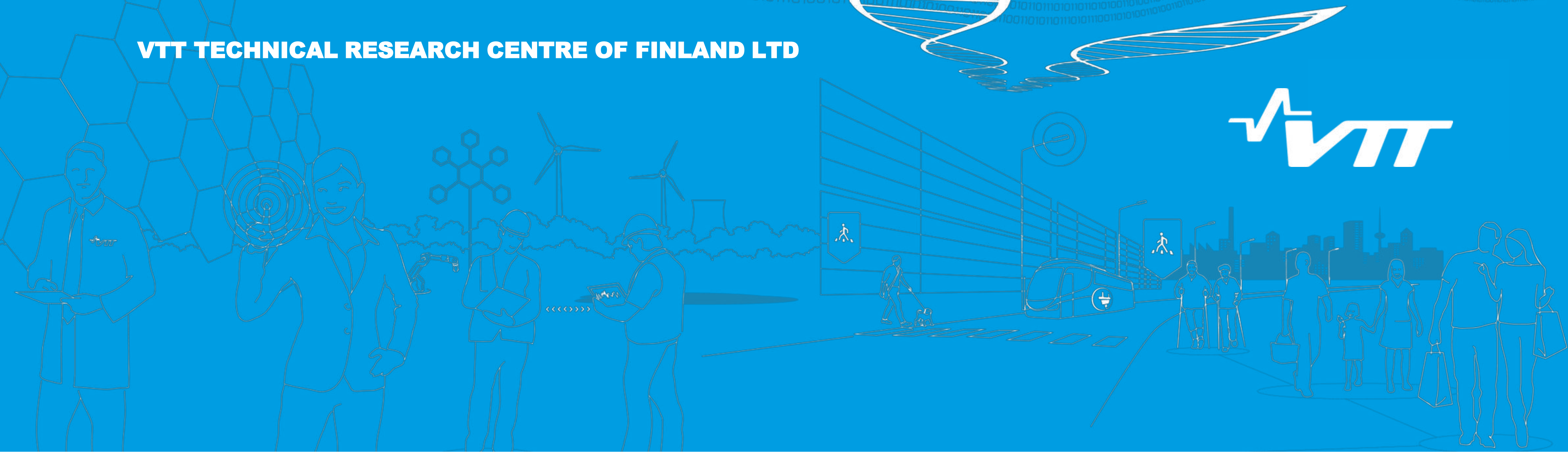

Additive manufacturing Design Hub & Modeling Factory

EMMC webinar

2018-01-23

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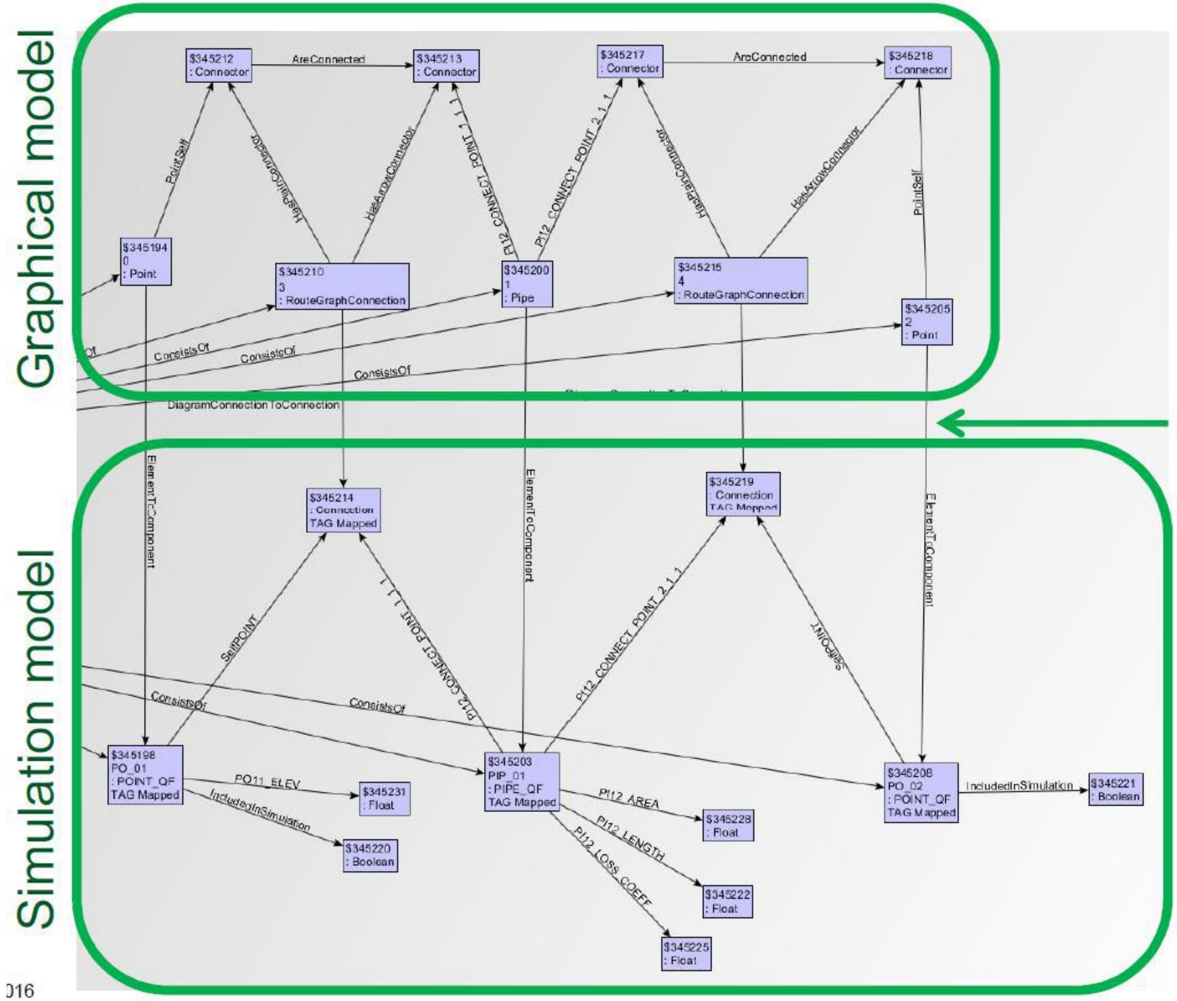
- General points

  - Semantic integration platform: rapid integrations possible, **deeper integration** levels than just data integration possible
  - **Various modeling paradigms and languages** can be used together
  - Allow users to user their favorite tools in data production and analysis
  - Not everything should be integrated: concentrate on **model/paradigm 'families'**
  - Utilize large **open source solver libraries** (e.g. physics, engineering, chemistry)
  - Interface with HPC, do not compete with specialized solutions (e.g. support work flow management, batch jobs etc, data formats etc.)
  - Support **surrogate model construction** (fast to simulate, automatable). In other words, computationally heavy models are transformed into more easily compatible fast models, which are suitable for web apps, optimization (iterative usage)
  - Enable **collaboration** in work rooms and **dissemination of results as web apps**

- Semantic platform



• Demo: Modelling Factory

- https://modellingfactory.org/
- http://modellingfactory.simupedia.com/amdh/
  (sample work room for metal powder 3D printing)
- Interested in trying it out yourself? Check out instructions at
- https://modellingfactory.org/instructions

eit RawMaterials

Demo: using Modelling Factory in materials, process and business design

- Use case: Metal parts manufacturing

AM Design Hub – what is it?

- **Additive Manufacturing Design Hub is web service, which demonstrates**
  - how product design and strategic design can be done collaboratively and simultaneously
  - how independently constructed simulation models can be combined to get answers to more complex design questions and impact assessments requiring data exchange and co-simulation
  - how different experts (engineers, life-cycle analysts, economists) can get a personalized view into the shared, *coherently updated* data in their own language
  - how the entire design chain from material properties to product distribution can be optimized
- **Application area:** Additive manufacturing using metal powders
- **Use case:** demonstration of the influence of materials properties on the profitability of the chosen product manufacturing method
- **Motivation:** Starting from prototypes, today's AM systems are not designed for series production. Also, process speed, material costs and process control have not been an issue for prototyping. Therefore, AM needs to show that it can manufacture parts economically, in volume and with constant quality for several applications. [Berger, 2016]

AM Process description (1)

- **Process description:** This web app provides a process control cockpit, which enables the user to first choose the process parameters of a 3D printer and simulate the printing of a product. The printing process is modeled as a simplified Selective Laser Melting (SLM) process (Powder Bed Fusion), where the incident laser beam melts/sinters metal powder particles into a prefedined 3D shape. Depending on the chosen process parameters (laser power, beam velocity), the metal material is subjected to different thermal history in different parts of the object to be printed. Consequently, the emergent phase content will vary locally as a function of the thermal history.

- From the phase content one can derive various material properties, e.g. hardness. The harder the material, the more difficult and costly it is to postprocess when making the actual product. Using a simple interpolation formula, the simulator derives the postprocessing costs of the product. These, in turn, are fed into another simulation model, which compares financial indicators of two different types of manufacturing processess (printing and casting) with each other. Moreover, with the aid of the economic simulator, the decision maker (e.g. business strategy planner) can produce estimates of the production speed and financial profitability of the different production processess.

AM Process description (2)

- **Modelling assumptions**
  - Printed material: EOS MaragingSteel MS1
  - Laser power sufficient to reach melting temperature
  - Homogenized powder bed
  - Several versions of temperature history model
    - Simplest version uses analytic Green’s function solutions and quadratures
    - FEM version of temperature solve utilizes Python libraries
    - Only a single layer laser treatment is modelled currently
    - Simplified phase kinetics (CCT diagrams and analytic approximations)
  - Economic model based on system dynamics modelling paradigm
    - Simplest verision contains no feedback loops within the economic model itsel
    - More complex quality measures of the emergent material properties have been computed but they are not included in the present version of the application. These measures can be utilized in various types of economic impact assessments.

Features

- **Features**
  - Dynamic co-simulation (different simulation models made by different experts can be linked and run together)
  - Various simulation paradigmas and programming languages supported (experts can use their preferred tools)
  - Possible to link open source and proprietary simulators and environments (licensing permitting)
  - Parametrization from materials databanks
  - Models, their user interfaces and parametrization data can be continuously improved by the users
  - If a user is not satisfied with the underlying assumptions, model performance or GUI, she can design her own version and share it with the others by publishing the modified version in the Modelling Factory (modellingfactory.org) service

Extending the services

- **Extensions**
  - The application can be extended in various ways. Some examples are given below.
  - Using integrated Life Cycle Analysis (LCA) tools, ecologic impacts could be computed in addition to the financial ones (main demo 2017)
  - Various types of production process models could be added
  - The current version of the Design Hub does not yet contain the optimization tools. Once this feature becomes available, it will be possible to optimize e.g. individual subprocesses or the entire production process. Of course, for more complicated processes the computation times will grow and some of the answers will have to be run in the batch mode. However, techniqeus will be developed for lightweight simulation, which is fast.
  - Direct integration with CAD system capable of forming optimal print sequence from the 3D product model.

Summary

- User groups: What technical experties are needed by end users?
- Why is it useful?

Different user groups

- Integrated tools, data and computational models can be constantly improved by any user at different levels of technical expertise:
  - (High level end user) The user can change preselected process parameters and background assumptions directly by altering the slider positions of the web app
  - (GUI maker) If the user wants to get more choice for alterable parameters displayed on the web app, she can design and publish a new web app with different outlook and control parameter choices
  - (Modeler, programmer) If the user knows how to improve the background computational models, she can also publish a new solver code and simply replace the old one with the new simulation model

What is AM Design Hub useful for?

- Process parameters => effect on the quality and properties of the product
- Emergent material properties => cost of processing further up the manufacturing chain
- More dimensions can be added: environmental footprints, suitability for end-of-life processing, etc.