

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

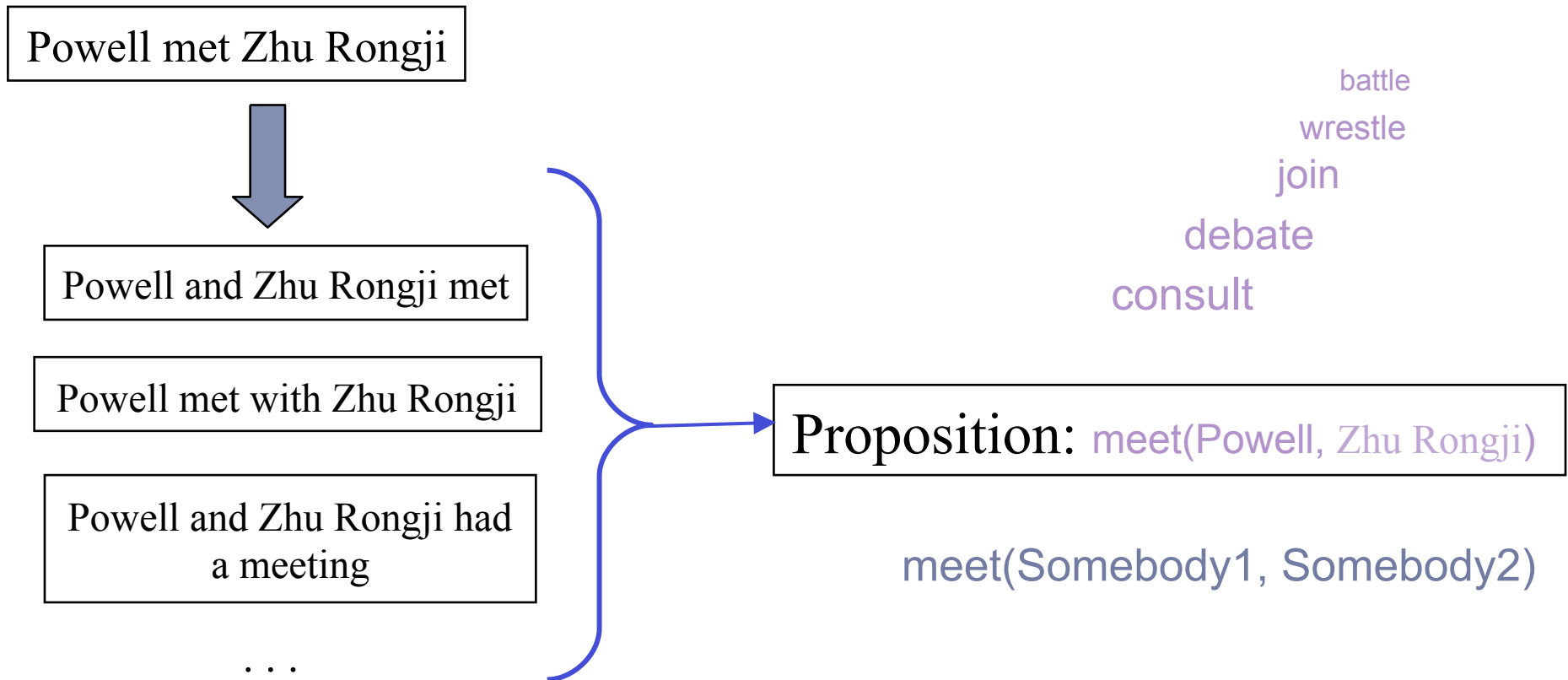
▶ Part 3

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.]

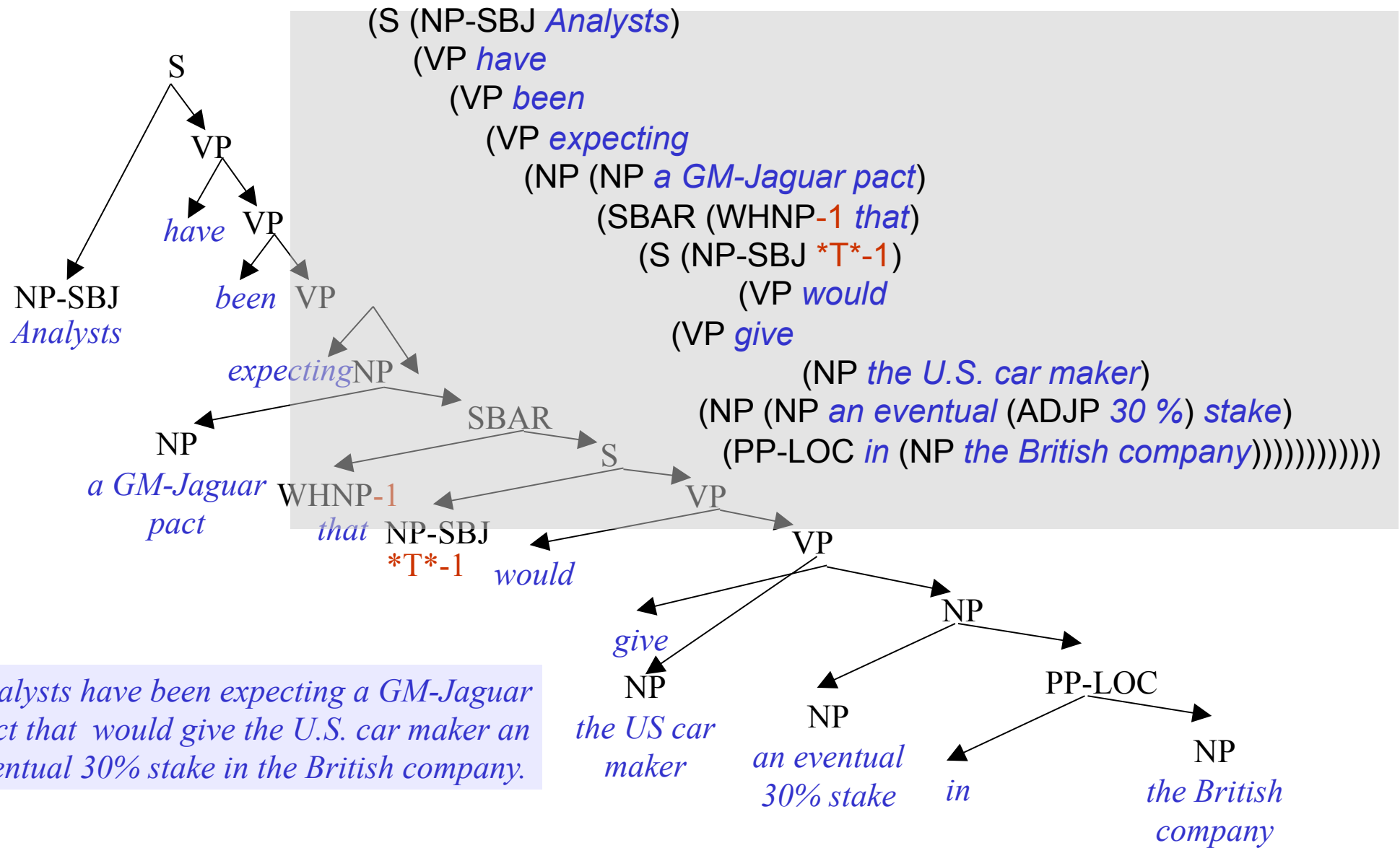
SUBJ

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

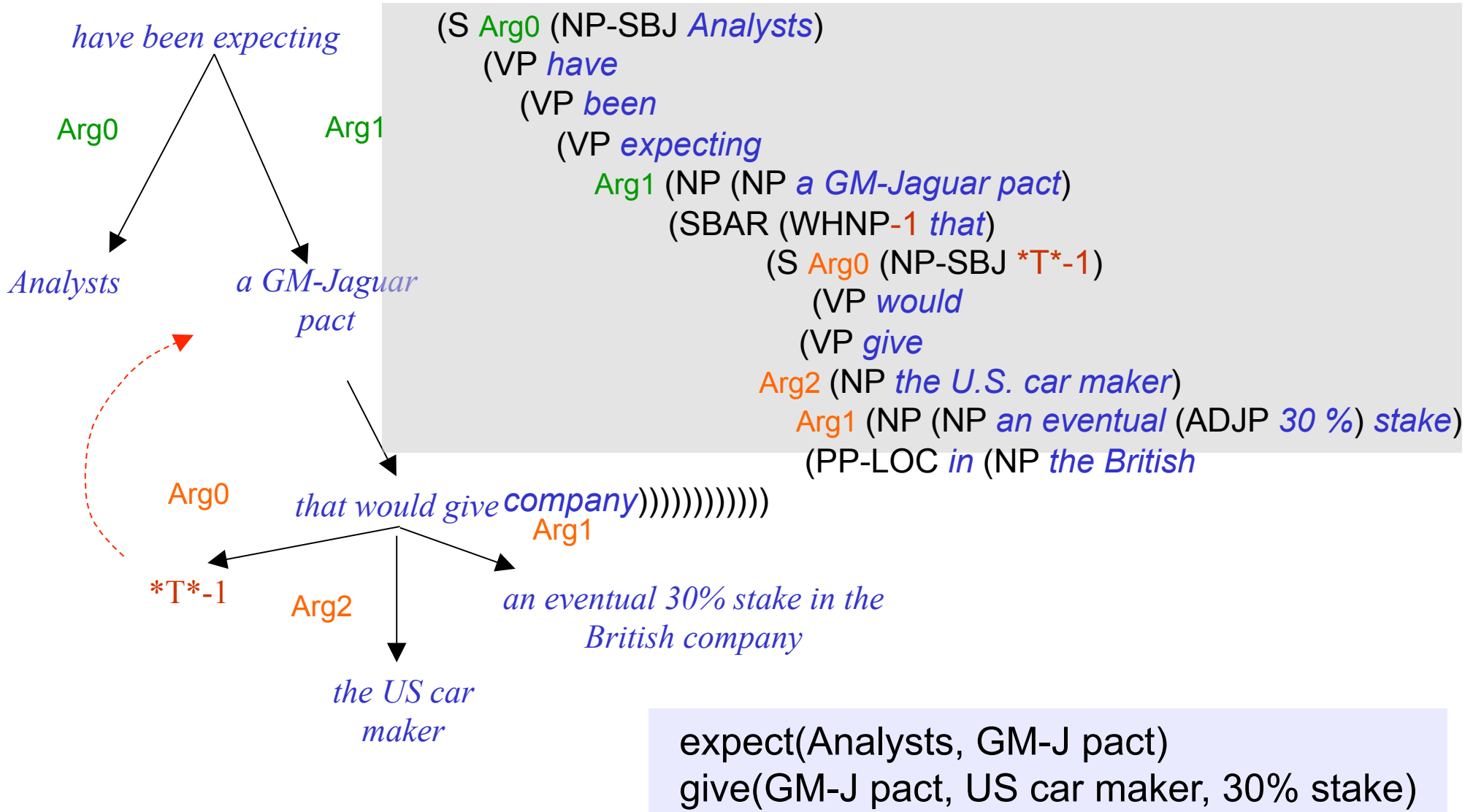
SUBJ

- ▶ [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?
- ▶ θ -Criterion (GB Theory): each NP of predicate in lexicon assigned unique θ -role (Chomsky 1981).

[_{Agent (or Source)} *Esau*] sold [_{Theme} *his birthright*]
[_{Goal} *to Jacob*] for a *bowl of porridge*.

[_{Goal} *Esau*] sold *his birthright*
[_{Source} *to Jacob*] for a [_{Theme} *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

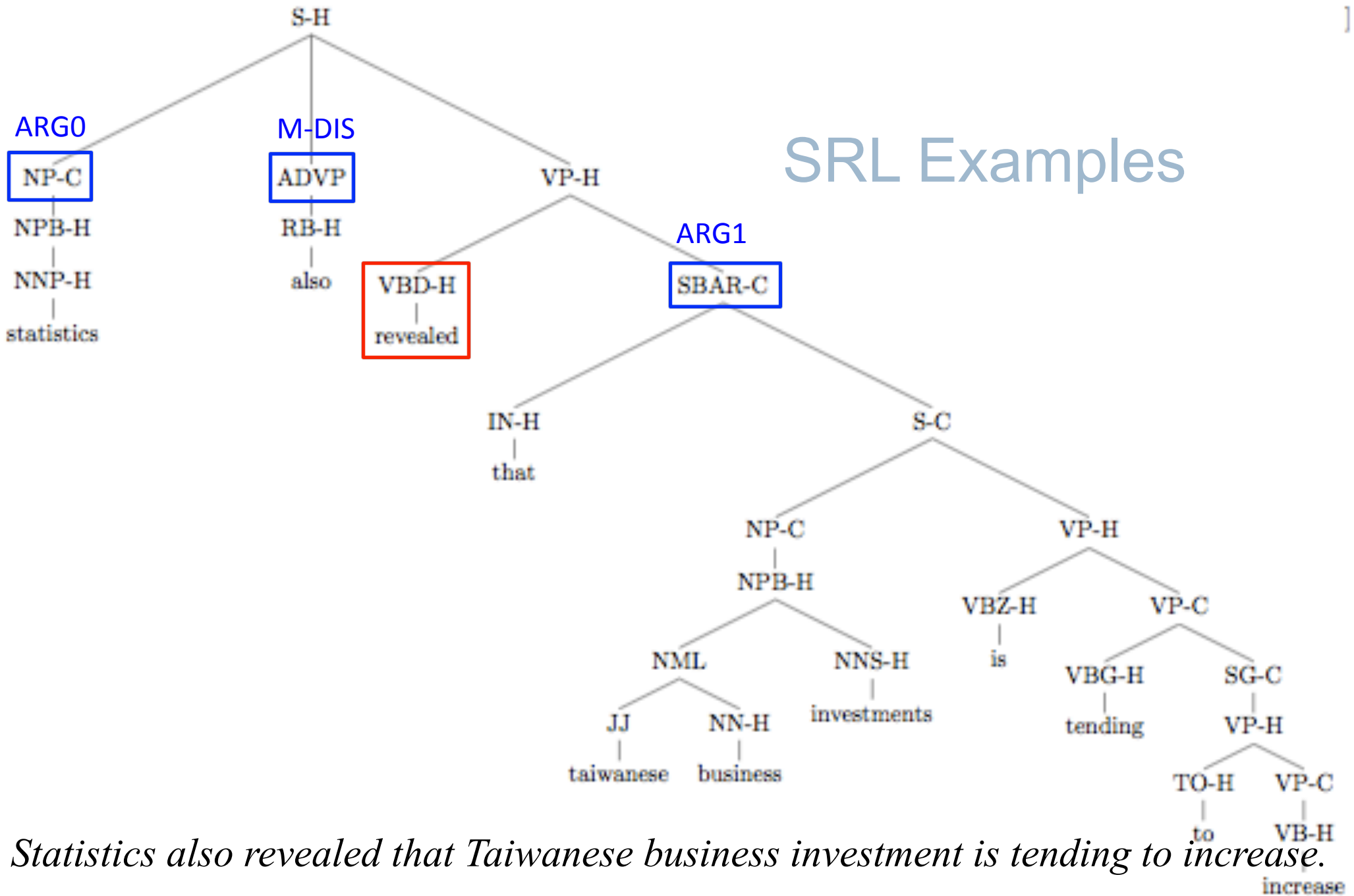
- Uuuuuusually...
 - Arg0 = agent, experiencer
 - Arg1 = patient, theme
 - Arg2 = benefactive / instrument / attribute / end state
 - Arg3 = start point / benefactive / instrument / attribute
 - Arg4 = end point

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

- **Variety of ArgM's:**

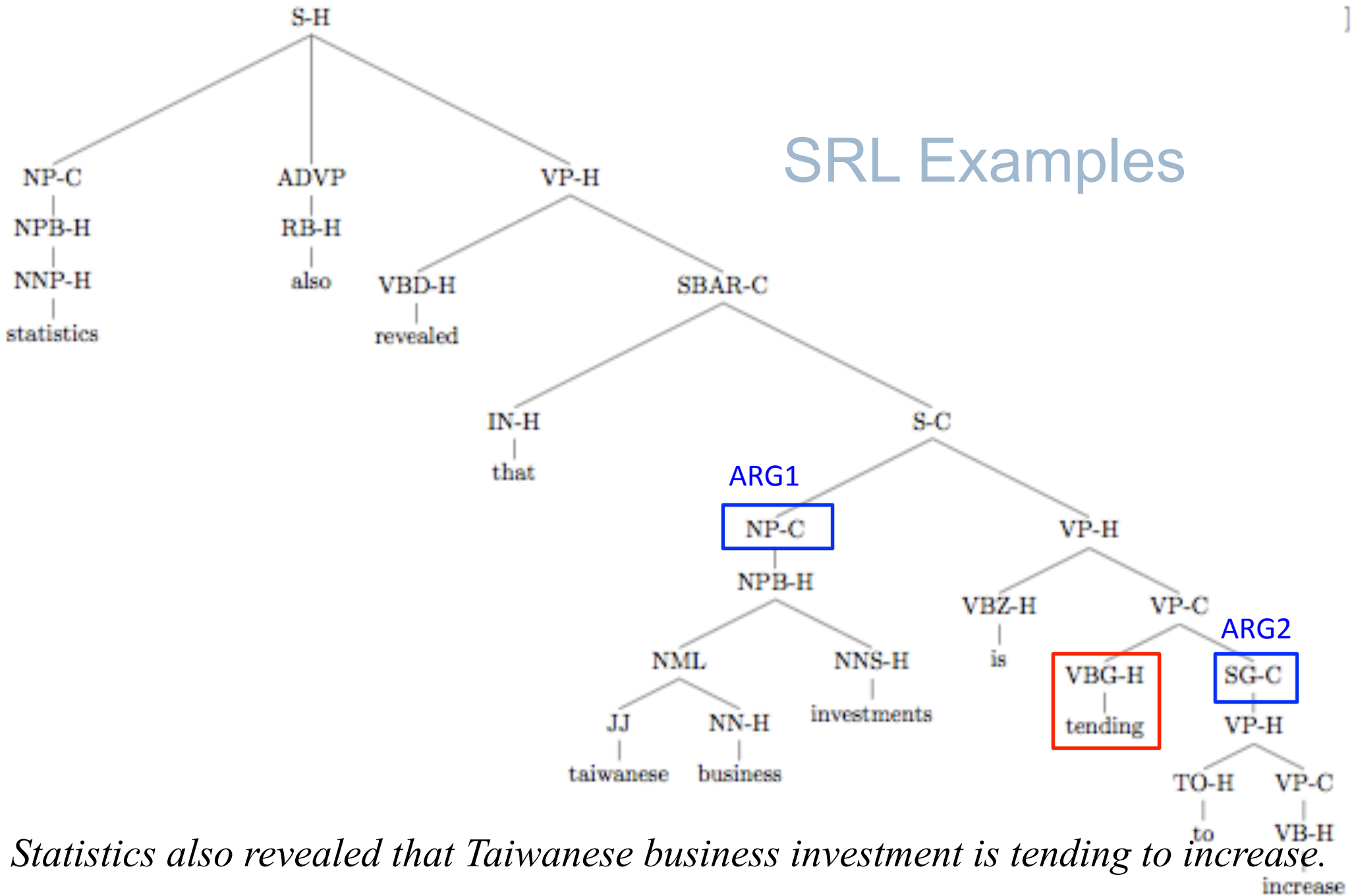
- TMP - when? *yesterday, 5pm on Saturday, recently*
- LOC - where? *in the living room, on the newspaper*
- DIR - where to/from? *down, from Antartica*
- MNR - how? *quickly, with much enthusiasm*
- PRP/CAU -why? *because ... , so that ...*
- REC - himself, themselves, each other
- GOL - end point of 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



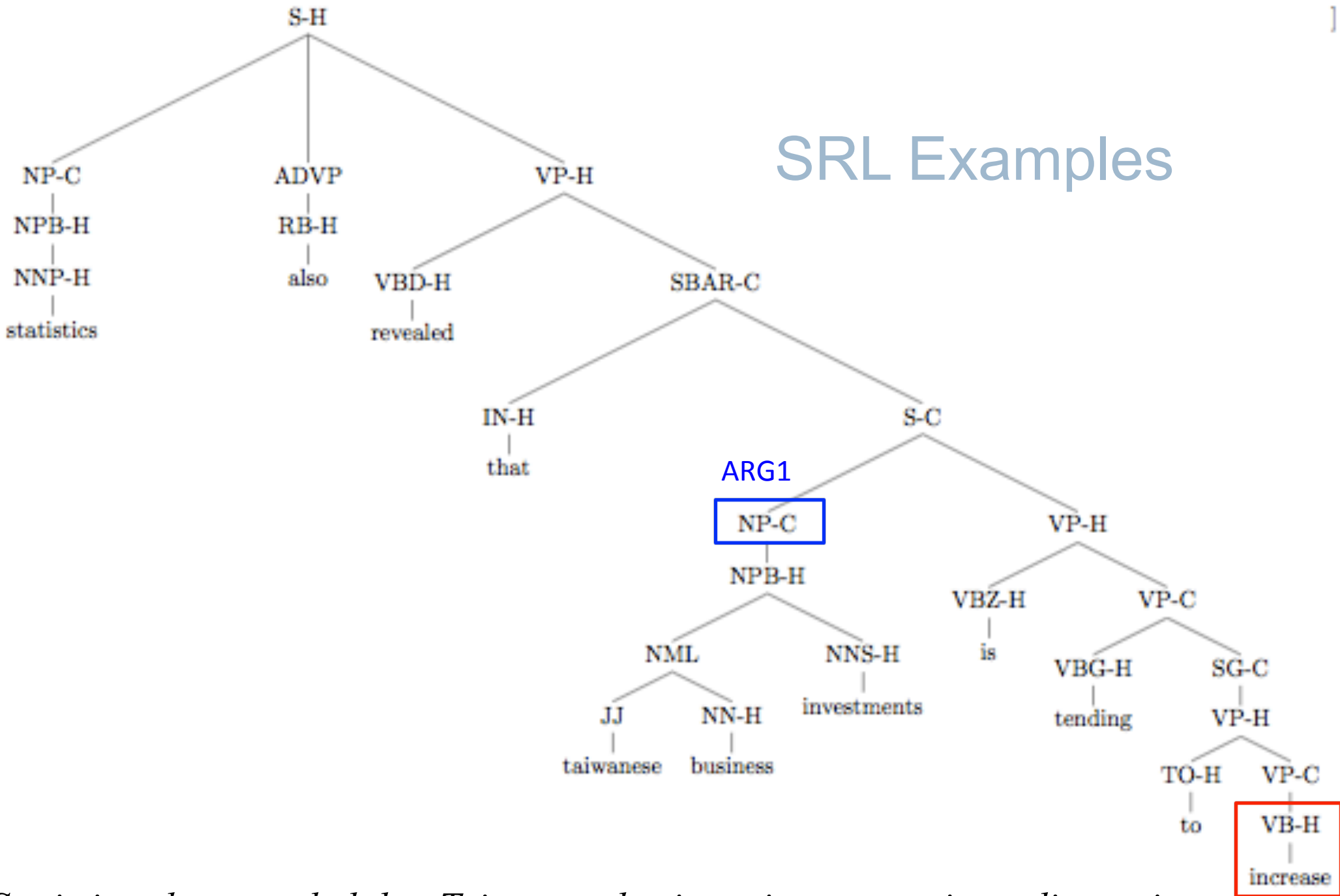
Statistics also revealed that Taiwanese business investment is tending to increase.

SRL Examples



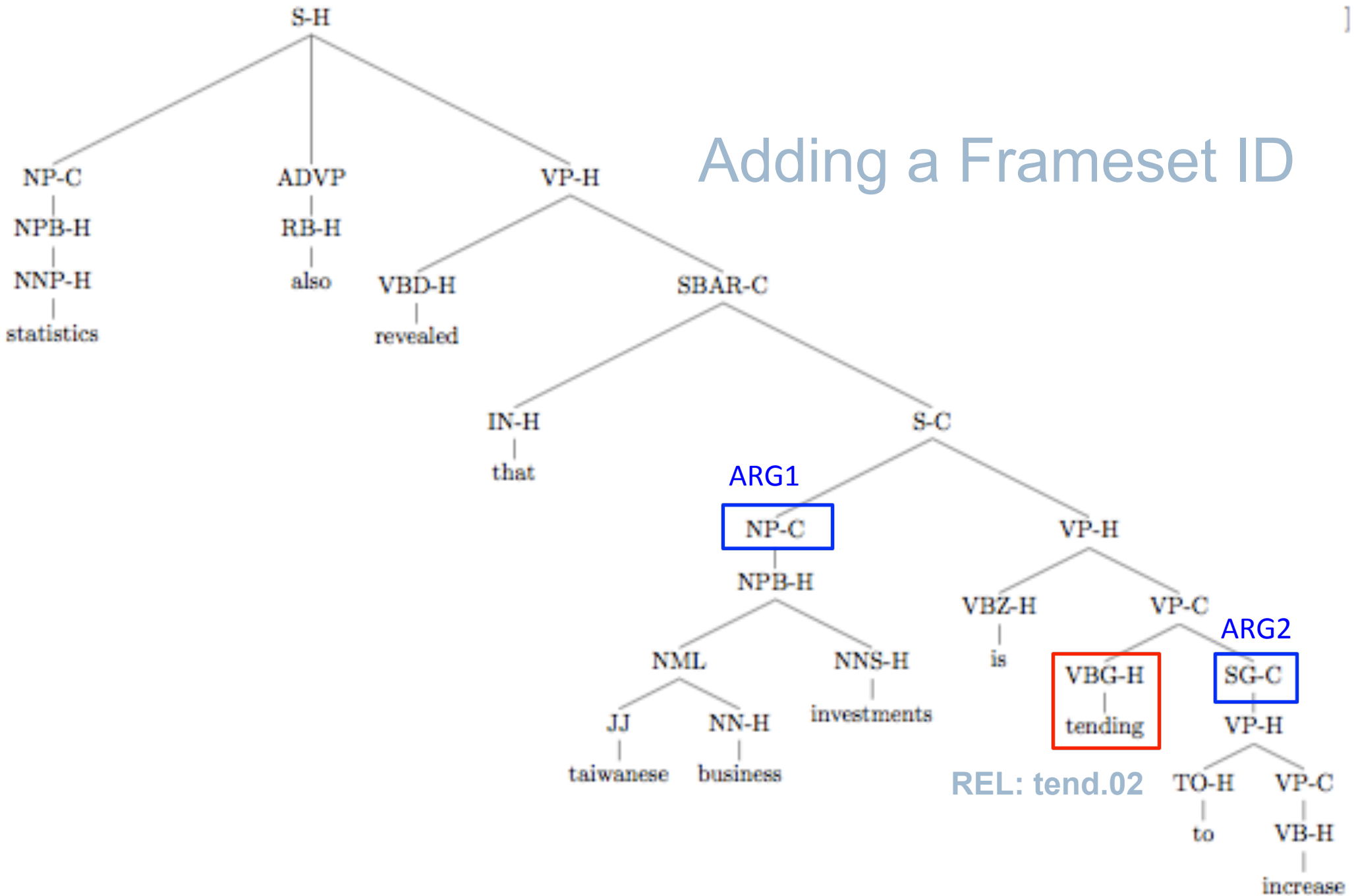
Statistics also revealed that Taiwanese business investment is tending to increase.

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.*

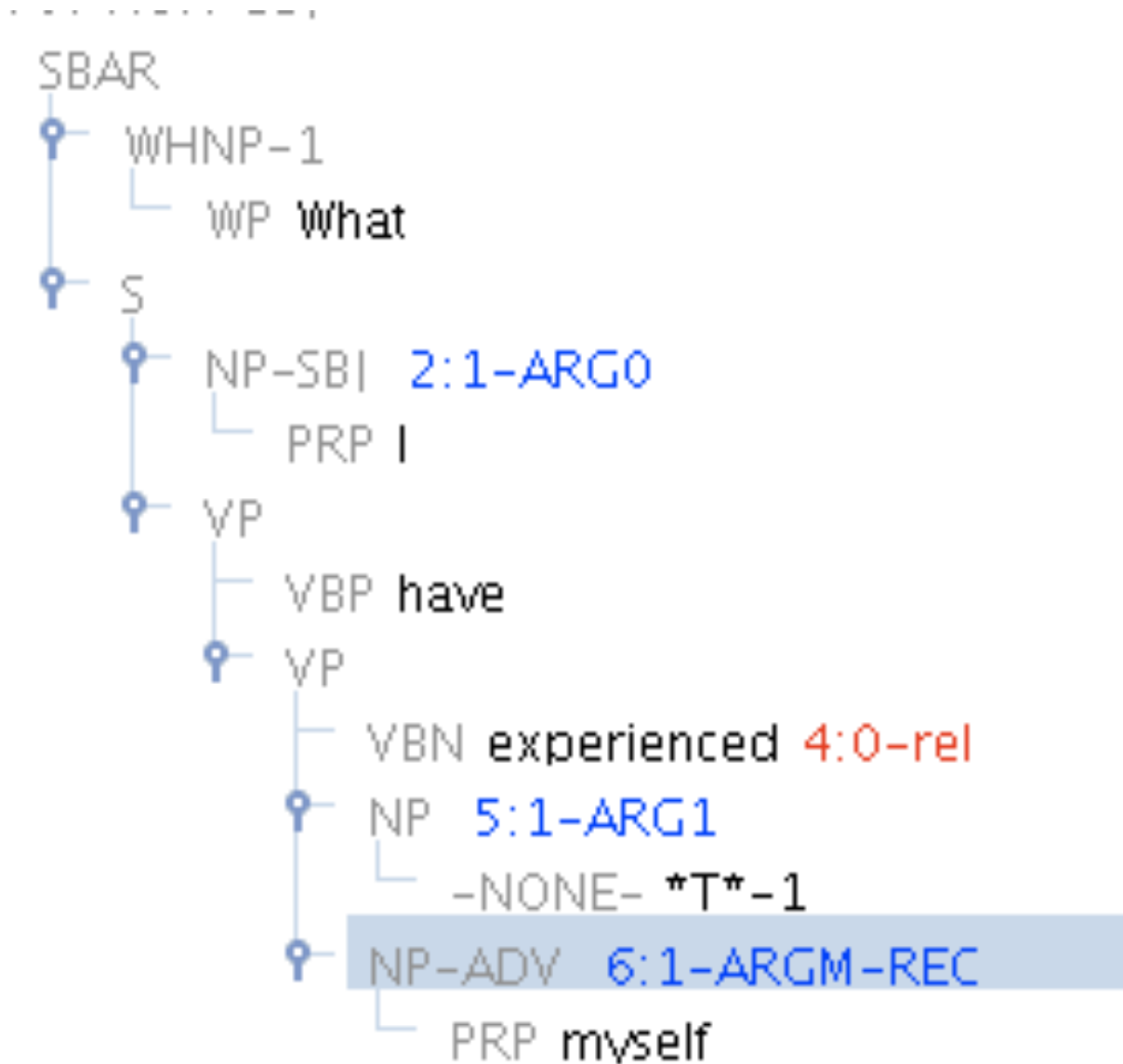
Arg1: *The cost, or premium*

REL: *tend*

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

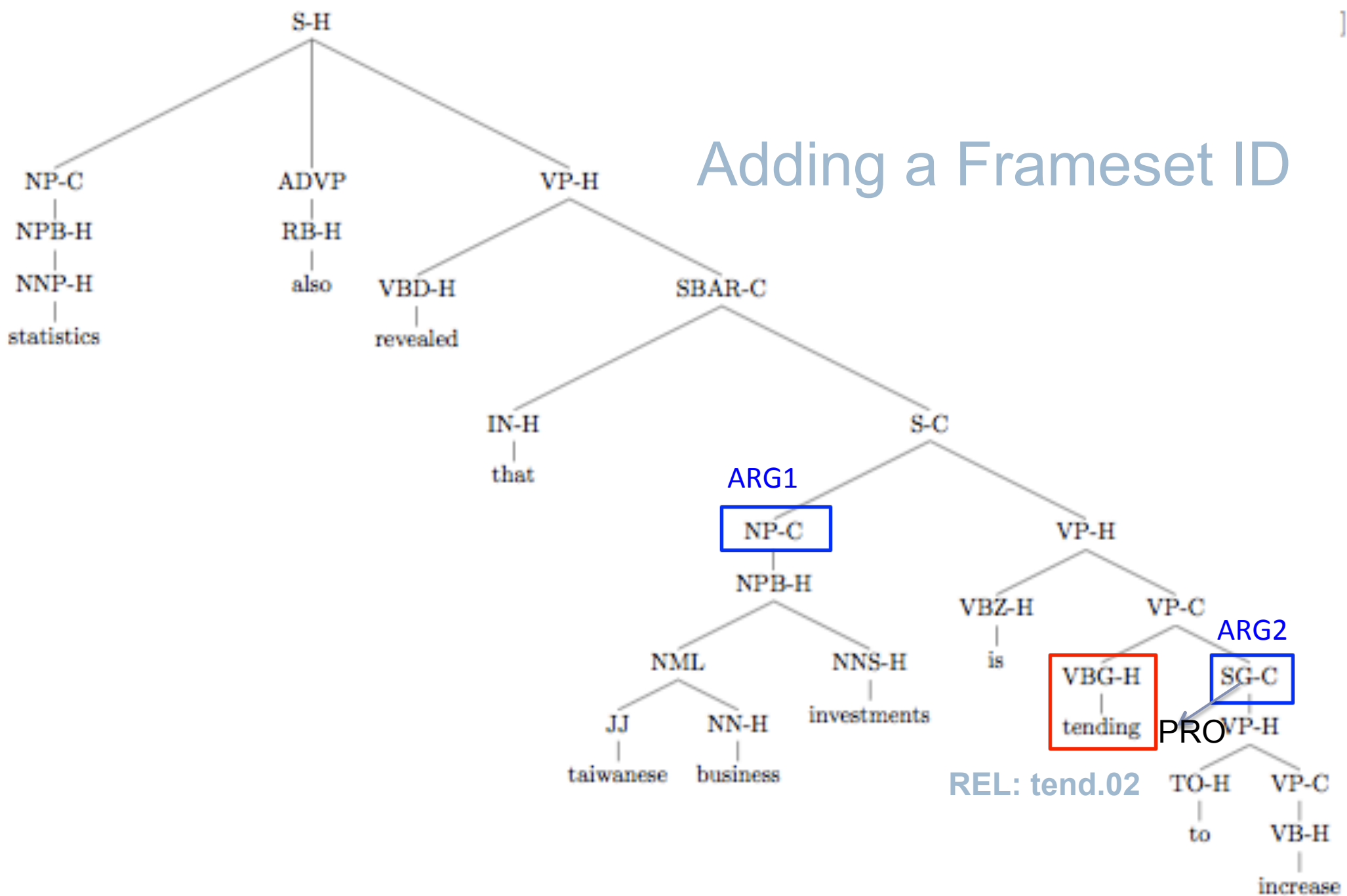
Visual Example: traces BASED on Jubilee

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

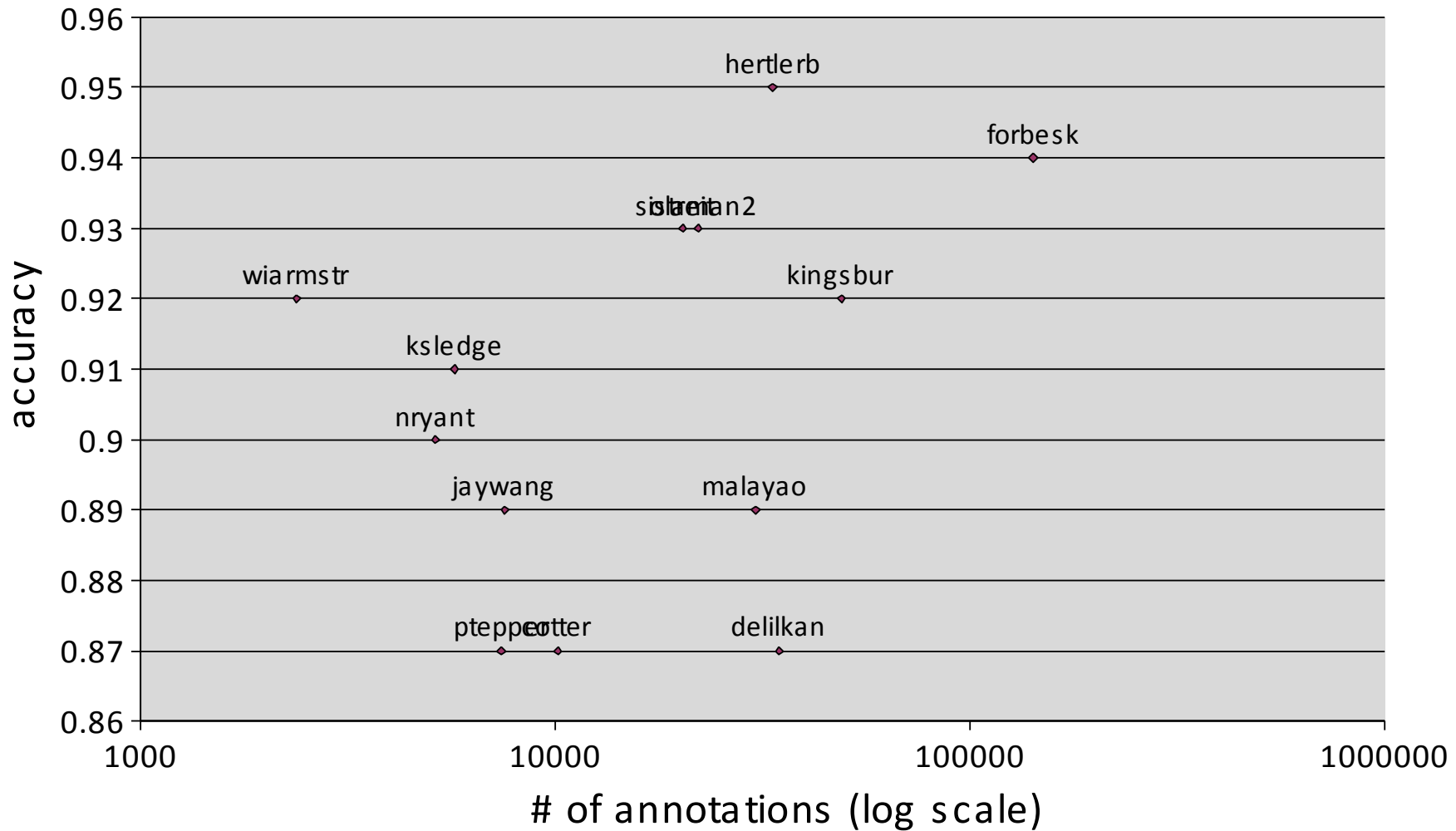
- ▶ PTB II - Extraction of all sentences with given verb
- ▶ Create Frame File for that verb *Paul Kingsbury*
 - ▶ (3100+ lemmas, 4400 framesets, 118K predicates)
 - ▶ Over 300 created automatically via VerbNet
- ▶ First pass: Automatic tagging (*Joseph Rosenzweig*)
 - ▶ <http://www.cis.upenn.edu/~josephr/TIDES/index.html#lexicon>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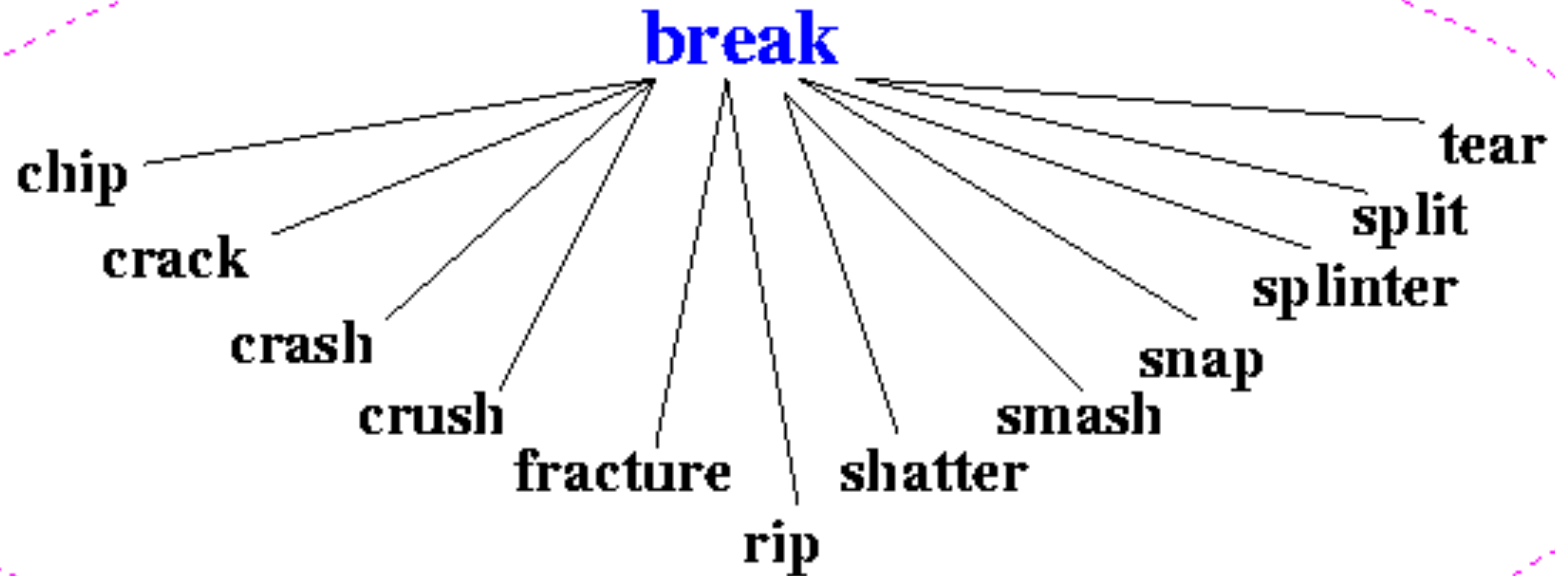
A Preliminary Classification of English Verbs, *Beth Levin*

- ▶ 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 -

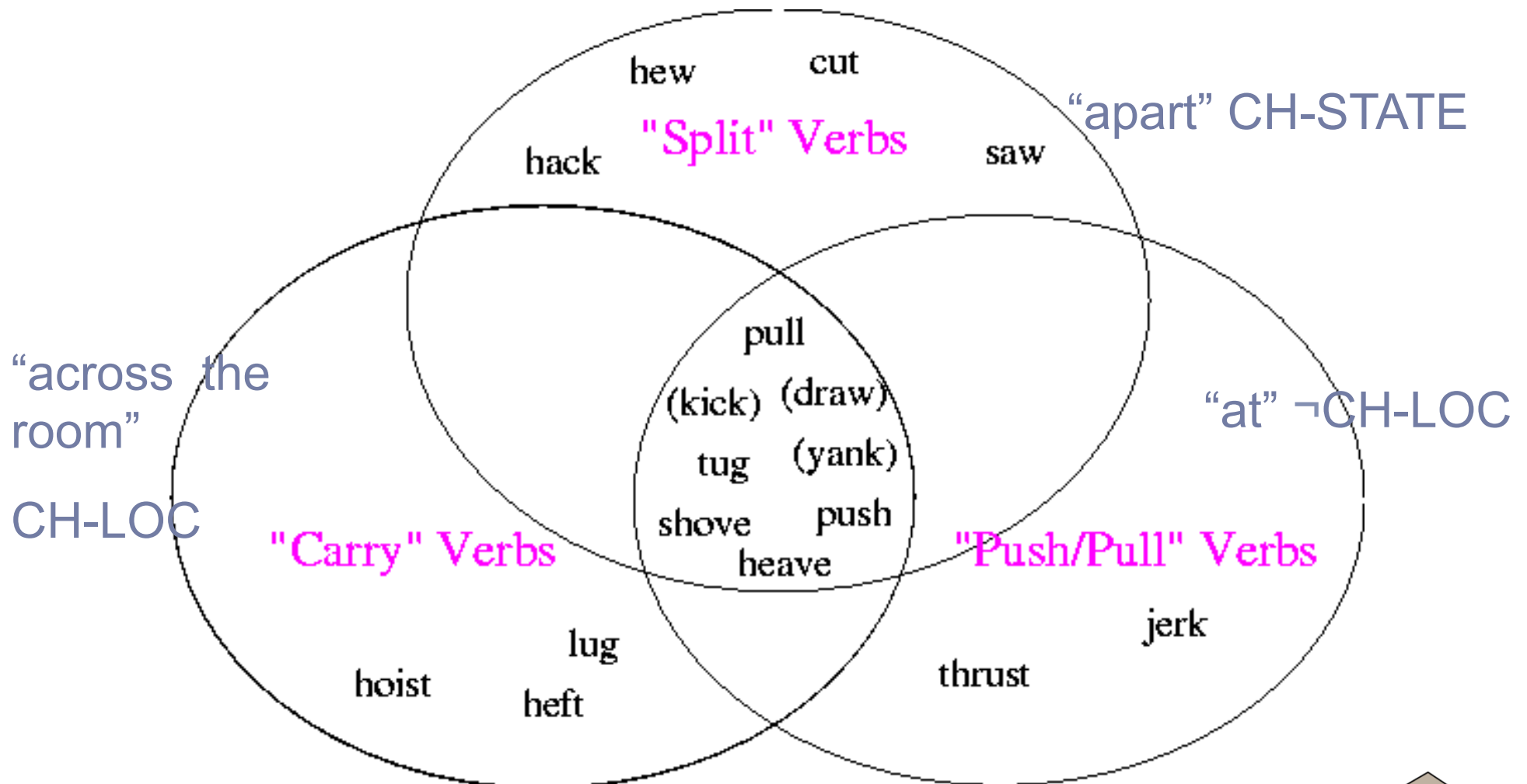
Change-of-state



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, ...;*

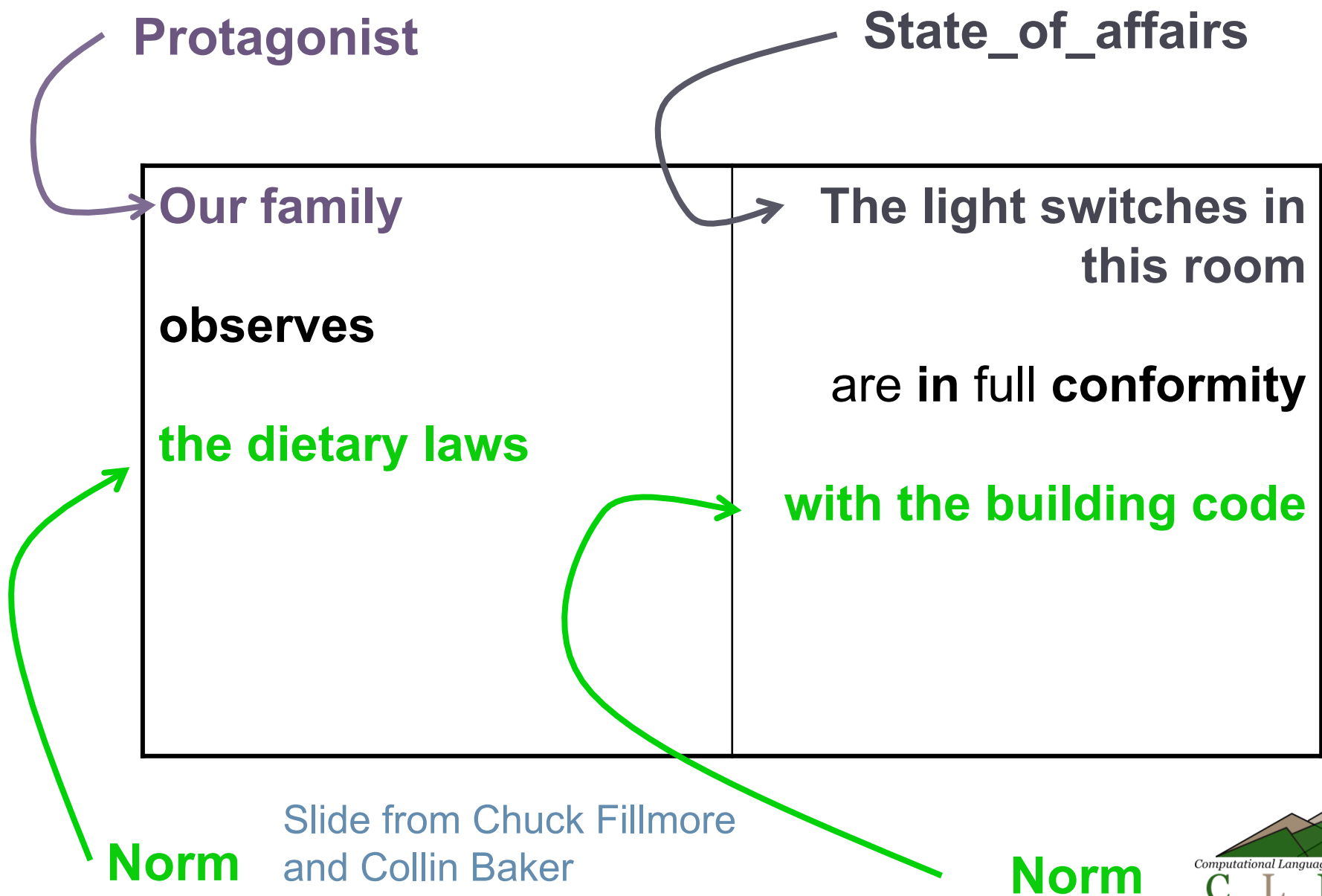
AND NOT ONLY WORDS FOR POSITIVE RESPONSES TO NORMS

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

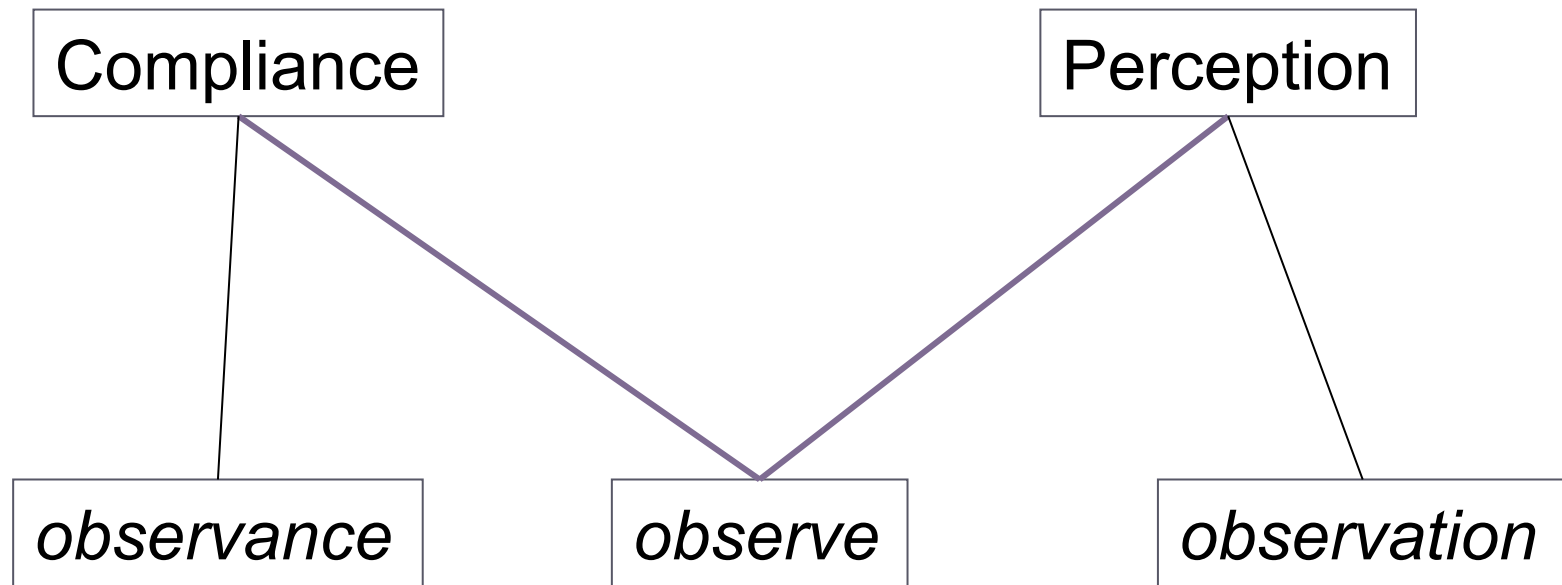
N - *breach, disobedience, transgression, violation,...;*

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

Tagging Compliance sentences



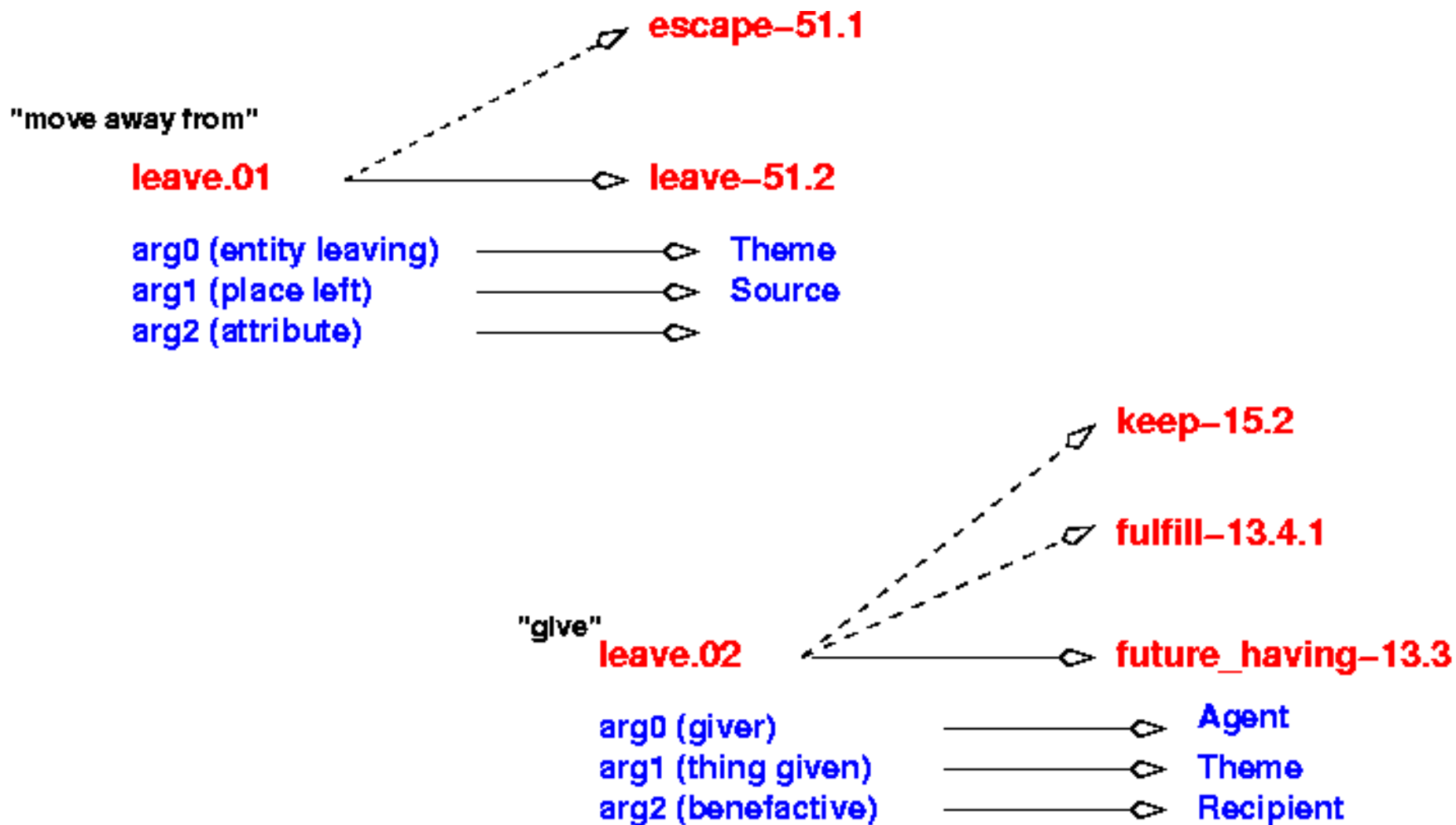
words, frames, lexical units



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 = <i>leave.02</i> | Sense = <i>give</i> | VerbNet class = <i>future-having 13.3</i> |
| 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)

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

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

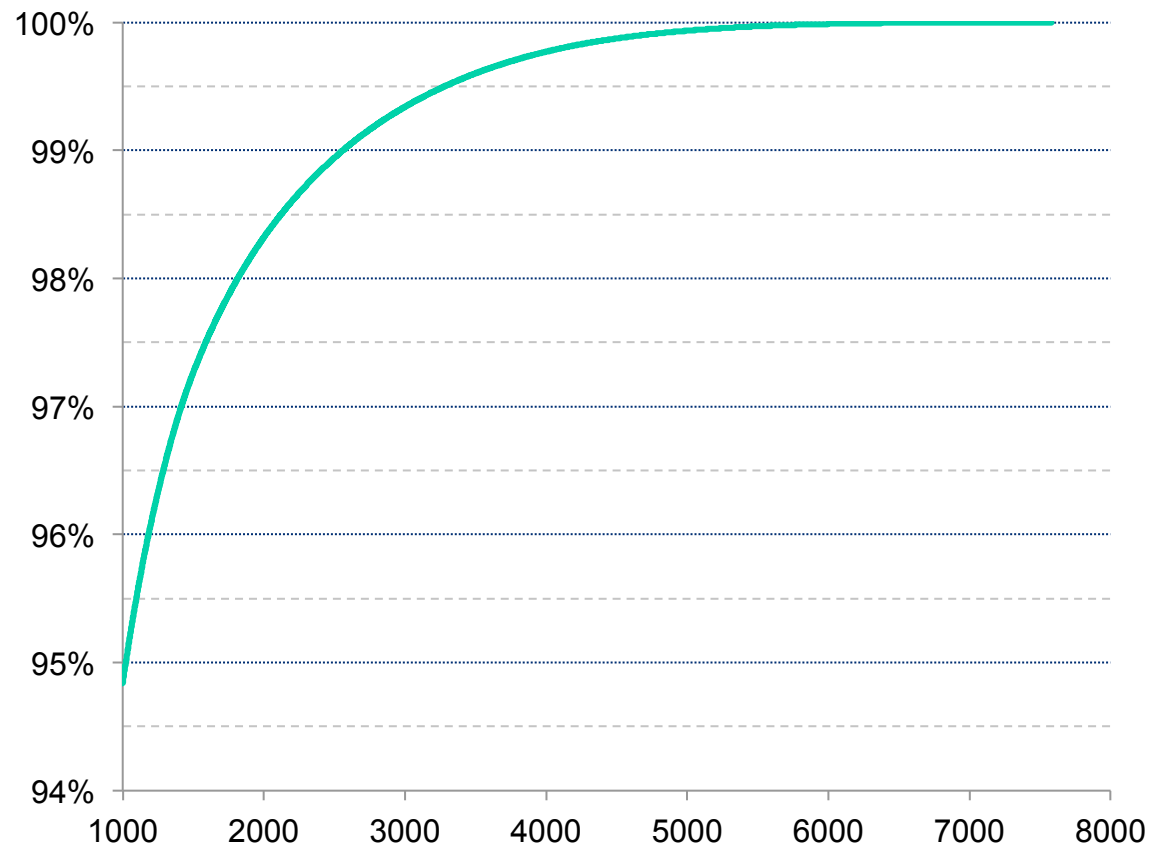
Annotated Data – Current PropBank Status

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)

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

- 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**_{ARG0}] [decision_{REL}]
[to say look I don't want to go through this anymore_{ARG1}]”

- ▶ Example within an LVC: *Make a decision*

- ▶ “...[**the President**_{ARG0}] [made_{REL-LVB}]
the [fundamentally correct_{ARGM-ADJ}]
[decision_{REL}] [to get on offense_{ARG1}]”

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?
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