

Introduction to Semantic Web Ontology Languages

Using Ontologies

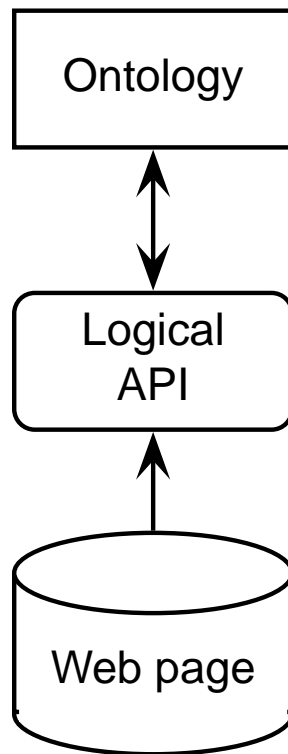
Enrico Franconi

franconi@inf.unibz.it

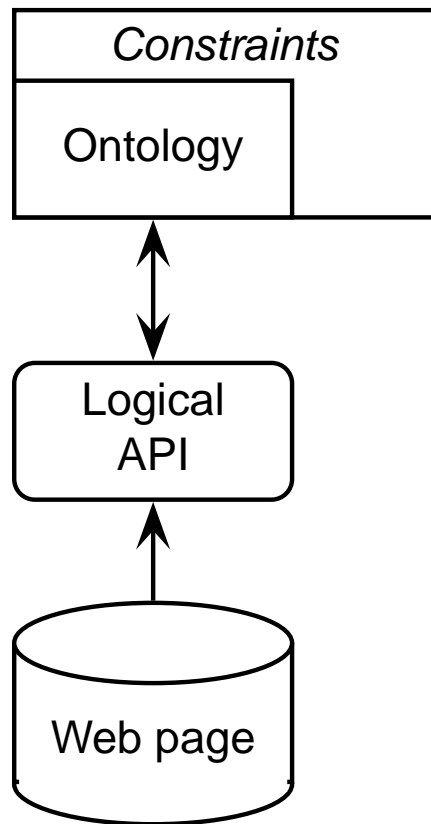
<http://www.inf.unibz.it/~franconi>

Faculty of Computer Science, Free University of Bozen-Bolzano, Italy

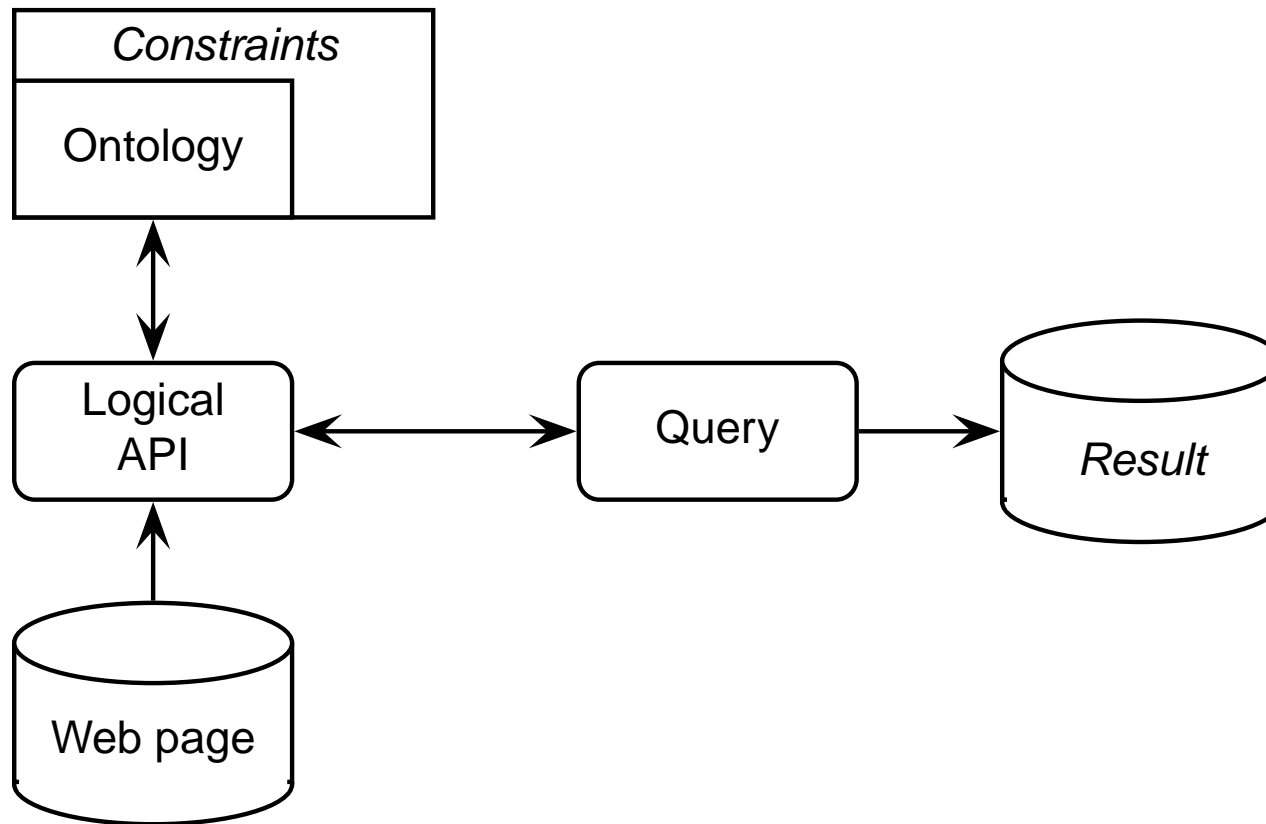
Ontologies linked with Information Sources



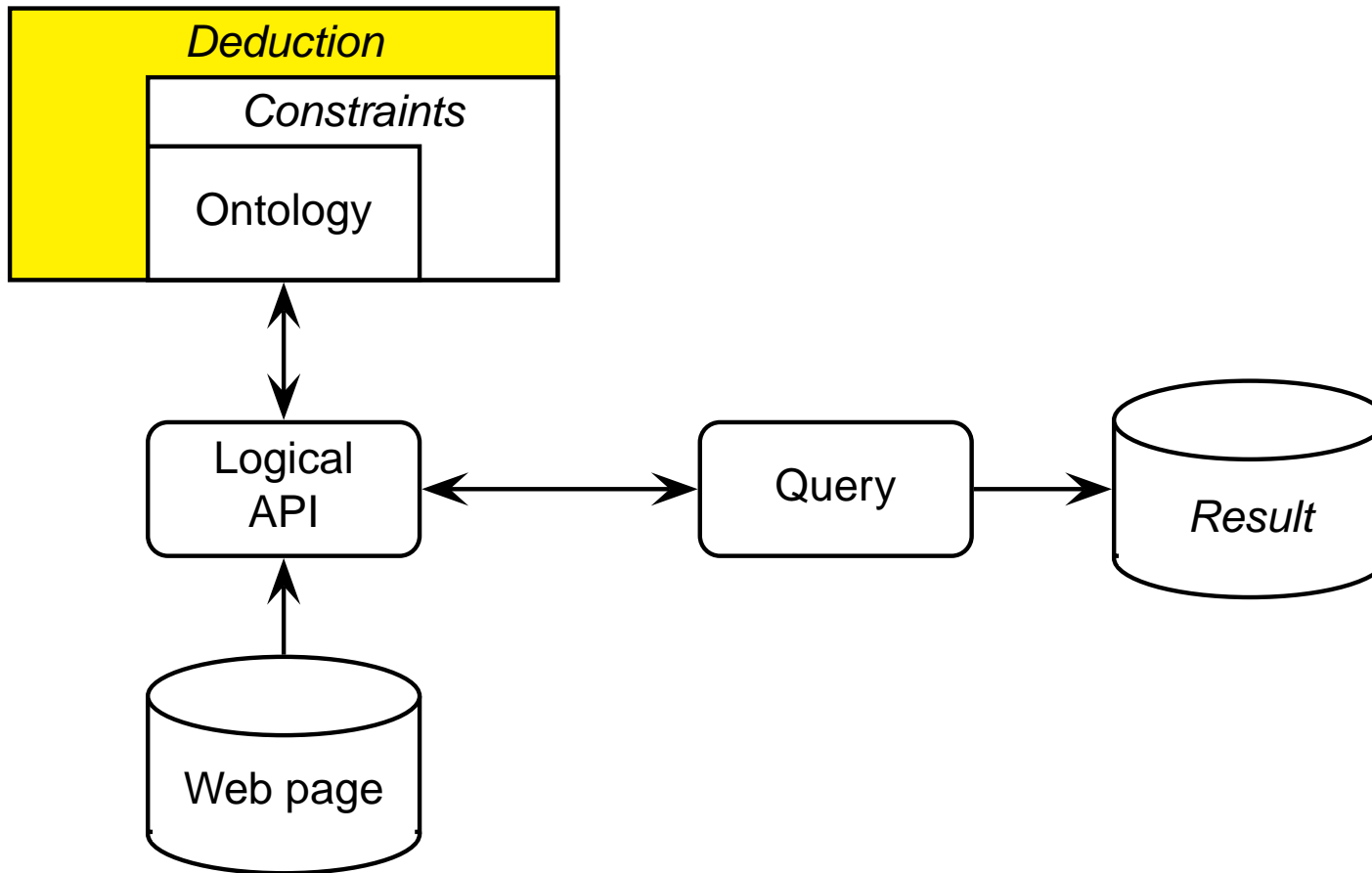
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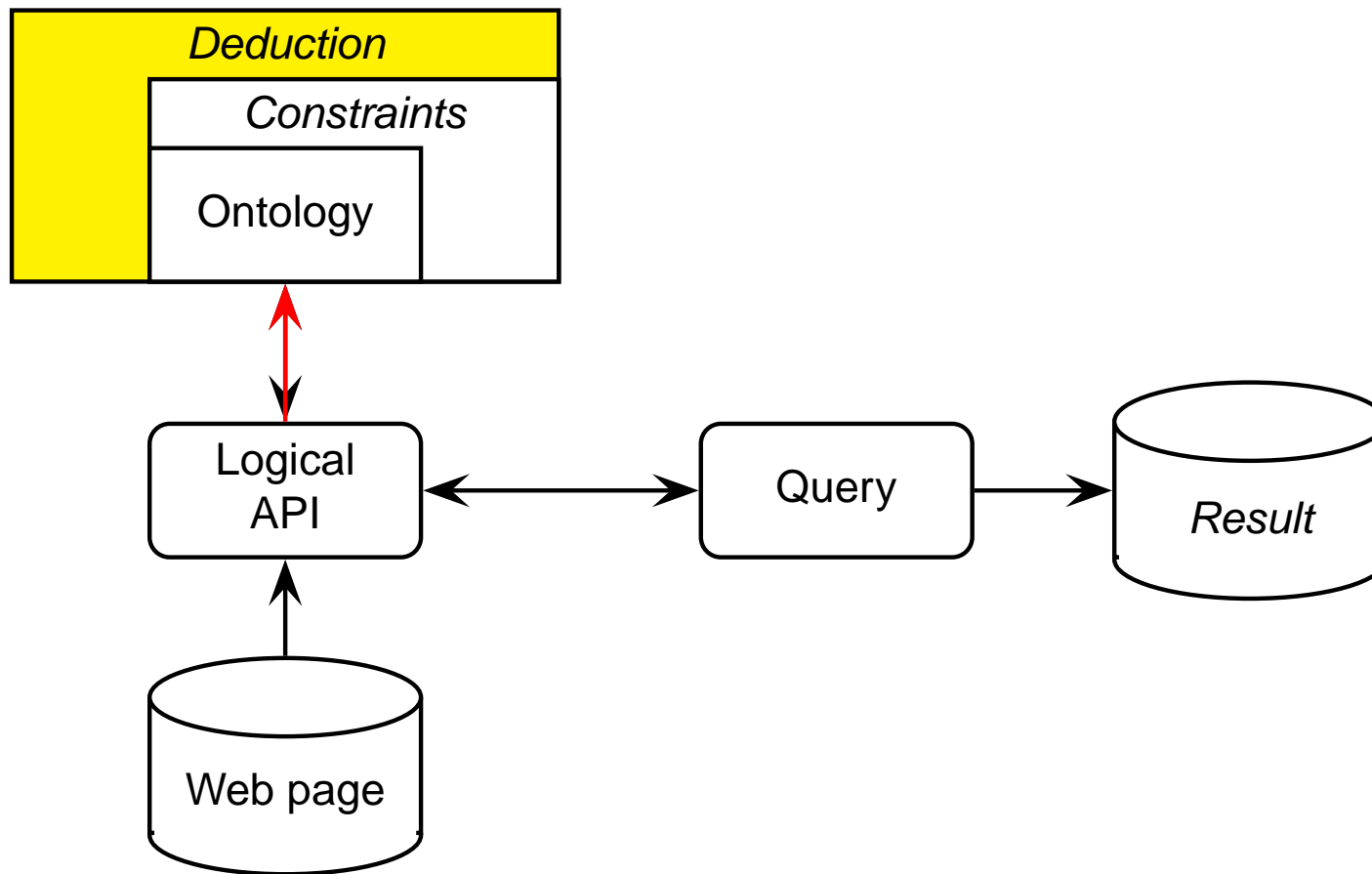
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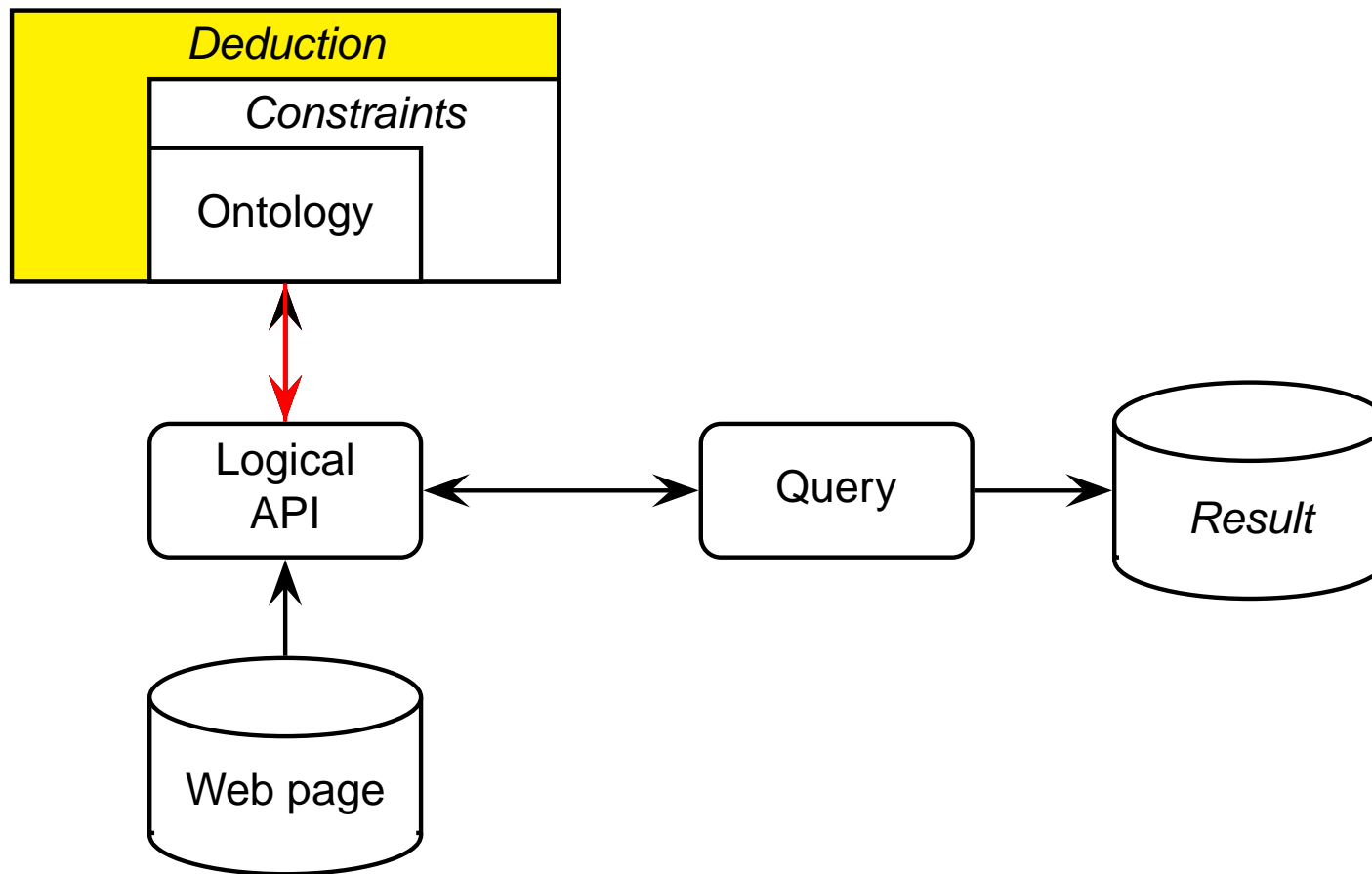
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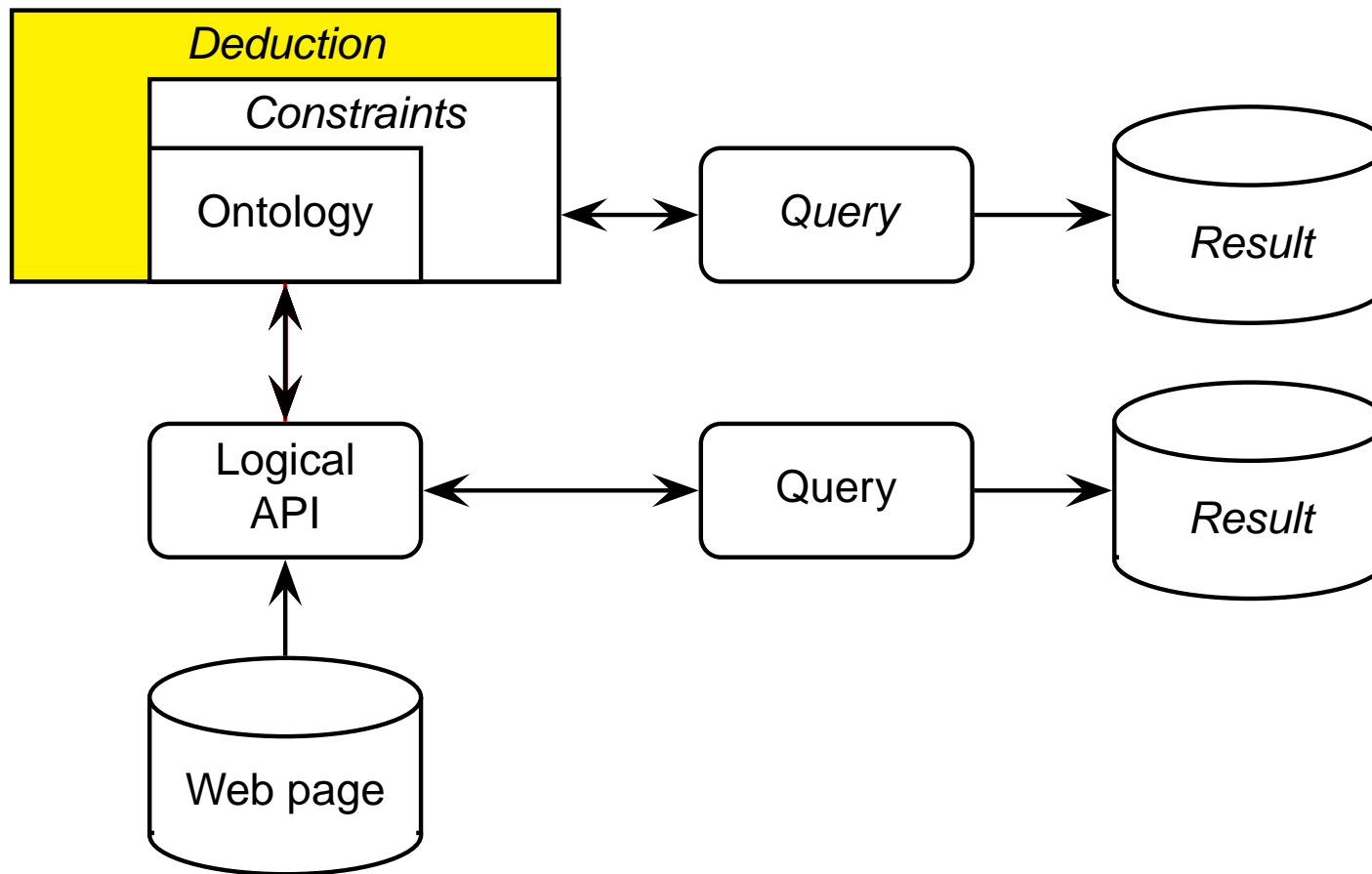
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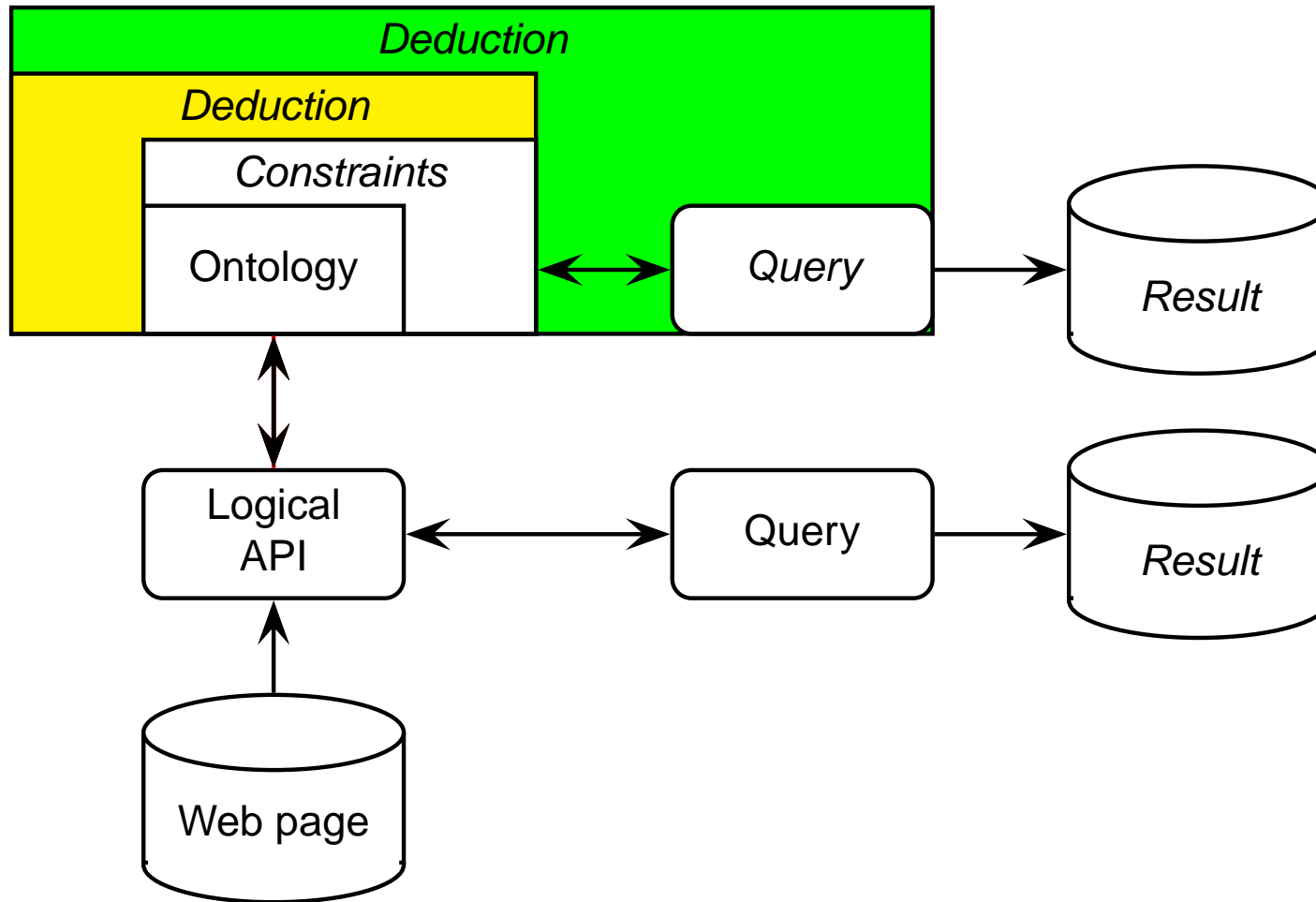
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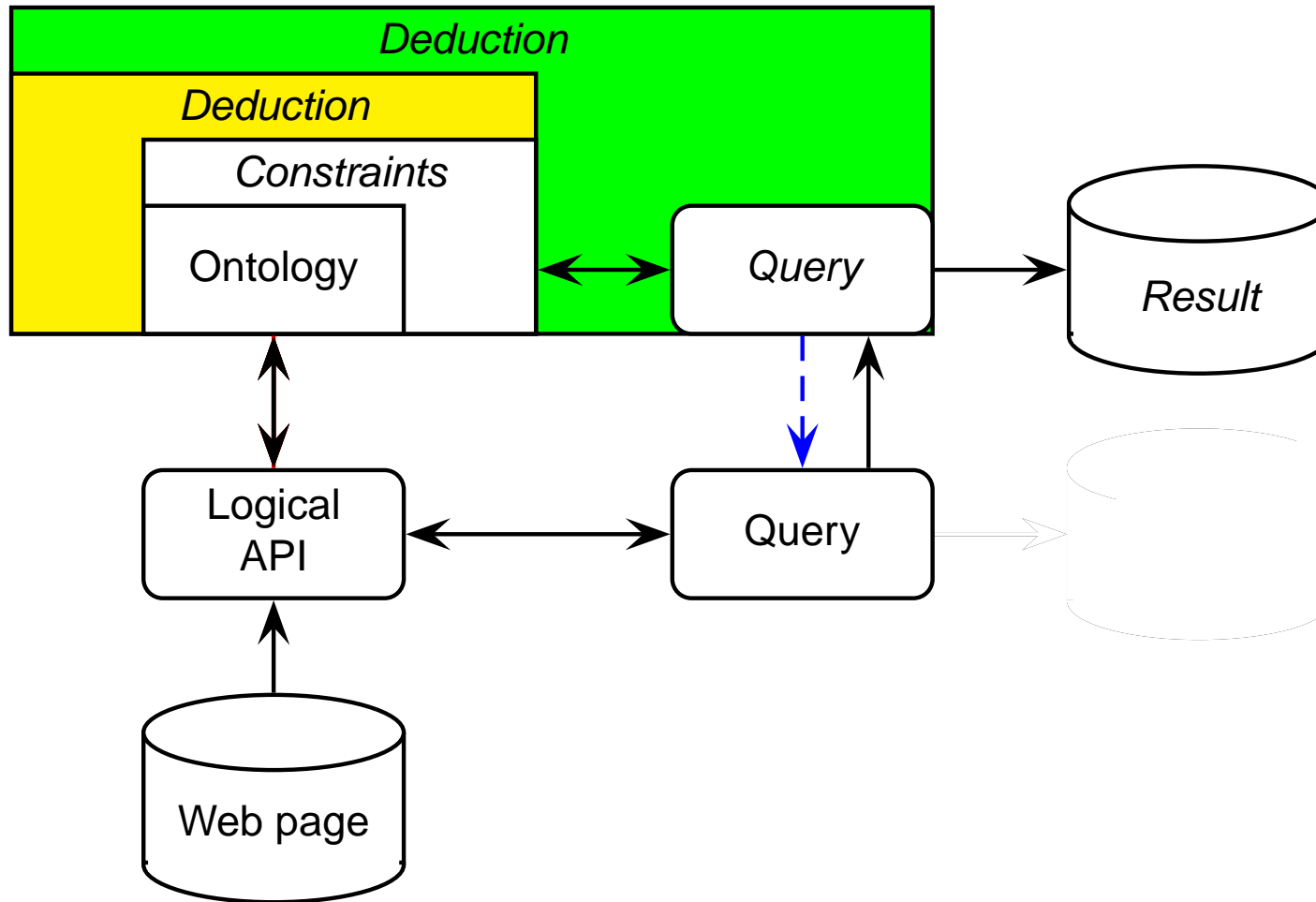
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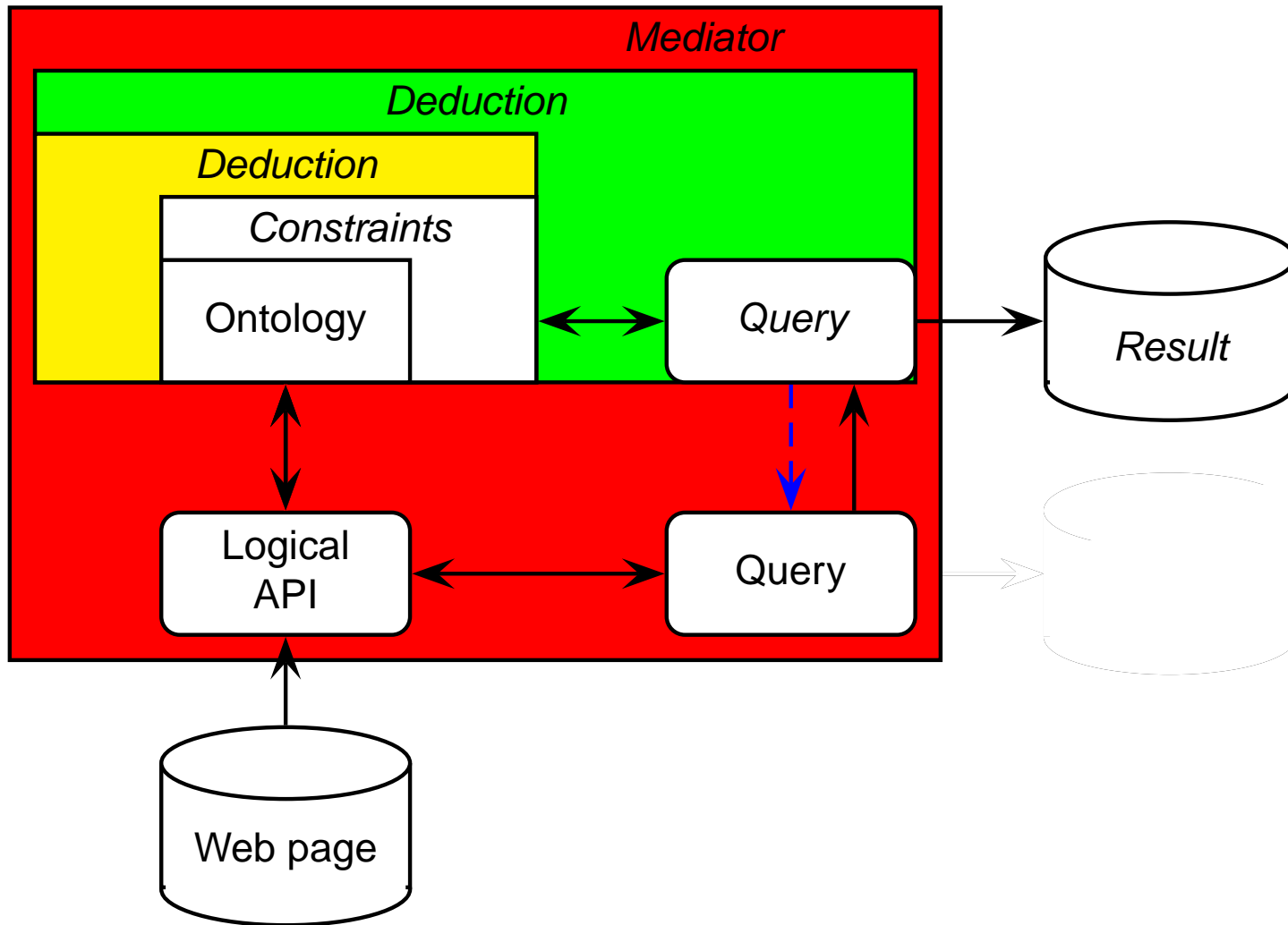
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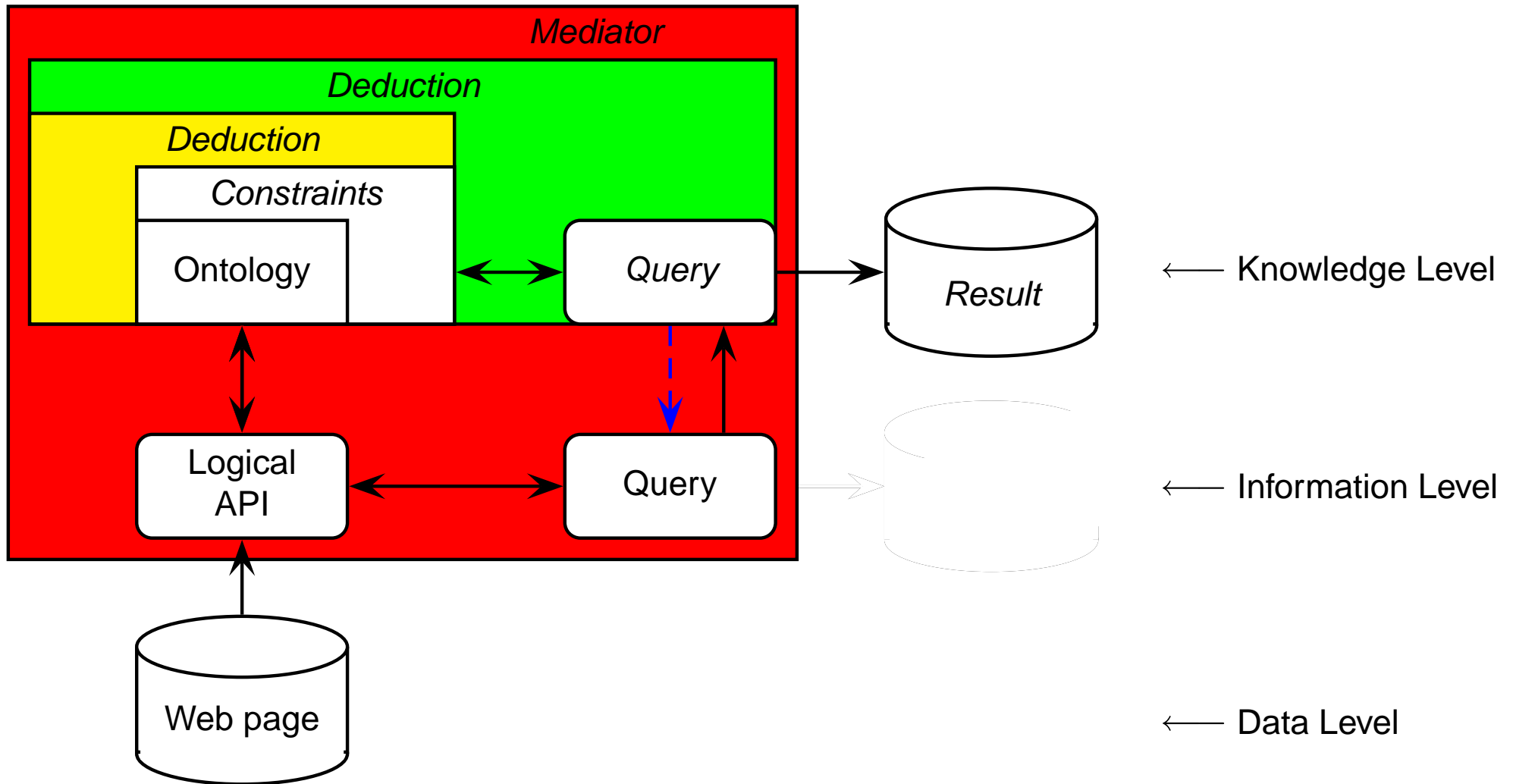
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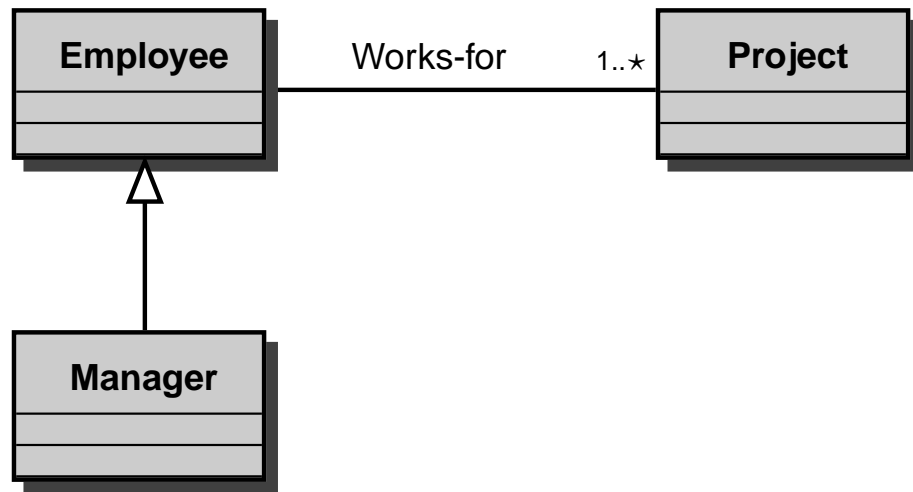
Queries with Ontologies: the DB assumption

- Basic assumption: **consistent** information with respect to the constraints introduced by the ontology
- DB assumption: **complete information about each term** appearing in the ontology
- *Problem*: answer a query over the ontology vocabulary

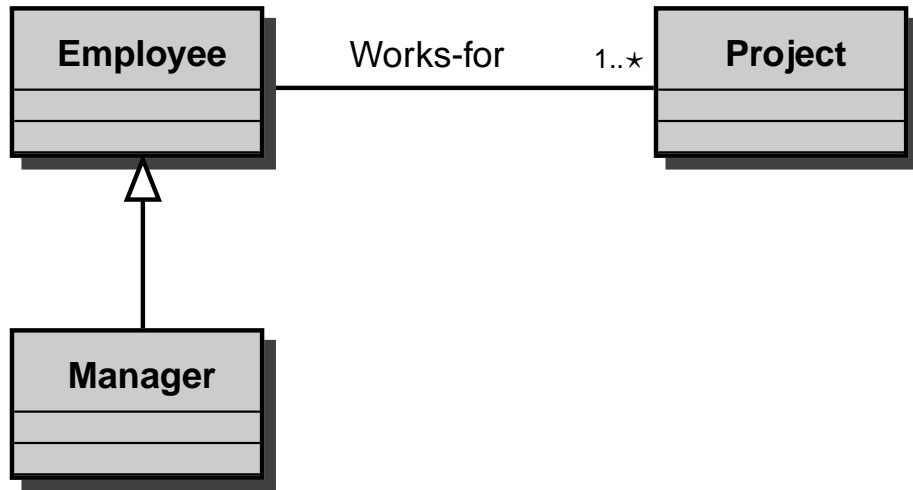
Queries with Ontologies: the DB assumption

- Basic assumption: **consistent** information with respect to the constraints introduced by the ontology
- DB assumption: **complete information about each term** appearing in the ontology
- *Problem*: answer a query over the ontology vocabulary
- *Solution*: use a standard DB technology (e.g., SQL, datalog, etc)

Example with DB assumption



Example with DB assumption



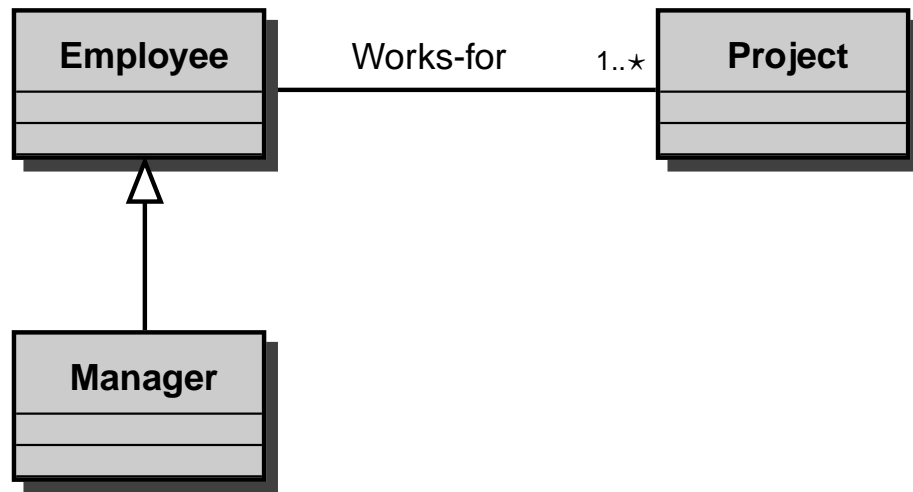
Employee = { **John**, **Mary**, **Paul** }

Manager = { **John**, **Paul** }

Works-for = { (**John**, **Prj-A**), (**Mary**, **Prj-B**) }

Project = { **Prj-A**, **Prj-B** }

Example with DB assumption



Employee = { **John**, **Mary**, **Paul** }

Manager = { **John**, **Paul** }

Works-for = { (**John**, **Prj-A**), (**Mary**, **Prj-B**) }

Project = { **Prj-A**, **Prj-B** }

$Q(X) \text{ :- Manager}(X), \text{ Works-for}(X, Y), \text{ Project}(Y)$

$\implies \{ \text{John} \}$

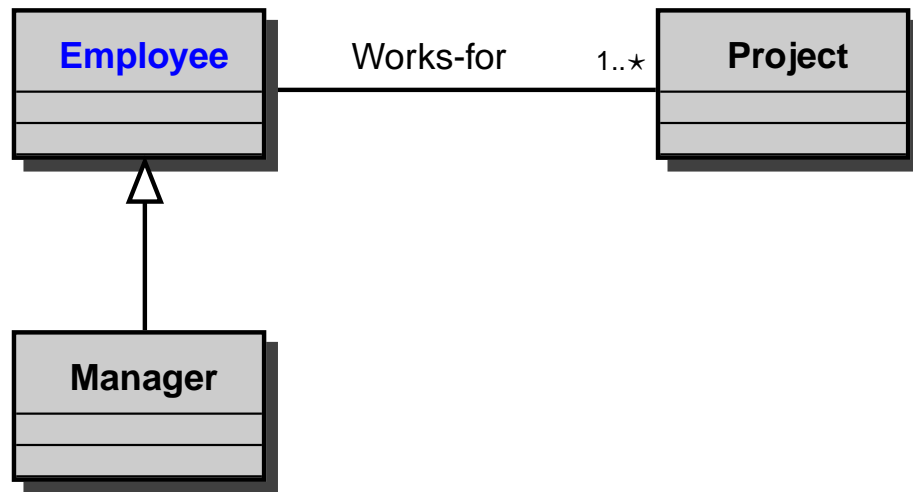
Weakening the DB assumption

- The DB assumption is against the principle that an ontology presents a richer vocabulary than the data stores.

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- The DB assumption is against the principle that an ontology presents a richer vocabulary than the data stores.
- Partial DB assumption: **complete information about some term** appearing in the ontology
- Standard DB technologies do not apply
- The query answering problem in this context is inherently complex

Example with partial DB assumption

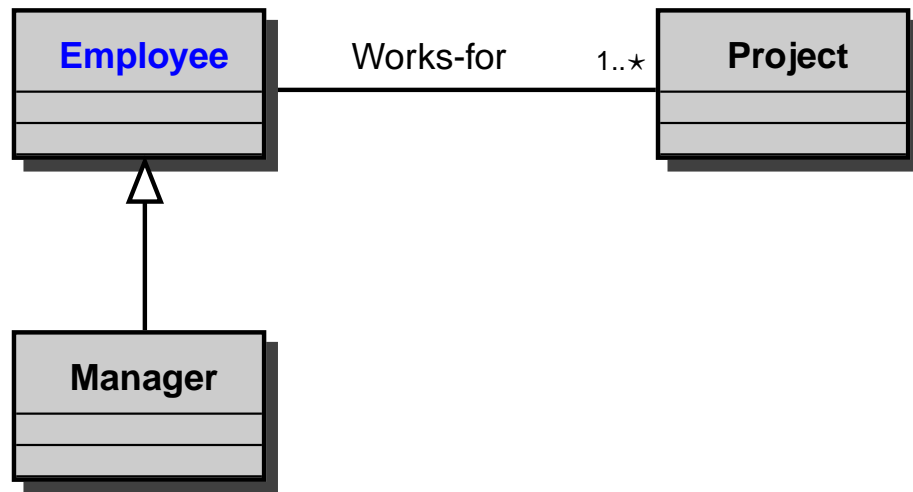


Manager = { **John**, **Paul** }

Works-for = { (**John**, **Prj-A**), (**Mary**, **Prj-B**) }

Project = { **Prj-A**, **Prj-B** }

Example with partial DB assumption



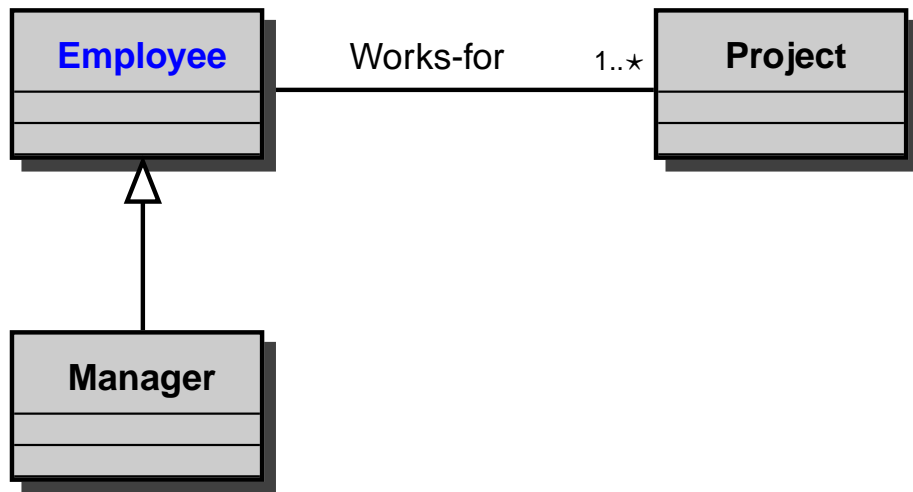
Manager = { **John**, **Paul** }

Works-for = { (**John**, **Prj-A**), (**Mary**, **Prj-B**) }

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Q(X) :- Employee(X)

Example with partial DB assumption



Manager = { **John**, **Paul** }

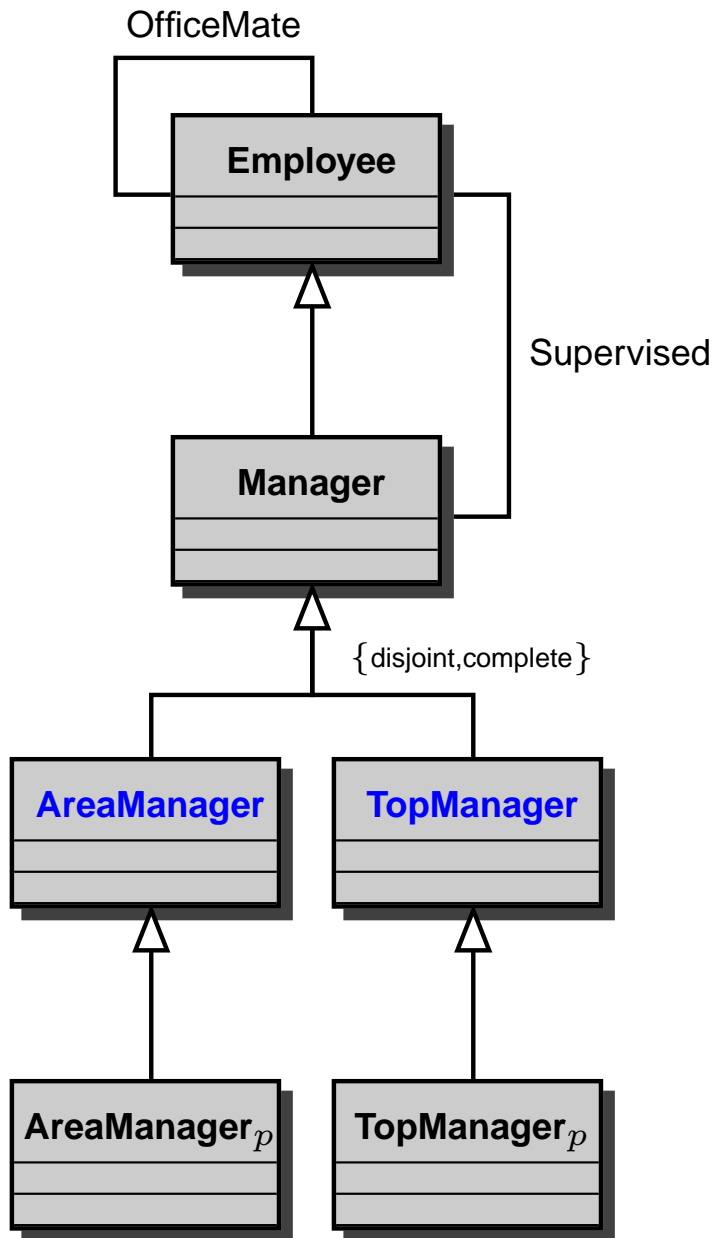
Works-for = { (**John**, **Prj-A**), (**Mary**, **Prj-B**) }

Project = { **Prj-A**, **Prj-B** }

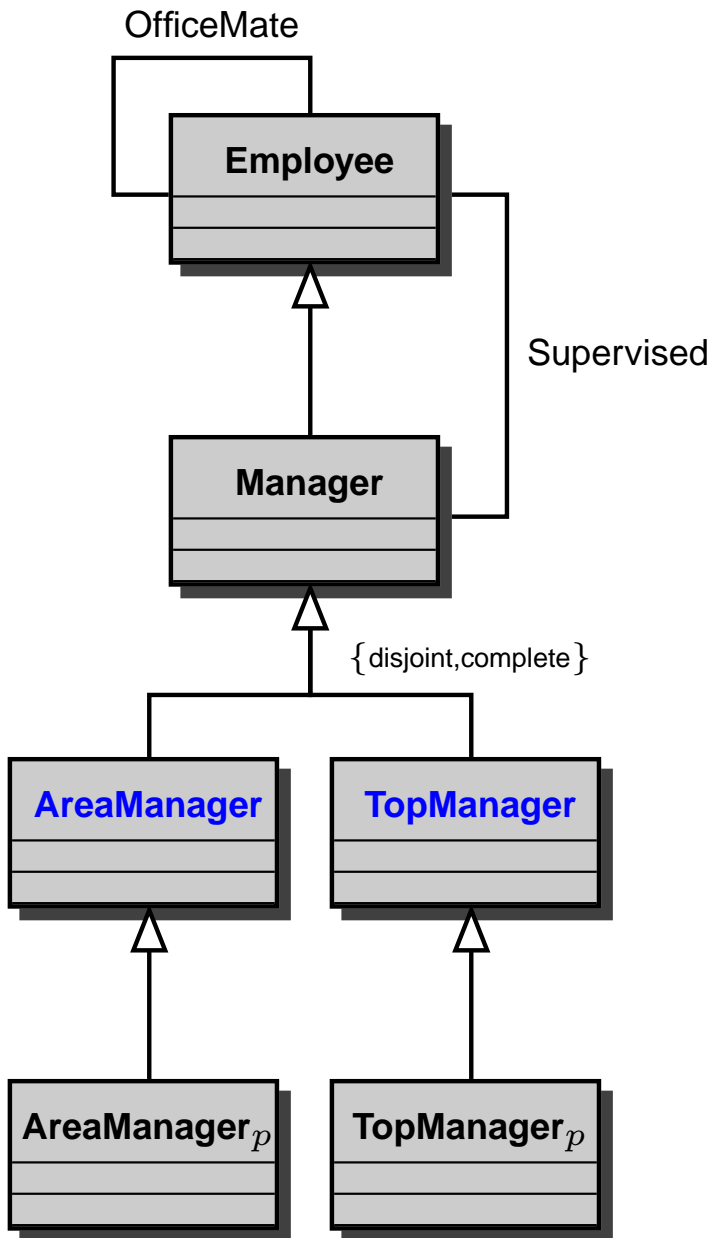
$Q(X) :- \text{Employee}(X)$

$\Rightarrow \{ \text{John}, \text{Paul}, \text{Mary} \}$

Andrea's Example



Andrea's Example



Employee = { **Andrea**, **Paul**, **Mary**, **John** }

Manager = { **Andrea**, **Paul**, **Mary** }

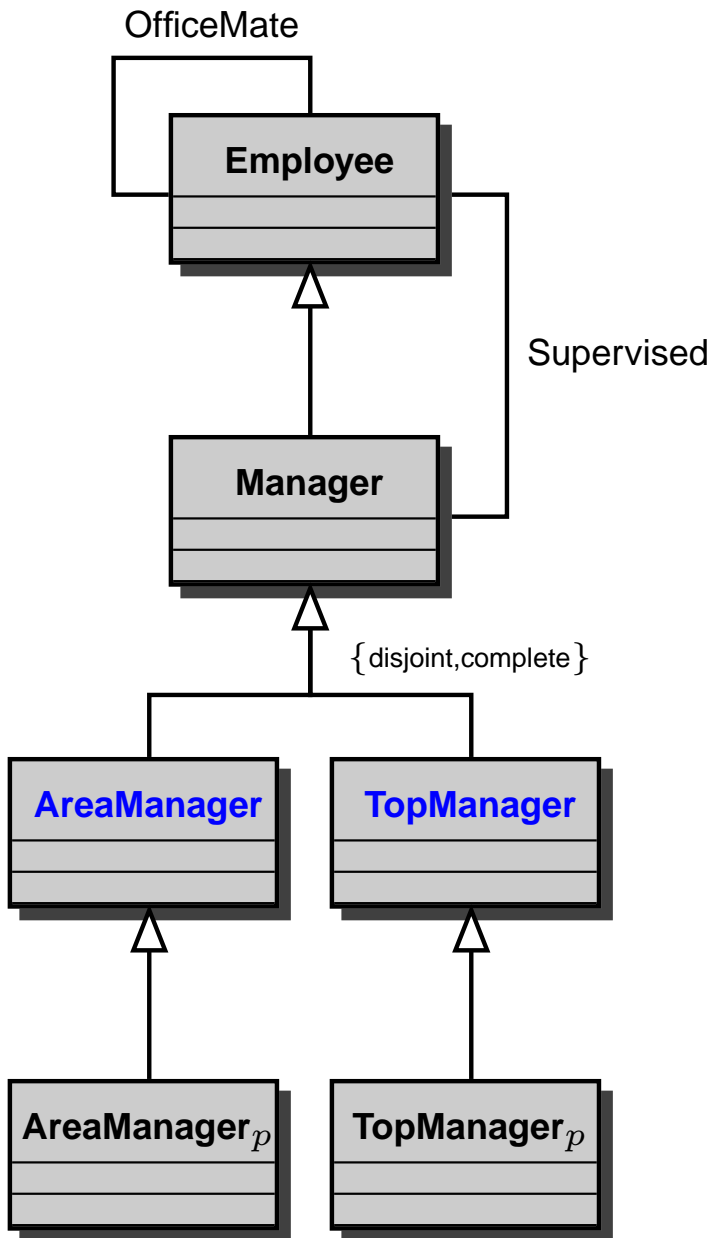
AreaManager_p = { **Paul** }

TopManager_p = { **Mary** }

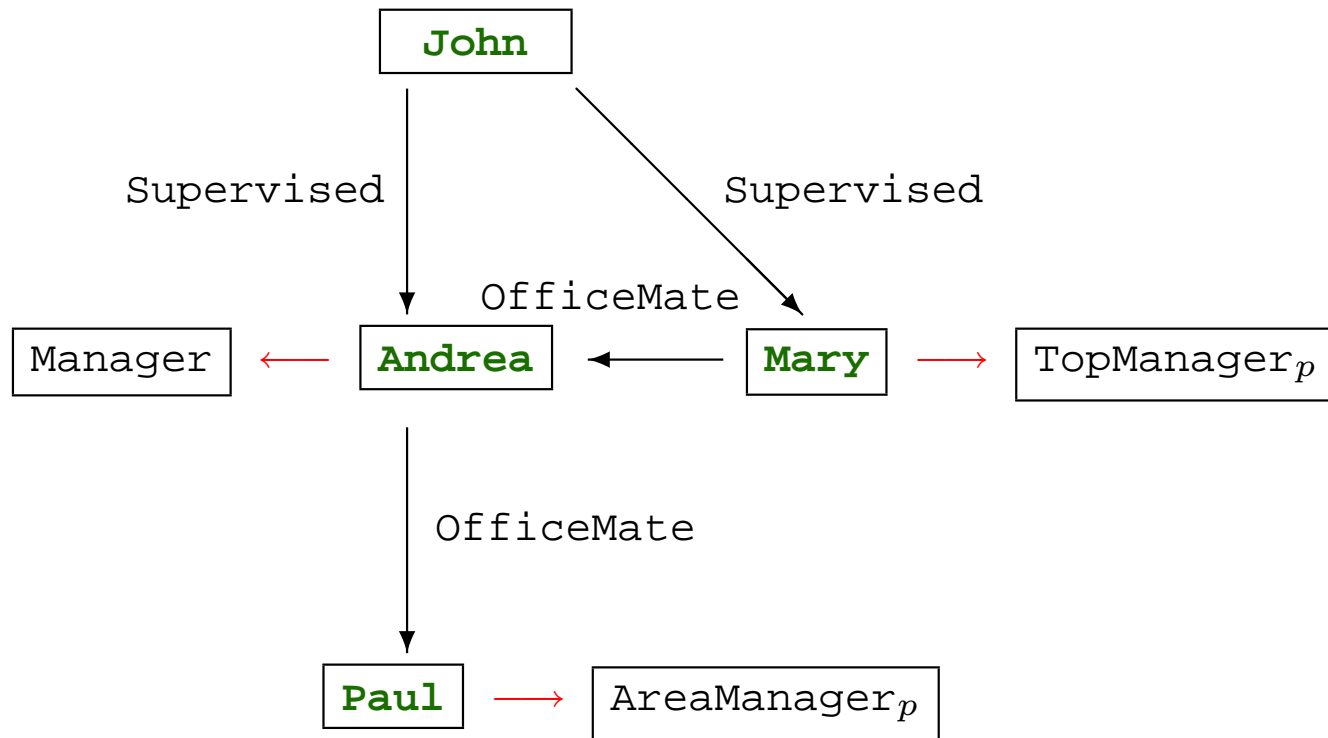
Supervised = { (**John**, **Andrea**), (**John**, **Mary**) }

OfficeMate = { (**Mary**, **Andrea**), (**Andrea**, **Paul**) }

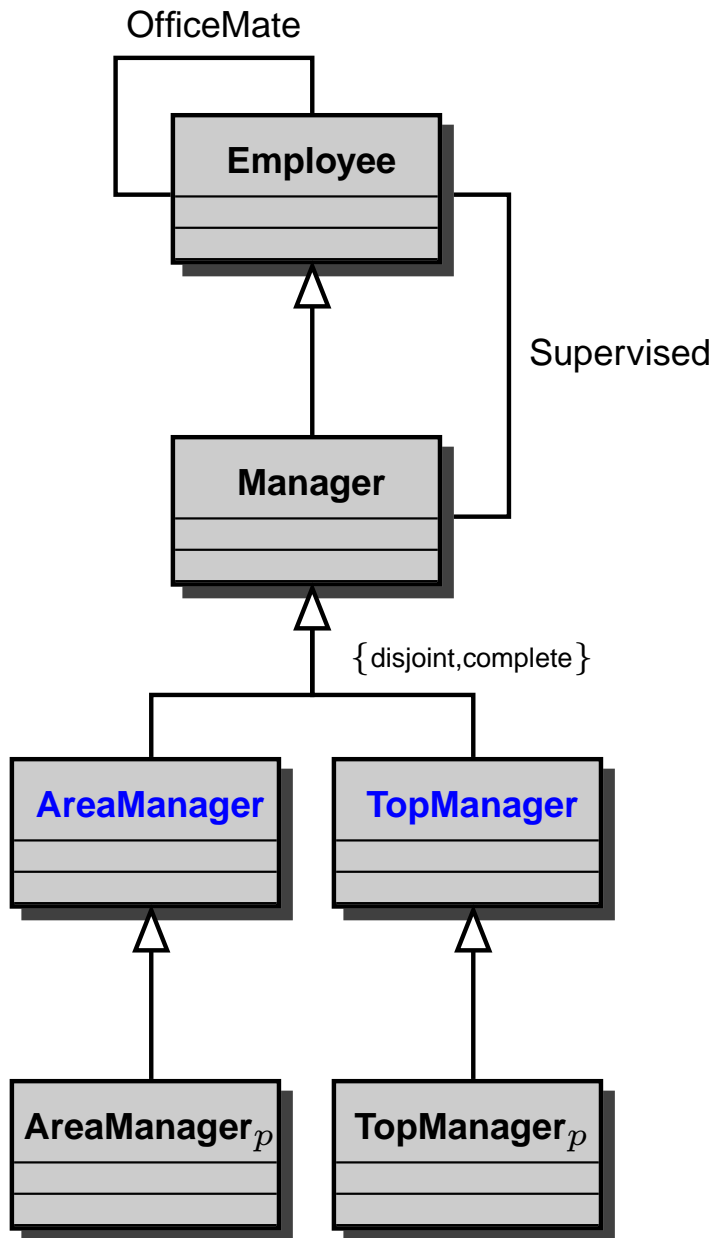
Andrea's Example



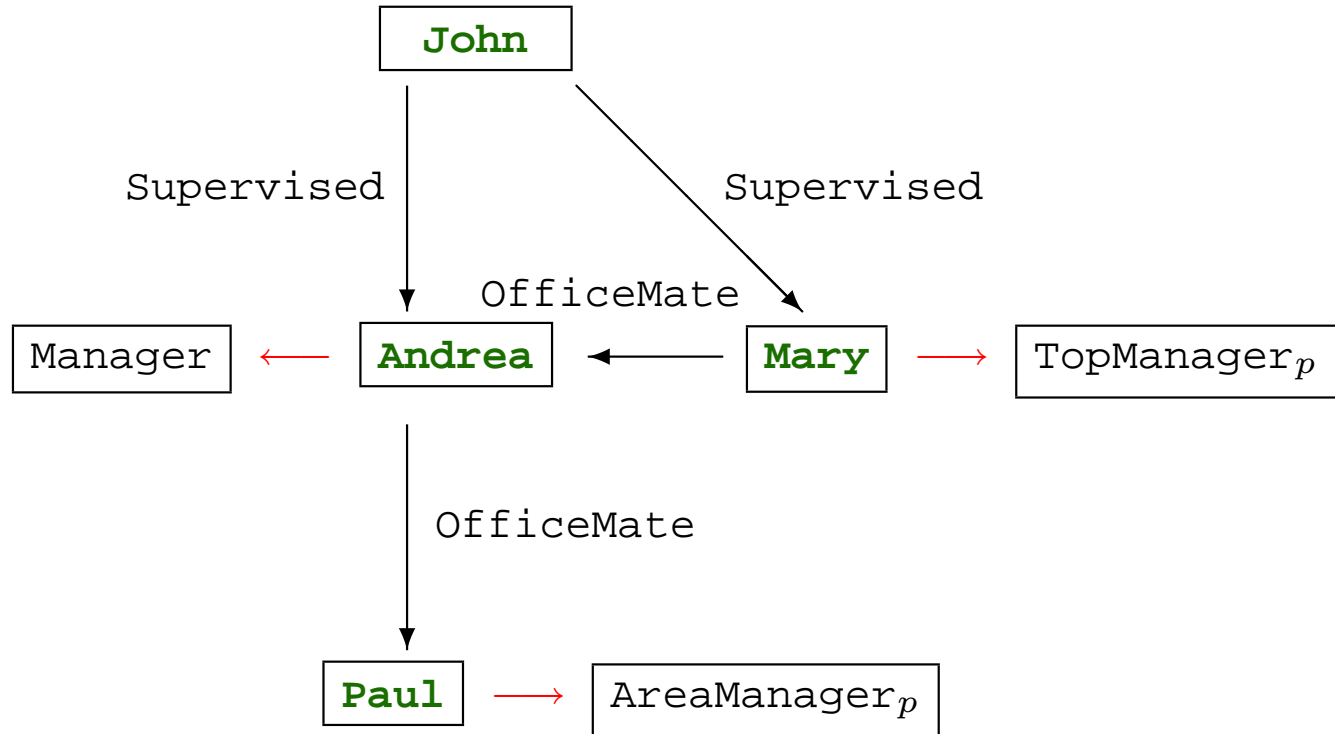
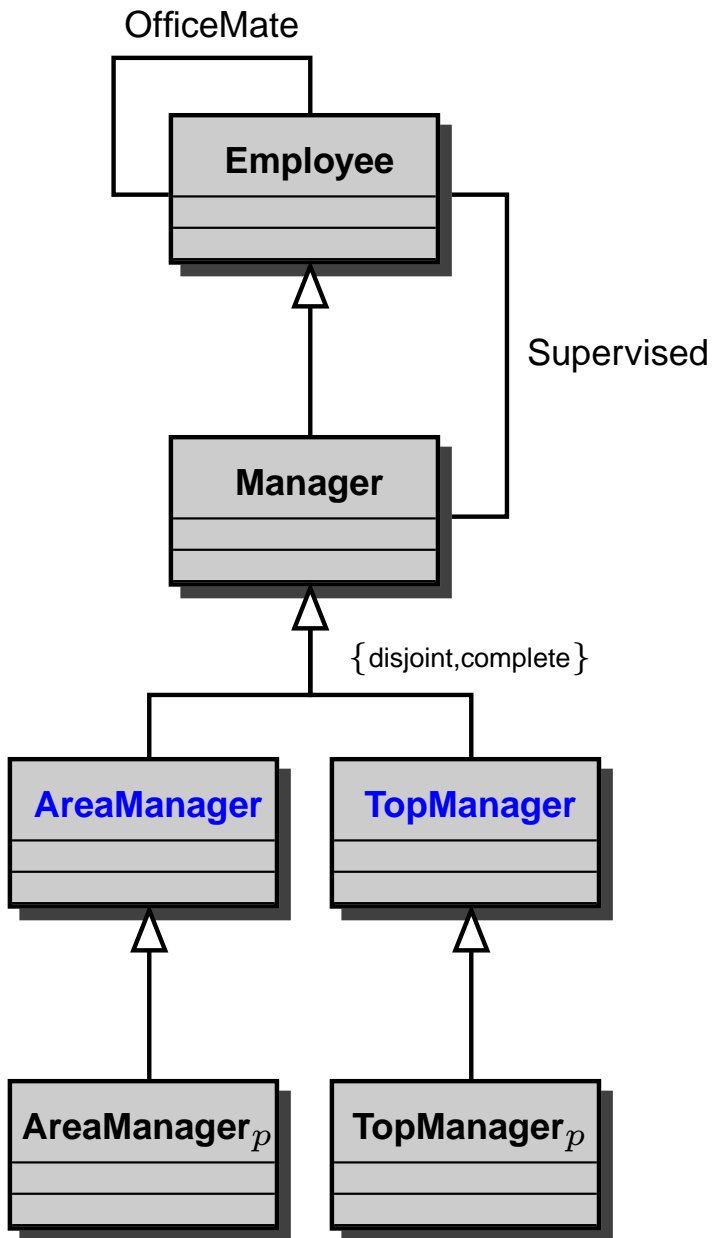
$Employee = \{ \text{Andrea, Paul, Mary, John} \}$
 $Manager = \{ \text{Andrea, Paul, Mary} \}$
 $AreaManager_p = \{ \text{Paul} \}$
 $TopManager_p = \{ \text{Mary} \}$
 $Supervised = \{ (\text{John, Andrea}), (\text{John, Mary}) \}$
 $OfficeMate = \{ (\text{Mary, Andrea}), (\text{Andrea, Paul}) \}$



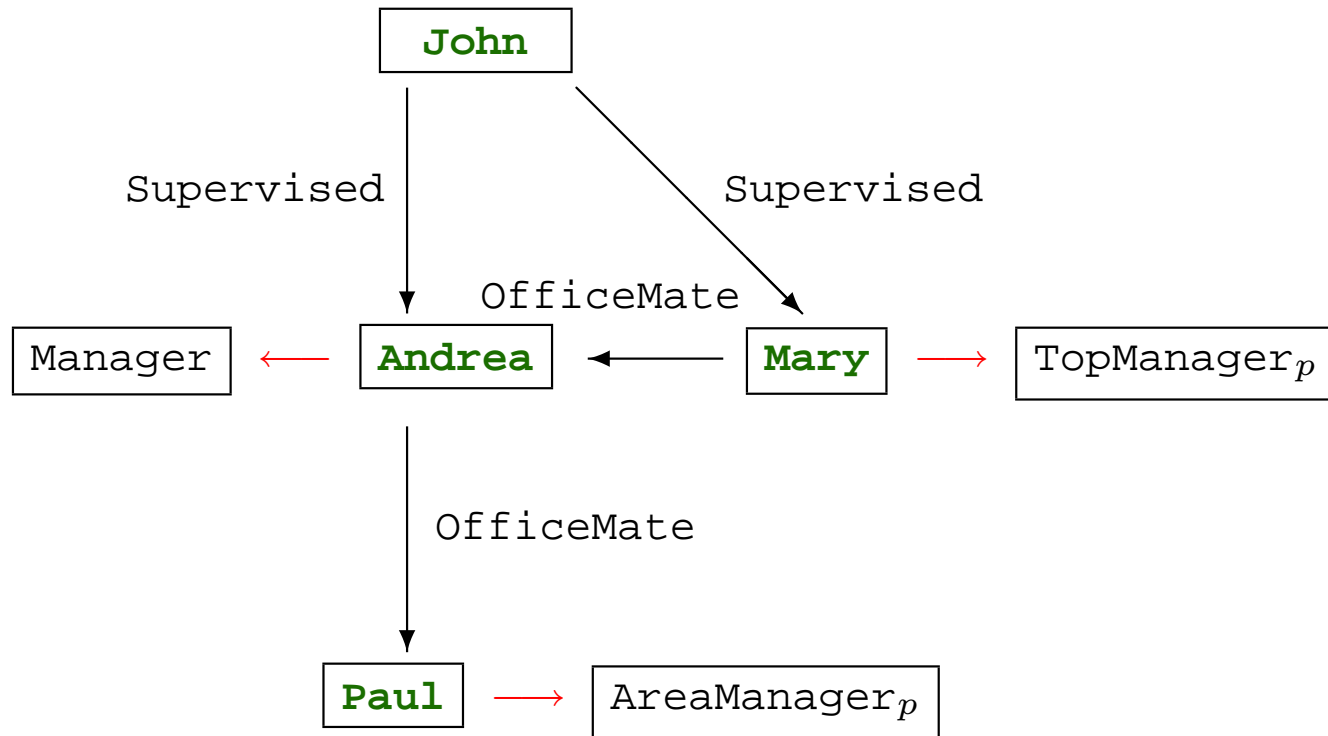
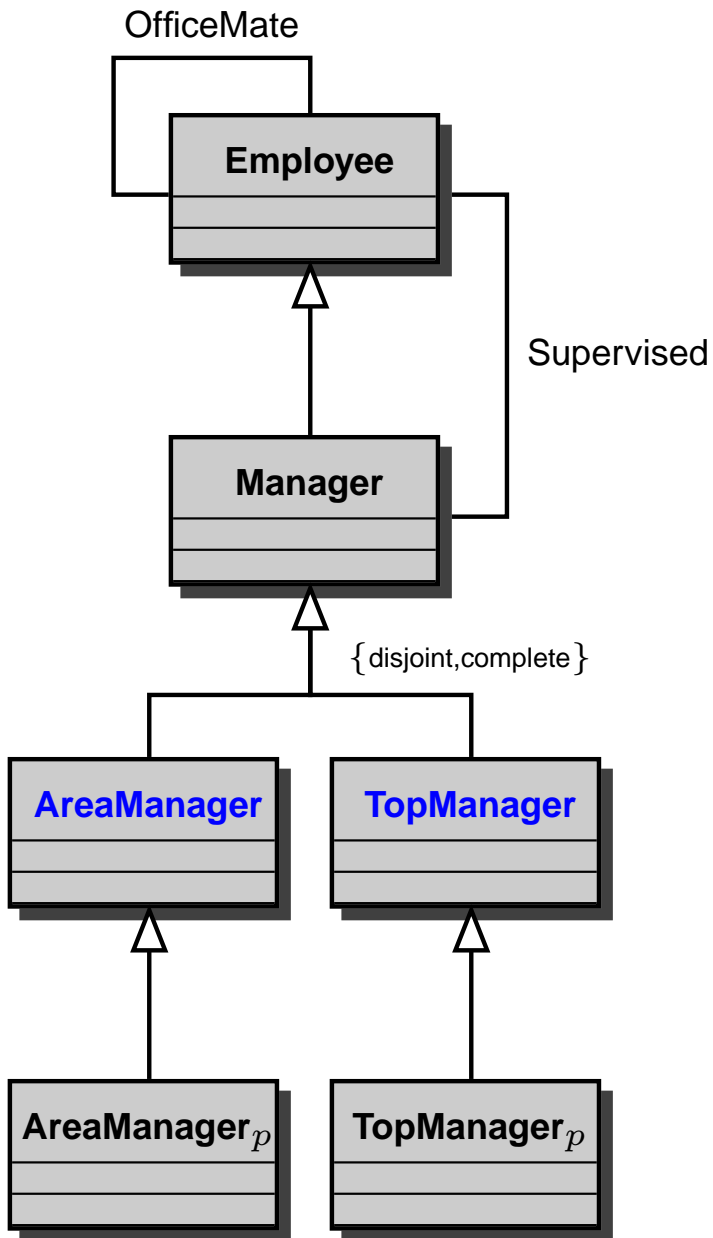
Andrea's Example (cont.)



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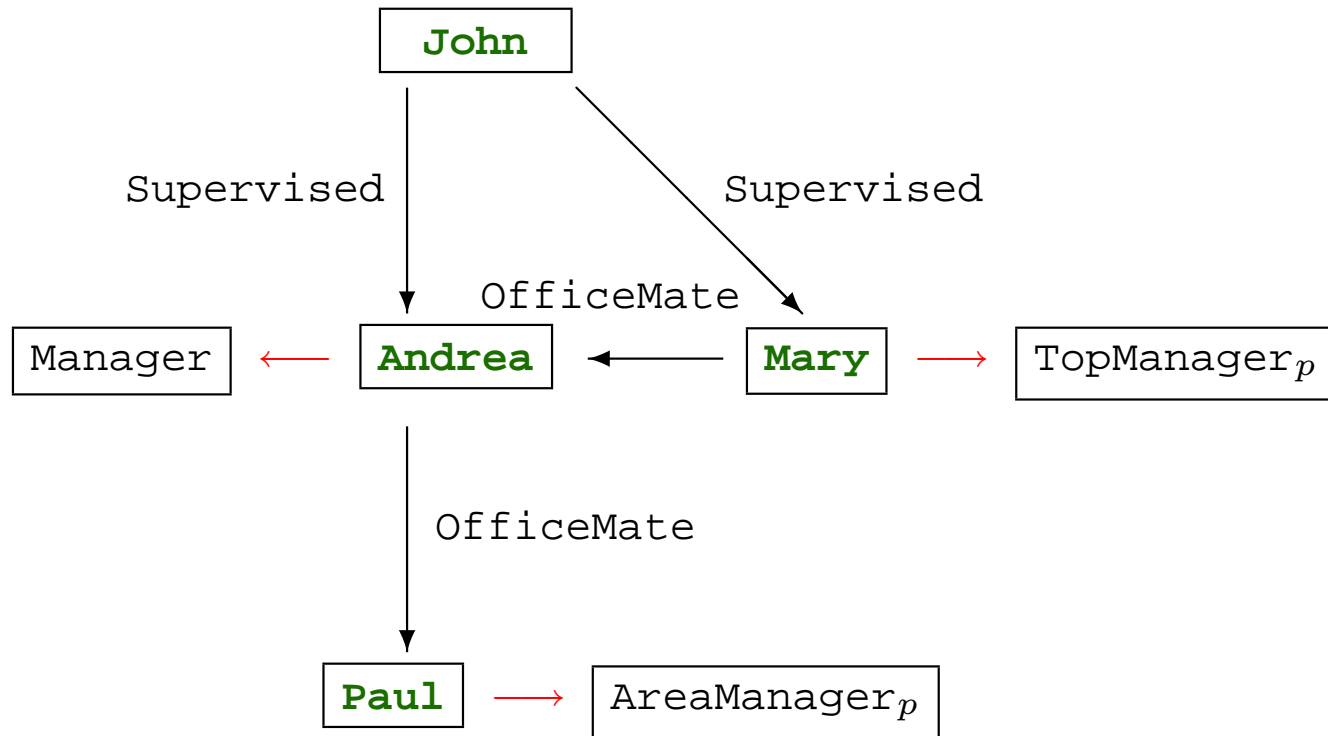
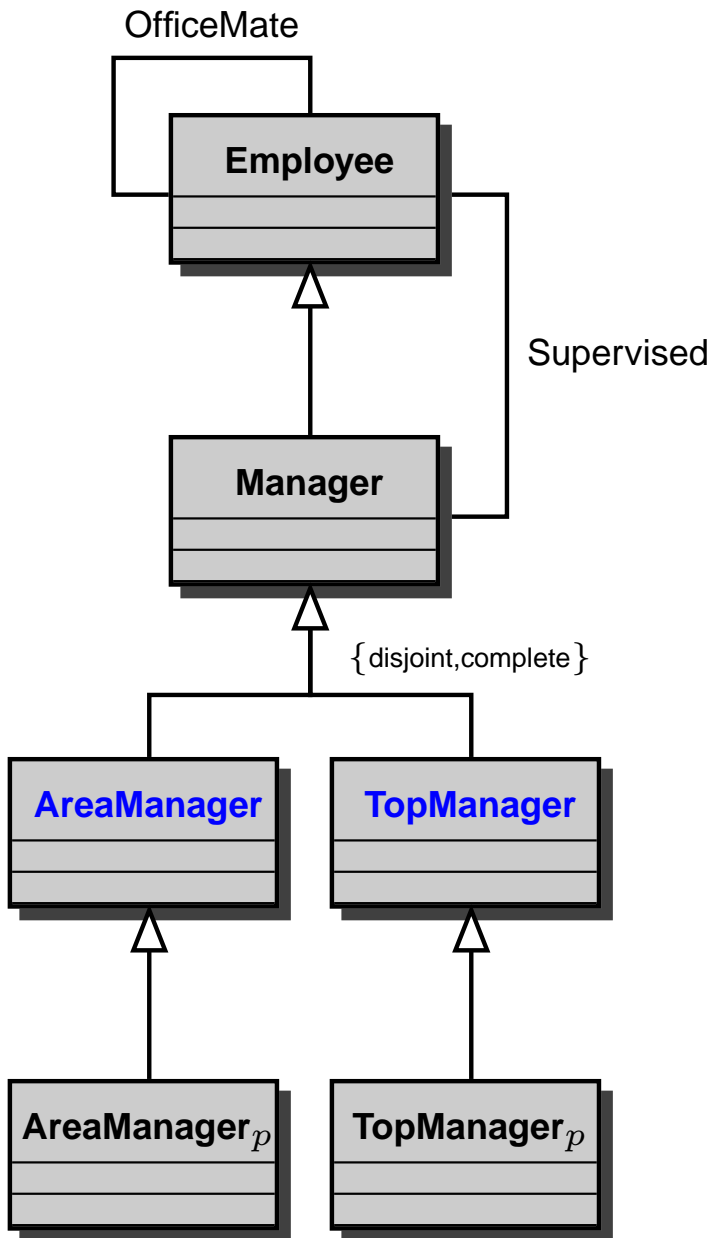


Andrea's Example (cont.)



$Q(X) :- Supervised(X, Y), TopManager(Y),$
 $Officemate(Y, Z), AreaManager(Z)$

Andrea's Example (cont.)



$Q(X) \text{ :- Supervised}(X, Y), \text{ TopManager}(Y),$
 $\text{Officemate}(Y, Z), \text{ AreaManager}(Z)$

$\Rightarrow \{ \text{John} \}$

The general case: View based Query Processing

In general, the **mapping** between the ontology and the information source terms can be given in terms of a set of **sound** or **exact views**:

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- **GAV** (global-as-view): a view over the information source is given for some term in the ontology

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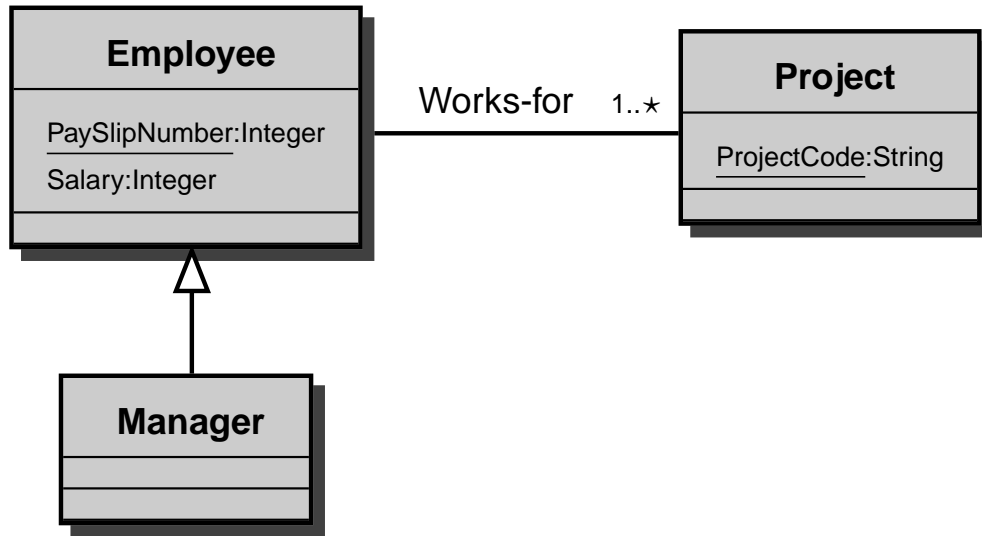
- **GAV** (global-as-view): a view over the information source is given for some term in the ontology
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 - an ER schema can be easily mapped to its corresponding relational schema in normal form via a GAV mapping

The general case: View based Query Processing

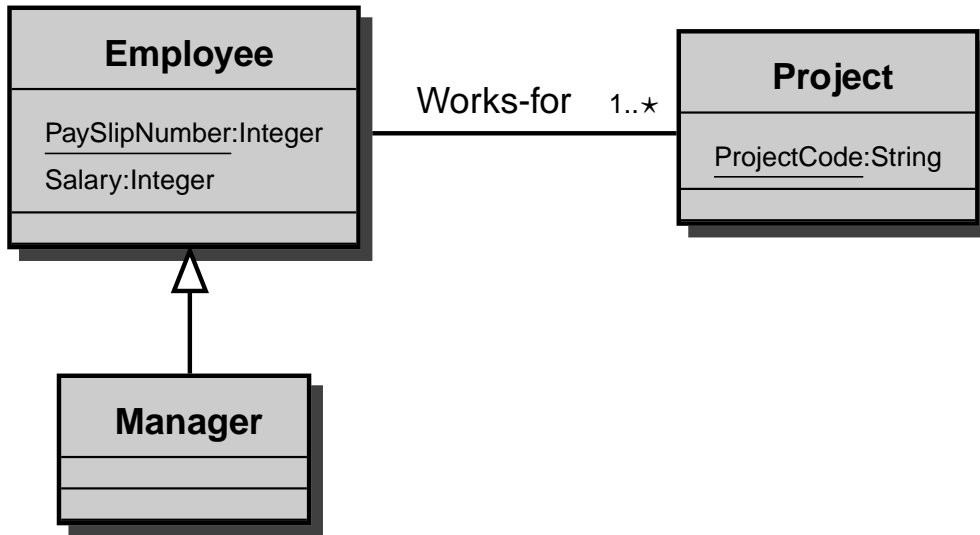
In general, the **mapping** between the ontology and the information source terms can be given in terms of a set of **sound** or **exact views**:

- **GAV** (global-as-view): a view over the information source is given for some term in the ontology
 - both the DB and the partial DB assumptions are special cases of GAV
 - an ER schema can be easily mapped to its corresponding relational schema in normal form via a GAV mapping
- **LAV** (local-as-view): a view over the ontology terms is given for each term in the information source;
- **GLAV**: mixed from the above.

Sound GAV mapping



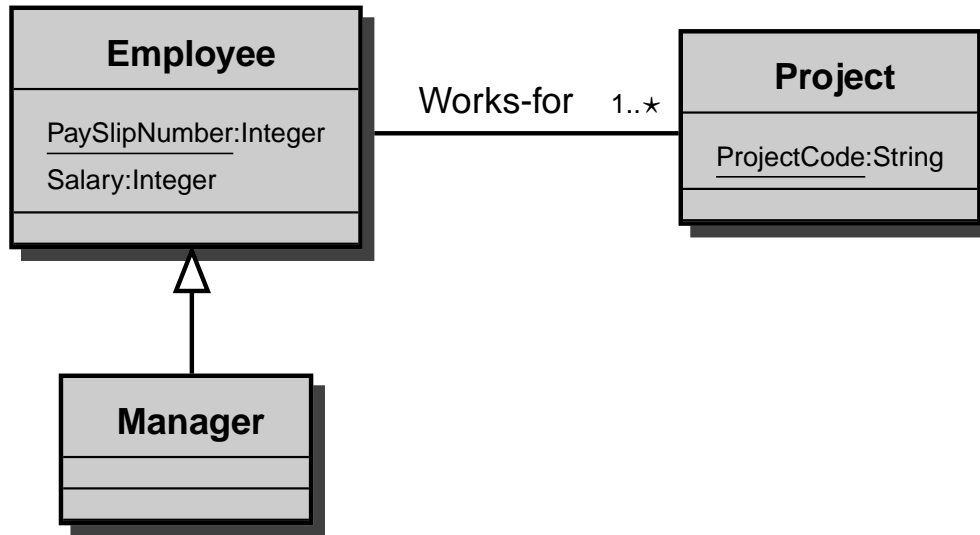
Sound GAV mapping



1-`Employee` (PaySlipNumber, Salary, ManagerP)

2-`Works-for` (PaySlipNumber, ProjectCode)

Sound GAV mapping



1-`Employee`(PaySlipNumber, Salary, ManagerP)

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`Employee(X) :- 1-Employee(X,Y,Z)`

`Employee(X) :- 2-Works-for(X,Y)`

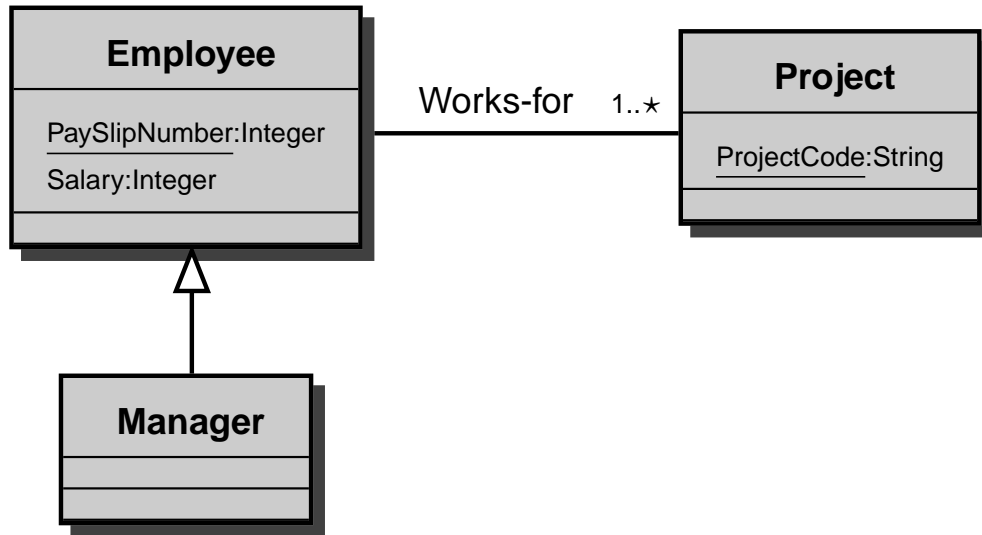
`Manager(X) :- 1-Employee(X,Y, true)`

`Project(Y) :- 2-Works-for(X,Y)`

`Works-for(X,Y) :- 2-Works-for(X,Y)`

`Salary(X,Y) :- 1-Employee(X,Y,Z)`

Queries with Sound GAV mapping



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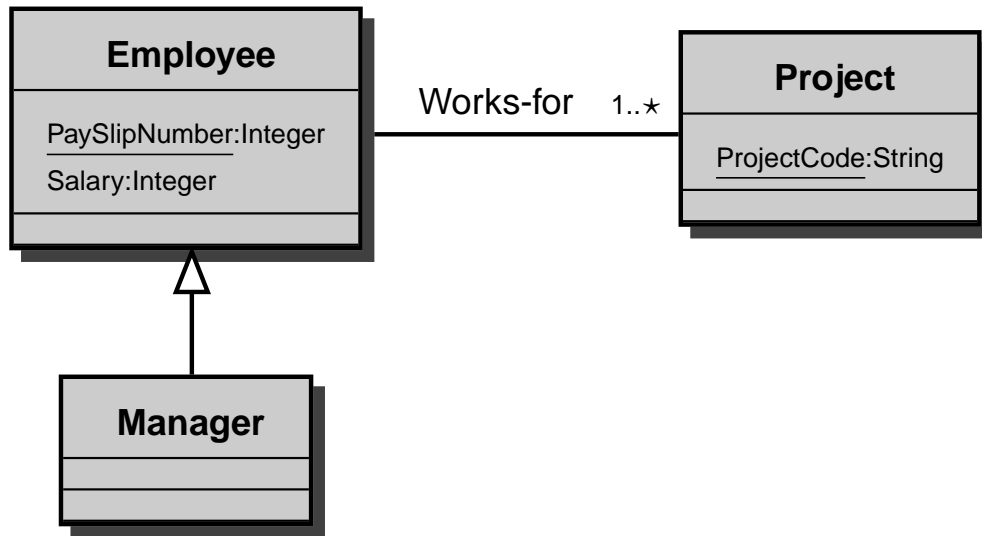
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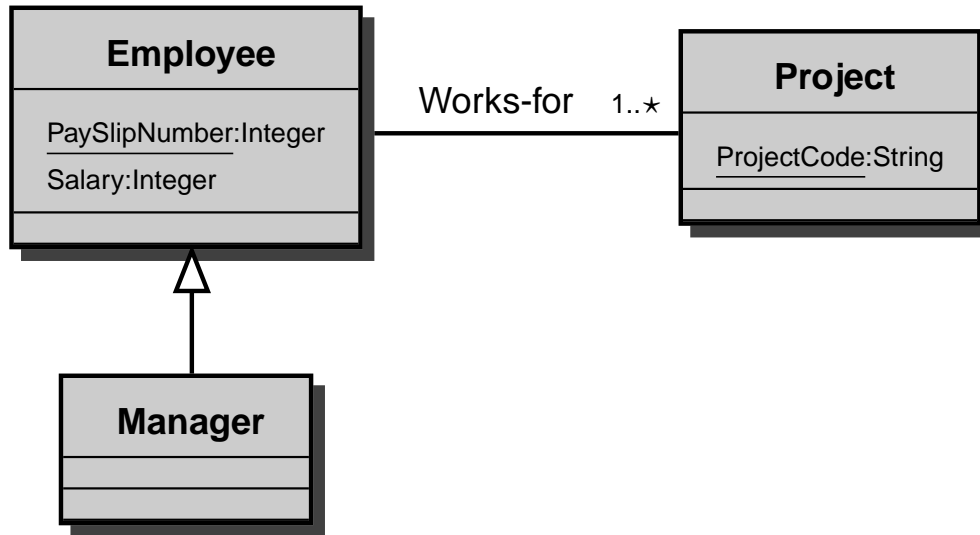
`Project(Y) :- 2-Works-for(X,Y)`

`Works-for(X,Y) :- 2-Works-for(X,Y)`

`Salary(X,Y) :- 1-Employee(X,Y,Z)`

`Q(X) :- Employee(X)`

Queries with Sound GAV mapping



1- $\text{Employee}(\underline{\text{PaySlipNumber}}, \text{Salary}, \text{ManagerP})$

2- $\text{Works-for}(\underline{\text{PaySlipNumber}}, \underline{\text{ProjectCode}})$

$\text{Employee}(X) :- 1\text{-Employee}(X, Y, Z)$

$\text{Employee}(X) :- 2\text{-Works-for}(X, Y)$

$\text{Manager}(X) :- 1\text{-Employee}(X, Y, \text{true})$

$\text{Project}(Y) :- 2\text{-Works-for}(X, Y)$

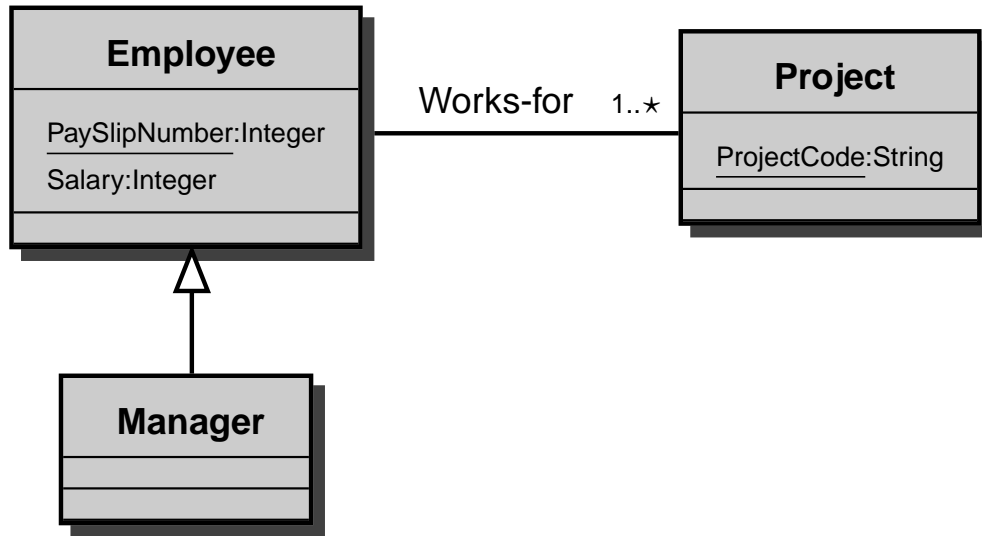
$\text{Works-for}(X, Y) :- 2\text{-Works-for}(X, Y)$

$\text{Salary}(X, Y) :- 1\text{-Employee}(X, Y, Z)$

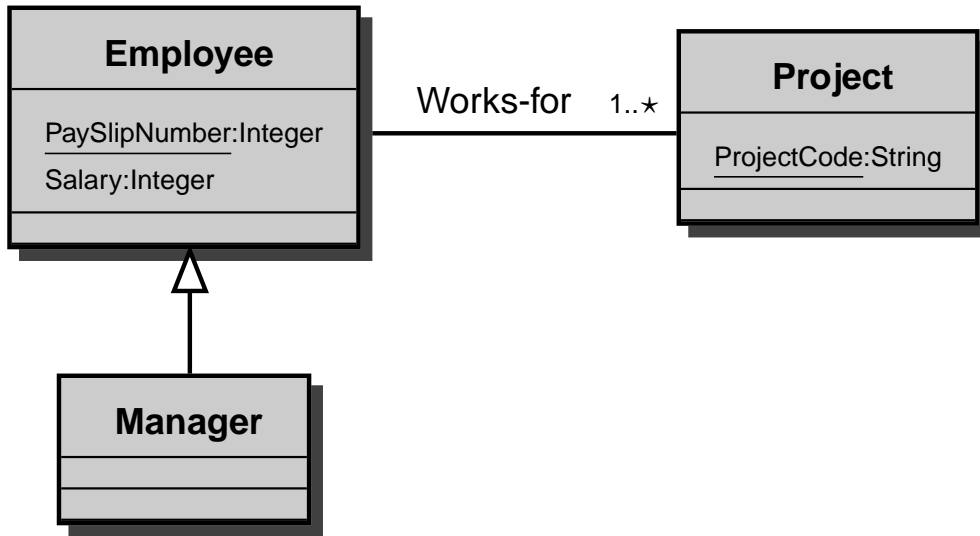
$Q(X) :- \text{Employee}(X)$

$\Rightarrow Q'(X) :- 1\text{-Employee}(X, Y, Z) \cup 2\text{-Works-for}(X, W)$

Sound LAV mapping



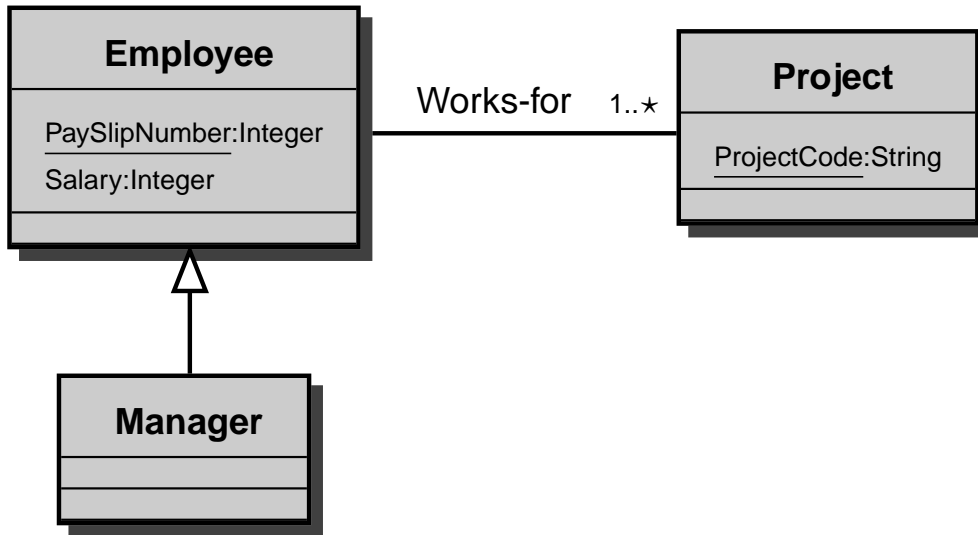
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Sound LAV mapping



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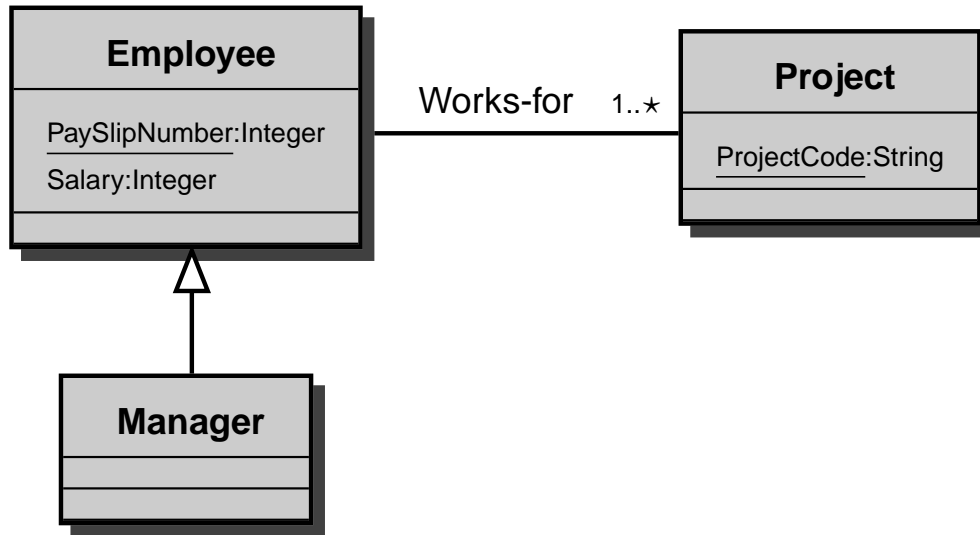
2-`Works-for(PaySlipNumber, ProjectCode)`

1-`Employee(X,Y,Z) :- Manager(X), Salary(X,Y), Z=true`

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2-`Works-for(X,Y) :- Works-for(X,Y)`

Queries with Sound LAV mapping



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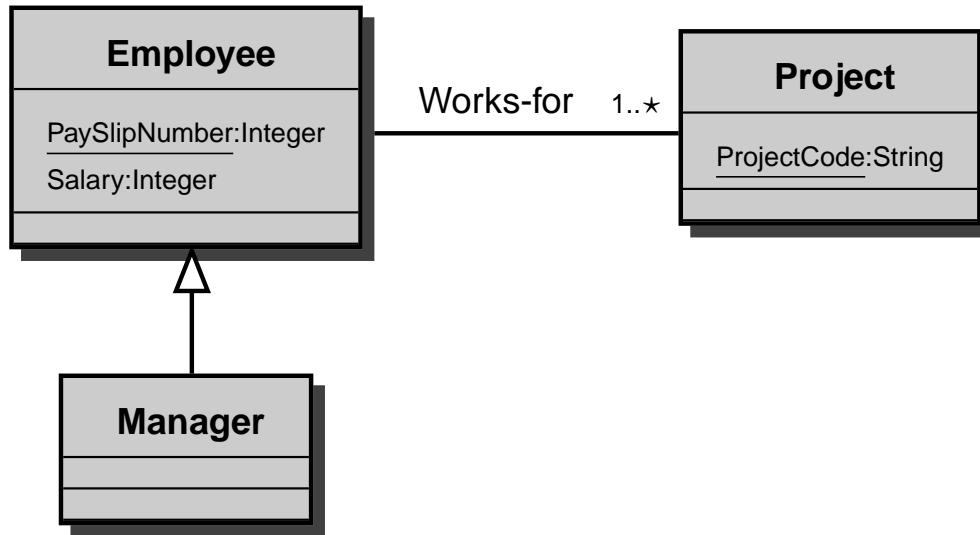
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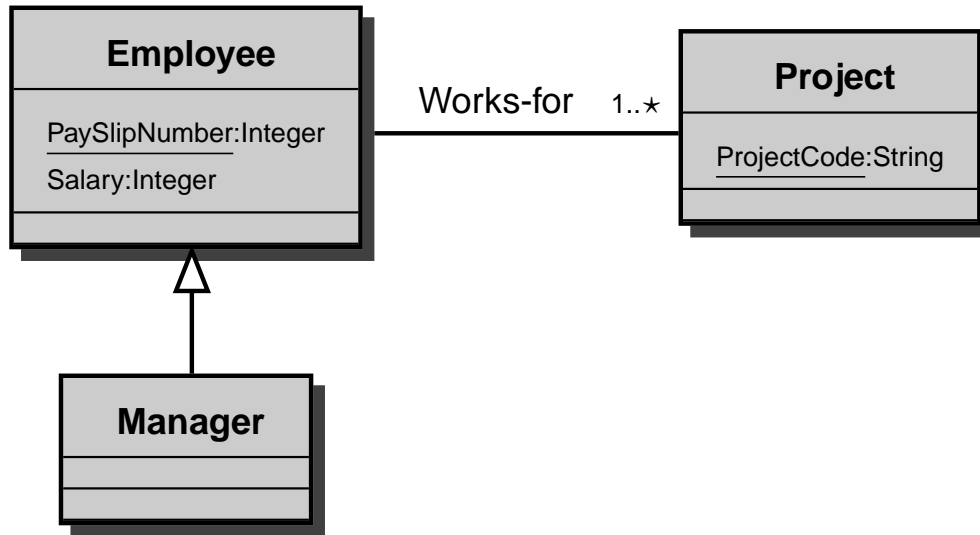
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`Q(X) :- Manager(X), Works-for(X,Y), Project(Y)`

Queries with Sound LAV mapping



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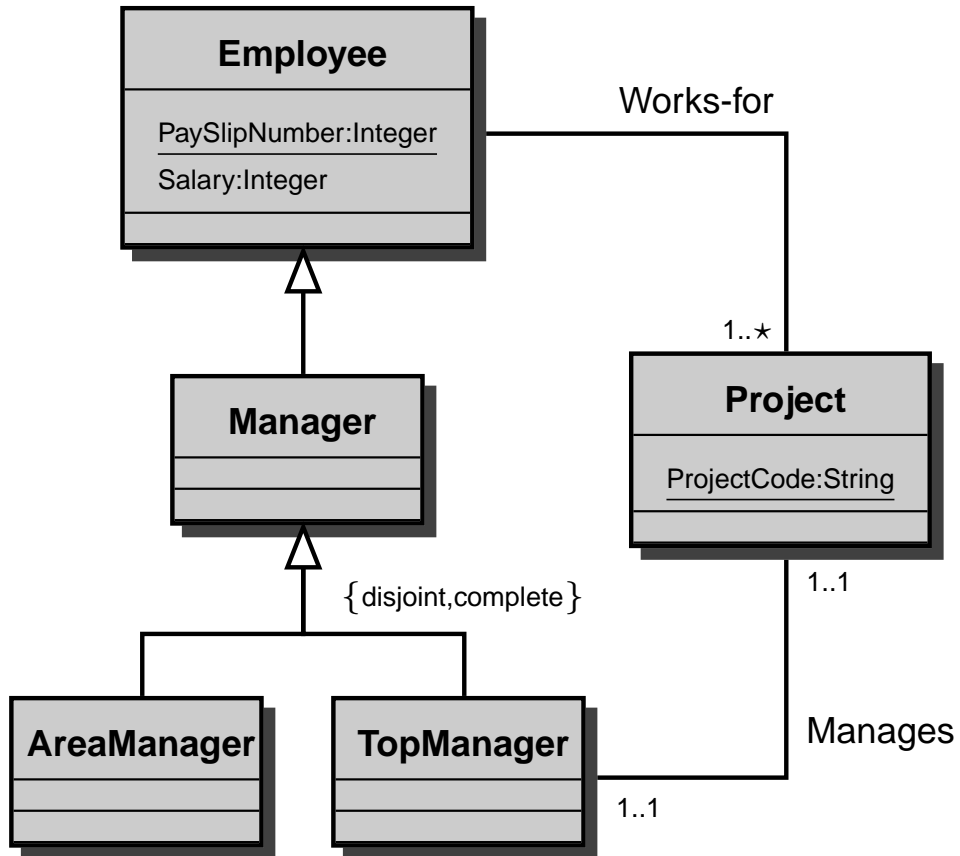
2-`Works-for(X,Y) :- Works-for(X,Y)`

`Q(X) :- Manager(X), Works-for(X,Y), Project(Y)`

\Rightarrow `Q'(X) :- 1-Employee(X,Y,true), 2-Works-for(X,Z)`

Reasoning over queries

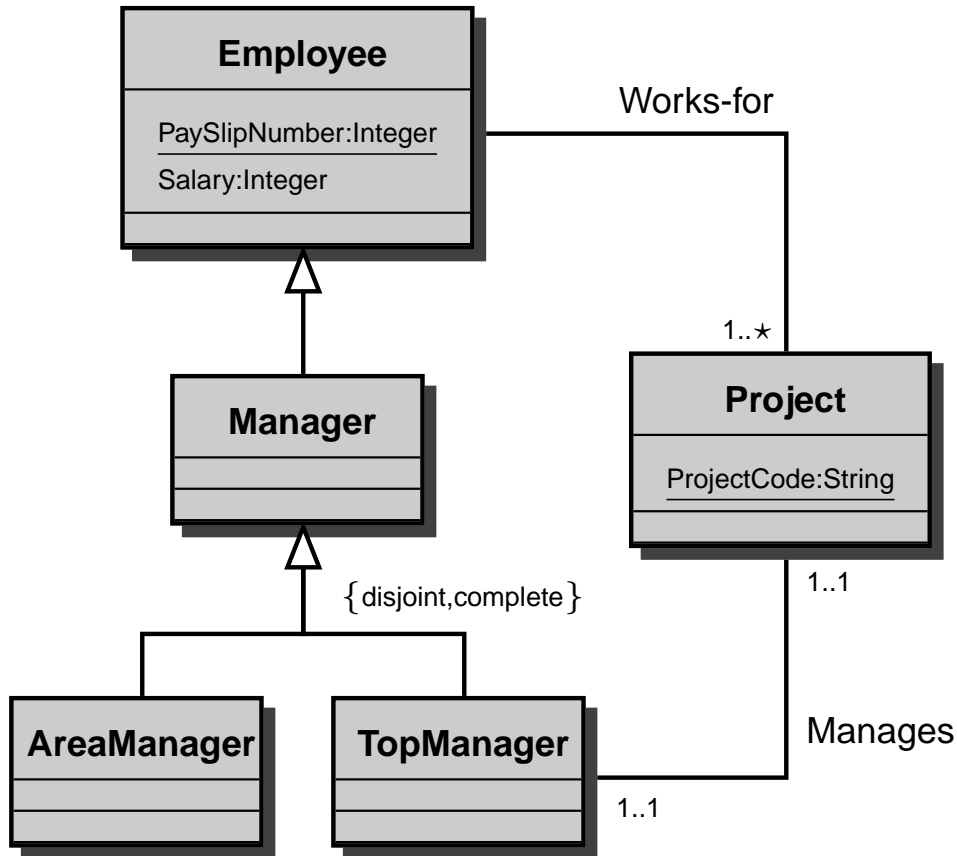
$Q(X, Y) :- \text{Employee}(X), \text{Works-for}(X, Y), \text{Manages}(X, Y)$



$\forall x. \text{Manager}(x) \rightarrow \forall y. \neg \text{WORKS-FOR}(x, y)$

Reasoning over queries

$Q(X, Y) :- \text{Employee}(X), \text{Works-for}(X, Y), \text{Manages}(X, Y)$



$\forall x. \text{Manager}(x) \rightarrow \forall y. \neg \text{WORKS-FOR}(x, y)$



INCONSISTENT QUERY!