

Semantic Interpretation & Episodic memory

CS 395 GAI

Spring, 2005

Overview

- Some phenomena
- Example: SOPHIE
 - Semantic grammar
 - Dialogue mechanism
- Example: Listener
 - Explanation Agent NLU system
 - Accessing episodic memory via analogy

Word sense ambiguity

- “I drank the gin with ice”
 - Common elements:
(performedBy drink1440 GenericHuman032)
(inputsDestroyed drink1440 gin1468)
(isa drink1440 DrinkingEvent)
(isa ice1500 (SolidFn Water))
(instrument-Generic drink1440 ice1500)
(with-UnderspecifiedAgent drink1440 ice1500)
(subEvents drink1440 ice1500)
 - Additional hypotheses in one interpretation:
(possessiveRelation gin1468 ice1500)
(with-UnderspecifiedAgent gin1468 ice1500)
(instrument-Generic gin1468 ice1500)
(subEvents gin1468 ice1500)

Arglisa relations as filters

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Pronouns

- John walks to the store. He bought some shoes. He wore them home. He saw Jane. Jane liked them. He thanked her.

Coreference

- Nero, sitting by the desk, whined. The feline started pawing the drawer.
- Lyndon Johnson was President during the Vietnam War. He escalated the debacle. LBJ's greatest achievement was in civil rights. This heroic effort cost him any chance at re-election.

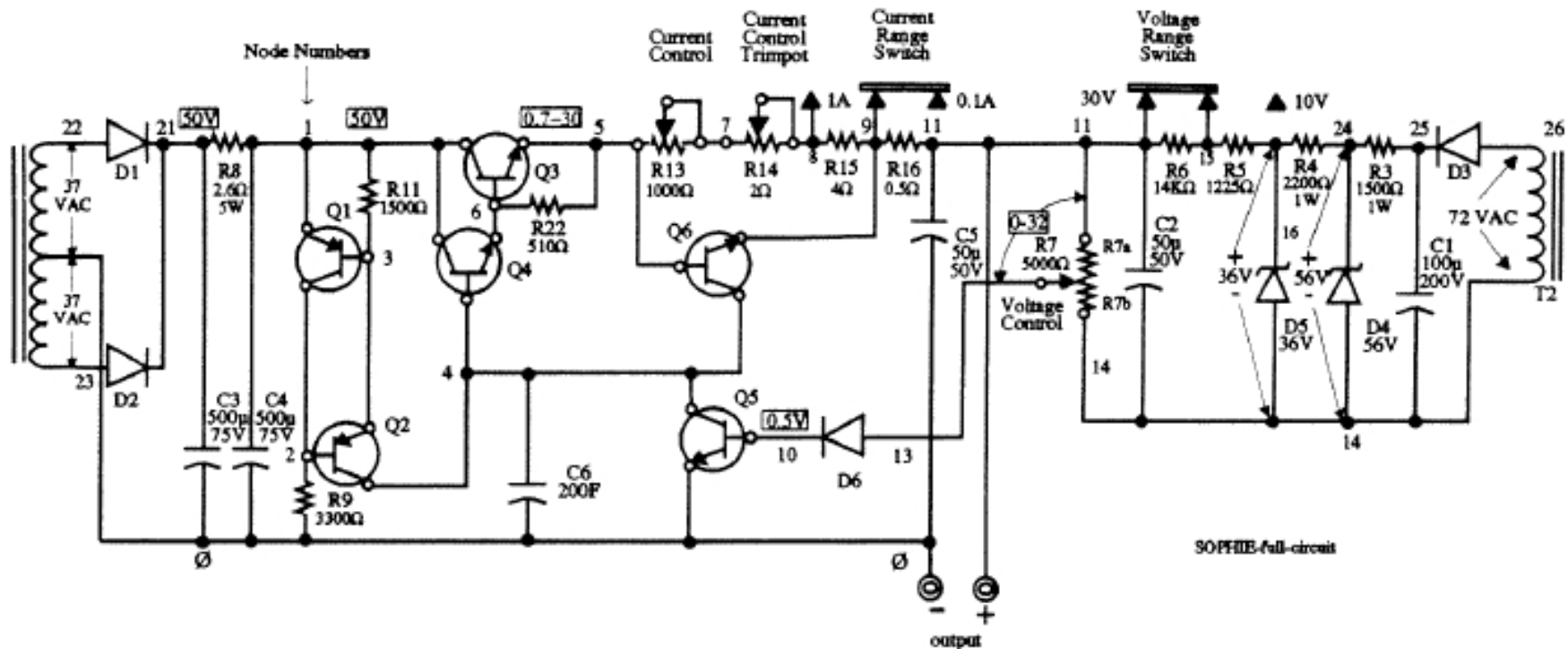
Anaphora

- General name for coreference phenomena
- General solution: Maintain a list of discourse entities
 - Search history list for nearest entity that satisfies constraints
 - Constraints include
 - Semantic consistency: Coreferent items must be capable of belonging to the same collections.
 - Number/Gender agreement
 - Recency: Most recent entity satisfying other constraints should be preferred

Selectional restrictions

- Argument constraints on relationships help disambiguate meaning
 - “I drank the gin with ice.” versus “I drank the gin with a friend.”

Example: SOPHIE



- Your goal: Troubleshoot this power supply
- You work through a virtual language-using assistant

A dialogue with SOPHIE

WELCOME TO SOPHIE - A SIMULATED ELECTRONICS LABORATORY.

The circuit (Figure 3.1) is based on the Heathkit IP-28 power supply. The IP-28 is a reasonably sophisticated power supply with both current limiting and voltage limiting behavior. These two interrelated feedback loops make troubleshooting this circuit non-trivial.

>>INSERT A FAULT

The student tells SOPHIE to give him a fault which he can troubleshoot. SOPHIE randomly selects a fault, inserts it into a model of the instrument and tells the student how the front panel controls are presently set.

THE INSTRUMENT HAS A FAULT AND ITS PRESENT CONTROL SETTINGS ARE:
CC 1.0 CURRENT CONTROL-FROM 0.0 (MIN CURRENT) TO 1.0
CR HIGH CURRENT RANGE SWITCH, HIGH=1 AMP, LOW=.1 AMP
LOAD 1000 LOAD RESISTANCE IN OHMS
VC 1.0 VOLTAGE CONTROL-FROM 0.0 (MIN VOLTAGE) TO 1.0
VR HIGH VOLTAGE RANGE SWITCH, HIGH=30, LOW=10 VOLTS

Use of a history list

>>WHAT IS THE OUTPT?

OUTPT => OUTPUT

THE OUTPUT VOLTAGE IS 1.2 VOLTS.

SOPHIE corrects the student's typing mistake.

Notice that "the output" was disambiguated as the output voltage.

IF YOU ARE NOT SURE WHETHER A VALUE IS CORRECT, YOU CAN ASK "IS THAT VALUE CORRECT?"

The system points out a feature that the student may not otherwise be aware of. "Correct" here means what it is in a working instrument.

>>IS THAT RIGHT

IN A WORKING CIRCUIT THE OUTPUT VOLTAGE IS 30.1 VOLTS.

THAT VALUE IS INCORRECT.

"That" here refers to the value of the previous measurement. SOPHIE, in addition to the faulted instrument, has a working circuit which can be used to take reference measurements.

>>WHAT IS THE VOLTAGE BETWEEN THE CURRENT LIMITING TRANSISTOR

...AND THE CONSTANT CURRENT SOURCE?

THE VOLTAGE AT N4 IS 2.48 VOLTS.

In addition to specific part names, SOPHIE recognizes references to parts by their section. Notice that although the sentence says "voltage between x and y", it really means "voltage at z with respect to ground". The output routines rephrase the input in a simpler form (i.e. between x and y reduces to N4).

>>WHAT IS IT BETWEEN THERE AND THE BASE OF Q6
THE VOLTAGE BETWEEN N4 AND N5 IS 1.28 VOLTS.

Here "it" refers to "the voltage" and "there" refers to N4.
Also notice that "between" has to be treated differently,
i.e. two nodes are explicit now.

>>IS THERE ANY RIPPLE IN THE VOLTAGE AT THE BASE OF Q4?
I'M SORRY, I DO NOT HANDLE AC CHARACTERISTICS.

SOPHIE recognizes that the student is moving into an area that it is
unable to handle. This is currently done by keyword recognition (e.g.
ripple) but points out a technique that should be incorporated in
other aspects of the system as well.

>>WHAT IS THE BASE CURRENT OF Q3
THE BASE CURRENT OF Q3 IS 12 MICROAMPS.

SOPHIE can answer questions about current, resistance, and power
dissipation as well as voltage. The output and input routines know
about unit prefixes.

>>THRU THE EMITTER?
THE EMITTER CURRENT OF Q3 IS -.26 MILLIAMPS.

This is a type of sentence fragment that occurs frequently in
dialogues that we will refer to as an ellipsis. Rather than
specifying a complete thought, an ellipsis only gives that piece of
the thought which contrasts an earlier thought. Notice that the
referent cannot be determined on syntactic grounds (as is possible
with the ellipsis "the emitter current"; yet this is the sort of
statement a student might make if the last answer had caused a slight
shifting of his thinking.

>>COULD THE PROBLEM BE THAT Q5 IS BAD?
PLEASE BE MORE SPECIFIC ABOUT HOW Q5 IS FAULTED.

The student develops an idea about what is wrong and asks to have it evaluated.

>>COULD IT BE SHORTED?
THE SHORTED MODES OF A TRANSISTOR CURRENTLY IMPLEMENTED ARE: ALL JUNCTIONS SHORTED OR ONE JUNCTION SHORTED WITH THE OPPOSITE TERMINAL MODELLED OPEN.

A hypothesis must be completely (or non-ambiguously) specified before evaluation can take place. Even though the last statement generated an error condition, it is still used to determine possible pronoun referents.

SHOULD Q5 HAVE ALL JUNCTIONS SHORTED?

> NO

WHICH TERMINAL SHOULD BE MODELLED OPEN?

> THE BASE

OK, I'LL LET Q5 HAVE ITS EMITTER COLLECTOR JUNCTION SHORTED AND ITS BASE OPEN

At this point, SOPHIE looks back over the student's measurements to determine if he should have "known better". See (Brown and Burton 1975) or (Brown et al. 1975) for further description.

HMMM, LET ME COMPUTE ON THAT FOR A MINUTE.

When the system knows there maybe a long wait, a "delaying" message is printed to let the student know something is happening.

WHEN THE SETTINGS WERE:

CC=1.0, CR=HIGH, LOAD=1000, VC=1.0, VR=HIGH,
THAT FAULT CONFLICTS WITH THE FOLLOWING MEASUREMENT.
YOU OBSERVED THAT THE VOLTAGE BETWEEN N4 AND N5 WAS 1.28 VOLTS.
IF Q5 HAD ITS EC SHORTED AND ITS BASE OPEN IT WOULD BE 1.1 MILLIVOLTS.
IN A WORKING CIRCUIT IT IS 1.43 VOLTS.

BUT THAT FAULT DOES EXPLAIN THE VALUES YOU OBSERVED FOR
THE OUTPUT VOLTAGE, THE VOLTAGE AT N4, THE VOLTAGE BETWEEN N4 AND N10,
THE EMITTER CURRENT OF Q3 AND THE BASE CURRENT OF Q3.

>>WHAT COULD BE WRONG

The student cannot go further and asks for assistance. SOPHIE
proposes some possible hypotheses for the student to explore.

THERE ARE LOTS OF FAULTS WHICH WOULD EXPLAIN THE MEASUREMENTS YOU
HAVE TAKEN. HERE ARE SOME POSSIBILITIES:

THE RESISTANCE OF R8 CHANGES
THE LEAKAGE RESISTANCE OF C4 CHANGES
THE BETA OF Q3 CHANGES
R15 IS OPEN
Q6 IS FAULTED

>>IF R8 WERE 30K, WHAT WOULD THE OUTPUT VOLTAGE BE?

IF THE VALUE OF R8 WERE 30000
UNDER THE PRESENT SETTINGS, THE OUTPUT VOLTAGE WOULD BE .904 VOLTS.
IN A WORKING CIRCUIT IT IS 30.1 VOLTS.

The student doesn't believe one of the possibilities so he checks it
using a hypothetical statement. Even though the voltage in this case
and that in the case of a faulted circuit are not the same, they
qualitatively agree.

>>REPLACE Q6

The student guesses maybe Q6 is bad and tries to replace it. When the student replaces a part SOPHIE queries him to insist that he know how it is faulted.

I AM GOING TO ASK YOU SOME QUESTIONS ABOUT HOW Q6 IS FAULTED.
ARE ANY JUNCTIONS SHORTED?

> YES

WHICH JUNCTIONS ARE SHORTED?

> ALL

If the response to a query is not understood, further specification of the expected response is given.

PLEASE SPECIFY THE JUNCTIONS AS EC EB AND CB (SEPARATED BY SPACES).
WHICH JUNCTIONS ARE SHORTED?

> EC EB AND CB

Q6 IS NOT FAULTED IN THAT MANNER.

The part would be replaced if any of the junctions had been shorted. SOPHIE would normally have critiqued the student's hypothesized fault. This was not included in the dialogue to save space.

Q6 NOT REPLACED.

>>VOLTAGE DROP ACROSS R5

THE VOLTAGE ACROSS R5 IS -.028 MILLIVOLTS.

Some noun phrase utterances are recognized as questions.

>>WHAT ABOUT R3?
THE VOLTAGE ACROSS R3 IS 71.6 VOLTS.

Another ellipsis. The context of the previous question is used to determine "what" about R3.

>>REPLACE R3
IS R3 OPEN OR SHORTED OR DOES IT HAVE THE WRONG VALUE?
> IT IS OPEN
R3 REPLACED

>>IS THERE ANYTHING ELSE WRONG
NO

After fixing the fault, the student uses SOPHIE to explore other aspects of the circuit's behavior.

>>IF C2 WERE LEAKY, WHAT WOULD THE VOLTAGE ACROSS IT BE?

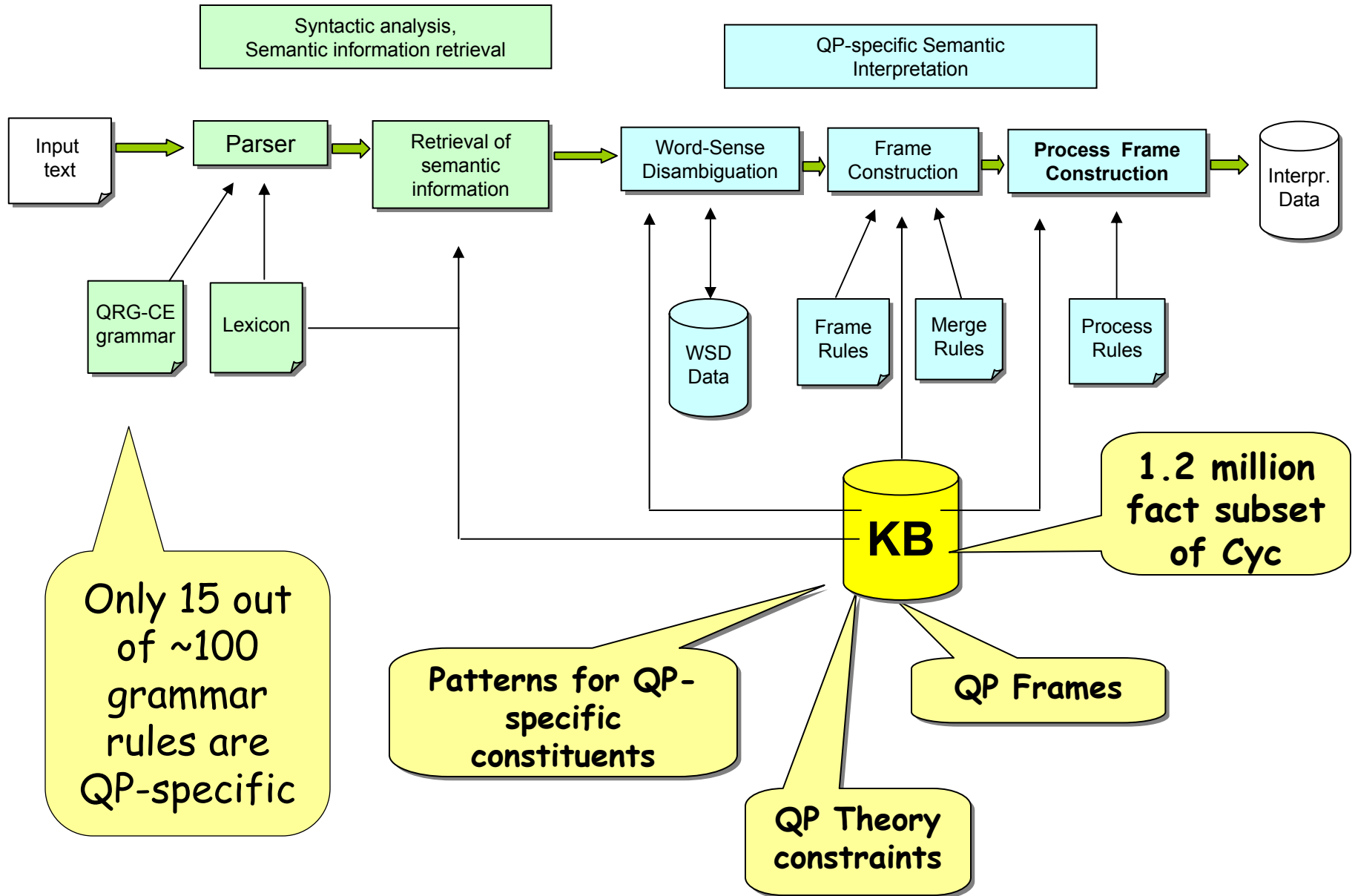
The referent to "it" in this case occurs earlier in the same sentence.

IS IT OKAY IF I USE 10000 FOR THE LEAKAGE RESISTANCE OF C2?
> YES
IF THE LEAKAGE RESISTANCE OF C2 WERE 10000
UNDER THE PRESENT SETTINGS, THE VOLTAGE ACROSS C2 WOULD BE 26.3 VOLTS.
IN A WORKING CIRCUIT IT IS 28.9 VOLTS.

>>WHAT HAPPENS IF C1 SHORTS?
UNDER THE SETTINGS:
CC=1.0, CR=HIGH, LOAD=1000, VC=1.0, VR=HIGH,
IF C1 WERE SHORTED, D3 WOULD BECOME OVERLOADED.

In the case where nothing more interesting happens, "what happens" questions default to the output voltage.

The EA natural language system



Restrictions in the EA NLU

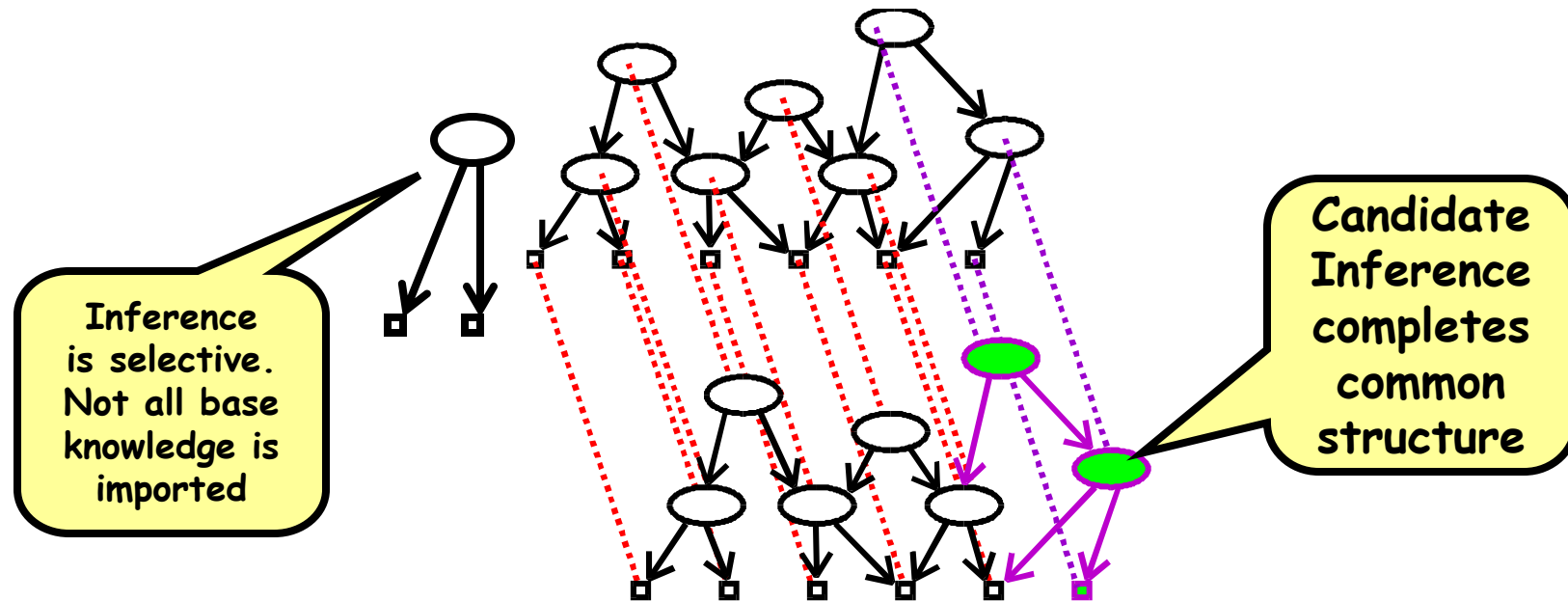
- Active voice, present tense
- No verb particles
 - ‘Select’ instead of ‘decide on’
- No coordinated verb phrases
 - ‘The liquid expands and boils in the cylinder.’
- No conjoined prepositional phrases
 - ‘The cylinder contains 200 ml of water and alcohol.’
- No compound nouns
 - Hyphenated (‘ice-cube’) or contracted (‘icecube’) entries

Using semantic interpretations

- Turn it into some executable procedure
 - NL front ends to databases
 - Intelligent tutoring systems
- Store it as new knowledge
 - Presumably used somehow in the future
 - How can we exploit this for entertainment systems?

Structure-Mapping Theory (Gentner, 1983)

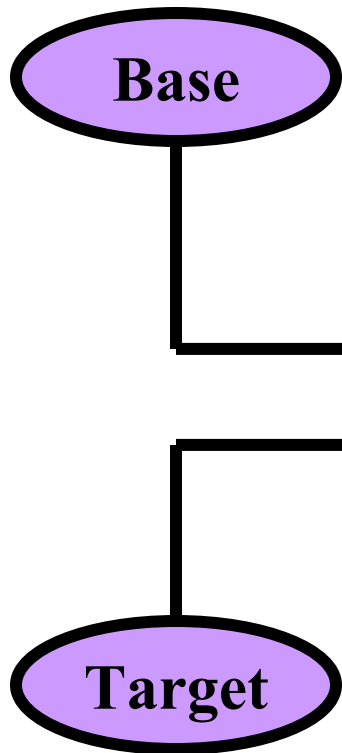
- Analogy and similarity involve
 - correspondences between structured descriptions
 - candidate inferences fill in missing structure in target



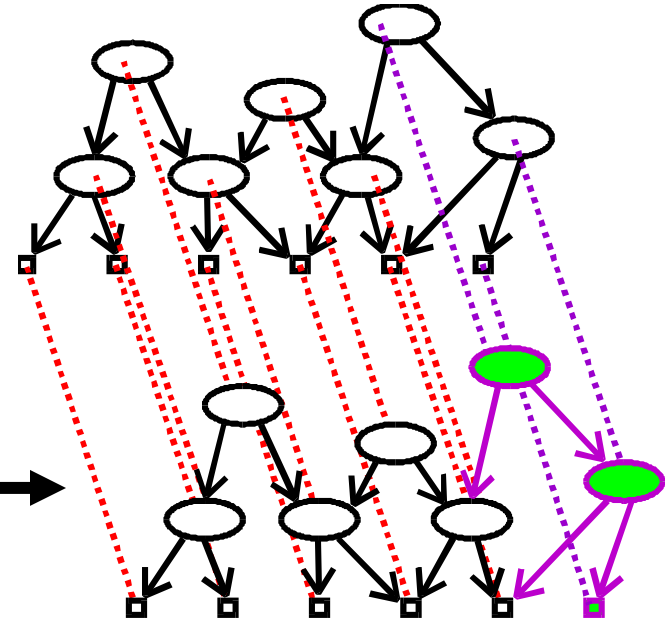
- Constraints
 - *Identity*: Match identical relations, attributes, functions. Map non-identical functions when suggested by higher-order matches
 - *1:1 mappings*: Each item can be matched with at most one other
 - *Systematicity*: Prefer mappings involving systems of relations, esp. including higher-order relations
- Also provides account of similarity, metaphor
- Growing body of evidence that same processes are used in perception, problem solving, conceptual change...

SME: Structure-Mapping Engine

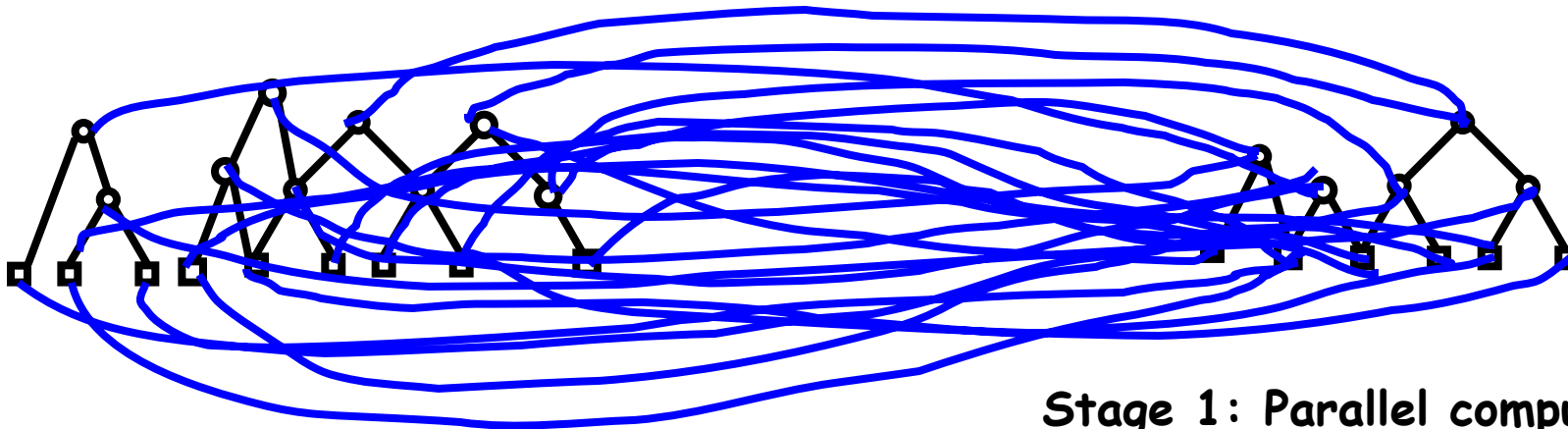
Inputs = propositional descriptions, w/
incremental updates
Output = one or two mappings



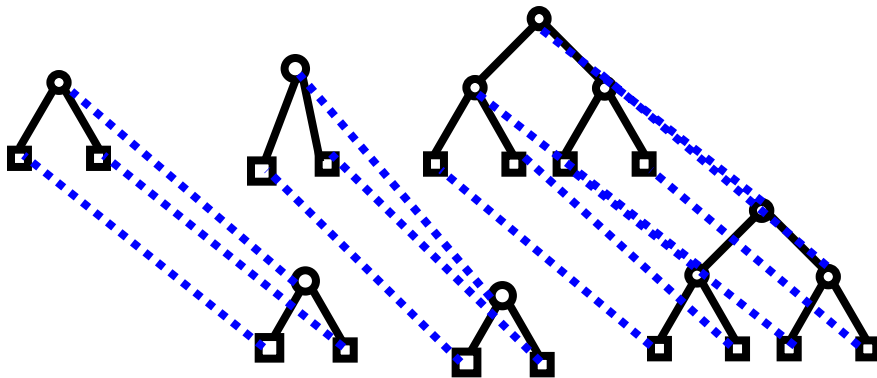
Operates in polynomial time,
by exploiting graph labels & greedy algorithms



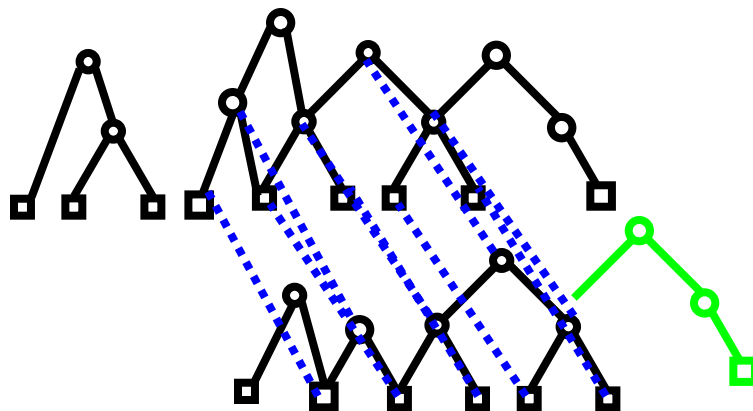
Mappings =
correspondences
+ structural evaluation
+ candidate inferences



Stage 1: Parallel computation of blind local matches

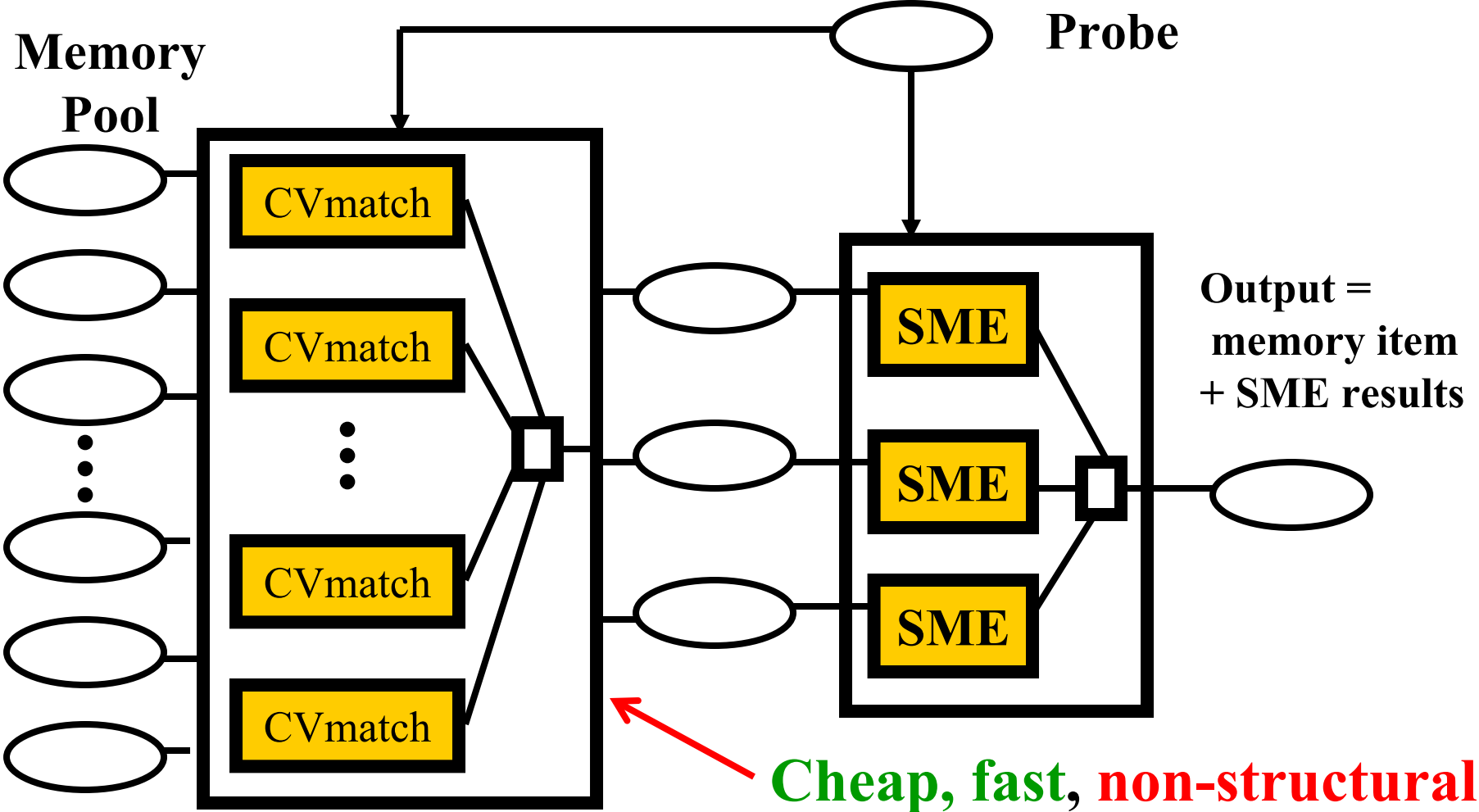


Stage 2: Structurally consistent kernels

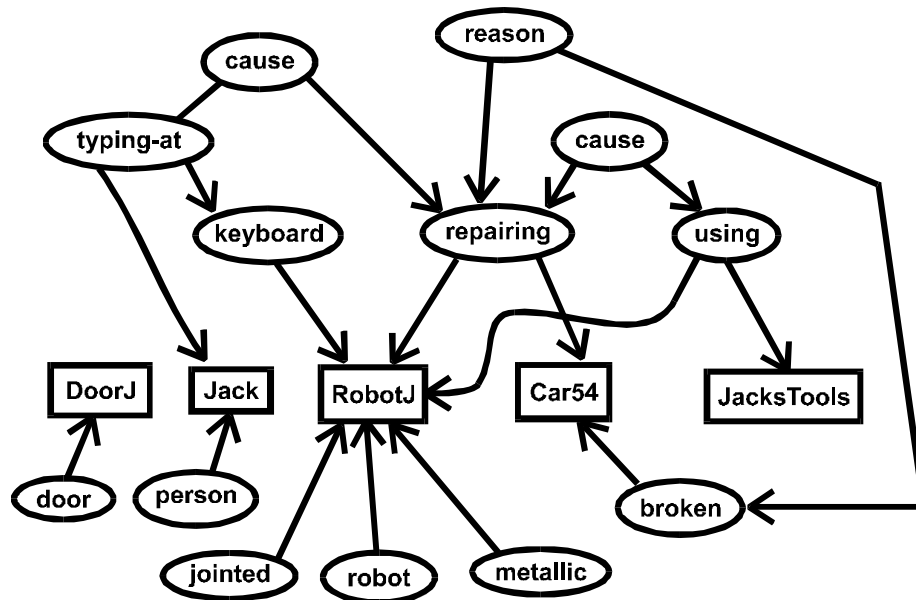


Stage 3: Maximal global alignment; candidate inferences

MAC/FAC provides similarity-based retrieval



No hand-indexing of cases required



Jack's Robot Repair description:

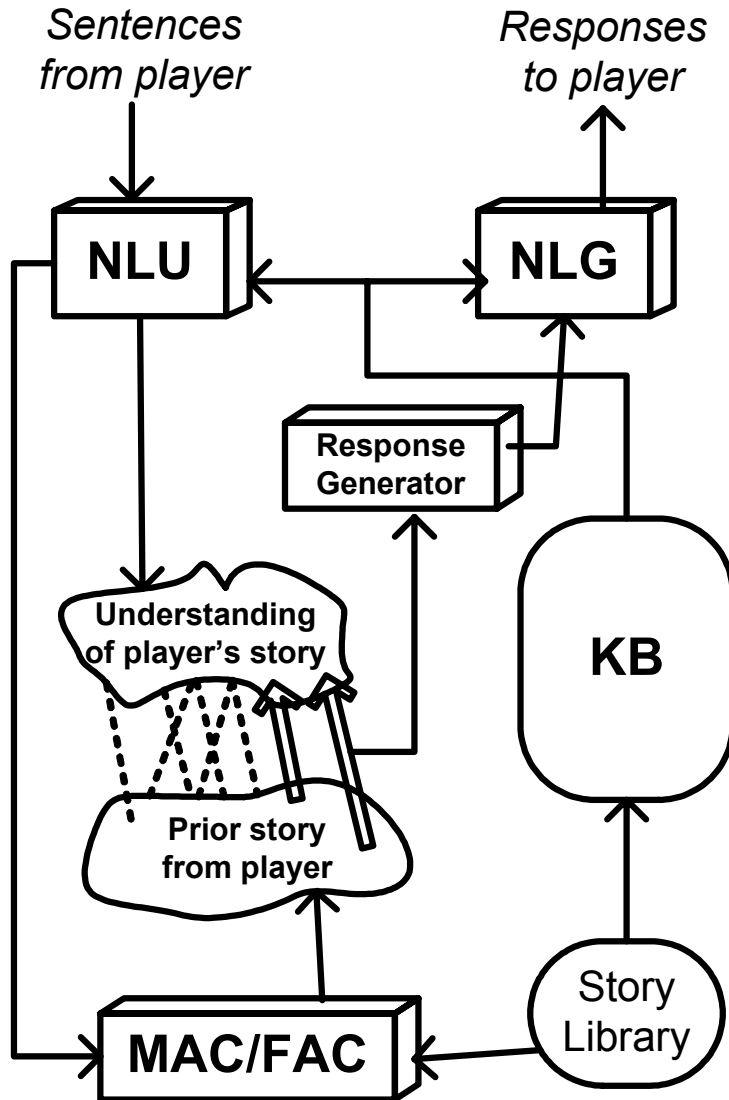
```
(REASON (REPAIRING ROBOTJ CAR54)
 (BROKEN CAR54))
(CAUSE (TYPING-AT JACK
 (KEYBOARD ROBOTJ))
 (REPAIRING ROBOTJ CAR54))
(CAUSE (REPAIRING ROBOTJ CAR54)
 (USING ROBOTJ HANDTOOLSJ))
(DOOR DOORJ)
(JOINTED ROBOTJ)
(METALLIC ROBOTJ)
(ROBOT ROBOTJ)
(PERSON JACK)
```

Content vector for description indicates relative occurrence of predicates (attributes, relations, and functions)

Dot product estimates size of match hypothesis network for corresponding structural descriptions

BROKEN	0.0833
CAUSE	0.16667
DOOR	0.0833
JOINTED	0.0833
KEYBOARD	0.0833
METALLIC	0.0833
PERSON	0.0833
REASON	0.0833
REPAIRING	0.0833
ROBOT	0.0833
TYPING-AT	0.0833

Listener architecture



- Your version also has shallow (Eliza) response subsystem
- Integration of the deep and shallow response systems has not been heavily tested