Logic Programming Infrastructure for Inferences on FrameNet

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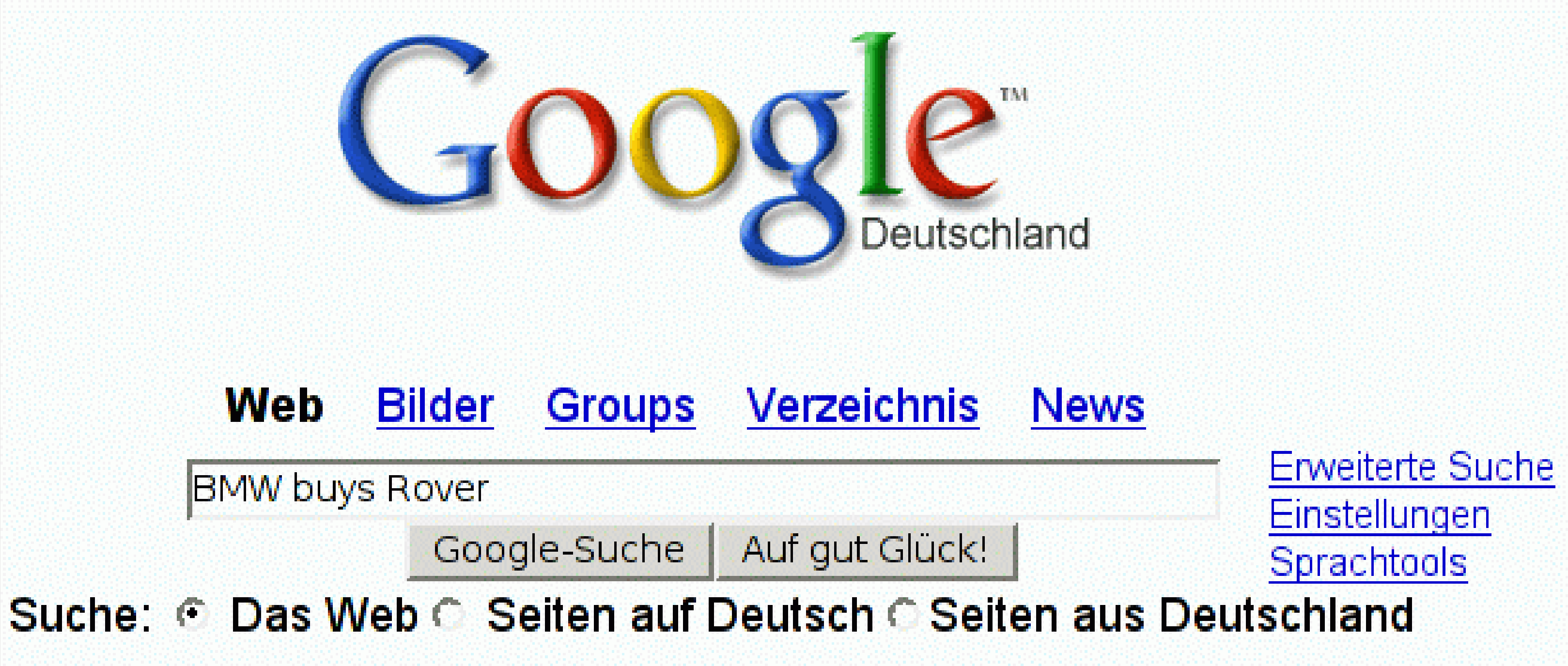
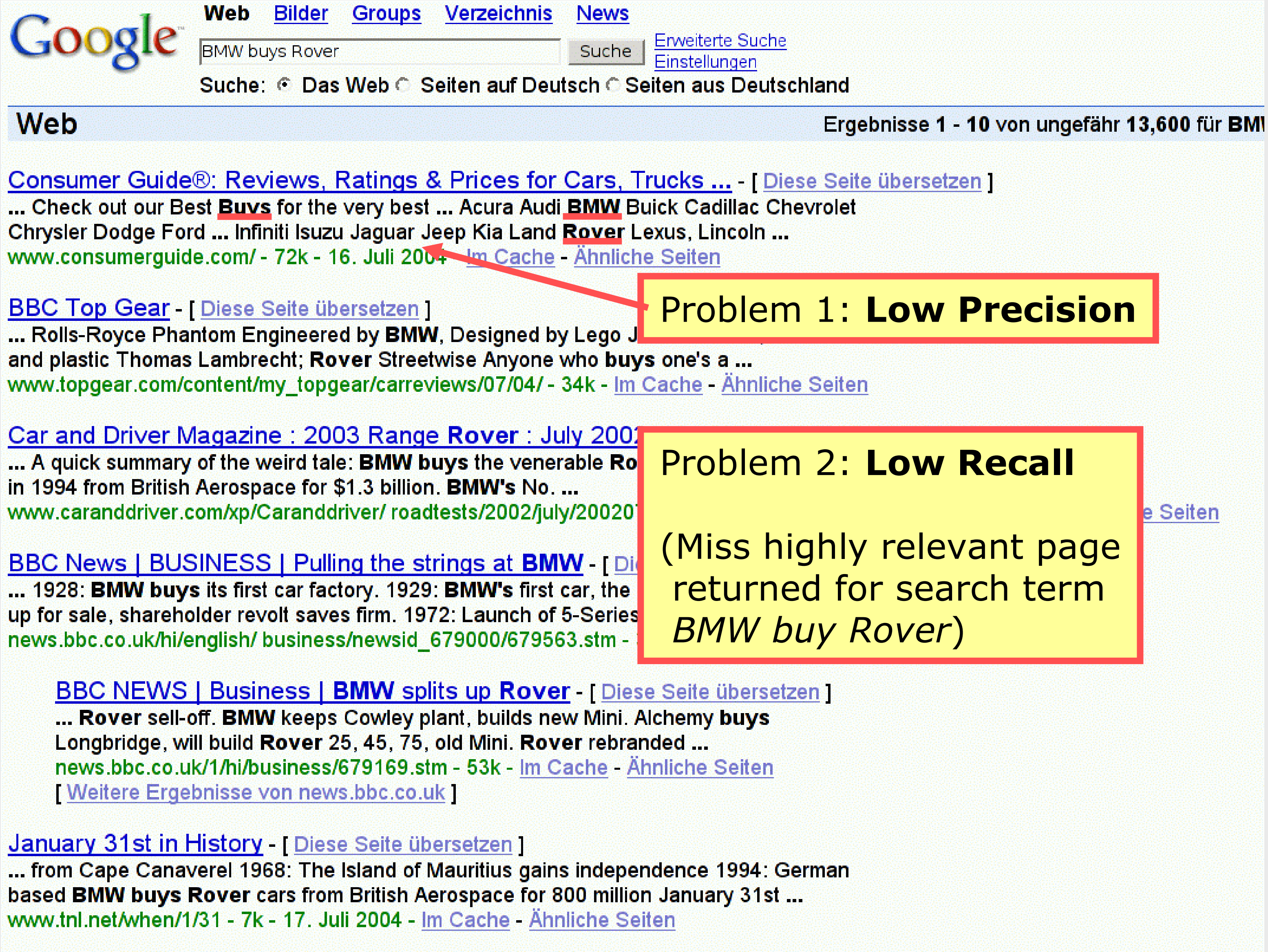
Motivation



BMW buys Rover

Suche: ● Das Web ○ Seiten auf Deutsch ○ Seiten aus Deutschland

Motivation



BMW buys Rover

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Web Ergebnisse **1** - **10** von ungefähr **13,600** für **BMW**

Consumer Guide®: Reviews, Ratings & Prices for Cars, Trucks ... - [Diese Seite übersetzen]
... Check out our Best **Buys** for the very best ... Acura Audi **BMW** Buick Cadillac Chevrolet Chrysler Dodge Ford ... Infiniti Isuzu Jaguar Jeep Kia Land **Rover** Lexus, Lincoln ...
www.consumerguide.com/ - 72k - 16. Juli 2004 - Im Cache - Ähnliche Seiten

BBC Top Gear - [Diese Seite übersetzen]
... Rolls-Royce Phantom Engineered by **BMW**, Designed by Lego J
and plastic Thomas Lambrecht; **Rover** Streetwise Anyone who **buys** one's a ...
www.topgear.com/content/my_topgear/carreviews/07/04/ - 34k - Im Cache - Ähnliche Seiten

Car and Driver Magazine : 2003 Range **Rover** : July 2002
... A quick summary of the weird tale: **BMW buys** the venerable **Ro**
in 1994 from British Aerospace for $1.3 billion. **BMW's** No. ...
www.caranddriver.com/xp/Caranddriver/ roadtests/2002/july/20020 ... e Seiten

BBC News | BUSINESS | Pulling the strings at **BMW** - [Di
... 1928: **BMW buys** its first car factory. 1929: **BMW's** first car, the
up for sale, shareholder revolt saves firm. 1972: Launch of 5-Series
news.bbc.co.uk/hi/english/ business/newsid_679000/679563.stm -

BBC NEWS | Business | **BMW** splits up **Rover** - [Diese Seite übersetzen]
... **Rover** sell-off. **BMW** keeps Cowley plant, builds new Mini. Alchemy **buys** Longbridge, will build **Rover** 25, 45, 75, old Mini. **Rover** rebranded ...
news.bbc.co.uk/1/hi/business/679169.stm - 53k - Im Cache - Ähnliche Seiten
[Weitere Ergebnisse von news.bbc.co.uk]

January 31st in History - [Diese Seite übersetzen]
... from Cape Canaverel 1968: The Island of Mauritius gains independence 1994: German based **BMW buys Rover** cars from British Aerospace for 800 million January 31st ...
www.tnl.net/when/1/31 - 7k - 17. Juli 2004 - Im Cache - Ähnliche Seiten

Problem 1: **Low Precision**

Problem 2: **Low Recall**

(Miss highly relevant page returned for search term *BMW buy Rover*)

Approaches

- Stemming (buys – buy)
- Synonyms (purchase – buy), e.g. from WordNet
- Compare words on page and words of query term

Statistics based methods mostly help to improve recall

Idea of our Approach: Combination (roughly):

- **Linguistic methods**
  state-of-the-art parsing, synonyms, feature structures,
  word sense disambiguation

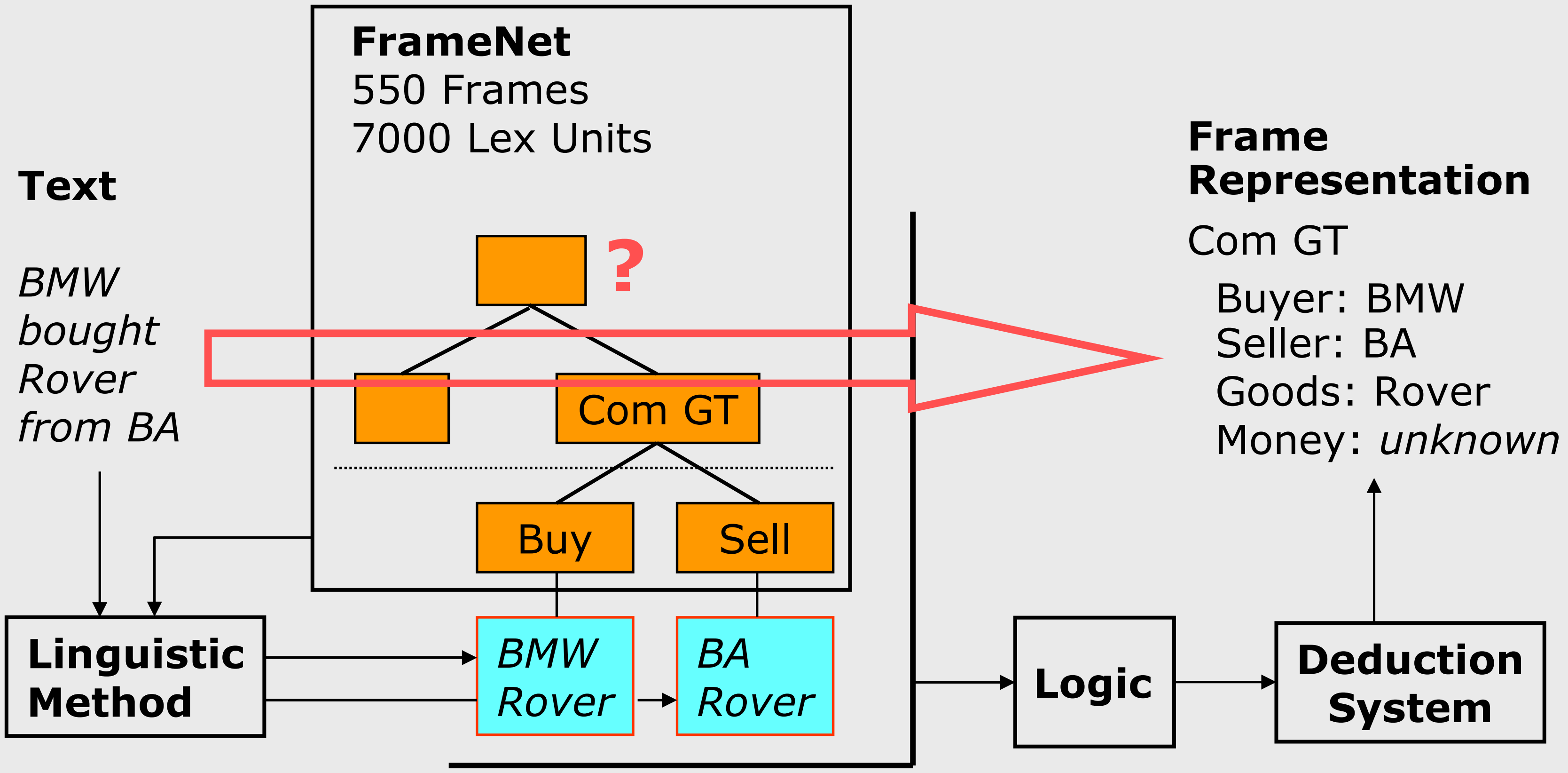
  -> High recall

- **Logic based method**
  Structured, frame-like representation
  Reasoning with background knowledge

  -> high precision

Next: knowledge representation framework

From Natural Language Text to Frame Representation



Representing Text as Logical Facts

BMW bought Rover from BA

Assumption: linguistic method delivers:

```
buy1:   buy
           buyer: "BMW"
           goods: "Rover"
```

... as a Logic Program (facts):

```
buy(buy1).
buyer(buy1,"BMW").
goods(buy1,"Rover").
```

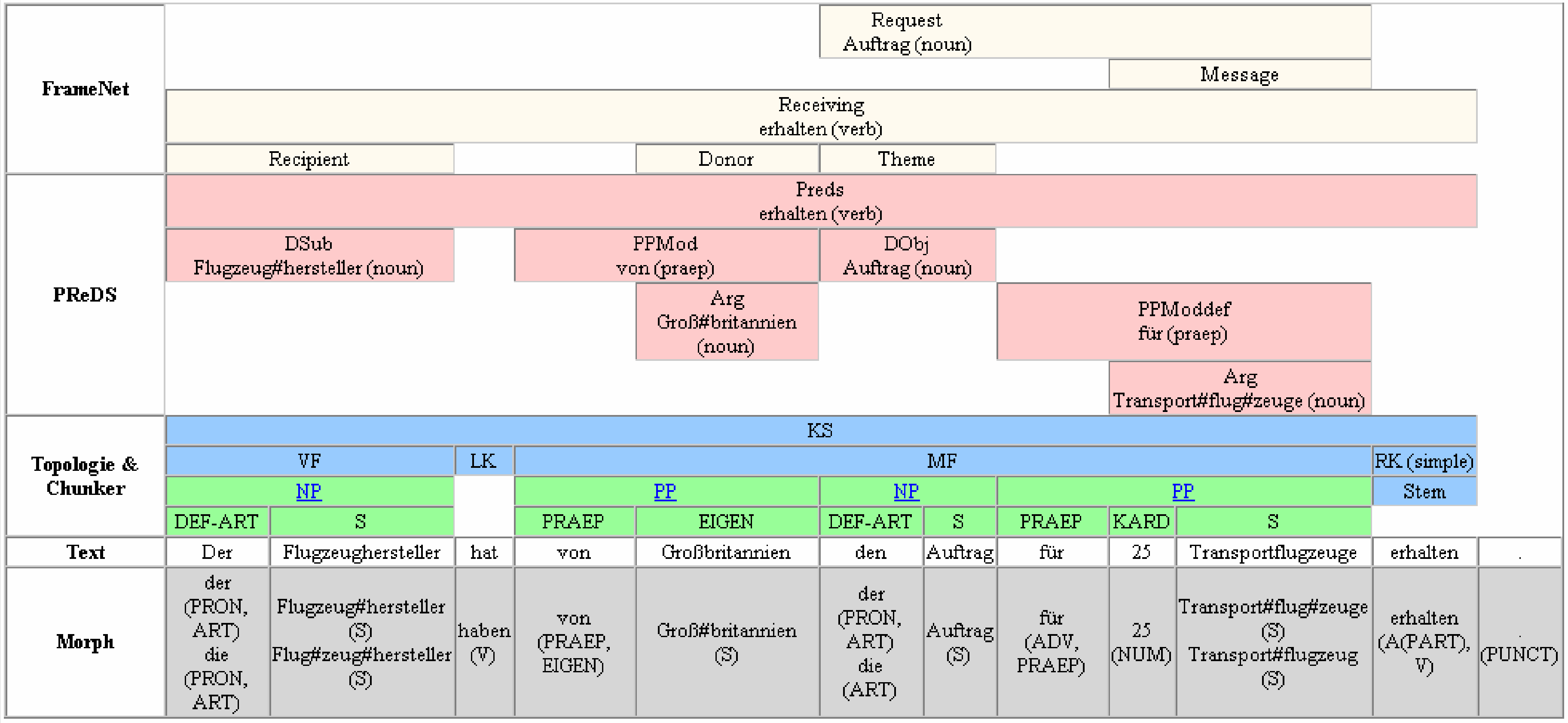
How to realize this task:

- Linguistic method knows about "basic" FrameNet Frames (those admitting linguistic realization)
- Lexical units of FrameNet frames backed up by WordNet Synonym sets
- Mapping of parse trees to frames can be learned

Extension: some parsers (Xerox LFG parser) deliver additional valuable information, e.g. that BMW is a manufacturer

A First Application: Transfer of Role Fillers

(Slide by Gerd Fliedner)



FrameNet						Request Auftrag (noun)						
									Message			
	Receiving erhalten (verb)											
	Recipient				Donor	Theme						
PReDS	Preds erhalten (verb)											
	DSub Flugzeug#hersteller (noun)			PPMod von (praep)		DObj Auftrag (noun)						
					Arg Groß#britannien (noun)			PPModdef für (praep)				
									Arg Transport#flug#zeuge (noun)			
Topologie & Chunker	KS											
	VF		LK	MF							RK (simple)	
	NP			PP		NP		PP			Stem	
	DEF-ART	S		PRAEP	EIGEN	DEF-ART	S	PRAEP	KARD	S		
Text	Der	Flugzeughersteller	hat	von	Großbritannien	den	Auftrag	für	25	Transportflugzeuge	erhalten	.
Morph	der (PRON, ART) die (PRON, ART)	Flugzeug#hersteller (S) Flug#zeug#hersteller (S)	haben (V)	von (PRAEP, EIGEN)	Groß#britannien (S)	der (PRON, ART) die (ART)	Auftrag (S)	für (ADV, PRAEP)	25 (NUM)	Transport#flug#zeuge (S) Transport#flugzeug (S)	erhalten (A(PART), V)	. (PUNCT)

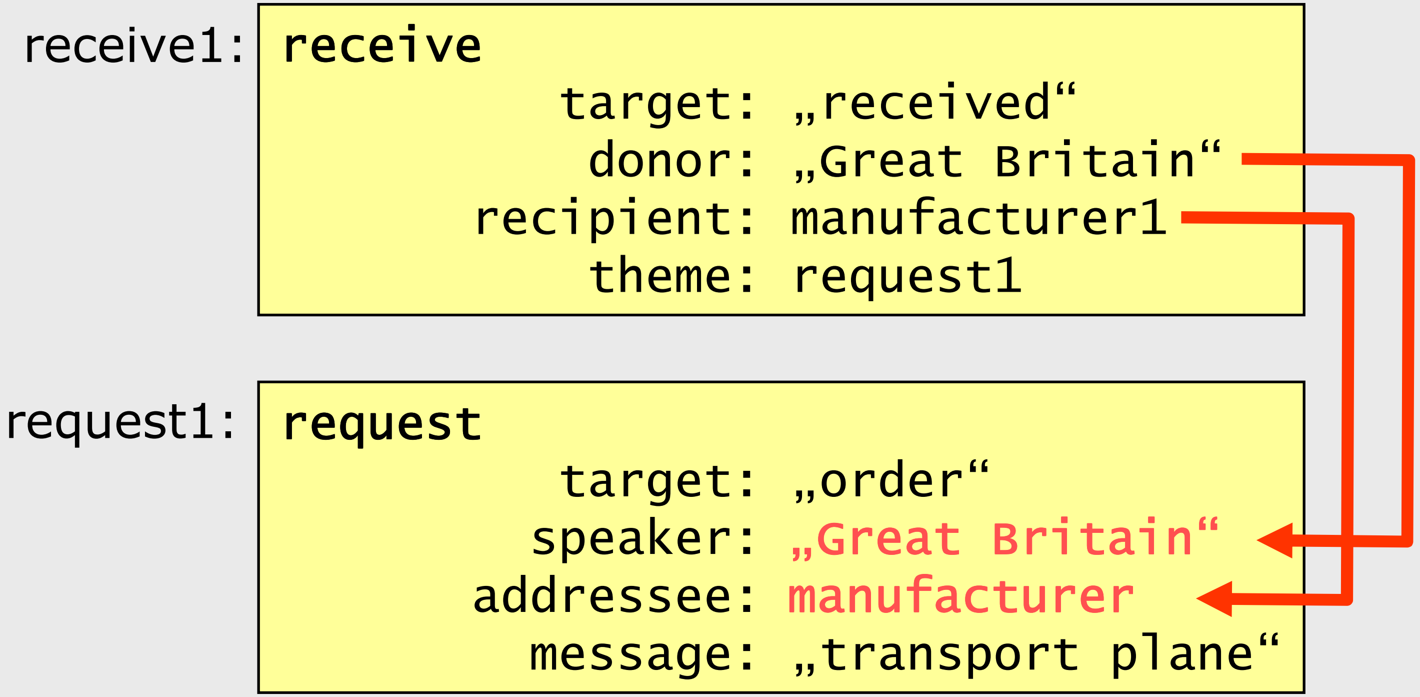
The plane manufacturer has from Great Britain the order for 25 transport planes received.

"Challenge": Fill in the missing elements of „Request“ frame

Transfer of Role Fillers

The plane manufacturer has from Great Britain the order for 25 transport planes received.

Parsing gives **partially** filled FrameNet frame instances of „receive‟ and „request‟:



```
receive1: receive
                   target: „received“
                    donor: „Great Britain“
                recipient: manufacturer1
                    theme: request1

request1: request
                   target: „order“
                  speaker: „Great Britain“
                addressee: manufacturer
                  message: „transport plane“
```

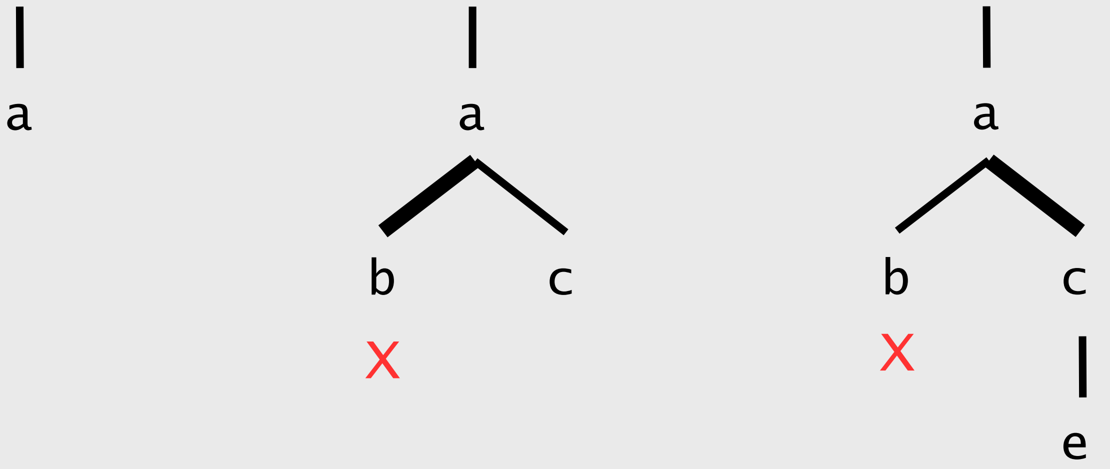
- Transfer of role fillers done so far manually
- Can be done automatically. **By „model generation‟**

Computing Models with KRHyper

- Disjunctive logic programs
- Stratified default negation
- Perfect model semantics
- Also stable models, possible models
- Serious implementation (OCaml)

```
a.                 (1)
b ; c :- a.        (2)
a ; d :- c.        (3)
false :- a,b.      (4)
```

```
e :- c, not d.   (5)
```



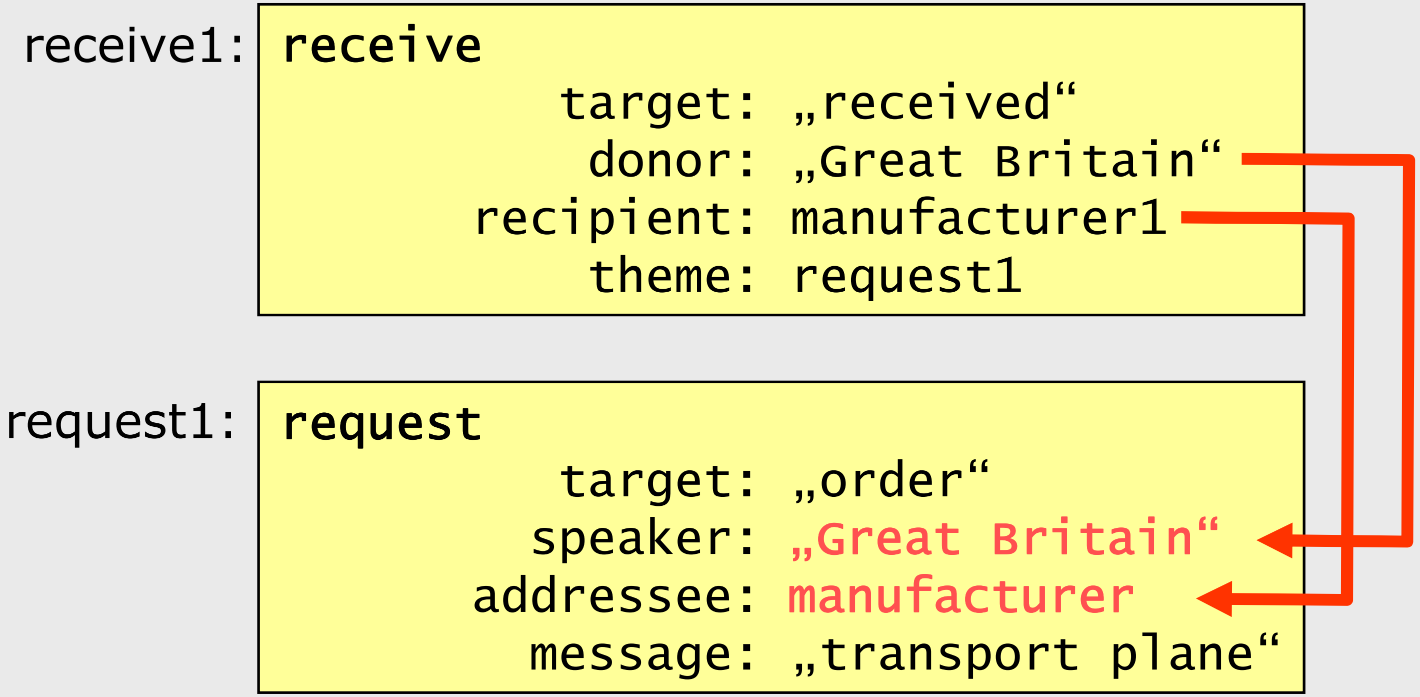
{} ⊭ (1)   {a} ⊭ (2)   {a,b} ⊭ (4) X   {a,c} ⊨ (1)-(4)

- Variant for predicate logic
- Extensions: minimal models, abduction, **default negation**

Transfer of Role Fillers

The plane manufacturer has from Great Britain the order for 25 transport planes received.

Parsing gives **partially** filled FrameNet frame instances of „receive‟ and „request‟:

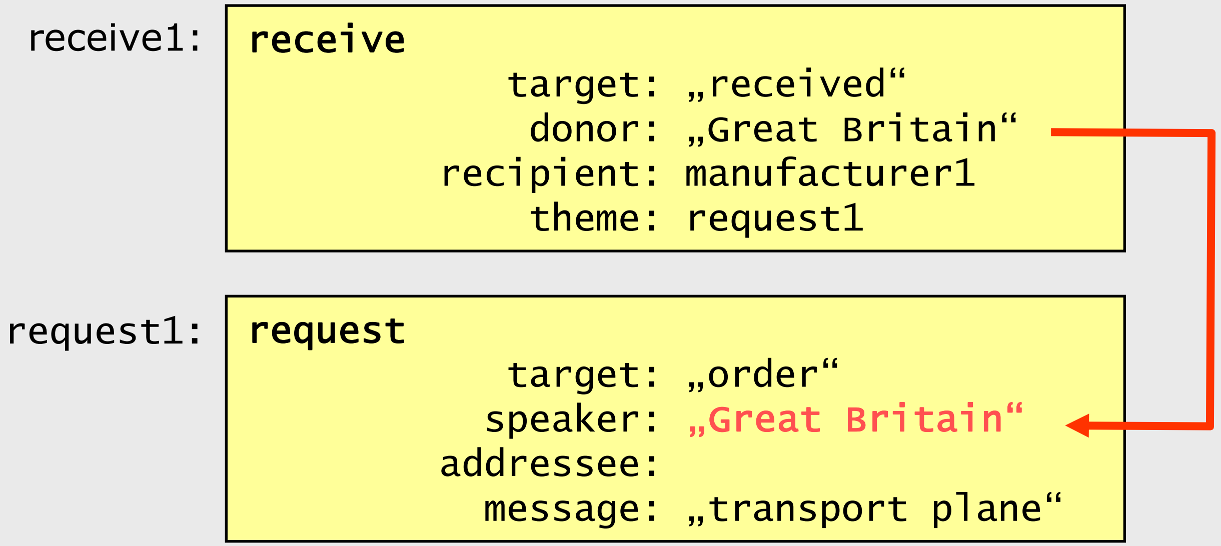


```
receive1: receive
                  target: „received“
                   donor: „Great Britain“
               recipient: manufacturer1
                   theme: request1

request1: request
                  target: „order“
                 speaker: „Great Britain“
               addressee: manufacturer
                 message: „transport plane“
```

- ➢ Transfer of role fillers done so far manually
- ➢ Can be done automatically. **By „model generation‟**

Transfer of Role Fillers by Logic Programming



```
receive1:  receive
                      target: „received“
                       donor: „Great Britain“
                   recipient: manufacturer1
                       theme: request1

request1:  request
                      target: „order“
                     speaker: „Great Britain“
                   addressee:
                     message: „transport plane“
```

Rules

```
speaker(Request, Donor) :-
        receive(Receive),
        donor(Receive, Donor),
        theme(Receive, Request),
        request(Request).
```

Facts

```
receive(receive1).
donor(receive1,
        „Great Britain“).
theme(receive1,request1).
request(request1).
```

Translation of FrameNet Frames to Logic Programs

So far:

- logical representation of analyzed text, and
- impression of usefulness of logic programming approach using hand-crafted "expensive" rules. But:

FrameNet offers useful information that can be translated once and for all into a logic program, in a systematic way:

- Inheritance among frames
- "Uses" relationships (partial inheritance)
- "Subframe" relationships

This way, FrameNet is equipped with a formal semantics!

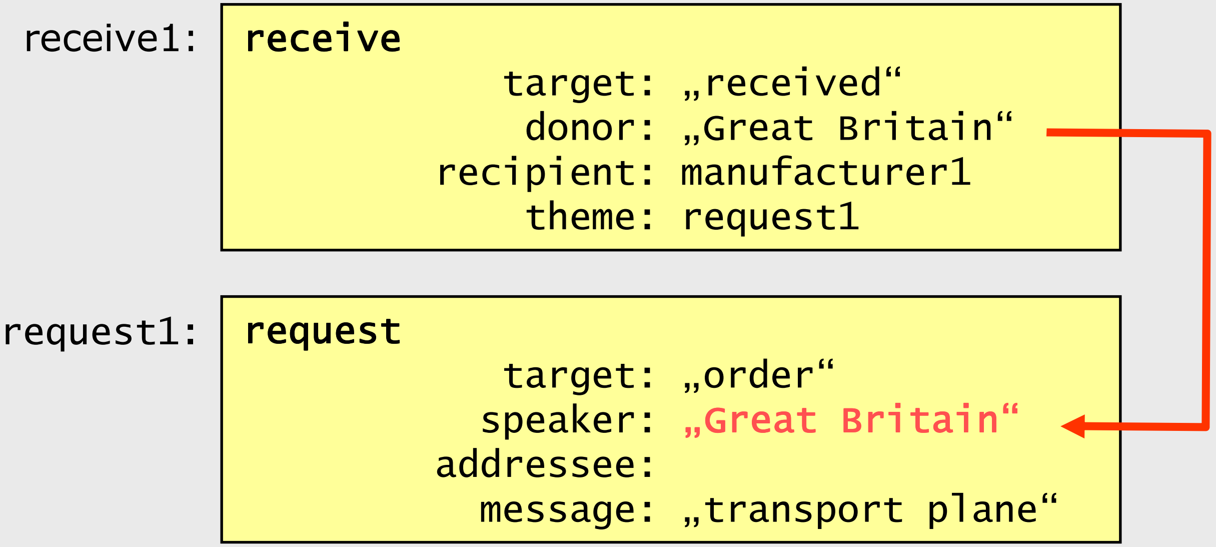
Also realized in our translation: default values

Next: default values in some detail, "Uses" relationship in brief

Default Values

Insert default value as a role filler in absence of specific information

Example:



```
receive1:  receive
                      target: „received“
                       donor: „Great Britain“
                   recipient: manufacturer1
                       theme: request1

request1:  request
                      target: „order“
                     speaker: „Great Britain“
                   addressee:
                     message: „transport plane“
```

Should transfer "donor" role filler only if "speaker" is not already filled:

```
default_request_speaker(Request, Donor) :-
        receive(Receive),
        donor(Receive, Donor),
        theme(Receive, Request),
        request(Request).
```

Default Values

Insert default value as a role filler in absence of specific information

Example:
In Stock Market context use default "share" for "goods" role of "buy":

```
default_buy_goods(Buy, "share") :-
        'Buy is an event in a stock market context'.
```

Example:
Disjunctive (uncertain) information

Linguistic analysis is uncertain whether "Rover" or "Chrysler" was bought:

```
default_buy_goods(buy1,"Rover").
default_buy_goods(buy1,"Chrysler").
```

This amounts to *two* models, representing the uncertainty
They can be analyzed further

Default Values

Insert default value as a role filler in absence of specific information

Example:
Generic "typed" default value:

```
default_commerce_goods_transfer_money(_,unspecified_money).
```

Generic default value, general scheme:

default_F_R(_,unspecified).

where F is a Frame with role R

Note:

Apply general scheme only to basic frames, but omit FEE role.
Otherwise every frame will be filled right away, which is pointless!

Default Value – General Transformation

Technique:

```
        a :- not not_a.
        not_a :- not a.
```

has two stable models: one where a is true and one where a is false

Choice to fill with default value or not:

```
goods(F,R) :-
        not not_goods(F,R),
        buy(F),
        default_buy_goods(F,R).

not_goods(F,R) :-
        not goods(F,R),
        buy(F),
        default_buy_goods(F,R).
```

Case of waiving default value:

```
false :-
        buy(F),
        default_buy_goods(F,R1),
        goods(F,R1),
        goods(F,R2),
        not equal(R1,R2).

equal(X,X).
```

Require at least one filler for role:

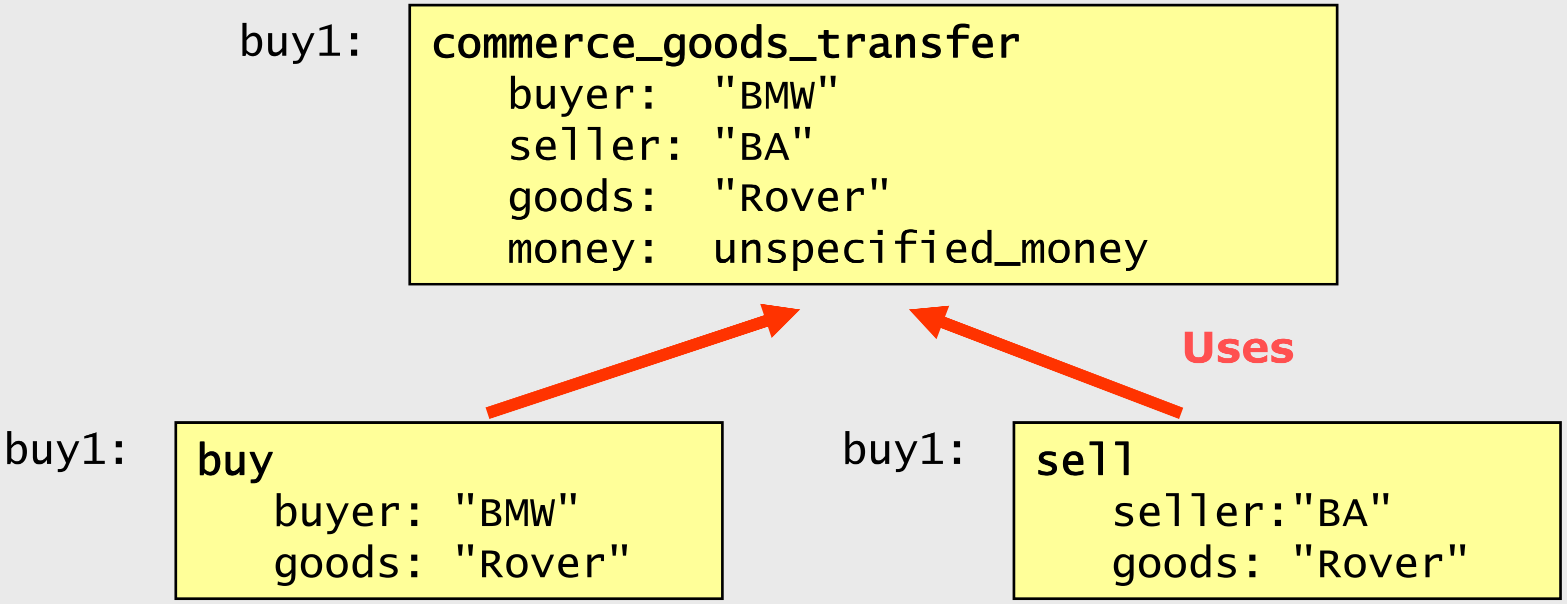
```
false :-
        buy(F),
        not some_buy_goods(F).
```

Role is filled:

```
some_buy_goods(F) :-
        buy(F),
        goods(F,R).
```

The "Uses" Relation

Pragmatics: offer different perspectives on Frames



```
buy1: commerce_goods_transfer
         buyer:  "BMW"
         seller: "BA"
         goods:  "Rover"
         money:  unspecified_money
```

Uses

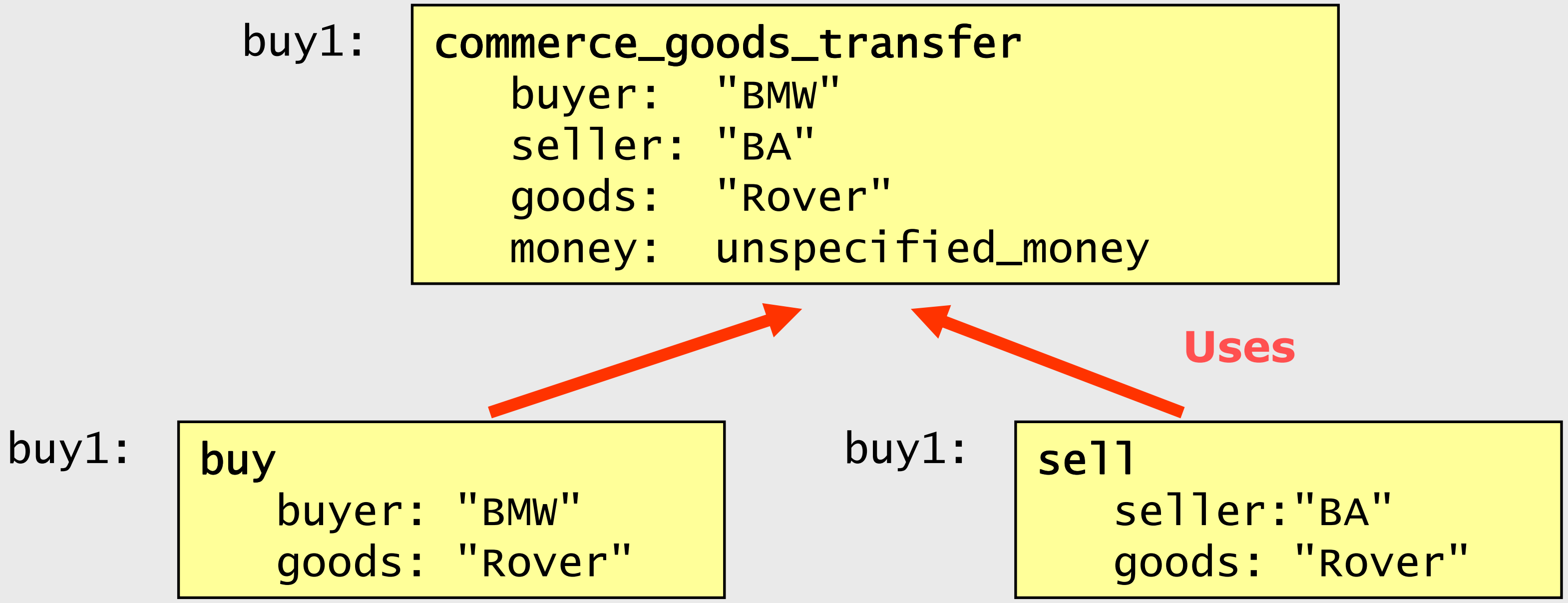
```
buy1: buy
         buyer: "BMW"
         goods: "Rover"
```

```
buy1: sell
         seller:"BA"
         goods: "Rover"
```

Technically: partial inheritance

The "Uses" Relation – Partial Inheritance

"Upwards" inheritance:



```
buy1: commerce_goods_transfer
         buyer:  "BMW"
         seller: "BA"
         goods:  "Rover"
         money:  unspecified_money
```

Uses

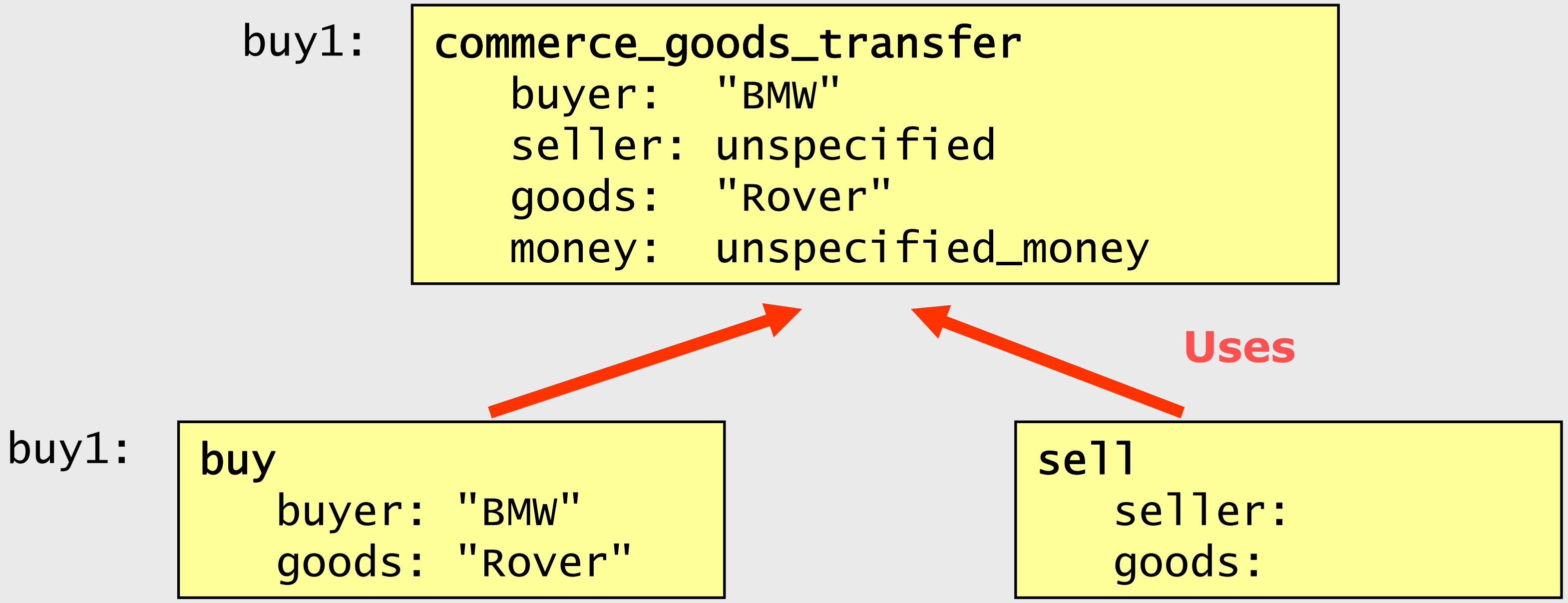
```
buy1: buy
         buyer: "BMW"
         goods: "Rover"
```

```
buy1: sell
         seller:"BA"
         goods: "Rover"
```

- Create instance of "used" frame
- ransfer role fillers of "using" frame
- Use default values for extra roles of "used" frame

The "Uses" Relation – Partial Inheritance

"Upwards" inheritance – slightly different scenario:



```
buy1: commerce_goods_transfer
         buyer:  "BMW"
         seller: unspecified
         goods:  "Rover"
         money:  unspecified_money
```

Uses

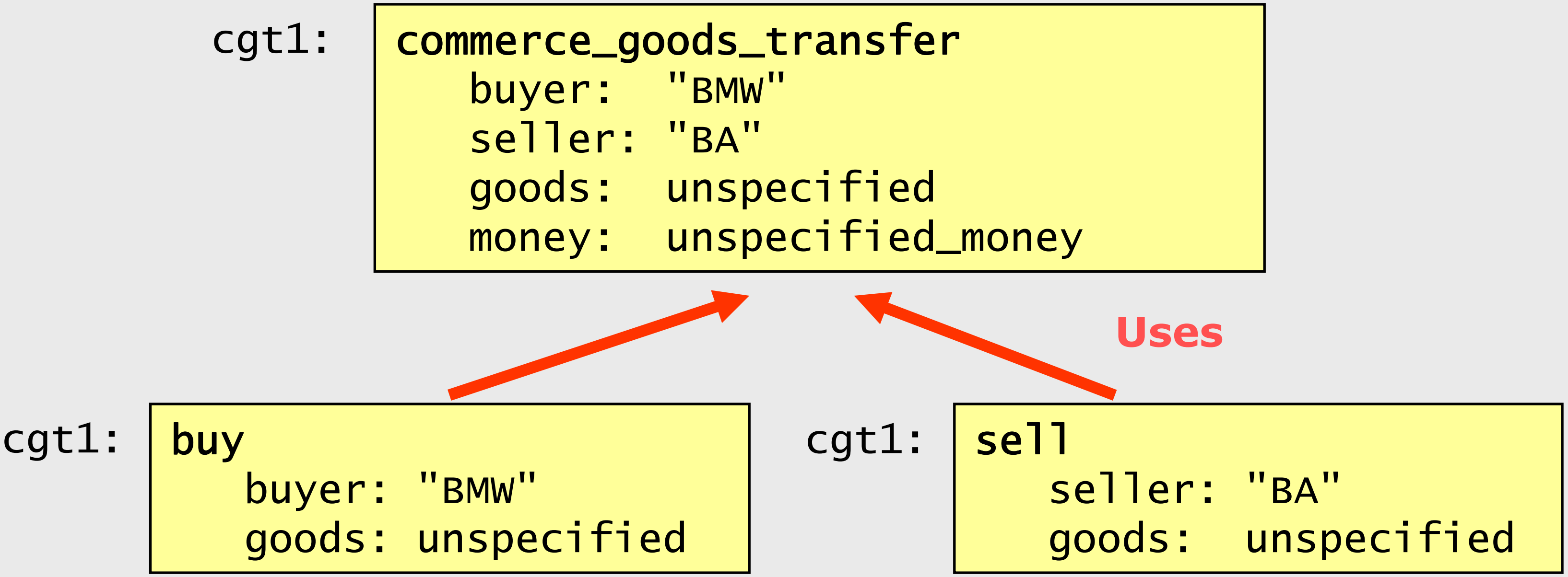
```
buy1: buy
         buyer: "BMW"
         goods: "Rover"
```

```
sell
   seller:
   goods:
```

- Create instance of "used" frame
- transfer role fillers of "using" frame
- Use default values for extra roles of "used" frame

The "Uses" Relation – Partial Inheritance

"Downwards " inheritance:



```
cgt1: commerce_goods_transfer
         buyer:  "BMW"
         seller: "BA"
         goods:  unspecified
         money:  unspecified_money
```

Uses

```
cgt1: buy
         buyer: "BMW"
         goods: unspecified
```

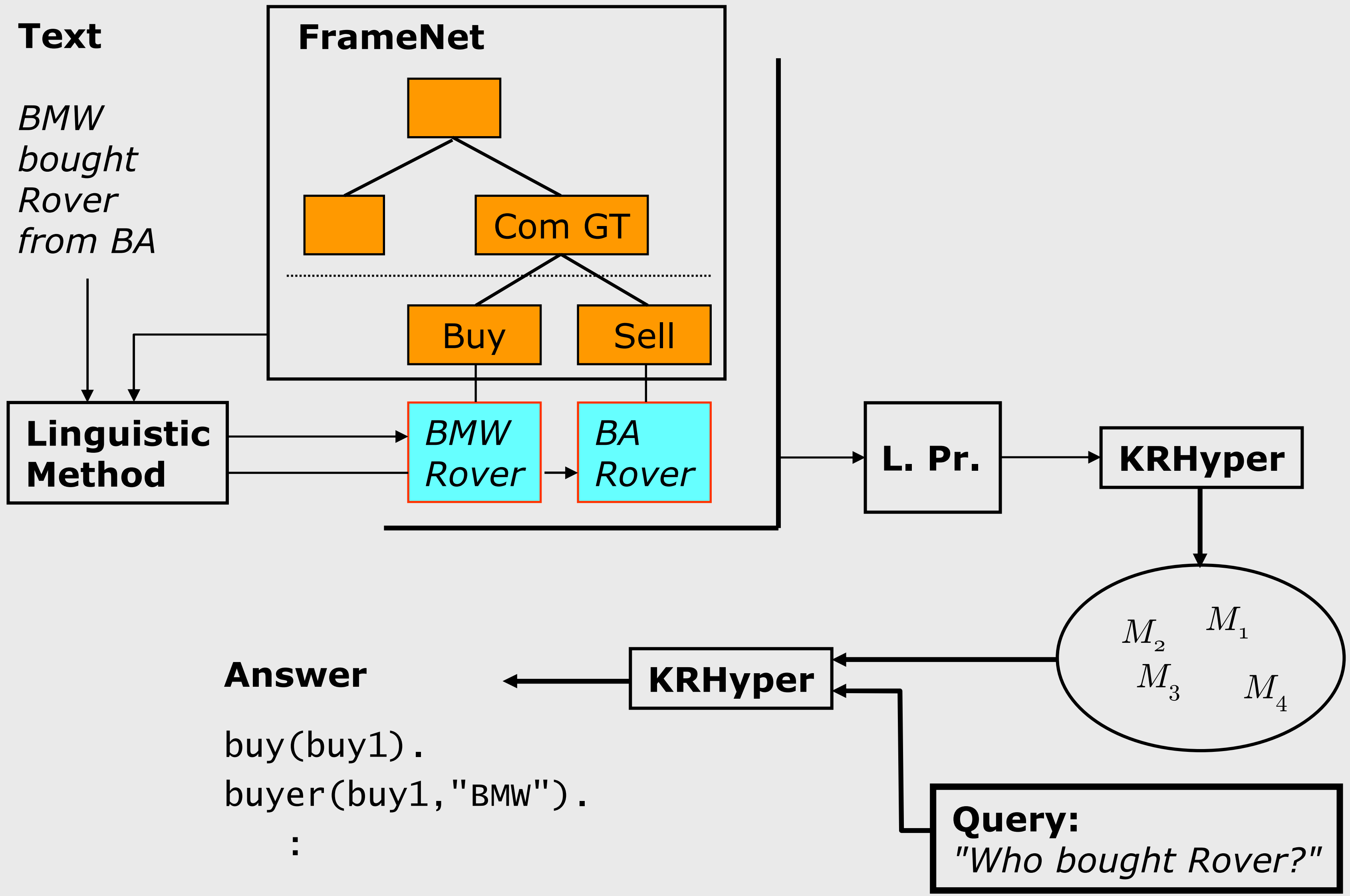
```
cgt1: sell
         seller: "BA"
         goods:  unspecified
```

- Create instances of "using" frames
- Transfer role fillers of "used" frame

Note: "money" role is not inherited

Rules accomplishing partial inheritance can be derived automatically!

Query Evaluation



Text

BMW bought Rover from BA

FrameNet

Com GT

Buy

Sell

Linguistic Method

BMW Rover

BA Rover

L. Pr.

KRHyper

M_2 M_1 M_3 M_4

KRHyper

Query: *"Who bought Rover?"*

Answer

```
buy(buy1).
buyer(buy1,"BMW").
    :
```

Query Evaluation - Technical

Who bought Rover from whom?

As a conjunctive query:

```
Q:     solution(Buyer,Seller) :-
              commerce_goods_transfer(E),
              buyer(E,Buyer),
              goods(E,"Rover"),
              seller(E,Seller).
```

Assume models of text M_1,...,M_n already computed

Different Reasoning Tasks

Credulous: exists M_i such that $M_i \cup \{Q\} \models$ `solution(`B`,`S`) ?`
(for some B and S)

Skeptical: for all M_i, does $M_i \cup \{Q\} \models$ `solution(`B`,`S`) hold?`
(for some B and S)

Both can be solved by inspecting models of $M_i \cup \{Q\}$

Next Step: RTE Challenge

- Recognizing Text Entailment Challenge
  Bar Ilan University, Israel, November 2004
- Compare natural language processing systems for IR, QA, ...
  on a common test set
- "Textual entailment problem":
  - Given: a text snippet "text"
  - Given: a text snippet "hypothesis"
  - Question: Does "text" entail "hypothesis"?
- 300 sample pairs available now as a test set, total 1000
- Test goes beyond word sense disambiguation and beyond named entity recognition. Need "semantic" processing
- Challenge is considered as difficult by its creators
- Our approach:
  - compute models of "text" and "hypothesis"
  - compare models using further background knowledge

RTE Challenge - Examples

Text	**Hypothesis**	**Status**
Doug Lawrence bought the impressionist oil landscape by J. Ottis Adams in the mid-1970s at a Fort Wayne antiques dealer	*Doug Lawrence sold the impressionist oil landscape by J. Ottis Adams*	False
Eyeing the huge market potential, currently led by Google, Yahoo took over search company Overture Services Inc last year	*Yahoo bought Overture.*	True
The market value of u.s. overseas assets exceeds their book value.	*The market value of u.s. overseas assets equals their book value.*	False
Crude oil for April delivery traded at $37.80 a barrel, down 28 cents	*Crude oil prices rose to $37.80 per barrel*	False
Guerrillas killed a peasant in the city of Flores	*Guerrillas killed a civilian*	True
Clinton's new book is not big seller here	*Clinton's book is a big seller*	False

Conclusions

Summary

- Propose model computation paradigm for "semantical" processing of natural language text
- Target application: information retrieval from templates, question answering
- Builds on readily developed FrameNet ontology

Lots of Open Ends

- Implementation (Master's thesis, in progress)
- Practical evaluation, in particular RTE challenge
- Negation, Anaphora resolution
- Background knowledge: combination with ontologies like SUMO
- Relevance of proposed framework for Semantic Web