北京建筑大学
BEIJING UNIVERSITY OF CIVIL ENGINEERING AND ARCHITECTURE

BIM语义

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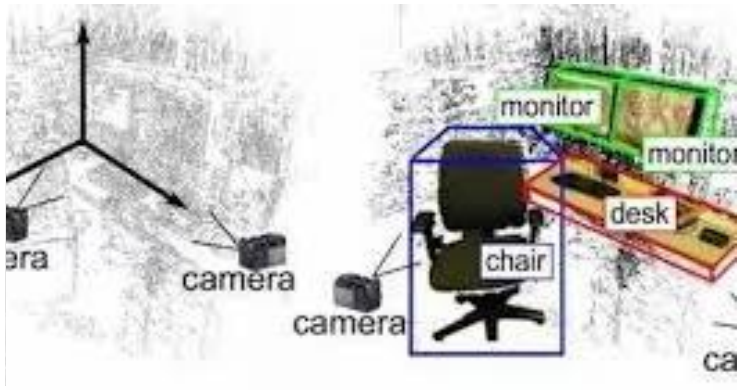
语义主体变化

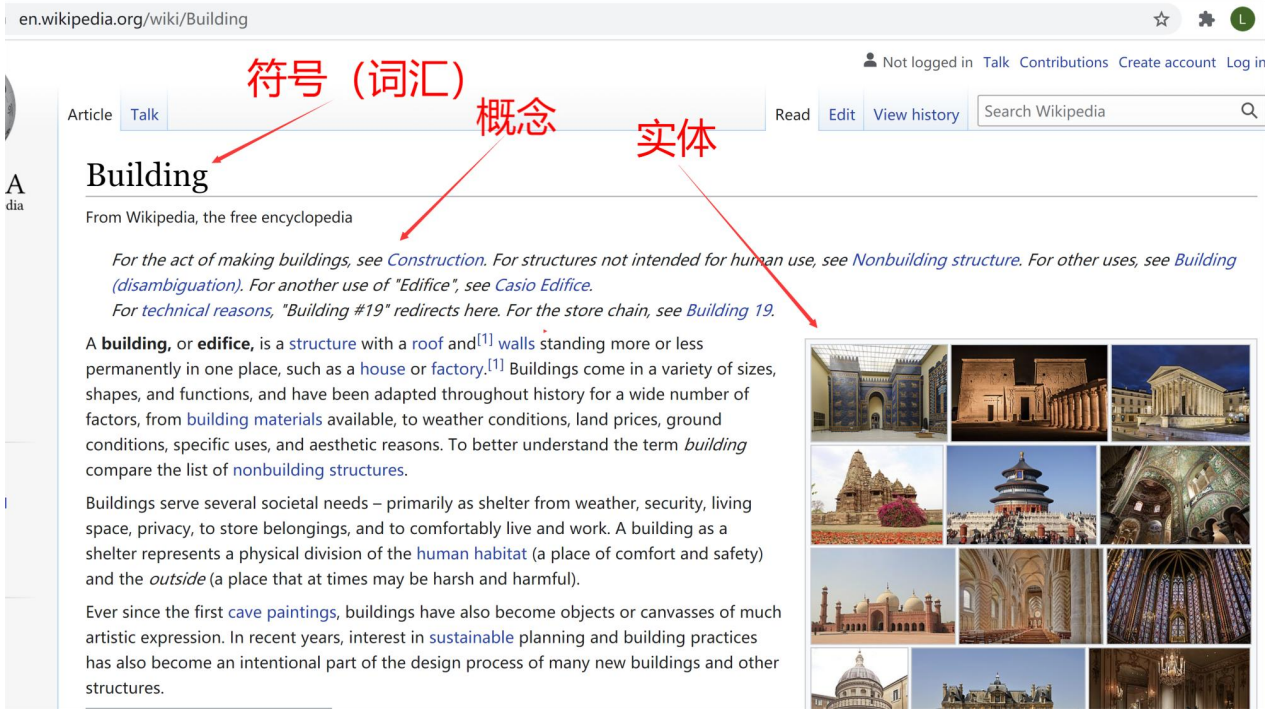
信息化 → 数字化 → 智能化



- 从研究历史来说，智能与智慧的研究要远远早于数字化；
- 从研究主体上看，传统的智能与智慧研究是针对“人”的，人类天生具有数字化的能力。
- 从现状上说，数字化是智能化的基础，主要原因在于主体从“人”转变为“机器”（智能体）；机器不具有数字化能力。

机器的特点

- 计算机（机器）以数字电路为主，擅长处理数字信号或符号信号
- 机器很难处理非结构化/半结构化数据（类模拟数据）
- 机器对**结构化数据**的处理能力成熟

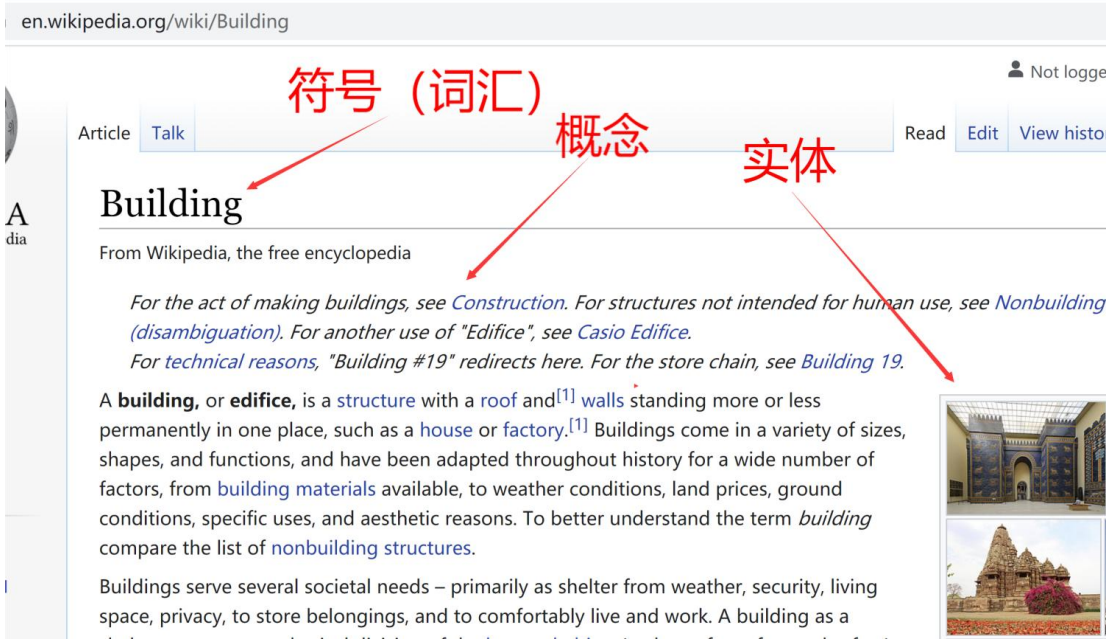


现有知识库对语义的定义是**给“人”使用**的，**并不针对“机器”**。机器很难理解这些语义；因此，自然语言处理/理解很多工作旨在让机器能够理解非结构化语言。

机器的语义——借鉴面向对象思想

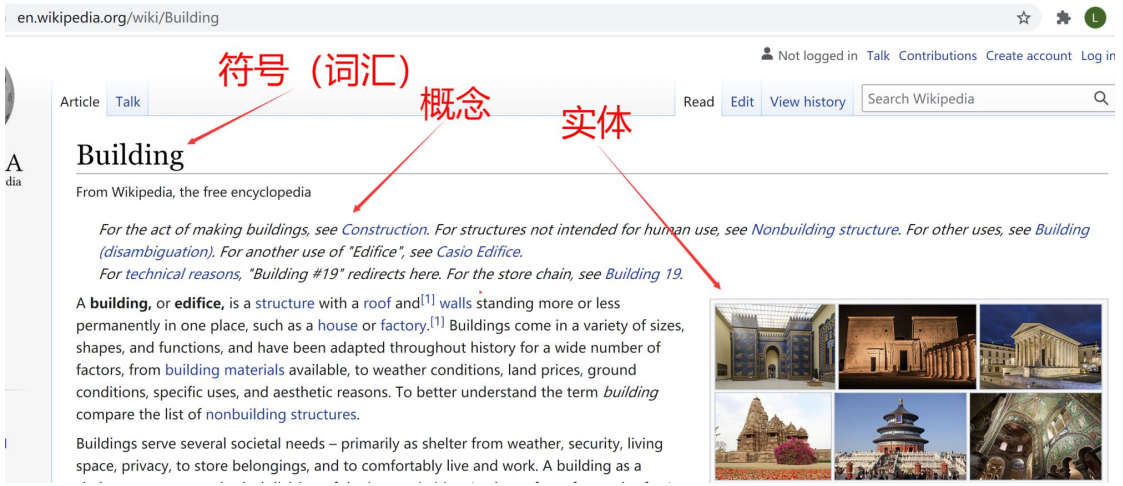
非结构化概念转变为结构化数据，面向对象思想是一个借鉴

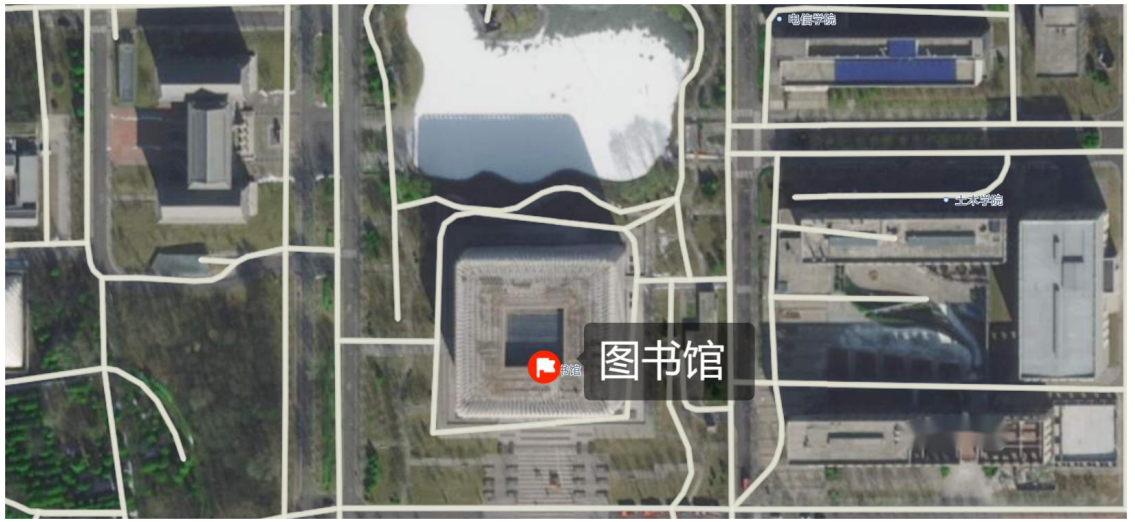
- 标签 – 编码
  - Building → IfcBuilding, 10-01.00.00
- 概念 – 属性+行为
  - A building is a structure with a roof and walls standing more or less permanently in one place.
  - 属性：roof, walls, place, …
  - 行为：building.stand(place)
- 实体（殊相） - 实例



机器的语义——非结构化向结构化转变

- **普遍性/类**
  - 类：Building
    - 属性：roof，walls，place
    - 行为：stand()
- **实体/殊相**
  - 实体：xx大学图书馆
    - 属性：roof=xx，walls={yy, zz}，place=永源路
    - 行为：stand(永源路)





BIM的语义——IFC标准

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- **BIM编码标准：定义语义标签**
- **IFC**
  - **定义了一套语义标签**
  - **给出了非结构化概念描述**
  - **给出了语义概念中的基本属性定义（结构化）**

非结构化概念描述

5.4.3.5.1 Semantic definitions at the entity

Entity definition

A building represents a structure that provides shelter for its occupants or contents and stands in one place. The building is also used to provide a basic element within the spatial structure hierarchy for the components of a building project (together with site, storey, and space).
NOTE Definition from ISO 6707-1:
Construction work that has the provision of shelter for its occupants or contents as one of its main purpose and is normally designed to stand permanently in one place.
A building is (if specified) associated to a site. A building may span over several connected or disconnected buildings. Therefore building complex provides for a collection of buildings included in a site. A building can also be decomposed in (vertical) parts, where each part defines a building section. This is defined by the composition type attribute of the supertype *IfcSpatialStructureElements* which is interpreted as follow:

- **COMPLEX**: building complex
- **ELEMENT**: building
- **PARTIAL**: building section

The IfcBuilding is used to build the spatial structure of a building (that serves as the primary project breakdown and is required to be hierarchical). The spatial structure elements are linked together by using the objectified relationship IfcRelAggregates. Figure 150 shows the IfcBuilding as part of the spatial structure. It also serves as the spatial container for building and other elements.
NOTE Detailed requirements on mandatory element containment and placement structure relationships are given in view definitions and implementer agreements.

[Building composition]($imageman://id=2006805526;mdg=Global;name=Building composition;type=Bitmap;)
Figure 150 – Building composition

Systems, such as building service or electrical distribution systems, zonal systems, or structural analysis systems, relate to IfcBuilding by using the objectified relationship IfcRelReferencedInSpatialStructure.
Figure 151 describes the heights and elevations of the IfcBuilding . It is used to provide the height above sea level of the project height datum for this building, that is, the internal height 0.00. The height 0.00 is often used as a building internal reference height and equal to the floor finish level of the ground floor.

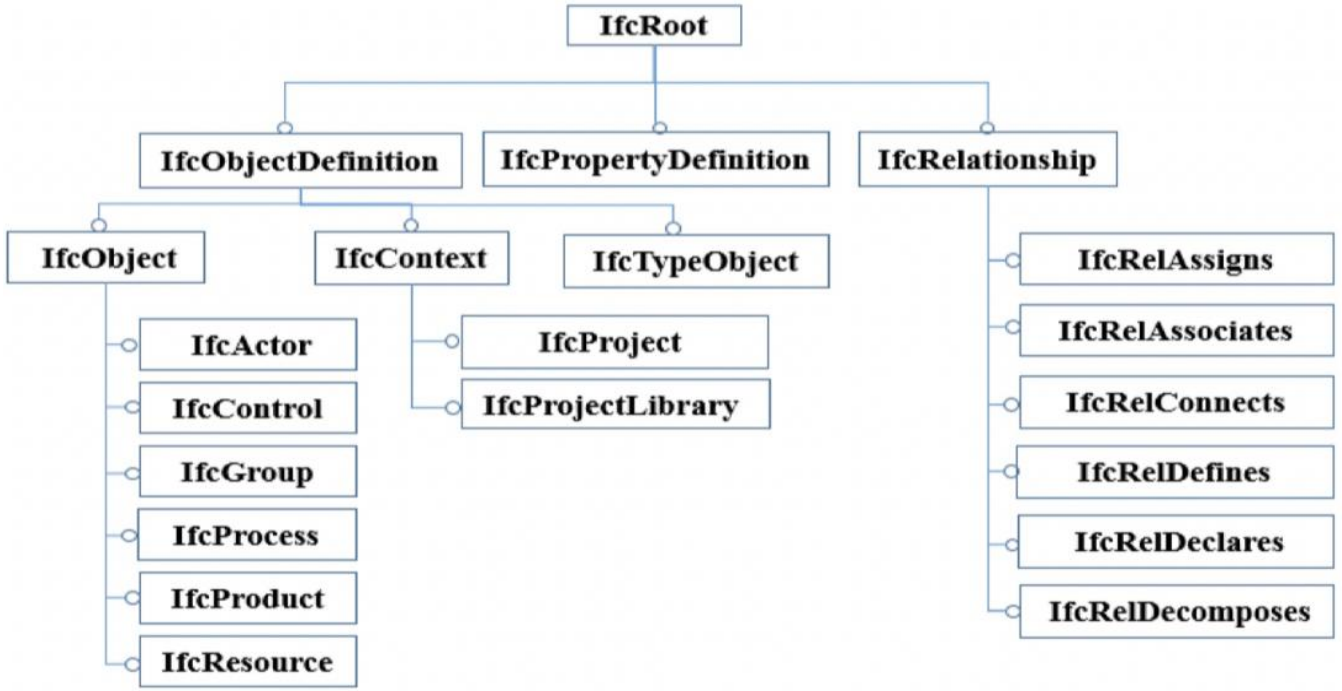
- base elevation of building provided by: *IfcBuilding.ElevationOfRefHeight*, it is usually the top of construction slab.
- base elevation of terrain at the perimeter of the building provided by: *IfcBuilding.ElevationOfTerrain*, it is usually the minimum elevation is sloped terrain
- total height of building, also referred to as ridge height (top of roof structure, e.g the ridge against terrain): provided by BaseQuantity with Name="TotalHeight"
- eaves height of building (base of roof structure, e.g the eaves against terrain): provided by BaseQuantity with Name="EavesHeight"

结构化概念属性定义

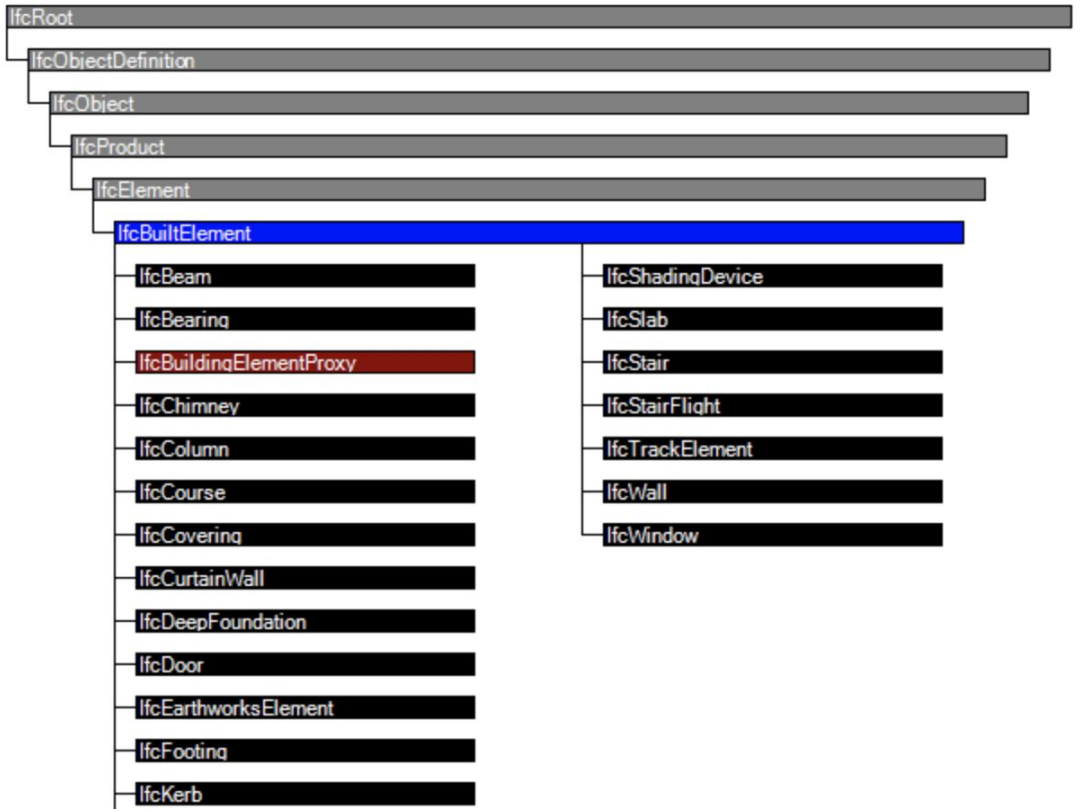
#	Attribute	Type	Cardinality	Description
IfcRoot				
1	GlobalId	IfcGloballyUniqueId		Assignment of a globally unique identifier within th
2	OwnerHistory	IfcOwnerHistory	?	Assignment of the information about the current ov captured about the recent changes of the object, NOTE only the last modification in stored - eitl IFC4 CHANGE The attribute has been change
3	Name	IfcLabel	?	Optional name for use by the participating softwar required. This would be enforced by a where rule.
4	Description	IfcText	?	Optional description, provided for exchanging infor
IfcObjectDefinition				
	HasAssignments	IfcRelAssigns @RelatedObjects	S[0:?]	Reference to the relationship objects, that assign (the association to products, processes, controls, r
	Nests	IfcRelNests @RelatedObjects	S[0:1]	References to the decomposition relationship bein decomposition relationship. An object occurrence IFC4 CHANGE The inverse attribute datatype
	IsNestedBy	IfcRelNests @RelatingObject	S[0:?]	References to the decomposition relationship bein decomposition relationship. An object or object typ IFC4 CHANGE The inverse attribute datatype
	HasContext	IfcRelDeclares @RelatedDefinitions	S[0:1]	References to the context providing context inform non-spatial object. IFC4 CHANGE The inverse attribute datatype
	IsDecomposedBy	IfcRelAggregates @RelatingObject	S[0:?]	References to the decomposition relationship bein decomposition relationship. An object definitions c IFC4 CHANGE The inverse attribute datatype

BIM的语义——IFC继承关系

最下层的实体可以被实例化，其他上层实体是抽象类，只能被继承不能实例化



实体的继承结构信息



建筑构件实体的继承关系架构

BIM的语义——IFC空间关系

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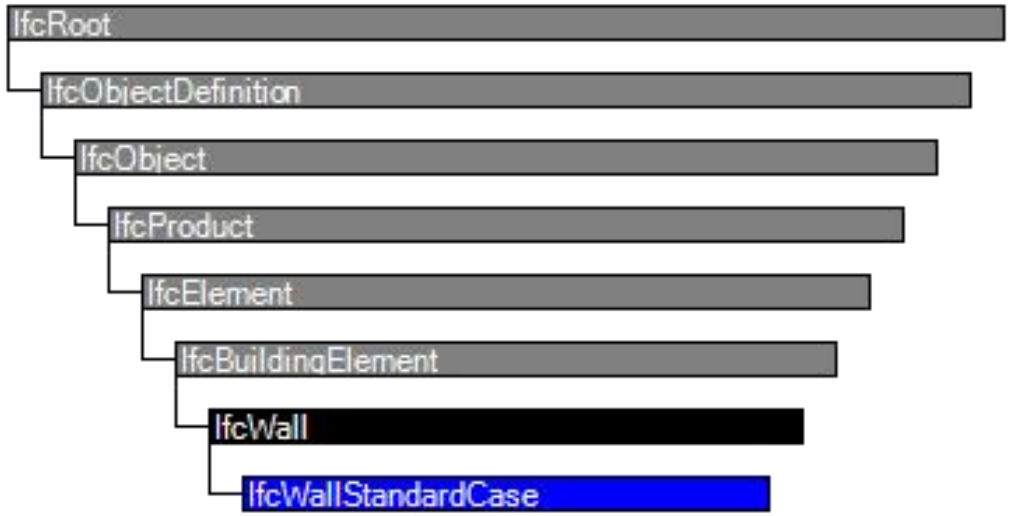
IFC

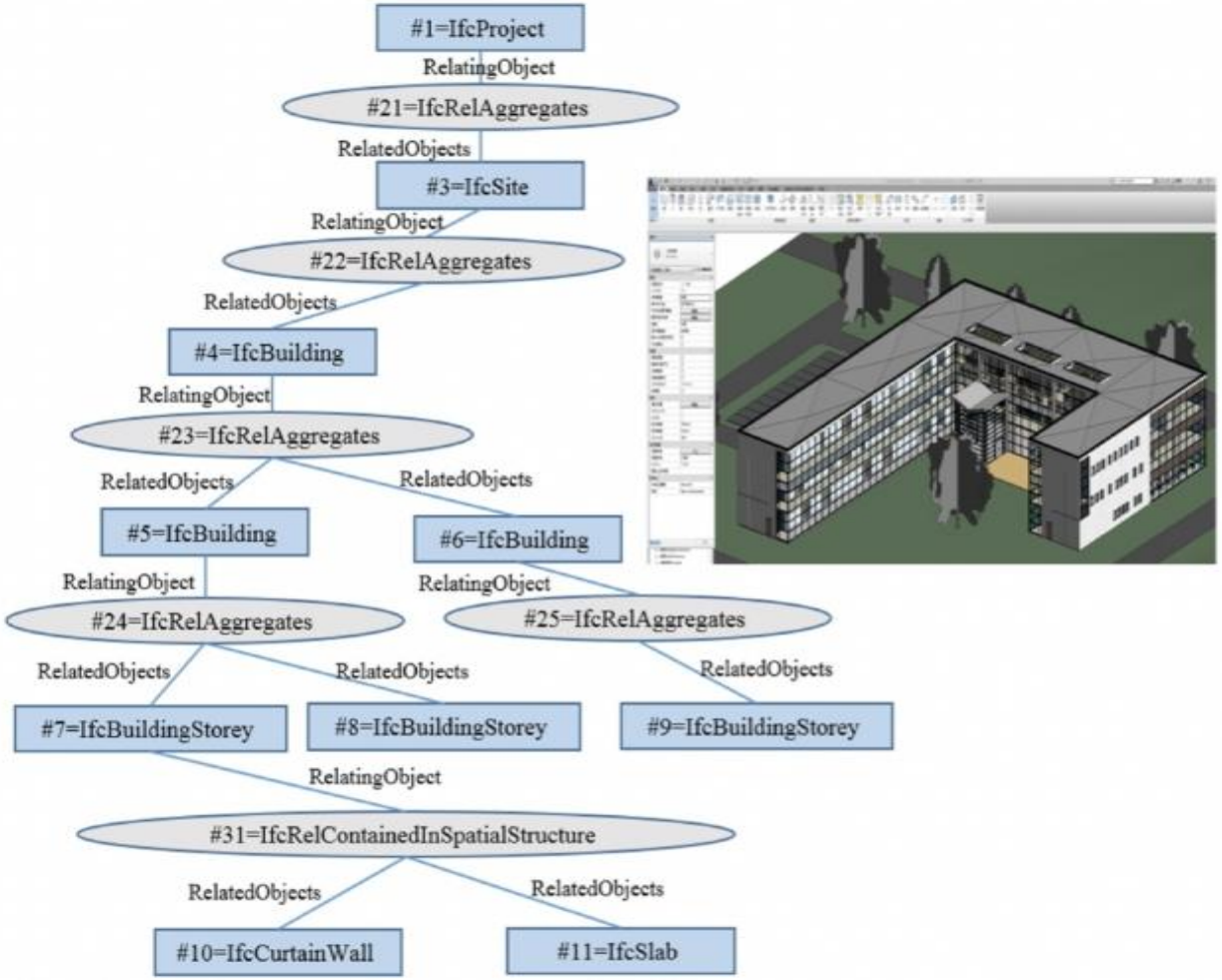
描述真实物理对象的语义

描述关系、过程、空间等抽象对象的语义

缺少对行为的定义



建筑构建实体实例



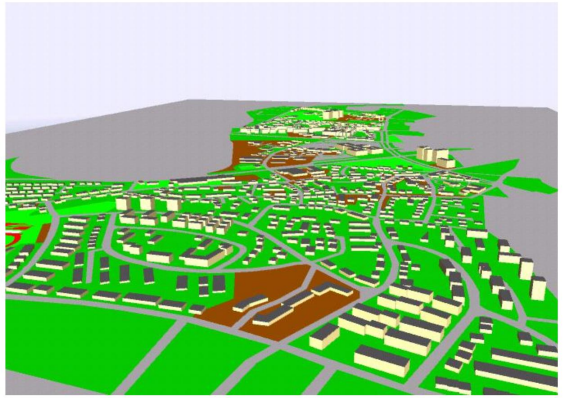
空间组织关系

CIM的语义

- **CityGML**
  - **定义了一套语义标签**
  - **给出了非结构化概念描述**
  - **给出了语义概念中的基本属性定义（结构化）**
  - **缺少对行为的定义**

10.3 Building model **非结构化概念描述**

The building model is one of the most detailed thematic concepts of CityGML. It allows for the represe thematic and spatial aspects of buildings and building parts in five levels of detail, LOD0 to LOD4. Th model of CityGML is defined by the thematic extension module *Building* (cf. chapter 7). Fig. 26 examples of 3D city and building models in LOD1 – 4.



结构化概念属性定义

```
<xs:complexType name="AbstractBuildingType" abstract="true">
  <xs:complexContent>
    <xs:extension base="core:AbstractSiteType">
      <xs:sequence>
        <xs:element name="class" type="gml:CodeType" minOccurs="0"/>
        <xs:element name="function" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="usage" type="gml:CodeType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="yearOfConstruction" type="xs:gYear" minOccurs="0"/>
        <xs:element name="yearOfDemolition" type="xs:gYear" minOccurs="0"/>
        <xs:element name="roofType" type="gml:CodeType" minOccurs="0"/>
        <xs:element name="measuredHeight" type="gml:LengthType" minOccurs="0"/>
        <xs:element name="storeysAboveGround" type="xs:nonNegativeInteger" minOccurs="0"/>
        <xs:element name="storeysBelowGround" type="xs:nonNegativeInteger" minOccurs="0"/>
        <xs:element name="storeyHeightsAboveGround" type="gml:MeasureOrNullListType" minOccurs="0"/>
```

行为是语义的真正价值

- 行为是语义的真正价值
- 我们关注一个事物时，更关注其功能（也即，行为）
- 属性是功能性能相关的参数

车身级别	5门 / 5座 / 中大型 / SUV
发动机	2.0L / 265马力 / 直列4缸
变速箱	8档 / 手自一体
最高车速km/h	225
0-100km/h加速	6.9
工信部/官方油耗(L)	7.9
燃料形式	汽油
环保标准	国6
保修政策	三年或10万公里

车是一种交通工具；人开车可以实现人和物的运输。从车角度，“运输”是车的功能。车的参数是为了描述车的“运输”性能。

BIM语义

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