

# Enabling Dynamic Smart Spaces using IoT- enhanced NGSI-LD Data Models



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INSTITUTE OF COMPUTER SCIENCE



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**CWSI 2022 – Connected World  
and Semantic Interoperability  
Workshop**

# The emergence of smart cities



# Towards Smart Buildings

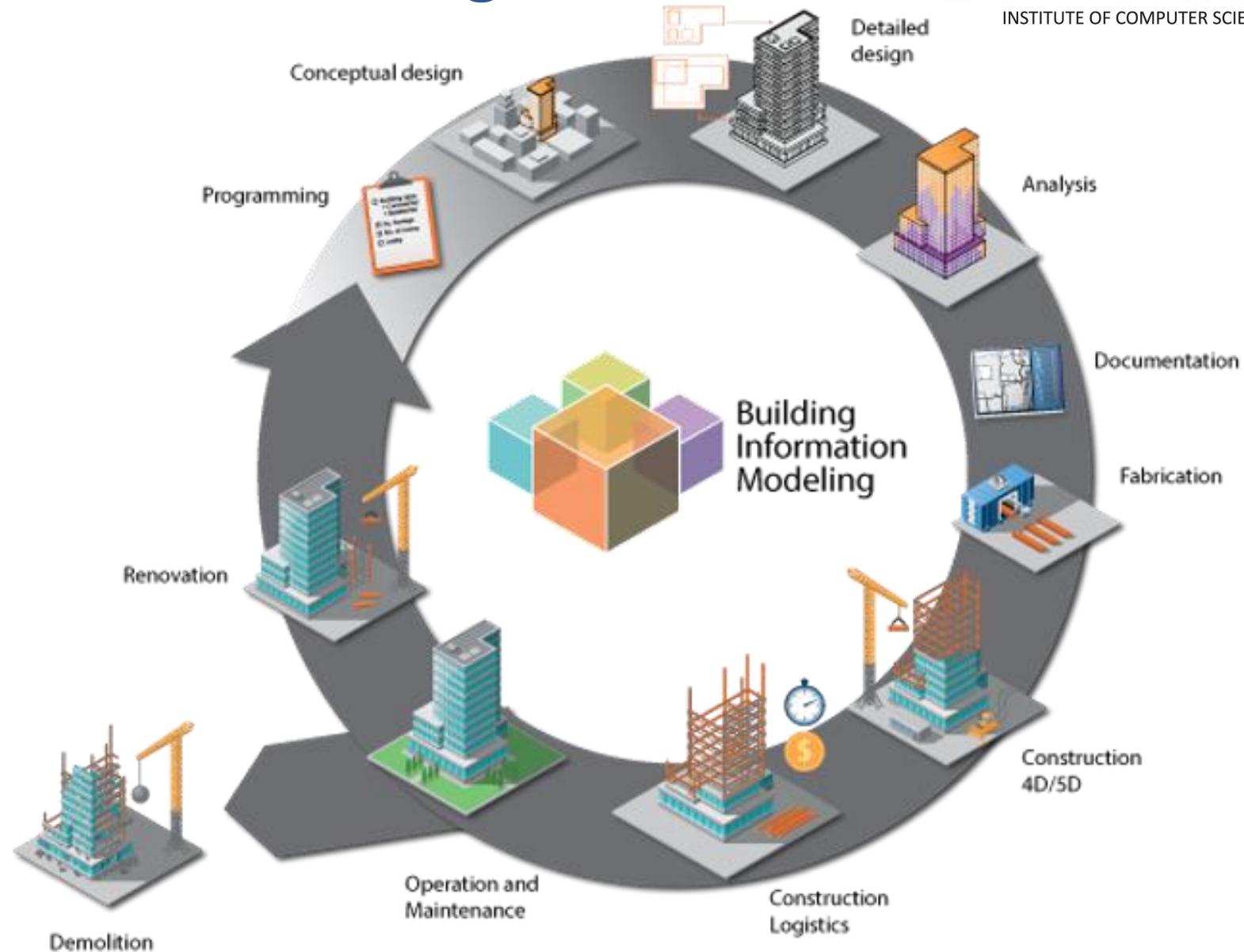


Evolution

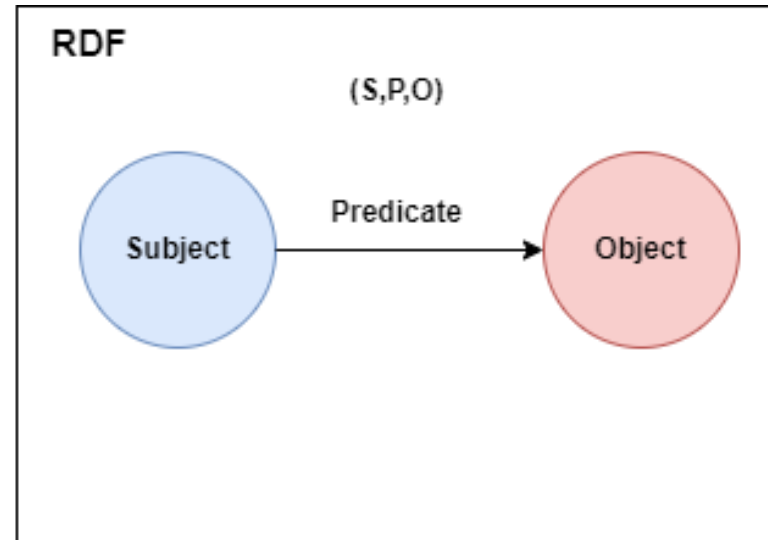
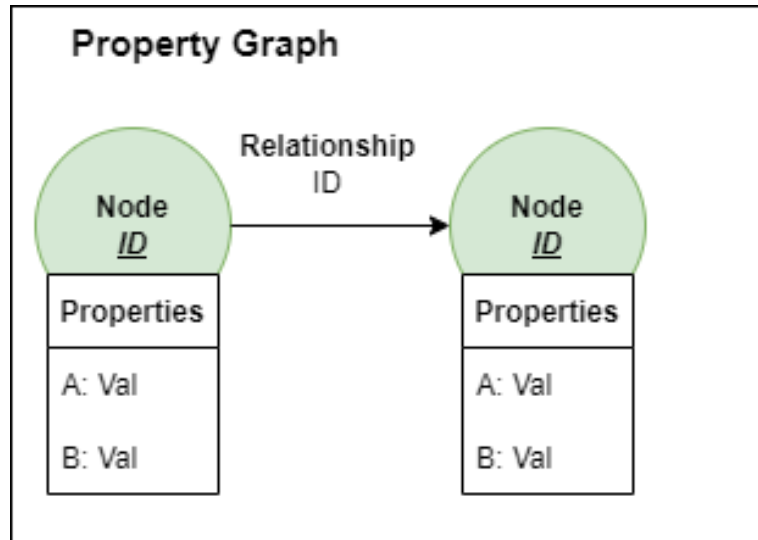




# Towards Smart Buildings Models



# BIM: Property Graphs and RDF



Company 1



Company 2



Company 3



*Static and rigid information repositories, no connection between silos.*

# Problem



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*How do we deal with the modeling of static and dynamic properties of smart spaces?*

- *Do we use property graphs? RDF ontologies?*
- *How do we handle semantic interoperability?*

# Problem



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*How do we deal with the modeling of static and dynamic properties of smart spaces?*

- *Do we use property graphs? RDF ontologies?*

*What if we could use both at the same time.*

- *How do we handle semantic interoperability?*

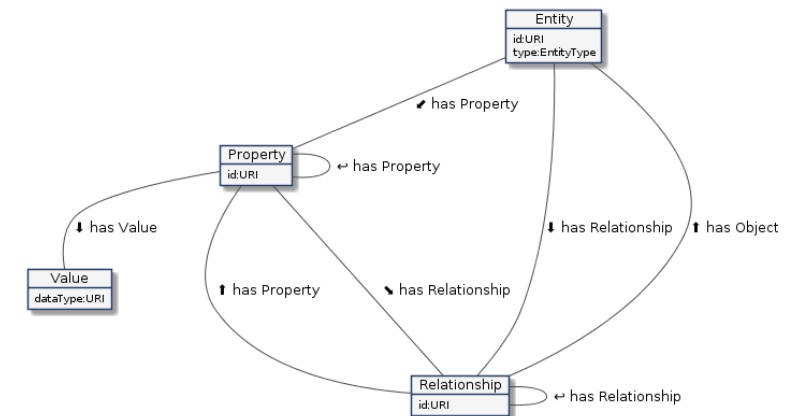
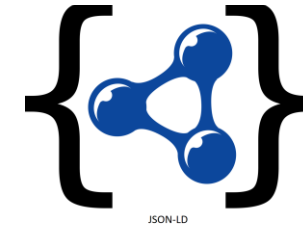
*What if we could utilize the world of linked data.*

# NGSI-LD in a nutshell



## Next Generation Service Interfaces-Linked Data Data Model + API

- Standardised by **ETSI**, and the evolution of **NGSI-v2**
- It is based on **JSON-LD**  
(connected to the world of linked data)
- NGSI-LD's design was focused on supporting the **property graph paradigm**.  
(Entity, Property, Relationship, Value), with its meta model **on the basis of RDF**.  
Trying to achieve the best of both worlds.





# Existing NGSI-LD models



**Smart  
Data Models**

A GLOBAL PROGRAM LED BY



Building	updated Building/doc/spec.md
BuildingOperation	updated BuildingOperation/doc/spec.md
BuildingType	updated BuildingType/doc/spec.md
Enclosure_incubated	Enclosure incubated
Floor_incubated	new incubted data model
VibrationsObserved	updated VibrationsObserved/doc/spec.md

# Initial Design Considerations



- Map a specific ontology to NGSI-LD for our data representations?

## Building Topology (BOT) Ontology

<https://w3c-lbd-cg.github.io/bot/>

## SemIoTic metamodels

Roberto Yus, Georgios Bouloukakis, Sharad Mehrotra, and Nalini Venkatasubramanian. 2022. The SemIoTic Ecosystem: A Semantic Bridge between IoT Devices and Smart Spaces. *ACM Transactions on Internet Technology – TOIT* (2022).

## Smart Appli- ances REFerence (SAREF) ontology

<https://saref.etsi.org/>

- What entities do we want to be able to represent with our data model?

# Modeling of Spaces



**Community**

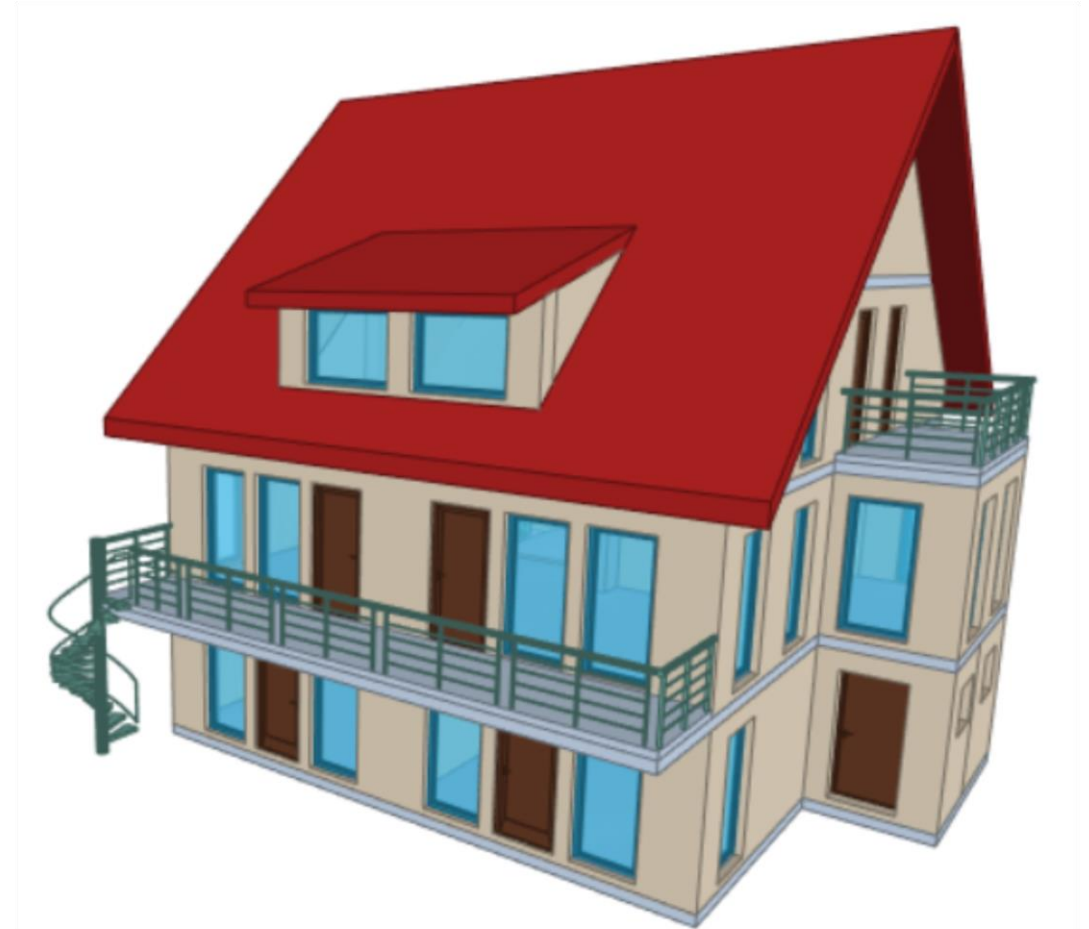


# Modeling of Spaces



Community

Building



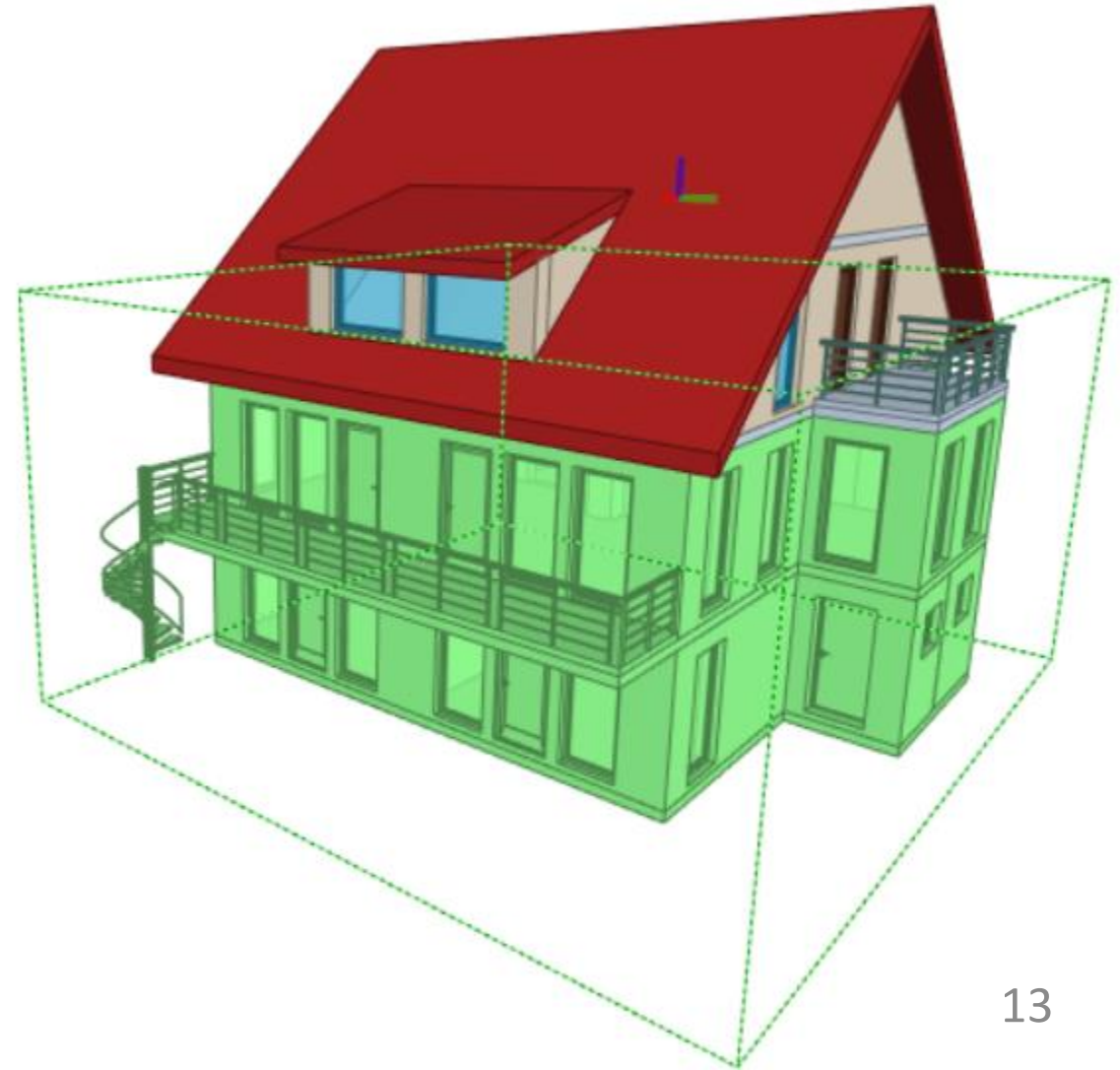
# Modeling of Spaces



Community

Building

Floor





# Modeling of Spaces

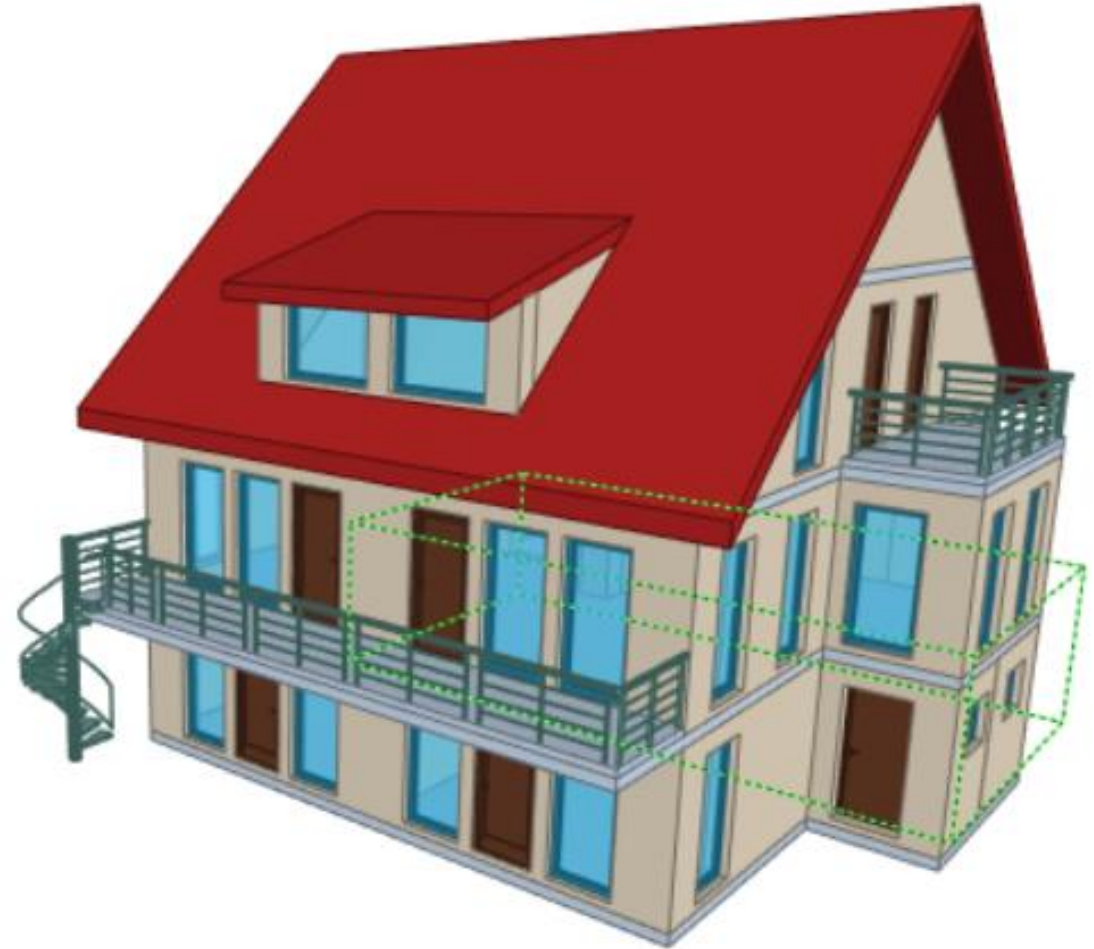


Community

Building

Floor

Zone



# Modeling of Spaces



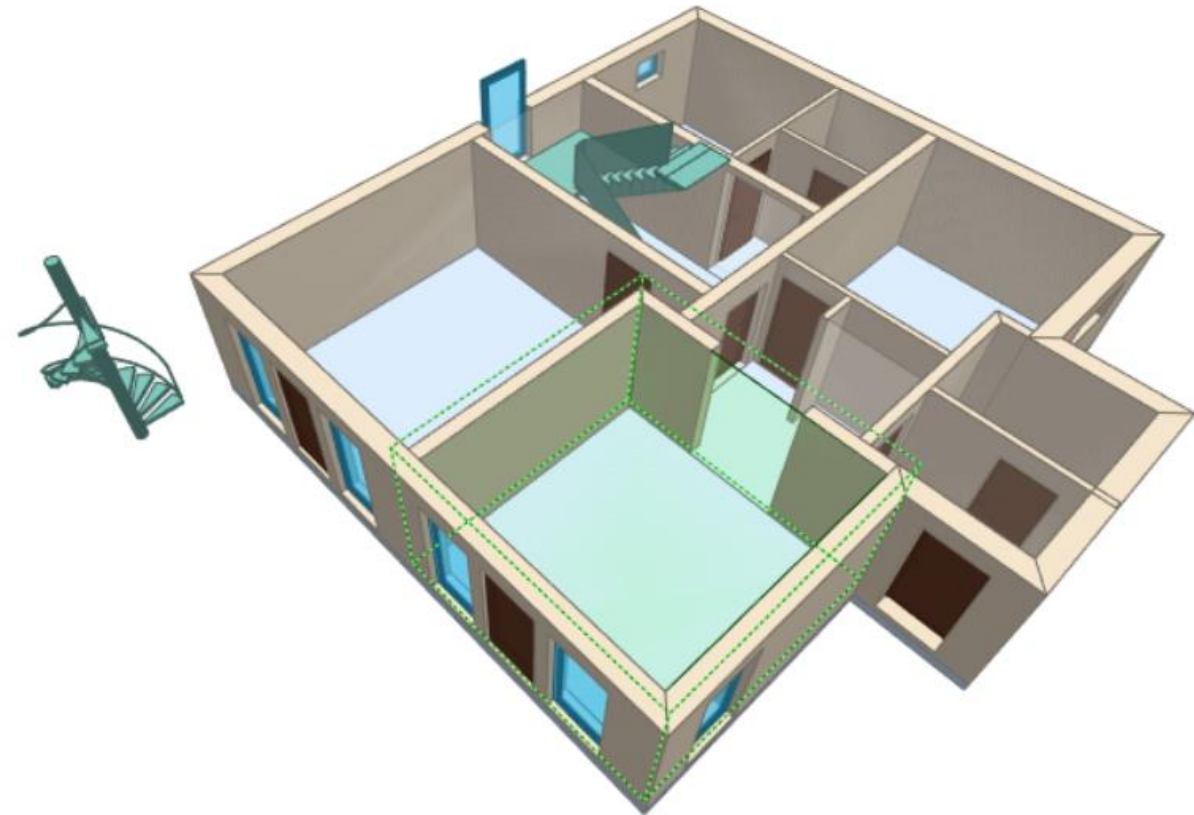
**Community**

**Building**

**Floor**

**Room**

**Zone**



# Modeling of Spaces



**Community**

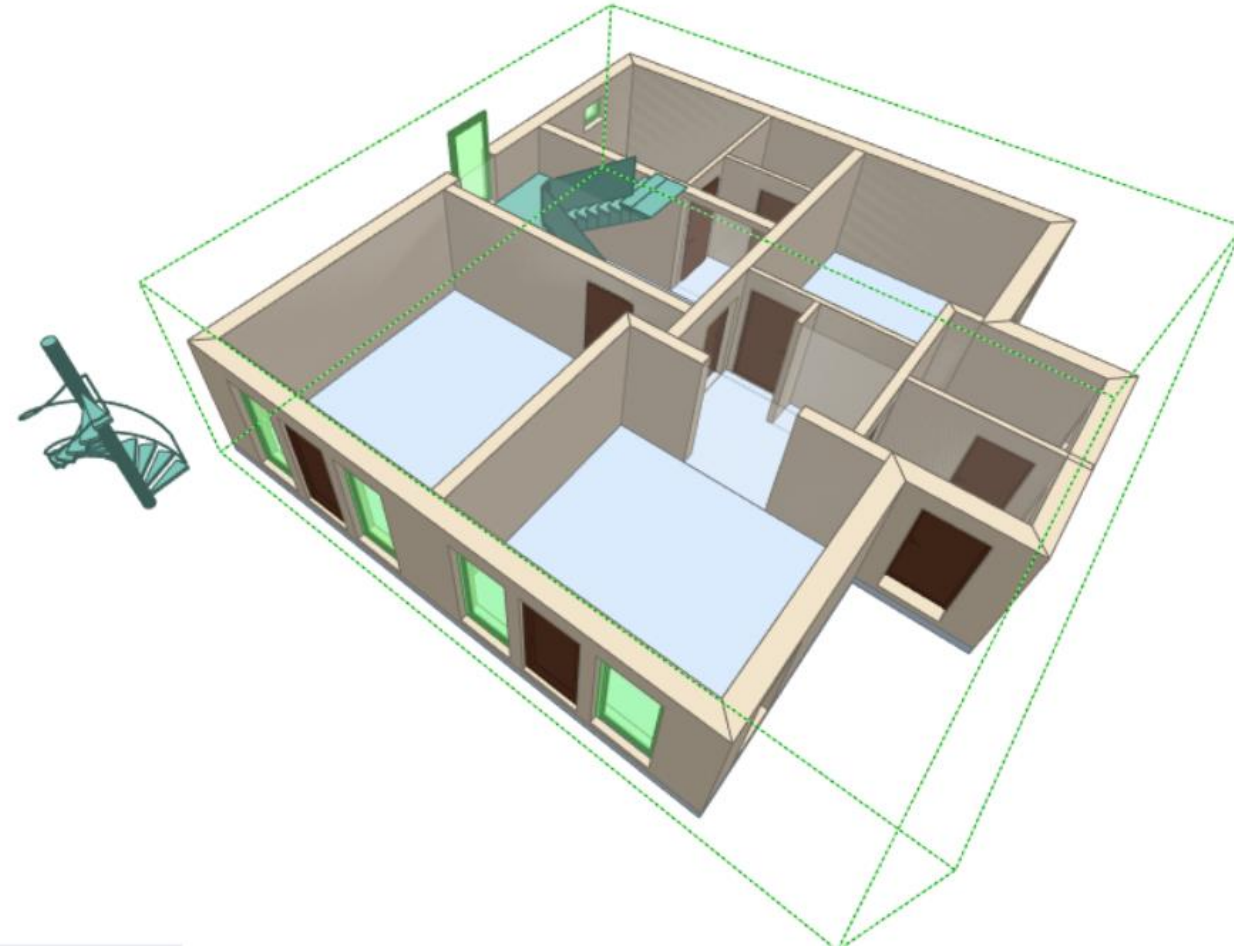
**Building**

**Floor**

**Room**

**Window**

**Zone**



# Modeling of Spaces



Community

Building

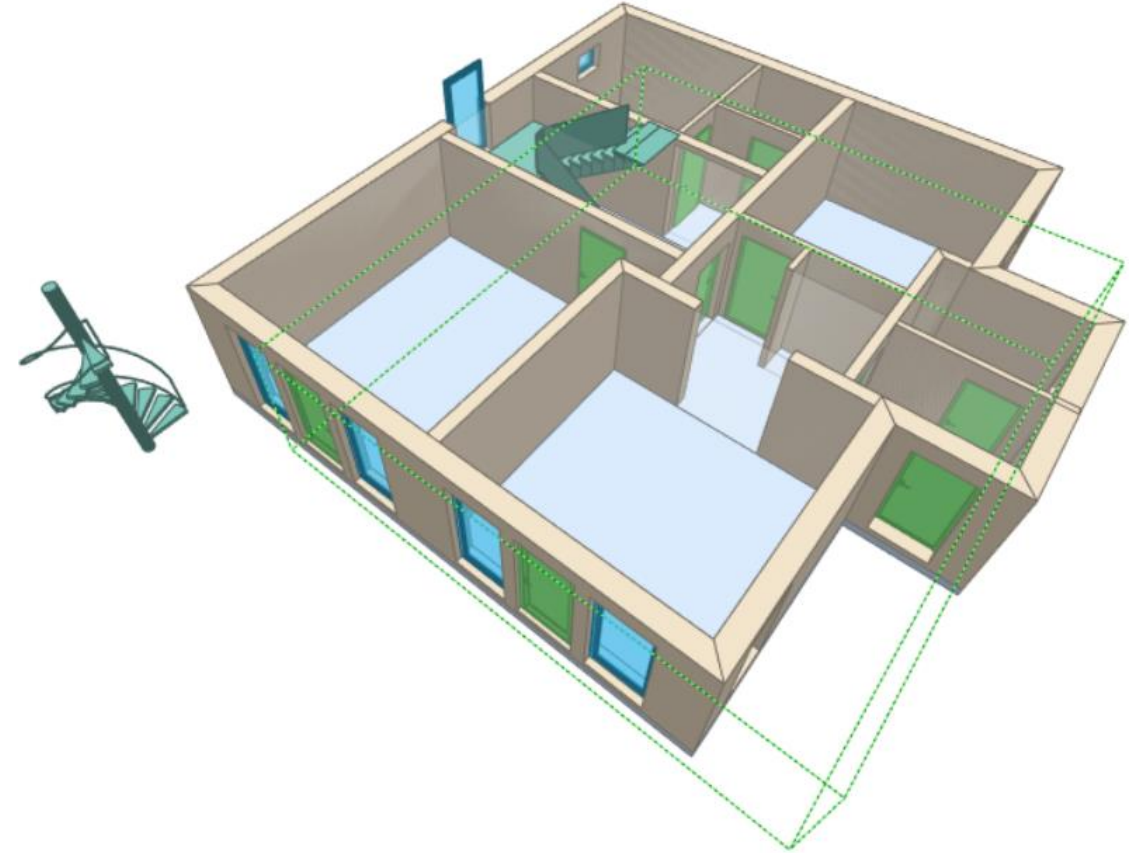
Floor

Zone

Room

Window

Door





# Modeling of Spaces



**Community**

**Building**

**Floor**

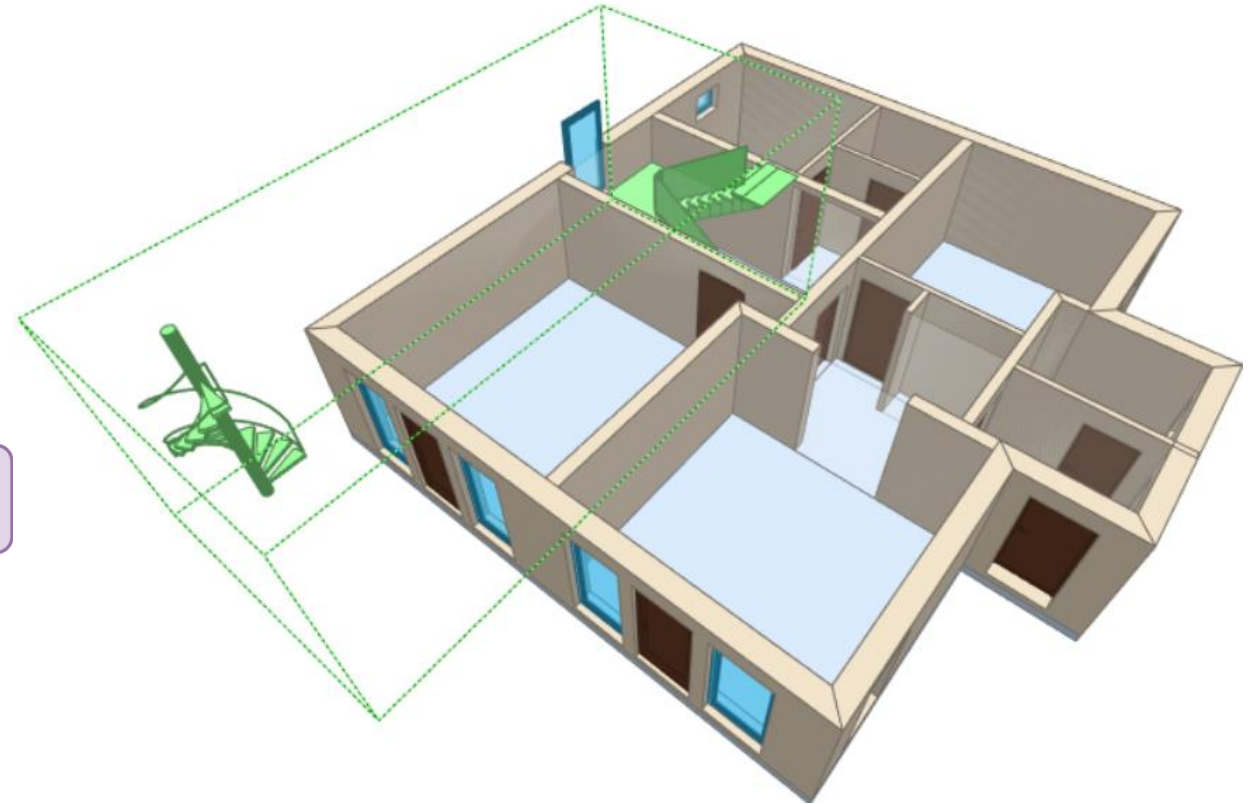
**Room**

**Window**

**Door**

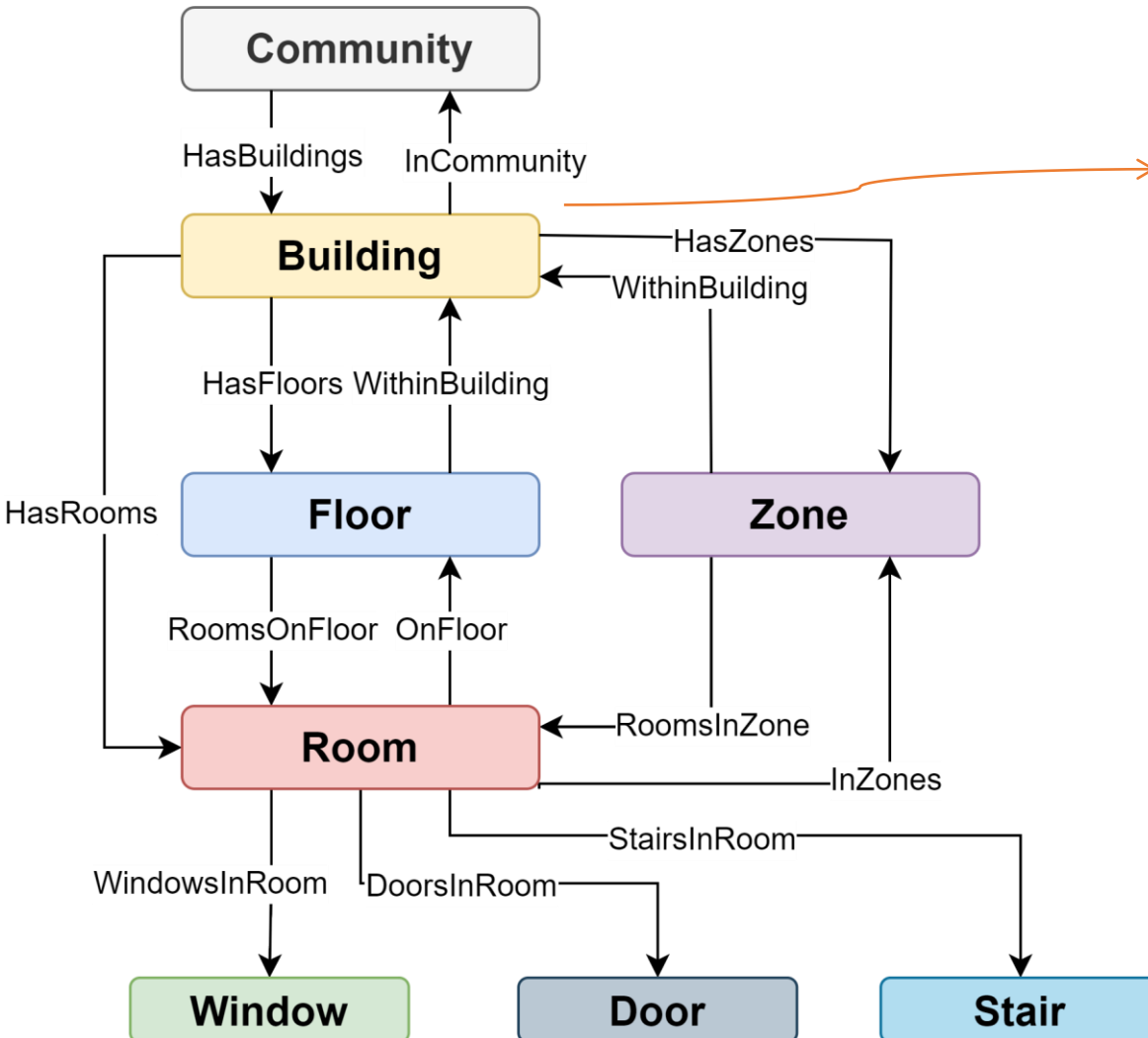
**Stair**

**Zone**





# Modeling of Spaces: Properties and relationships



```
1  "id": "urn:ngsi-ld:Building:Test:SmartCitiesdomain:
   SmartBuildings:3isw_NcDz2ghLEYGeHmBHm",
2  "type": "Building",
3  "name": "Default Building",
4  "category": ["civic"],
5  "dataProvider": "ICS_Forth",
6  "description": "A fake office building",
7  "floorsAboveGround": 3,
8  "floorsBelowGround": 1,
9  "InCommunity": ["urn:ngsi-ld:Community:Test:SmartCitiesdomain:
   SmartBuildings:ExampleCommunity"],
10 "HasFloors": ["urn:ngsi-ld:Floor:Test:SmartCitiesdomain:
   SmartBuildings:38vC2rMpPDpQ1cy52XqxrF",...],
11 "HasZones": ["urn:ngsi-ld:Zone:Test:SmartCitiesdomain:
   SmartBuildings:0aJ7eg0In66uiXCDk6uTq7",...],
12 "HasRooms": ["urn:ngsi-ld:Room:Test:SmartCitiesdomain:
   SmartBuildings:1OKccvw796094cljFtqofp",...],
13 ...
```

# Generating compatible data



I don't want to create data by hand, it is too bothersome and takes valuable time!

I guess I'll keep what I have been using until now.



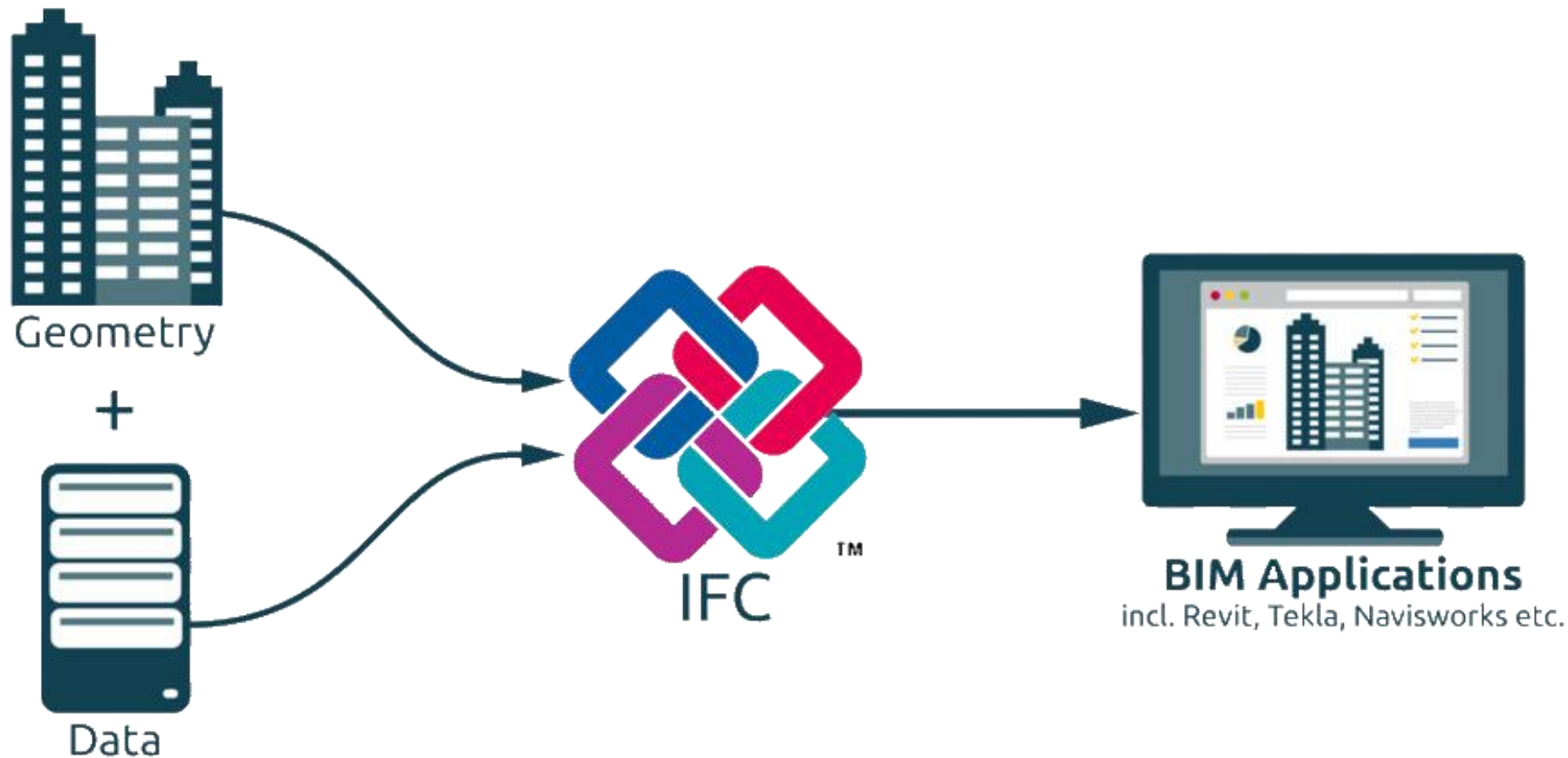
# Industry Foundation Classes (IFC)



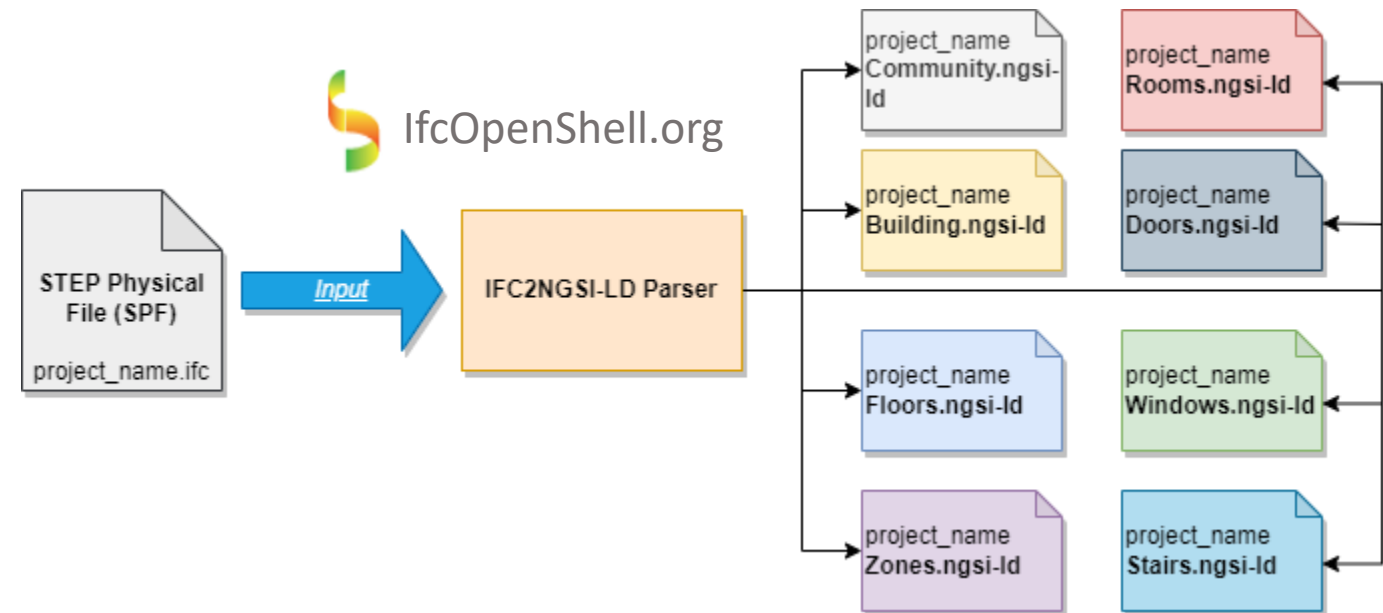
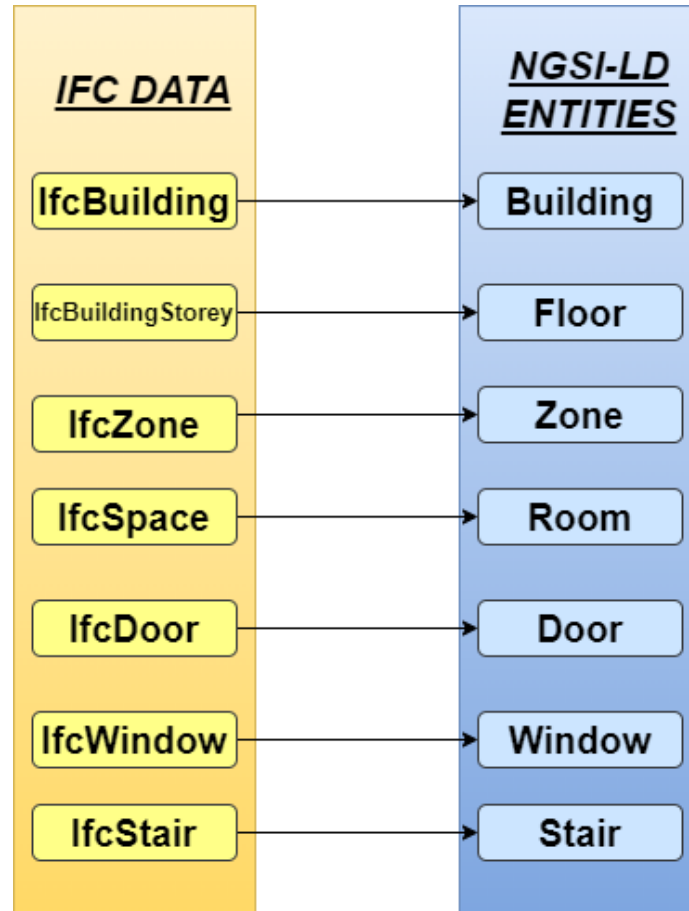
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# IFC2NGSI-LD parser



# Presented models until now

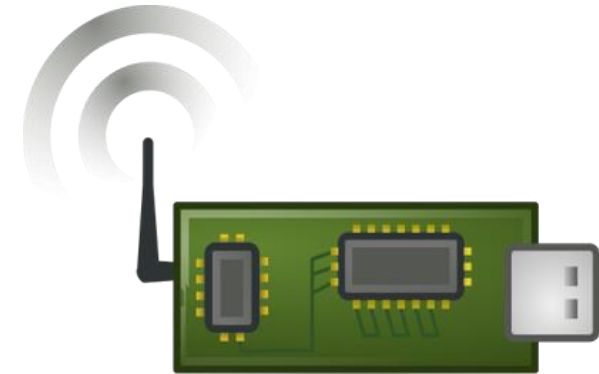


## Smart Buildings -> Static + Dynamic properties

- *Static Properties*



- Dynamic Properties





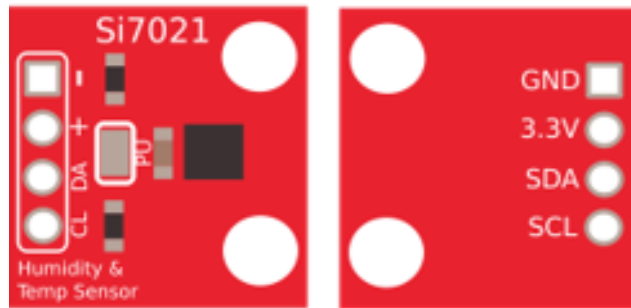
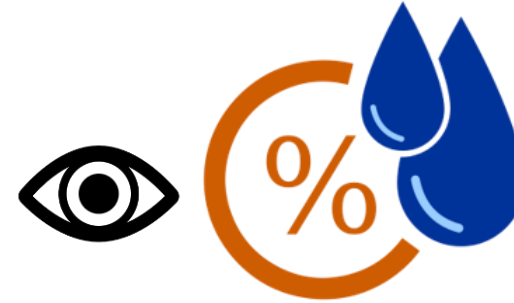
# Modeling of Devices



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<LoRaWAN>

<MQTT>



# Modeling of Devices



## **Device1:**

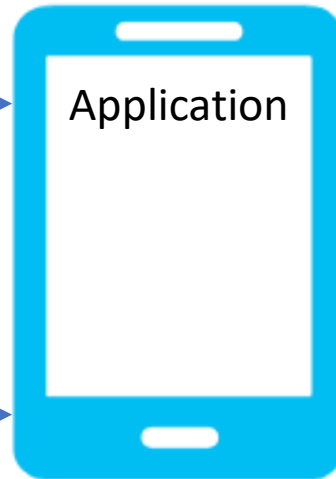
**Id:** urn:ngsi-Id:

**Name:** HumiditySensorC1

**Humidity\_percentage:** 65%

**Temperature:** 25°C

*GET Humidity\_percentage*



## **Device2:**

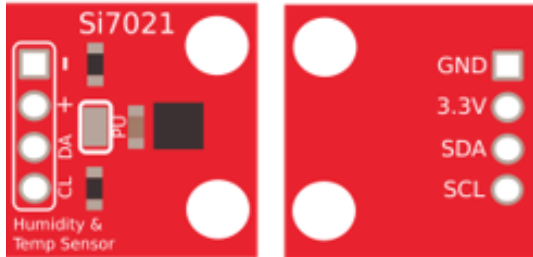
**Id:** urn:ngsi-Id:

**Name:** HumiditySensorB3

**Reading:** 65%

*GET Reading*

# Modeling of Devices



**Device1:**  
**Id:** Device1\_ID  
**Name:** HumiditySensorC1  
**Observations:** [Obs1,Obs2]



**Device2:**  
**Id:** Device2\_ID  
**Name:** HumiditySensorB3  
**Observations:** [Obs3]

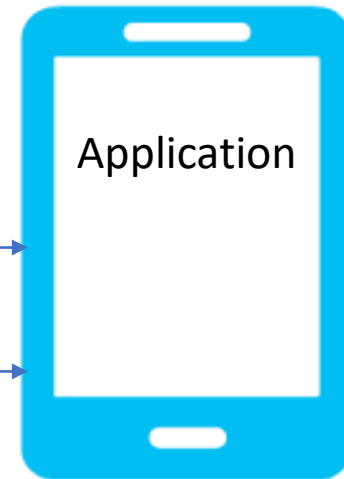
**Observation\_1:**  
**Id:** Obs1  
**Name:** Humidity\_percentage  
**Value:** 65%  
**measurementType:** Humidity

**Observation\_2:**  
**Id:** Obs2  
**Name:** Temperature  
**Value:** 25°C  
**measurementType:** Temperature

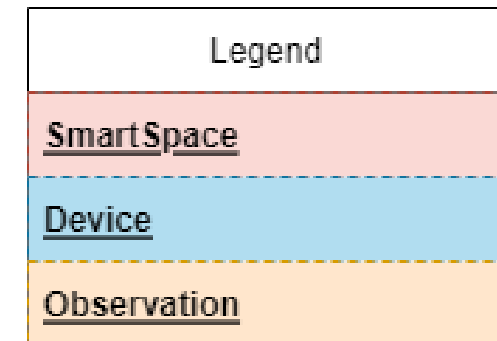
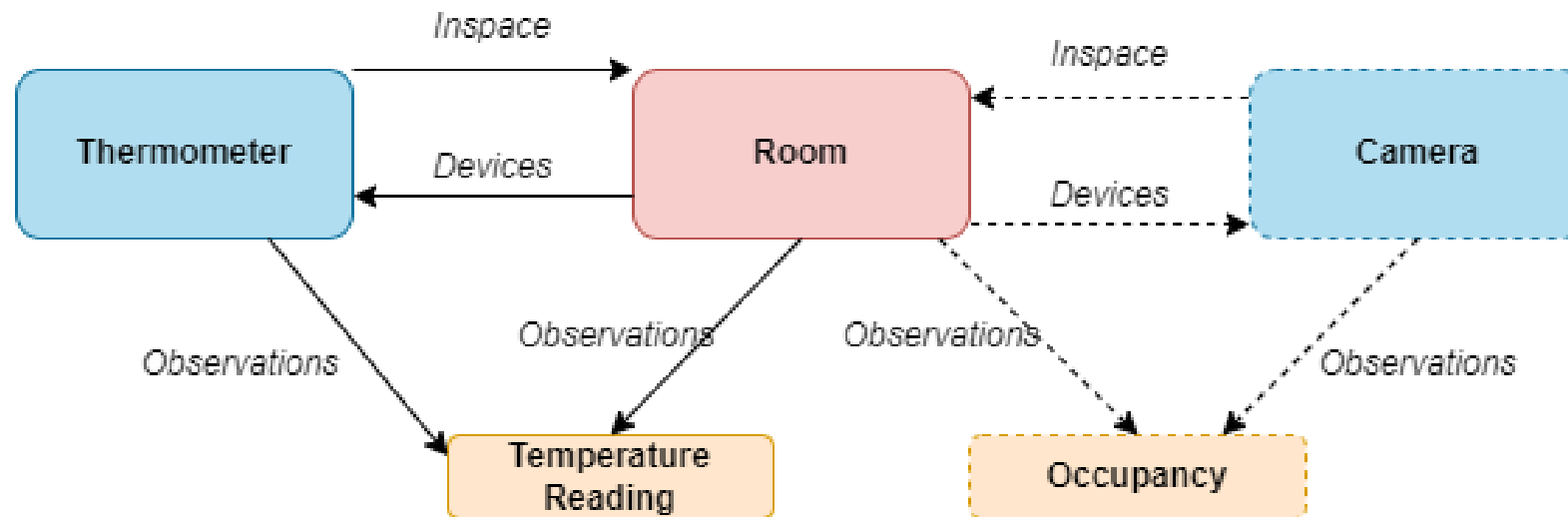
**Observation\_3:**  
**Id:** Obs3  
**Name:** Reading  
**Value:** 65%  
**measurementType:** Humidity

*Get Observations*

**Filter:**  
*measurementType==Humidity*



# Modeling of Devices



# Validation



## *.IFC Data Parser*

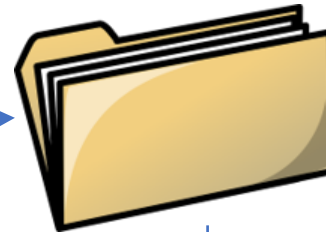
## *NGSI-LD Files/Data*



.IFC

IFC2NGSI-LD  
parser

.ngsi-ld



Visualise



Store on  
NGSI-LD  
Broker

Orion-LD Context  
Broker

perform complex IoT queries

NGSI-LD





# Enabling Dynamic Smart Spaces using IoT-enhanced NGSI-LD Data Models



- Created NGSI-LD models for **static and dynamic properties** of smart buildings, following a decoupling logic of observations from physical properties.
- **A parser** from the IFC file scheme to our data models has also been provided for the ease of generating compatible data from existing large-scale buildings.
- **Validating on Real Open Datasets** and showcased how the NGSI-LD API can be harnessed to handle such information and perform complex IoT queries



/SAMSGBLab/iotspaces-DataModels



/SAMSGBLab/iotspaces-IFC2NGSI-LD\_parser

# The future



What's  
Next?

- ❑ *How can contextual smart building information be used to enhance the design and information processing of smart buildings.*
- ❑ *Examine limitations of current implementations of NGSI-LD compatible middleware*



**Thank you  
for your  
time!**

