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Knowledge Representation Language

Quixote

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Quixote

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object , constraint, module
abduction, hypothetical reasoning
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big-*Quixote* & micro-*Quixote*
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Quixote

A Knowledge Representation Language *Quixote*

What is *Quixote* ?

Core Language for knowledge information processing in FGCS & Follow-on Project

- Deductive Object-Oriented DB (DOOD)
 - O-O feature, rule, deduction
- Constraint Logic Programming (CLP)
 - subsumption, abductive reasoning
- big-*Quixote* & micro-*Quixote*

Key Features of *Quixote*

- (1) Object Identity
- (2) Subsumption Constraint
- (3) Property Inheritance
- (4) Hierarchical Module
- (5) Query with Hypothesis & Answer with Assumption
- (6) Calling External Solver

new features

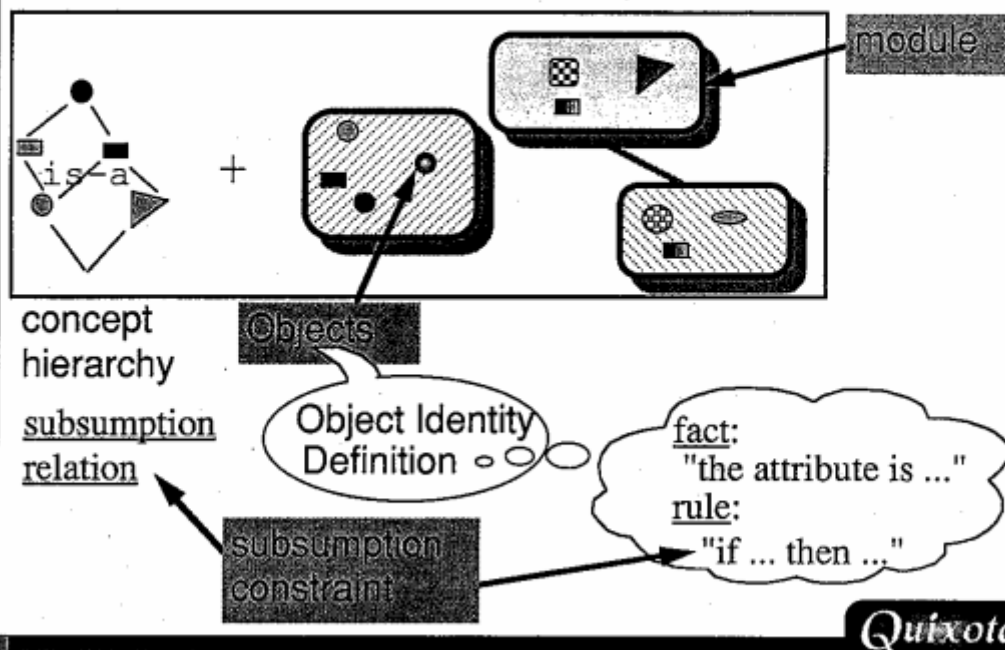
\in (element of)
 \neq (disequation)

NAF
 (Negation as Failure)

math module

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Overview of *Quixote* DB



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Example: Classical Music DB

Object:

composer: Beethoven, Mozart, ...
music: op109, K467,
sounds (*.au, *.mid), picture (*.gif)

Relation:

"Violin ISA stringed instrument."

Rule:

"When you are gloomy, you had better listen to pieces in a major key. "

Question & Answer

assumption, hypothesis



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What is an object?

- simple concept → atom
 mozart, violine, k227, ... : basic object term
 - compound concept → combination of objects : complex object term
 "opus 73 of Beethoven"
 op73[conductor=beethoven] ≠ op73[conductor=strauss]
- Object Identifier (OID)

object term

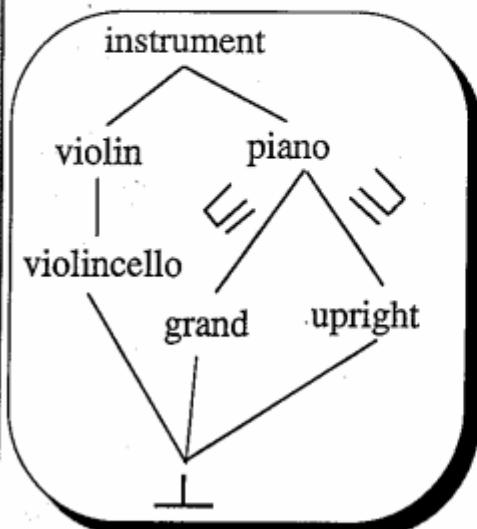
intrinsic attributes

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Relation between Objects

Subsumption Relation among Object terms



IS-A
A-Kind-Of (AKO)

grand[maker=steinway] ≡ instrument

- lattice
- meet glb
- join lub

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Property as Constraints

Object can have various properties.

k551

composed by Mozart
a kind of symphony
name is "jupiter"
performed by violin,viola,oboe,...

extrinsic
attribute

dotted term

k551.composer \cong mozart
k551.type \sqsubseteq symphony
k551.name \cong "jupiter"
k551.perform \cong_H
{violin,viola,oboe,...}

subsumption constraint

k551/[composer=mozart,
type -> symphony,
name="jupiter",
perform* =*=
{violin,viola,oboe, ...}]

attribute term

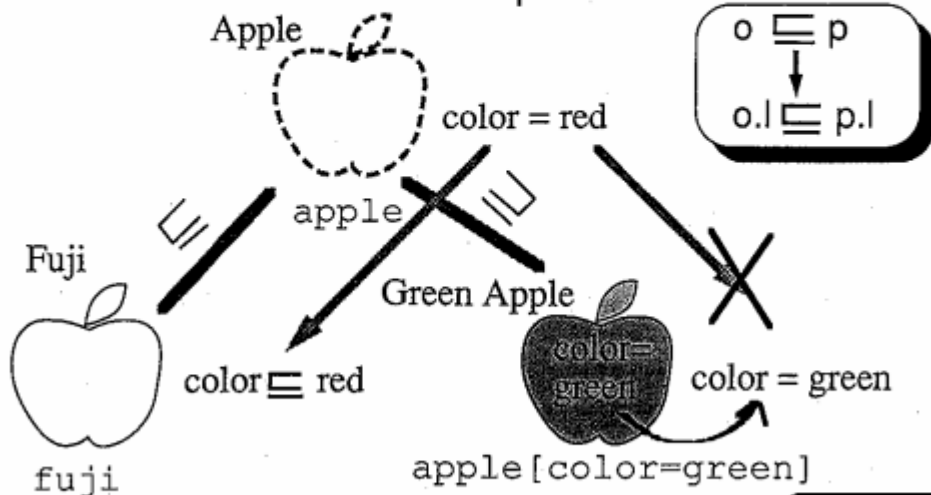
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Property Inheritance

Property Inheritance by subsumption rel. \sqsubseteq

Intrinsic Attributes as Exception



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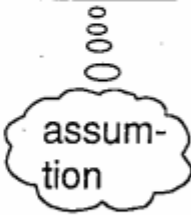
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Rule -- intentional definition of object

$\boxed{\text{head}}$ $\boxed{\text{body}}$ $m_i : \text{module}$
 $m_0::a_0 \Leftarrow m_1:a_1, \dots, m_n:a_n \parallel C;;$

$m_0::o_0 \mid C_H \Leftarrow m_1:o_1, \dots, m_n:o_n \parallel C_v \cup C_d;;$
 $\boxed{\text{head constraint}}$ $\boxed{\text{body constraint}}$ $\text{dotted-term constraint}$

If a_i is satisfied in m_1, \dots under constraint C then a_0 is satisfied in m_0 .



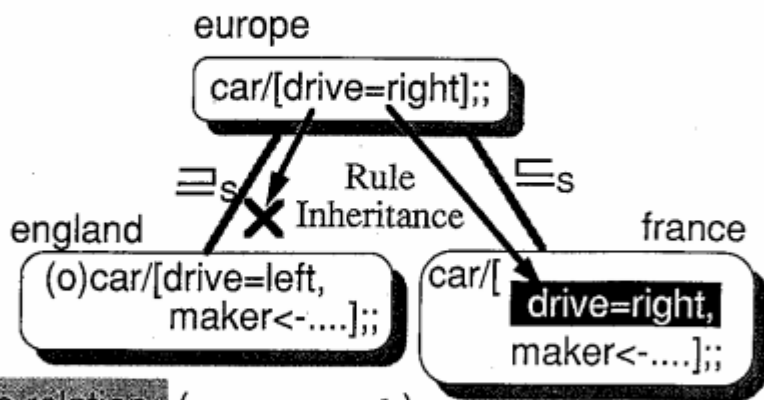
`music::k551/[type=symphony, name=jupiter];;`
`music::X/[instrument* ==={violin,piano}]`
`<= X/[type=violin_sonata];;`
 ("Violin sonata is played by the violin and piano.")

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Module and Rule Inheritance

"In Europe, cars usually drive on the right. But in England, cars drive on the left."



$\text{sumbodule relation } (\text{super } \Xi_s \text{ sub})$

`europe Ξ_s england ;; europe Ξ_s france ;;`

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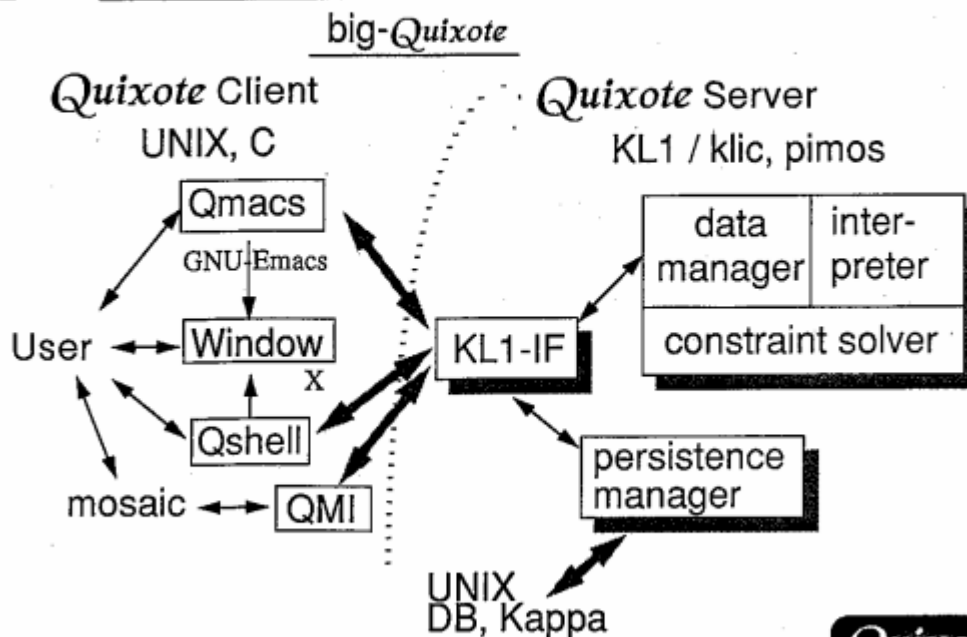
big-*Quixote* vs. micro-*Quixote*

	big- <i>Quixote</i>	micro- <i>Quixote</i>
OS/machine	UNIX (klic)	UNIX, DOS, Mac
Language	KL1, C, Lisp	C
Code Size	6Mbyte	199Kbyte
subsumption inheritance module	○	○
assumptionQA	○	○
solution merge	○	×
DB feature	○	×
external solver call	math module	external call

Quixote



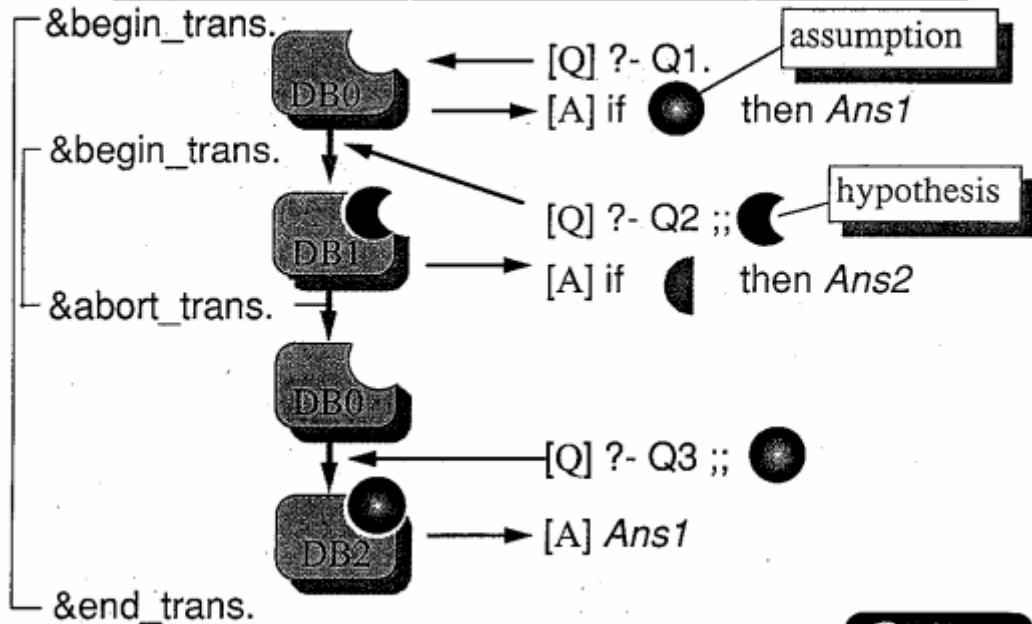
System Configuration of big-*Quixote*



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Query with hypothesis & Answer with assumption



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Answer with assumption

```
major  $\equiv$  c_major;;
music::k551/[type=symphony, name=jupiter];;
music::k467/[type=piano_con, key=c_major];;
listening::prefer[mood=gloom, music=X] <=
  music:X/[key -> major];;
("Major key pieces are preferable when gloomy.")
```

?- listening:prefer[mood=gloom, music=k467].

Ans yes.

?- listening:prefer[mood=gloom, music=k551].

Ans IF `music:k551.key \equiv major` THEN yes.

("If k551 is a major key piece, then yes.")

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Query with hypothesis

```
major  $\equiv$  d_major;;
listening::prefer[mood=gloom, music=X] <=
  music:X/[key -> major];;
```

?- listening:prefer[mood=gloom, music=k385].

Ans no.

(There is no object "k385" in the "music" module.
Properties of only existing objects can be assumptions.)

```
?- listening:prefer[mood=gloom, music=k385] ;;
  &program;; music::k385/[key=d_major];; &end.
```

Ans yes.

hypothesis is added to DB

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Question using new features

Element_of and disequation constraints

"What are pieces by Mozart or Beethoven except symphony?"

```
?-music:X/[type=T, composer=C] ||
```

```
{T  $\neq$  symphony, C  $\in$  {mozart,beethoven}}.
```

Math module

"What did Mozart conduct when he was 24?"

```
music::X/[age_of_composer=A] <=
  X/[composer=C, year=Y], C/[born=B],
  &math:subtract(Y, B, A).
```

```
?- music:X/[composer=mozart, age_of_composer=24].
```



external call (cf. Helios)

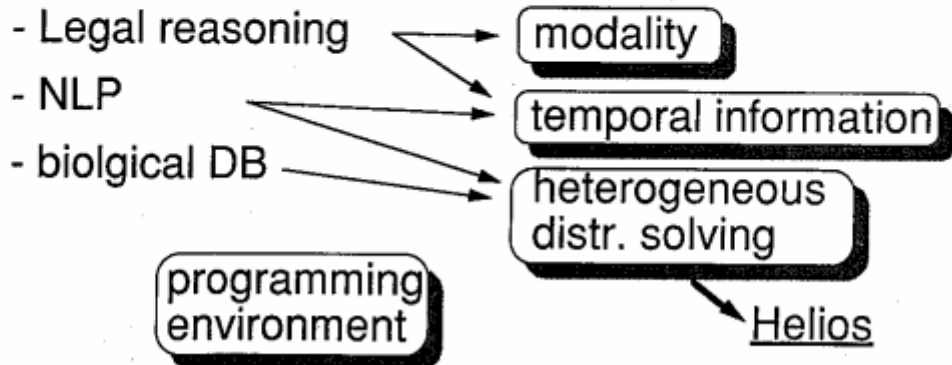
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Contribution & Future Research

KRL based on subsumption constraints
with logic and OO concepts.

Effective in the following applications:



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