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

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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

Duration: 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

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Semantic 3D city models
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Linking the two worlds
Conclusions and outlook

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

- District heating network
- Electrical network
Outline

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Sim. tool A (Power Pl.)
Sim. tool B (Building)
Sim. tool C (Geoth. HP)
Sim. tool D (Power Pl.)
Sim. tool E (DH netw.)
Sim. tool F (PV)
Sim. tool G1 (Wind turb.)
Sim. tool G2 (Wind turb.)
Sim. tool G3 (Wind turb.)
Sim. tool H (El. netw.)
Sim. tool I (Power Pl.)
Sim. tool J (Building)
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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.)

- **Scenario ADE**
  - [https://en.wiki.utilitynetworks.sig3d.org/images/upload/20171207_Agugiaro_Scenario_ADE_0.2.pdf](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.*
Extending the 3D City Database

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https://github.com/gioagu
Connecting the simulation tools

Sim. tool A (Power Pl.)
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Sim. tool J (Building)

O(n^2) complexity
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

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Simulation (linked to a Scenario)

Simulator A
Simulator B
Simulator C

Output Port
Input Port

Port-Connection

(Co-)Simulation graph
How to link the two worlds?

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City-wide data

3DCityDB “plus”

Co-simulation topology and initialisation parameters

Technical simulations

Specific simul. tools

Co-simulation environment
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This is the link to CityGML CityObject(s)!!
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
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. 
Proposed workflow

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Initialisation

- 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

(Extended)

3DCityDB

- semantic representation of data
- store / retrieve scenarios

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