The Neural Basis of Thought and Language

Week 12

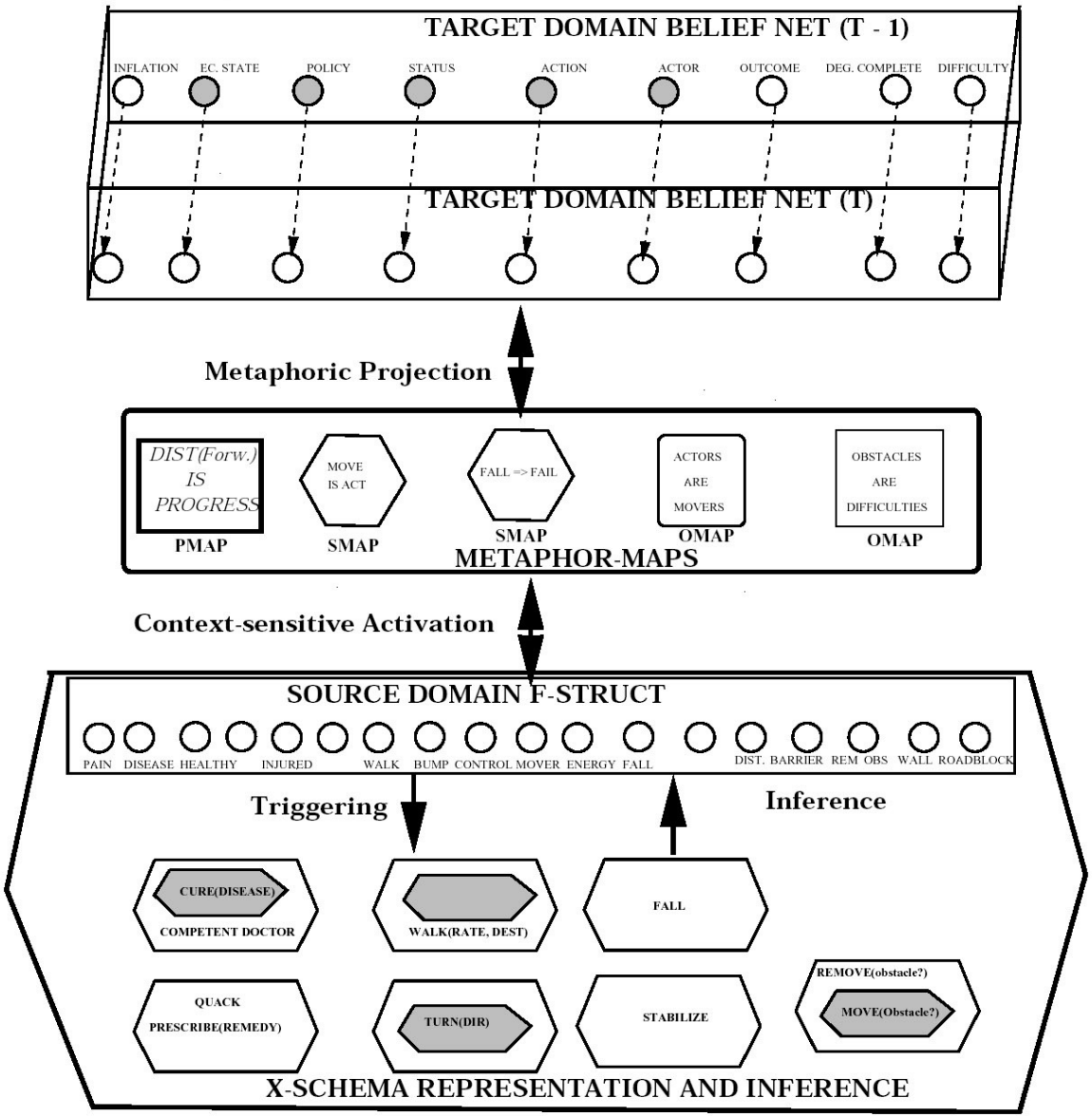
Metaphor and Automatic Reasoning, plus Grammars

Schedule

- Assignment 8 due Thursday
- Last Week
  - Event Structure Metaphor
  - Bayes nets
- This Week
  - Inference, KARMA: Knowledge-based Action Representations for Metaphor and Aspect
  - Grammar
- Next Week
  - More grammar

Questions

1. How are the source and target domains represented in KARMA?
2. How does the source domain information enter KARMA? How should it?
3. What is chart parsing? Using a plausible CFG grammar, what is the parse of “Pat ate the kiwi”?
4. How well can CFGs represent English? What are some mechanisms for improvement?
5. What is unification?



KARMA

- DBN to represent target domain knowledge
- Metaphor maps link target and source domain
- X-schema to represent source domain knowledge

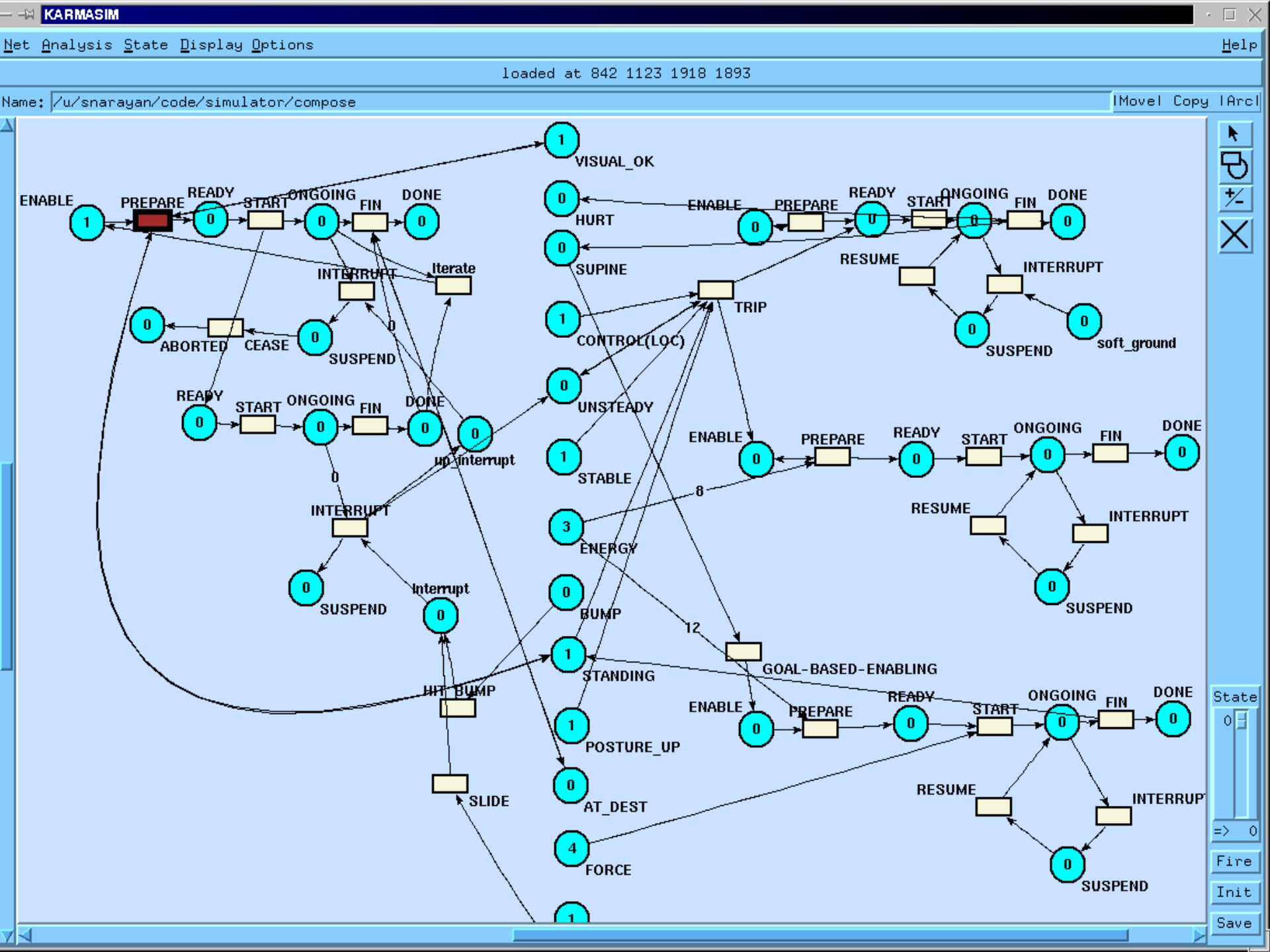
Metaphor Maps

- map entities and objects between embodied and abstract domains

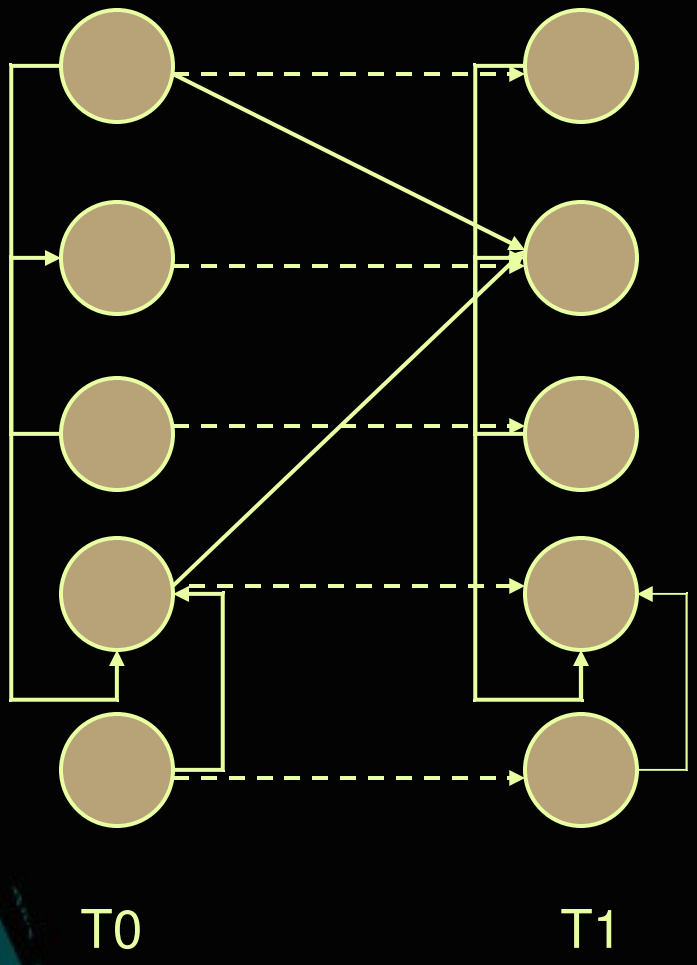
- invariantly map the aspect of the embodied domain event onto the target domain

  by setting the evidence for the status variable based on controller state (event structure metaphor)

- project x-schema parameters onto the target domain


KARMASIM
Net Analysis State Display Options
Help
loaded at 842 1123 1918 1893
Name: /u/snarayan/code/simulator/compose
Move Copy Arc
ENABLE
PREPARE
READY
START
ONGOING
FIN
DONE
VISUAL_OK
HURT
SUPINE
CONTROL(LOC)
UNSTEADY
STABLE
ENERGY
BUMP
STANDING
POSTURE_UP
AT_DEST
FORCE
TRIP
RESUME
INTERRUPT
SUSPEND
soft_ground
Iterate
ABORTED
CEASE
up_interrupt
Interrupt
HIT_BUMP
SLIDE
GOAL-BASED-ENABLING
State
Fire
Init
Save

DBN for the target domain



Economic State

[recession,nogrowth,lowgrowth,higrowth]

Policy

[Liberalization, Protectionism]

Goal

[free trade, protection]

Outcome

[success, failure]

Difficulty

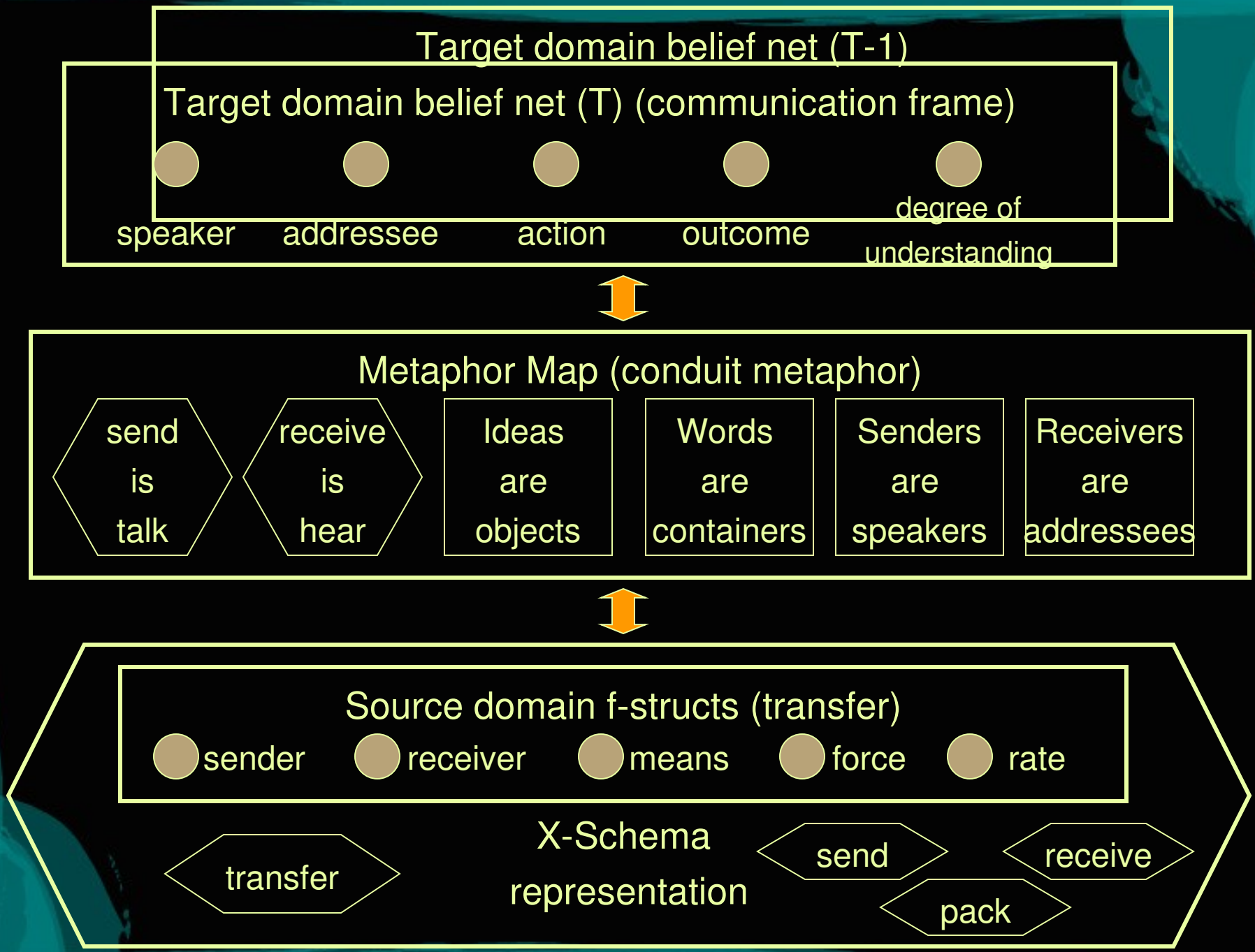
[present, absent]

Let’s try a different domain

- I didn’t quite *catch* what he was saying
- His slides are *packed* with information
- He *sent* the audience a clear message

When we can get a good *flow* of information from the streets of our cities *across* to, whether it is an investigating magistrate in France or an intelligence operative in the Middle East, and begin to *assemble* that kind of information and analyze it and *repackage* it and *send* it back out to users, whether it's a policeman on the beat or a judge in Italy or a Special Forces Team in Afghanistan, then we will be getting close to the kind of capability we need to deal with this kind of problem. That's going to take a couple, a few years.

9/11 Commission Public Hearing, Monday, March 31, 2003


Target domain belief net (T-1)
Target domain belief net (T) (communication frame)
speaker
addressee
action
outcome
degree of understanding
Metaphor Map (conduit metaphor)
send is talk
receive is hear
Ideas are objects
Words are containers
Senders are speakers
Receivers are addressees
Source domain f-structs (transfer)
sender
receiver
means
force
rate
transfer
X-Schema representation
send
receive
pack

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5. What is unification?

How do the source domain f-structs get parameterized?

- In the KARMA system, they are hand-coded.
- In general, you need analysis of sentences:
  - syntax
  - semantics

Syntax captures:

- constraints on word order
- constituency (units of words)
- grammatical relations (e.g. subject, object)
- subcategorization & dependency (e.g. transitive, intransitive, subject-verb agreement)

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Grammar

- A grammar is a set of rules defining a formal language
- an example is right-regular grammar
- a more common example is Context-Free Grammar

$$\alpha \rightarrow \beta$$

- $\forall$ α : single non-terminal
- β : any combination of terminals and non-terminals

$S \rightarrow NP\ VP$

$NP \rightarrow Det\ Noun \mid ProperNoun$

$VP \rightarrow Verb\ NP \mid Verb\ PP$

$PP \rightarrow Preposition\ NP$

$Noun \rightarrow kiwi \mid orange \mid store$

$ProperNoun \rightarrow Pat \mid I$

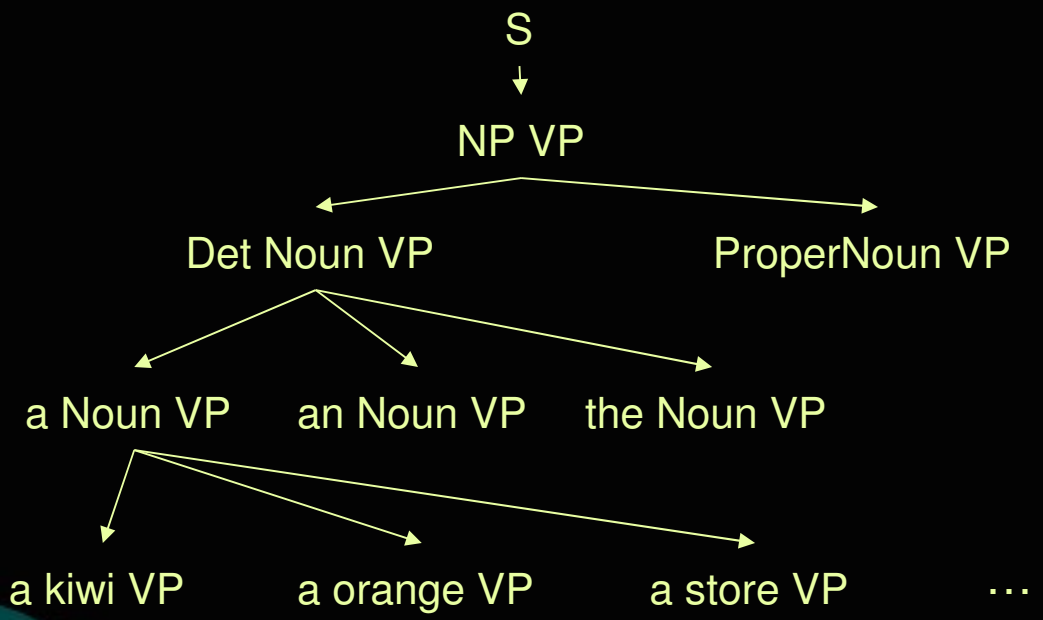
$Det \rightarrow a \mid an \mid the$

$Verb \rightarrow ate \mid went \mid shop$

$Preposition \rightarrow to \mid at$

Sentence generation: *Pat ate the kiwi*

- start from S and apply all applicable rules
- forward expansion



S → NP VP

NP → Det Noun | ProperNoun

VP → Verb NP | Verb PP

PP → Preposition NP

Noun → kiwi | orange | store

ProperNoun → Pat | I

Det → a | an | the

Verb → ate | went | shop

Preposition → to | at

(DFS)

Chart parsing

- On board

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Notice the ungrammatical and/or odd sentences that we can generate?

S → NP VP
NP → Det Noun | ProperNoun
VP → Verb NP | Verb PP
PP → Preposition NP

Noun → kiwi | orange | store
ProperNoun → Pat | I
Det → a | an | the
Verb → ate | went | shop
Preposition → to | at

- * Pat ate a orange
- * Pat shop at the store
- * Pat went a store
- ? Pat ate a store
- ? The kiwi went to an orange

need to capture agreement, subcategorization, etc

you could make many versions of verbs, nouns, dets
➔ cumbersome

Unification Grammar

- Basic idea: capture these agreement features for each non-terminal in feature structures

Enforce constraints on these features using unification rules

VP → Verb NP

VP.agreement ↔ Verb.agreement

S → NP VP

NP.agreement ↔ VP.agreement

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Unification

- On board