On the Structure of the Information Space

(an informal overview)

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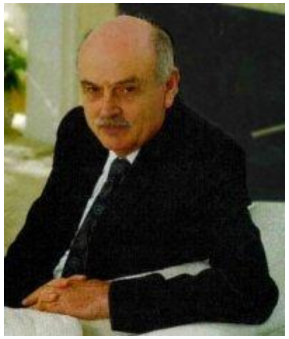
People make history

- Charles W. Bachman
  "*the programmer as navigator*" – IDS, CODASYL, pointers, machines, **files**

- Edgar F. Codd
  "*the casual user*" –
  logic, algebra, tables as **abstract data types**



- Peter P. Chen –
  "modeling the things in the real world" –
  diagrams, pictograms, **concepts**

Designing along 3 stages

Conceptual stage – Entity-Relationship model

Logical stage – Abstract data type

Physical stage – DBMSs

From database design to full-fledged information system design

- “Active conceptual modeling” (Chen, ER 2006).
- Our proposal: at the conceptual stage, extend the ER approach to treat, not only facts, but also events and agents.
- Approach: notions taken from Semiotics
- Scope: application domains including public and business administration, literary genres, education and training ...

Topics

- Part 1 – Design at the conceptual stage
  - Facts
  - Events
  - Agents
- Part 2 – Design at the logical stage
  - Facts
  - Events
  - Agents
- Part 3 – Example application: a literary genre
- Concluding remarks

Part 1

Design at the

Conceptual stage

Three-schema
ER conceptual specifications

- static schema – facts – entities, relationships, attributes, is-a, part-of, ...
- dynamic schema – events – application-domain operations (STRIPS), plans, ...
- behavioural schema – agents – situation-goal rules, typical plans, ...

Conceptual stage:

Facts

Facts as elements of the Information Space

- The ER model: entities and their properties (attributes and binary relationships)
- Facts – assertions about existing entity instances and their properties
- State – all facts holding at a moment of time
- Situation – a logical expression involving facts

Composing utterances

- Utterances: chains of facts
- Saussurean model
- syntagmatic axis: composing the chain –
  Joe’s age is 25 ***and*** Joe works for Acme ***and***…
- paradigmatic axis: selecting alternatives for certain positions in the chain –
  Joe ***or*** Moe ***or***…
  age 25 ***or*** age 38 ***or*** age 7 ***or***…

Differences within a paradigm

- Joe’s age is 25 ***and*** Joe works for Acme ***and***…
- Moe’s age is 38 ***and*** Moe works for Acme ***and***…
- (*) Joe’s age is 7 ***and*** Joe works for Acme ***and***…

- Differences may or may not be “functional”
- The axes are ***not*** orthogonal:
  – integrity constraints, business rules, conventions,…
- Conflicts, binary oppositions, negation

On the choice of paradigms: classes and classification

- Property irregularities:

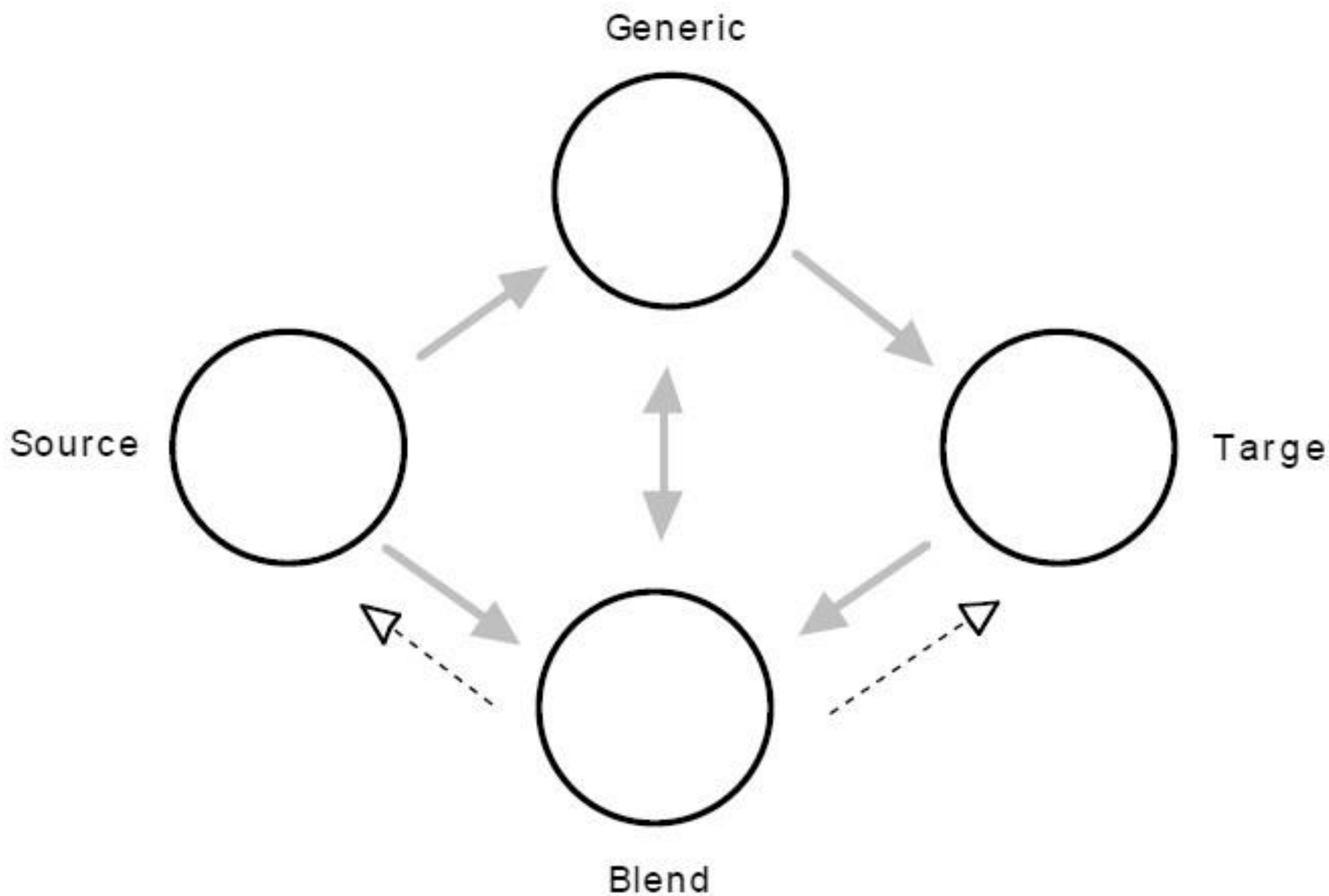
  – unknown, non-applicable, defaults, diversity.

- Arbitrariness of pre-defined classes.
- Lakoff’s claim: construct classes around typical representatives, similarity indicators.
- Use clustering methods.
- From standard to pragmatic time-varying classes (“all I need to know for my trip”), folksonomies.

Similarity and analogy

- Similarity: in the same domain.
- Analogy: across different domains.
- Using analogy to construct new classes.
- Fauconnier and Turner's four-space approach: source, target, generic, and blend (employee, student, person, **trainee**)
- Map the analogous properties, creative conflict resolution: re-use and adapt.

Fauconnier and Turner's four-space approach



Going down to details

- Semantic hierarchies (modularization): *is-a*, *part-of*,…
- The Product Division is *part-of* Acme
- The Sales Division is *part-of* Acme
- Joe is assigned to the Sales Division *and* Moe is assigned to the Sales Division *and* Moe reports to Joe

Already observed by Saussure – several successive paradigmatic / syntagmatic planes (structure-preserving mappings): sentences, words, morphemes, …

Six kinds of *part-of*

- Component / Integral Object - handle / cup
- Member / Collection – card / deck
- Portion / Mass – slice / pie
- Stuff / Object – gin / martini
- Feature / Activity – paying / shopping
- Place / Area – Everglades / Florida

Characteristics of utterances

- **Coherent**, cohesive: e.g. constituent facts about the same entity, plus navigation across links:

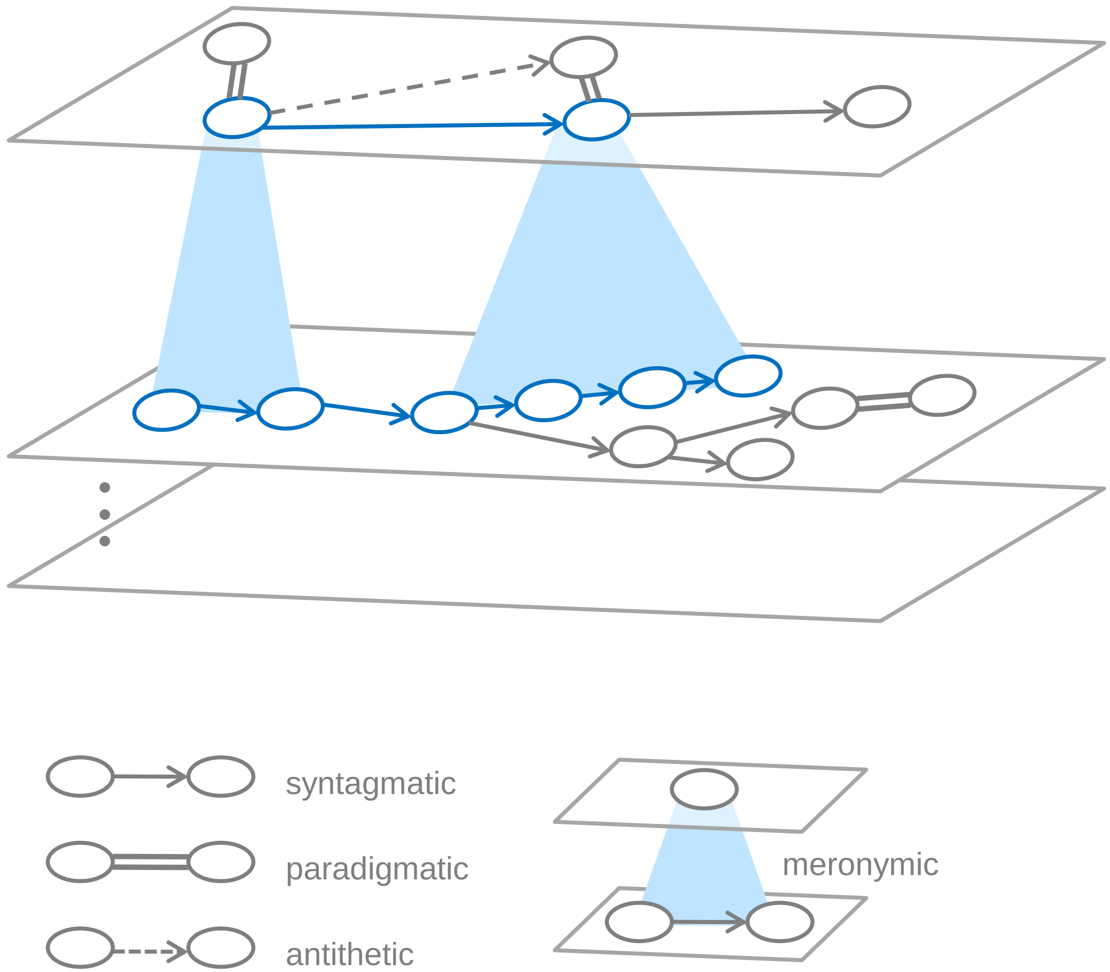
  Joe is assigned to the Sales Division *and* Moe is assigned to the Sales Division *and* Moe reports to Joe

- It may be possible to select among **alternatives**
- But the composition is **restricted** by integrity constraints and other rules
- Descriptions at different levels of **detail**

Relations between facts (consequence of the specification)

- Syntagmatic – <u>coherence</u> inside an utterance
- Paradigmatic – <u>alternatives</u> within a common paradigm
- Antithetic – negative <u>restrictions</u> imposed on the information space
- Meronymic – successive levels of <u>detail</u> (semantic hierarchies)

Structure of the Information Space
- an intuitive view -



The four master tropes

(Kenneth Burke, 1969; Hayden White,1973)

- **Metonymy –** contiguity, relatedness through direct association
  → **syntagmatic**
- **Metaphor –** similarity despite difference
  → **paradigmatic**
- **Irony –** marked direct opposition
  → **antithetic**
- **Synecdoche –** relatedness through categorical hierarchy
  → **meronymic**

"They are the basic rhetorical structures by which we make sense of experience."
(Jonathan Culler, 2009)

Expect the unexpected

- “Marked” states **will** (ironically) arise!
- Wrong beliefs concerning facts and rules, misconceptions, miscontruals.
- Cooperative *responses* involving data and metadata.
- Double-loop learning, *deconstructing* (Derrida, Culler) the design.
- Leave room for error, fraud, contradiction, and exceptional situations.

Conceptual stage:

Events

Modelling events

- plot = partially-ordered sequence of **events**
- events = associated with **operations** executed by agents, defined by pre-/post-conditions
- plots = **plans** (obtained by a plan-generator)
- (not all is covered: non-determinism, natural events, external agents, ...)
- 4-sided view of composition process - results from:

4 relations between events (same as for facts)

Plots and Saussure's axes

- Saussure's work in linguistics:
  syntagmatic and paradigmatic axes
- two dimensions (not orthogonal!)
  - syntagmatic: positions in the plot (horizontal axis)
  - paradigmatic: choices for positions (vertical axis)
- which events can be in some position in a plot?

  answer: the events must be **<u>related</u>** somehow:
  - horizontal sequence – syntagmatic relation
  - vertical choice – paradigmatic relation

Some "normal" plots

- syntagmatic relation event1 ***and*** event2:

if event1 leaves the world in a situation that enables the occurrence of event2 – example:

abduct followed by **rescue**

- paradigmatic relation event1^a ***or*** event1^b:

if event1^a and event1^b produce a similar effect on the world – example:

abduct **rescue**
or or
elope **capture**

Some transgressive plots

- antithetic relation if the occurrence of each of two events presupposes contexts that are (in principle...) incompatible – examples:

  abduct followed by **capture**

  (unnecessary use of force, possibly wrong belief)

  elope followed by **rescue**

  (different love feelings)

But suppose there occurs a change concerning beliefs or even facts...

Zooming in

- meronymic relation mapping event1 into event1(i):

  if a *plan sequence* involving event1(i) , for i=1..n, gives a lower level rendering of event1 – example:

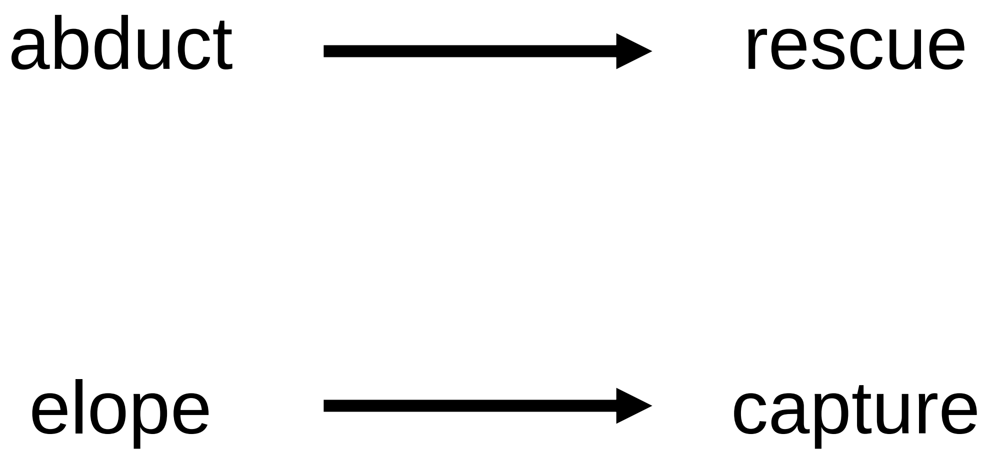
  abduct can be unfolded into:

  ride seize carry

Remark: the 2 first relations induce a 2-dimensional space, crossed in an oblique angle by the antithetic relation. The meronymic relation introduces a third dimension, thus spanning another 2-dimensional surface wherein the other three relations recur.

Syntagmatic relations

(diagram)

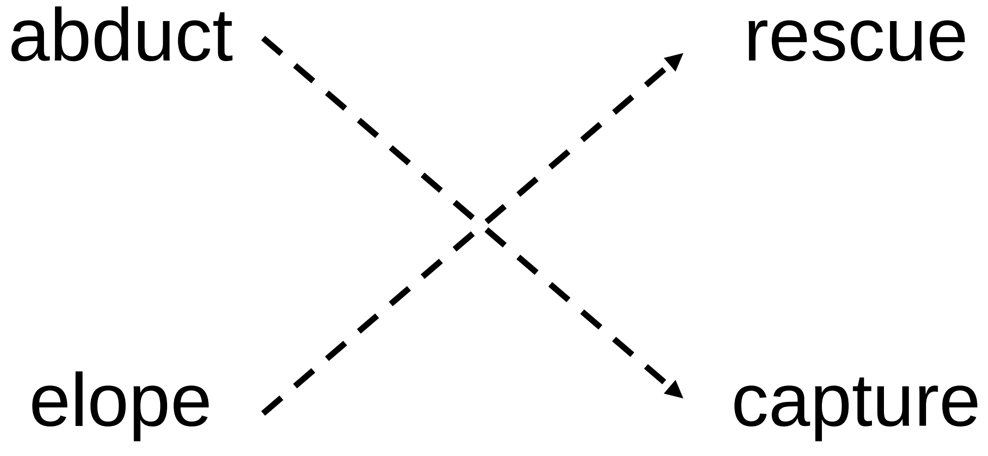


Paradigmatic relations
(diagram)

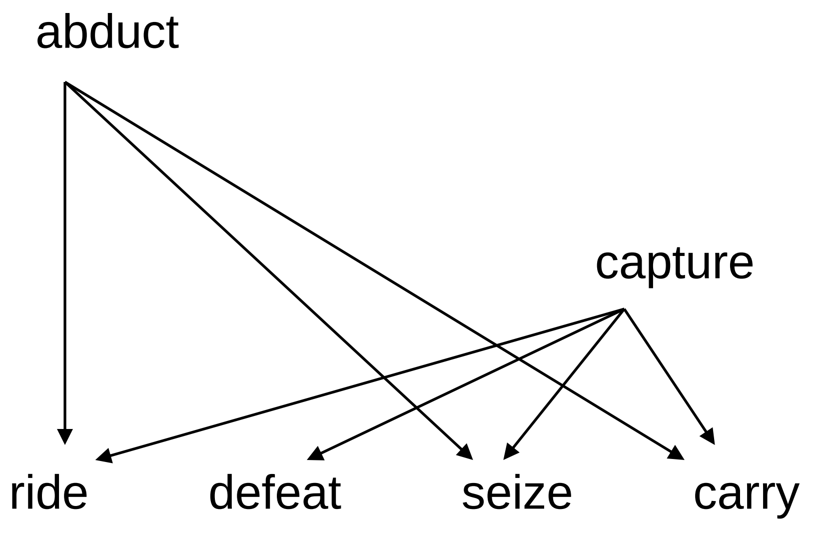
abduct ‖ elope

rescue ‖ capture

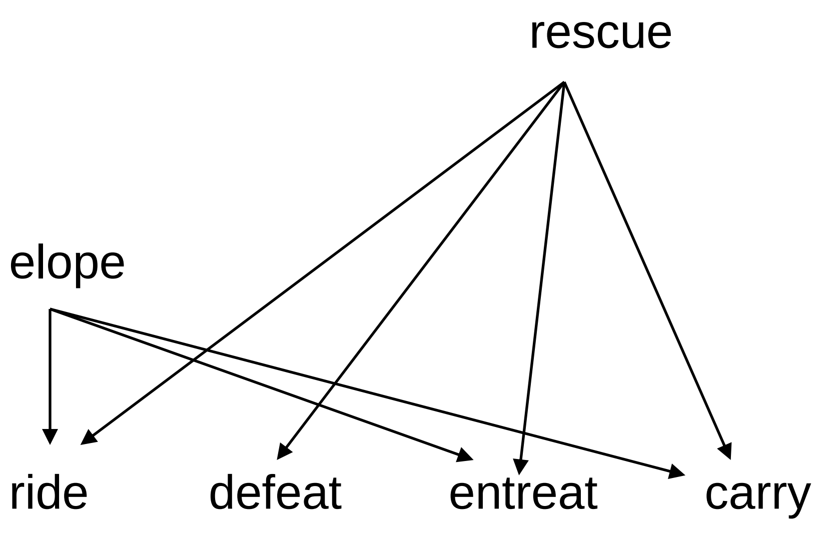
Antithetic relations
(diagram)



Meronymic relations (1) (diagram)



Meronymic relations (2) (diagram)



Plots and the four master tropes

rhetorical figures (Lakoff, Burke, Hayden White):

metonymy	syntagmatic relation	**coherence**
metaphor	paradigmatic relation	**alternatives**
irony	antithetic relation	**sudden shifts**
synecdoche	meronymic relation	**details**

The external *deus ex machina*

- irony involves extreme binary oppositions:
  good/evil, love/hate, strong/weak, etc.

- **facts:** C1 is strong, or
  beliefs: C2 believes that C1 is strong

- **variations** in the context, affecting beliefs or facts, allow ***unexpected*** turns in a plot

- Aristotle: complex plots feature:
  αναγνορισισ (recognition) and περιπετεια (reversal)

- Greek theater: god lowered onto the stage using a crane
  – our approach: user, through a computer input device...

Dispute for a princess

(A brief survey of stories from different countries)

- The Sanskrit *Ramayana* .... [abduct-rescue]
- The Irish *Story of Deirdre* .... [elope-capture]
- The true case of Patricia Hearst .... [abduct-capture]
  (Stockholm syndrome - Nils Bejerot)
- The Roman *Rape of the Sabines* .... [abduct-capture]
- The Greek legend of *Helen of Troy* .... [elope-rescue]
- The *Tristan and Isolde* romance .... [elope-rescue]

Conceptual stage:

Agents

Modelling agents

- Situation-goal rules
- Typical plans
- Agent profiles – cognitive and affective traits
- Roles – buyer, seller, etc.
- Roles in folklore genres (Propp):
  hero, princess, donor, helper, villain, false hero, dispatcher

Goal and plan interferences

Robert Willensky - *Planning and Understanding - a Computational Approach to Human Reasoning*. Addison-Wesley (1983).

Classification:

	negative	positive
internal	**conflict**	**overlapping**
external	**competition**	**concord**

Agents and the four relations

- syntagmatic relation - if one favours the other, so that they would be willing to pursue a joint line of action;
- paradigmatic relation - if one is similar to the other, in which case they can either act independently or seek to emulate each other in the quest for some goal;
- antithetic relation - if one opposes the other, in which case they behave as enemies;
- meronymic relation - if one is an individual and the other is either a hierarchical superior or some group or organization of which the former is part (e.g. a troop of soldiers, the inhabitants of a town, the members of a knightly fellowship, etc.).

Human (as opposed to *machine*) decision-making

“He [the English philosopher Herbert Spencer] made parallel lists of reasons for and against the move, giving each reason a numerical value. The sums being 110 points for remaining in England and 301 for going [to New Zealand], he remained”

(Will Durant, *The Story of Philosophy*).

You strive and strive,
but what do you seek?

Li T’ai-Po

Drives, attitudes, emotions, beliefs

- Situations motivate goals - trigger situation-goal rules.
- A specific goal is just one way to satisfy one or more upper-level goals – e.g. “raise price” < “increase profit”.
- Decide what to do (goals) - drives at the top of goal hierarchies: sense of duty, material gain, pleasure seeking, spiritual endeavour.
- Decide how to do (plans) - attitudes: pleasing, adaptable, outgoing, careful, self-controlled.
- Decide whether or not to commit: emotional satisfaction expected at goal state, as compared to the current state - anger, disgust, fear, joy, sorrow, surprise.
- “To believe” (rightly or not) rather than “to know”.

Part 2

Design at the

Logical stage

Logical stage:

Facts

To represent and handle facts

---- corresponding to the static schema:

an abstract data type:

- frames
- frame-sets
- frame-manipulation algebra (FMA)

Design at the logical stage: From tables to frames and frame-sets

- In the World Wide Web environment, data comes from multiple sources, on a highly irregular basis.

- Whereas relational tables are homogeneous (nulls are exceptions), must be in first normal form, and union compatibility is required for certain operations - but these restrictions are ***not*** inherent in the ER model!

- **Frames**, with a long tradition in AI applications, provides a more flexible ER-compatible abstract data type for passing from the conceptual to the logical stage.

- In turn, **frames** and **frame-sets** can be conveniently converted into RDF representation at the physical design stage.

Frames and frame-sets - examples

Class employee: `[name:_, age:_, salary:_, works/1:_]`

Class works: `[name:_,cname:_,status:_]`

Mary:
```
[name:'Mary', salary:150,
 works/1:'Acme']
```

Acme:
```
[cname:'Acme', headquarters:'Carfax',
 works/2:['John','Mary']]
```

Acme employees:
```
[[name:'Mary', salary:150,
  works/1:'Acme'],
 [name: 'John', age: 46,
  salary: 100, scholarship: 50,
  works/1: 'Acme']]
```

A semiotic view of ‘completeness’ (1)

- Taking the LISP primitives as example
- List – a single data structure for chains and sets
- Composing a list: CONS
- Extracting from the list: CAR, CDR
- For chains, where only the positions matter, this is enough
- For sets, it is necessary to extract by comparing values: EQ
- Negation: NOT

A semiotic view of ‘completeness’ (2)

The LISP primitives cover the first three relations between facts:

- Syntagmatic:
  compose a chain – CONS
  extract from chain – CAR, CDR
- Paradigmatic:
  collect in a set – CONS,
  select from set – CAR, CDR, EQ
- Antithetic: NOT

A semiotic view of ‘completeness’ (3)

The basic Relational Algebra operators (over first-normal-form tables) also cover the first three relations between facts:

- Syntagmatic – product, projection
- Paradigmatic – union, selection
- Antithetic – difference

Remark:

completeness proved through a comparison with Relational Calculus – but semiotic completeness can also be claimed ……

…… except that NF2 tables would need additional operators

Frame Manipulation Algebra (FMA) operations

Defined on frames and frame-sets

Executable as embedded in a logic programming language

Unification and most specific generalization over frames and frame-patterns are also provided

Operations:

- Syntagmatic – product, projection
- Paradigmatic – union, selection
- Antithetic – difference
- Meronymic – combination, factoring

Logical stage:

Events

To represent and handle events

---- corresponding to the dynamic schema:

an abstract data type:

- plots (which are **frame-like** structures)
- libraries (sets of plots)
- plot manipulation algebra (PMA)

An engine:
Plan-generation / Plan-recognition

- Plan-generation:

  executable specifications, simulation, online access to conceptual schema

- Plan-recognition:

  typical plans, re-use, check what a person is trying to do, logs and plot mining

Logical stage:

Agents

To represent and handle agents

---- corresponding to the behavioural schema:

ongoing research:

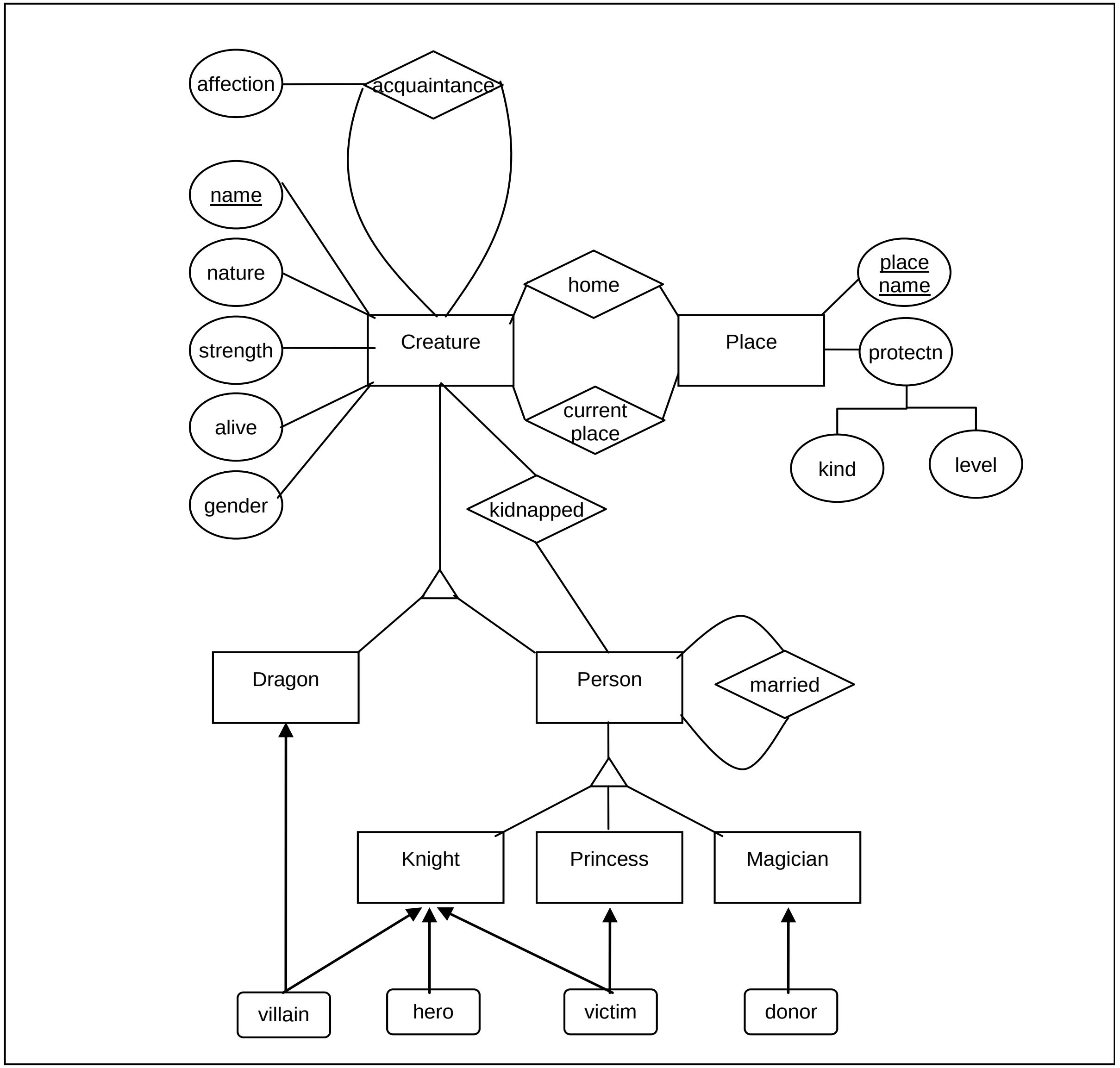
- drawing from Elaine Rich's work using **frame-like** stereotypes, to represent cognitive and affective chacteristics of agents

Part 3

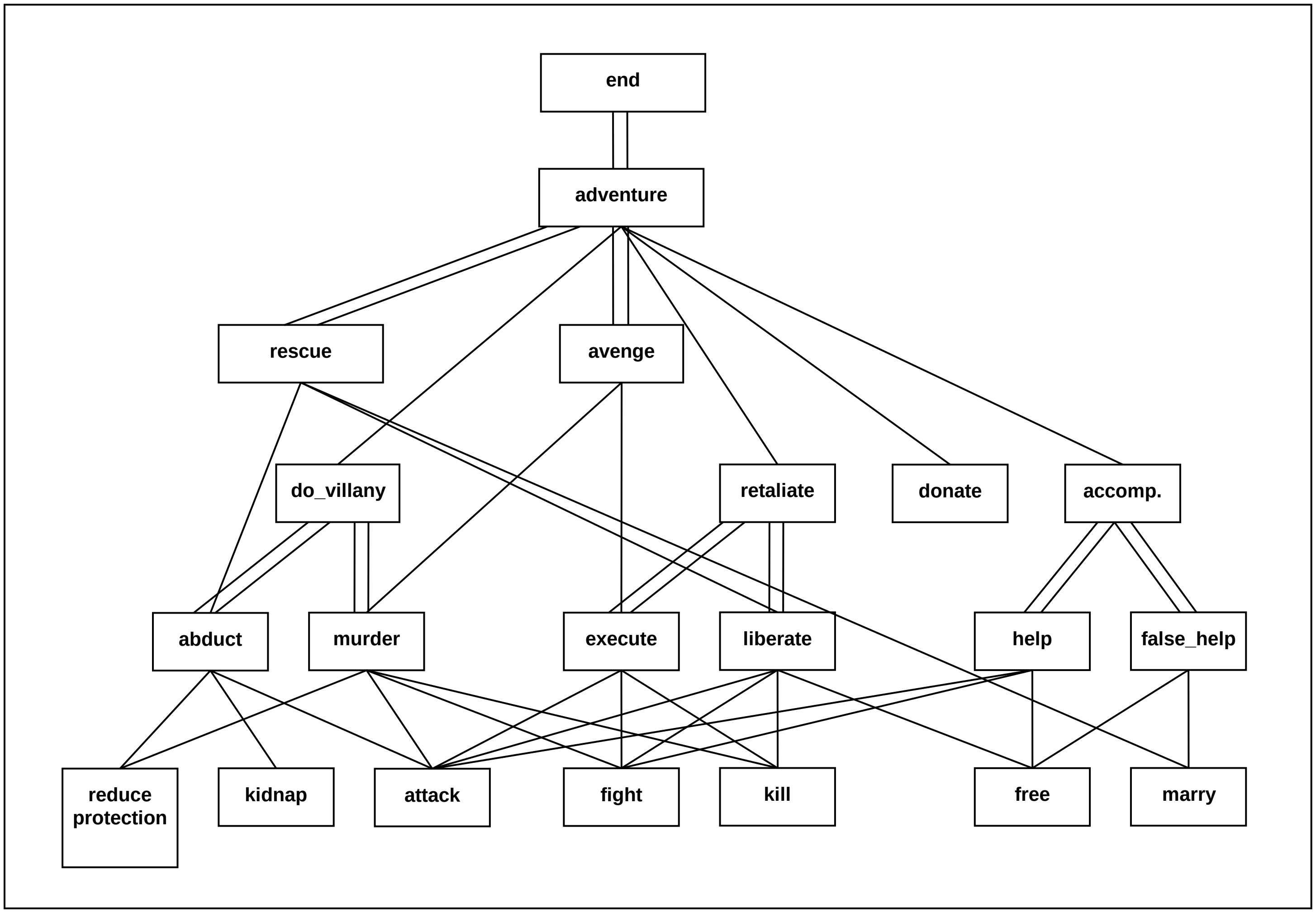
Example application:

a literary genre

Swords and Dragons: ER diagram



Swords and Dragons: Hierarchy of typical plans



Swords and Dragons: Static schema

```
entity(character,name).
entity(person,name).
entity(knight,name).
entity(princess,name).
….
is_a(knight,person).
is_a(princess,person).
is_a(magician,person).
is_a(dragon,character).
role(hero,knight).
….
attribute(character,strength).
relationship(home,[character,place]).
relationship(current_place,[character,place]).
relationship(acquaintance,[character,character]).
….
```

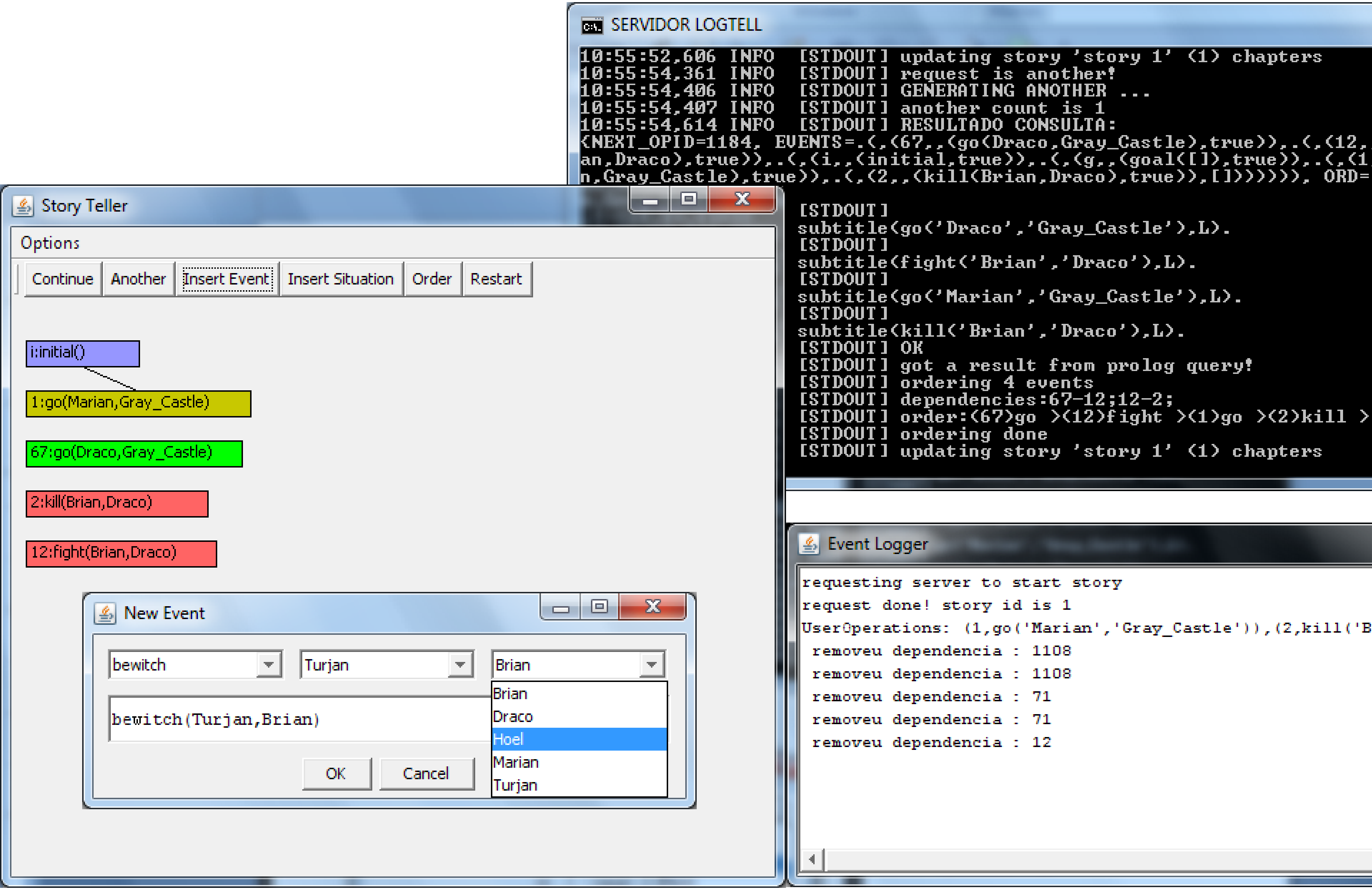
Swords and Dragons: Dynamic schema

```
….
operator(5,
       fight(CH1,CH2),
       [  alive(CH1), alive(CH2),
          nature(CH1,KIND1),
          nature(CH2,KIND2),
          dif(KIND1,KIND2),
          dif(KIND1,0.0), dif(KIND2,0.0),
          strength(CH1,LS1), strength(CH2,LS2),
          {LS1>=10.0, LS2>=10.0},
          current_place(CH2,PL), current_place(CH1,PL),
          protection(PL,[KIND3,L_PROT]),
          {L_PROT=<0.0,
            NEW_LS1=LS1-LS2,
            NEW_LS2=LS2-LS1} ],
       [not(strength(CH1,LS1)), not(strength(CH2,LS2)),
          strength(CH1,NEW_LS1), strength(CH2,NEW_LS2)],
       10,
       [strength(CH1,NEW_LS1), strength(CH2,NEW_LS2)],
       [],[]):-
       db(character(CH1)),
       db(character(CH2)).
….
```

Swords and Dragons: Behavioural schema

```
….
/* The strongest hero wants to become stronger
   than the villain */
rule([   e(i,strength(HERO,Lh)),
           e(i,villain(VIL)),
           e(i,strength(VIL,Lv)),
           h({Lh=<Lv})   ],
      ([T],
       [ h(T,strength(HERO,LS)),
              h({LS > Lv}),
              h(T>i)],
       true))
      :- findall(S,(db(strength(H,S)),db(hero(H))),Ss),
         max_list(Ss,Lh),
         db(hero(HERO)),
         db(strength(HERO,Lh)).
….
```

The *Logtell* prototype – plot composition



The *Logtell* prototype – animation

Concluding remarks

- The importance of Semiotics to the design of Information Systems
- The importance of a Computer Modelling approach to Semiotics
- Main points of our project, at this moment:
  - the four semiotic relations
  - frames (and frame-like structures) at the logical stage
  - executable specifications – prototype tools

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