

# Semantic Role Labeling Tutorial

NAACL, June 9, 2013

Part 1: Martha Palmer, University of Colorado

Part 2: Shumin Wu, University of Colorado

Part 3: Ivan Titov, Universität des Saarlandes

# Outline

## ▶ Part 1

Linguistic Background, Resources, Annotation

Martha Palmer, University of Colorado

## ▶ Part 2

Supervised Semantic Role Labeling and Leveraging  
Parallel PropBanks

Shumin Wu, University of Colorado

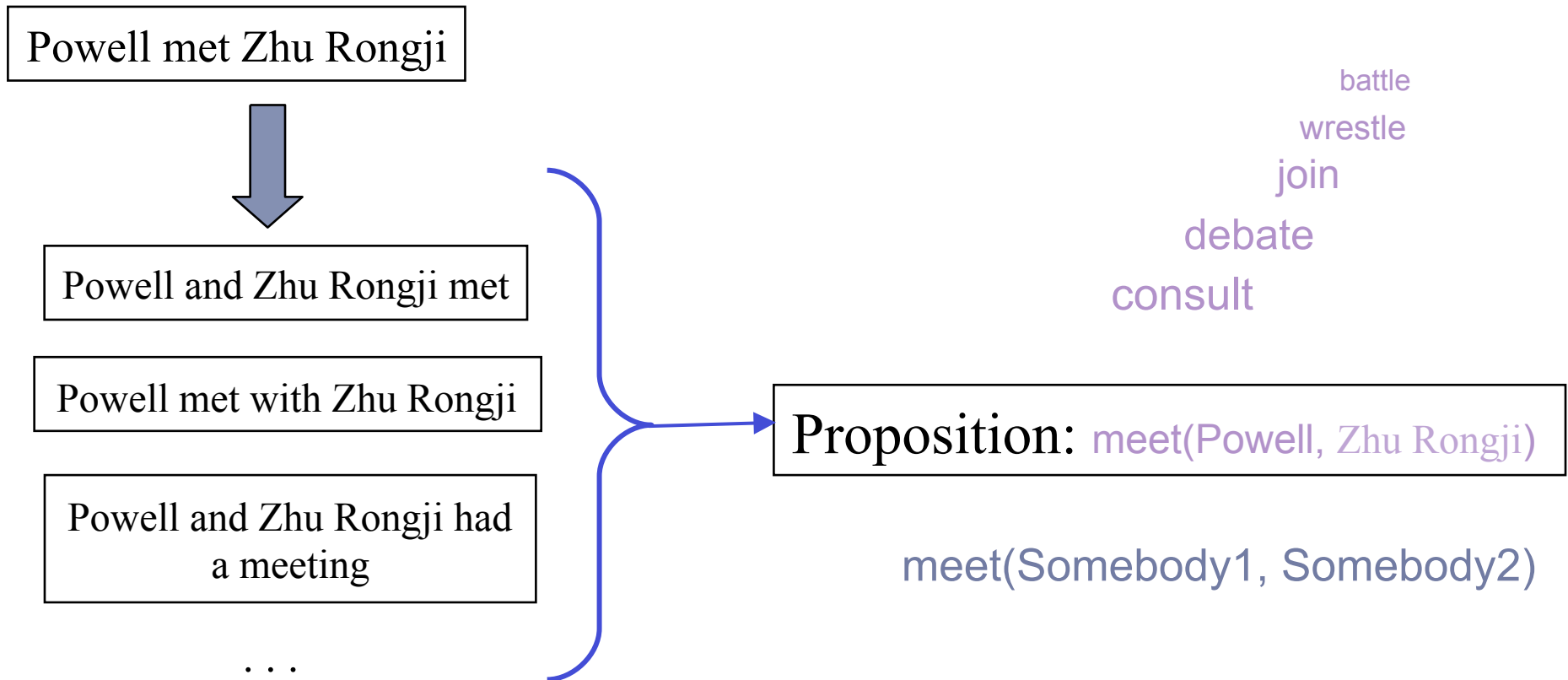
## ▶ Part 3

Semi- , unsupervised and cross-lingual approaches

Ivan Titov, Universität des Saarlandes, Universteit van  
Amsterdam

# Motivation: From Sentences to Propositions

*Who did what to whom, when, where and how?*



When Powell met Zhu Rongji on Thursday they discussed the return of the spy plane.

`meet(Powell, Zhu)    discuss([Powell, Zhu], return(X, plane))`

# Capturing semantic roles

SUBJ

- ▶ Dan broke [ the laser pointer.]

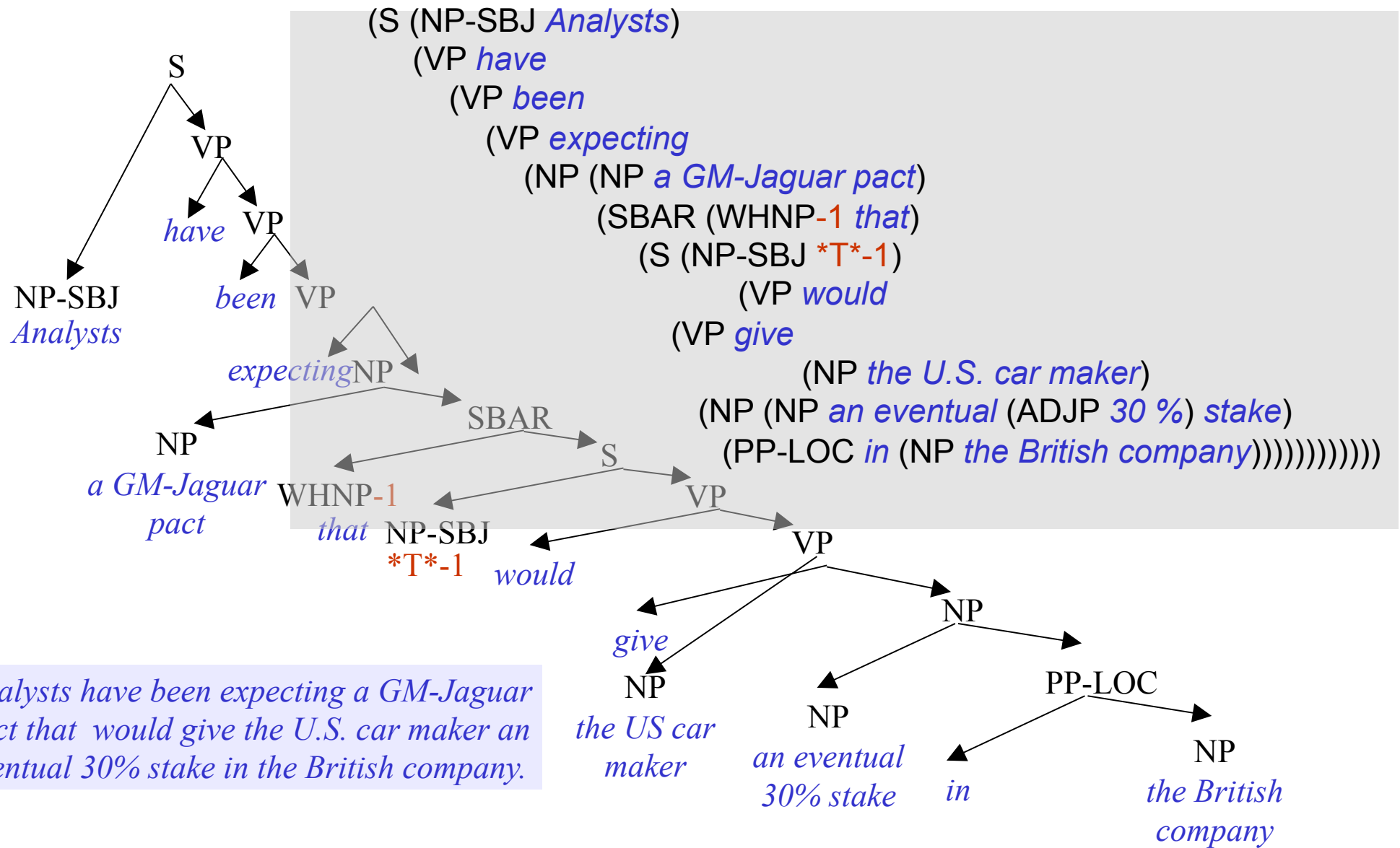
SUBJ

- ▶ [The windows] were broken by the hurricane.

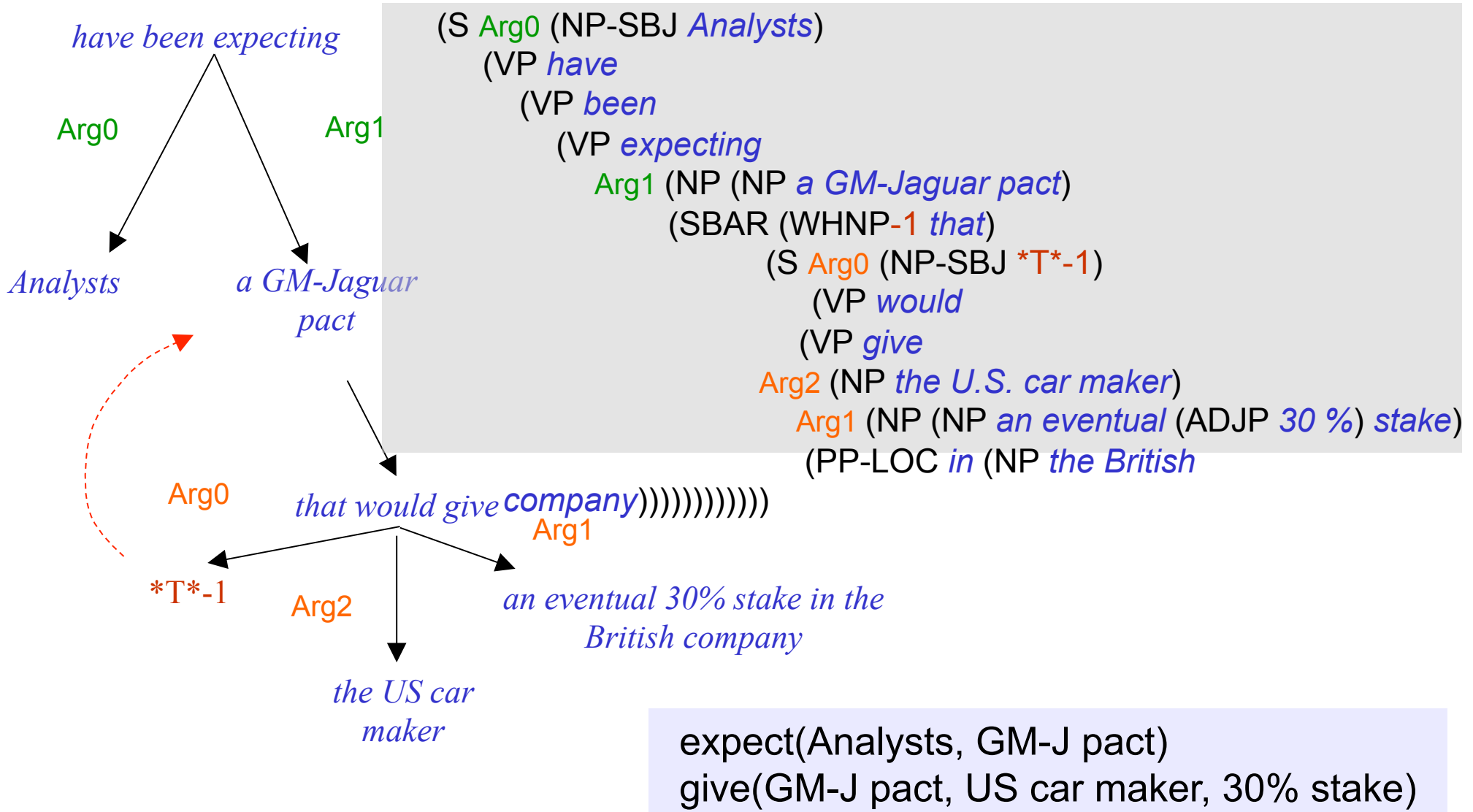
SUBJ

- ▶ [The vase] broke into pieces when it toppled over.

# PropBank - A TreeBanked Sentence



# The same sentence, PropBanked



# SRL Questions

- ▶ Why Arg0 and Arg1?
- ▶ What about nouns and adjectives?
- ▶ What about other languages?
- ▶ How does PropBank relate to VerbNet and FrameNet?
- ▶ Will we ever get past the WSJ?
- ▶ How do SRL systems get trained?
- ▶ Can this be done without training data?
- ▶ .....

# Why Arg0? Linguistic Background and Resources

- ▶ **Fillmore – Cases**
  - ▶ Useful generalizations, fewer sense distinctions,
- ▶ **Dowty – Proto-typical Agents and Patients**
  - ▶ A bag of “agentive” entailments
  - ▶ **PropBank**
- ▶ **Levin – Verb classes based on syntax**
  - ▶ Syntactic behavior is a reflection of the underlying semantics
  - ▶ **VerbNet**
- ▶ **Back to Fillmore and FrameNet**
- ▶ **SemLink**
- ▶ **PropBank → AMR**



# Linguistic Background: Case Theory,

*The Case for Case, Charles J. Fillmore*

- ▶ Case relations occur in deep-structure
  - ▶ Surface-structure cases are derived
  
- ▶ A sentence is a verb + one or more NPs
  - ▶ Each NP has a deep-structure case
    - ▶ *A(gentive)*
    - ▶ *I(nstrumental)*
    - ▶ *D(ative) - recipient*
    - ▶ *F(active) – result*
    - ▶ *L(ocative)*
    - ▶ *O(bjective) – affected object, theme*
  
  - ▶ Subject is no more important than Object
    - ▶ Subject/Object are surface structure

# Case Theory Benefits - Generalizations

## ▶ Fewer tokens

- ▶ Fewer verb senses
- ▶ E.g. *cook/bake* [ \_\_O(A)] covers
  - ▶ Mother is cooking/baking the potatoes
  - ▶ The potatoes are cooking/baking.
  - ▶ Mother is cooking/baking.

## ▶ Fewer types

- ▶ “Different” verbs may be the same semantically, but with different subject selection preferences
- ▶ E.g. *like* and *please* are both [ \_\_O+D]

## ▶ Great, let's do it!

# Oops, problems with Cases/Thematic Roles

- ▶ How many and what are they?
- ▶ Fragmentation: 4 Agent subtypes? (Cruse, 1973)
  - ▶ *The sun melted the ice./This clothes dryer doesn't dry clothes well*
- ▶ Ambiguity: Andrews (1985)
  - ▶ Argument/adjunct distinctions – Extent?
  - ▶ *The kitten licked my fingers.* – Patient or Theme?
- ▶  $\theta$ -Criterion (GB Theory): each NP of predicate in lexicon assigned unique  $\theta$ -role (Chomsky 1981).

[<sub>Agent (or Source)</sub> *Esau*] sold [<sub>Theme</sub> *his birthright*]  
[<sub>Goal</sub> *to Jacob*] for a *bowl of porridge*.

[<sub>Goal</sub> *Esau*] sold *his birthright*  
[<sub>Source</sub> *to Jacob*] for a [<sub>Theme</sub> *bowl of porridge*].

Jackendoff

# Thematic Proto-Roles and Argument Selection, *David Dowty, 1991*

Role definitions have to be determined verb by verb, and with respect to the other roles

- ▶ Event-dependent Proto-roles introduced
  - ▶ Proto-Agent
  - ▶ Proto-Patient
- ▶ Prototypes based on shared entailments

# Proto-Agent- the *mother*

## ▶ Properties

- ▶ Volitional involvement in event or state
- ▶ Sentience (and/or perception)
- ▶ Causes an event or change of state in another participant
- ▶ Movement (relative to position of another participant)
- ▶ (exists independently of event named)
  - \*may be discourse pragmatic

# Proto-Patient – the *cake*

## ▶ Properties:

- ▶ Undergoes change of state
- ▶ Incremental theme
- ▶ Causally affected by another participant
- ▶ Stationary relative to movement of another participant
- ▶ (does not exist independently of the event, or at all)
- ▶ \*may be discourse pragmatic

# Argument Selection Principle

- ▶ For 2 or 3 place predicates
- ▶ Based on empirical count (total # of entailments for each role).
  - ▶ Greatest number of Proto-Agent entailments → Subject;
  - ▶ greatest number of Proto-Patient entailments → Direct Object.
- ▶ Alternation predicted if number of entailments for each role similar (non-discreteness).

*[Mother AGENT] baked a cake.*

*[The cake PATIENT] baked.*

# PropBank Semantic Role Labels – based on Dowty’s Proto-roles

- PropBank Frame for *break*:

Frameset **break.01** “break, cause to not be whole”:

Arg0: breaker

Arg1: thing broken

Arg2: instrument

Arg3: pieces

- ▶ Why numbered arguments?

- ▶ Lack of consensus concerning semantic role labels
- ▶ Numbers correspond to verb-specific labels
- ▶ Arg0 – Proto-Agent, and Arg1 – Proto-Patient, (Dowty, 1991)
- ▶ Args 2-5 are highly variable and overloaded – poor performance



# PropBank seeks to provide consistent argument labels across different syntactic realizations

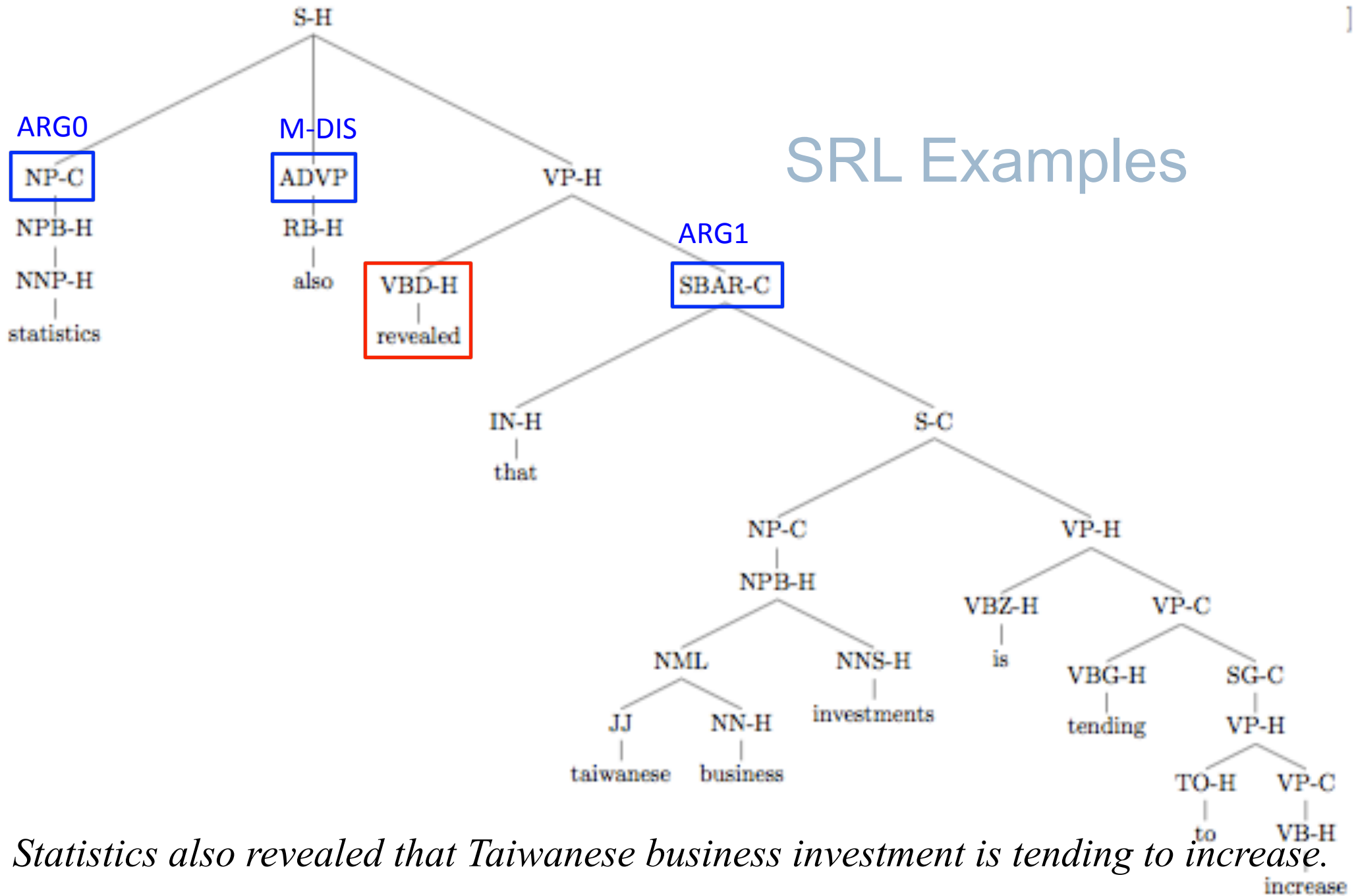
- Uuuuuusually...
  - Arg0 = agent, experiencer
  - Arg1 = patient, theme
  - Arg2 = benefactive / instrument / attribute / end state
  - Arg3 = start point / benefactive / instrument / attribute
  - Arg4 = end point

# PropBank seeks to assign functional tags to all modifiers or adjuncts to the verb

- **Variety of ArgM's:**

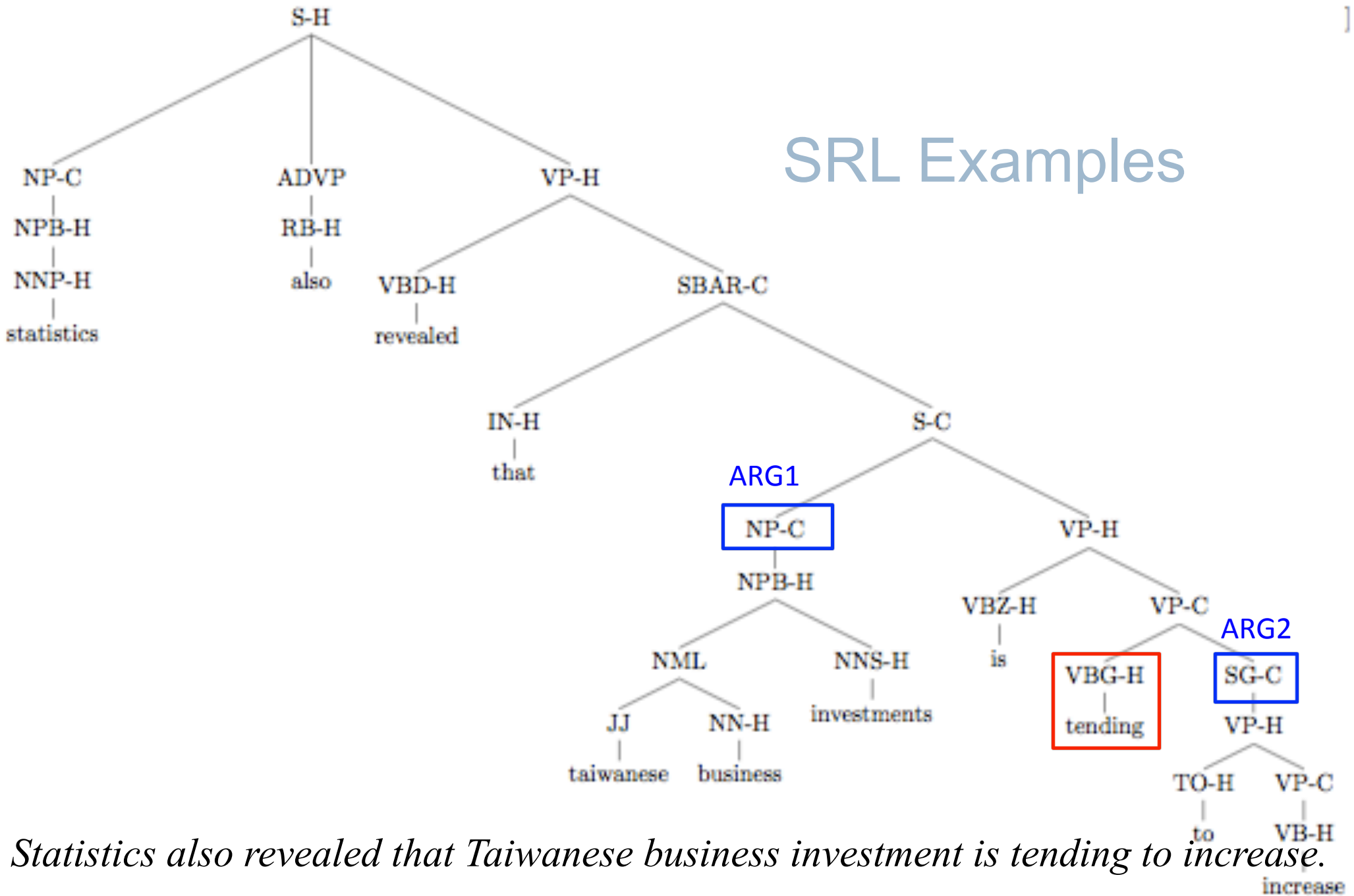
- TMP - when? *yesterday, 5pm on Saturday, recently*
- LOC - where? *in the living room, on the newspaper*
- DIR - where to/from? *down, from Antartica*
- MNR - how? *quickly, with much enthusiasm*
- PRP/CAU -why? *because ... , so that ...*
- REC - himself, themselves, each other
- GOL - end point of motion, transfer verbs? *To the floor, to Judy*
- ADV - hodge-podge, miscellaneous, “nothing-fits!”
- PRD - this argument refers to or modifies another: *...ate the meat raw*

# SRL Examples



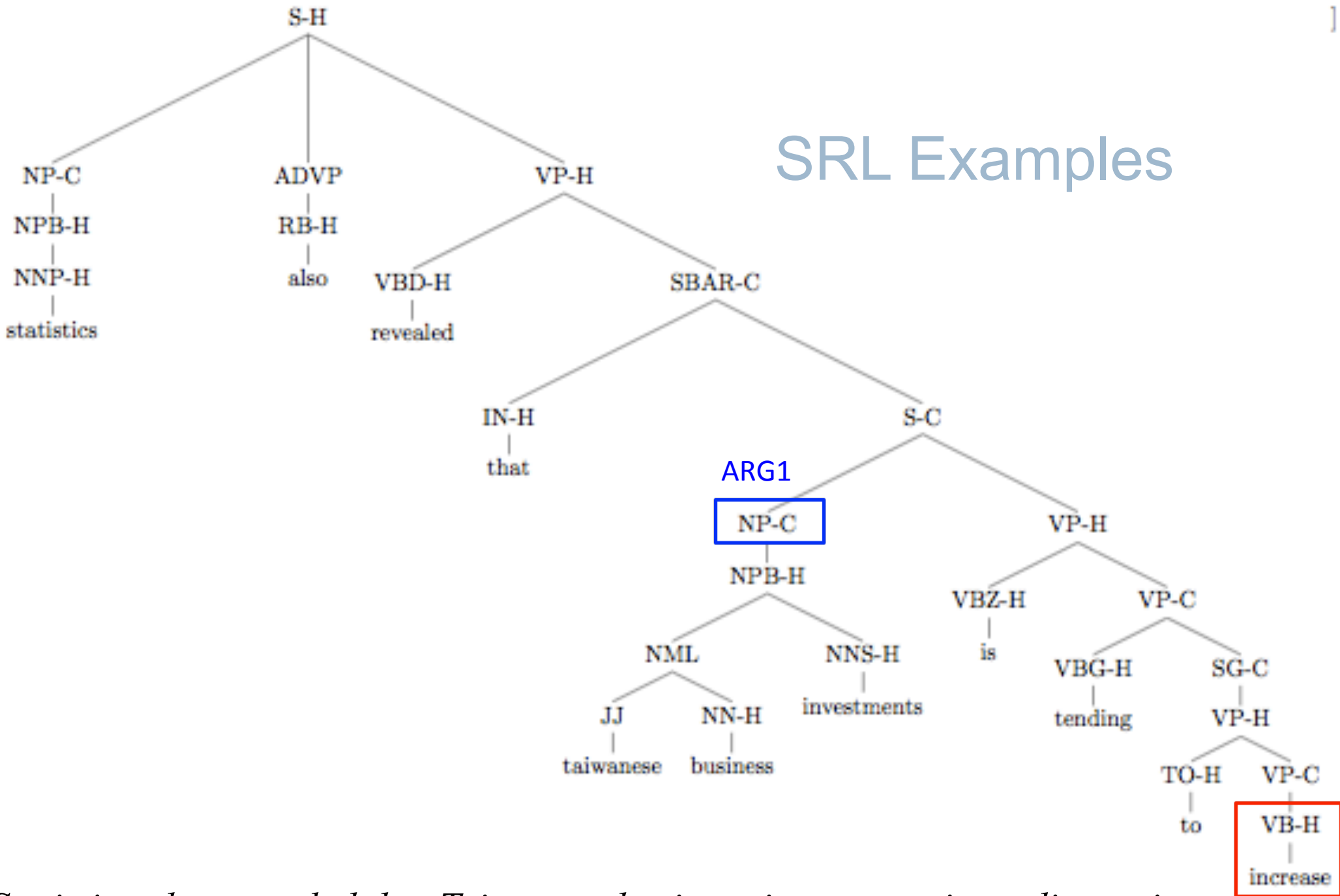
*Statistics also revealed that Taiwanese business investment is tending to increase.*

# SRL Examples



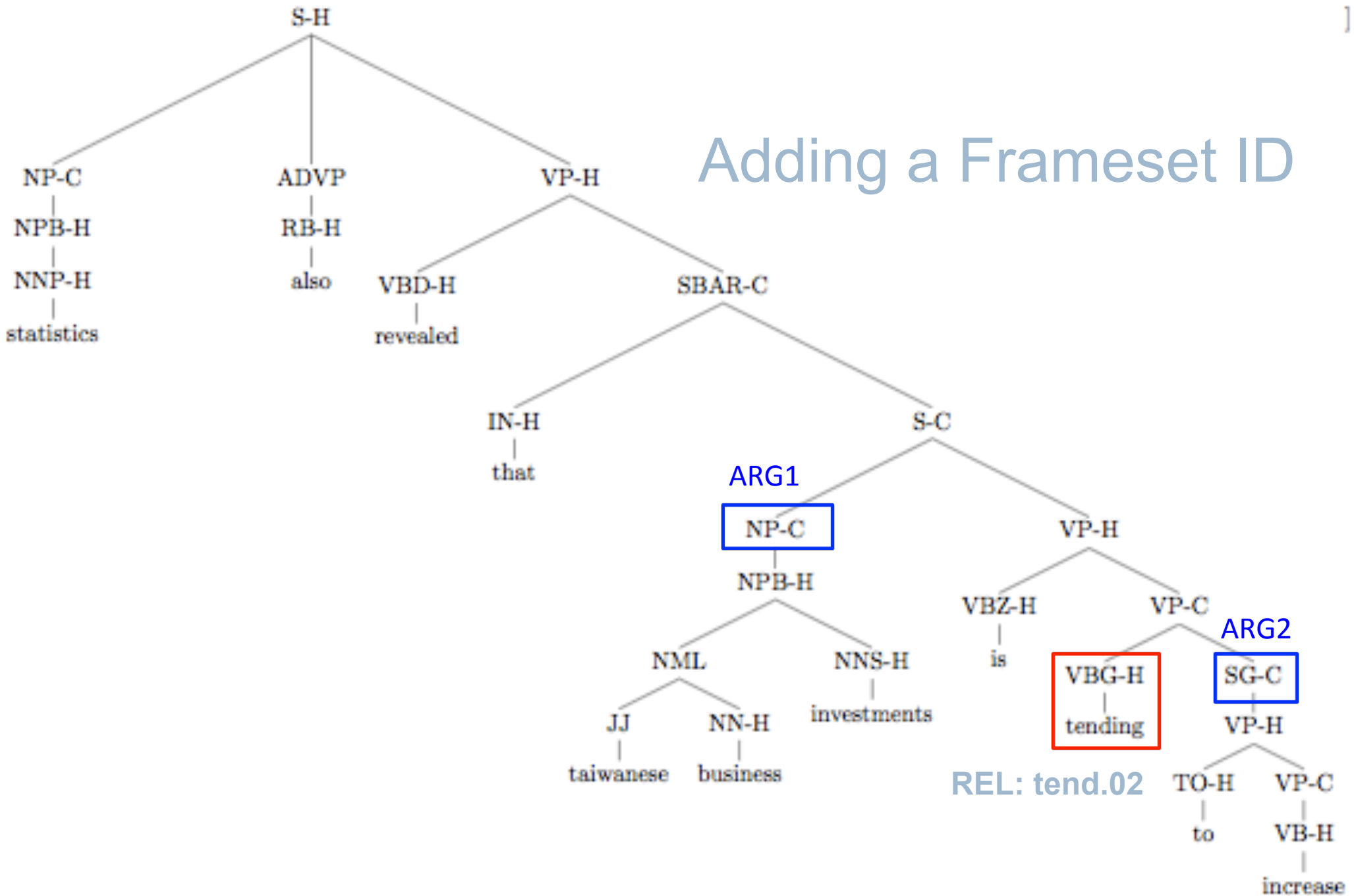
*Statistics also revealed that Taiwanese business investment is tending to increase.*

# SRL Examples



*Statistics also revealed that Taiwanese business investment is tending to increase.*

# Adding a Frameset ID



*Statistics also revealed that Taiwanese business investment is tending to increase.*

# Why do we need Frameset ID's?

PropBank Frames Files: *tend.01* , *care for*

Roles:

Arg0: tender

Arg1: thing tended (to)

Example: *John tends to the needs of his patrons.*

Arg0: *John*

REL: *tend*

Arg1: *the needs of his patrons*

# Sense distinctions in PropBank – coarse-grained

PropBank - Frames Files: tend.02, *have a tendency*

Roles:

Arg1: Theme

Arg2: Attribute

Example: *The cost, or premium, tends to get fat in times of crisis.*

Arg1: *The cost, or premium*

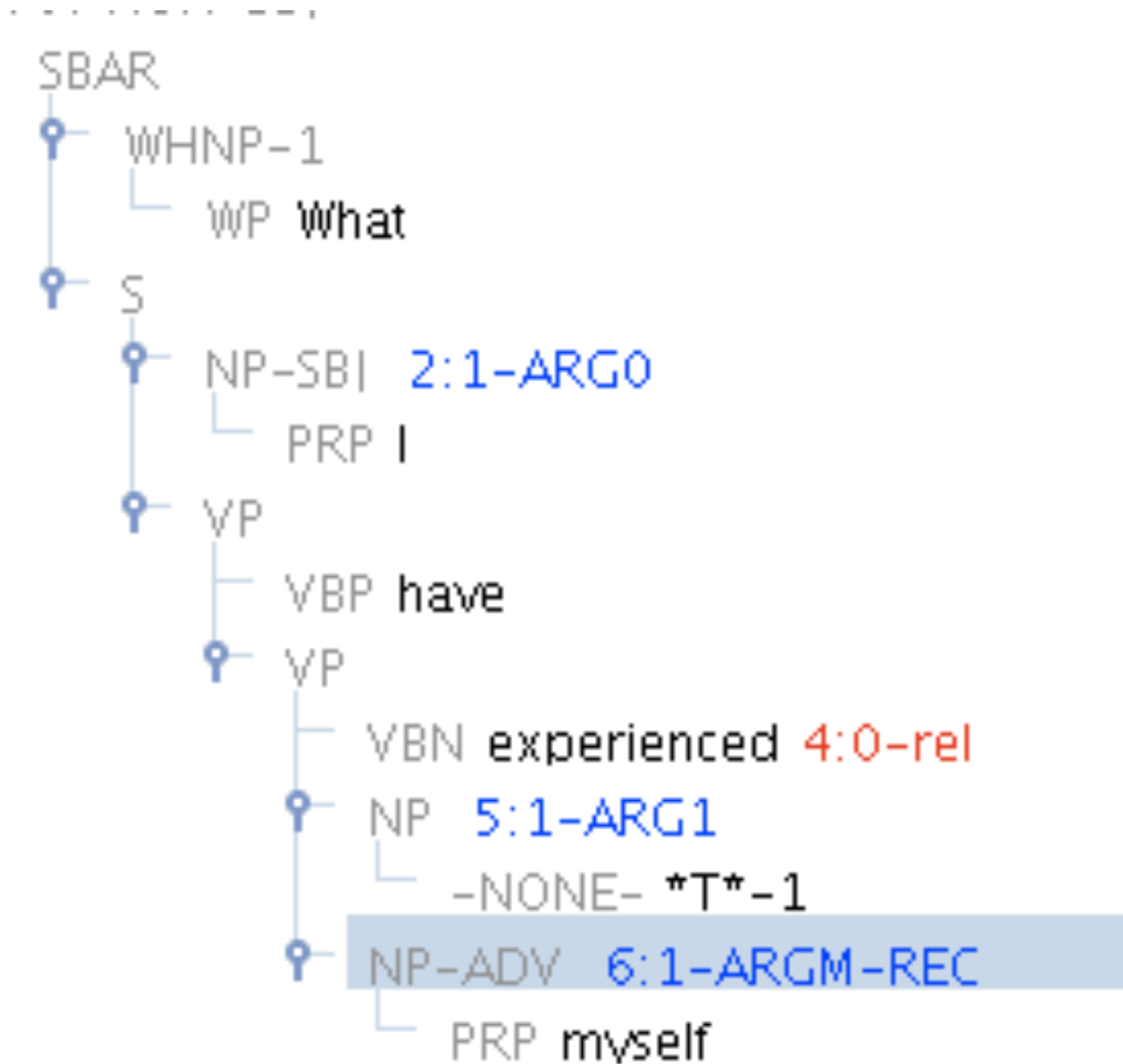
REL: *tend*

Arg2: *to get fat in times of crisis.*



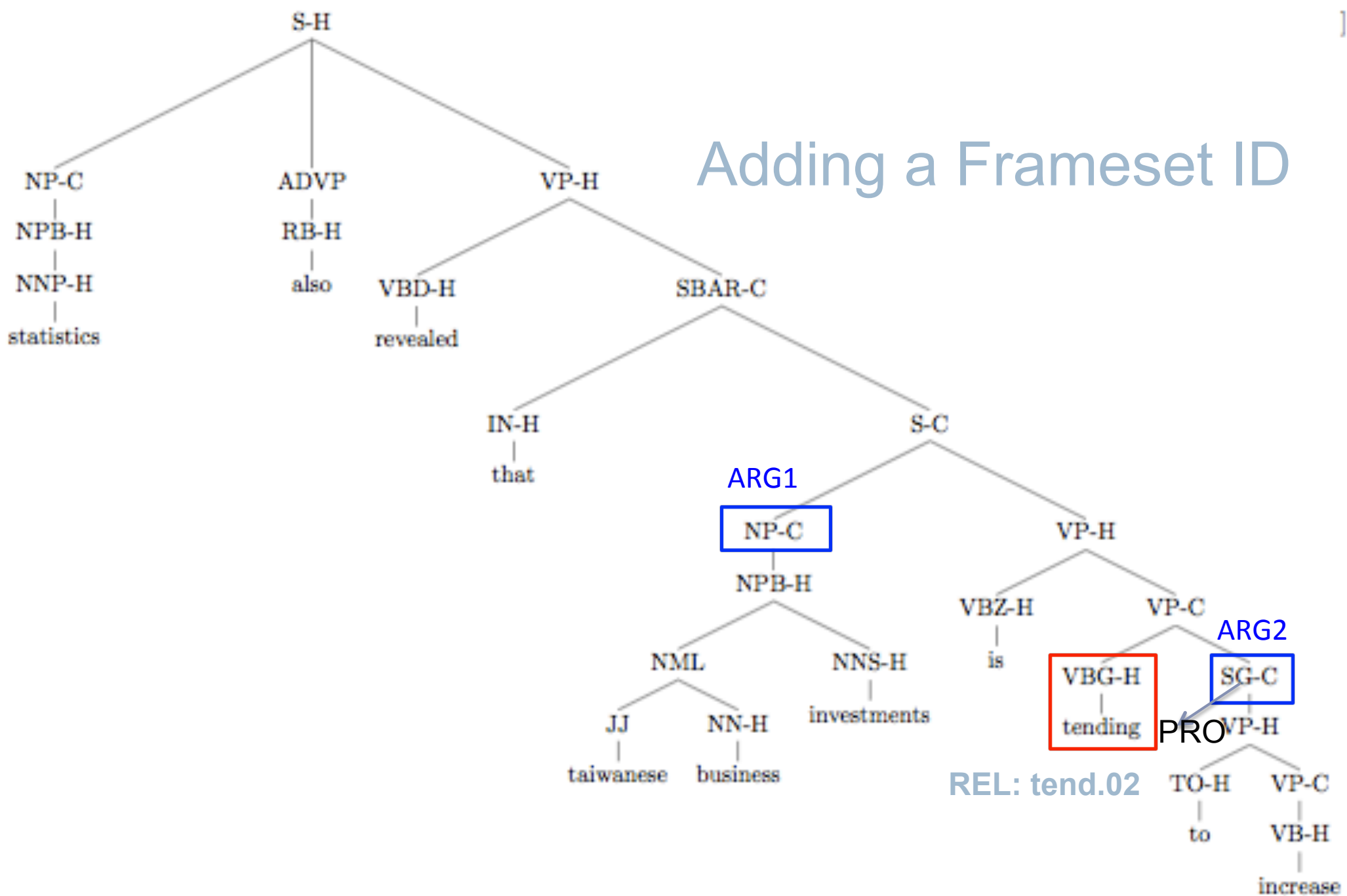
# Visual Example: traces BASED on Jubilee

*Choi, et. al., NAACL-10 Demo*



CC or

# Adding a Frameset ID



*Statistics also revealed that Taiwanese business investment is tending to increase.*

# Actual data for *leave*

Leave .01 “move away from” Arg0 rel Arg1 Arg3

Leave .02 “give” Arg0 rel Arg1 Arg2

sub-ARG0 obj-ARG1 44

sub-ARG0 20

sub-ARG0 NP-ARG1-with obj-ARG2 17

sub-ARG0 sub-ARG2 ADJP-ARG3-PRD 10

sub-ARG0 sub-ARG1 ADJP-ARG3-PRD 6

sub-ARG0 sub-ARG1 VP-ARG3-PRD 5

NP-ARG1-with obj-ARG2 4

obj-ARG1 3

sub-ARG0 sub-ARG2 VP-ARG3-PRD 3

# Annotation procedure, WSJ PropBank

*Palmer, et. al., 2005*

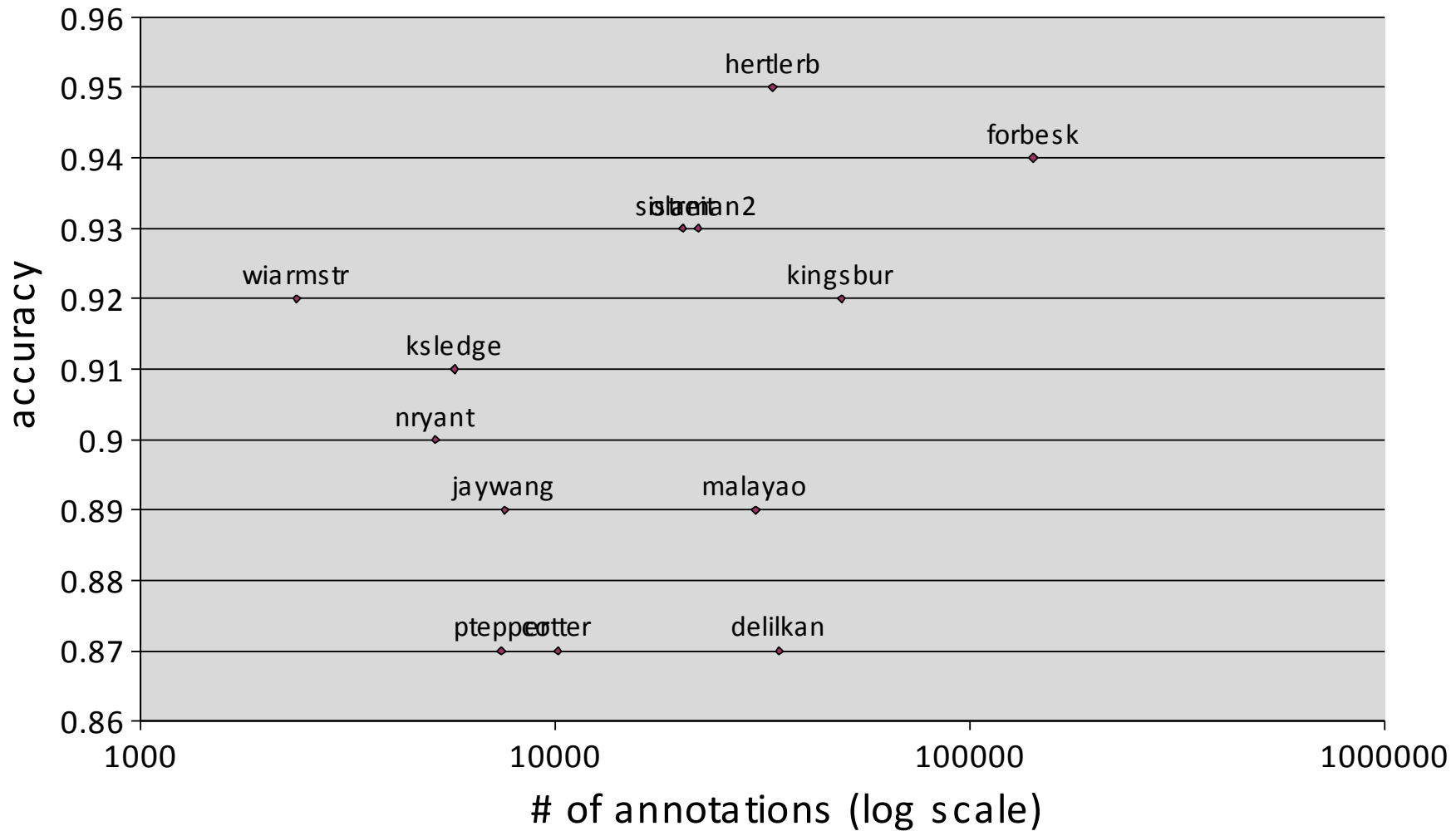
- ▶ PTB II - Extraction of all sentences with given verb
- ▶ Create Frame File for that verb *Paul Kingsbury*
  - ▶ (3100+ lemmas, 4400 framesets, 118K predicates)
  - ▶ Over 300 created automatically via VerbNet
- ▶ First pass: Automatic tagging (*Joseph Rosenzweig*)
  - ▶ <http://www.cis.upenn.edu/~josephr/TIDES/index.html#lexicon>
- ▶ Second pass: Double blind hand correction

*Paul Kingsbury*

- ▶ Tagging tool highlights discrepancies *Scott Cotton*
- ▶ Third pass: *Solomonization* (adjudication)
  - ▶ *Betsy Klipple, Olga Babko-Malaya*

# Annotator accuracy – ITA 84%

## Annotator Accuracy-primary labels only



# SRL Questions

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- ▶ .....

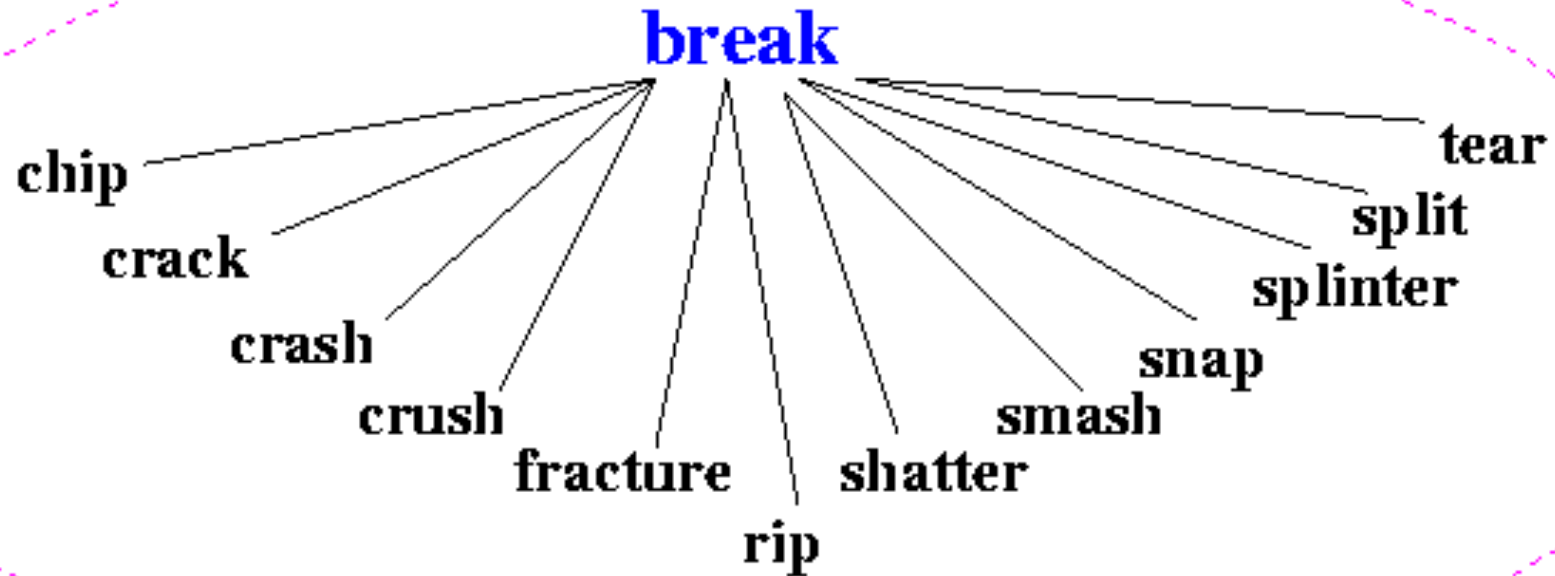
# A Preliminary Classification of English Verbs, *Beth Levin*

- ▶ Based on diathesis alternations
  - ▶ The range of syntactic variations for a class of verbs is a reflection of the underlying semantics
  - ▶ 47 top level classes, 193 second and third level, 3100 verbs
- ▶ Based on pairs of syntactic frames.

*John broke the jar. / Jars break easily. / The jar broke. / \*John broke at the jar.*  
*John cut the bread. / Bread cuts easily. / \*The bread cut/John cut at the bread..*
- ▶ Reflect underlying semantic components  
**contact, directed motion,  
exertion of force, change of state**
- ▶ Synonyms, syntactic patterns (*conative*), relations

# Break Levin class -

*Change-of-state*

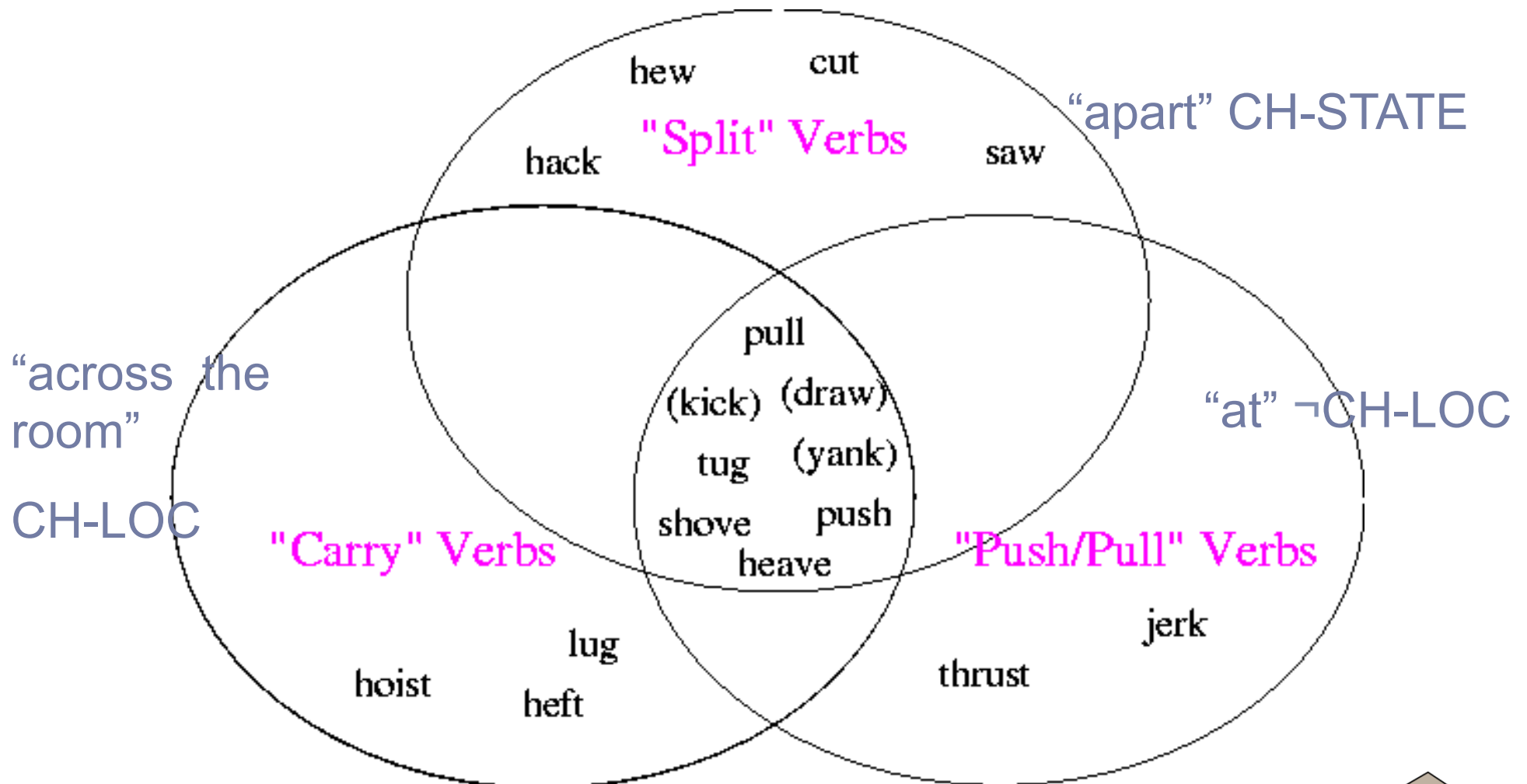




# Confusions in Levin classes?

- ▶ Not semantically homogenous
  - ▶ {**braid**, *clip*, *file*, *powder*, *pluck*, etc...}
- ▶ Multiple class listings
  - ▶ homonymy or polysemy?
- ▶ Alternation contradictions?
  - ▶ *Carry* verbs disallow the Conative, but include
  - ▶ {*push*, *pull*, *shove*, *kick*, *draw*, *yank*, *tug*}
  - ▶ also in *Push/pull* class, does take the Conative

# Intersective Levin Classes



Dang, Kipper & Palmer, ACL98

# Intersective Levin Classes

- ▶ More syntactically and semantically coherent
  - ▶ sets of syntactic patterns
  - ▶ explicit semantic components
  - ▶ relations between senses



**VERBNET**

[verbs.colorado.edu/verb-index/  
index.php](http://verbs.colorado.edu/verb-index/index.php)

# VerbNet – Karin Kipper Schuler

- ▶ **Class entries:**
  - ▶ Capture generalizations about verb behavior
  - ▶ Organized hierarchically
  - ▶ Members have common semantic elements, **semantic roles (28)** and syntactic frames
- ▶ **Verb entries:**
  - ▶ Refer to a set of classes (different senses)
  - ▶ each class member linked to WN synset(s) and FrameNet frames
- ▶ **Currently 6300 verbs**
- ▶ **Adding Constructions**

*Hwang, et.al, NAACL-HLT Construction Workshop, 2010*

*Bonial, et. al., ACL RELMS Workshop, 2011*

# VerbNet example – Pour-9.5

VerbNet: pour-9.5 - Mozilla Firefox  
http://verbs.colorado.edu/verb-index/pour-9.5.php

RETURN HOME | BACK | SEARCH      VerbNet v2.3      VIEW OR MANAGE ALL COMMENTS | UNIVERSITY OF COLORADO

*No Comments*      **pour-9.5**      POST COMMENT      CLASS HIERARCHY  
*Members: 8, Frames: 5*      **POUR-9.5**  
*NO SUBCLASSES*

**MEMBERS** KEY

DRIBBLE (FN 1; WN 1, 2)	SPEW (FN 1; WN 1, 2, 3)
DRIP (FN 1; WN 1, 2)	SPILL (FN 1; WN 1, 2, 3)
POUR (FN 1; WN 1, 3, 4)	TRICKLE (WN 1)
SLOP (WN 1)	
SLOSH (WN 3)	

**ROLES** REF

- AGENT [+ANIMATE]
- THEME [+SUBSTANCE | [+CONCRETE & +PLURAL]]
- LOCATION [+LOCATION & -REGION]
- SOURCE [+LOCATION & -REGION]

**FRAMES** REF KEY

Done

VerbNet: po... Downloads verbs.colora... Pooling 2 Microsoft... 100% 1:34 PM

*How does VerbNet relate to FrameNet?*

# FrameNet, Chuck Fillmore

- The **lexical unit** (Cruse 1986), – a pairing of a word with a sense (or a FrameNet frame.)
- In one of its senses, the verb *observe* evokes a frame called **Compliance**: this frame concerns people's responses to norms, rules or practices.
  - ▶ *Our family **observes** the Jewish dietary laws.*
  - ▶ *You have to **observe** the rules or you'll be penalized.*

# The FrameNet Product – **ADD STATS**

## The FrameNet database constitutes

- ▶ a set of **frame descriptions**
  - ▶ **Frames, Frame Elements, Valence Possibilities**
- ▶ a set of **corpus examples** annotated with respect to the frame elements of the frame evoked by each lexical unit
- ▶ **lexical entries**, including definitions and displays of the combinatory possibilities of each lexical unit, as automatically derived from the annotations
- ▶ a display of **frame-to-frame relations**, showing how some frames are elaborations of others, or are components of other frames.

# Frame Elements for Compliance

**The Frame Elements** that figure in the Compliance **frame** are called

- ▶ **Norm** (the rule, practice or convention)
- ▶ **Protagonist** (the person[s] reacting to the Norm)
- ▶ **Act** (something done by the Protagonist that is evaluated in terms of the Norm)
- ▶ **State\_of\_affairs** (a situation evaluated in terms of the Norm)



- You do a whole frame for just *observe*?
- No. There are other Compliance words too.

V - *adhere, comply, conform, follow, heed, obey, submit, ...;*

AND NOT ONLY VERBS

N - *adherence, compliance, conformity, obedience, observance, ...;*

A - *compliant, obedient, ...;*

PP - *in compliance with, in conformity to, ...;*

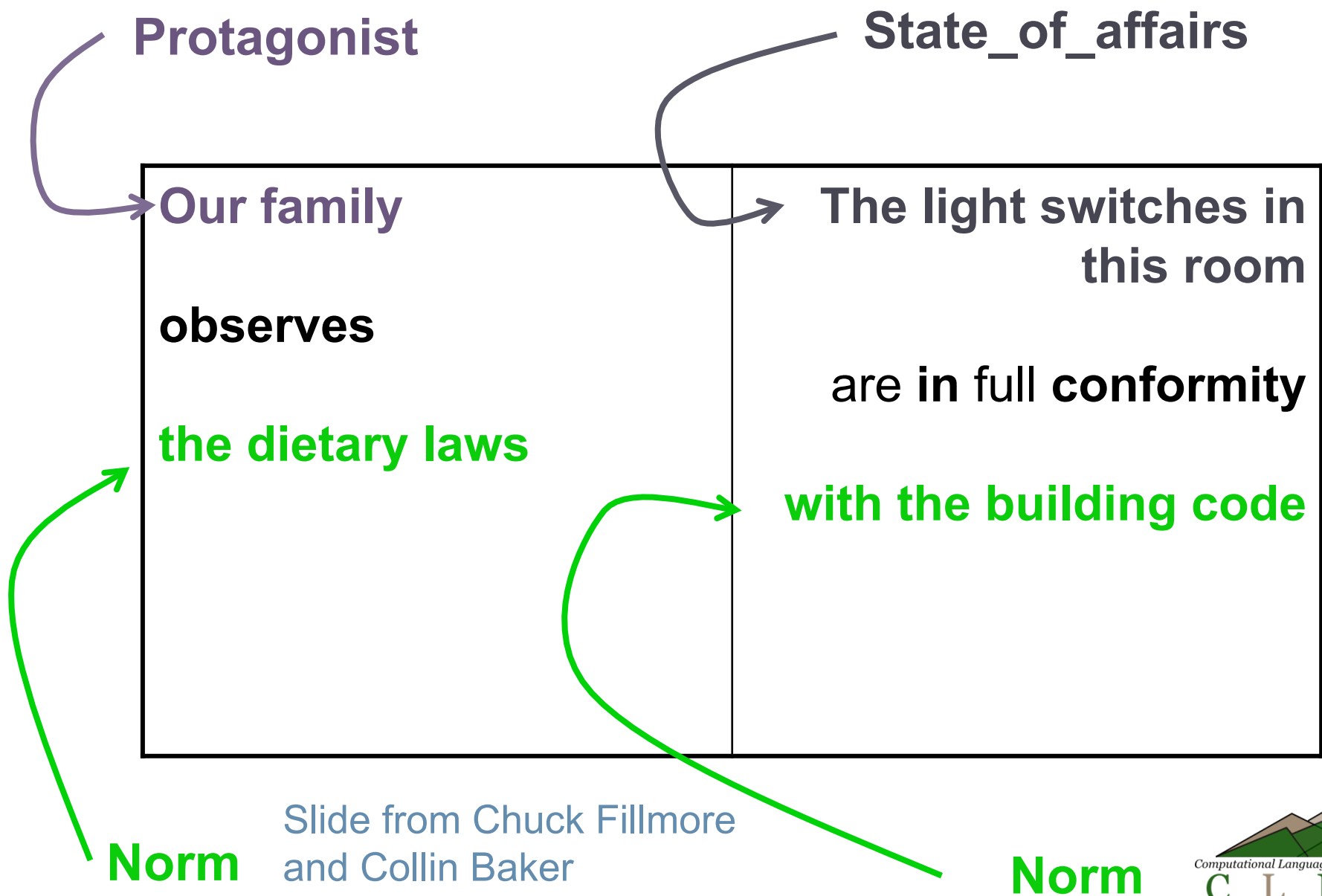
AND NOT ONLY WORDS FOR POSITIVE RESPONSES TO NORMS

V - *break, disobey, flout, transgress, violate ,...;*

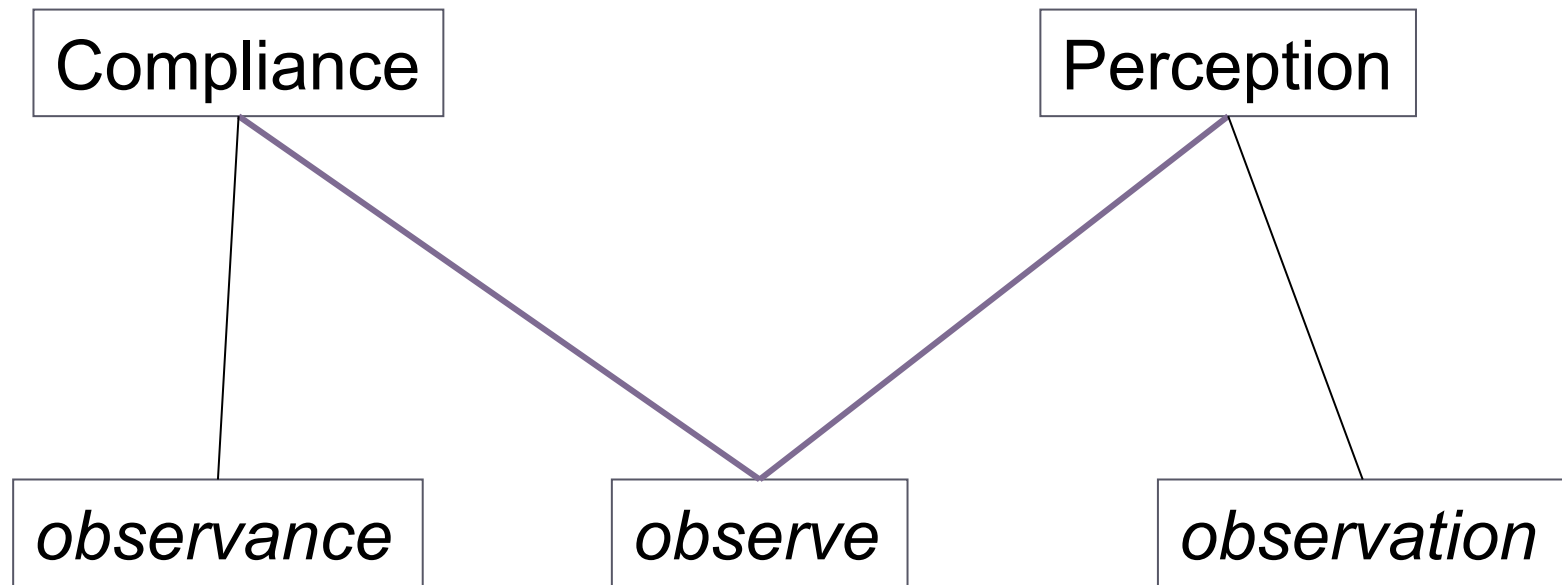
N - *breach, disobedience, transgression, violation,....;*

PP - *in violation of, in breach of, ...*

# Tagging Compliance sentences



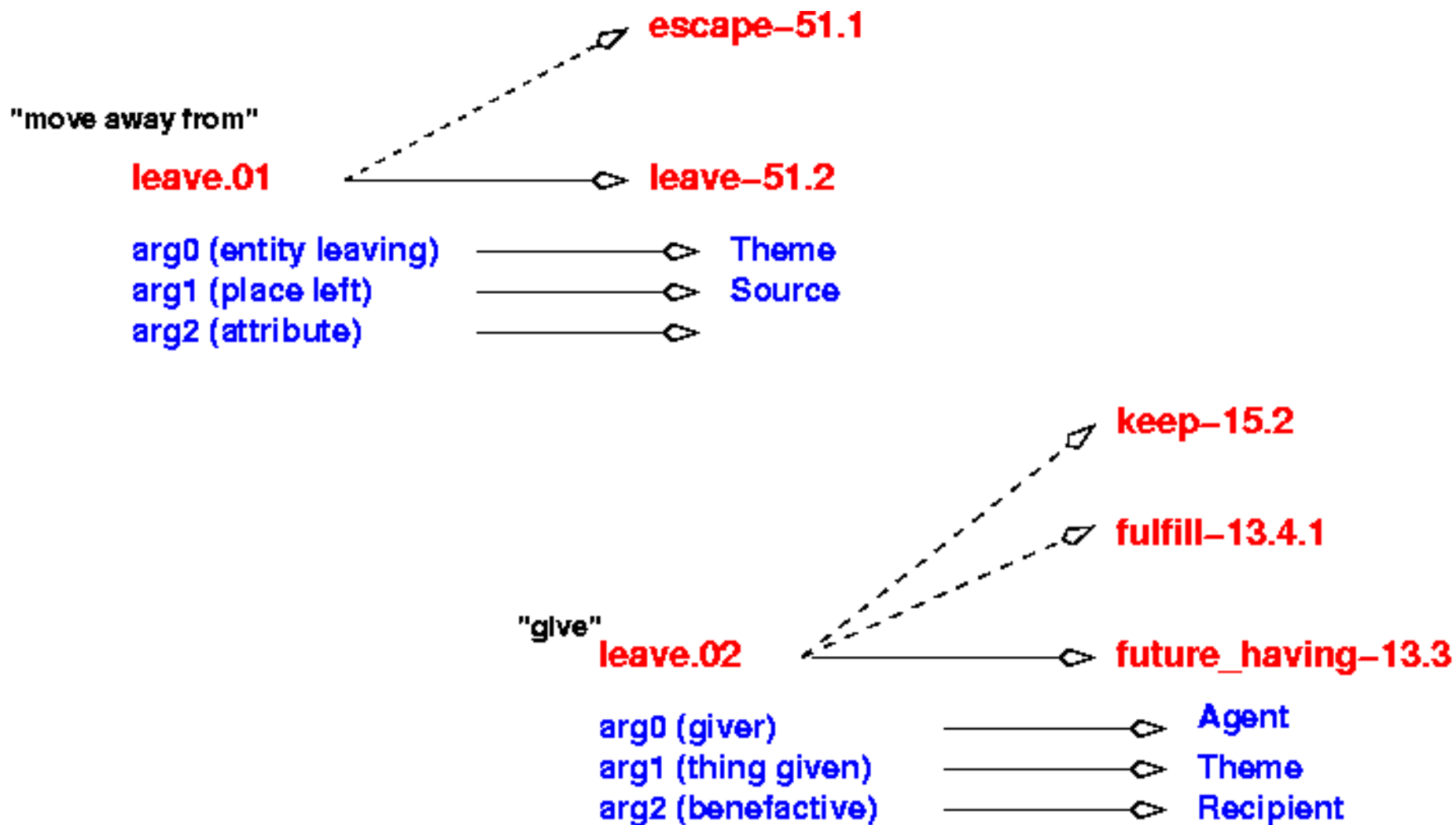
# words, frames, lexical units



2 lexical units sharing same form:  
Compliance.*observe*,  
Perception.*observe*

# Mapping from PB to VerbNet - SemLink

<http://verbs.colorado.edu/semlink>



# Mapping from PropBank to VerbNet (similar mapping for PB-FrameNet) - SemLink

Frameset id = <b><i>leave.02</i></b>	Sense = <i>give</i>	VerbNet class = <b><i>future-having 13.3</i></b>
Arg0	Giver	Agent/Donor*
Arg1	Thing given	Theme
Arg2	Benefactive	Recipient

\*FrameNet Label

*Baker, Fillmore, & Lowe, COLING/ACL-98*  
*Fillmore & Baker, WordNetWKSHP, 2001*

# PropBank/FrameNet - SemLink

Buy

Sell

Arg0: buyer

Arg0: seller

Arg1: goods

Arg1: goods

Arg2: seller

Arg2: buyer

Arg3: rate

Arg3: rate

Arg4: payment

Arg4: payment

More generic, more neutral – maps readily to VN,TR

*Rambow, et al, PMLB03*

# Can SemLink improve Generalization?

- ▶ After PropBank, SRL improved from 77% to 88% Automatic parses, 81% F, **Brown corpus, 68%**
- ▶ Overloaded Arg2-Arg5
  - ▶ PB: verb-by-verb
  - ▶ VerbNet: same thematic roles across verbs
- ▶ Example
  - ▶ Rudolph Agnew,..., was **named** [ARG2 {Predicate} a nonexecutive director of this British industrial conglomerate.]
  - ▶ ....the latest results appear in today's New England Journal of Medicine, a forum likely to **bring** new attention [ARG2 {Destination} to the problem.]
- ▶ Use VerbNet as a bridge to merge PB and FN and expand the Size and Variety of the Training

# VerbNet - Arg2 groupings; (Total count 11068)

<b>Group1 (43.93%)</b>	<b>Group2 (14.74%)</b>	<b>Group3 (32.13%)</b>	<b>Group4 (6.81%)</b>	<b>Group5 (2.39%)</b>
<b>Recipient; Destination; Location; Source; Material; Beneficiary</b>	<b>Extent; Asset</b>	<b>Predicate; Attribute; Theme; Theme2; Theme1; Topic</b>	<b>Patient2; Product</b>	<b>Instrument; Actor2; Cause; Experiencer</b>



# Process

- ▶ Retrain the SRL tagger
  - ▶ Original: Arg[0-5,A,M]
  - ▶ ARG2 Grouping: Arg[0,2-5,A,M] Arg1-Group[1-6]
- ▶ Evaluation
  - ▶ WSJ            [+6%]
  - ▶ Brown         [+10%]
- ▶ More Coarse-grained or Fine-grained?
  - ▶ more specific: data more coherent, but more sparse
  - ▶ more general: consistency across verbs even for new domains?

# PropBank/VerbNet/FrameNet - SemLink

- ▶ Complementary resources
- ▶ Redundancy is harmless, may even be useful
- ▶ PropBank provides the best training data
- ▶ VerbNet provides the clearest links between syntax and semantics
- ▶ FrameNet provides the richest semantics
- ▶ Together they give us the most comprehensive coverage
  
- ▶ SemLink - <http://verbs.colorado.edu/semlink/>
  - ▶ WSJ, sense tags and SRL, mappings to VN and FN

# WSJ instance example from SemLink

Pierre Vinken , 61 years old ,  
will join  
the board  
as a nonexecutive director Nov. 29.

nw/wsj/00/wsj\_0001.parse

0 8 gold join-v 22.1-2-1 Cause\_to\_amalgamate join.01

0:2-ARG0=Agent;Agent

7:0-ARGM-MOD

8:0-rel

9:1-ARG1=Patient;Part\_1

11:1-ARGM-PRD 15:1-ARGM-TMP

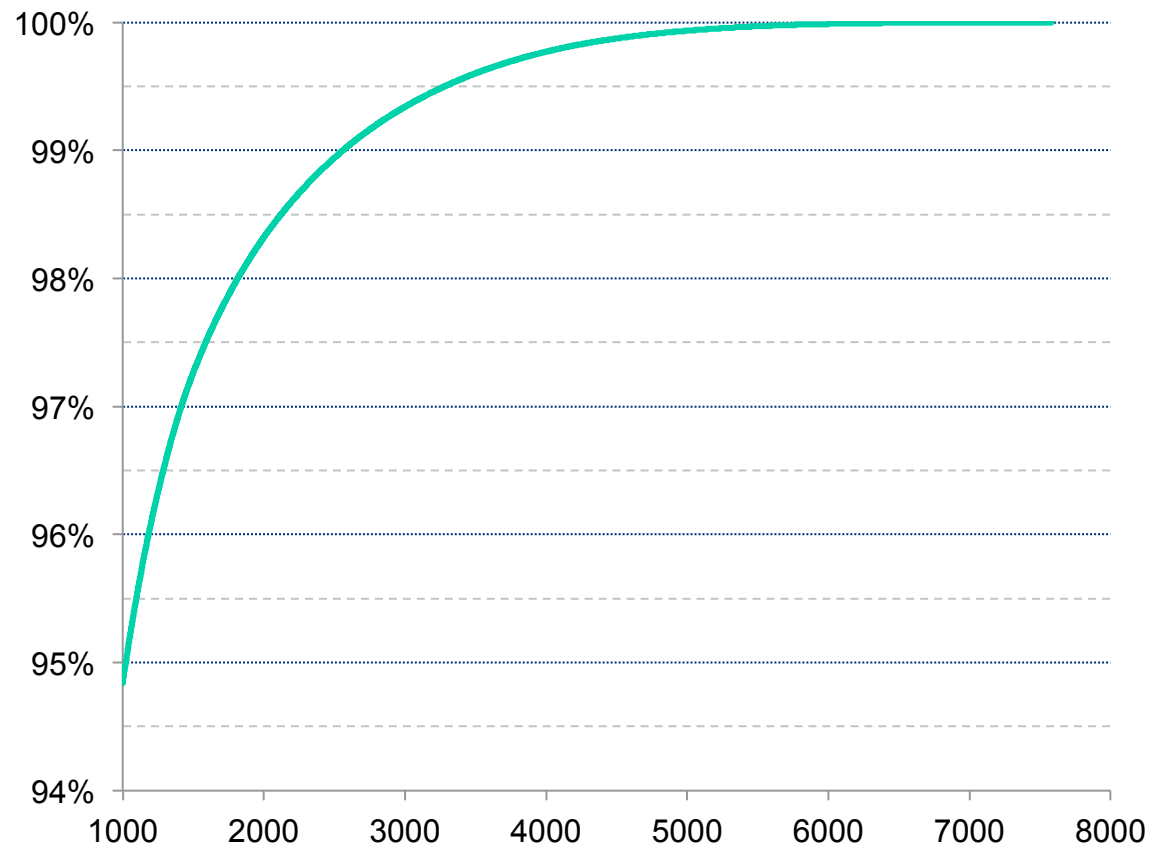
# Annotated Data – Current PropBank Status

*Pradhan, et.al., IJSC 2007, Albright, et. al., JAMIA, 2013, Palmer, et. al., ICON-09*

- ▶ **DARPA-GALE, OntoNotes 5.0**
  - ▶ BBN, Brandeis, **Colorado**, Penn
  - ▶ Multilayer structure: NE, TB, **PB, WS**, Coref
  - ▶ Three languages: **English, Arabic**, Chinese
  - ▶ Several Genres (@ ≥ 200K ): NW, BN, BC, WT
    - ▶ Close to 2M words @ language (less PB for Arabic)
  - ▶ Parallel data, E/C, E/A
  - ▶ PropBank frame coverage for rare verbs
  - ▶ Recent PropBank extensions
- ▶ **Clinical Notes – 400K available, goal is 700K**
- ▶ **Hindi/Urdu PropBank, 400K Hindi, 200K Urdu**
- ▶ **BOLT – discussion forums, SMS, email, Egyptian**

# PropBank Verb Frames Coverage

- ▶ The set of verbs is open
- ▶ But the distribution is highly skewed
- ▶ For English, the 1000 most frequent lemmas cover 95% of the verbs in running text.
- ▶ Graphs show counts over English Web data containing 150 M verbs.



# Verb Frames Coverage By Language – Current Count of Senses (lexical units)

<b><i>Language</i></b>	<b><i>Final Count</i></b>	<b><i>Estimated Coverage in Running Text</i></b>
<b>English</b>	<b>10,615*</b>	<b>99%</b>
<b>Chinese</b>	<b>24,642</b>	<b>98%</b>
<b>Arabic</b>	<b>7,015</b>	<b>99%</b>

- Only 111 English adjectives

# Included in OntoNotes 5.1: Extensions to PropBank

- ▶ **Original annotation coverage:**
  - ▶ PropBank: verbs; past participle adjectival modifiers
  - ▶ NomBank: relational and eventive nouns.
- ▶ **Substantial gap – now bridging**
  - ▶ Uniform treatment of light verbs,
  - ▶ Additional predicative adjectives,
  - ▶ Eventive nouns

# Gaps in proposition coverage

- ▶ Event Coreference chains include **nominalizations** with and without **light verbs**
  - ▶ “China has *threatened* to *slap* **sanctions** on American companies that *sell* arms to its rival Taiwan as part of a range of punitive **actions** Beijing is *taking* to *protest* the deal... ‘China will *make* further **judgments** as appropriate,’ *Xinhua reported.*”
  - ▶ Light verb/nominalization examples:  
*slap* **sanctions**, *taking* **actions**, *make* **judgments**
- ▶ PropBank structures for eventive nouns
  - ▶ **sanction**(China, US companies),
  - ▶ **act**(China),
  - ▶ **judge**(China, US companies)



# 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>]  
the [fundamentally correct<sub>ARGM-ADJ</sub>]  
[decision<sub>REL</sub>] [to get on offense<sub>ARG1</sub>]”

## 2-pass annotation, post-processing

- ▶ *China will make further judgments as appropriate.*
- ▶ Verb - REL: [*make*],
  - ▶ Arg0: *China*,
  - ▶ ArgPRX: *further judgments as appropriate.*
- ▶ Noun – RELPRX: [*judgment*]
  - ▶ Arg0: *China*
  - ▶ ArgM-PRD: *as appropriate*
- ▶ Merged – REL: RELPRX: [*make*] [*judgment*]
  - ▶ Arg0: *China*
  - ▶ ArgM-PRD: *as appropriate*

# Abstract Meaning Representations – AMR, Maximal Use of PropBank Frame Files,

*Knight, et. al., LAW-2013*

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

# SRL Questions

- ▶ Why Arg0 and Arg1?
- ▶ What about nouns and adjectives?
- ▶ What about other languages?
- ▶ How does PropBank relate to VerbNet and FrameNet?
- ▶ Will we ever get past the WSJ?
- ▶ How do SRL systems get trained?
- ▶ Can this be done without training data?
- ▶ .....

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