MSFA-based Annotation of Texts for Semantic Information

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Presentation for Pat Pantel
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Overview

- Introducing Multi-layered/dimensional Semantic Frame Analysis (MSFA; henceforth)
  (Kuroda & Isahara 2005; Kuroda et al. 2006)
- By specifying its
  - Motivation
  - Methodology
  - Prospective products from MSFA-based annotation

Motivation

Many people think

- It would be nice if we had corpora annotated for semantic information.
  - It would make NLP researchers, linguists and cognitive scientists all happy
- And it would be *very* nice
  - if the annotation is informative enough
  - and if the corpus is large enough.

But

- Language is complex.
  - After decades of research in many fields including Artificial Intelligence, cognitive psychology, linguistics, and NLP, it is still unclear how people make sense out of a text.
- Semantics is (still) a beast (if not so much as pragmatics).
  - At first glance, it is not clear what to annotate
  - Too much freedom is allowed.

Problem

- We could proceed roughly as follows:
  1. Choose a text T.
  2. Identify all and only meaningful substrings s_1, s_2, ..., s_n, of T.
  3. Annotate such substrings with adequate labels.
- Here come crucial problems ...

Problem

1. What guarantees the meaningfulness of substrings?
   - We need a good *theory* of meaningfulness.
2. How to deal with overlaps of allegedly meaningful substrings?
   - We need a descriptive model more powerful than phrase structure analysis that requires mutual exclusivity among substrings.

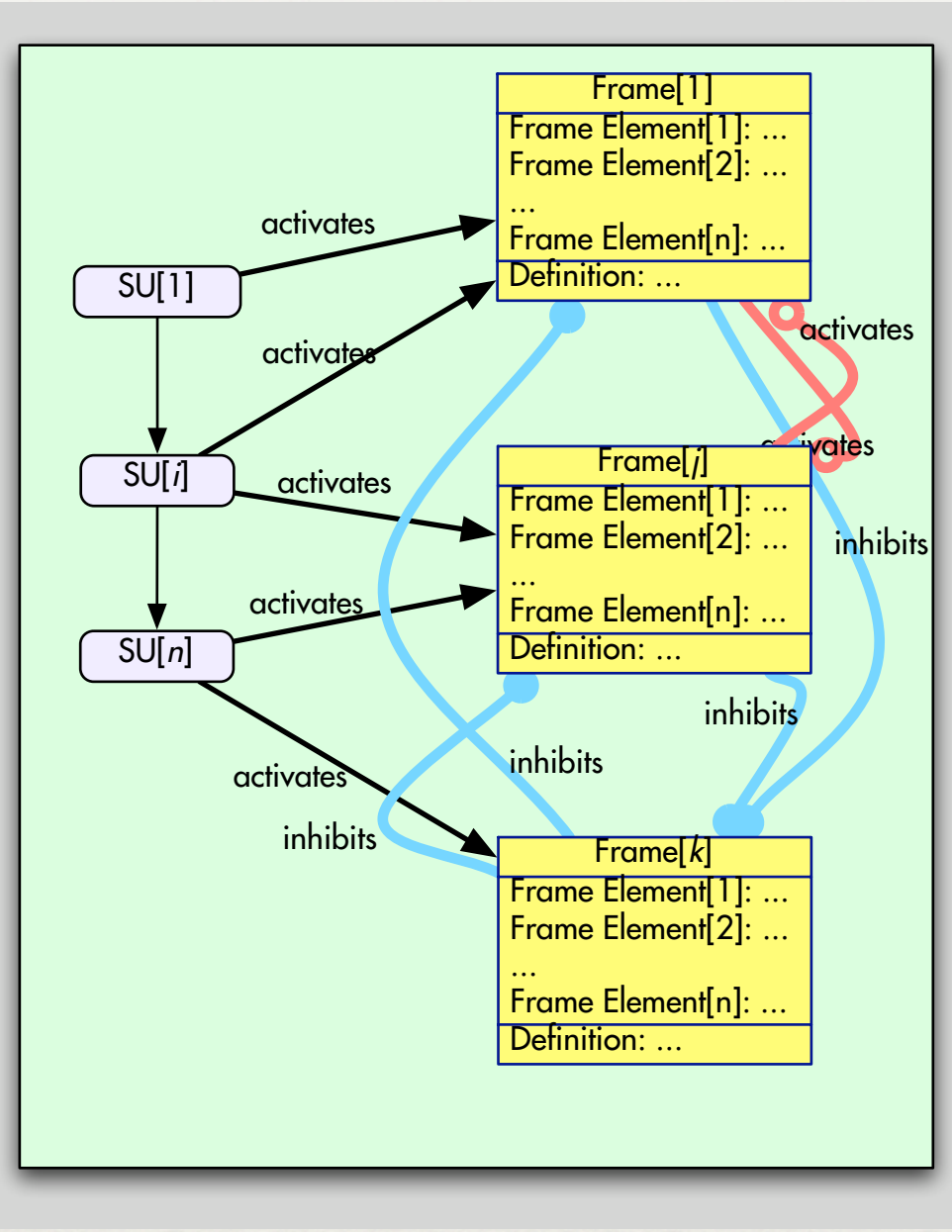
Approach

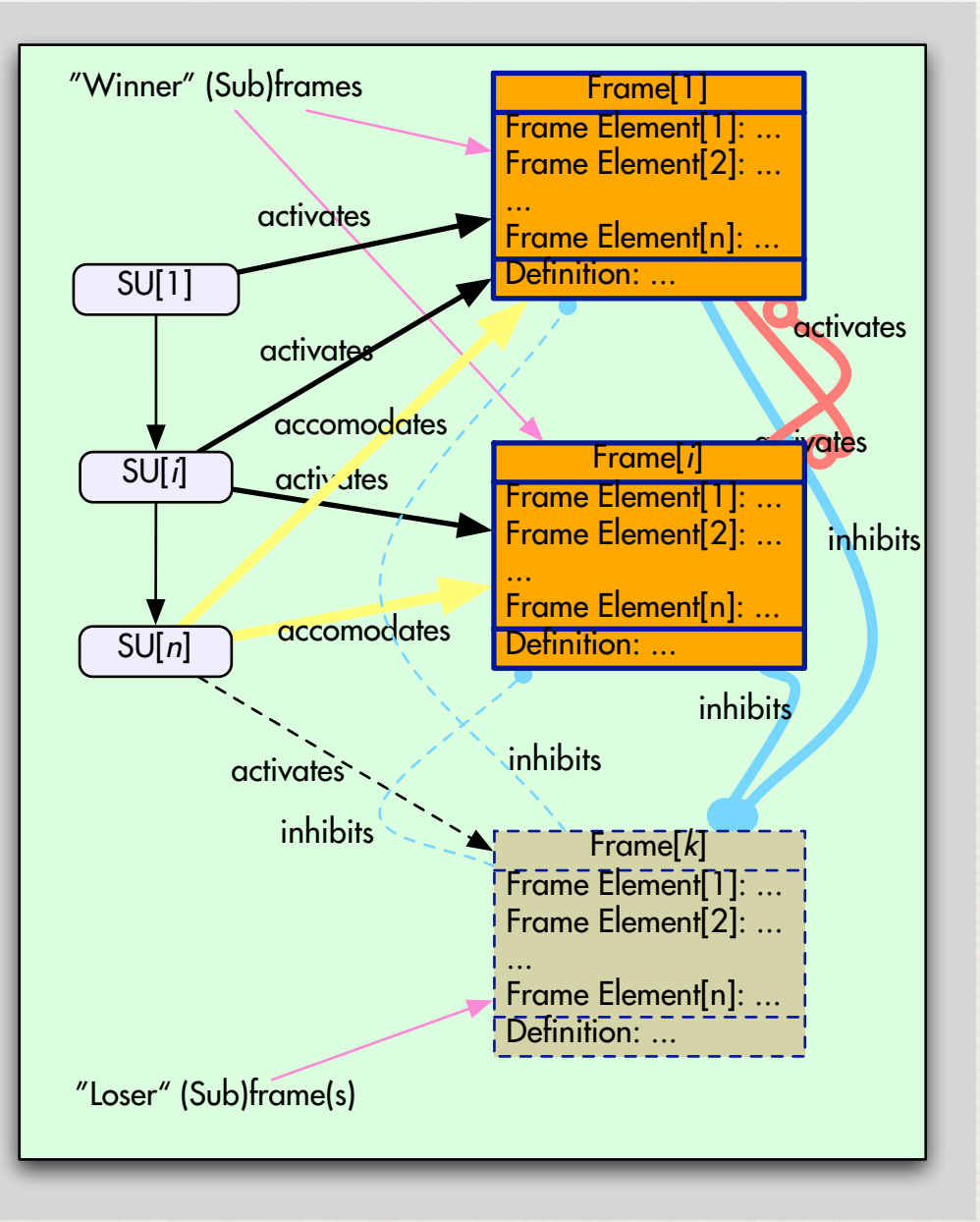
- For Problem 1, we adopt Frame Semantics/ FrameNet (Fillmore et al. 1998).
- For Problem 1, we adopt the idea of (Parallel Multiple) Pattern Matching Analysis (Kuroda 2000).
- MSFA integrates the two.

Methodology

Frame Semantics View

- A frame-evoking unit $(s)u_i$ in a sentence S "evokes" a set of "frames" $\{f_{i,1}, f_{i,2}, \ldots, f_{i,Ni}\}$.
- All units do so independently, giving the set $F(S) = \{\{f_{1,1}, f_{1,2}, \ldots, f_{1,N1}\}, \ldots, \{f_{i,1}, f_{i,2}, \ldots, f_{i,Ni}\}, \ldots\}$
- $F(S)$ undergoes a "selection" in the Darwinian fashion, giving a much smaller set $G(S) = \{f_1, f_2, \ldots, f_m\}$ $(\in F)$.
- The meaning of S is determined by $G(S)$.


Frame[1]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...
activates
SU[1]
activates
activates
SU[i]
activates
Frame[j]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...
inhibits
activates
SU[n]
inhibits
inhibits
activates
inhibits
Frame[k]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...


"Winner" (Sub)frames
Frame[1]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...
activates
SU[1]
activates
accomodates
SU[i]
activates
Frame[i]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...
activates
inhibits
SU[n]
accomodates
inhibits
activates
inhibits
Frame[k]
Frame Element[1]: ...
Frame Element[2]: ...
...
Frame Element[n]: ...
Definition: ...
"Loser" (Sub)frame(s)

Remarks

- Frame-evoking units need not be words.
- Longer units, even when discontinuous, show stronger evocation effect.
  - confirmed by psychological experiments (Nakamoto & Kuroda 2007)
  - in conformity with *Idiom Principle* (Sinclair 1991) and *One Sense per Collocation* Hypothesis (Yarowsky 1993)

Remarks

- Of course, some words *do* evoke specific frames.
  - Verbs with finer-grained semantics like *assassinate, rob* evoke, but generic verbs like *attack, hit* don't.
  - Nouns with finer-grained semantics like *prey, victim, assassin, robber, prey* do, but generic nouns like *man, woman, animal* don't.
- They are lexical items with high recall and low precision in predictiveness.

Method Redefined

- Given a sentence *S* (of a text *T*).
- Identify as many frame-evoking units, or "evokers," as possible.
- Label each frame-evoker with
  - a specific frame name like <Predation>, <Robbery>, <Assassination>
  - or a specific frame element name such as <Prey>, <Predator>, <Victim>, <Robber>, <Assassin> if possible.

Semantic Roles and Types

- Situation-specific semantic roles (= frame elements) like *prey, predator, victim, robber* plays a major role in semantic annotation.
  - They are the key to the effective description of so-called "selectional restrictions" (Resnik 1993, 1997)
- This means that we can benefit from effective identification of role names.
  - Yet most thesauri including WordNet conflate role names and type names.

Remarks

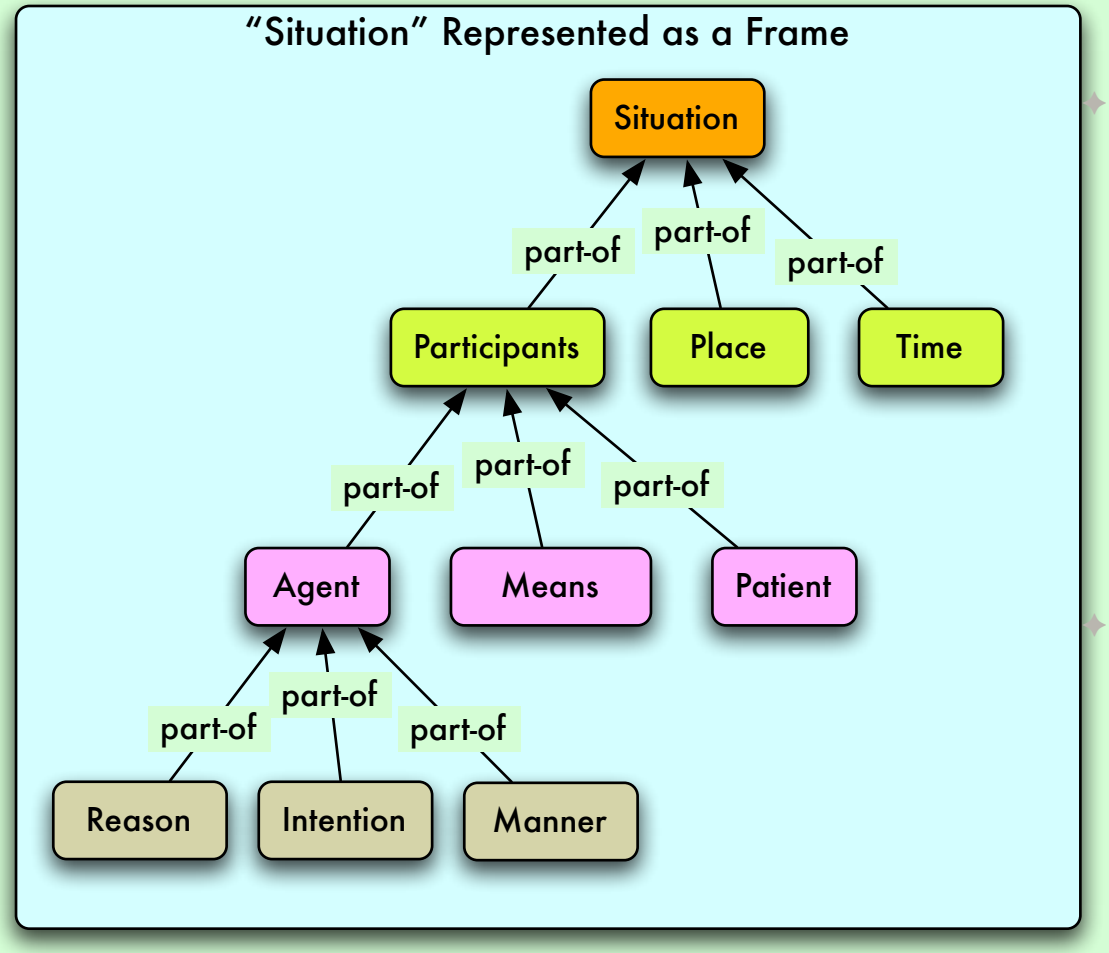
- Basic distinction is between object-denoting nouns and non-object-denoting nouns (Guarino 1991; Gentner & Kurtz 2005). The latter includes:
  - names for roles (e.g., *predator*, *prey*)
  - names for functions or functional parts/components (e.g., *filter, face, engine, seat*)
  - nouns for values (e.g., *meter(s), litter(s)*)
- These typically behave as frame-evokers.

Remarks

- But certain object nouns (e.g., *wolf, shark*) behave like role-denoting nouns (e.g., *predator in the woods, predator in the sea*)
  - when they are regarded as "representative" instances for the relevant roles.
- Conjecture
  - Expressions containing frame-evoking elements make good seeds for the bootstrap methods like *Espresso* (Pantel & Pennachiotti 2006)

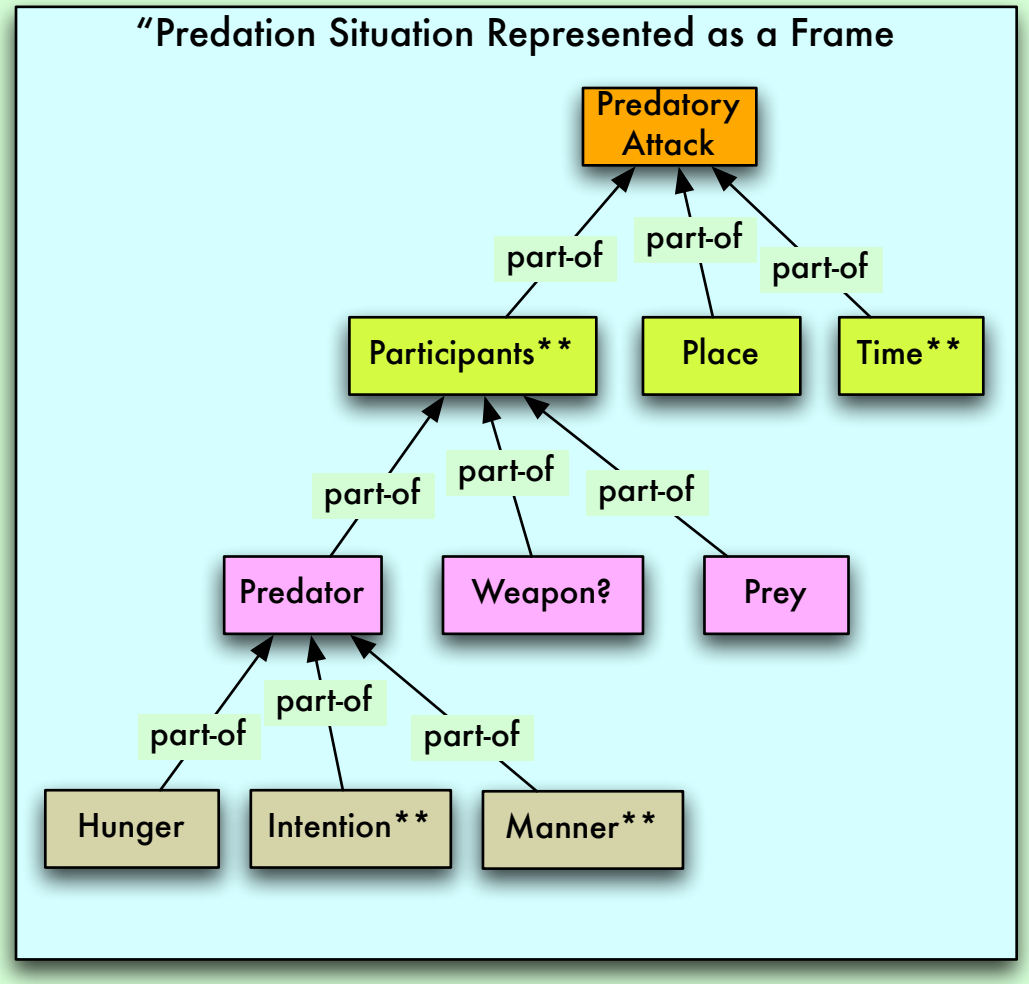
How to Annotate with MSFA

Situation as a Frame



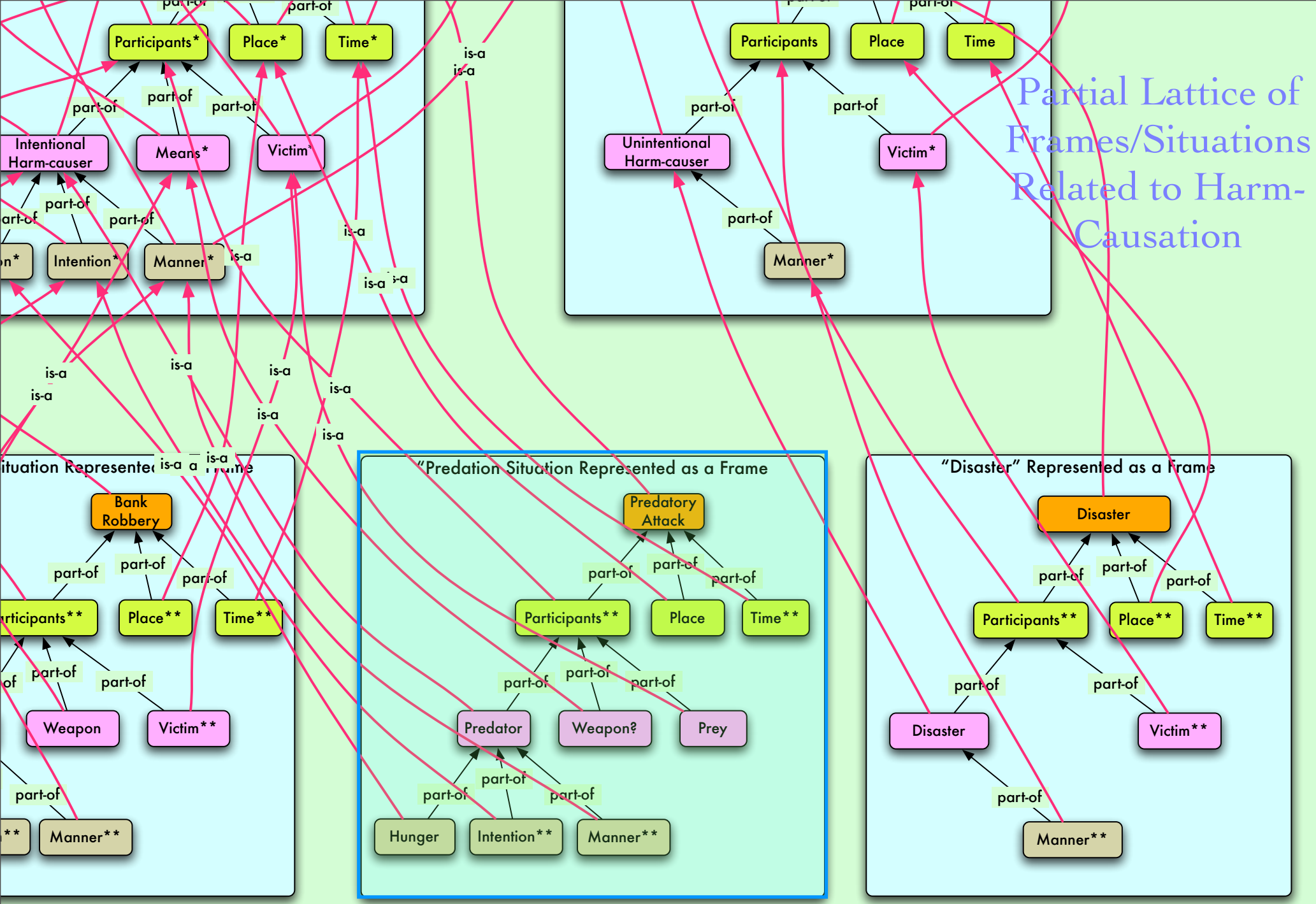
- Basic components of a situation
  - Participants
  - Time
  - Place
- And with generic thematic/semantic roles like Agent, Means, Patient

Subclassing a Situation

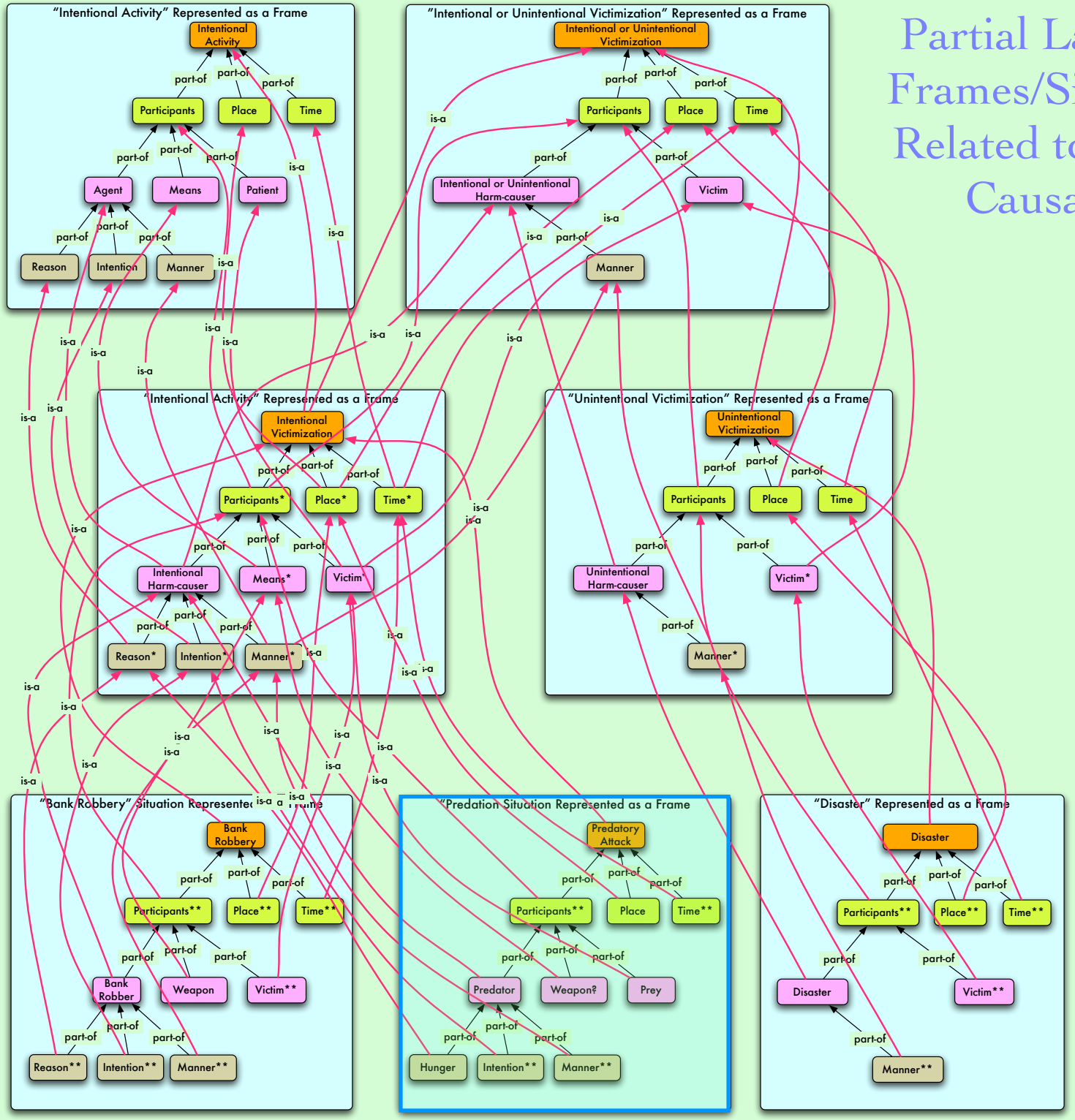


Conceptual elaboration/ subclassing takes place, giving arise such finer-grained concepts as:

- Predator is-a Agent
- Weapon is-a Means
- Prey is-a Patient


Partial Lattice of Frames/Situations Related to Harm-Causation
Participants*
Place*
Time*
Intentional Harm-causer
Means*
Victim*
Intention*
Manner*
Participants
Place
Time
Unintentional Harm-causer
Victim*
Manner*
is-a
part-of
"Predation Situation Represented as a Frame
Predatory Attack
Participants**
Place
Time**
Predator
Weapon?
Prey
Hunger
Intention**
Manner**
"Disaster" Represented as a Frame
Disaster
Participants**
Place**
Time**
Disaster
Victim**
Manner**
Bank Robbery
Place**
Time**
Weapon
Victim**
Manner**

Partial Lattice of Frames/Situations Related to Harm-Causation



Deriving role hierarchies

- The following role hierarchies derive from situation hierarchies under <Victimization> and <Intentional Activity>:
  - <Predator> is-a <Harm-causer> and is-a <Agent>
  - <Robber> is-a <Harm-causer> and is-a <Agent>
  - <Prey> is-a <Victim> (of a <Predator>) and ?is-a <Patient>
  - <Bank> is-a <Victim> (of a <Bank Robber>)
  - <Disaster> is-a <Harm-causer> but not is-a <Agent>

So, why Multilayered?

- For a given S, a set of frames/situations $F(S) = \{f_1, f_2, \ldots, f_n\}$ determine the meaning of, or the "understood content" of S.
- All such frames/situations have an internal structure independent of each other.
- They need to be specified on distinct layers.
- This allows us to proper management of "overlaps" among semantic labels/identifiers.

MSFA Sample

(1) As usual, hungry lions are looking for impalas.

Sample MSFA of (1)

Frame ID (local)	F0	F1	F2	F3	F4	F5	F6
Frame-to-Frame relations (global)			prepares F6	characterizes F4	part_of F5	part_of F6; presupposes F2	
Frame Name (gloabal)	Setting	Habituality	Hunger	Progression	Searching	Hunting	Predation[+potential]
As		Habituality.EVO					
usual							
,							
hungry		Agent	Hunger.EVO	Agent	Searcher	Hunter	Predator
lions	ANIMAL[+generic][+plural][-referential]		Hunger-Experiencer				
are		Habitual Activity		Progression.EVO <1,2>		Hunting.GOV	Predation[+potential].GOV
look				Activity<1,2>	Searching.GOV <1,2>		
ing				Progression.EVO <1,2>			
for				Activity<2,2>	Searching.GOV <2,2>		
impalas	ANIMAL[+generic][+plural][-referential]				Object	Target	Prey
.							

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Semantic types can be specified here

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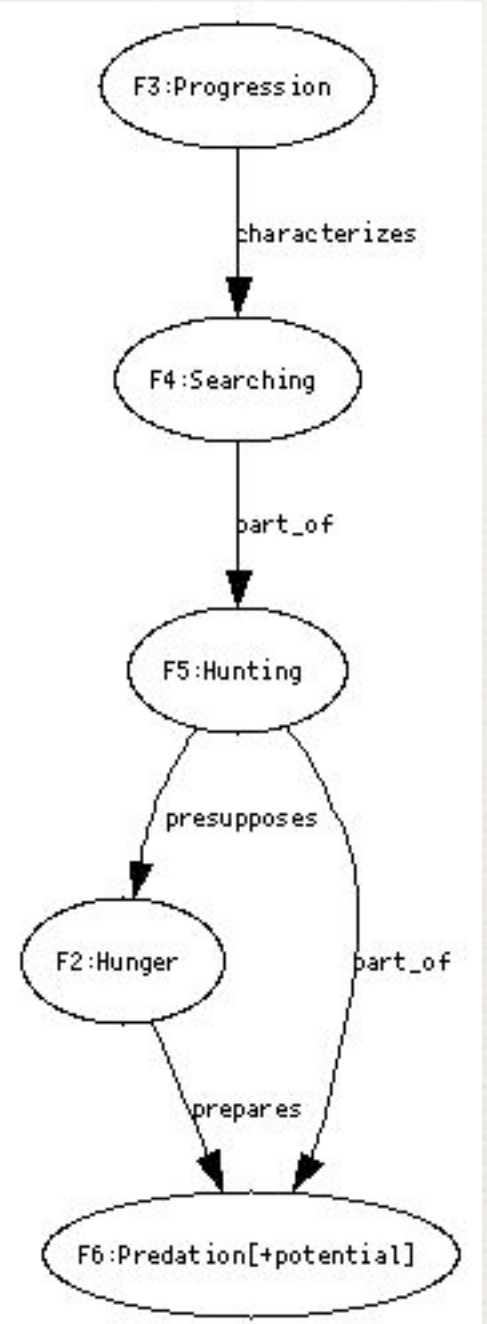

MSFA encodes

- *lions* as instantiation of <Hunger-Experiencer>
- *hungry lions* as instantiation of semantic roles
  - <Agent> of <Progression>, <Searcher>, <Hunter> , and <Predator>
- *hungy* as evoker of <Hunger>
- *look for* as evoker <Searching>
- *are looking for* as evoker of <Hunting> and <Predation>
- *are ... ing* as evoker of <Progression>

PMA supports MSFA

M-ID	Pattern-ID	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	
M-to-M relations												
M-forms	s	As	usual	,	hungry	lions	are	look	ing	for	impalas	encoded frame
As	p1	As*	OBJ		SUBJ[1,2]	SUBJ[2,2]	V					
usual	p2	as	usual*		SUBJ[1,2]	SUBJ[2,2]	V					<Habituality>
,	p3			,								
hungry	p4				hungry	SUBJ						<Hunger>
lions	p5				MOD	lions	V					
are	p6				SUBJ[1,2]	SUBJ[2,2]	are		ADJ			
look	p7				SUBJ[1,2]	SUBJ[2,2]		look				
ing	p8				SUBJ[1,2]	SUBJ[2,2]	are	V	ing			<Progression>
for	p9				SUBJ[1,2]	SUBJ[2,2]		look		for	OBJ	<Searching>
impalas	p10				SUBJ[1,2]	SUBJ[2,2]		V		P	impalas	

Lexical/Morphological PMA

PMA in a Nutshell

- Each row, called "subpattern," encodes dependency/(co-)argument structure of a lexical item
  - This is true of all kinds of lexical classes: subpattern of a noun encodes its co-argument structure.
- "superposition" (= vertical, columnwise (feature) unification) of subpatterns gives the overall dependency structure of a sentence.
  - By definition, all symbols are feature-complexes.

Superlexical PMA

M-ID	Pattern-ID	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	
M-to-M relations												
M-forms	s	As	usual	,	hungry	lions	are	look	ing	for	impalas	encoded frame
As usual, SUBJ V	p1, p2, p3	As*	usual*	,	SUBJ[1,2]	SUBJ[2,2]	V[1,4]	V[2,4]	V[3,4]	V[4,4]		<Habituality>
SUBJ are looking for OBJ	p6, p7, p8				SUBJ[1,2]	SUBJ[2,2]	are	look	ing	for	OBJ	<Searching>, <Progression>
hungry lions V impalas	p4, p5, p10				hungry	lions	V[1,4]	V[2,4]	V[3,4]	V[4,4]	impalas	<Hunting>, part-of <Predation>

Superlexical PMA identifying a latent semantic relation between *(hungry) lions* and *impalas*, and being likely to evoke <Predation> (and <Hunting>, too)

Lexical-to-Superlexical

Superlexical PMA

M-ID	Pattern-ID	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	
M-to-M relations												
M-forms	s	As	usual	,	hungry	lions	are	look	ing	for	impalas	encoded frame
As usual, SUBJ V	p1, p2, p3	As*	usual*	,	SUBJ[1,2]	SUBJ[2,2]	V[1,4]	V[2,4]	V[3,4]	V[4,4]		<Habituality>
SUBJ are looking for OBJ	p6, p7, p8				SUBJ[1,2]	SUBJ[2,2]	are	look	ing	for	OBJ	<Searching>, <Progression>
hungry lions V impalas	p4, p5, p10				hungry	lions	V[1,4]	V[2,4]	V[3,4]	V[4,4]	impalas	<Hunting>, part-of <Predation>

Lexical PMA

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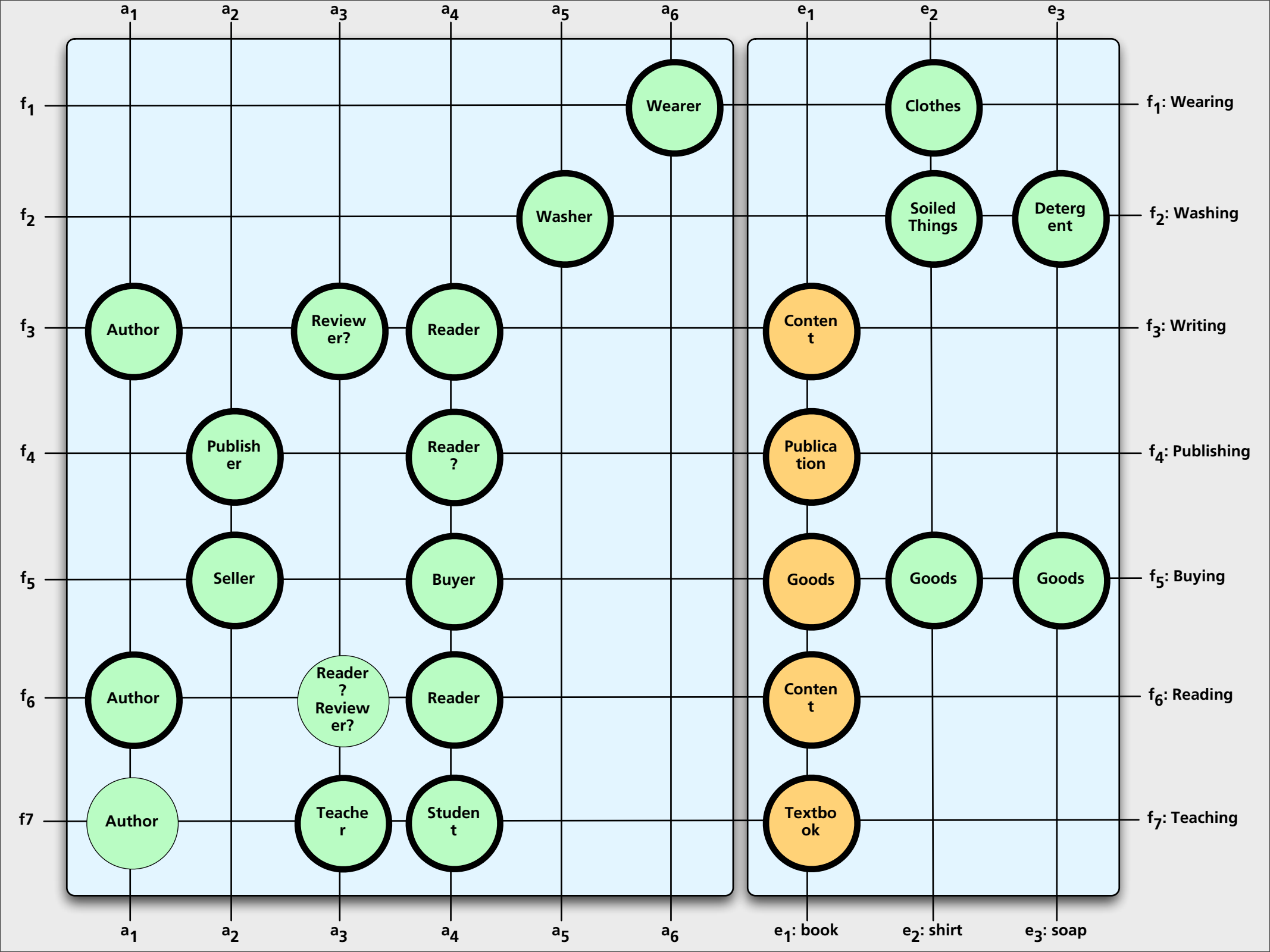
M-to-M relations												
M-forms	s	As	usual	,	hungry	lions	are	look	ing	for	impalas	encoded frame
As	p1	As*	OBJ		SUBJ[1,2]	SUBJ[2,2]	V					
usual	p2	as	usual*		SUBJ[1,2]	SUBJ[2,2]	V					<Habituality>
,	p3			,								
hungry	p4				hungry	SUBJ						<Hunger>
lions	p5				MOD	lions	V					
are	p6				SUBJ[1,2]	SUBJ[2,2]	are		ADJ			
look	p7				SUBJ[1,2]	SUBJ[2,2]		look				
ing	p8				SUBJ[1,2]	SUBJ[2,2]	are	V	ing			<Progression>
for	p9				SUBJ[1,2]	SUBJ[2,2]		look		for	OBJ	<Searching>
impalas	p10				SUBJ[1,2]	SUBJ[2,2]		V		P	impalas	

Is it Enough?

- So far, so good.
- But real text often contains such crazy expressions as the following:

(2) The other day, he *washed* the book by mistake.


a1
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a6
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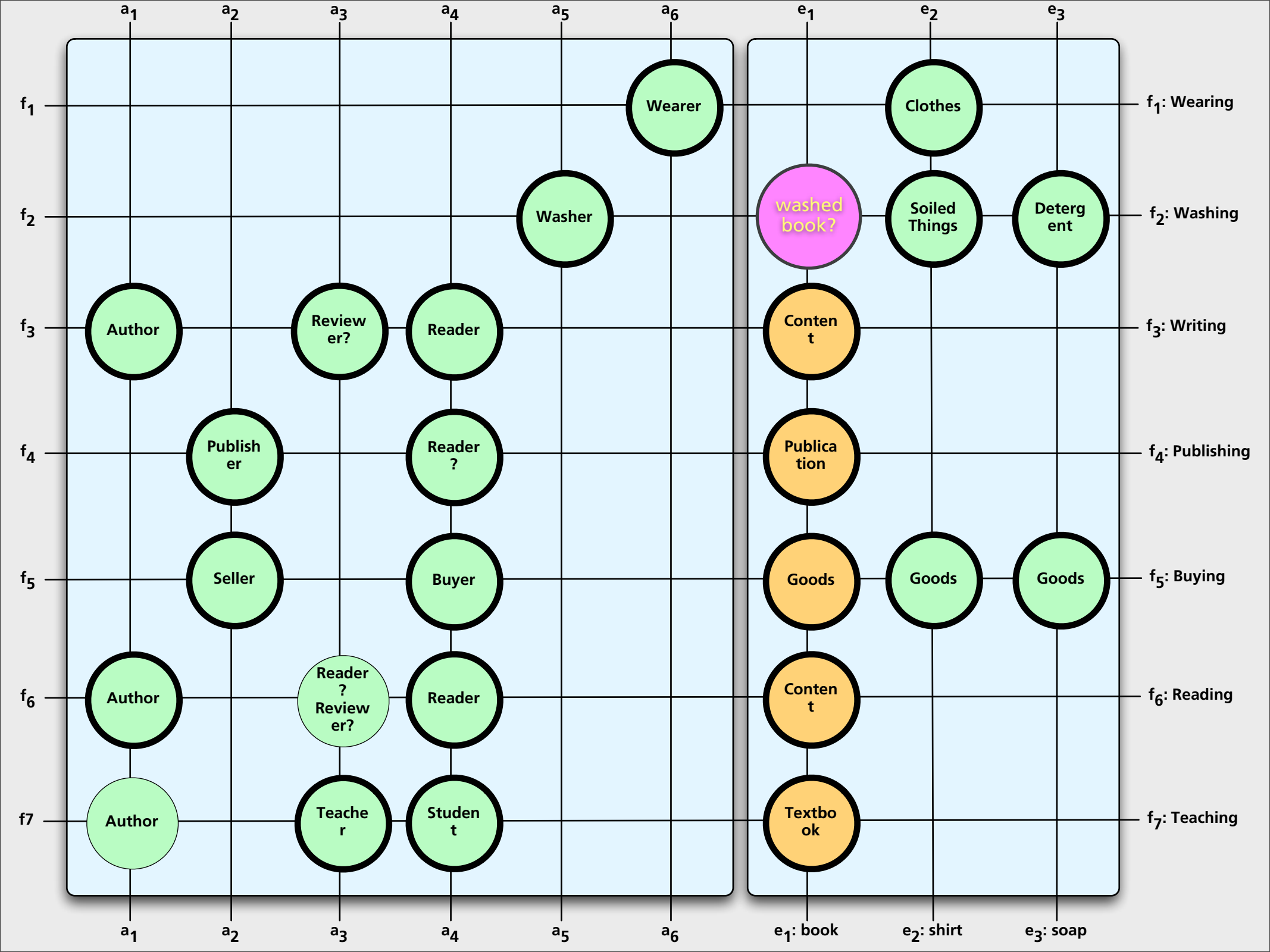
e3
f1
f2
f3
f4
f5
f6
f7
Wearer
Clothes
Washer
Soiled Things
Detergent
Author
Reviewer?
Reader
Content
Publisher
Reader?
Publication
Seller
Buyer
Goods
Goods
Goods
Author
Reader? Reviewer?
Reader
Content
Author
Teacher
Student
Textbook
f1: Wearing
f2: Washing
f3: Writing
f4: Publishing
f5: Buying
f6: Reading
f7: Teaching
e1: book
e2: shirt
e3: soap


a1
a2
a3
a4
a5
a6
e1
e2
e3
f1
f2
f3
f4
f5
f6
f7
Wearer
Washer
Author
Reviewer?
Reader
Publisher
Reader?
Seller
Buyer
Author
Reader? Reviewer?
Reader
Author
Teacher
Student
Clothes
washed book?
Soiled Things
Detergent
Content
Publication
Goods
Goods
Goods
Content
Textbook
f1: Wearing
f2: Washing
f3: Writing
f4: Publishing
f5: Buying
f6: Reading
f7: Teaching
e1: book
e2: shirt
e3: soap

Moral

- Modal modifiers like *by mistake* schange selectional restrictions drastically.

Prospective Products

Targeted Products

- MSFA-based labeling all and only meaningful substrings produces the following stuff as by-product:
  - a database of finer-grained frames/situations
  - a database of superlexical, often discontinuous, patterns with frame-evocation effect
  - a database of phrases coupled with frame elements
  - a database of words or morphemes (i.e., lexicon)

Remarks

- Semantic annotation with MSFA is applied to Japanese texts.
- English examples in this talk are just samples.

Again, many people think

- It would be nice if we had corpora annotated for semantic information.
  - It would make NLP researchers, linguists and cognitive scientists all happy
- And it would be *very* nice
  - if the annotation is informative enough
  - and if the corpus is large enough.

Current Status

- Reality:
  - adequacy and coverage are in trade-off relation.
- Our strategy
  - start with a very small corpus with adequate annotation, hoping to enlarge it by bootstrapping.
- Status Quo
  - after annotating 140 sentences, we have ~700 frames, ~4,500 frame elements, ~2,500 words/phrases (in types).

Conclusion?

- A very long, but very fun way to go.

Thank you