Geospatial preprocessing for situational assessment through hydraulic simulations

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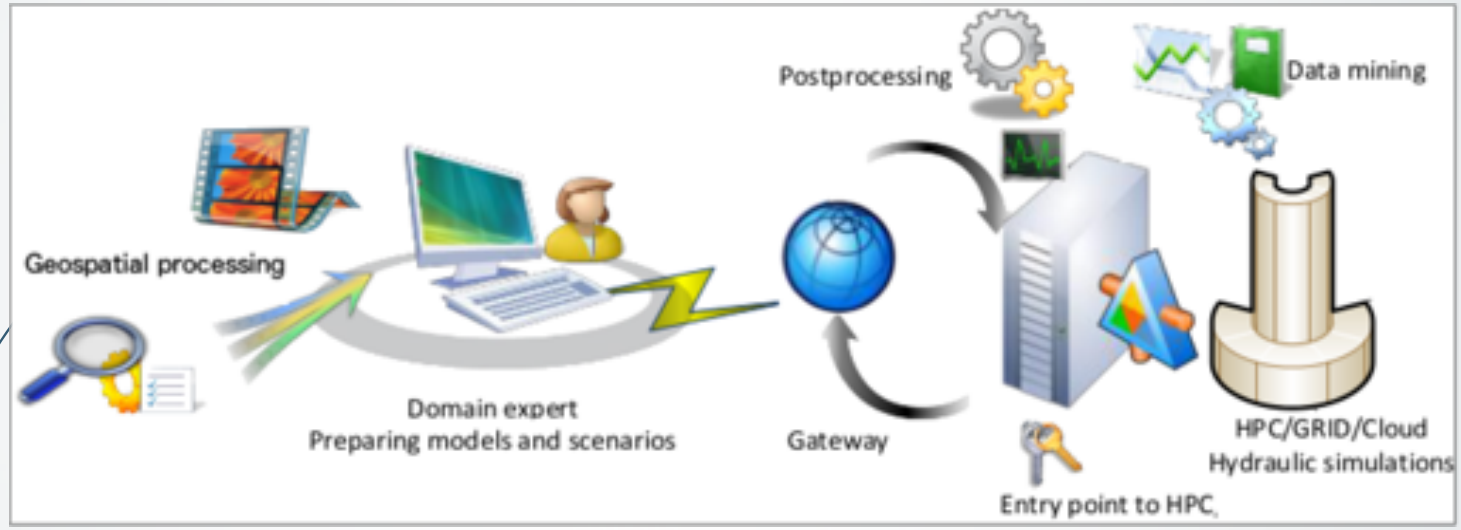
Integrated system for hydraulic simulations

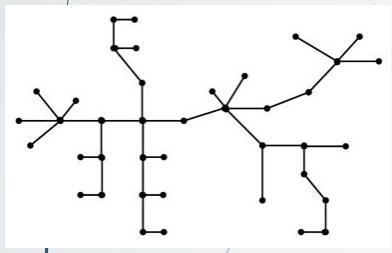


- Situational assessment of water-supply systems in large cities through hydraulic simulations
- Collaboration and application of modern technologies e.g. HPC, GIS and data mining in hydraulic domain
- Partners from commercial spheres: DHI Slovakia and Bratislava Water-Supply Company

Prior works

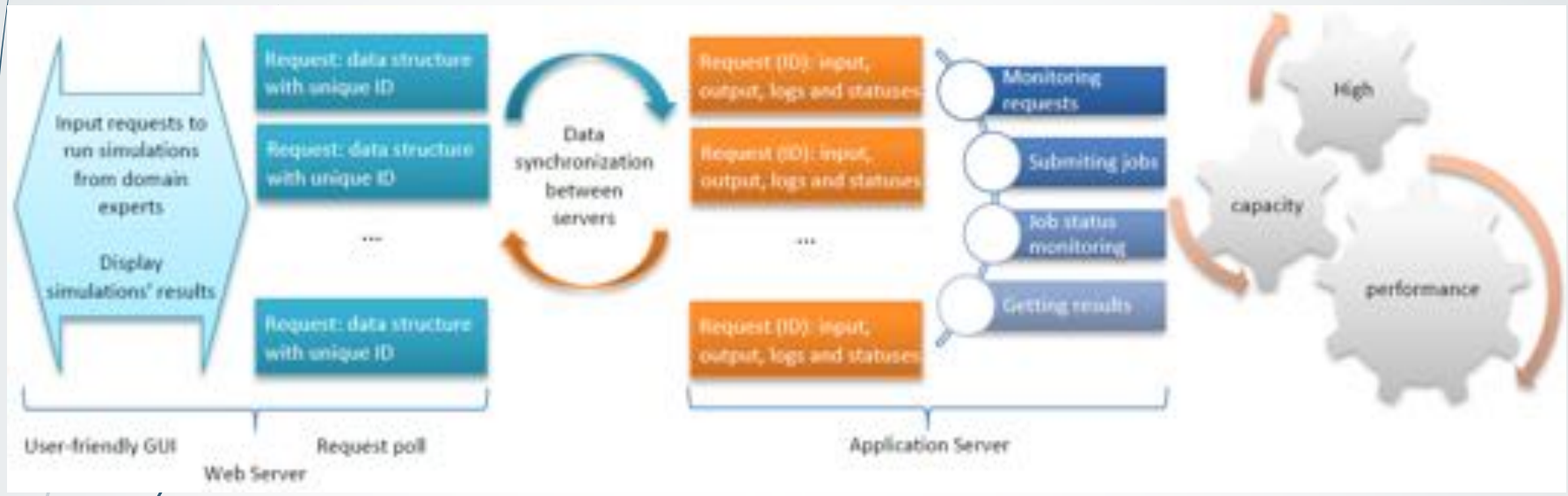
- V. Tran, V. Sipkova, L. Hluchy, G. Nguyen, M. Dobrucky, J. Astalos: Problem solving environment for water-supply systems. In proceedings of the 15th IEEE International Conference on Electronics, Informatics and Communications **ICEIC 2016**, p. 119-122. ISBN 978-146738016-4.
- G. Nguyen, V. Sipkova, P.Krammer, L.Hluchy , M. Dobrucky, V. Tran, O. Habala: Integrated system for hydraulic simulations. **Computing and Informatics, 2015**, vol. 34, no. 5, ISSN 1335-9150, Current Content.
- G. Nguyen, V. Sipkova, P.Krammer, L.Hluchy , M. Dobrucky, J. Astalos: Center for Risk Research in Urban Water-supply Systems. In proceedings of the 19th IEEE International Conference on Intelligent Engineering Systems **INES 2015**, p. 39-43. ISBN 978-1-4673-7938-0.

Mathematical modelling



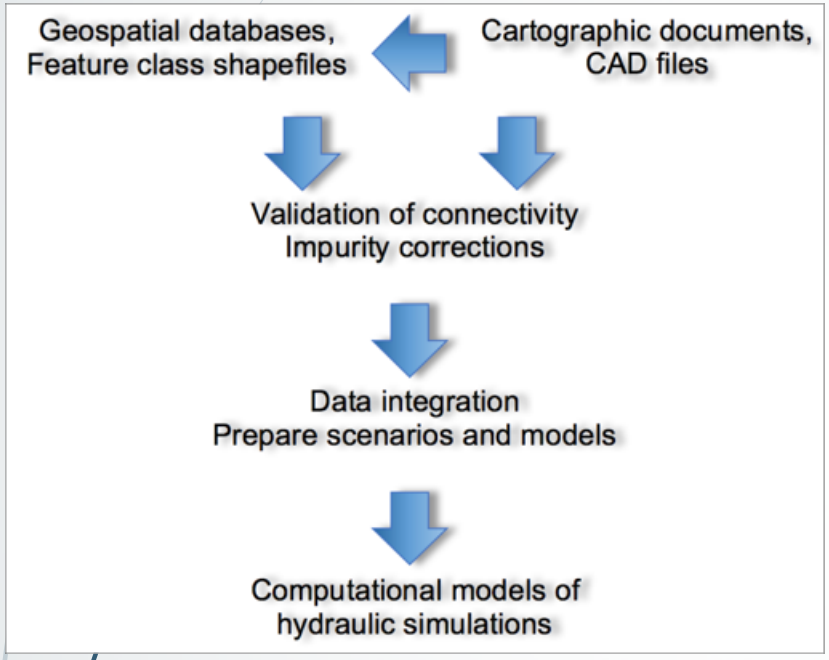
- Water-supply network is defined as graph ***G = (V, E)***
  - V is a set of vertices (nodes)
  - E is a set of edges (links)
- Geographical position is assigned to each vertex as triplet
  - ***g = (x, y, z)***
- Node properties (elevation, demand, head, pressure) are assigned to each vertex ***ov = (ov_1,ov_2,… ,ov_n)***
- Link properties (length, diameter, flow, velocity, pressure headloss, status, material, roughness, pump and valve settings, chemical reaction rate) are assigned to each edge
  - ***oe = (oe_1, oe_2, …, oe_m)***

Simulation workflow



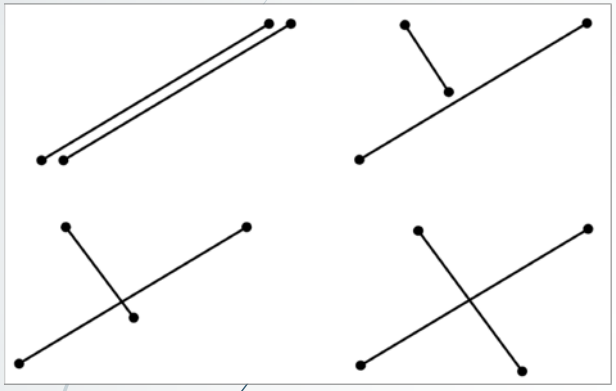
- Collaboration with hydraulic gateway
- Monitoring simulations' states and cluster workload
- Unified states for HPC and Grid jobs: simplified and unified job states for end-users
- Epanet is one of the most advanced tools for hydraulic analysis. Input is the mathematical representation of the water-supply network. Its core is hydraulics solver applies the Todini's Gradient Method, which is a variant of the Newton-Raphson method

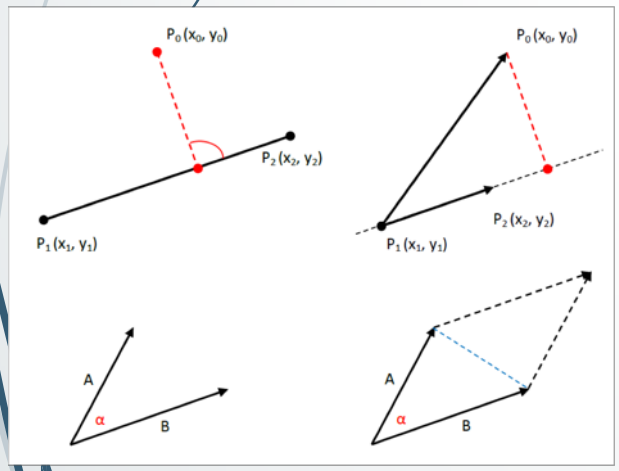
Data digitalization process



- Data collection: materials transformed from CADs, paper maps, monitoring systems, etc.
- **Data manipulation and adaptation: eliminate errors and impurities**
- Data management: (increasing volume) separated shape files → DBMS
- Data analysis
- Data visualization

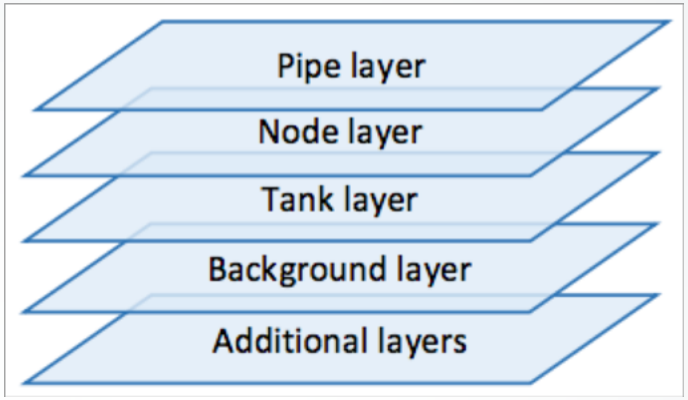
Geometry and Impurities in data





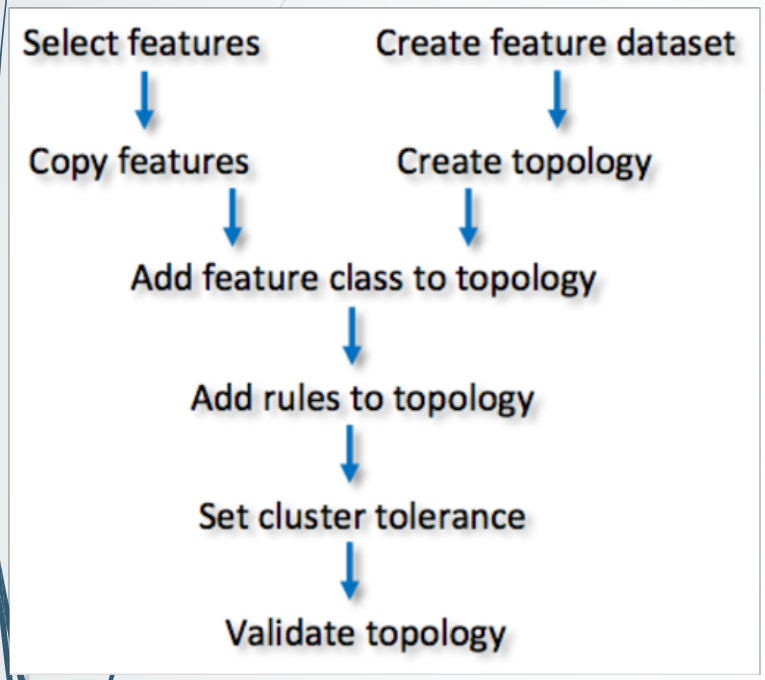
- Impurities
  - lines do not intersect at the crossing point,
  - small gaps/spaces are between two lines or between a
  - line and an endpoint,
  - points that do not lie on lines although they should, e.g. pumps or valves on pipes,
  - duplicate lines, etc.
- Geometry: distance between point and line, point and point, line and line
  - Apply to large number of water-supply network points (pipe connections, pumps) and lines (pipes)

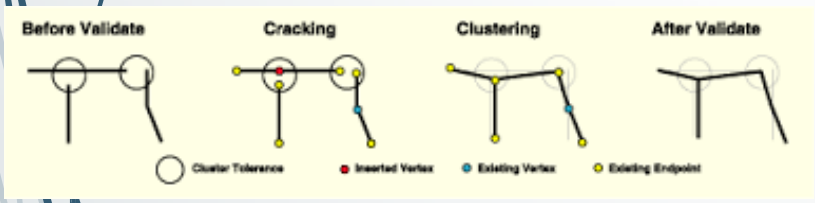
Geospatial layers and tools



- Geographic layering: one of the universal principles of GIS
- Existing a number of software components for working with maps and geographic information
- Python: new age scripting language, which extends ArcGIS ability for data analysis, data conversion, data management, map automation, helping to increase productivity (ArcPy)

Geospatial preprocessing





- Setting tools and parameters for the given location (coordination system of the city),
- Topographic validation of geographic information: the aim is to validate topological integrity of geospatial data,
- Corrections of errors and impurities based the topological integrity viewpoint validated from the previous step.
  - Trim lines, Extend lines, Snap
  - Optional tools

Evaluations

- First step
  - Comparison with the special small map prepared in advance for the evaluation purpose
  - The map is prepared in advance for the evaluation purpose, carefully and manually cleaned in details
- Second step
  - 5 different locations/partitions of Bratislava surrounding
  - Comparison under visualization for main pipelines
  - Consultations about results with domain experts
- Positive results in short: 95% accuracy

Simulation post-processing

- Transformation of simulation outputs back into the GIS environment consists of
  - transforming Epanet's simulation outputs from the text format into the CSV format
  - importing files from the CSV format into MDB for ArcGIS
- In GIS environment users has options to define visualization effects, as color ranges, diagrams, line thickness, for different features, e.g. velocity, head-loss

Future steps

- Problems
  - Parallel lines (pipes) near tanks
  - A line crosses other parallel lines near tanks
  - Blocking issue the commercial license of the proprietary product chosen by domain experts at the beginning of the project

- Future works
  - We will focus on open source GIS environments e.g. QGIS
  - Open data science trend supported by the European Commission under the INSPIRE infrastructure for spatial information in Europe. http://inspire. ec.europa.eu/
  - Combine spatial data from different sources and to share it between many users and applications

Conclusion

- Semi-automatic tool for geospatial preprocessing of real and large-scale datasets
- Integrated systems built on cooperation of modern IT technologies
- Mathematical modeling for situational assessments of water-supply network in big city
- Hydraulic simulation for incoming situations for comprehensive view and better emergency plans

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Thank you
for your attention

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