Using information from BIM and GIS for automated model creation

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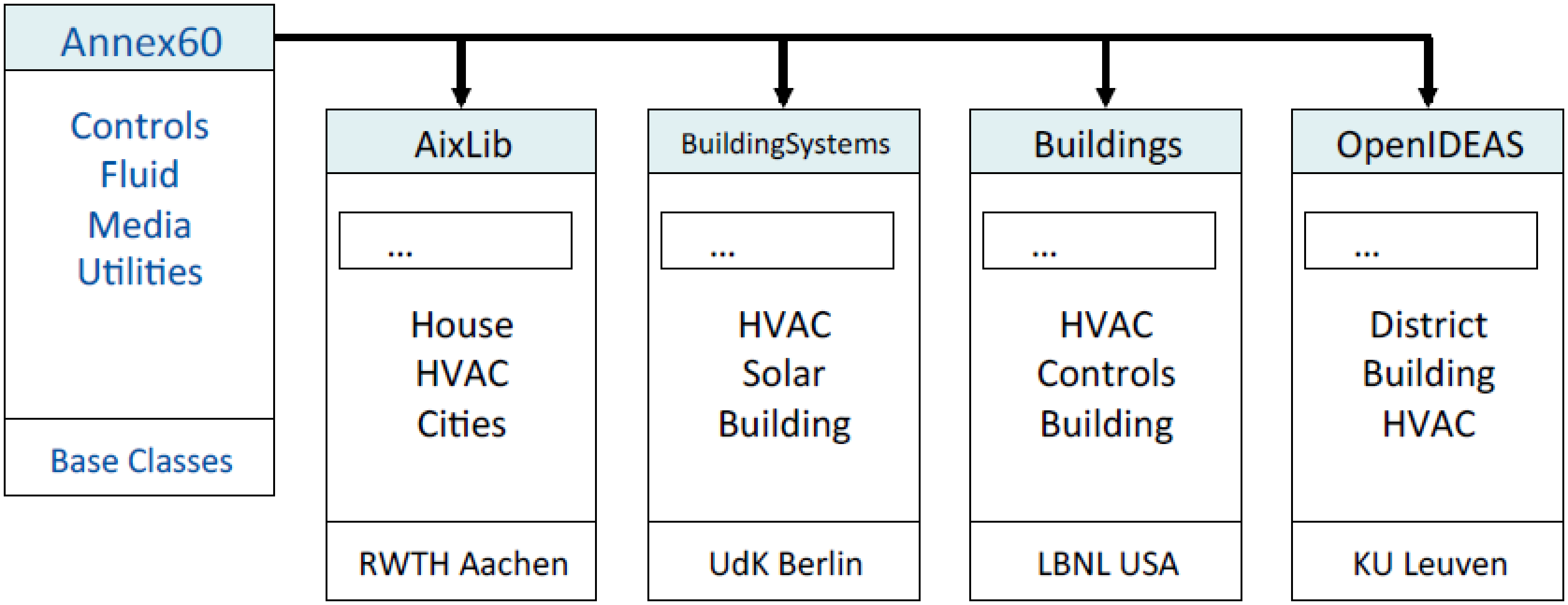
Annex60 Activity 1.1
Modelica Libraries

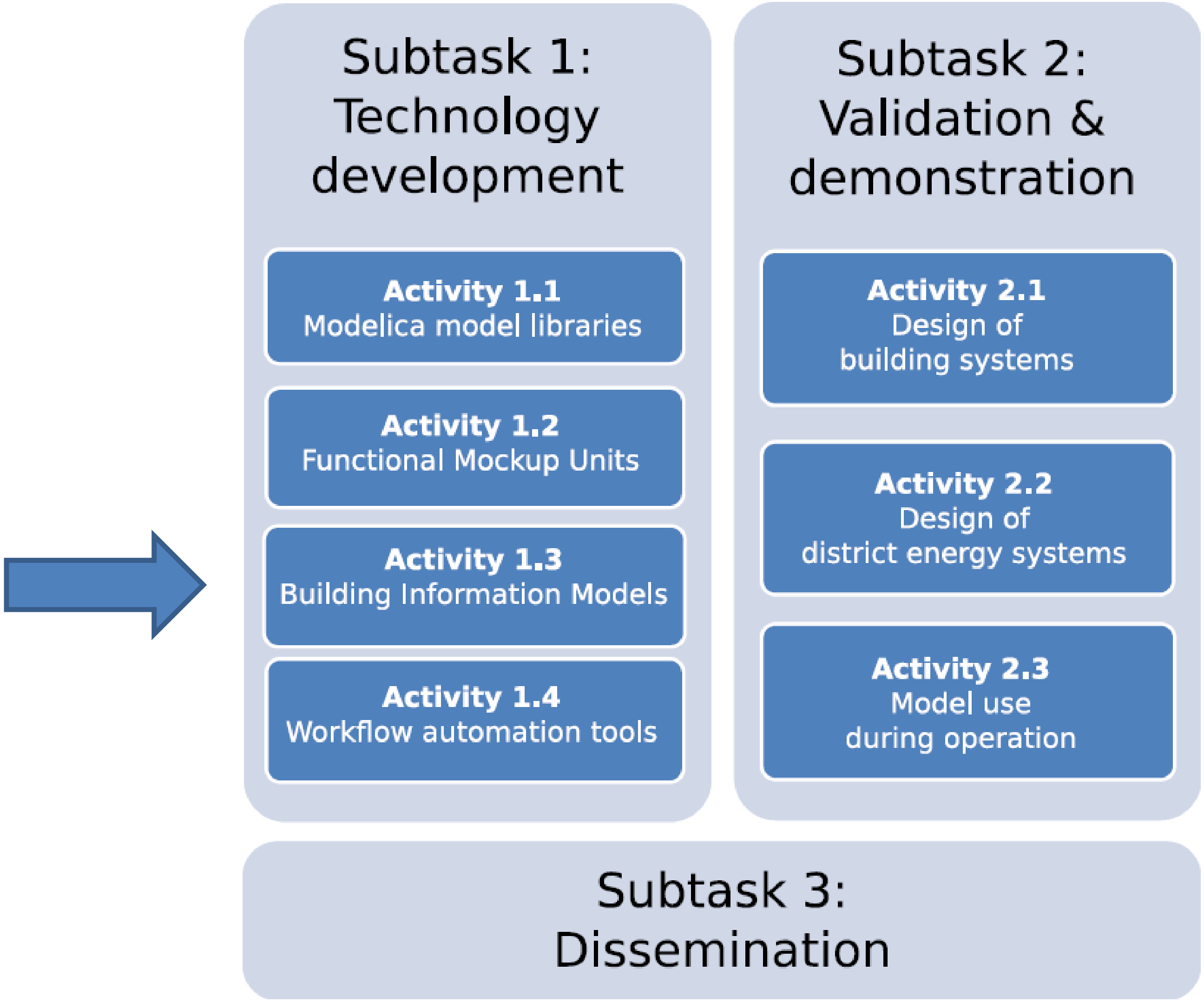


Modelica Libraries: Roles & Actors

- Developer: Write equations of basic models
- User_1: Instantiate & connect & parameterize models to build up a system model
- User_2: Parameterize existing system model & simulate

- Save time by re-using existing information

Annex 60 Activity 1.3



Subtask 1: Technology development

Activity 1.1
Modelica model libraries

Activity 1.2
Functional Mockup Units

Activity 1.3
Building Information Models

Activity 1.4
Workflow automation tools

Subtask 2: Validation & demonstration

Activity 2.1
Design of building systems

Activity 2.2
Design of district energy systems

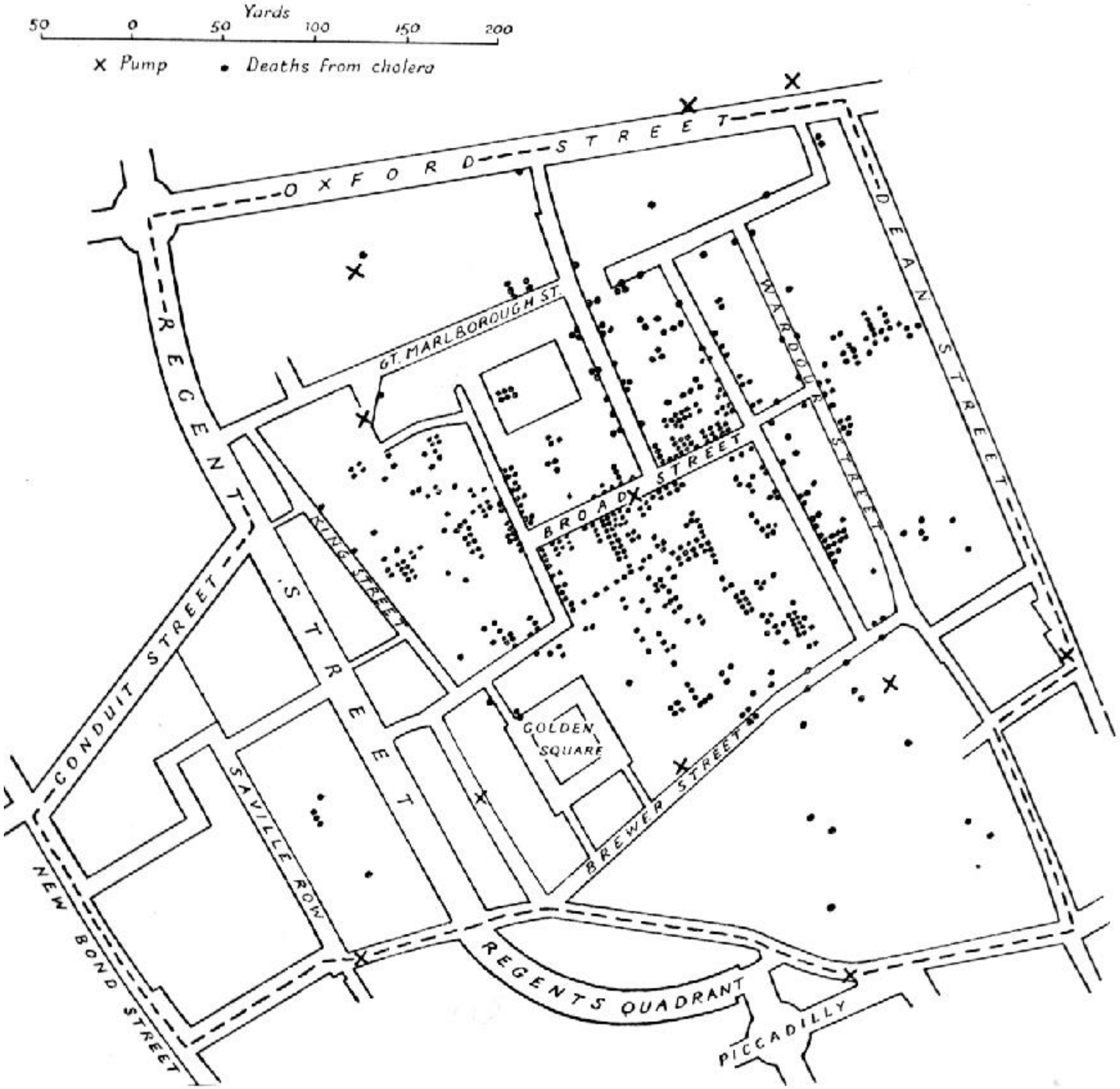
Activity 2.3
Model use during operation

Subtask 3: Dissemination

What is GIS?

- Geographic Information System
- Connect geographic/spatial information with other information
  - Ex1: Start with existing map, add an info layer with e.g. sensor data
  - Ex2: To every photo in your collection add a tag with geo info

First GIS: Cholera & water sources



GIS Applications, Databases, Libraries

- ArcGIS (by Esri ~ 40% market share)
- QGIS (open-source, Python interface)
- GRASS GIS
- PostGIS database
- Leaflet.js visualization library
- OpenLayers visualization library
- …

https://en.wikipedia.org/wiki/Comparison_of_geographic_information_systems_software

GIS File Exchange Formats

- GML
- cityGML
- KML
- Shapefile (ESRI)
- geoJSON
- TopoJSON

https://en.wikipedia.org/wiki/GIS_file_formats

Geography Markup Language

- ISO 19136:2007
- Based on XML
- Primitives:
  - Geometries: Point, LineString, Polygon
  - Feature: physical entity like Building, River, …
  - …
- Profile: define subset of GML

GML application schema

- Application schemas: define the object types and attributes of interest for certain application
- Defined by additional XSD
- Some application schemas:
  - CityGML: for virtual 3D city / regional models
  - Coverages: for e.g. sensor data

CityGML

- Object types:
  - Sites (building, bridges, tunnels)
  - Vegetation
  - Water body
  - …

CityGML Level of detail

- LOD 0 – regional, landscape
- LOD 1 – city, region
- LOD 2 – city districts, projects
- LOD 3 – architectural models (outside), landmarks
- LOD 4 – architectural models (interior)

CityGML Level of detail

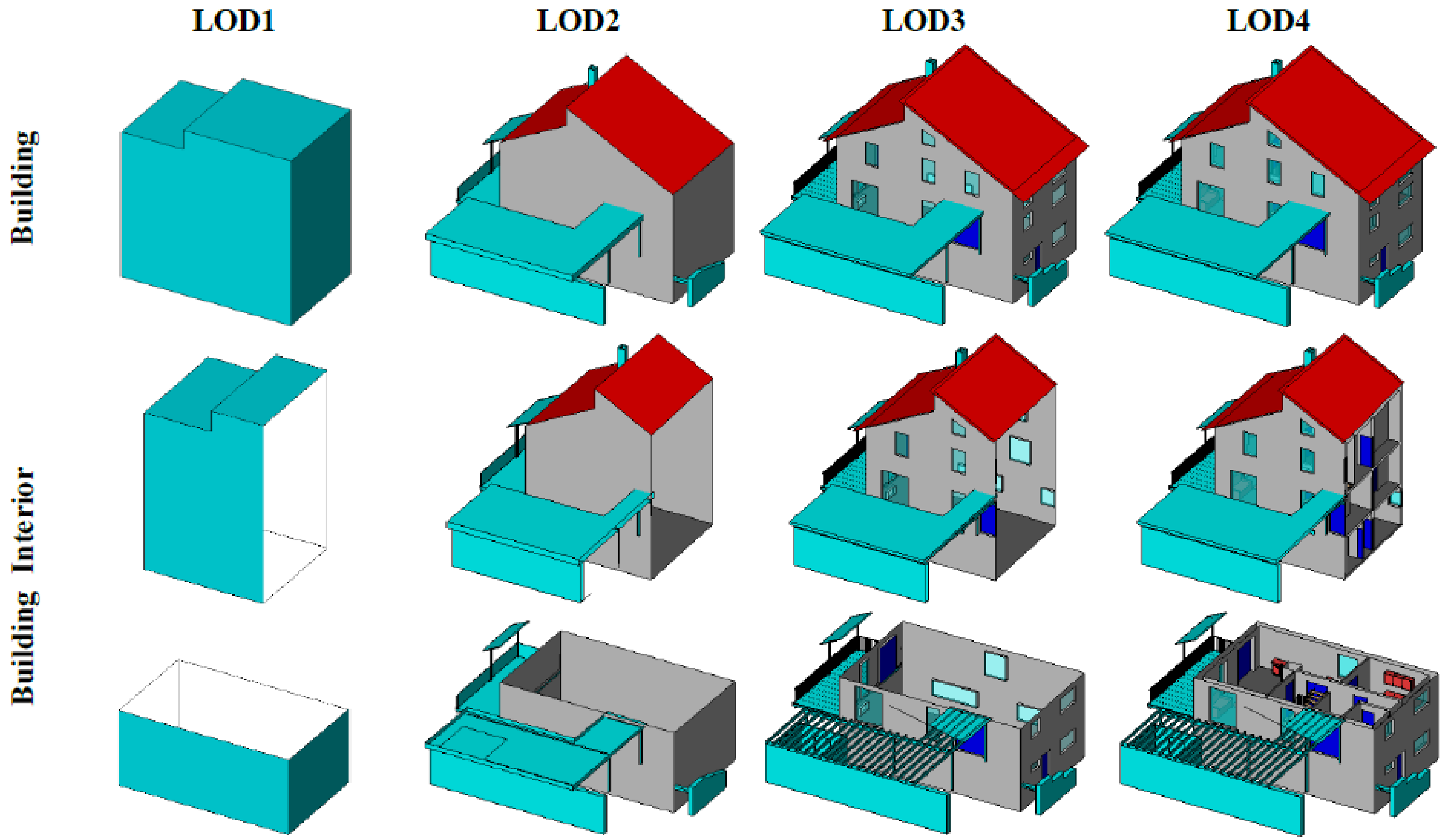


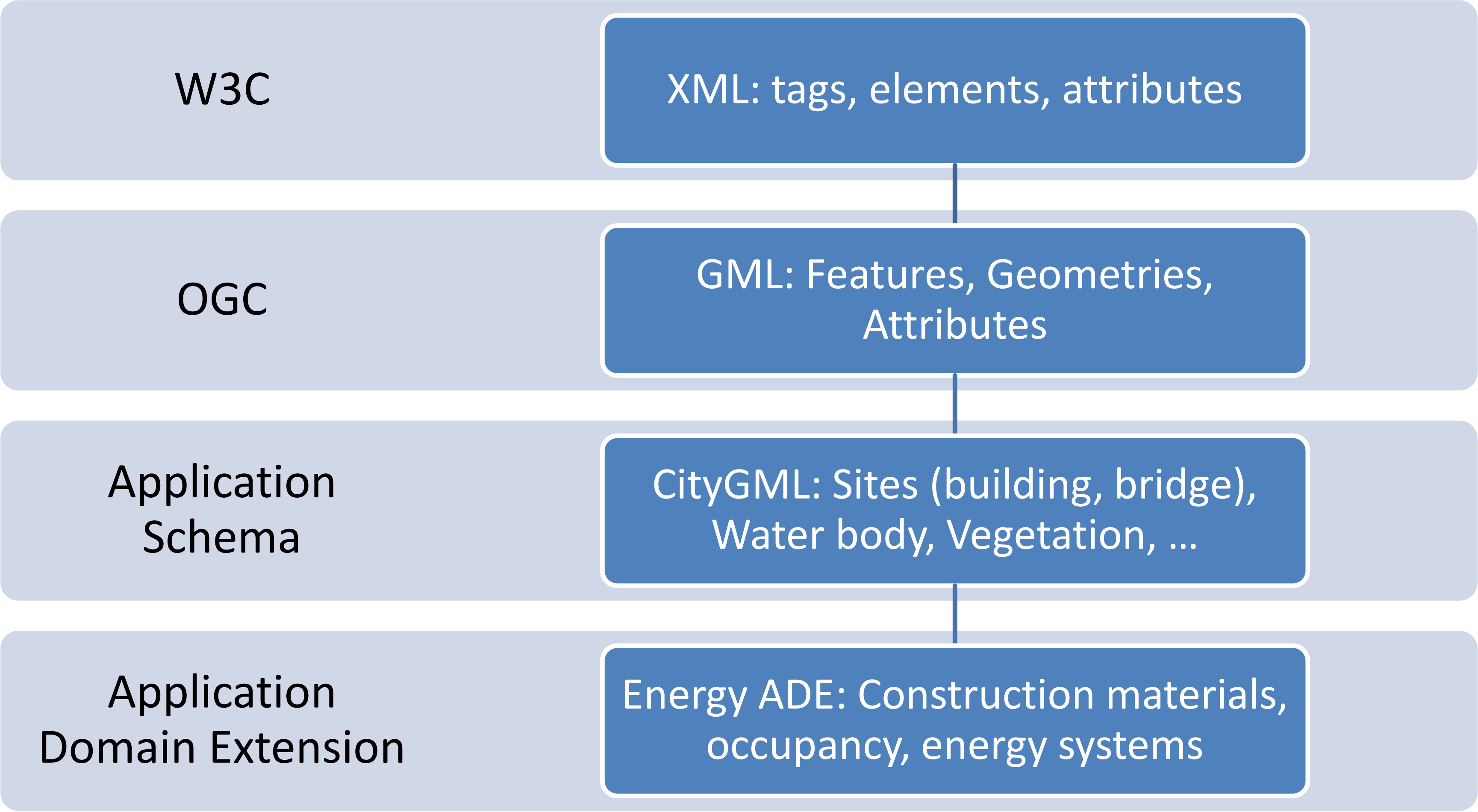
Fig. 30: Building model in LOD1 – LOD4 (source: Karlsruhe Institute of Technology (KIT), courtesy of Franz-Josef Kaiser).

Figure taken from CityGML Encoding standard

CityGML ADE

- ADE = Application Domain Extension
- Extension of CityGML: Define new properties for elements using an additional XSD
- Existing relevant ADEs:
  - Energy ADE https://github.com/cstb/citygml-energy
  - Utility Network ADE
  - GeoBIM ADE (implemented in bimServer.org)
  - http://www.citygmlwiki.org/index.php?title=CityGML-ADEs

Getting specific



W3C

XML: tags, elements, attributes

OGC

GML: Features, Geometries, Attributes

Application Schema

CityGML: Sites (building, bridge), Water body, Vegetation, …

Application Domain Extension

Energy ADE: Construction materials, occupancy, energy systems

Demo CityGML

- Open FZKViewer
- Open Ettenheim LoD3 v0.4.0 example
- Enable the Properties Toolbar (View Menu)
- In the Browser, select a building, look at properties
- Query -> Entity -> CityGML

What is BIM?

- Building Information Modeling
- A general concept to store information that is
  - Multi-disciplinary
  - Consistent, non-redundant, unambigous
  - Regarding the whole lifecycle of a building

Chuck Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. Wiley. 2nd Edition

What is BIM not?

- A certain software tool
- 3D CAD
- Single discipline

Chuck Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston. *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. Wiley. 2nd Edition

BIM Applications

- Autodesk Revit
- ArchiCAD
- Tekla BIMsight
- …
- BIMserver

BIM File Exchange Formats

- IFC: Industry Foundation Classes

- gbXML: green building XML
- DXF: Drawing Exchange Format
- IGES: Initial Graphics Exchange Specification

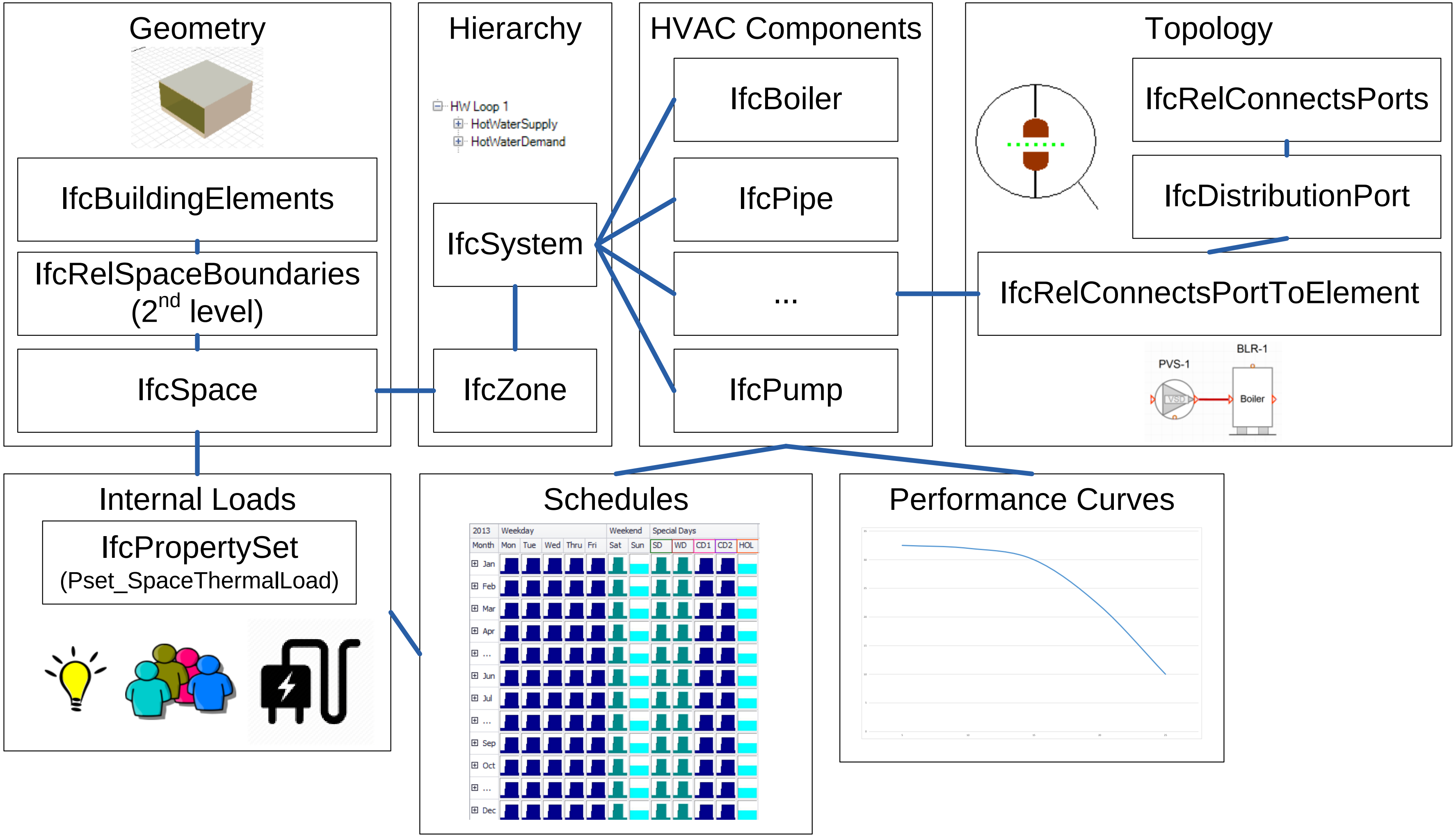
Industry Foundation Classes

- ISO 16739:2013
- Developed by buildingSMART (formerly: IAI)
- IFC-SPF versus IFC-XML
- ifc2x3 (2006/2007) versus ifc4 (2013)

Model View Definition

- No single tool needs everything from IFC
- MVD defines a subset required for a certain use case
- MVD for building performance simulation ?

MVD for BEPS



Geometry

IfcBuildingElements

IfcRelSpaceBoundaries (2nd level)

IfcSpace

Hierarchy

IfcSystem

IfcZone

HVAC Components

IfcBoiler

IfcPipe

...

IfcPump

Topology

IfcRelConnectsPorts

IfcDistributionPort

IfcRelConnectsPortToElement

Internal Loads

IfcPropertySet (Pset_SpaceThermalLoad)

Schedules

Performance Curves

IFC Viewers

- FZK Viewer
- Solibri Model Viewer
- Constructivity Viewer
- http://www.ifcwiki.org/index.php/Free_Software

Other IFC Tools

- Space Boundary Tool
- Solibri Model Checker
- IfcOpenShell-python
  https://github.com/IfcOpenShell/IfcOpenShell
- FreeCAD (with Python interface)
  http://freecadweb.org/

Demo IFC

- Open FZKViewer
- Open 5_BIGboy_ARC+MEP.ifc

Reading data into Modelica

- ModelicaStandardTables
- Weather data reader: Convert TMY3 so that MSL Tables can read it
- Records as Datasheets e.g. Annex60.Fluid.Movers.Data.Pumps.Wilo.StratosXYZ http://markummitchell.github.io/engauge-digitizer/
- ExternData: XML, INI, JSON, Matlab https://github.com/modelica-3rdparty/ExternData

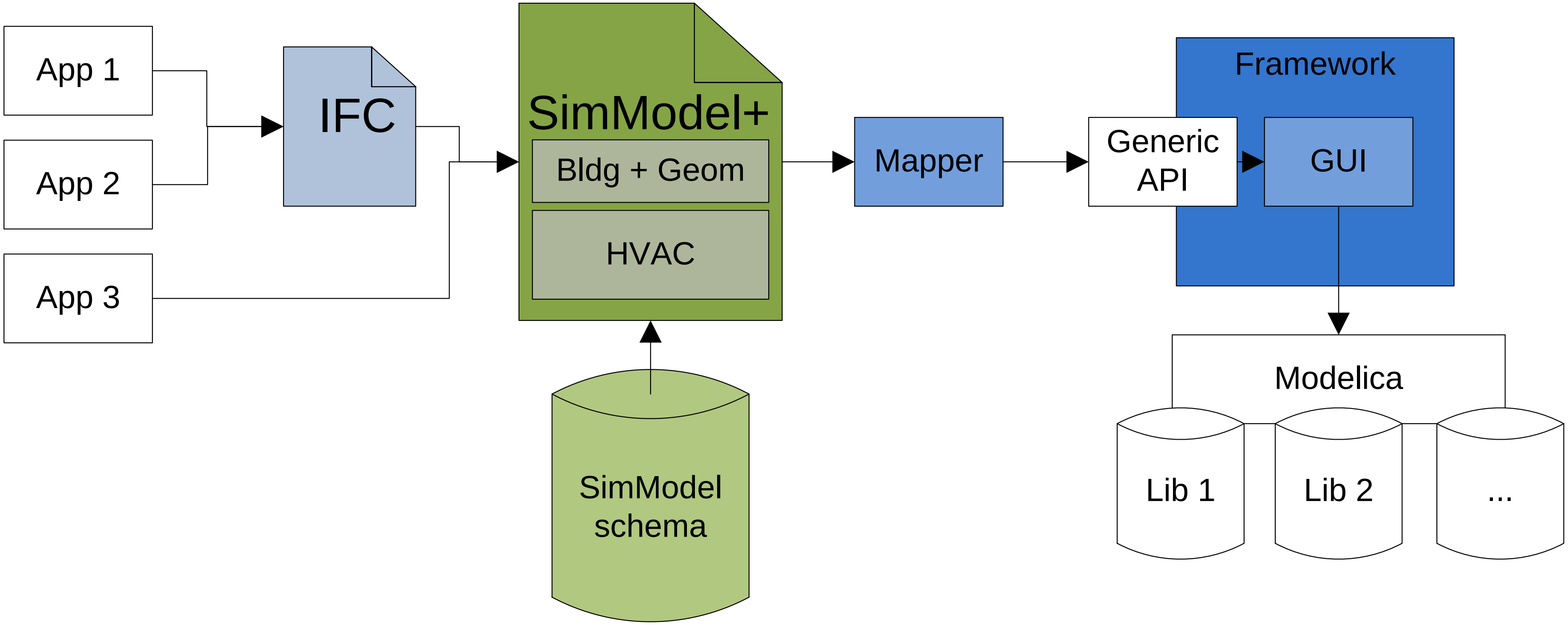
Writing Modelica code

- Read information from file / database
- Process
- print() Statements in Python/C/Java
- Templates
  - TEASER
  - CoTeTo

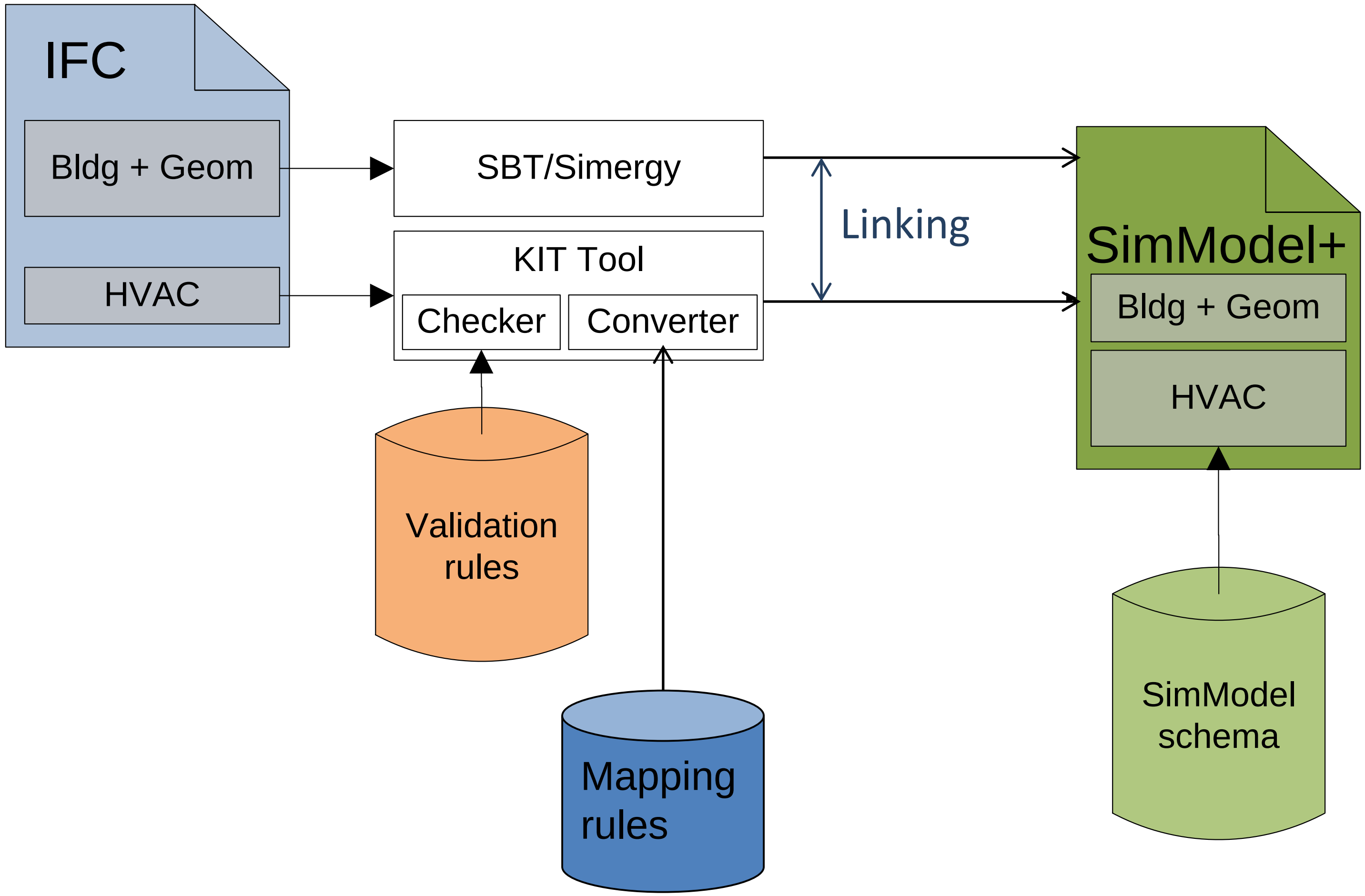
Demo ExternData and CoTeTo

- ExternData: XML
- CoTeTo: Fluid_json

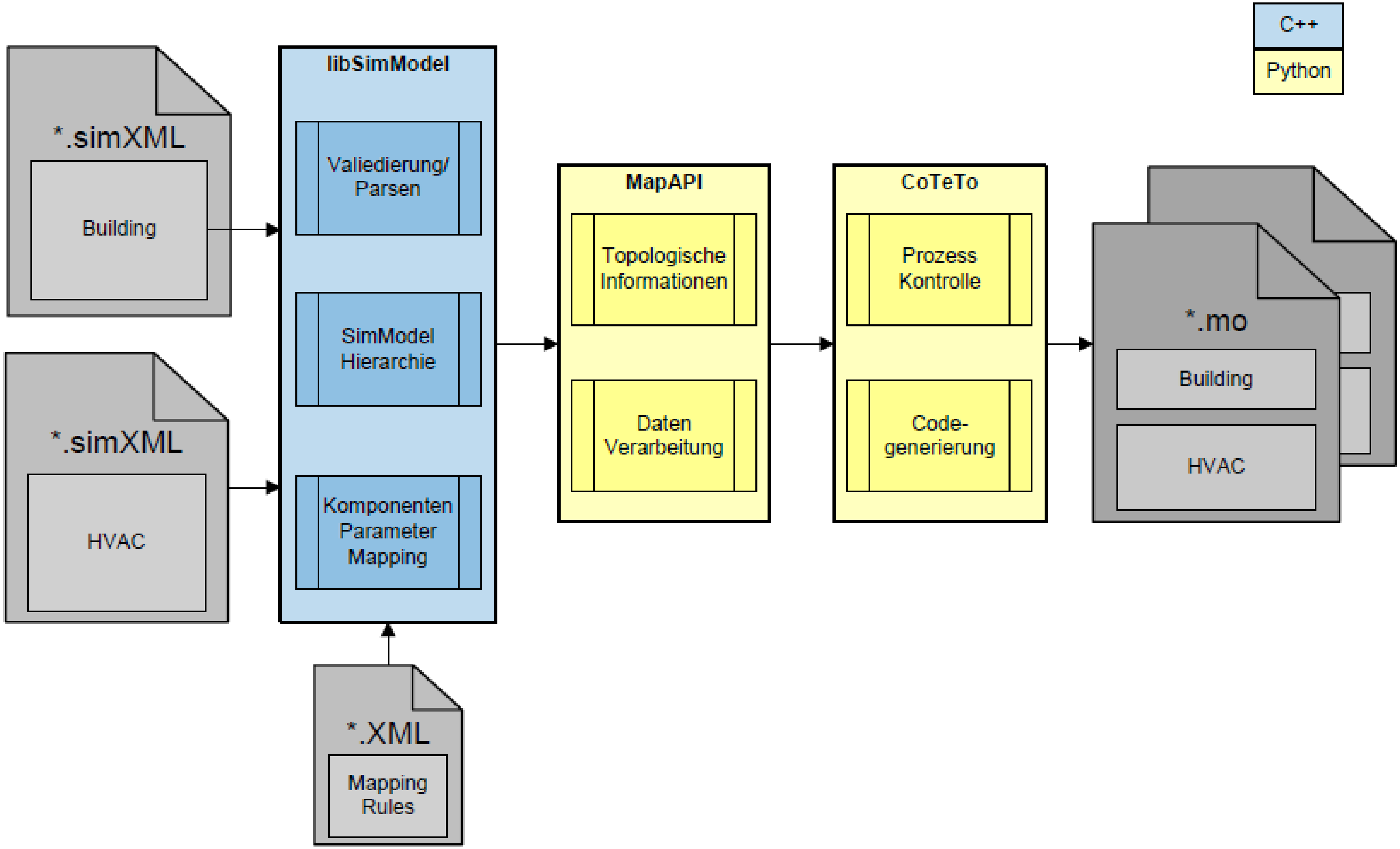
Activity 1.3 general process



IFC -> SimModel



SimModel -> modelica



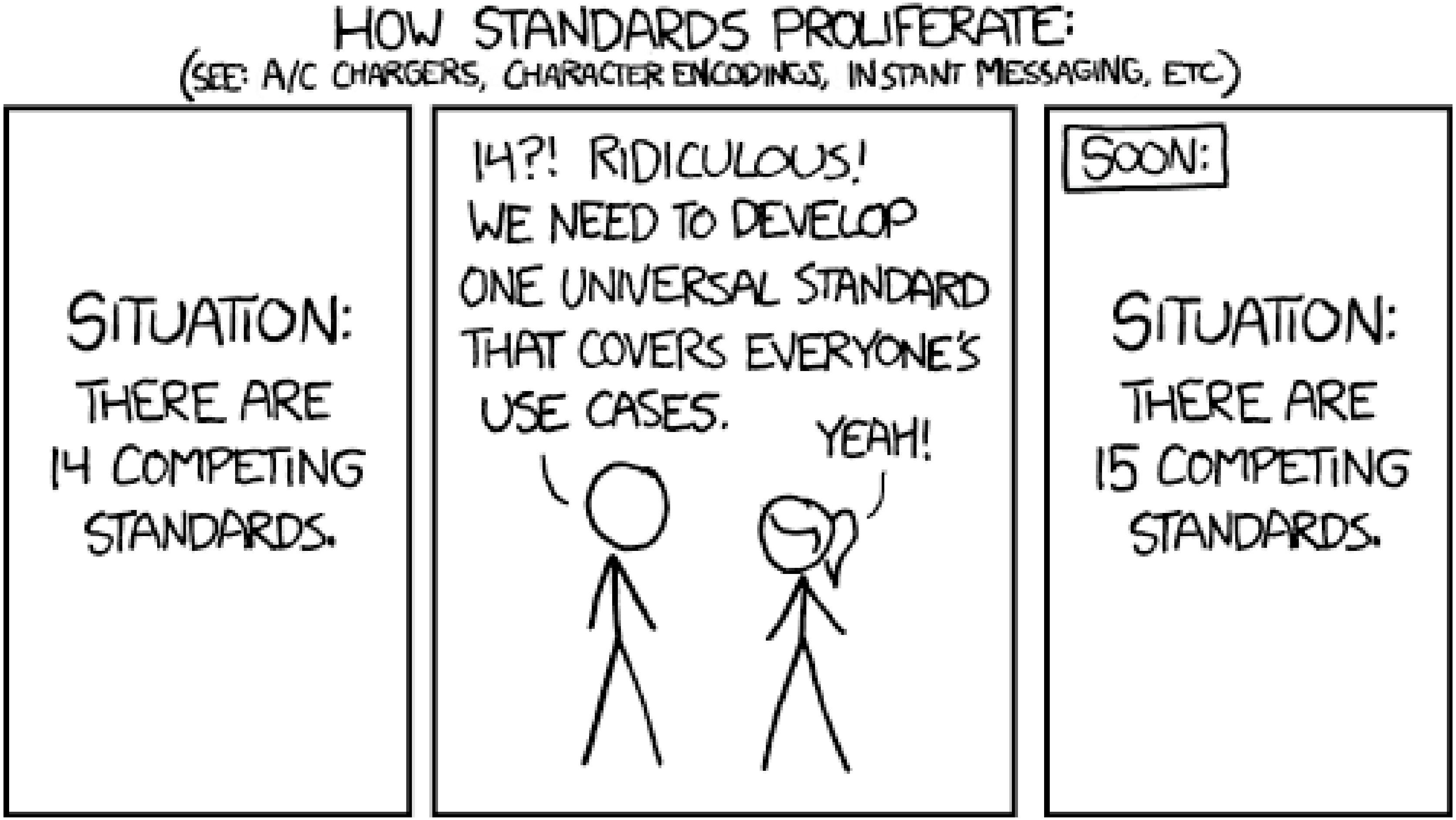
Lessons learned

- IFC2x3 versus 4, Step versus XML
  - HVAC components, parsing the file
- Material Name, Material Properties
  - Dictionaries to translate or
  - PropertySets as defined by MVD
- Vendor catalogues
  - Currently developed as ISO 16757

Summary

- Re-use existing information
- Re-use existing standards and tools

- Parameterize existing models:
  - ModelicaStandardTables
  - JSON, INI, XML + ExternData
- Instantiate models+topology:
  - Read info to Python and process
  - Print out using templating engine


HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)
SITUATION: THERE ARE 14 COMPETING STANDARDS.
14?! RIDICULOUS! WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.
YEAH!
SOON:
SITUATION: THERE ARE 15 COMPETING STANDARDS.

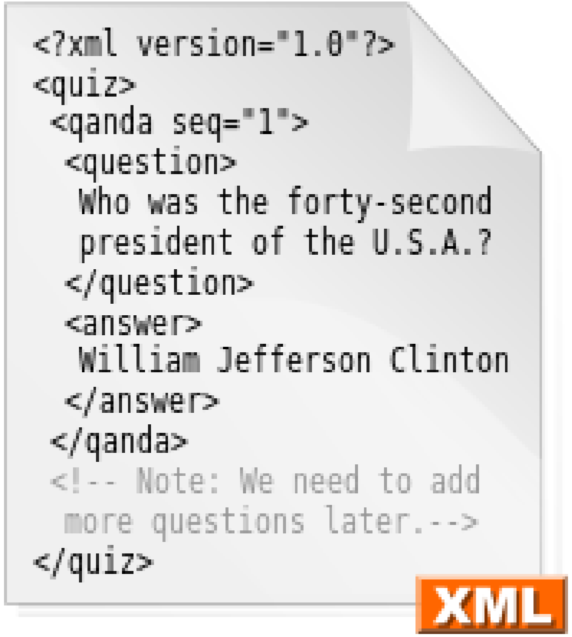
File Formats

- Text: IDF, INI
- XML: ifcXML, gbXML, SimXML, CityGML
- Step: ifc2x3
- JSON: geoJSON, TopoJSON
- CSV, mat, hdf5, epw, TMY3, netCDF, …

- Databases

XML and XSD

- XML: Extensible Markup Language
- Schema: elements and attributes
- Schema definition language
  - DTD: Document Type Definition
  - XSD: XML Schema Definition
  - Relax NG
  - Schematron



```
<?xml version="1.0"?>
<quiz>
 <qanda seq="1">
  <question>
   Who was the forty-second
   president of the U.S.A.?
  </question>
  <answer>
   William Jefferson Clinton
  </answer>
 </qanda>
 <!-- Note: We need to add
  more questions later.-->
</quiz>
```

XSD other use cases

- Validate XML file
- Create database that mirrors XML file structure
- Create UML diagram to visualize data structure