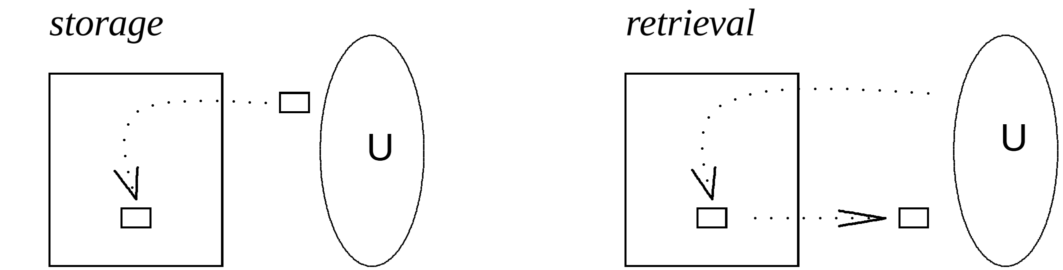
22. Database semantics

22.1 Database metaphor of natural communication

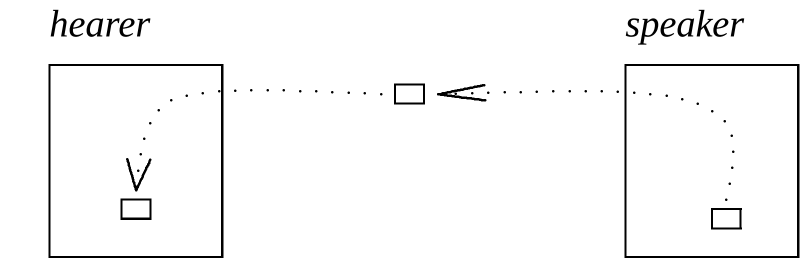
22.1.1 Interaction with a conventional database



moment of time t_1 $<$ t_2

database A = A

22.1.2 Interaction between speaker and hearer



moment of time t_2 $>$ t_1

database H $\neq$ S

22.1.3 DB interaction and NL communication

- ENTITIES INVOLVED

  Database interaction: takes place between two different entities, the user and the database.

  NL communication: takes place between two similar and equal cognitive agents, the speaker and the hearer.

- ORIGIN OF CONTROL

  Database interaction: operations of input and output are controlled by the user.

  NL communication: there is no user. Instead, the cognitive agents control each other by alternating in the speaker- and the hearer-mode (*turn taking*).

- METHOD OF CONTROL

  Database interaction: user controls the operations of the database with a programming language the commands of which are executed as electronic procedures.

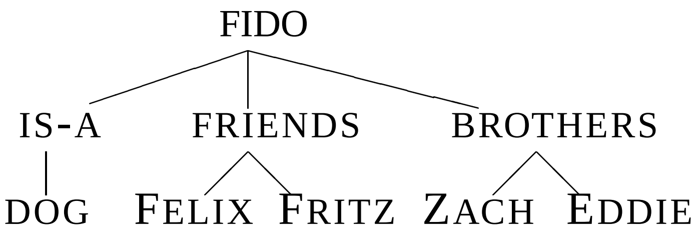
  NL communication: speaker controls language production as an autonomous agent, coding the parameters of the utterance situation into the output expressions. The hearer's interpretation is controlled by the incoming language expression.

- TEMPORAL ORDER

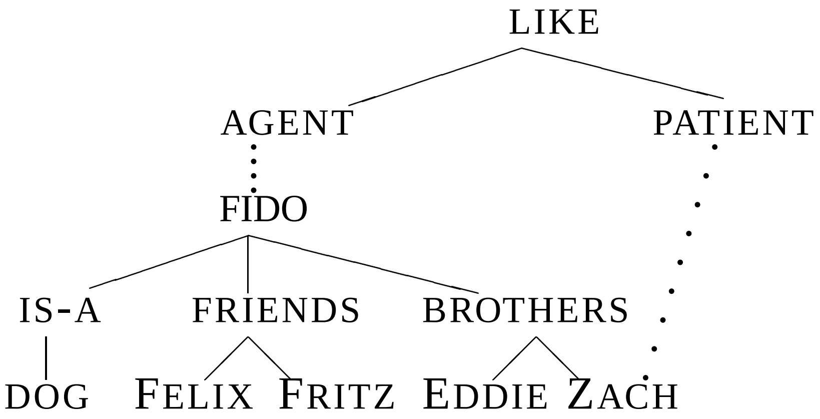
  Database interaction: output (database as 'speaker') occurs necessarily *after* the input (database as 'hearer').

  NL communication: production (output procedure of the speaker) occurs necessarily *before* interpretation (input procedure of the hearer).

22.1.4 Sketch of a simple subcontext



22.1.5 Pragmatic interpretation of 22.1.1



22.2 Descriptive aporia and embarrassment of riches

22.2.1 Model-theoretic definition of a context

Let $\mathcal{MS}$ be a model structure (A,I,J,$\leq$,F), where A, I, J are sets, $\leq$ is a simple ordering on J, and F is a denotation function.

A, I, J, and F have the following definition:

A = {a_0, a_1, a_2, a_3, a_4}, I = {i_1}, J = {j_1}

F(fido')(i_1, j_1) = a_0

F(felix')(i_1, j_1) = a_1

F(fritz')(i_1, j_1) = a_2

F(zach')(i_1, j_1) = a_3

F(eddie')(i_1, j_1) = a_4

F(dog')(i_1, j_1) = {a_0}

F(fido-friends')(i_1, j_1) = {a_1, a_2}

F(fido-brothers')(i_1, j_1) = {a_3, a_4}

22.2.2 Extending the hearer context to the meaning of a new sentence such as Fido likes Zach

Requires automatic addition of 'F(like)(i_1, j_1) = {(a_0,a_3)}' to 22.2.1

22.2.3 Creating a *frame*

```
(make-frame
  fido
    (is-a (value dog))
    (friends (value felix fritz))
    (brothers (value zach eddie))
)
```

22.2.4 Definition of 22.4.2 as a *frame*

```
(fido
  (is-a (value dog))
  (friends (value felix fritz))
  (brothers (value zach eddie))
)
```

22.2.5 Retrieving information

```
(get-values ’FIDO ’FRIENDS)
(FELIX FRITZ)
```

22.2.6 Extending the hearer context to Fido likes Zach

Requires deriving

```
(fido
 (like (value Zach)
)
```

and automatically adding the part

```
(like (value Zach)
```

as a new slot into 22.2.4.

22.3 Propositions as sets of coindexed proplets

22.3.1 Proposition 3.4.2 as a set of proplets (preliminary format)

$$
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: field} \\ \text{role: argument} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x1} \\ \text{functor: contain} \\ \text{prn: 23} \\ \text{id: 7} \end{array}\right]
\end{array}\right]
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: contain} \\ \text{role: functor} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x2} \\ \text{argument 1: field} \\ \text{argument 2: triangle} \\ \text{prn: 23} \\ \text{epr: 23 and 24} \end{array}\right]
\end{array}\right]
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: triangle} \\ \text{role: argument} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x3} \\ \text{functor: contain} \\ \text{prn: 23} \\ \text{id: 8} \end{array}\right]
\end{array}\right]
$$

$$
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: field} \\ \text{role: argument} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x4} \\ \text{functor: contain} \\ \text{prn: 24} \\ \text{id: 7} \end{array}\right]
\end{array}\right]
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: contain} \\ \text{role: functor} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x5} \\ \text{argument 1: field} \\ \text{argument 2: square} \\ \text{prn: 24} \\ \text{epr: 23 and 24} \end{array}\right]
\end{array}\right]
\left[\begin{array}{l}
\textit{Type:} \\
\left[\begin{array}{l} \text{M-concept: square} \\ \text{role: argument} \end{array}\right] \\
\textit{Token:} \\
\left[\begin{array}{l} \text{I-concept}_{loc}\text{: x6} \\ \text{functor: contain} \\ \text{prn: 24} \\ \text{id: 9} \end{array}\right]
\end{array}\right]
$$

22.4 Proplets in a classic database

22.4.1 Types of databases

classic: record based
non-classic: based on the principle of slot and filler

22.4.2 Types of classic databases

Relational database, hierarchical database, network database

22.4.3 Relations between proplet features

type ↔ token
token ↔ prn
prn ↔ epr
token ↔ id
functor ↔ argument
modifier ↔ modified

22.4.4 Propositions 3.4.2 as a word bank

TYPES	SIMPLIFIED PROPLETS	
$\begin{bmatrix}\text{M-concept: contain}\\ \text{role: functor}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x2}\\ \text{argument 1:field}\\ \text{argument 2:triangle}\\ \text{prn: 23}\\ \text{epr: 23 and 24}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x5}\\ \text{argument 1:field}\\ \text{argument 2:square}\\ \text{prn: 24}\\ \text{epr: 23 and 24}\end{bmatrix}$
$\begin{bmatrix}\text{M-concept: field}\\ \text{role: argument}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x1}\\ \text{functor: contain}\\ \text{prn: 23}\\ \text{id: 7}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x4}\\ \text{functor: contain}\\ \text{prn: 24}\\ \text{id:7}\end{bmatrix}$
$\begin{bmatrix}\text{M-concept: square}\\ \text{role: argument}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x6}\\ \text{functor: contain}\\ \text{prn: 24}\\ \text{id: 9}\end{bmatrix}$	
$\begin{bmatrix}\text{M-concept: triangle}\\ \text{role: argument}\end{bmatrix}$	$\begin{bmatrix}\text{I-concept}_{loc}\text{: x3}\\ \text{functor: contain}\\ \text{prn: 23}\\ \text{id: 8}\end{bmatrix}$	

22.4.5 Example of a network database

owner records	*member records*			
Comp.Sci.	Riedle	Schmidt	Stoll	...
Mathematics	Müller	Barth	Jacobs	...
Physics	Weber	Meier	Miele	...

22.4.6 Types of continuations

intrapropositional:
from argument to functor, functor to argument, from modifier to modified and vice versa

extrapropositional:
epr from verb to verb, id from noun to noun

22.5 Example of a word bank

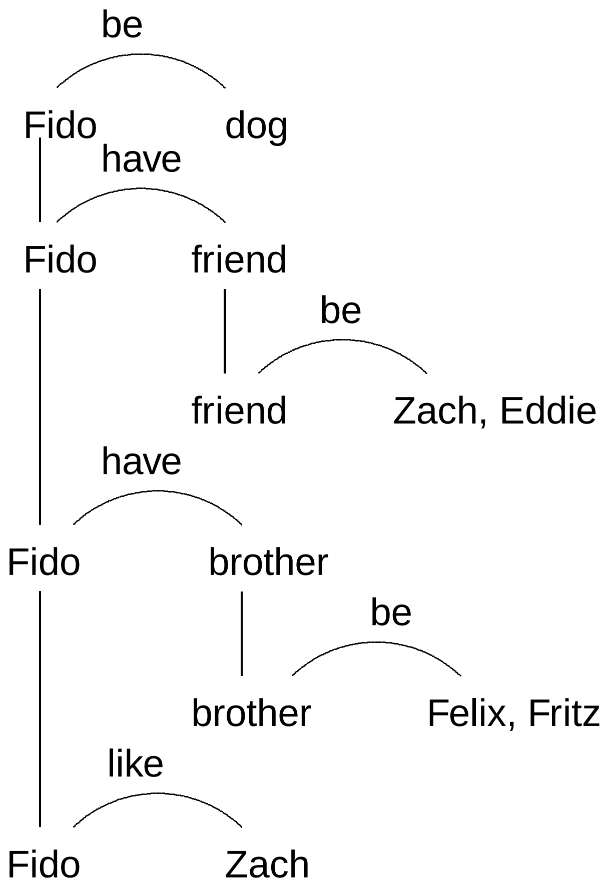
22.5.1 Propositional presentation of subcontext 22.1.4

1. Fido is a dog.
2. Fido has friends.
3. The friends are Zach and Eddie.
4. Fido has brothers.
5. The brothers are Felix and Fritz.

---

6. Fido likes Zach.

22.5.2 Graphical presentation of the propositions in 22.5.1



22.5.3 Subcontext 22.1.1 as a word bank

TYPES	PROPLETS		
$\left[\begin{array}{l}\text{M-concept: be}\\ \text{role: functor}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x1}\\ \text{arg1: Fido}\\ \text{arg2: dog}\\ \text{prn: 1}\\ \text{epr: 1 and 2}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x2}\\ \text{arg1: friend}\\ \text{arg2: Zach, Eddie}\\ \text{prn: 3}\\ \text{epr: 2 and 3}\\ \quad\text{3 and 4}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x3}\\ \text{arg1: brother}\\ \text{arg2: Felix, Fritz}\\ \text{prn: 5}\\ \text{epr: 4 and 5}\\ \quad\text{5 and 6}\end{array}\right]$
$\left[\begin{array}{l}\text{M-concept: brother}\\ \text{role: argument}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x4}\\ \text{functor: have}\\ \text{prn: 4}\\ \text{id:}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x5}\\ \text{functor: be}\\ \text{prn: 5}\\ \text{id:}\end{array}\right]$	
$\left[\begin{array}{l}\text{M-concept: dog}\\ \text{role: argument}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x6}\\ \text{functor: be}\\ \text{prn: 4}\\ \text{id:}\end{array}\right]$		
$\left[\begin{array}{l}\text{M-concept: Eddie}\\ \text{role: argument}\end{array}\right]$	$\left[\begin{array}{l}\text{I-concept}_{loc}\text{: x7}\\ \text{functor: be}\\ \text{prn: 3}\\ \text{id: 3}\end{array}\right]$		

$$\begin{bmatrix}\text{M-concept: Felix}\\ \text{role: argument}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x8}\\ \text{functor: be}\\ \text{prn: 5}\\ \text{id: 4}\end{bmatrix}$$

$$\begin{bmatrix}\text{M-concept: Fritz}\\ \text{role: argument}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x9}\\ \text{functor: be}\\ \text{prn: 5}\\ \text{id: 5}\end{bmatrix}$$

$$\begin{bmatrix}\text{M-concept: Fido}\\ \text{role: argument}\end{bmatrix} \quad \begin{bmatrix}\text{I-con.}_{loc}\text{: x10}\\ \text{functor: be}\\ \text{prn: 1}\\ \text{id: 1}\end{bmatrix} \begin{bmatrix}\text{I-con.}_{loc}\text{: x11}\\ \text{functor: have}\\ \text{prn: 2}\\ \text{id: 1}\end{bmatrix} \begin{bmatrix}\text{I-con.}_{loc}\text{: x12}\\ \text{functor: have}\\ \text{prn: 4}\\ \text{id: 1}\end{bmatrix} \begin{bmatrix}\text{I-con.}_{loc}\text{: x13}\\ \text{functor: like}\\ \text{prn: 6}\\ \text{id: 1}\end{bmatrix} \&$$

$$\begin{bmatrix}\text{M-concept: friend}\\ \text{role: argument}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x14}\\ \text{functor: have}\\ \text{prn: 2}\\ \text{id:}\end{bmatrix} \begin{bmatrix}\text{I-concept}_{loc}\text{: x15}\\ \text{functor: be}\\ \text{prn: 3}\\ \text{id:}\end{bmatrix}$$

$$\begin{bmatrix}\text{M-concept: have}\\ \text{role: functor}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x16}\\ \text{arg1: Fido}\\ \text{arg2: friend}\\ \text{prn: 2}\\ \text{epr: 1 and 2}\\ \quad\text{2 and 3}\end{bmatrix} \begin{bmatrix}\text{I-concept}_{loc}\text{: x17}\\ \text{arg1: Fido}\\ \text{arg2: brother}\\ \text{prn: 4}\\ \text{epr: 3 and 4}\\ \quad\text{4 and 5}\end{bmatrix}$$

$$\begin{bmatrix}\text{M-concept: like}\\ \text{role: functor}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x18}\\ \text{arg1: Fido}\\ \text{arg2: Zach}\\ \text{prn: 6}\\ \text{epr: 5 and 6}\end{bmatrix} \&$$

$$\begin{bmatrix}\text{M-concept: Zach}\\ \text{role: argument}\end{bmatrix} \quad \begin{bmatrix}\text{I-concept}_{loc}\text{: x19}\\ \text{functor: be}\\ \text{prn: 3}\\ \text{id: 2}\end{bmatrix} \begin{bmatrix}\text{I-concept}_{loc}\text{: x20}\\ \text{functor: like}\\ \text{prn: 6}\\ \text{id: 2}\end{bmatrix} \&$$

22.5.4 Semantic representation of proposition 6

$$\begin{array}{ll}
\text{TYPES} & \text{PROPLETS} \\
\begin{bmatrix}\text{M-concept: Fido}\\ \text{role: argument}\end{bmatrix} & \begin{bmatrix}\text{I-concept}_{loc}\text{: x13}\\ \text{functor: like}\\ \text{prn: 6}\\ \text{id: ?}\end{bmatrix} \\
\begin{bmatrix}\text{M-concept: like}\\ \text{role: functor}\end{bmatrix} & \begin{bmatrix}\text{I-concept}_{loc}\text{: x18}\\ \text{arg1: Fido}\\ \text{arg2: Zach}\\ \text{prn: 6}\\ \text{epr: ?}\end{bmatrix} \\
\begin{bmatrix}\text{M-concept: Zach}\\ \text{role: argument}\end{bmatrix} & \begin{bmatrix}\text{I-concept}_{loc}\text{: x20}\\ \text{functor: like}\\ \text{prn: 6}\\ \text{id: ?}\end{bmatrix}
\end{array}$$