UPDATES FROM PROJECT INTEGRCITY:

FIRST STEPS TOWARDS LINKING SEMANTIC 3D CITY MODELLING AND MULTI-DOMAIN CO-SIMULATION FOR ENERGY MODELLING AT URBAN SCALE

Edmund Widl, Giorgio Agugiaro, Pablo Puerto

Delft, 7 December 2018

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Outline

- A few words about project IntegrCiTy
- Semantic 3D city models
- Multi-domain co-simulation
- Linking the two worlds
- Conclusions

Project IntegrCiTy

Decision-support environment for planning and integrating multi-energy networks and low-carbon resources in cities

Framework: JPI Urban Europe, ENSCC Call

Durantion: 2016-2019

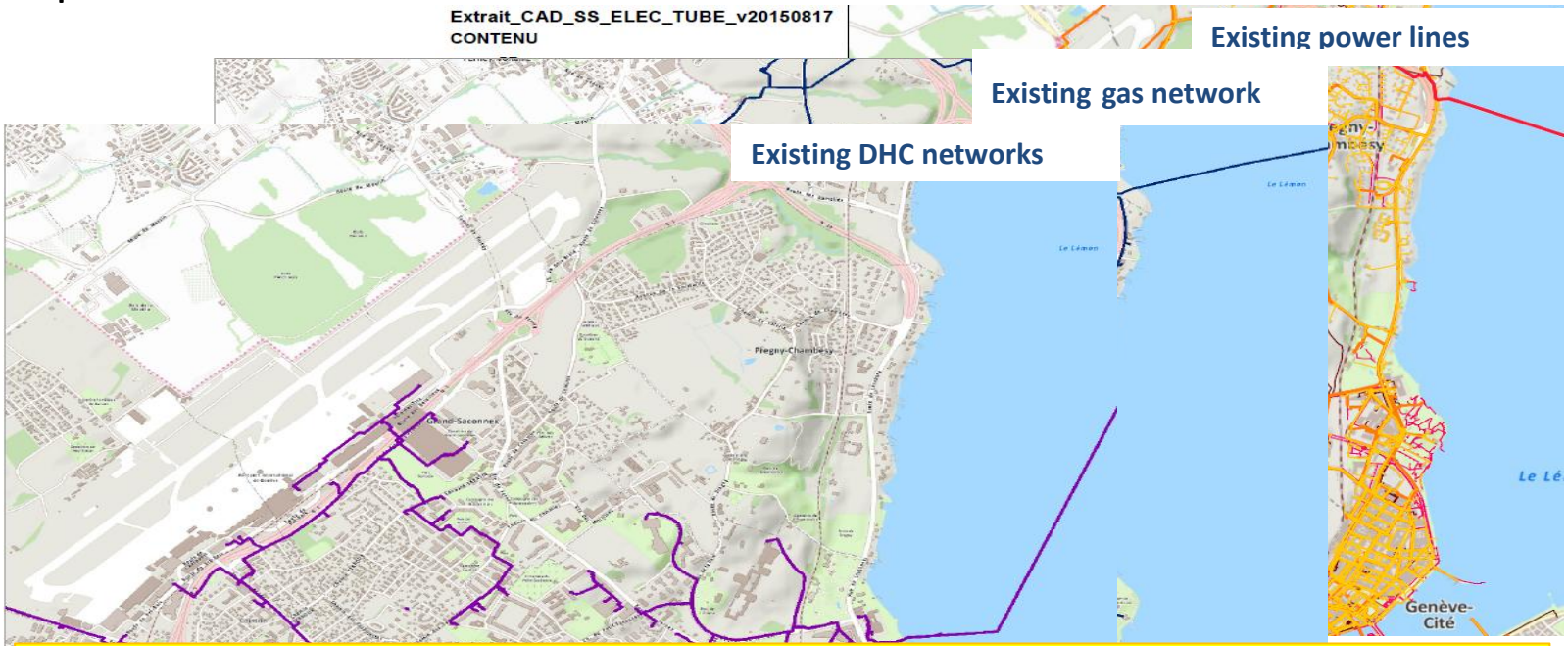
Members:

- 17 partners in Switzerland, Austria, Sweden
- 3 cities: Stockholm (S), Vevey (CH), Geneva (CH)

Homepage: http://iese.heig-vd.ch/projets/integrcity

Project IntegrCiTy

Energy networks in cities are still planned, built, operated and optimized in silo-like fashion



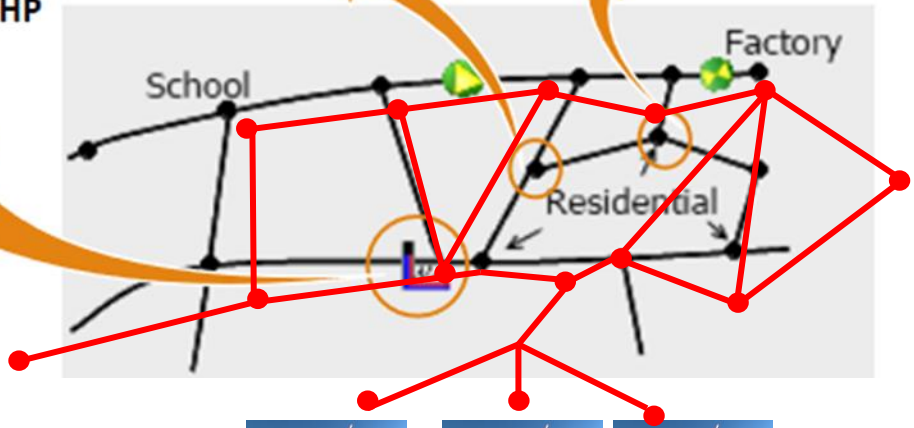
Interoperability *and* ***synergies*** *among existing and future* ***energy infrastructures****, through integrated modelling and multi-network simulation*

Project IntegrCiTy

Air HP

Geothermal HP

HPs/CHP



- District heating network
- Electrical network

Image: http://iese.heig-vd.ch/projets/integrcity

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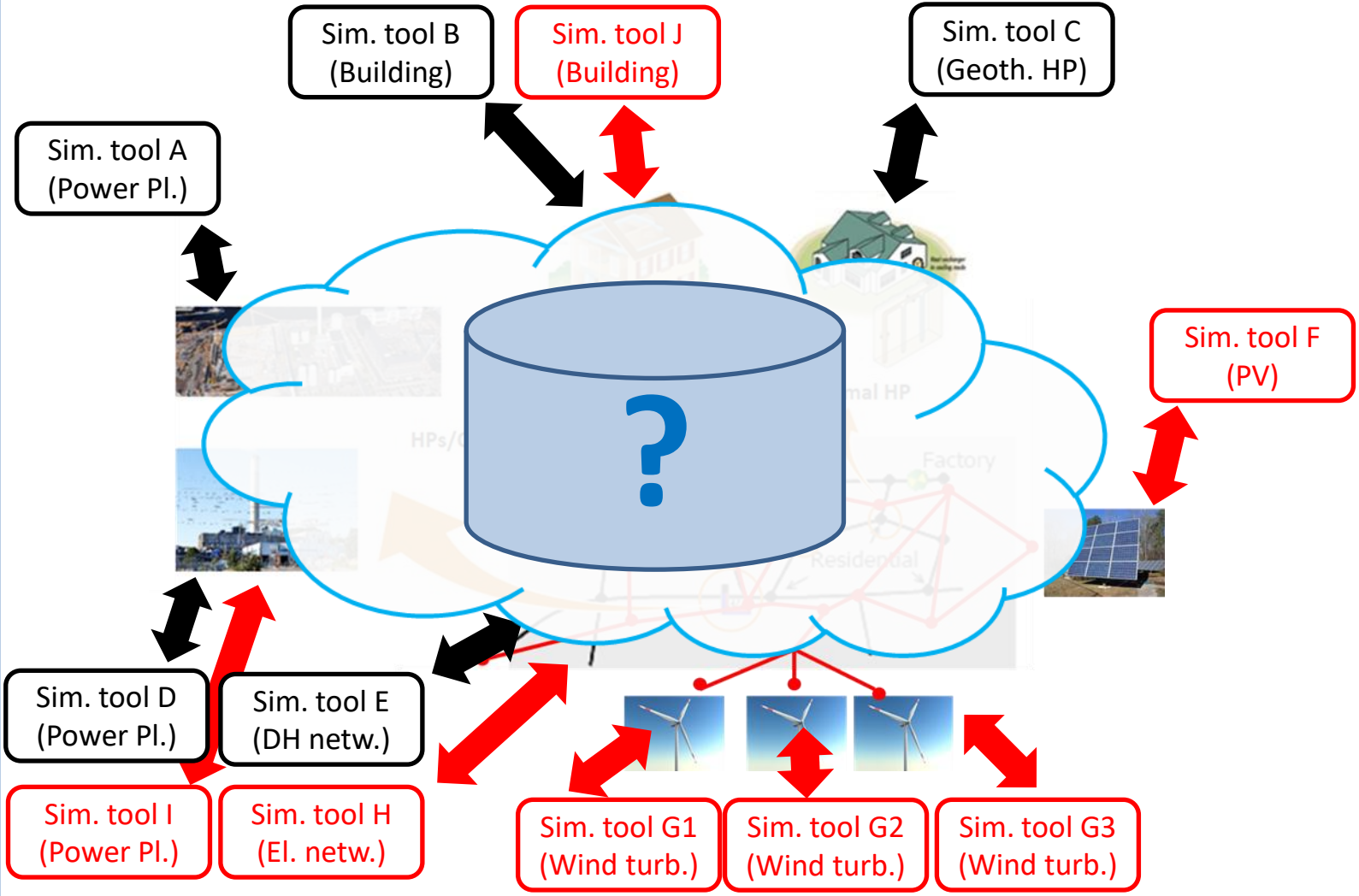
Semantic 3D city models

Multi-domain co-simulation

Linking the two worlds

Conclusions and outlook



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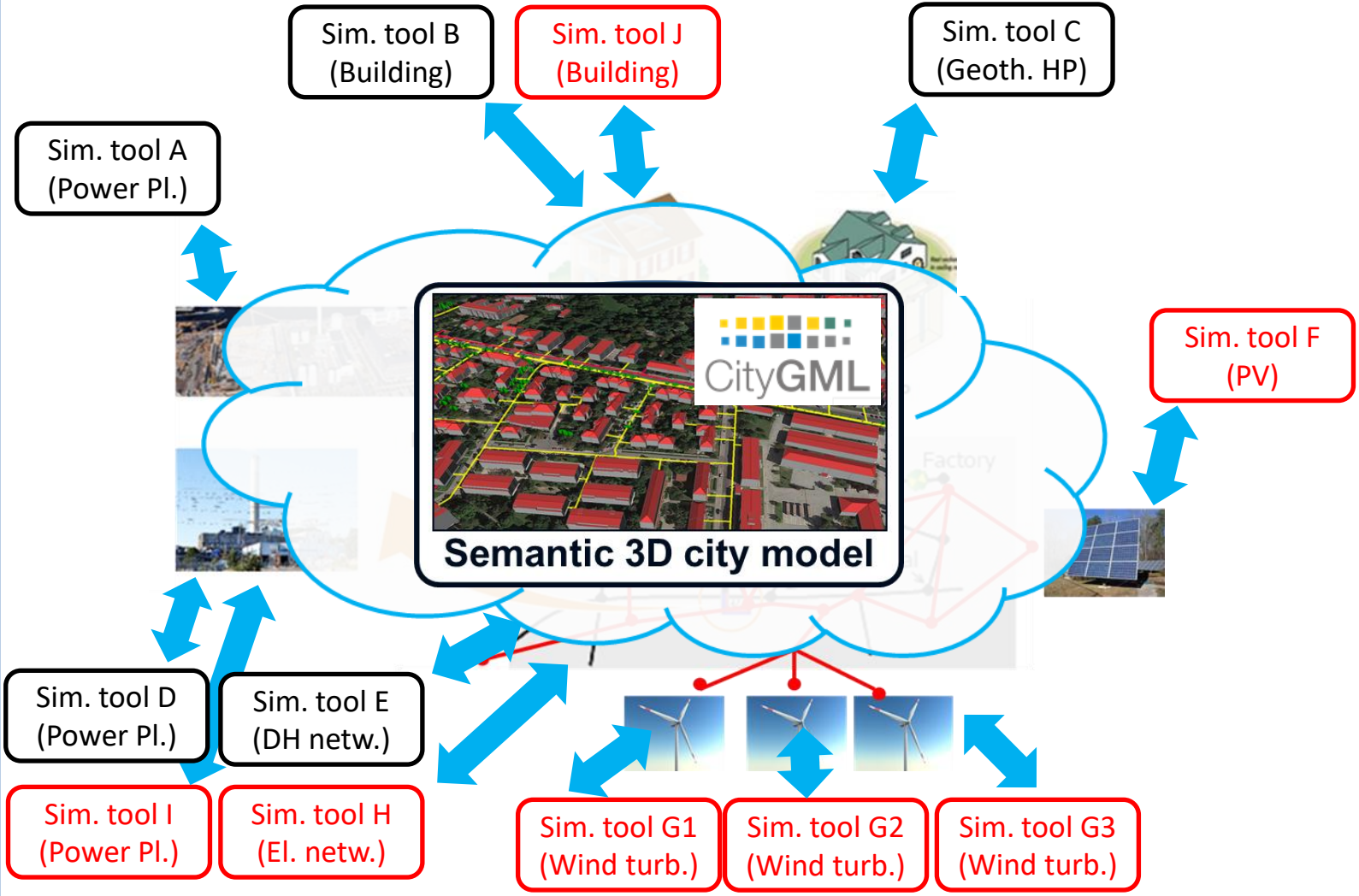

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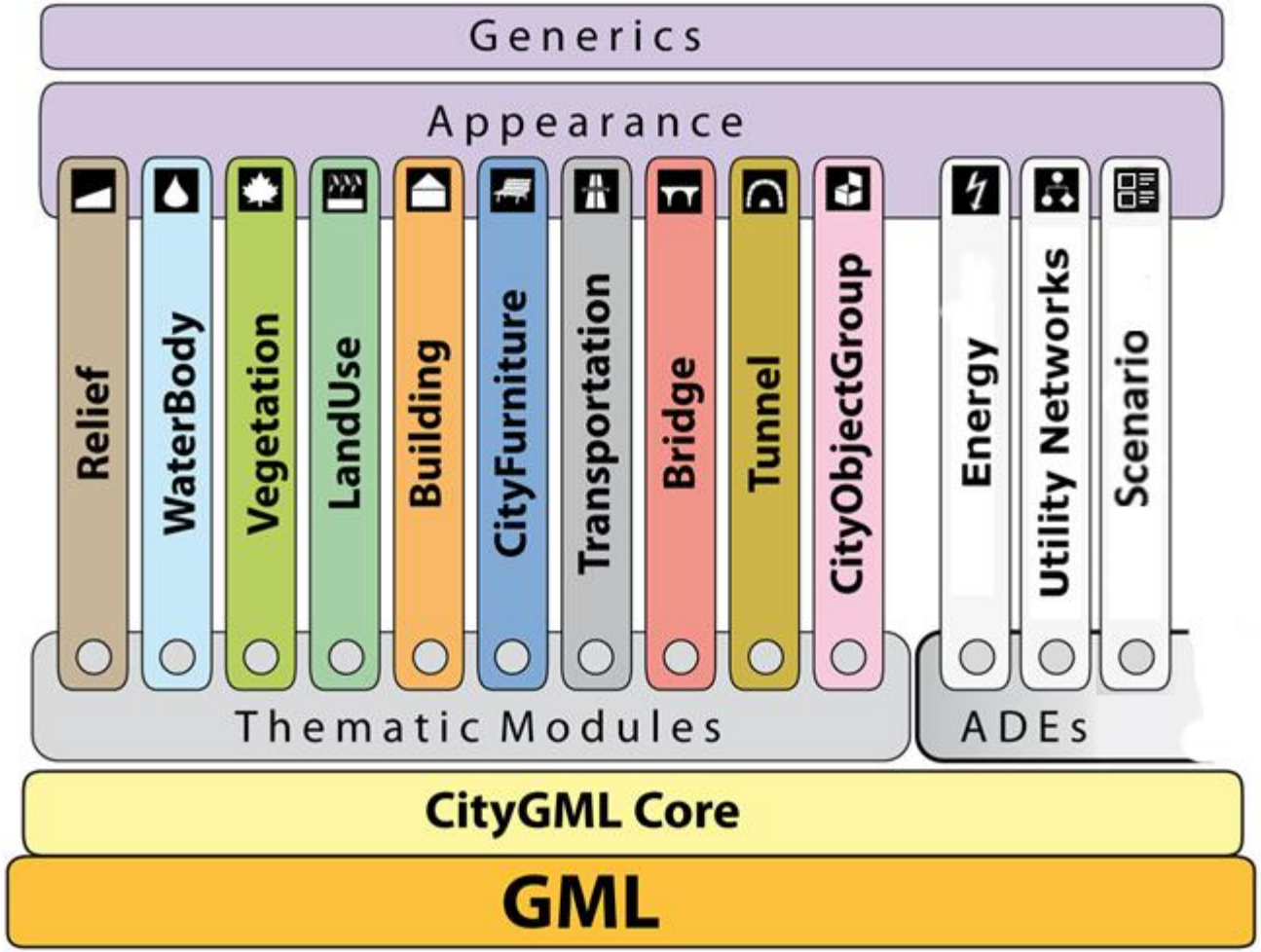
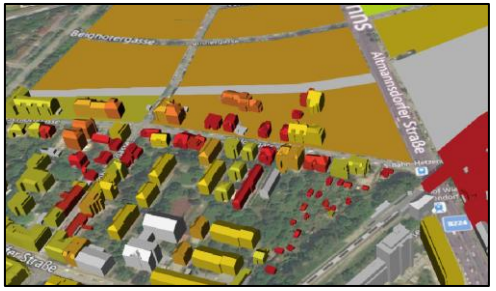


Image source: virtualcitySYSTEMS

Extending CityGML: ADEs

- **Energy ADE**
  - Defines standardised entities needed for building energy simulation and data management purposes at city scale



- **Utility Network ADE**
  - Defines standardised entities needed for utility networks (district heating, gas, power grid, etc.)

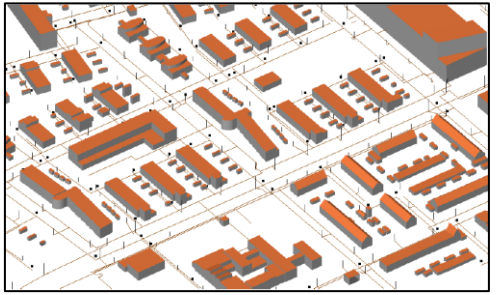
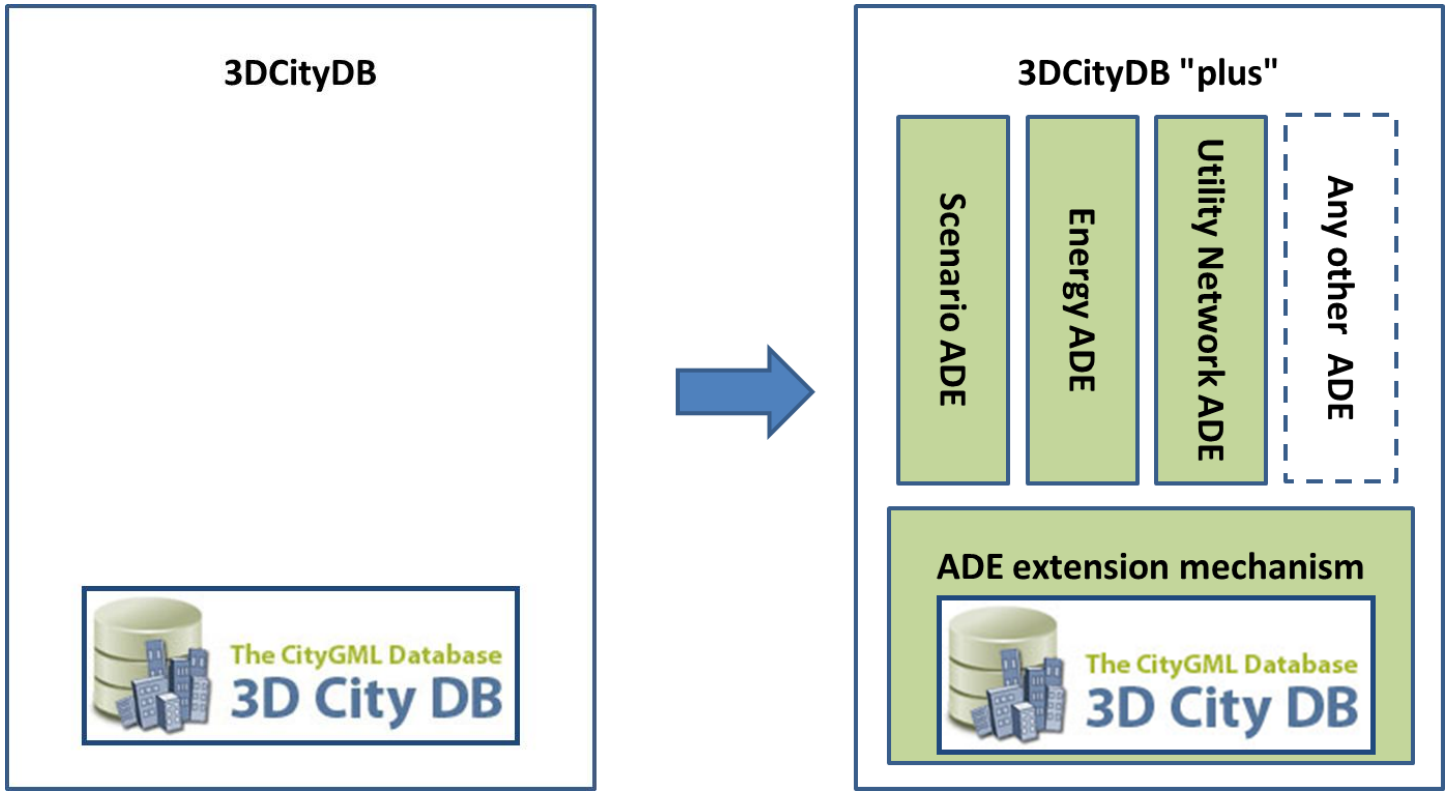


Image source: Den Duijn (2018)

- **Scenario ADE**
  - https://en.wiki.utilitynetworks.sig3d.org/images/upload/20171207_Agugiaro_Scenario_ADE_0.2.pdf

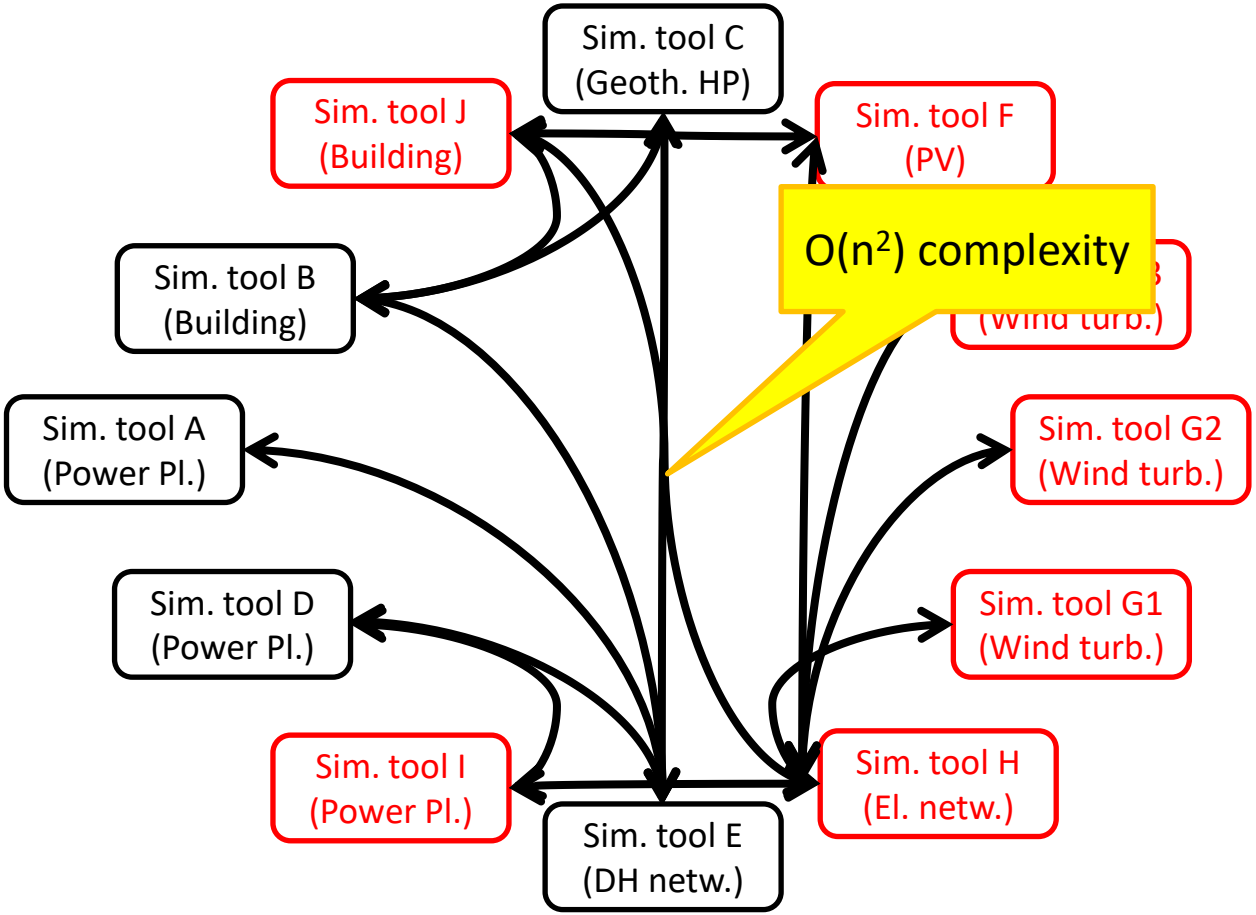
Schüler, N., Agugiaro, G., Cajot, S., Marechal, F., 2018
Linking interactive optimisation for urban planning with semantic 3D city models.
ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4, pp. 179-186.

Extending the 3D City Database



https://github.com/gioagu

Connecting the simulation tools



Today: simulation of energy sub-systems

- Many different **energy-related domains**
  - generation, distribution, storage, HVAC, thermal networks, power electronics, controls, etc.
- Many different **expert tools**
  - lots of *dedicated simulators* available for each domain
  - includes massive amount of expert *experience*
- Domains are **typically treated separately**
  - focus on *components*, not systems
  - *simplifying* models
  - *incompatible* tools

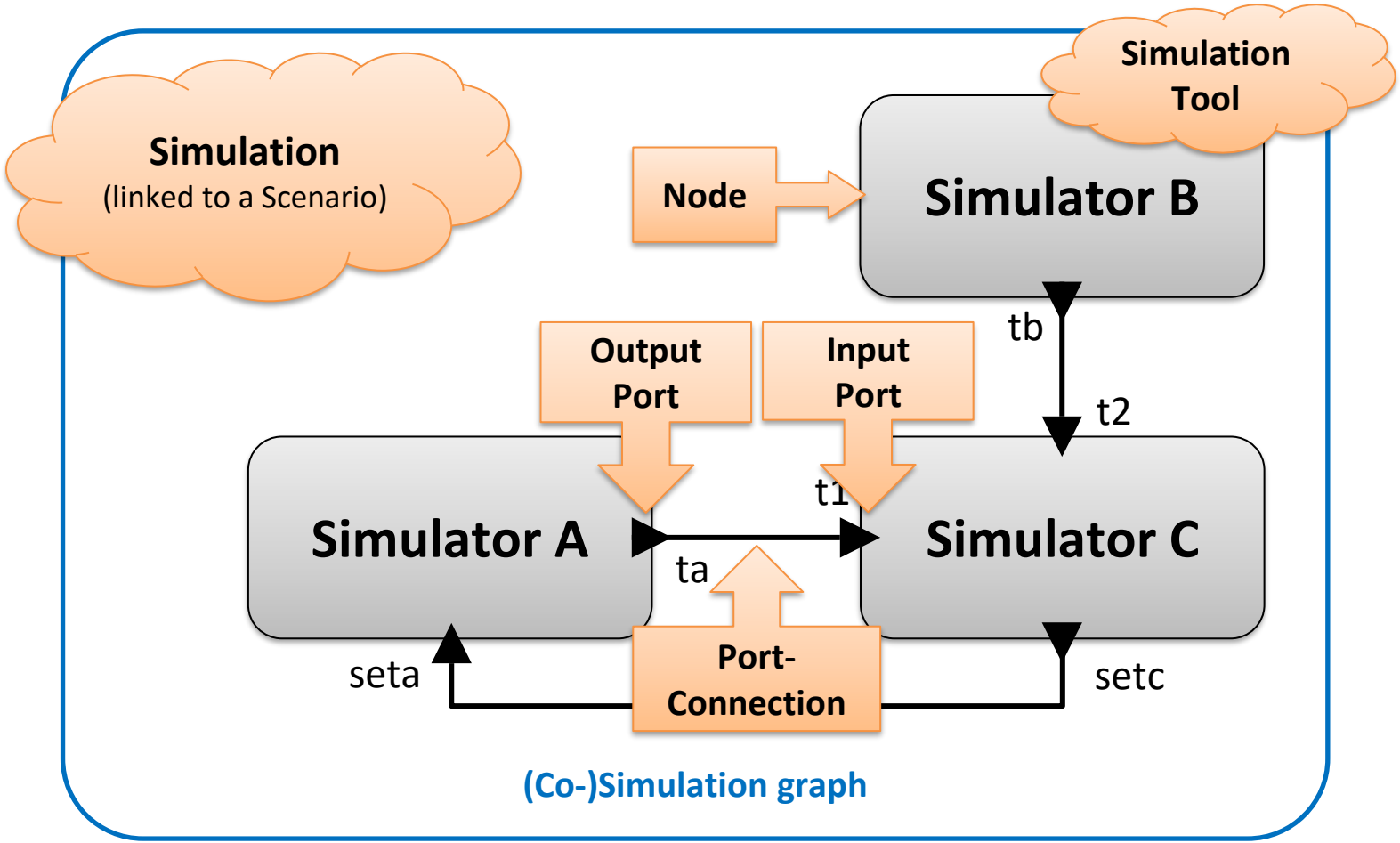
"Tomorrow": Co-simulation of multi-domain energy systems

- Biggest advantage is **modularity**
  - use *best available tool* for modeling and simulation of sub-system
  - modelers of different domains can *continue* using their *own tools*

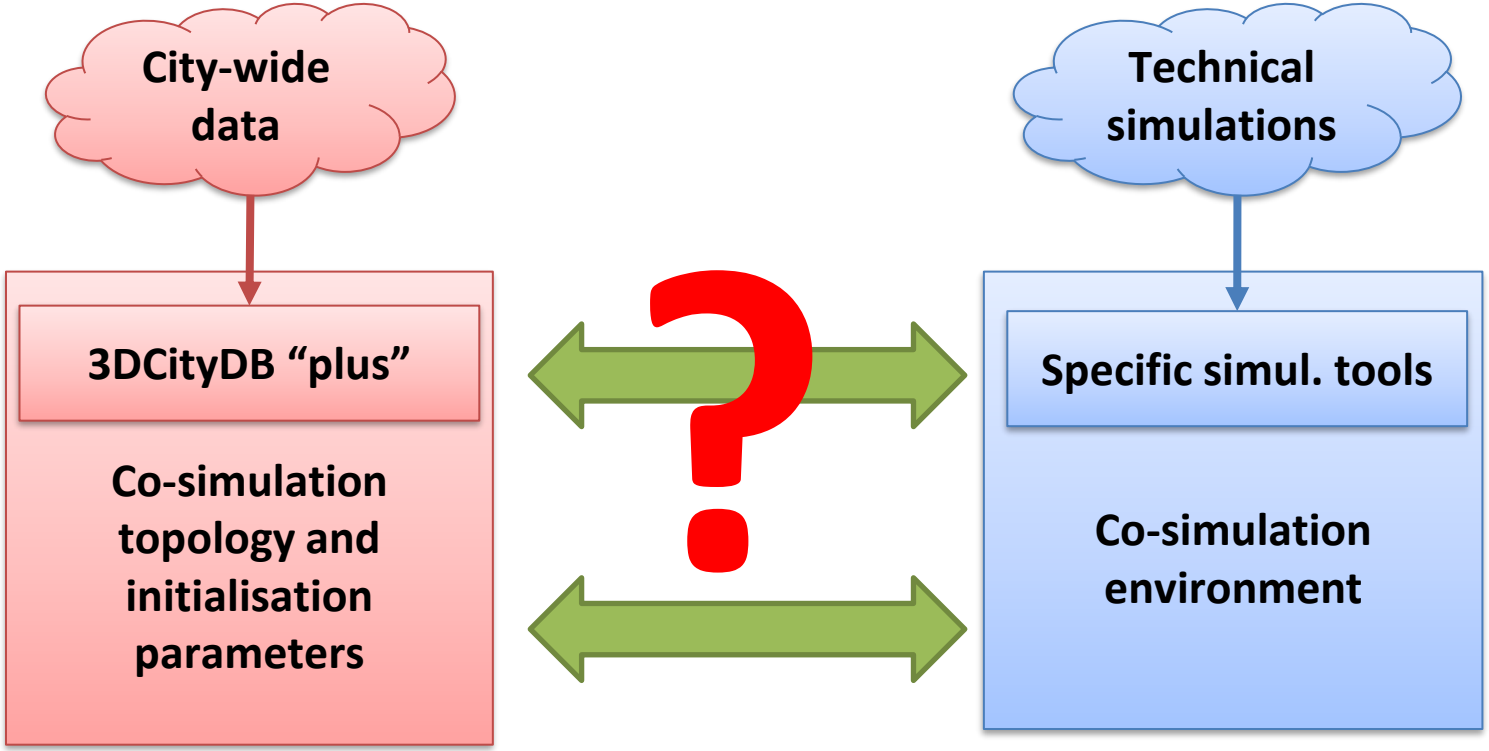
- Two **main challenges**
  - *interfacing* of models/applications
    - data access, start/resume/stop execution of model, etc.
  - *orchestration* of simulation components during runtime
    - synchronization of models/applications, data flow, parallelization, etc.

From $O(n^2)$ down to $O(n)$ complexity!

Example of co-simulation setup



How to link the two worlds?



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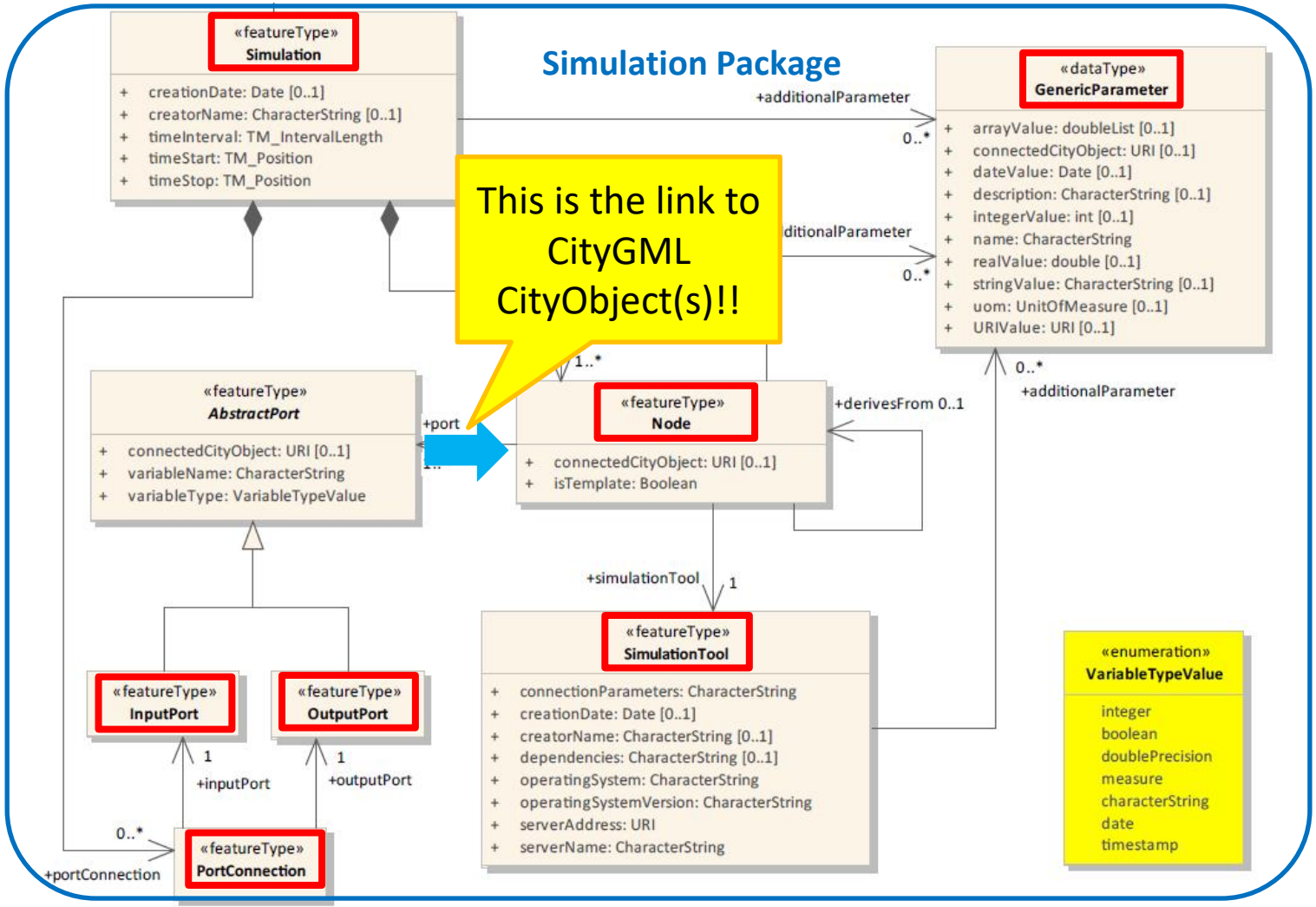


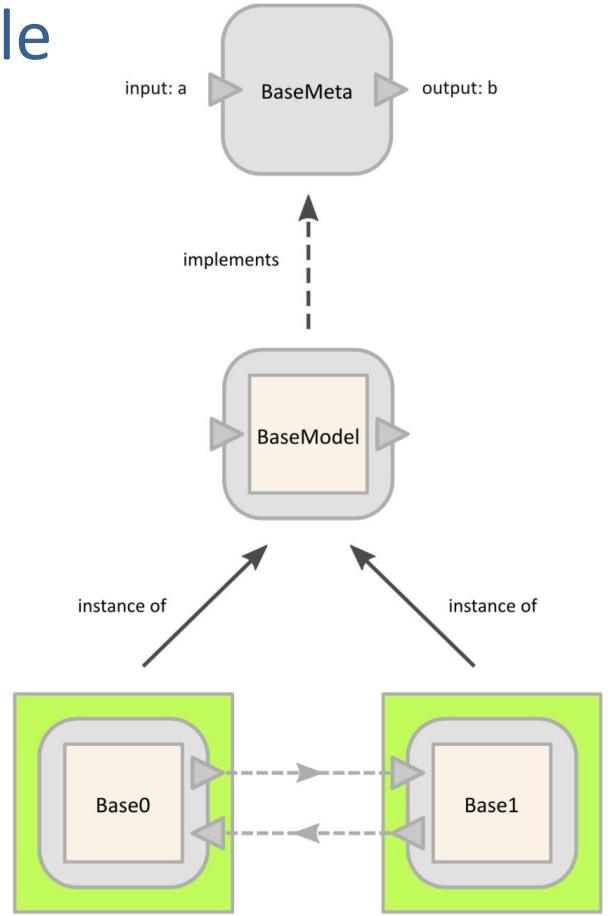
Implementation

- **Simulation Package**
  - Data model implemented for 3DCityDB (for PostgreSQL)
  - Database schema + set of stored procedures
  - Application-independent implementation!

- For IntegrCiTy: **OBNL** (OBvious Node Link co-simulator)
  - Light-weight co-simulation orchestrator (dev. @ HES-SO)
  - Open-source, Python package, works also with Docker

  - **Mapping** between OBNL and the Simulation Package
  - Additional **data access layer** (using SQLAlchemy) to facilitate the link between OBNL and the extended 3DCityDB

Example




```python
from ictdeploy import Simulator
# Create simulation.
sim = Simulator()
# Create meta-model.
sim.edit.add_meta(
  name='BaseMeta', set_attrs=['a'], get_attrs=['b']
)
# Create model.
sim.edit.add_model(
  name='BaseModel', meta='BaseMeta', ...
)
# Add nodes.
sim.edit.add_node(
  name='Base0', model='BaseModel',
  init_values={'c': 0.5}, ...
)
sim.edit.add_node(
  name='Base1', model='BaseModel',
  init_values={'c': 0.25}, ...
)
# Add links.
sim.edit.add_link(
  get_node='Base0', get_attr='b',
  set_node='Base1', set_attr='a'
)
sim.edit.add_link(
  get_node='Base1', get_attr='b',
  set_node='Base0', set_attr='a'
)
```

Widl, E., Agugiaro, G., Puerto, P., 2018,
First steps towards linking semantic 3D city modelling and multi-domain co-simulation for urban energy modelling at urban scale.
ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4, pp. 227-234.

Proposed workflow

Initialization

- retrieve initial conditions, model parameters, time series, etc.
- select or generate individual simulation models
- define co-simulation graph (nodes, links, etc.) and schedule

(Co-) Simulation

- run simulation
- no interaction with CityGML database needed (no storage of intermediate results)

Data post-processing

- retrieve selected simulation results

- semantic representation of data
- store / retrieve scenarios

- store data (incl. semantic relations)
- use a format that is usable for visualization

(Extended) 3DCityDB

Conclusions and outlook

- Initial work to bridge the gap between “GIS” and “technical-simulations” worlds
- **Simulation Package** models and stores meta-information for simulation or co-simulation
  - For simulation tools: configuration, initialization parameters, etc.
  - For co-simulation: additional information for coupling and orchestration
- Currently implemented in project **IntegrCiTy**, but…
- …developed tools are **generic and flexible** enough to be used also in other contexts
  - *Intentional* open development: test and give (constructive) feedback!

Thank you for your attention

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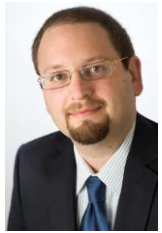

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