Ontologies

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Recent Advances in Programming Technologies

The Paradigms

Object orientation

decomposition of domain into interconnected objects

Component orientation

interface separation and instance plugability

Service orientation

descriptions, find and bind

LAN services

Web services

Cell phone/device based service orientation

Event orientation

asynchronous, push and pull styles

The Span of Applications

- Initial applications
  - desktop based
    - local database, local transactions, accounting, billing etc
  - network based
    - centralized database, transactions, networked access
  - web based, enterprise driven
    - large scale information and knowledge sharing
      - plain content
      - semantic content

Range of Applications

Academia

Health

Governance

Banking

Finance

Libraries

Law

Transportation

Logistics

Hotels and Tourism

Travel

Social networking

Event management

Industrial processes

Enterprise functioning

Scientific computing

Software Engineering

Linguistics and

What's common among them

They have commonly occurring entities in their respective domains

The entities are related to each other in some ways

Entities have attributes

There are processes involving state changes

Information finally gets represented and then manipulated through software applications

One should be able to make sense out of information, develop applications whenever needed, and share information among various

Consider the following problem

- Is Prof. RKJ available for meeting on Thursday at 9 AM on Nov 15th?
  - How would your program solve this problem automatically?
    - Where does Prof. RKJ work?
    - Is Nov. 15 holiday for the institute?
    - What are the published slots by the institute?
    - Which are the slots scheduled around 9 am on that day?
    - Is Prof. RKJ engaged in any one of those slots?
  - Manually, you can do it by browsing through the pages
    - information may be available
    - but it may not be in a directly programable format

Consider another problem

Is a room close to PSG available in Coimbatore in range Rs. 1500-5000 per day on Nov 7th?

- Which are the hotels in Coimbatore
- Their rates
- Room availability on a particular day
- The location of PSG
- The location of the hotels
- What does it mean by the term 'close to'? How close?

Another problem

Is there a hollywood movie containing a song by the indian artist Kishore Kumar?

- list of world movies
- from among them which are hollywood movies?
- list of tracks appearing them
- the singers of the tracks

Some more problems

- What are the side effects of Amoxicillin and are there treatments for those?
  - doctors may want to obtain this information
- Is there an outbreak of Dengue in a particular area?
- What percentage of population in Coimbatore represents uneducated girls?
- What is the procedure to apply for a visa?
- What structure does Raga Kalyani follow?

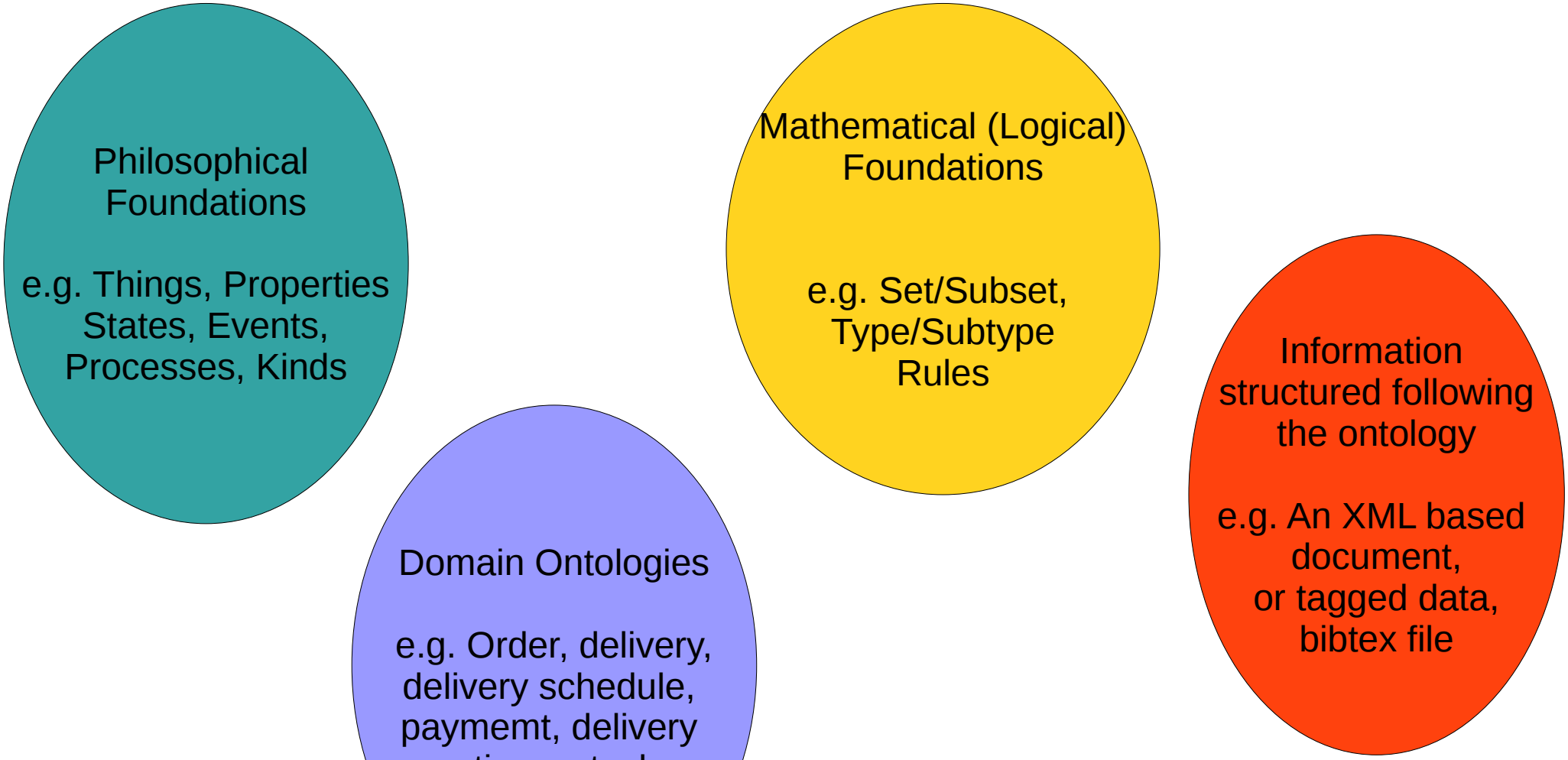
What is the composition of a given molecule?

The problem of Knowledge and Information Representation

- Software engineers develop applications
- Domain experts use them
- Domain experts handle information
- Software engineers provide ways to create, store, find, manipulate, backup and version information.
- Domain experts know the rules of their domain
- Software engineers create 'soft knowledge' that represents these rules.

The knowledge is then applied to the information

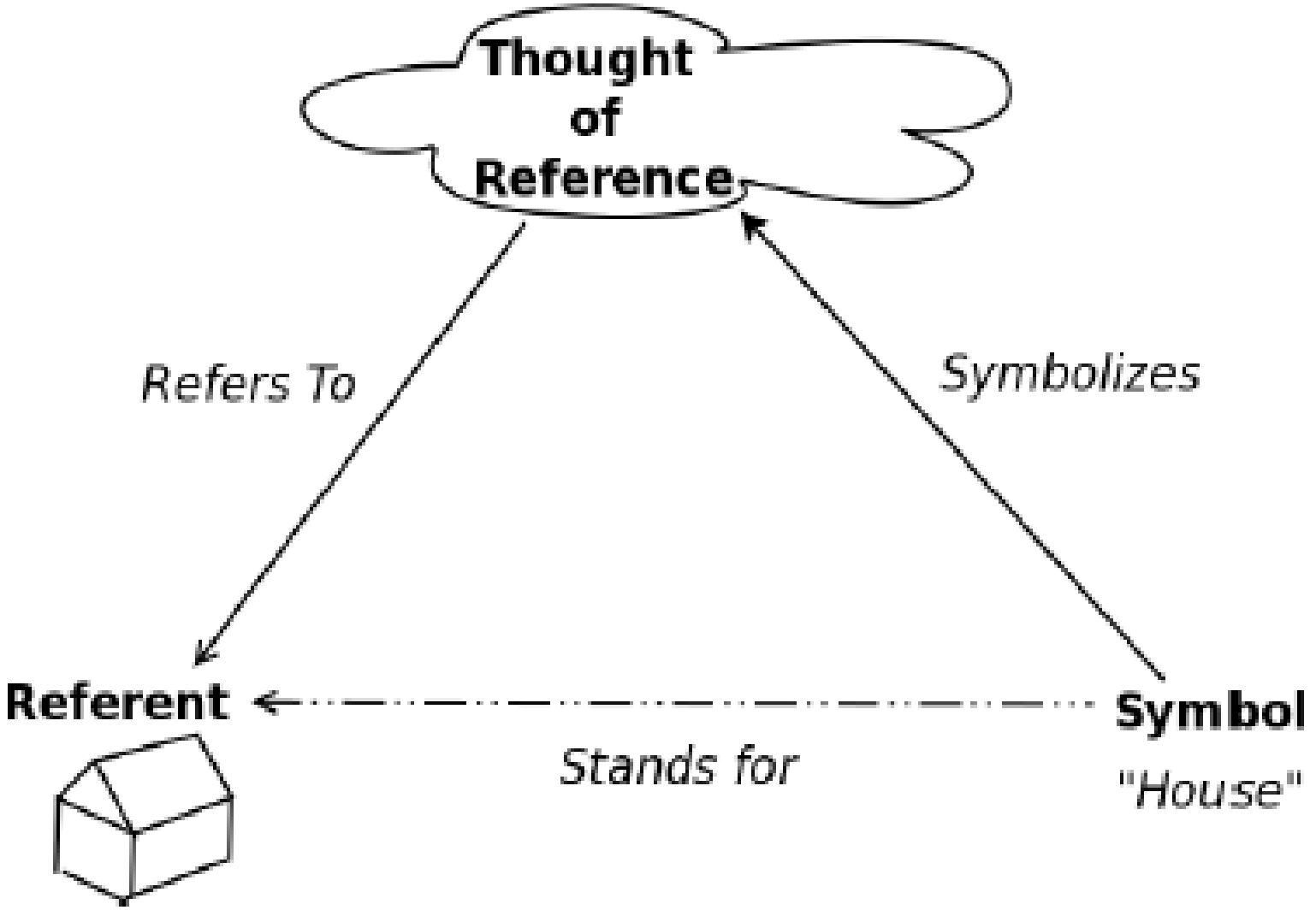
The branch of Ontology



Benefits from ontologies

- Domain Conceptualization in terms of precise semantic Information Systems Representation creating the actual instances and relationships
- Software Applications Building around ontological representation
- Information Sharing and Exchange in an interoperable way
- Knowledge Sharing and Exchange for high level (meta) abstraction sharing – 'share once and use again over instances'
- New Applications benefiting from Knowledge – since knowledge is shared, one is not stuck with proprietary formats. Benefits of interoperability and knowledge sharing makes the system open to new applications

Meaning Triangle



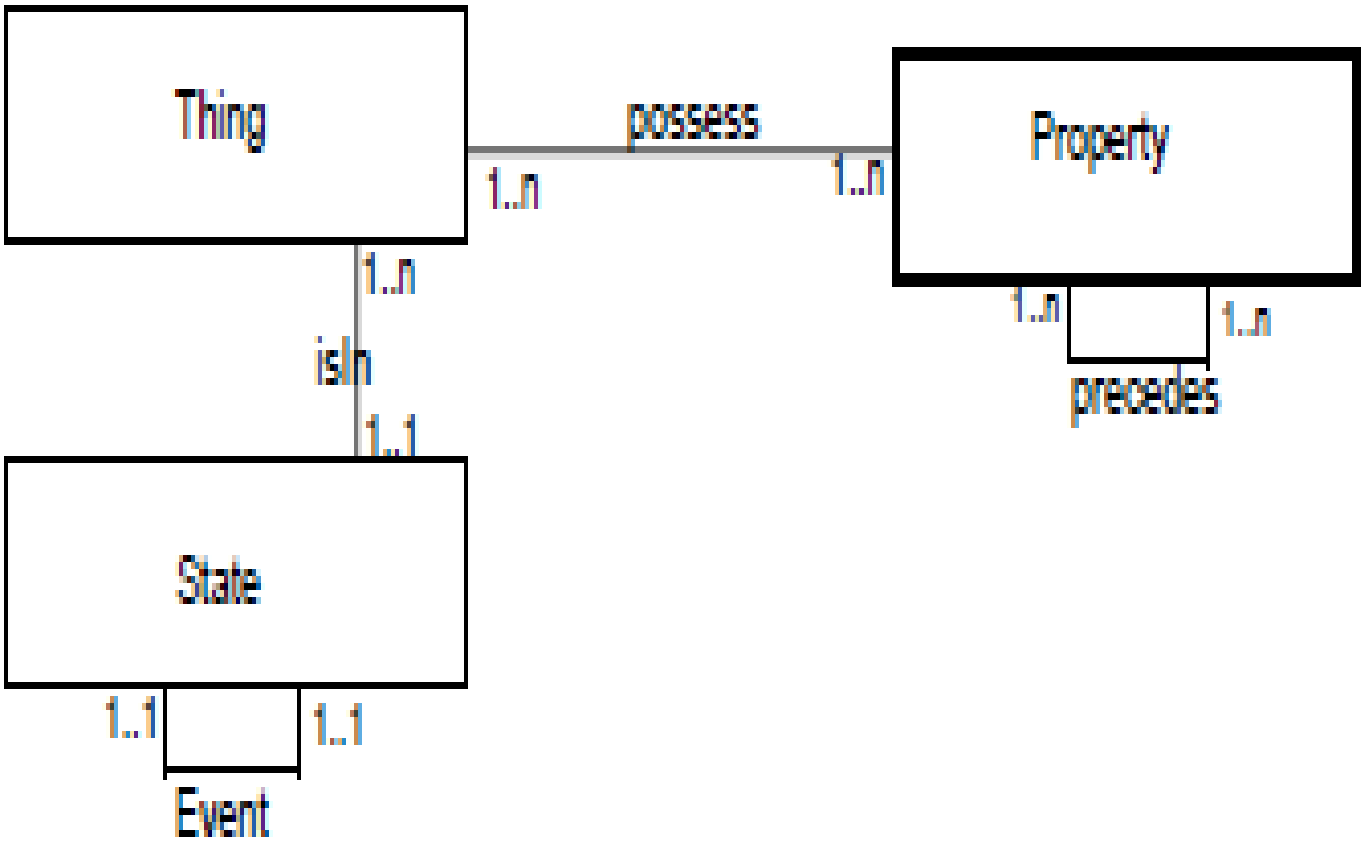
Bungean Ontology

- Bunge's Ontology (1977) is considered to be a general systems theory
- Wand and Weber adapted it to Software Systems later (1993, 1995)
- The postulates in Bungean ontology are widely accepted statements about real world phenomena.
- They are every day experiences, facts and observations.

Intrinsic Ontological Categories

Most significant and fundamental categories

- Thing
  - They have identity, existence in reality, substantial, they possess properties e.g. Book
- Property
  - They characterize objects in reality, objects have properties, they donot have independent existence apart from the objects to which they are associated e.g. White
- State
  - Everything is in some or the other state at a given time, captures changing nature of things, property, e.g. available mapped to a value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Event

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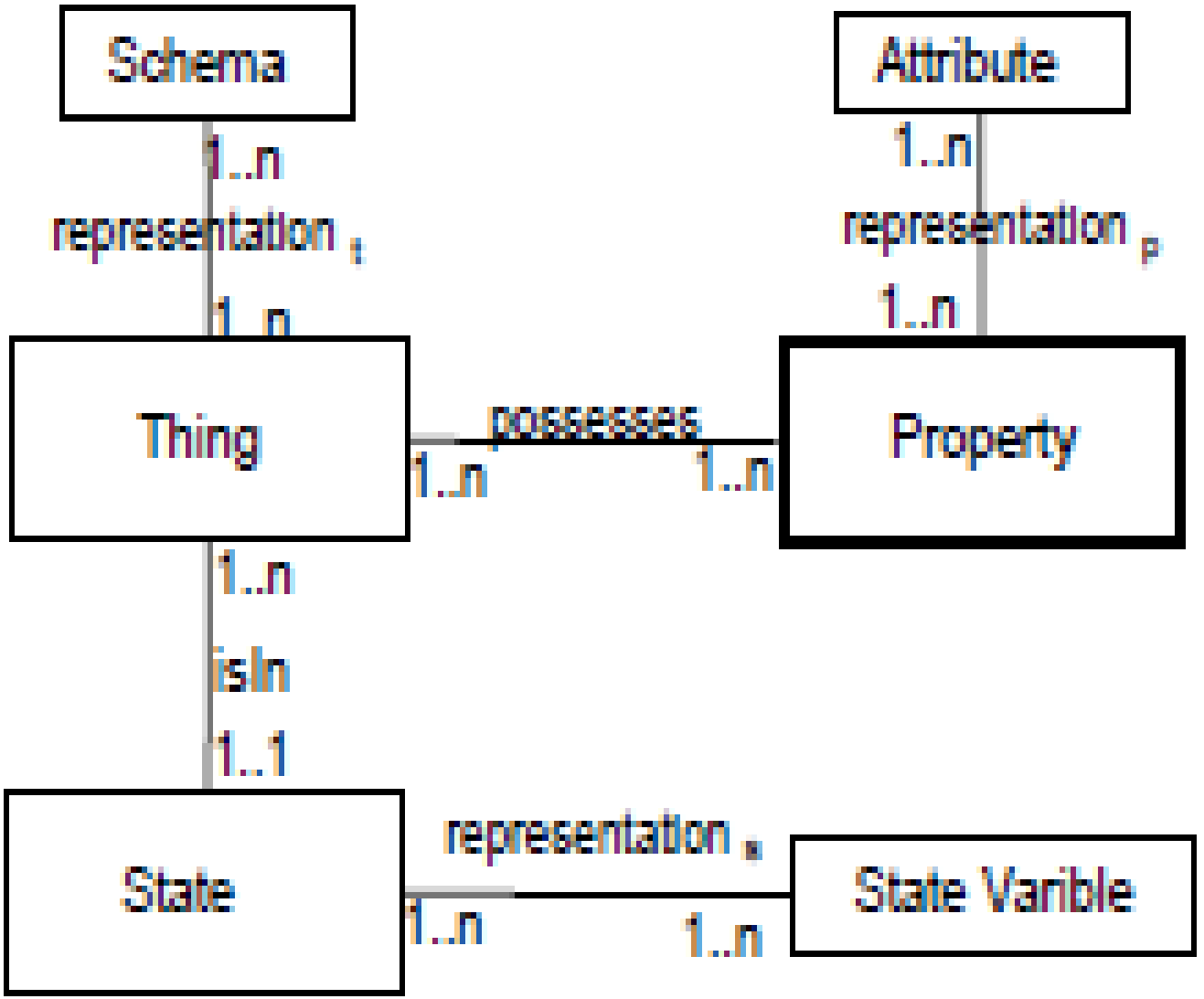
Representational Categories

- They provide a representation of an intrinsic category
- Schema
  - Representation of a Thing
    - e.g. Book {class no., title, authors}
- Attribute
  - Representation of a Property
    - e,g, Address {house no,, street no, pincode}
- State Variable
  - Representation of a State
    - e.g. Boolean book_status

Examples

Sr. No.	Thing	Properties	States	Schema
1.	Book as a Library Item	Title, Author, Price, ISBN, Publisher, Classification No.	onTheRack, issued, claimed, written-off, missing,	*Book*(Class. No, Title, Author), *Book*(ISBN, Title, Publisher)
2.	University Student	Reg. No. Names, Address, Date of Birth, Course Registered, Degree Awarded,	registered, graduated, migrated	*Student*(Reg.No, Name, Address) *Student*(Reg. No., Course Registered, Degree awarded)
3.	Cricket Player	Name, Runs Scored, Centuries Scored, Wickets Taken, 5-wicket Hauls,	playing, injured, rested, retired	*Player*(Name, Runs Scored, Centuries scored) *Player*(Name, Wickets Taken, 5-wicket haul)
4.	Network Printer	Name, Make, Location	on, off, busy, idle	*Printer*(Name, Make, Location)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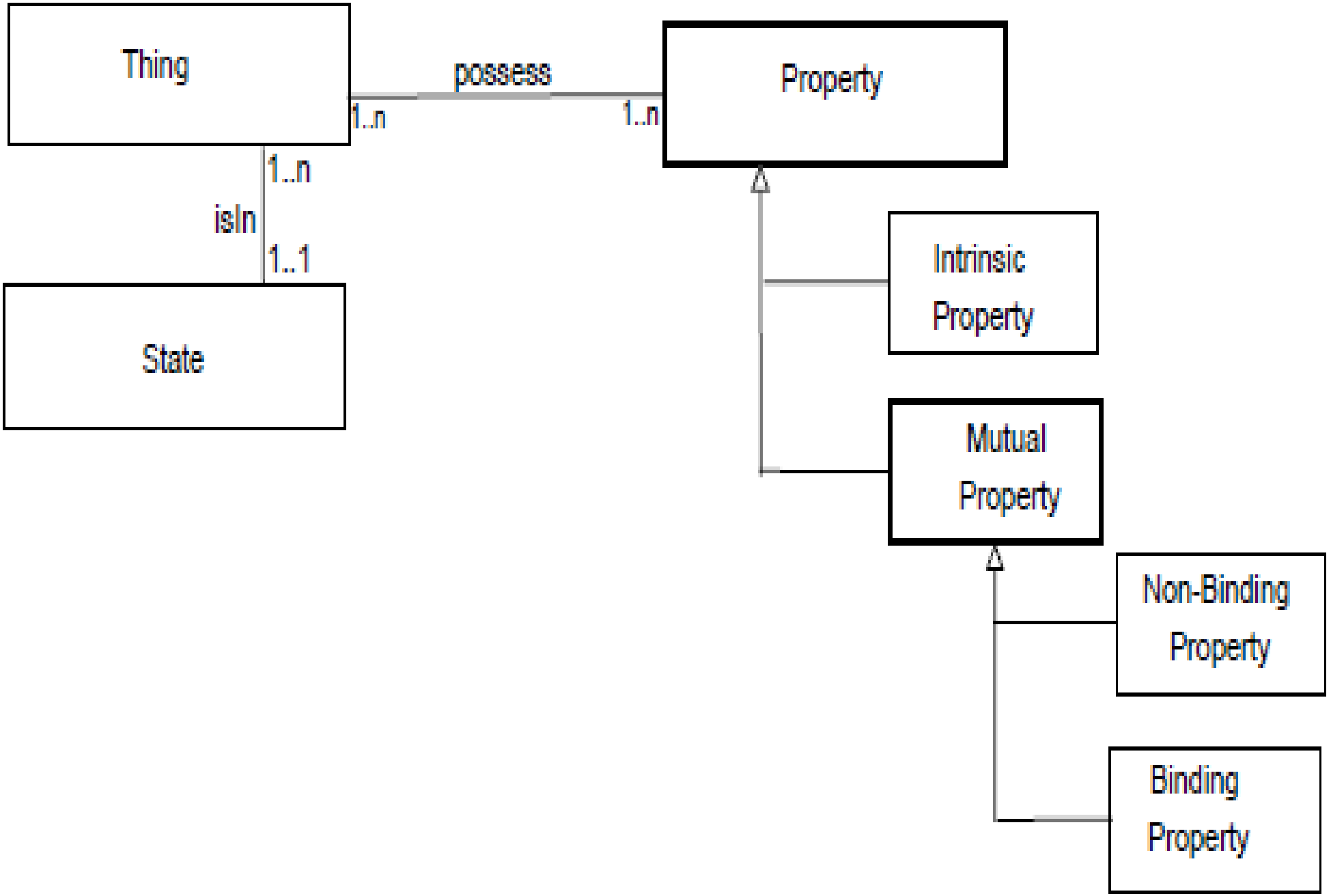
Properties

- Intrinsic properties
  - Associated with a single object e.g. Age and height of a person – the same person
- Mutual property
  - Relational properties between to objects
  - e.g. Worksfor between a company and an employee
    - Binding – sales relationship
    - Non binding – younger than relation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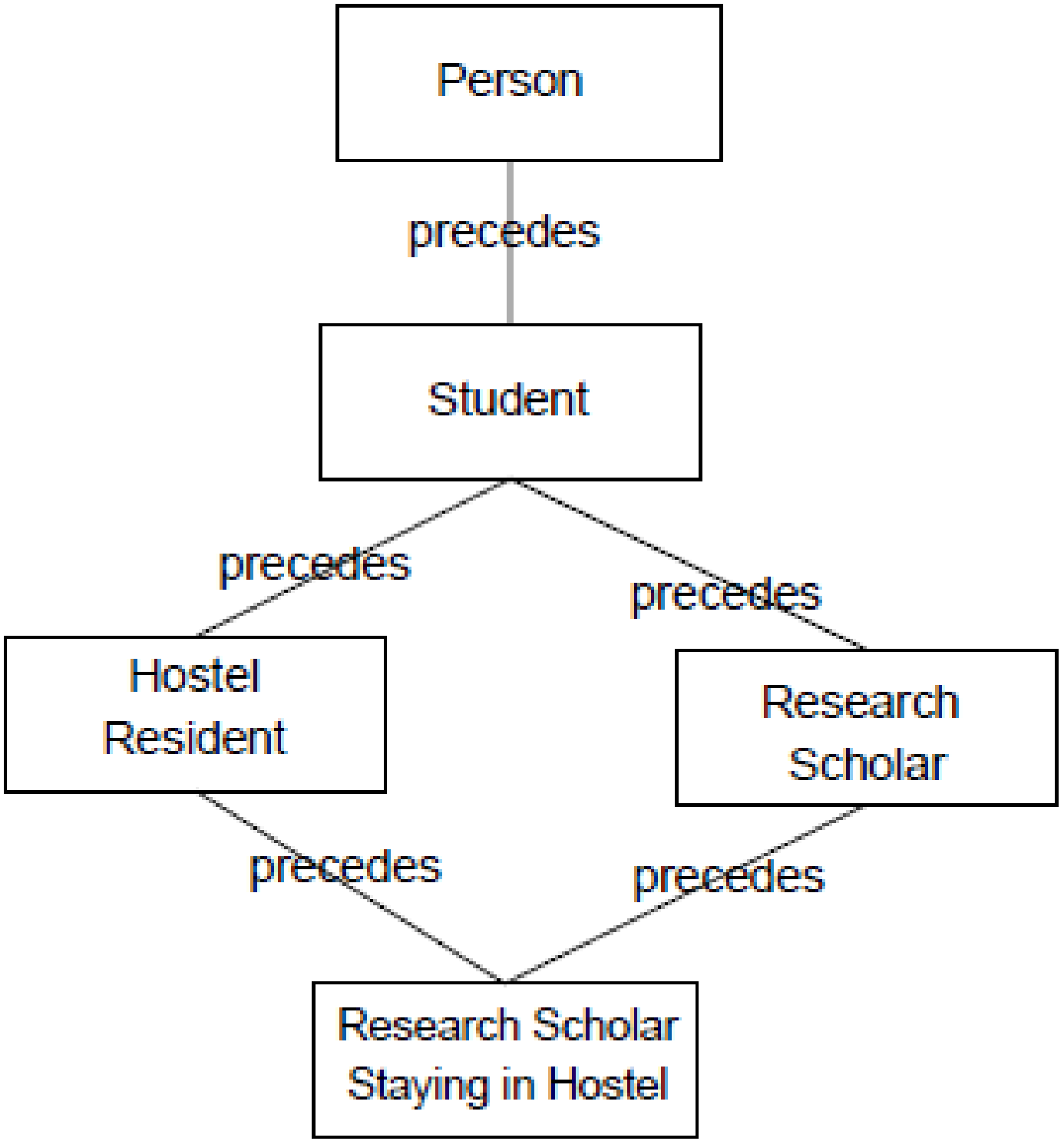
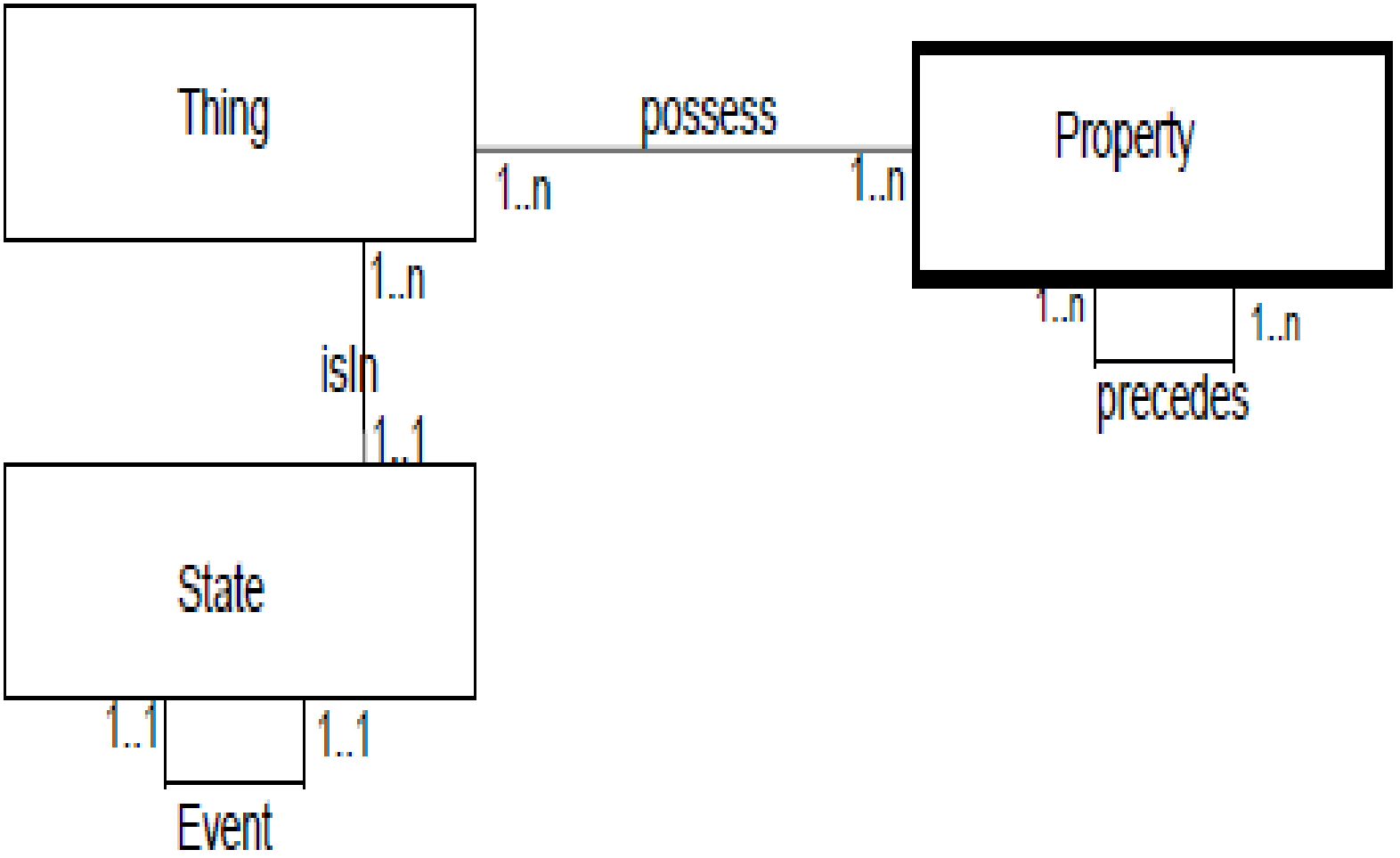
Property
Mutual
Property
Non-Binding
Property
Binding
Property

Primitive Relational Categories

- Relate two intrinsic categories
- Possesses : between Thing and Property
  - Book as a thing possesses properties author, title
- Precedes : between Property and Property
  - Being a person precedes being a student
- Event : between two states of a thing, change from state s1 to state s2


Person
precedes
Student
precedes
precedes
Hostel
Resident
Research
Scholar
precedes
precedes
Research Scholar
Staying in Hostel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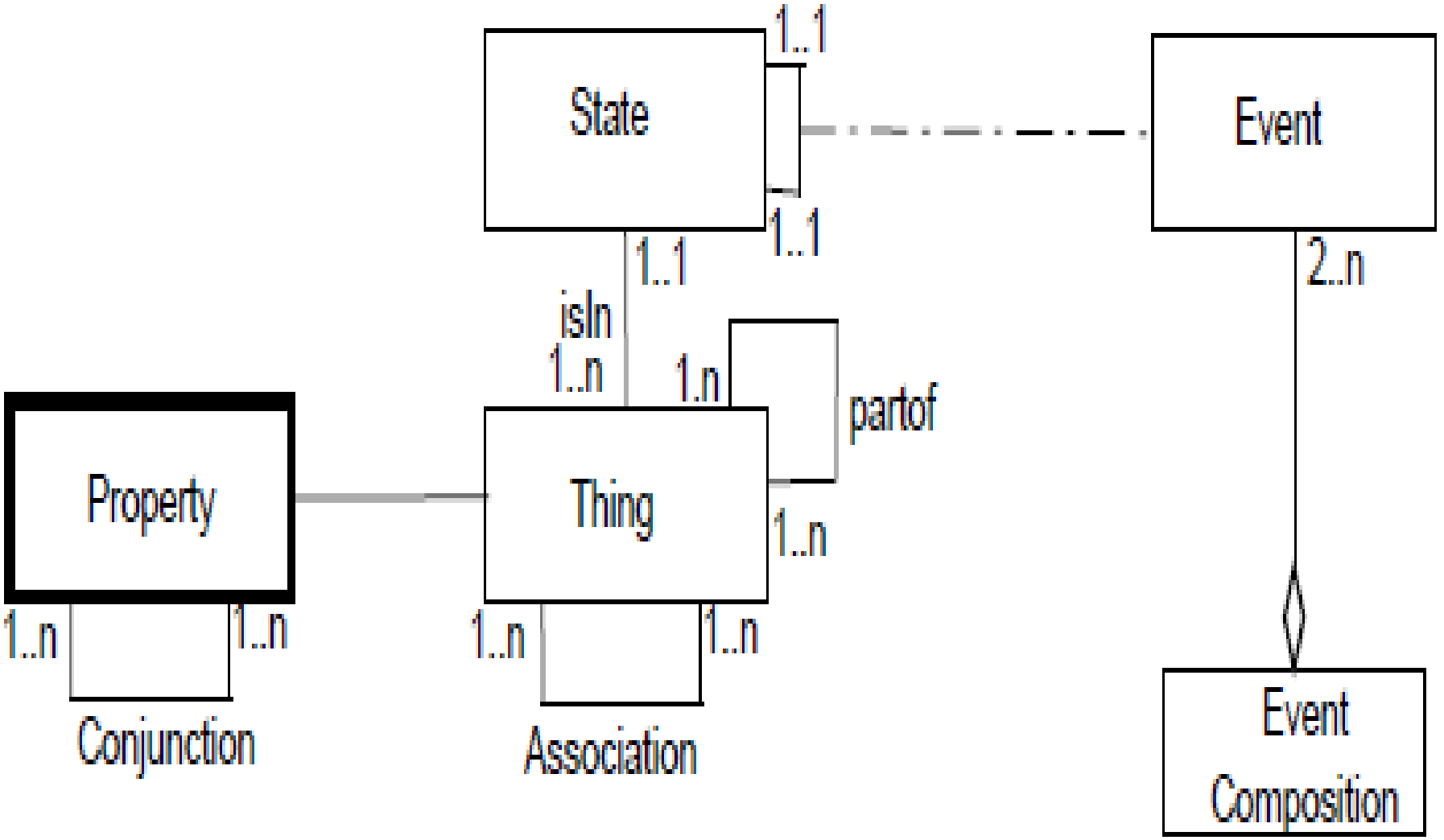
Composition Categories

- Complex category from simple categories
- Conjunction
  - Complex properties from simple properties
- Association
  - Complex things from simple things
- Event composition (process) is a complex event
- Part of – a complex thing


State
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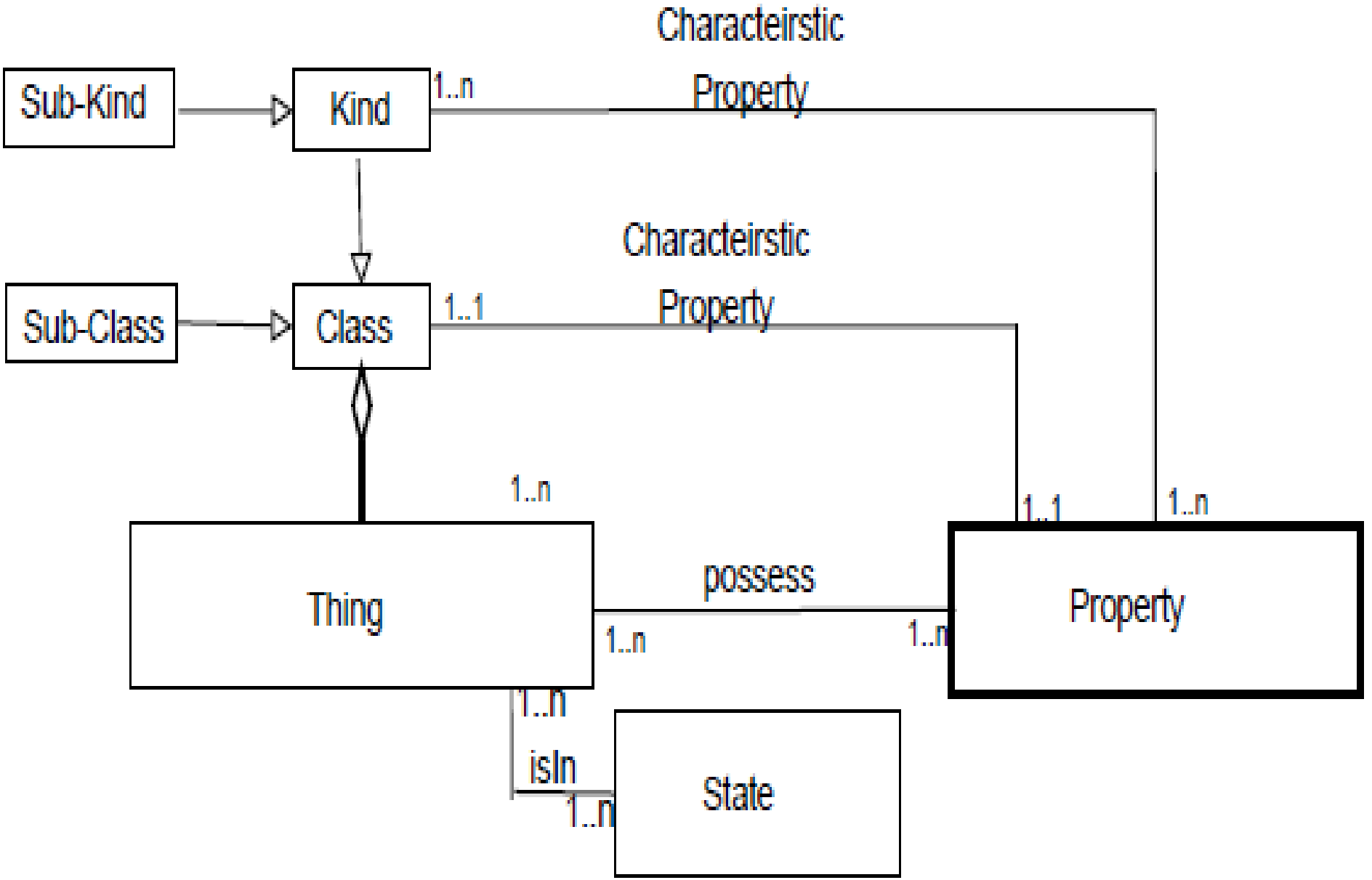
1..n
Conjunction
Association
Event
Composition

Collection Categories

- Class
  - Groups similar things together
  - They have a characteristic property
  - CSE students are students enrolled in cse
- Kind
  - Organizes a group of things by a set of properties
  - Child labor – group of children who have worksfor and who are underaged
- Other categories such as History and State Space
-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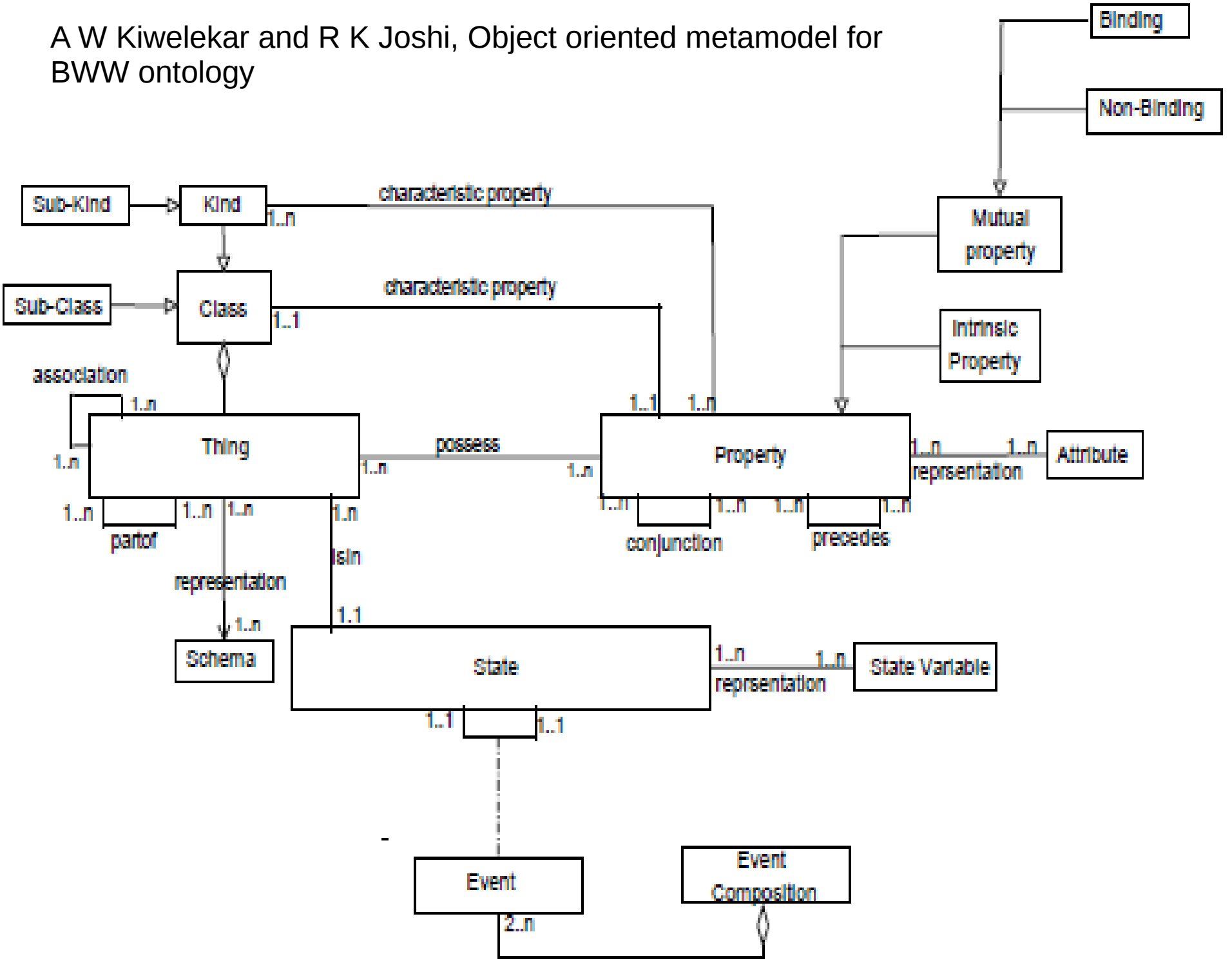
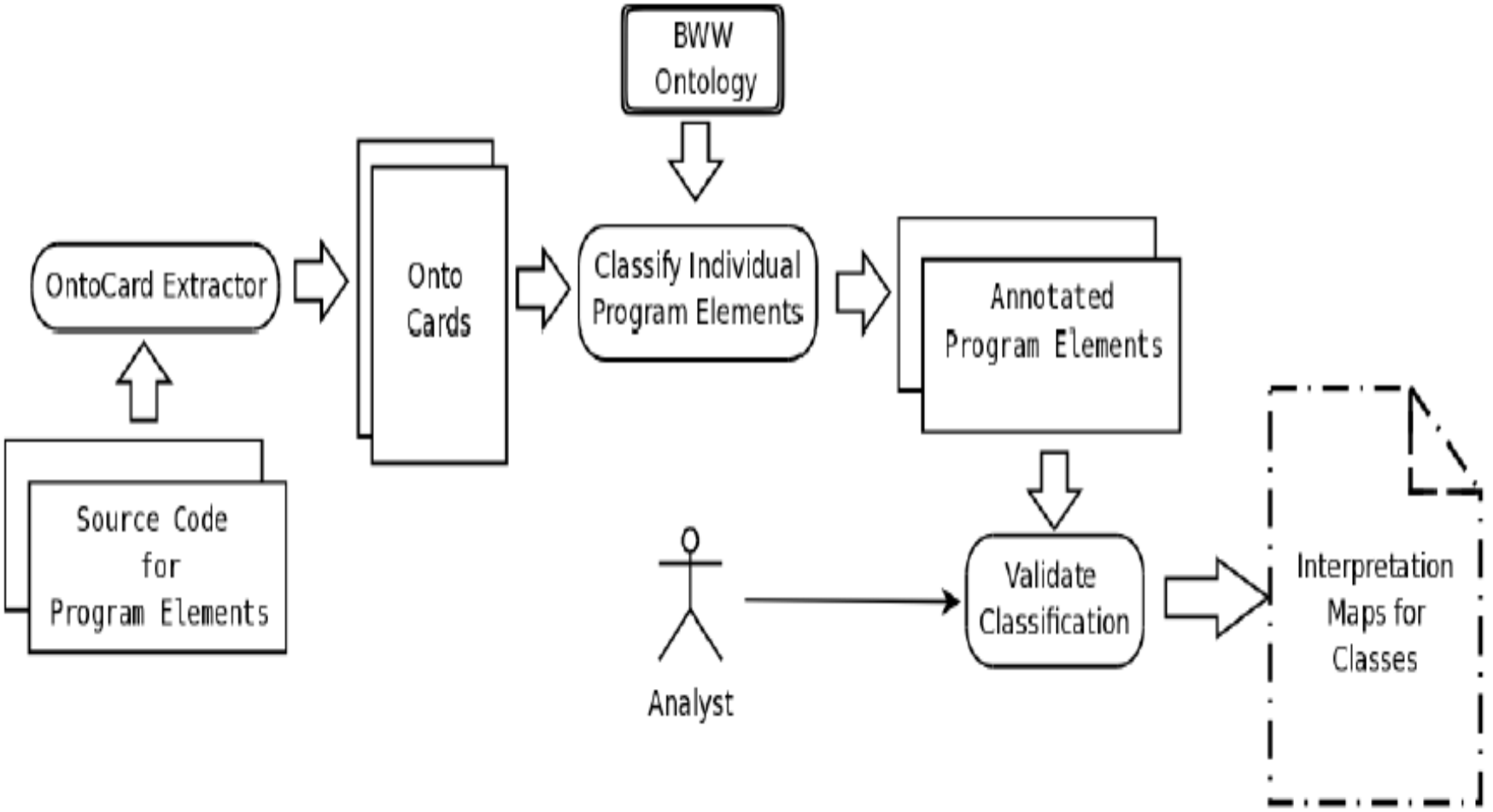
State

A W Kiwelekar and R K Joshi, Object oriented metamodel for BWW ontology



Application of Ontological Approach to Architecture Extraction

2013 IEEE 13th International Working Conference on Source Code Analysis and Manipulation (SCAM)



Onto Cards

Fully Qualified Name of a Class		
Member Analysis		
A class has attributes declaration.	*hasAttributes*	Y/N
A class has methods declaration.	*hasMethods*	Y/N
All the attributes and methods defined in a class are *static*.	*hasAllMembersStatic*	Y/N
A class has the method *main* defined in it.	*hasMain()*	Y/N
A class has the method *run* defined in it.	*hasRun()*	Y/N
A class has at least one method containing a looping construct.	*hasMethodContainingLoop*	Y/N
A class implements a non-null constructor method.	*hasConstructor*	Y/N
A class invokes methods from another class.	*hasInteractions*	Y/N

Rules for Ontological Categorization

$$\neg hasMain() \wedge \neg hasRun() \wedge hasAttributes \wedge \neg hasMethods \Rightarrow Property \quad \text{(Rule 1)}$$

$$\neg hasMain() \wedge \neg hasRun() \wedge hasAttributes \wedge hasMethods \wedge \neg hasAllMembersStatic \wedge hasConstructor \wedge hasInteractions \Rightarrow Thing \quad \text{(Rule 4)}$$

Rules for classifying into Event, Thing, Property, Process

Ontology Abstractions

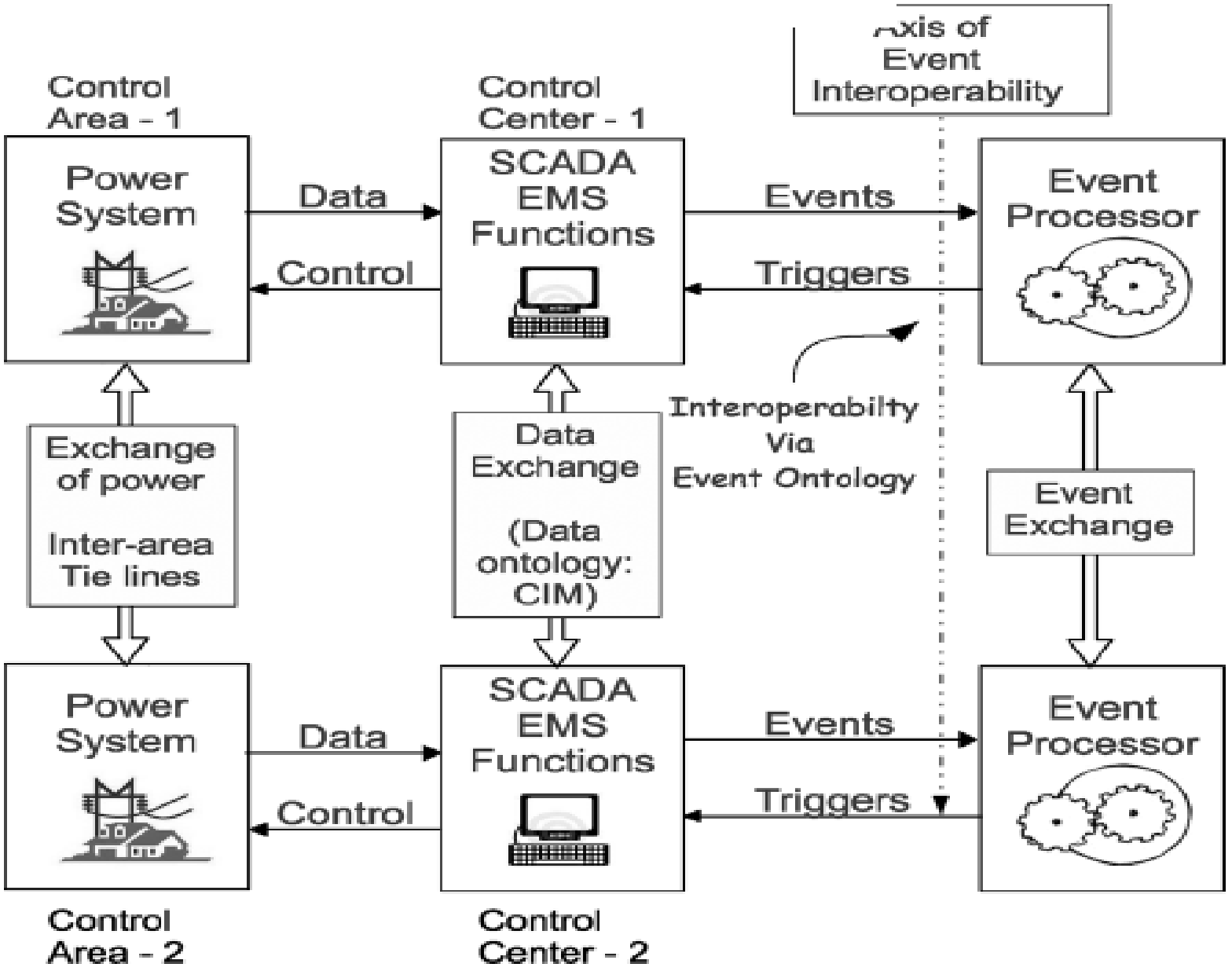
Upper Ontology

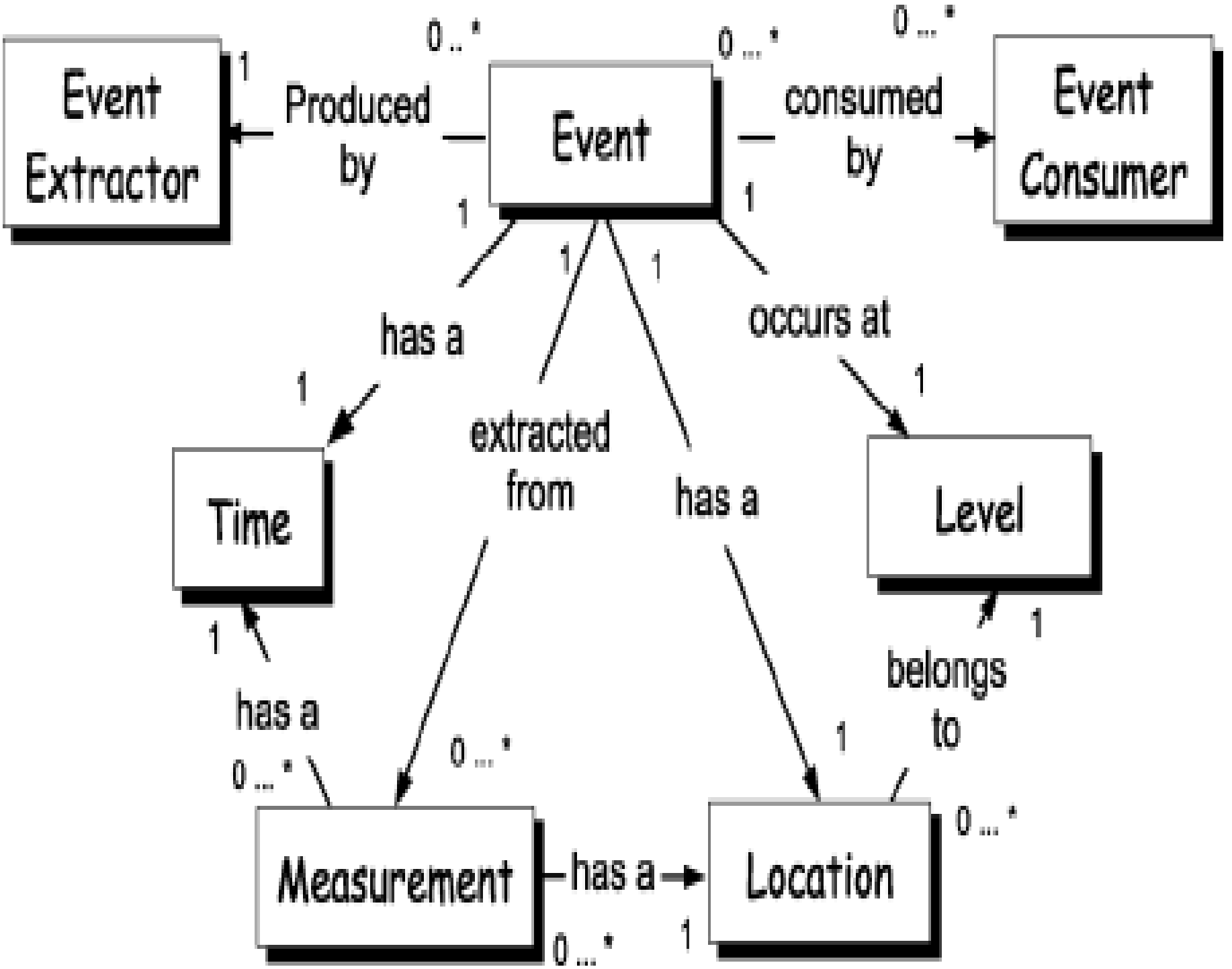
vs

Lower Ontology

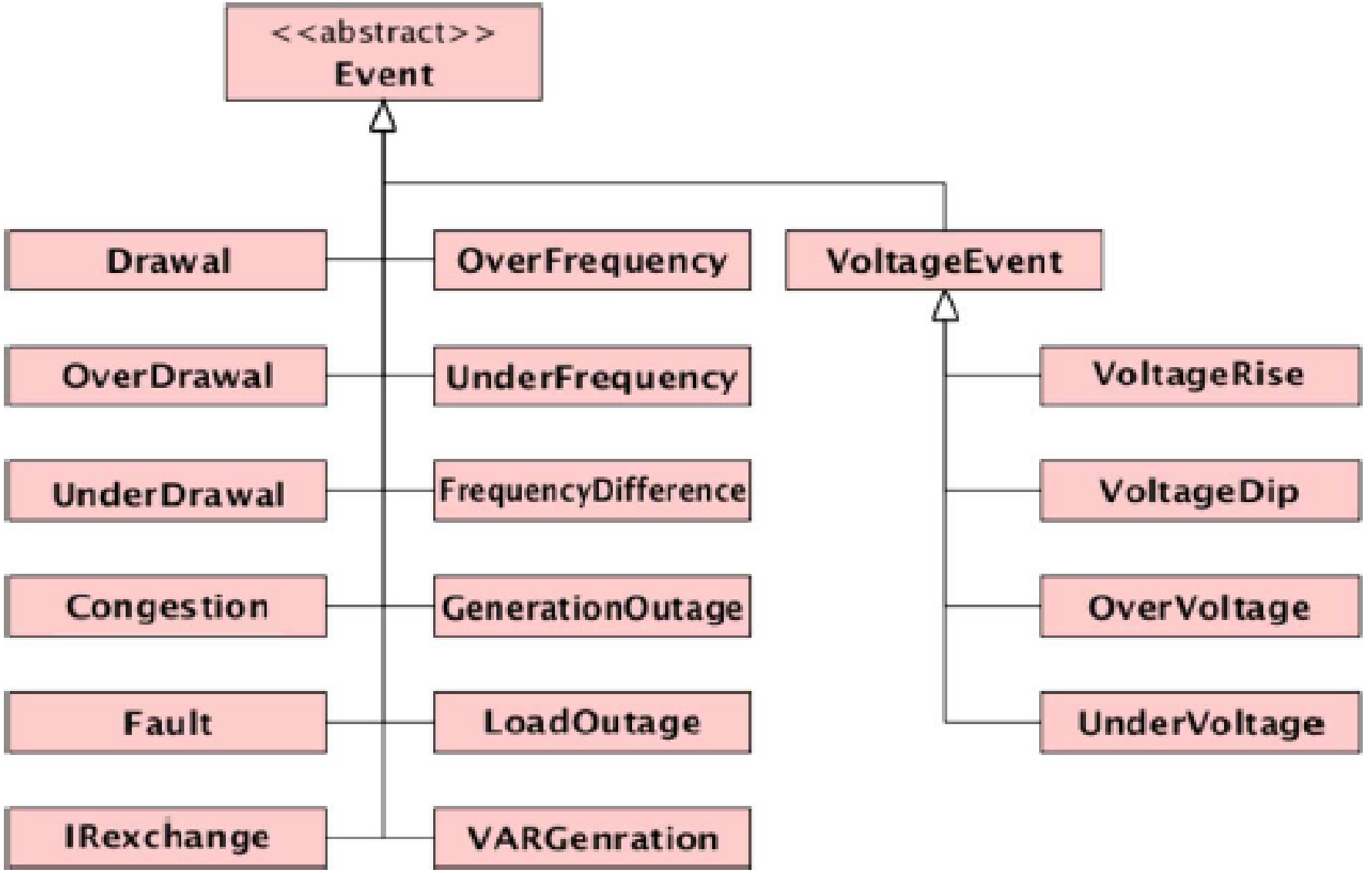
Domain Ontology

IEEE TRANSACTIONS ON SMART GRID, VOL. 3, NO. 1, MARCH 2012

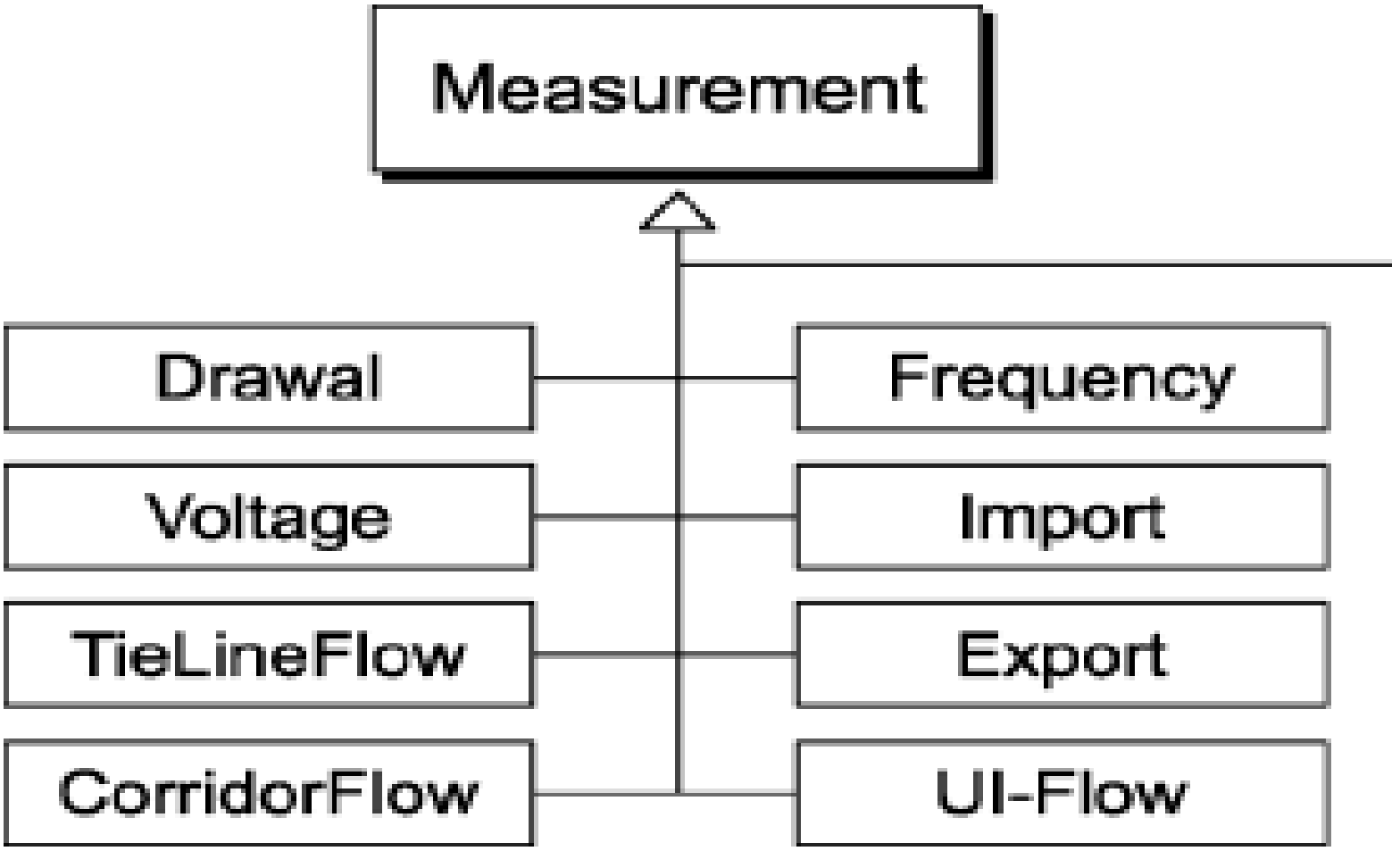



Event Extractor
1
Produced by
0..*
Event
1
0...*
consumed by
0...*
Event Consumer
1
1
1
has a
1
occurs at
1
Time
extracted from
has a
Level
1
1
has a
0...*
belongs to
1
0...*
0...*
Measurement
has a
Location
0...*
1
0...*

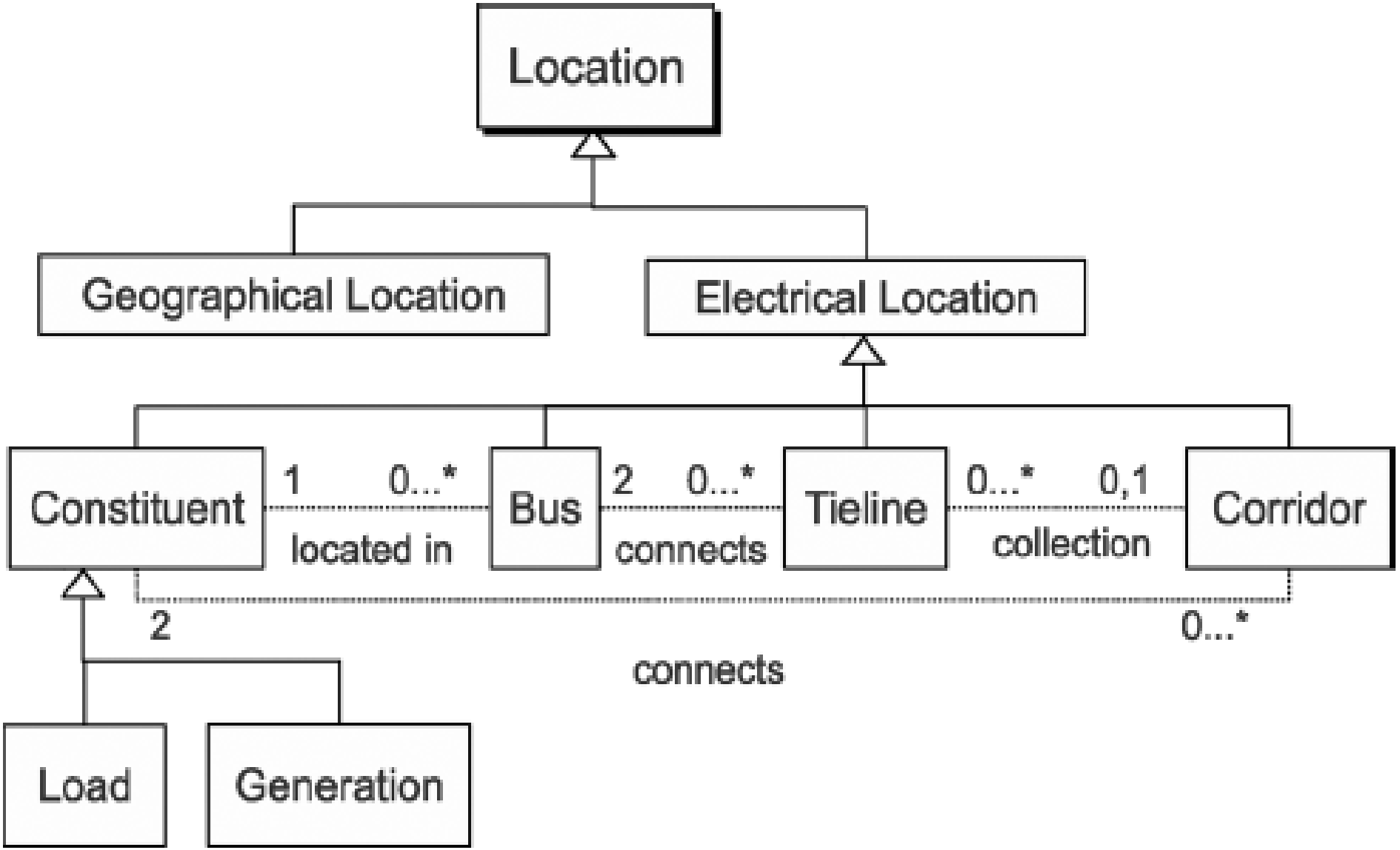
The Event Ontology



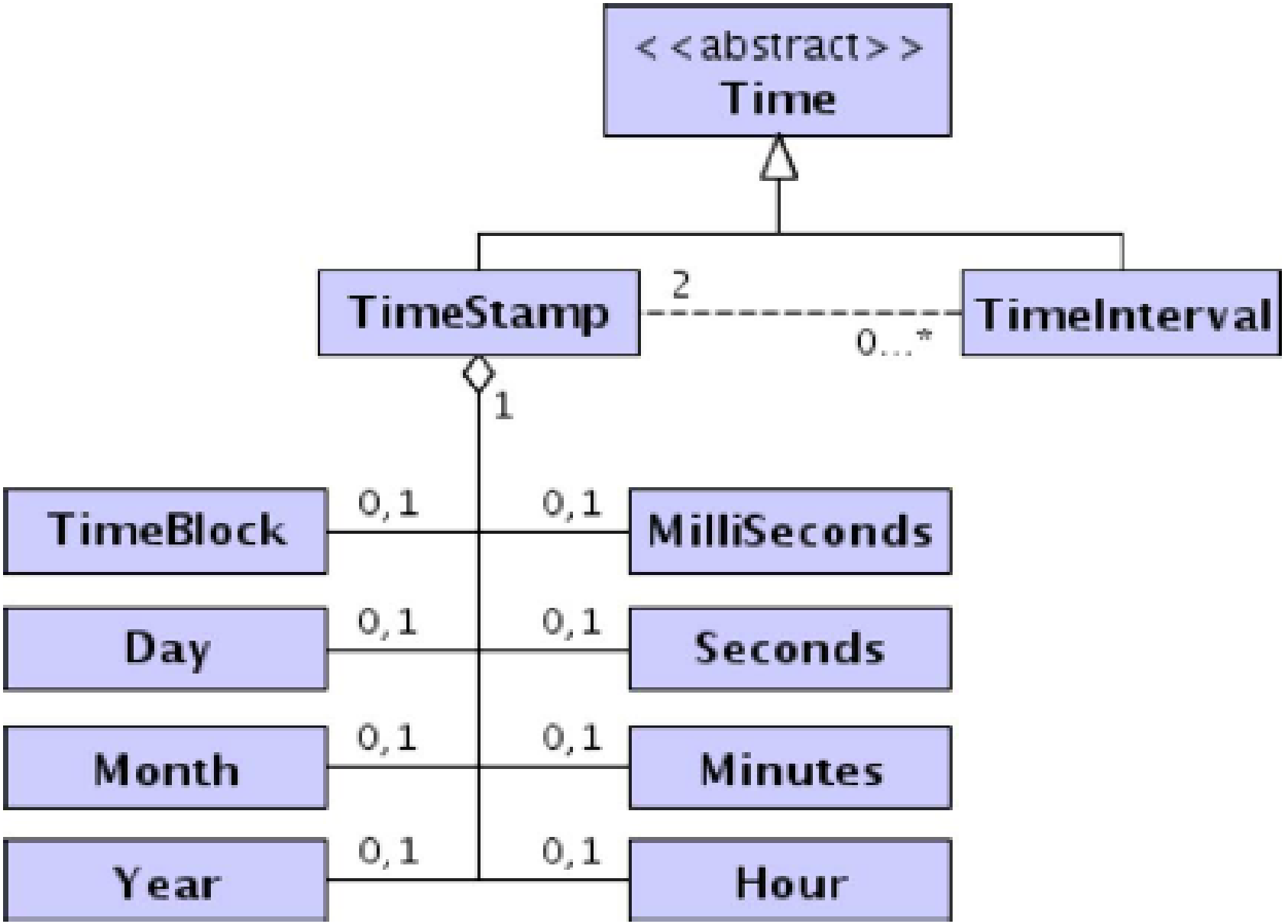
Measurement Ontology



Location Ontology



Time Ontology



Overdrawal Event Representation : XML RDF

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<xmlns:eo="http://www.iitb.ac.in/eventontology#"
rdf:RDF xmlns="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

 <eo:Overdrawal rdf:ID="od_1">
       <eo:timestamp>2011-03-08 19:05:00</eo:timestamp>
       <eo:frequency>49.79 Hz</eo:frequency>
       <eo:scheduled>3657 MW</eo:scheduled>
       <eo:actual>4352 MW</eo:actual>
       <eo:constituent.ID rdf:resource="#const_89" />
 </eo:Overdrawal>
```

Xml namespaces

Undervoltage Event Representation : XML RDF

```
<eo:UnderVoltage rdf:ID="uv_1">
      <eo:timestamp>2011-03-08 20:22:00</eo:timestamp>
      <eo:frequency>49.64 Hz</eo:frequency>
      <eo:rated>400 KV</eo:scheduled>
      <eo:actual>377 KV</eo:actual>
      <eo:Bus.ID rdf:resource="#bus_31" />
</eo:UnderVoltage>
```

Markup Representation Techniques

HTML

- web content tags, generic

XML

- richer tags, human understandable

Further standardization for more semantic content

- RDF, OWL

RDF (Resource Description Framework)

- W3C standard
- Metadata description
- Resource
- Predicates about resources