, as he described her-ADV

Description: same

# Single rooted structures

(s / see-01

:ARG0 (b / boy)

:ARG1 (g / girl

:ARG0-of (w / want-01

:ARG1 b)))

- *The boy saw the girl who wanted him.*
- *The boy saw the girl who he was wanted by.*
- *The girl who wanted the boy was seen by him.*

# Abstract Meaning Representation (AMR)

- There are no verbs in AMR!
- Also, there are no nouns in AMR
- A couple more points:
  - there are no adjectives in AMR
  - or adverbs
  - or affixes
- And, there are no zero pronouns
- Or auxiliary verbs (or prepositions, etc.)

# Maximal Use of PropBank Frame Files

He was not aware of research on smokers of the Kent cigarettes.

```
(r / realize-01
  :polarity -
  :ARG0 (h / he)
  :ARG1 (r3 / research-01
    :ARG1 (p4 / person
      :ARG0-of (s / smoke-02
        :ARG1 (c2 / cigarette
          :name (k / name
            :op1 "Kent"))))))))
```

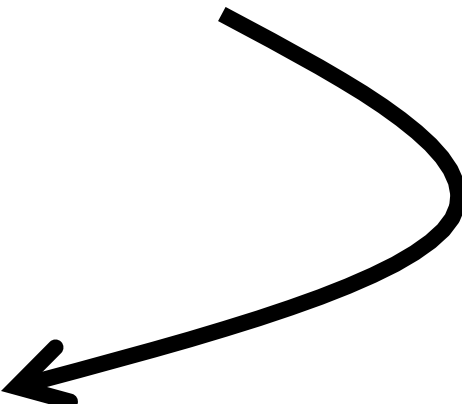
To get to canonical concept, we stem to English verbs,  
where PropBank arguments are best described.

General direction of stemming:

adverb → adjective → noun → verb



“John could not have heard about the professor’s creation of the microbial viruses that Mary sold to Russia yesterday.”



```
(p2 / possible
  :polarity -
  :domain (h / hear-01
    :ARG0 (p / person
      :name (n / name :op1 "John"))
    :ARG1 (c / create-01
      :ARG0 (p3 / professor)
      :ARG1 (v / virus
        :mod (m / microbe)
        :ARG1-of (s / sell-01
          :ARG0 (p4 / person
            :name (n2 / name :op1 "Mary"))
          :ARG2 (c2 / country
            :name (n3 / name :op1 "Russia"))
          :time (y / yesterday))))))
```

# How is it really different from PropBank?

- LOTS of additional relations/concepts in addition to numbered args, modifier tags of PB (types of ArgM's):
  - **General semantic roles:** :accompanier :age :beneficiary :cause :compared-to :concession :condition :consist-of :degree :destination :direction :domain :duration :employed-by :example :extent :frequency :instrument :li :location :manner :mod :mode :name :part :path :polarity :poss :purpose :source :subevent :subset :time :topic :value
  - **Quantities:** :quant :unit :scale
  - **Date-entity:** :day :month :year :weekday :time :timezone :quarter :dayperiod :season :decade :century :calendar :era :mod
  - **Ops:** :op1 :op2 :op3 :op4...

# How is it really different from PropBank?

- Numbered Args, + ArgMs:
  - COM: Comitative
  - LOC: Locative
  - DIR: Directional
  - GOL: Goal
  - MNR: Manner
  - TMP: Temporal
  - EXT: Extent
  - REC: Reciprocals
  - PRD: Secondary Predication
  - PRP: Purpose
  - CAU: Cause
  - DIS: Discourse
  - ADV: Adverbials
  - ADJ: Adjectival
  - MOD: Modal
  - NEG: Negation
  - DSP: Direct Speech

# How is it really different from PropBank?

- Introduction of additional discourse elements:
  - *But* = contrast: “The House has voted to raise the ceiling to \$ 3.1 trillion , **but** the Senate isn't expected to act until next week at the earliest.”
  - *Even though* = concession: “Workers described ‘clouds of blue dust’ that hung over parts of the factory, **even though** exhaust fans ventilated the area.”
- Differs from PDTB in that currently no annotation is done across sentences – PDTB is primarily discourse relations across sentences

# How is it really different from PropBank?

- It enriches PB annotations by providing more structuring of noun phrases, prepositional phrases, intra-sentential coreference and discourse relations
- It collapses many ways of saying the same thing, making much more extensive use of PropBank predicates.
- It provides an interpretation for negation and modality instead of just marking them as PropBank does.

# How is it really different from PropBank? Metonymy?

## When to do it?

- Introduction of understood, but not explicitly mentioned concepts:  
*Gas could go to \$ 10 a gallon*

(p / possible

:domain (g / go

:ARG1 (t / **thing**

:ARG2-of (p2 / **price-01**

:ARG1 (g4 / gas

:quant (v2 / volume-quantity

:unit (g5 / gallon)

:quant 1))))

:ARG4 (m2 / monetary-quantity

:unit (d2 / dollar)

:quant 10)))

# PropBank of Today

- PropBank has recently added many aspects of annotation that enrich semantics, moving away from language-particular syntactic facts
- Noun annotation
  - Eventive nouns: *destruction, escape*
  - Stative nouns: *fault, love*

# PB in comparison to AMR

- Similarly to PropBank, it isn't confounded by syntactic idiosyncrasies, function words, and light verb constructions.
- (“issue a warning” → warn-01)



# PropBank of Today

- Light Verb Construction Annotation
  - *Do an investigation, have a seat, make an offer, take a walk, give a sigh*
  - Previous treatments annotated these as if verb projected semantics, thematic roles
  - Light verb identified in verb annotation, marked as *LV*, noun predicate as PRR (predicating relation)
  - Noun predicate annotated in noun pass of annotation
  - Syntactic spans of both noun, verb are annotated
  - Both noun and verb are marked as complex relation

# PropBank Annotation of LVCs

*Hwang, et. al., LAW 2010 (ACL-10)*

Framefile Creation

Frame-files

Pass 1

Annotation of the **light verb** and the predicating expression

Pass 2

Annotation of the sentence with the **true predicate** as REL

Pass 3  
Automatic Pass

Arguments and the modifiers of the two previous passes are reconciled and merged into a single annotation.

# English Noun and LVC annotation

- Example Noun: *Decision*
  - Roleset: Arg0: decider, Arg1: decision...
  - “[...[**your**<sub>ARG0</sub>] [decision<sub>REL</sub>]  
[to say look I don't want to go through this anymore<sub>ARG1</sub>]]”
- Example within an LVC: *Make a decision*
  - “[...[**the President**<sub>ARG0</sub>] [made<sub>REL-LVB</sub>      PASS 1  
[**the fundamentally correct  
decision to get on offense**<sub>ARG-PRX</sub>]]”

# English Noun and LVC annotation

- Example Noun: *Decision*
  - Roleset: Arg0: decider, Arg1: decision...
  - “[your<sub>ARG0</sub>] [decision<sub>REL</sub>]  
[to say look I don't want to go through this anymore<sub>ARG1</sub>]”
- Example within an LVC: *Make a decision*
  - “[the President<sub>ARG0</sub>] [made<sub>REL-LVB</sub>] PASS 2  
the [fundamentally correct<sub>ARGM-ADJ</sub>]  
[decision<sub>REL</sub>] [to get on offense<sub>ARG1</sub>]”

# Current PropBank LVC definition

*English Light Verb Constructions: Form, Function and Productivity*

Claire Bonial

- English LVCS:
- High agreement rates between annotators for PropBank annotations
  - For corpus of likely light verbs (*give, have, take, make, do*), **93.8% ITA**
  - 14% of 3K instances were LVC's

# Issues: Distinguishing LVCs from heavy usages

- Several verbs seem to participate in complex predication but contribute at varying levels to semantics:
  - light: *produce an alteration* ‘alter’
  - light: *issue a complaint* ‘complain’
  - heavy: *register a complaint*
- English LVC’s don’t always have verbal counterparts
  - *make an exception*
  - *give an ovation*

# Accuracy & Agreement

- AMR uses the *smatch* metric to calculate agreement rates against consensus AMR annotations
- 4 annotators provided AMRs for all 180 adjudicated sentences (100 wsj, 80 webtext)
- average *smatch* agreement rates with consensus AMRs were 0.83 (wsj) and 0.73 (webtext)
- PB IAA generally between 92-98%

# Summarizing

- Similar to a very general labeled dependency tree w/out function words, where many nouns/adjectives have been given predicate-argument structures, with wikified NE's, abstract relations for discourse connectives, and “some” implicit arguments/relations AND coref – makes it a graph.
- Etymologically related paraphrases “fear.v/fear.n/afraid.adj/” are aliases for “fear” and get the same representation
- Travel/take a trip?
- Desire/want?
- Automatic clustering?



## A detailed example – what would we like for Deep NLU?

- *“Saucedo said that guerrillas in one car opened fire on police standing guard, while a second car carrying 88 pounds (40 kgs) of dynamite parked in front of the building, and a third car rushed the attackers away.”*
- *Saucedo said* – reporting event, evidential

# What would we like?

- *that guerrillas in one car opened fire on police standing guard*
- *opened fire* = aspectual context,
  - fire(guerillas, police)
- *standing guard* = support verb construction or aspectual?, reduced relative
  - guard(police, X)

# What would we like?

- *while a second car carrying 88 pounds (40 kgs) of dynamite parked in front of the building*
- *carrying* - reduced relative, correct head noun – pounds or dynamite?
  - carry(car2, dynamite)
- park(**car2**, front\_of(building))

# What we would like

- *and a third car rushed the attackers away*
- `rush(car3, attackers, away)`

# Not All Participants are Mentioned

- Instrument involved in the event
  - John left for D.C. ([plane/car/train?](#))
  - Mary wrote to her Mom ([pen/computer](#))
- Results of the activity
  - She translated the email. ([the translated mail](#))
- Complex Result of an event
  - He took Mass Ave to Park, and then east on Rt. 2.
  - Bill went [the same way](#).
- Entity presupposed by the expression
  - Mary shoveled the sidewalk. ([snow?](#))

# Implicit arguments

- *that guerrillas in one car opened fire on police standing guard*
- *opened fire* = aspectual context,
  - fire(guerillas, police)
- *standing guard* = support verb construction or aspectual?, reduced relative
  - guard(police, X)

# Implicit arguments

- *while a second car carrying 88 pounds (40 kgs) of dynamite parked in front of the building*
- `park(car2, front_of(building))`
- `park(drivers, car, front_of(building))`

# Coreference?

- “Saucedo said that *guerrillas* in one car opened fire on police standing guard, while a second car carrying 88 pounds (40 kgs) of dynamite parked in front of the building, and a third car rushed the *attackers* away.”
  - [guerrillas, driver] – [attackers]



(s / say-01

:ARG0 (p / person :name (n / name :op1 "Saucedo"))

:ARG1 (f / fire-01

:ARG0 (g2 / guerilla

:location (c2 / car :quant 1))

:direction (p2 / police

:ARG0-of (g / guard-01))

:time (a / and

:op1 (p3 / park-01

:ARG1 (c / car

:ord (o / ordinal-entity :value 2)

:ARG0-of (c3 / carry-01

:ARG1 (d / dynamite

:quant (m / mass-quantity :quant 88

:unit (p4 / pound))))))

:ARG2 (f2 / front

:op1 (b / building)))

:op2 (r / rush-01

:ARG0 (c4 / car

:ord (o2 / ordinal-entity :value 3))

:ARG1 (p5 / person

:ARG0-of (a2 / attack-01)

:ARG2-of (i / include-91

:ARG1 g2))

:ARG2 (a3 / away))))))

# Challenges AMR doesn't address

# Semantic similarity

*Stock prices rose precipitously.*

*The stock market leapt ahead.*

- Rise can refer to an increase of a scalar value
- Leaping ahead can metaphorically do the same.
- Stock market comprises stocks with prices.
- Metaphor, world knowledge, ...

# Jena Hwang – *Adapting to New Usages: Incorporating Constructions into VerbNet*

- Why constructions?

“They threw him out of the university”

*Ellos le echaron fuera de la universidad.*

- They *threw* him out of the university.
- They *hissed* him out of the university.

*Le silbó fuera de la universidad.*

“They whistled to him outside the university”

# New usages

- *Not all yarn frogs easily.*

# Metaphors

- *The curtain fell on the diva. (descend)*
- *His cigarette ash fell on the diva's skirt.*
- *By the time the Iron Curtain fell in 1989, differences ran deep indeed.*

# Tool Demo

- AMR Editor
  - <http://www.isi.edu/~ulf/amr/AMR-editor.html>
  - Tutorial sentences

# Aligning parallel corpora

- Subtrees of dependency parses of parallel English/Chinese corpora only have isomorphic matches about 30% of the time.
  - Yuan Ding, Thesis, 2005
- Parallel PropBank structures match almost 60%.
  - Wu & Palmer, SSST, 2011
- What about AMR's? Will they align even more?
  - Xue, Bojar, Hajič, Palmer, Urešová, Zhang, LREC 2014



# MATRIX Questions

## *Meaning in AMR's and Tectogrammatical Representation **Interchange***

- How distant/similar are AMR's and the Tectogrammatical Representation for English? Can we port the TR MT system to AMR's?
- How distant/similar are English AMR's, Chinese, and Czech AMR's?
- Which differences have the most impact on the graph matching?
- How much can deterministic reformatting of AMR's bridge the distances?

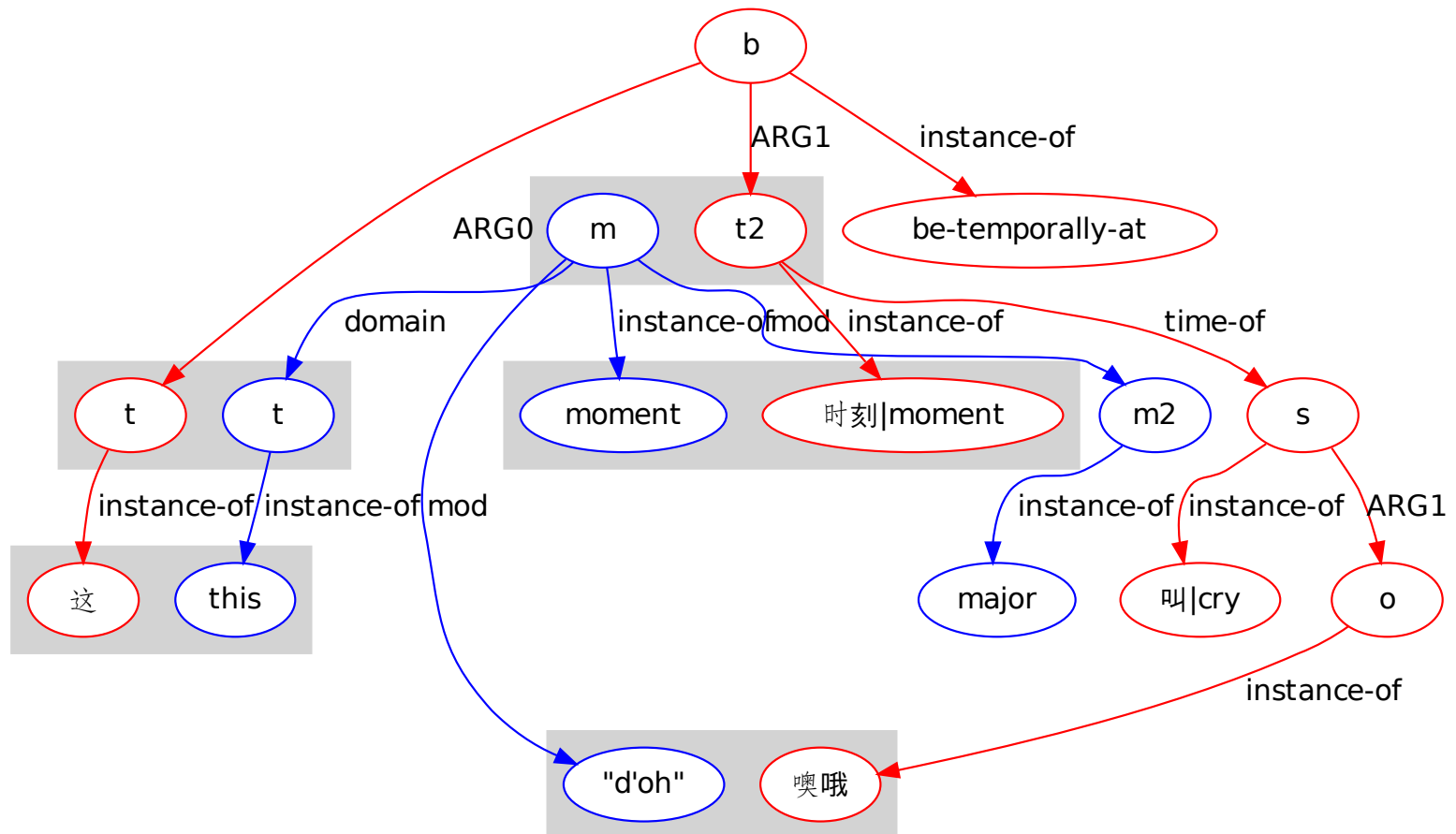
# Preparatory Efforts

- English, Chinese, and Czech AMR's of the same 100 sentences and their translations.
- A preliminary mapping from TR to AMR.
- Given a 1M word WSJ English corpus with parallel Czech translations, both in TR
  - And automatically produced AMR's (from OntoNotes, thanks to Ulf Hermjakob) for the same data

# Differences in Lexicalization and Annotation Choice

这是一个大叫“噢哦！”的时刻。

This is a major ``D'oh! " moment .



# Annotation Choice Differences

- Annotation choice
  - To reify or not to reify?
- Chinese: reifies “be\_temporally\_located\_at”
- English drops “be” and puts “this” as the :domain of “moment”:
  - (m / moment
    - :mod (m2 / major)
    - :domain (t / this)
    - :mod (d / d'oh :mode expressive))

# Alternatives Annotation Choices for English

- English could just as easily reify “is moment” as *temporal\_location.01*
  - (t / temporal\_location.01
    - :Arg1 (t2 / this)
    - :mod (m / major)
    - :mod (d / d'oh :mode expressive))
- English and Chinese would match more closely
- How often is this the case?

# Lexicalization differences

- Language specific lexicalization differences
- Simply different word choices
  - “major” vs. **major** / **cry**
- Often a single lexical item in one language is a multi-word expression elsewhere, w/ structure
  - “tells the tale” vs. **popsány**..
    - (t / tell.01                      (p / popsat.1  
       :Arg1 (t2 / tale)            (no :Arg1)
  - “**překračovat povolenou rychlost**” vs. “speeding”
- Should AMR make more of an effort to treat MWE’s as single lexical items?

# Questions to investigate

- If there are alternative annotation choices, can we deterministically produce them, resulting in better matches?
- Where there are language-specific different lexicalizations, are there resources that could provide bi-lingual mappings?
- How much should AMR abstract away from Multi-word expressions?
- When to reify? And when not?
- Etc.,

# Acknowledgments

- We gratefully acknowledge the support of the National Science Foundation Grant for Richer Representations for Machine Translation, DARPA-GALE via a subcontract from BBN, DARPA-BOLT & DEFT via a subcontract from LDC, and NIH THYME.
- Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation, DARPA or NIH.



# And thanks to

- Postdocs: Paul Kingsbury, Dan Gildea, Nianwen Xue, Jinying Chen
- Students: Joseph Rosenzweig, Hoa Dang, Tom Morton, Karin Kipper Schuler, Jinying Chen, Szu-Ting Yi, Edward Loper, Susan Brown, Dmitriy Dligach, Jena Hwang, Will Corvey, Claire Bonial, Jinho Choi, Lee Becker, Shumin Wu, Kevin Stowe
- Collaborators: Christiane Fellbaum, Suzanne Stevenson, Annie Zaenen, Orin Hargraves, James Pustejovsky