Metamodeling the Entity Relationship and Relational Data Model and their Transformation

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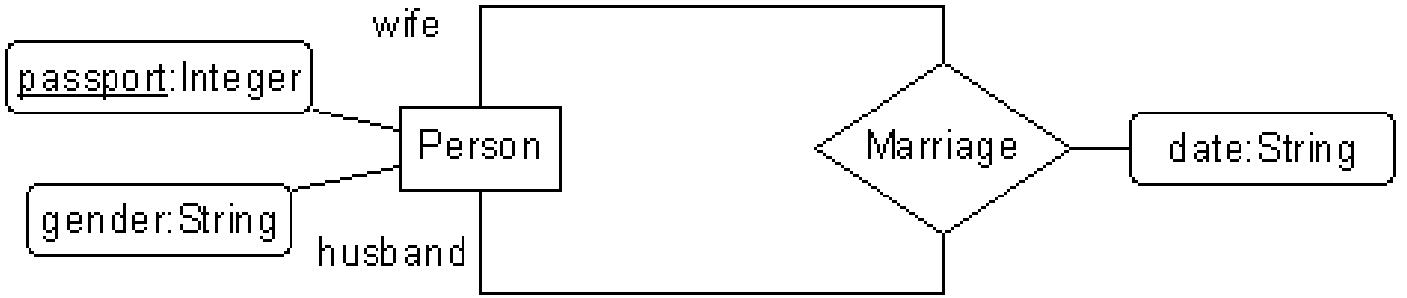
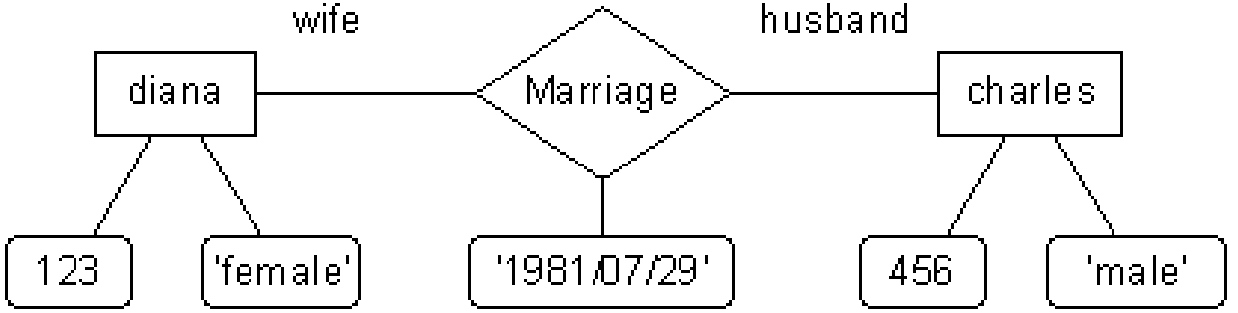
Transformation of an ER Schema into a Relational DB Schema

- Entity → Relational schema
  Entity key attributes → Key attributes in relational schema
  Non-key attributes → non-key attributes in relational schema
- Relship → Relational schema
  Each 'arm' of the relship →
    Key attributes of entity into relational schema
    Key of relational schema consists of key attributes of all entities
  Attributes of relship → Attributes in relational schema
- Example

  ER schema:
  Entity [Person(passport,gender)]
  Relship < Marriage(wife:Person,husband:Person;date:String) >

  Relational DB schema:
  Person(passport,gender)
  Marriage(wife_passport,husband_passport,date)



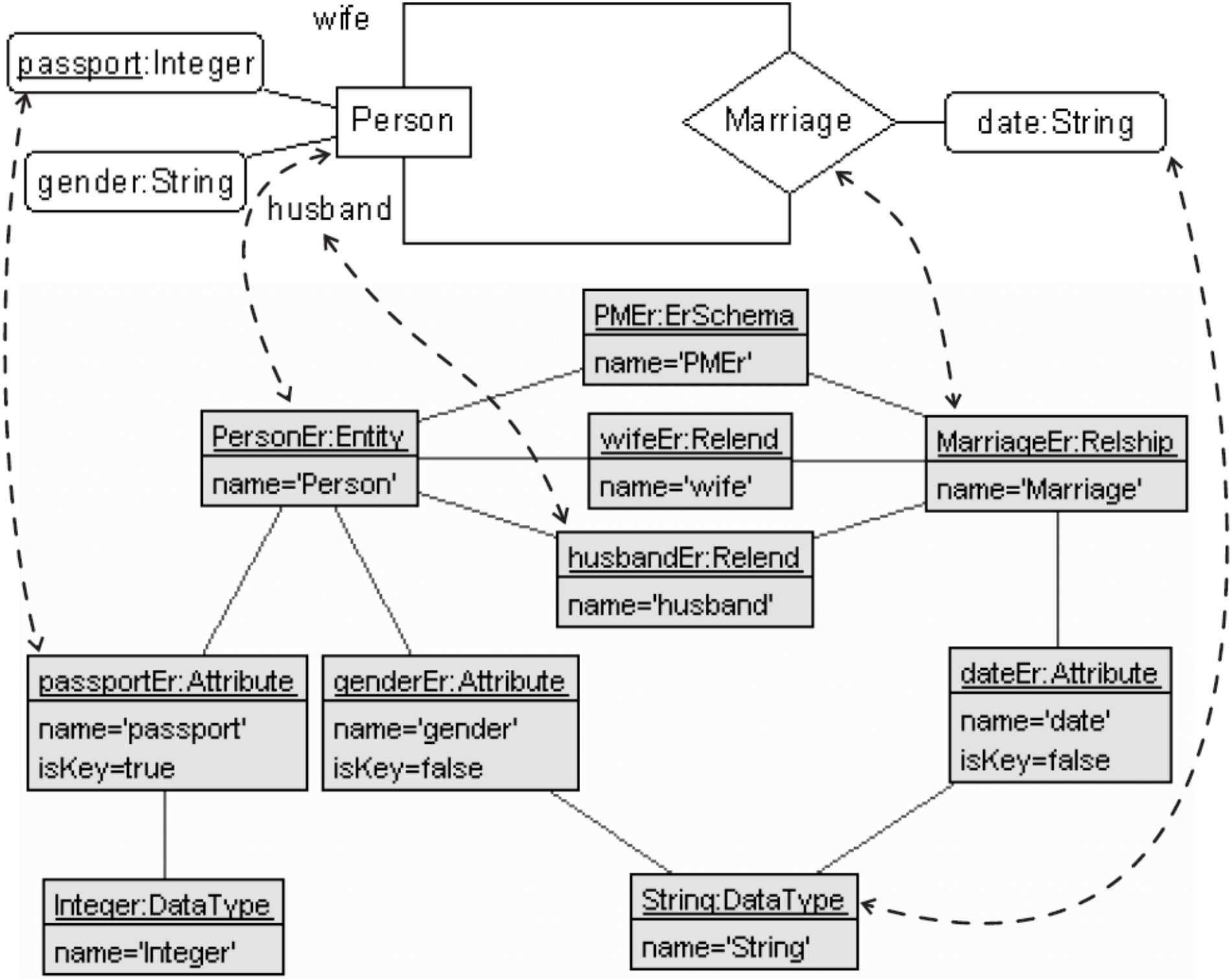


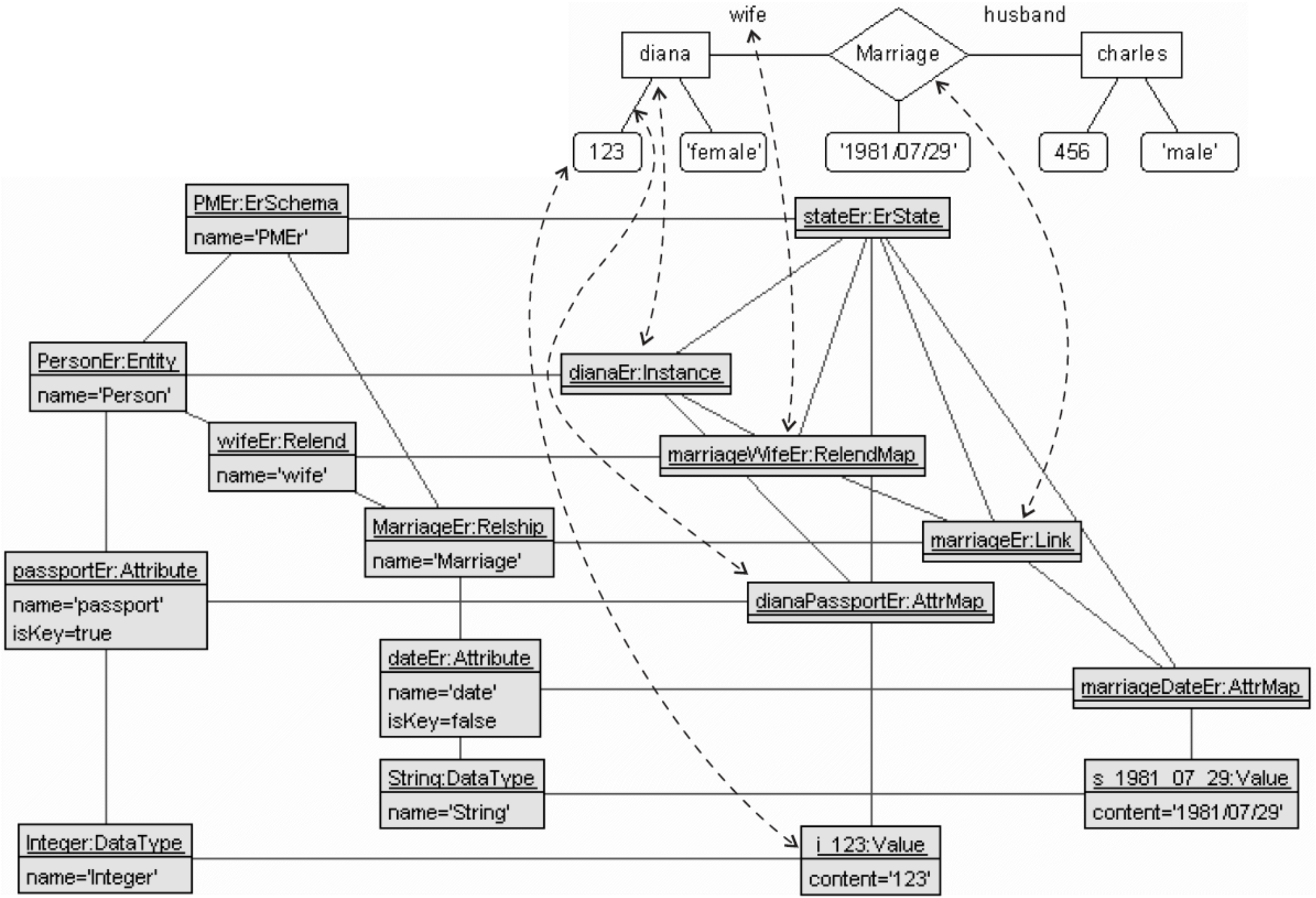
Person(passport:Integer,gender:String)

Marriage(wife_passport:Integer,husband_passport:Integer,date:String)

Person	passport	gender
	123	'female'
	456	'male'

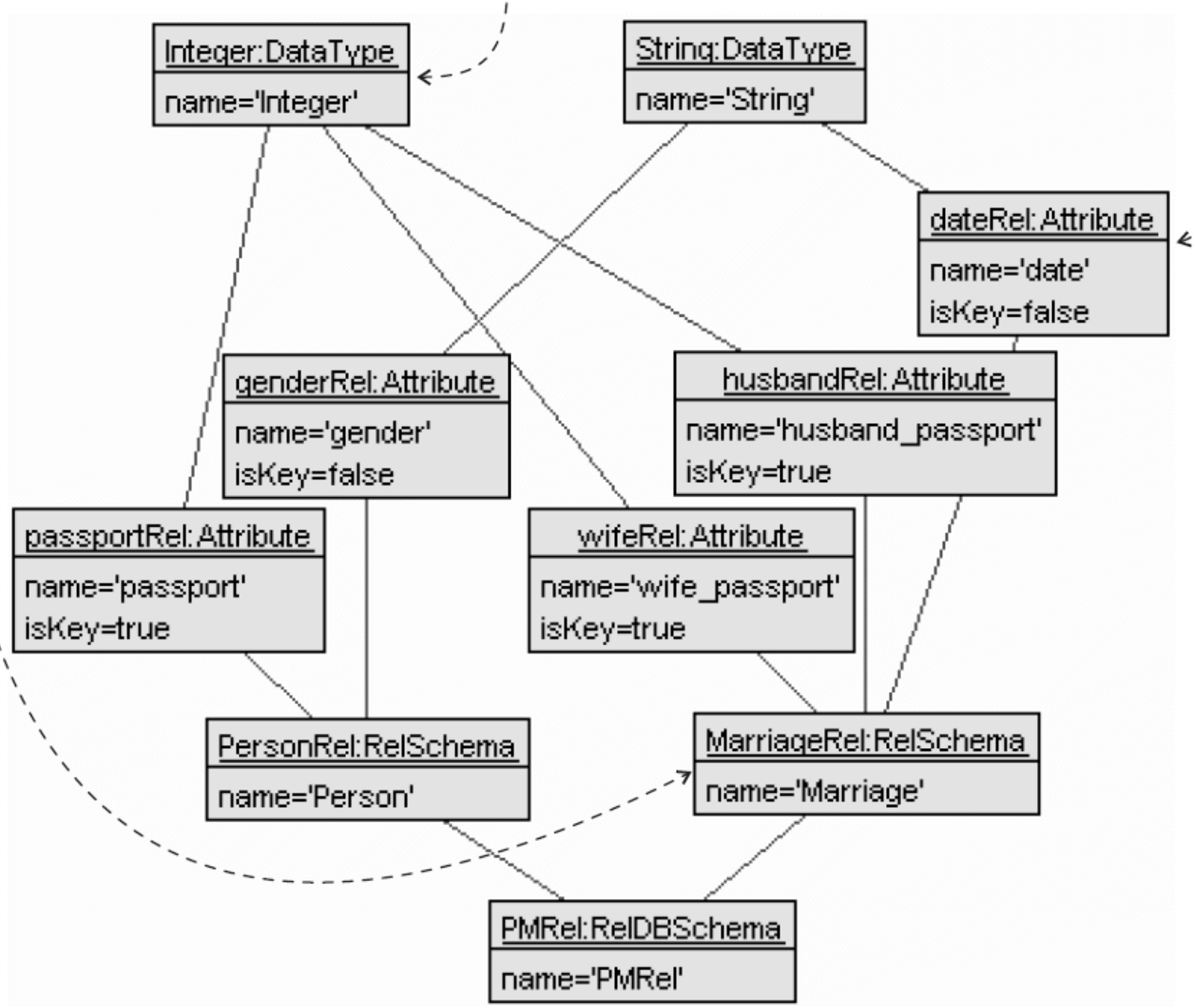
Marriage	wife_passport	husband_passport	date
	123	456	'1981/07/29'

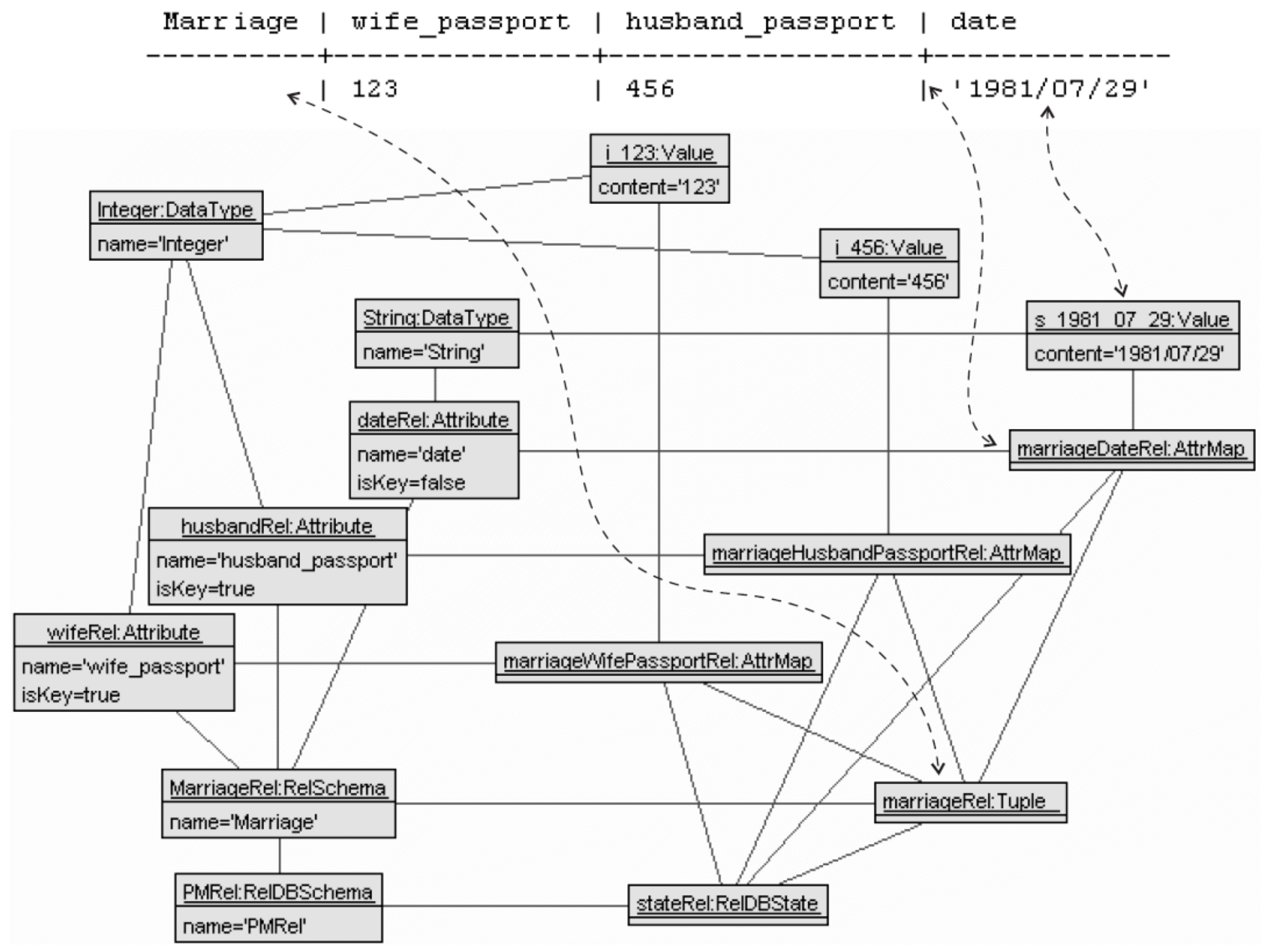

wife
passport:Integer
Person
Marriage
date:String
gender:String
husband
PMEr:ErSchema
name='PMEr'
PersonEr:Entity
name='Person'
wifeEr:Relend
name='wife'
MarriageEr:Relship
name='Marriage'
husbandEr:Relend
name='husband'
passportEr:Attribute
name='passport'
isKey=true
genderEr:Attribute
name='gender'
isKey=false
dateEr:Attribute
name='date'
isKey=false
Integer:DataType
name='Integer'
String:DataType
name='String'

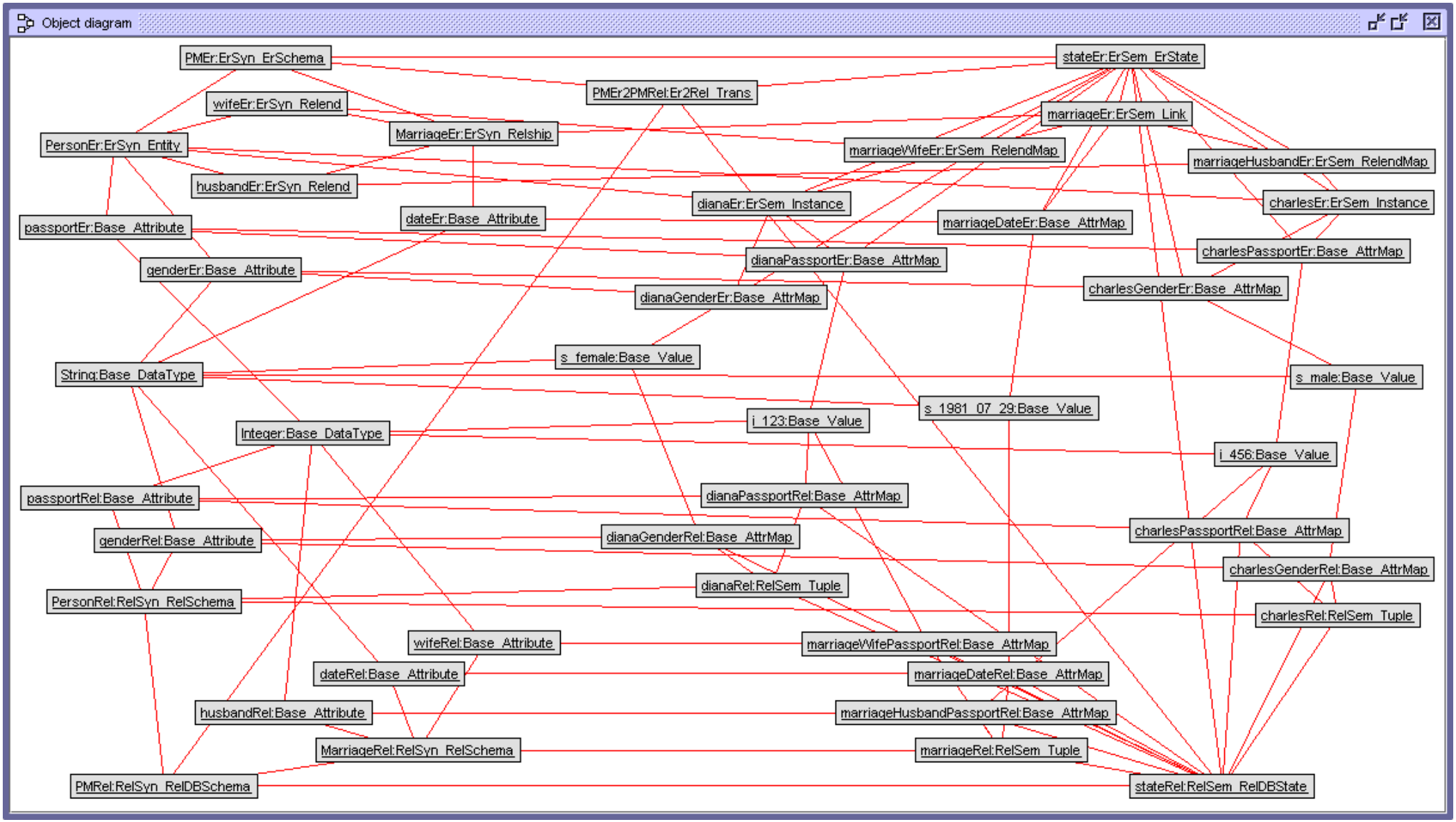

wife
husband
diana
Marriage
charles
123
'female'
'1981/07/29'
456
'male'
PMEr:ErSchema
name='PMEr'
stateEr:ErState
PersonEr:Entity
name='Person'
dianaEr:Instance
wifeEr:Relend
name='wife'
marriageWifeEr:RelendMap
MarriageEr:Relship
name='Marriage'
marriageEr:Link
passportEr:Attribute
name='passport'
isKey=true
dianaPassportEr:AttrMap
dateEr:Attribute
name='date'
isKey=false
marriageDateEr:AttrMap
String:DataType
name='String'
s_1981_07_29:Value
content='1981/07/29'
Integer:DataType
name='Integer'
i_123:Value
content='123'

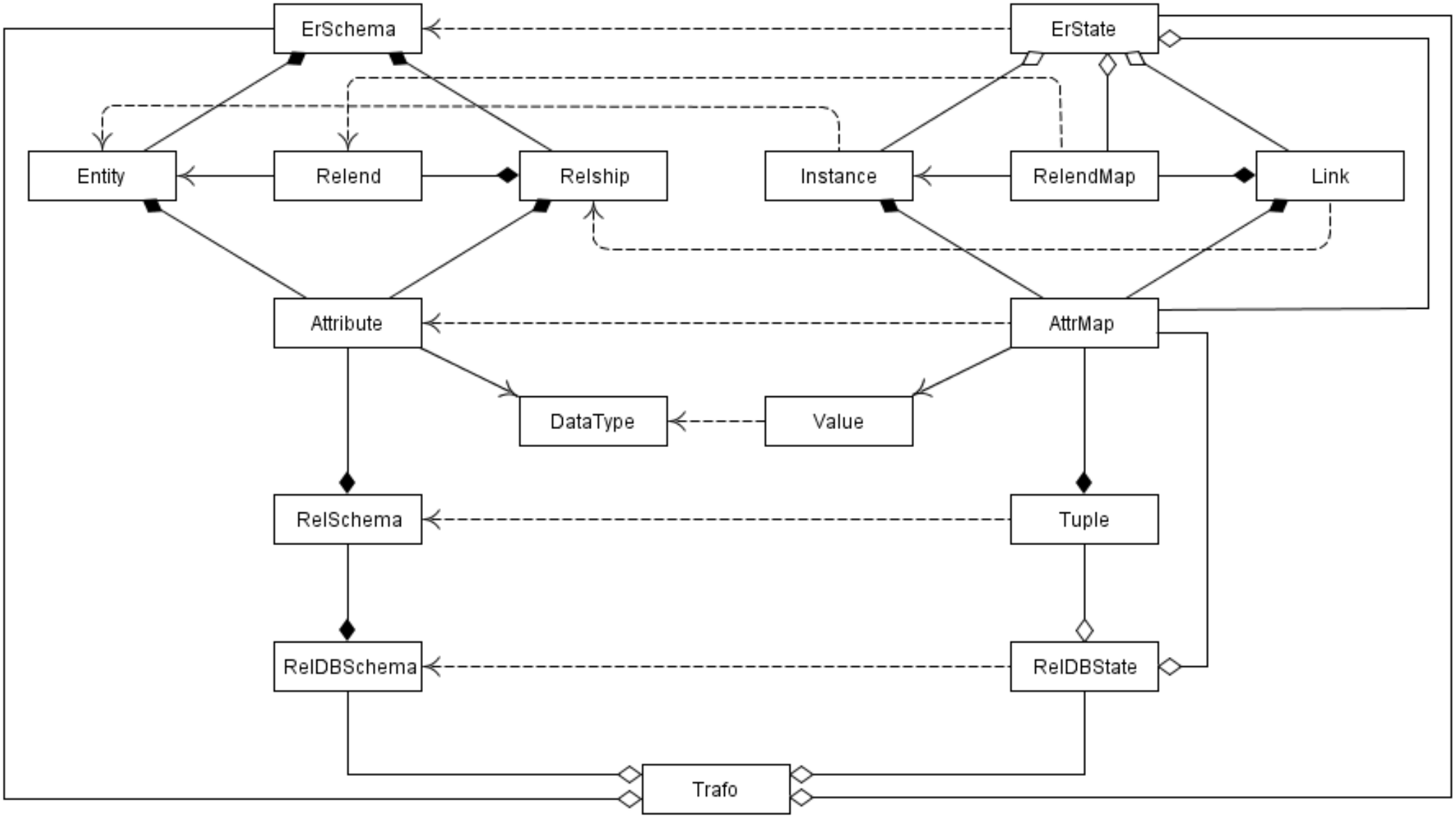
Person(passport:Integer,gender:String)

Marriage(wife_passport:Integer,husband_passport:Integer,date:String)

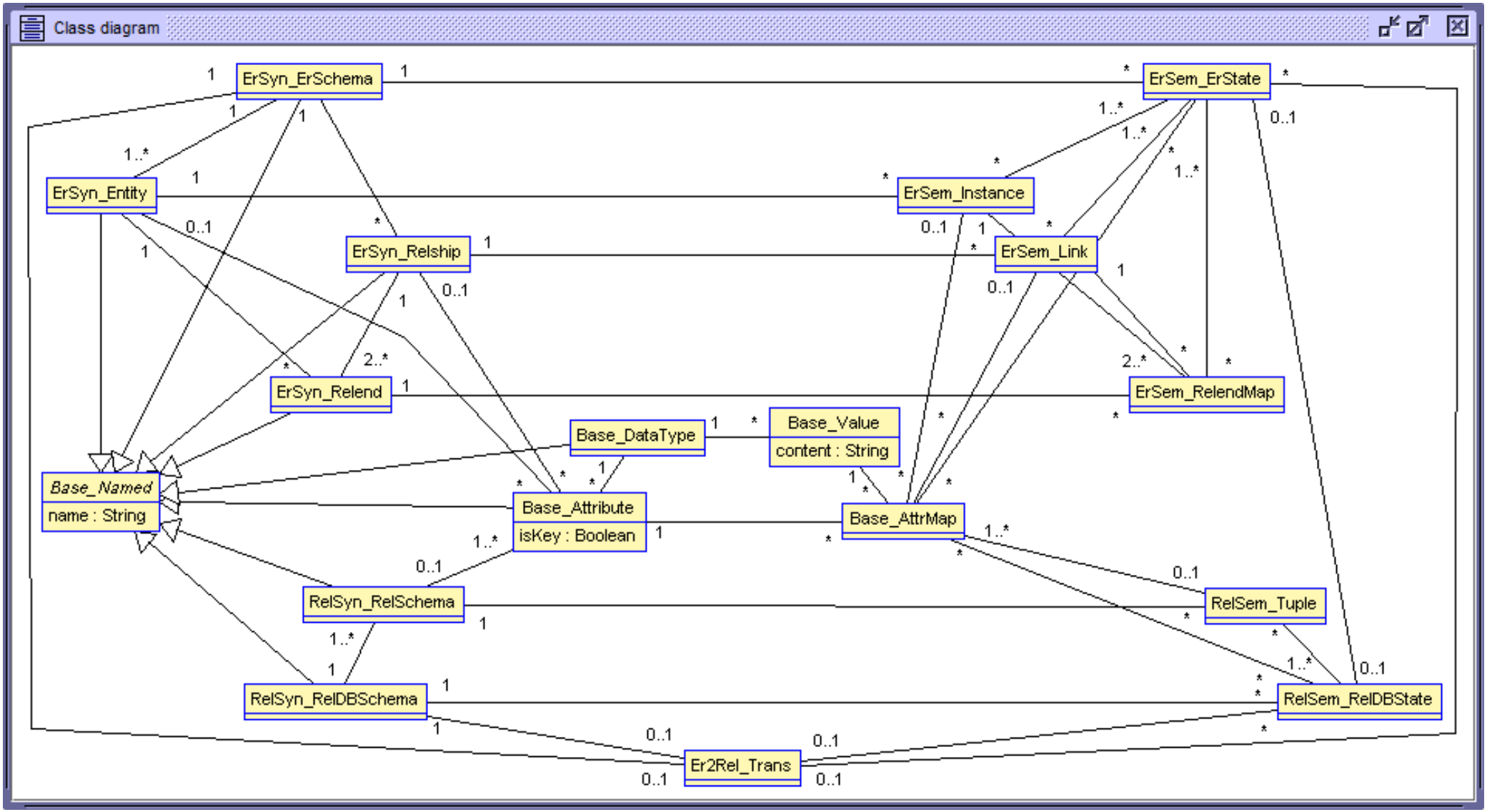


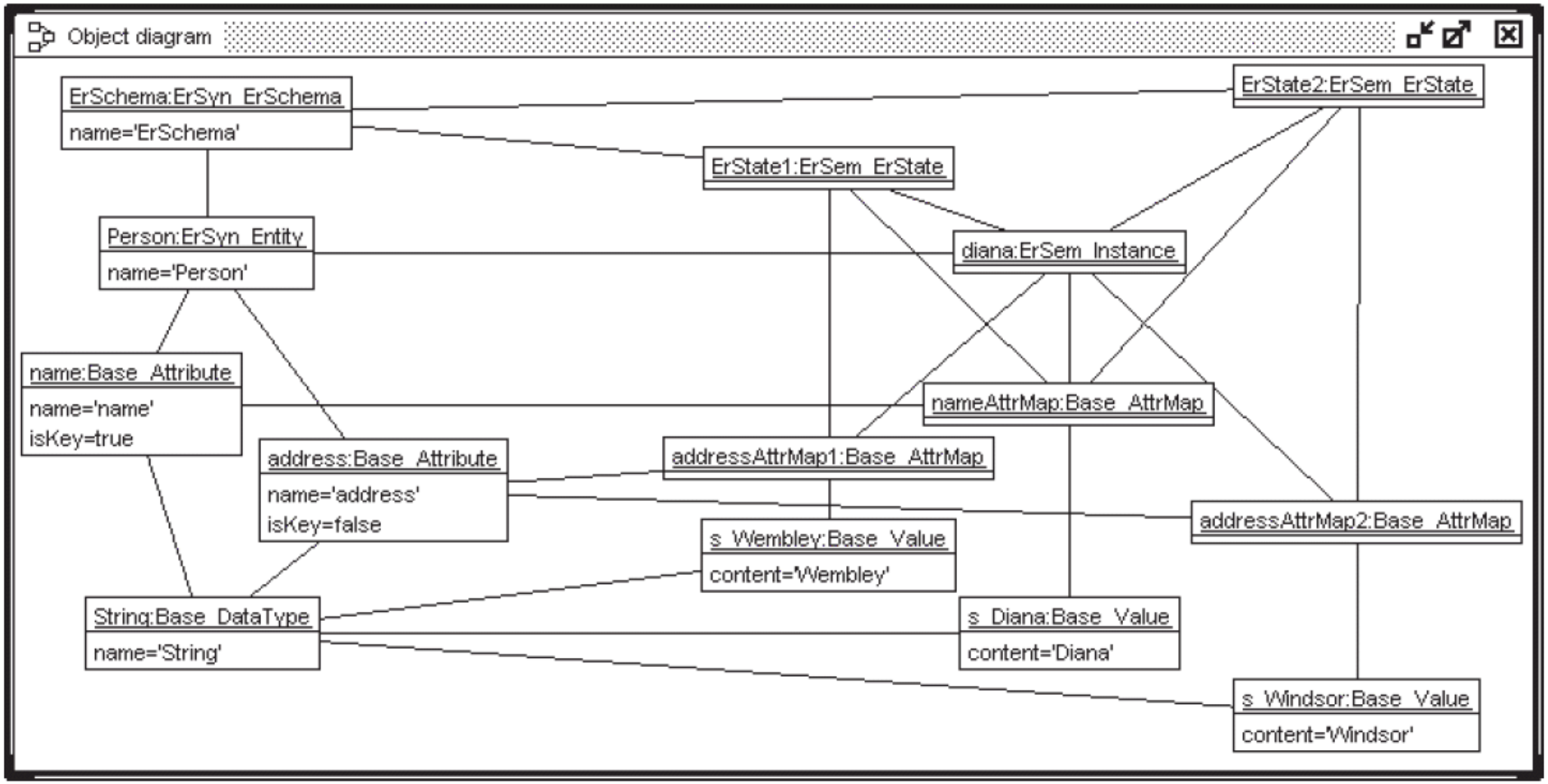

Marriage | wife_passport | husband_passport | date
123
456
'1981/07/29'
i_123:Value
content='123'
Integer:DataType
name='Integer'
i_456:Value
content='456'
String:DataType
name='String'
s_1981_07_29:Value
content='1981/07/29'
dateRel:Attribute
name='date'
isKey=false
marriageDateRel:AttrMap
husbandRel:Attribute
name='husband_passport'
isKey=true
marriageHusbandPassportRel:AttrMap
wifeRel:Attribute
name='wife_passport'
isKey=true
marriageWifePassportRel:AttrMap
MarriageRel:RelSchema
name='Marriage'
marriageRel:Tuple
PMRel:RelDBSchema
name='PMRel'
stateRel:RelDBState


Object diagram
PMEr:ErSyn_ErSchema
stateEr:ErSem_ErState
PMEr2PMRel:Er2Rel_Trans
wifeEr:ErSyn_Relend
marriageEr:ErSem_Link
MarriageEr:ErSyn_Relship
PersonEr:ErSyn_Entity
marriageWifeEr:ErSem_RelendMap
marriageHusbandEr:ErSem_RelendMap
husbandEr:ErSyn_Relend
dianaEr:ErSem_Instance
charlesEr:ErSem_Instance
dateEr:Base_Attribute
marriageDateEr:Base_AttrMap
passportEr:Base_Attribute
charlesPassportEr:Base_AttrMap
dianaPassportEr:Base_AttrMap
genderEr:Base_Attribute
charlesGenderEr:Base_AttrMap
dianaGenderEr:Base_AttrMap
s_female:Base_Value
String:Base_DataType
s_male:Base_Value
s_1981_07_29:Base_Value
i_123:Base_Value
Integer:Base_DataType
i_456:Base_Value
passportRel:Base_Attribute
dianaPassportRel:Base_AttrMap
charlesPassportRel:Base_AttrMap
genderRel:Base_Attribute
dianaGenderRel:Base_AttrMap
charlesGenderRel:Base_AttrMap
dianaRel:RelSem_Tuple
PersonRel:RelSyn_RelSchema
charlesRel:RelSem_Tuple
wifeRel:Base_Attribute
marriageWifePassportRel:Base_AttrMap
dateRel:Base_Attribute
marriageDateRel:Base_AttrMap
husbandRel:Base_Attribute
marriageHusbandPassportRel:Base_AttrMap
MarriageRel:RelSyn_RelSchema
marriageRel:RelSem_Tuple
PMRel:RelSyn_RelDBSchema
stateRel:RelSem_RelDBState



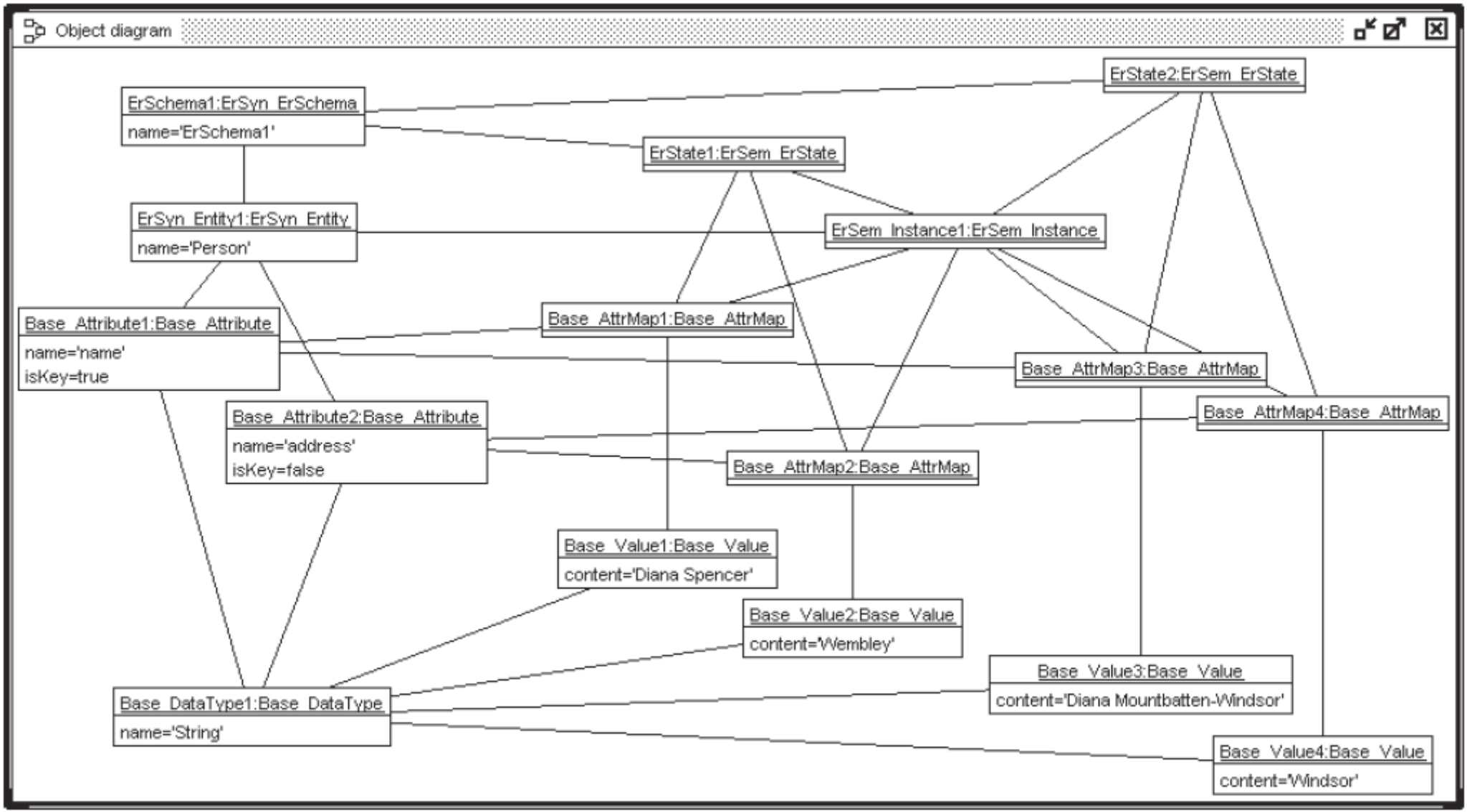
Used Association kinds: Composition, Aggregarion, Functional association with arrow, Functional association (from 'Semantics' part to 'Syntax' part) with dashed arrow


Class diagram
ErSyn_ErSchema
ErSyn_Entity
ErSyn_Relship
ErSyn_Relend
Base_Named
name : String
Base_DataType
Base_Value
content : String
Base_Attribute
isKey : Boolean
RelSyn_RelSchema
RelSyn_RelDBSchema
Er2Rel_Trans
ErSem_ErState
ErSem_Instance
ErSem_Link
ErSem_RelendMap
Base_AttrMap
RelSem_Tuple
RelSem_RelDBState



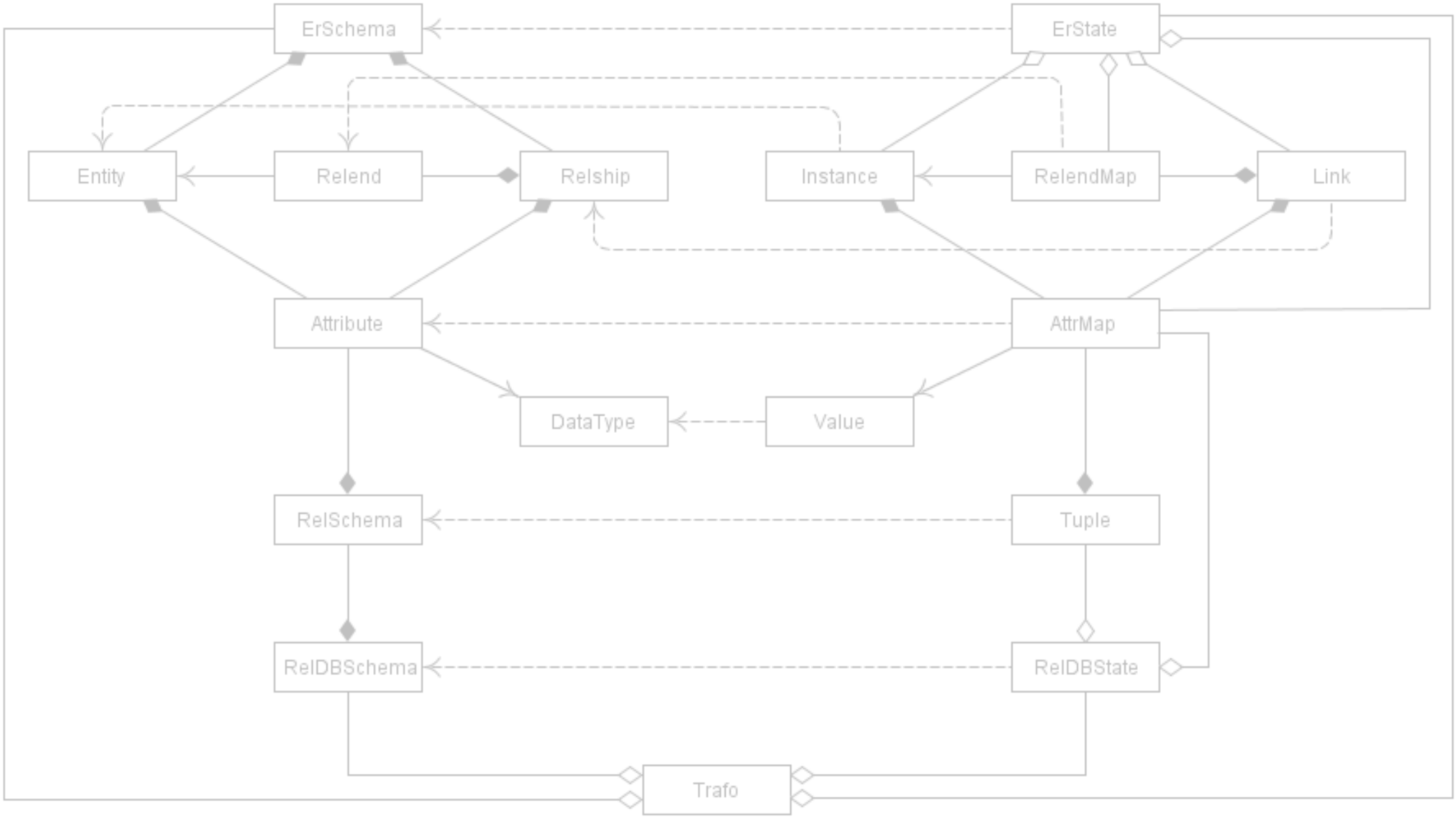
Object Diagram for *Diana moves from Wembley to Windsor*

Instance object occurs in 2 ErState objects,
AttrMap objects in 1 or 2 ErState objects

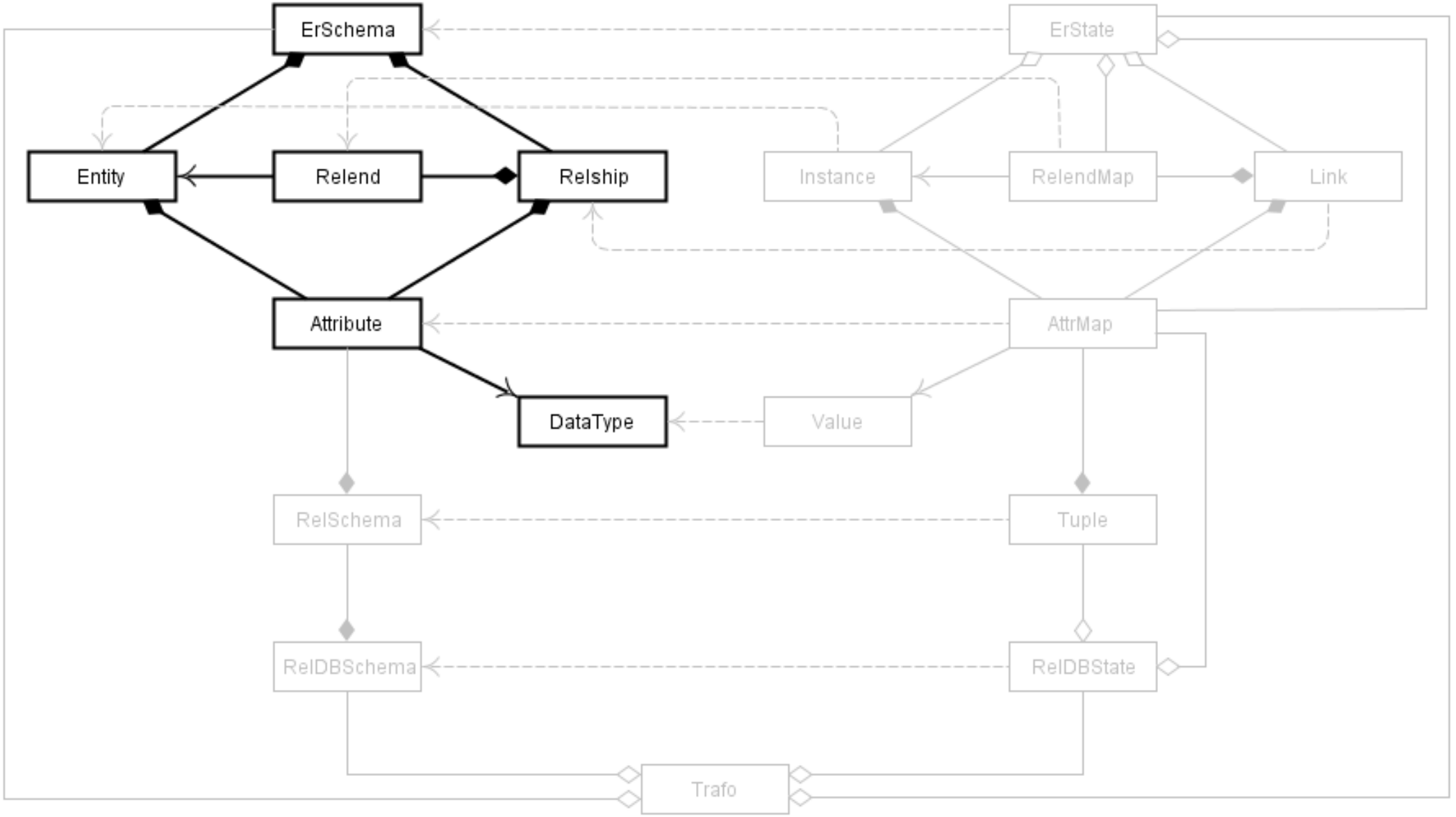


Object Diagram for *Diana moves and marries*

2 ErState objects only have the Instance object in common, rest is disjoint


ErSchema
ErState
Entity
Relend
Relship
Instance
RelendMap
Link
Attribute
AttrMap
DataType
Value
RelSchema
Tuple
RelDBSchema
RelDBState
Trafo

ER Syntax


ErSchema
ErState
Entity
Relend
Relship
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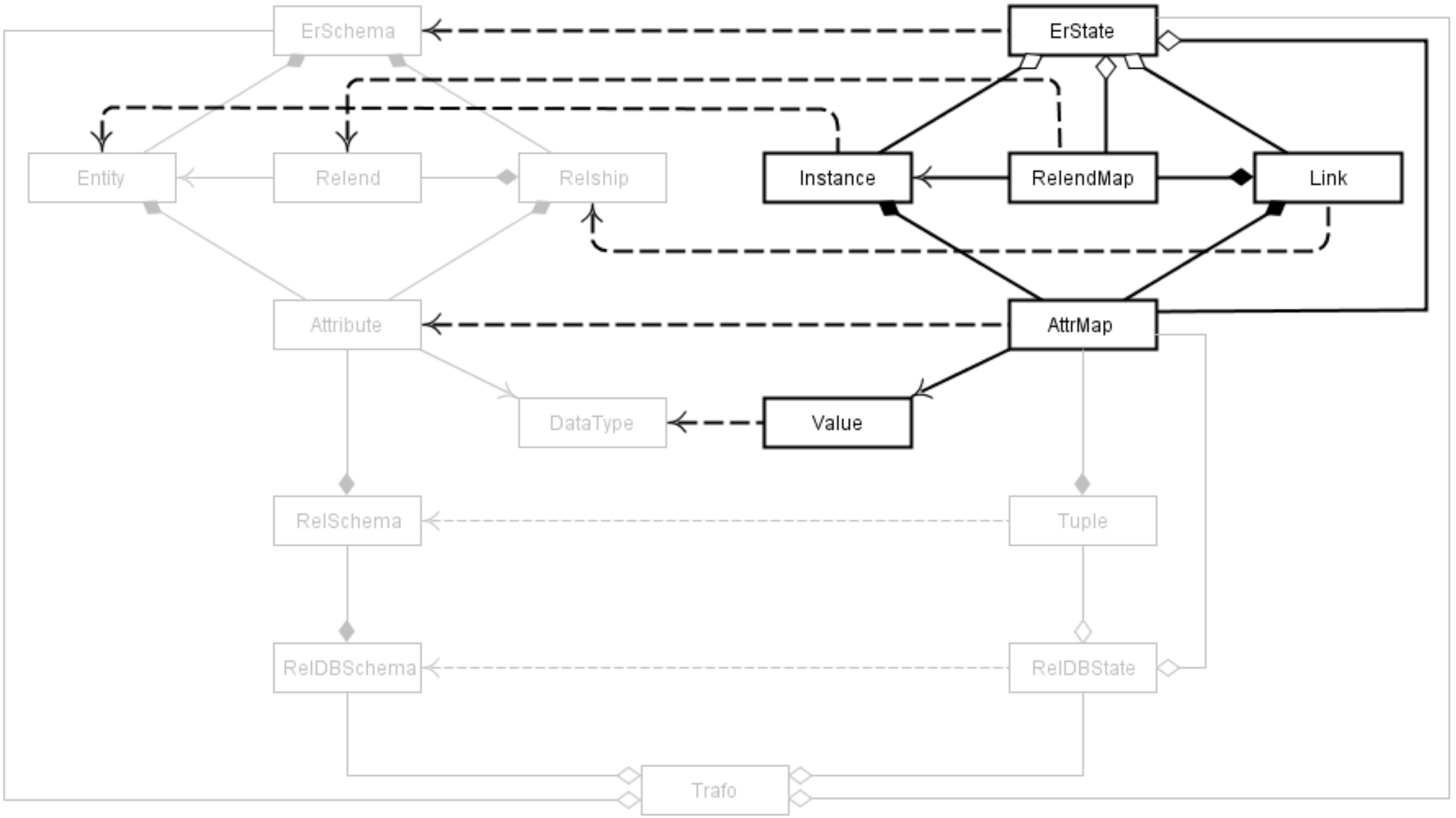
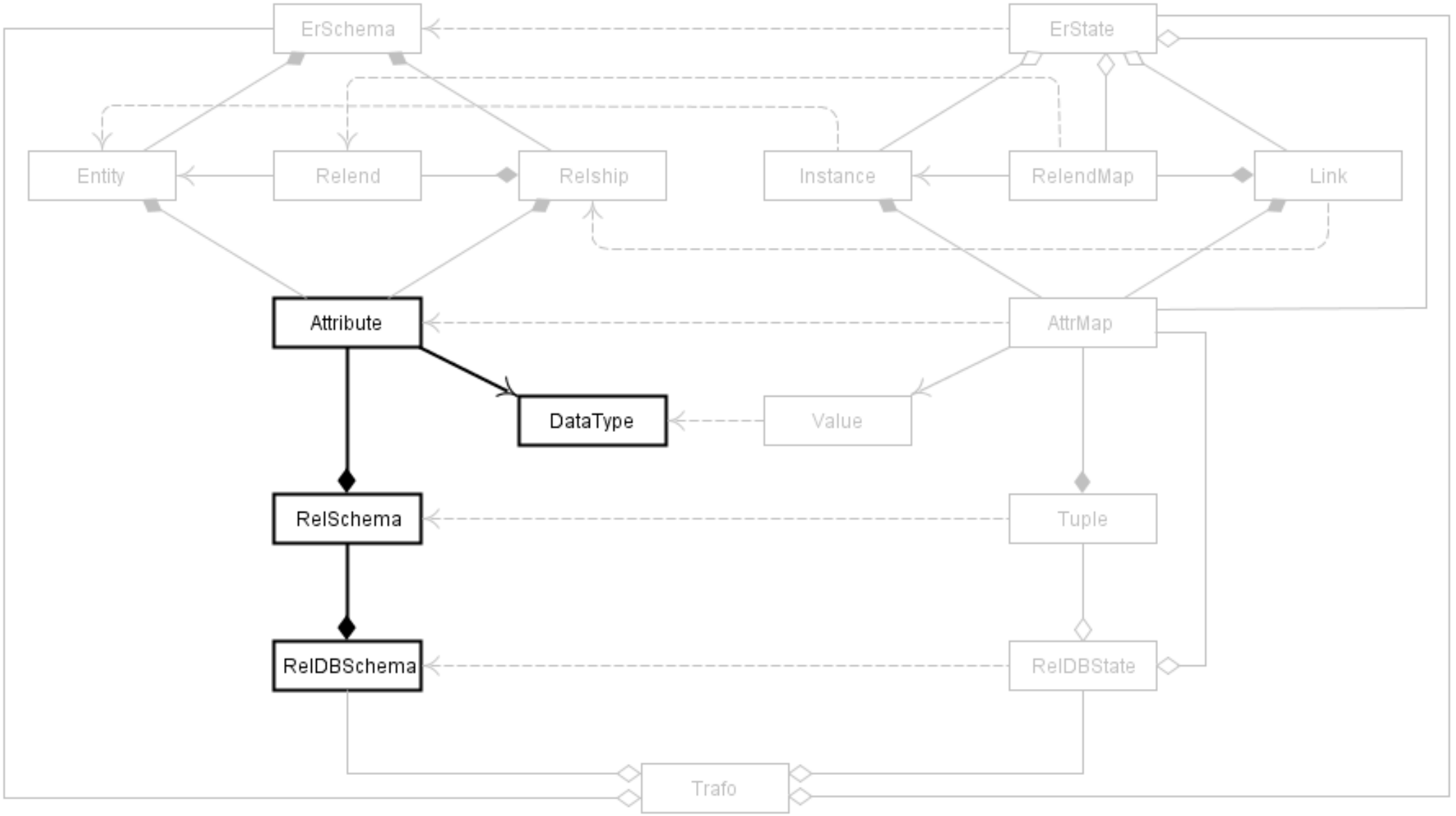
Link
Attribute
AttrMap
DataType
Value
RelSchema
Tuple
RelDBSchema
RelDBState
Trafo

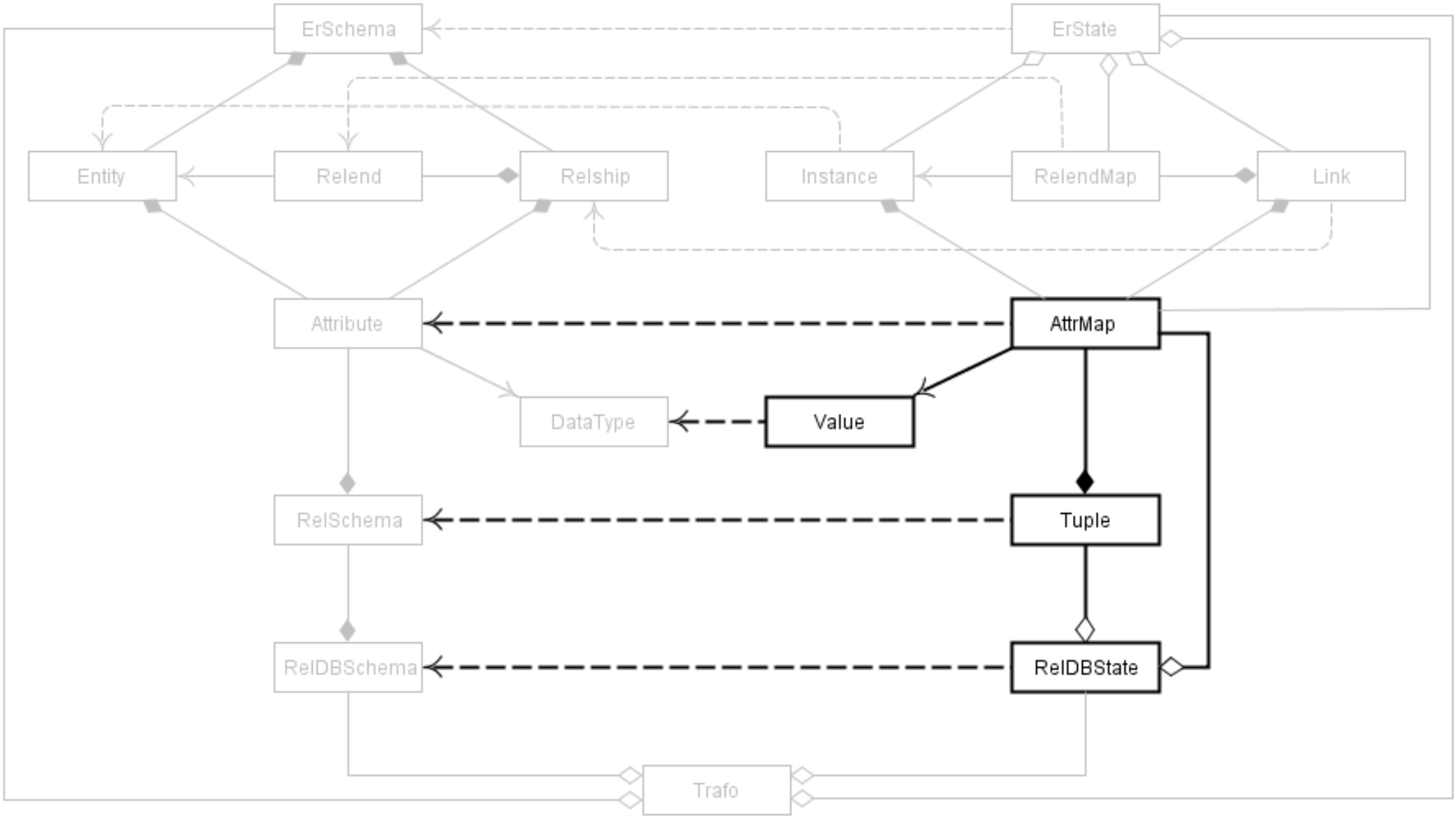
ER Semantics



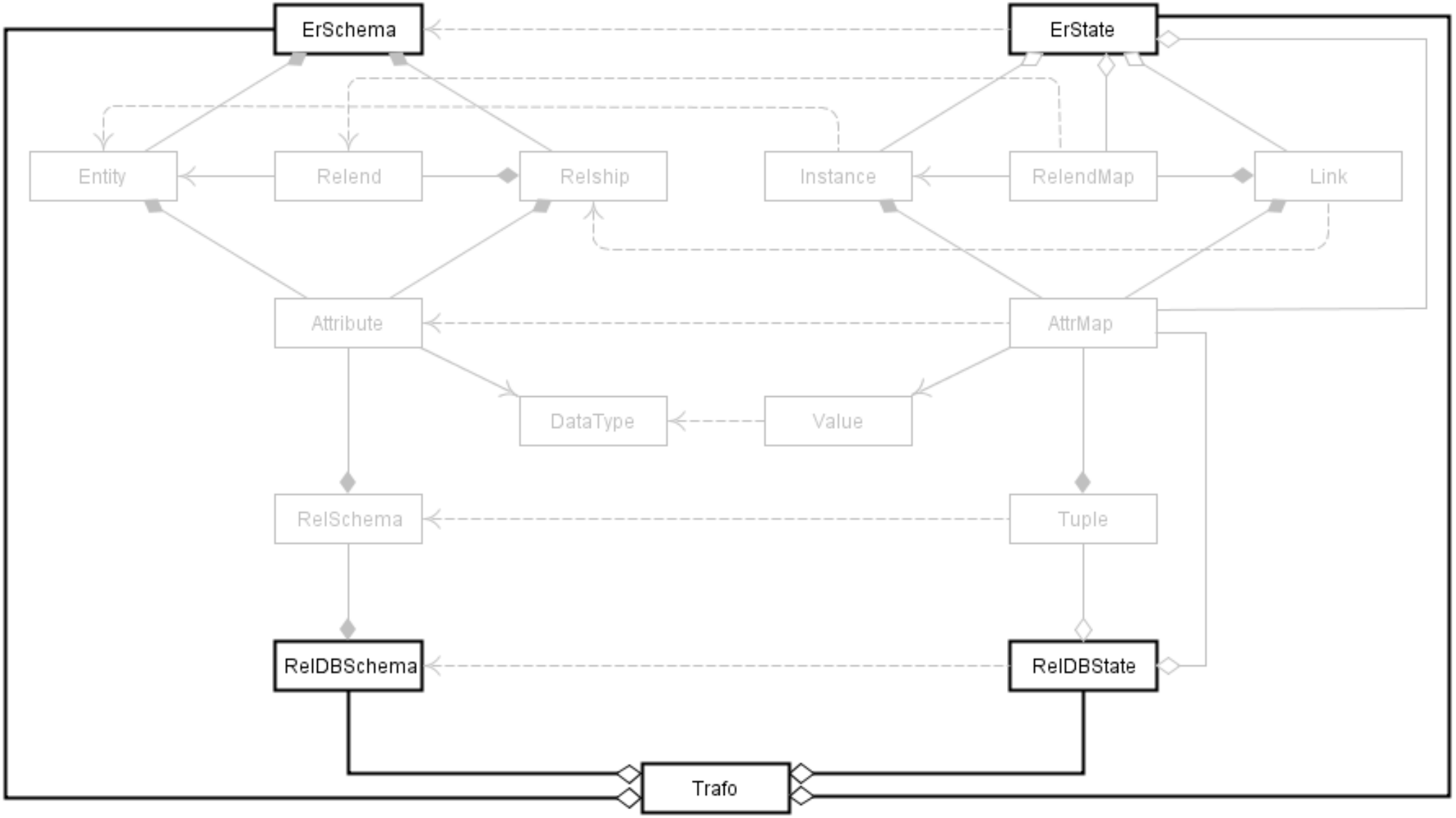
Relational Syntax



Relational Semantics



Transformation



CONSTRAINTS (EXCERPTS)

BASE

```
-- Naming restriction: Different DataTypes have different names

context self:Base_DataType inv uniqueDataTypeNames:
  Base_DataType.allInstances->
    forAll(self2 | self.name=self2.name implies self=self2)
```

CONSTRAINTS (EXCERPTS)

ER SYNTAX

```
-- Different ErSchemas have different names

context self:ErSyn_ErSchema inv uniqueErSchemaNames:
  ErSyn_ErSchema.allInstances->
    forAll(self2 | self.name=self2.name implies self=self2)

-- Within one ErSchema, different Entities have different names

context self:ErSyn_ErSchema inv uniqueEntityNamesWithinErSchema:
  self.entity->forAll(e1,e2 | e1.name=e2.name implies e1=e2)

-- The set of key attributes of an Entity is not empty

context self:ErSyn_Entity inv entityKeyNotEmpty:
  self.key()->notEmpty

-- The set of key attributes of a Relship is empty

context self:ErSyn_Relship inv relshipKeyEmpty:
  self.attribute->select(a | a.isKey)->isEmpty
```

CONSTRAINTS (EXCERPTS)

ER SEMANTICS

```
-- Two different Instances of one Entity can be distinguished in every
-- ErState where both Instances occur by a key Attribute of the Entity

context self:ErSem_Instance inv keyMapUnique:
  ErSem_Instance.allInstances->forAll(self2 |
    self<>self2 and self.entity=self2.entity
    implies
    self.erState->intersection(self2.erState)->forAll(s |
      self.entity.key()->exists(ka |
        self.applyAttr(s,ka)<>self2.applyAttr(s,ka))))
```

CONSTRAINTS (EXCERPTS)

REL SYNTAX

```
-- The set of key Attributes of a RelSchema is not empty

context self:RelSyn_RelSchema inv relSchemaKeyNotEmpty:
  self.key()->notEmpty
```

CONSTRAINTS (EXCERPTS)

REL SEMANTICS

```
-- Two different Tuples of one RelSchema can be distinguished in every
-- RelDBState where both Tuples occur by a key Attribute of the
-- RelSchema

context self:RelSem_Tuple inv keyMapUnique:
  RelSem_Tuple.allInstances->forAll(self2 |
    self<>self2 and self.relSchema=self2.relSchema
    implies
    self.relDBState->intersection(self2.relDBState)->forAll(s |
      self.relSchema.key()->exists(ka |
        self.applyAttr(s,ka)<>self2.applyAttr(s,ka))))
```

CONSTRAINTS (EXCERPTS)

TRANSFORMATION

```
-- For every Relship in the ErSchema there is a RelSchema having the
-- same name, Relends representing the arms of the relationship, and
-- Attributes with the same properties, i.e., name, DataType, and key
-- property

context self:Er2Rel_Trans inv forRelshipExistsOneRelSchema:
  self.erSchema.relship->forAll(rs |
    self.relDBSchema.relSchema->one(rl |
      rs.name=rl.name and
      rs.relend->forAll(re | re.entity.key()->forAll(rek |
        rl.attribute->one(ra |
          re.name.concat('_').concat(rek.name)=ra.name and
          rek.dataType=ra.dataType and ra.isKey))) and
      rs.attribute->forAll(rsa |
        rl.attribute->one(ra |
          rsa.name=ra.name and rsa.dataType=ra.dataType and
          ra.isKey=false))))
```

Thanks for your attention!