SMaRT-Online WDN

Online Security Management and Reliability Toolkit for Water Distribution Networks

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Project Results – Part 1

Online hydraulic simulation model

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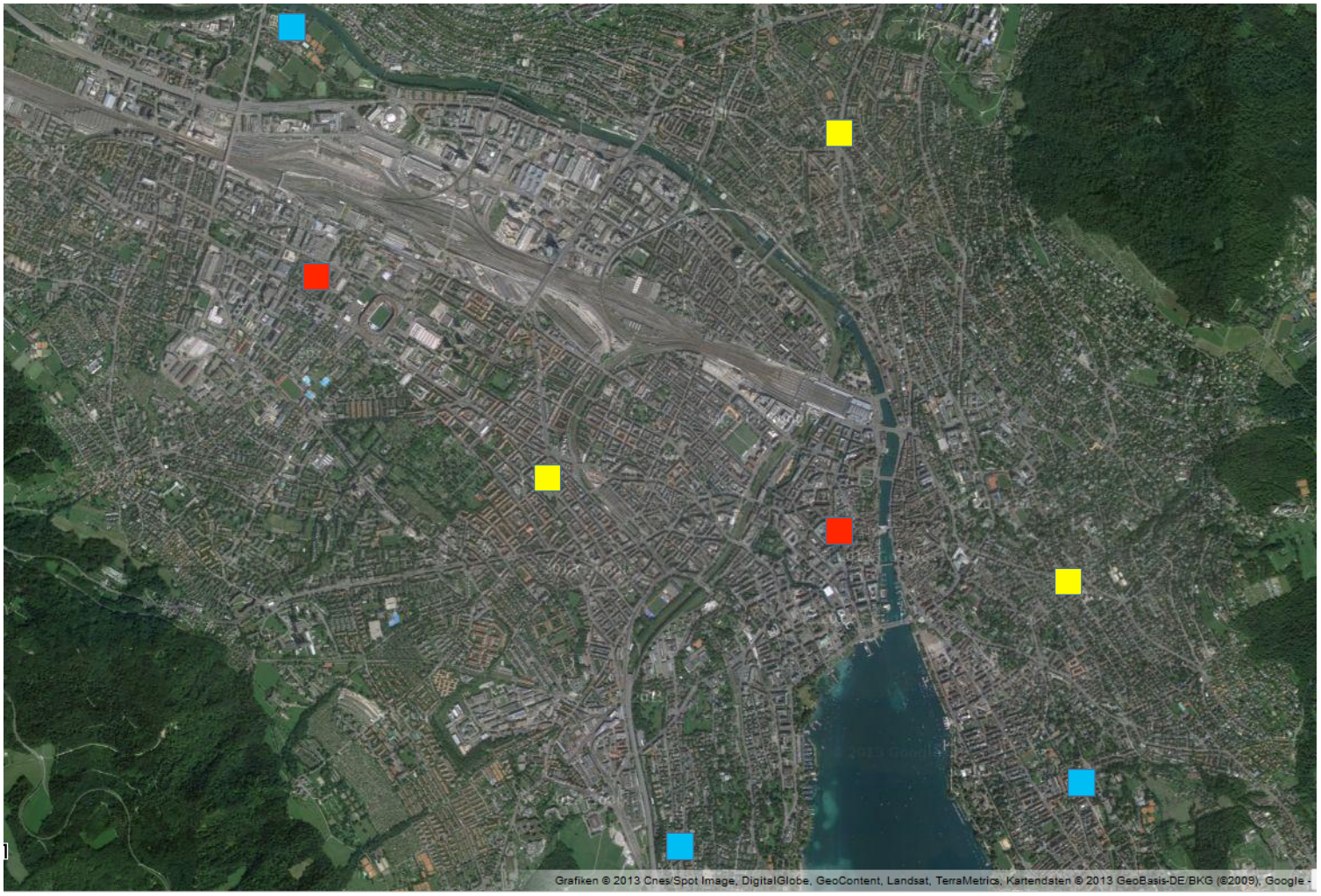
  - Hydraulic simulation models going online
- Research topics
  - Development of online software SIR OPC 9 for online integration of different software components necessary for the project
  - Adaptive Modeling, simplification and enhanced calculation
  - Concept for parameterization of the online model (data updates, frequency, attainable accuracy)
  - Online calibration of demands
  - Demand forecast software
  - Pilot applications
- Summary and Conclusions

Data acquisition in water works and distribution network



- Network operations (storage tanks, pumping stations, control valves, …)
- Multi parameter sensors (quality, pressure, flow)
- specific toxicity sensors

Hydraulic network simulation going online

Why do we need **Online-simulation**?

- Decision making
- Actions
- Respond to contamination event

Monitoring

Online-data interface

?

Acting

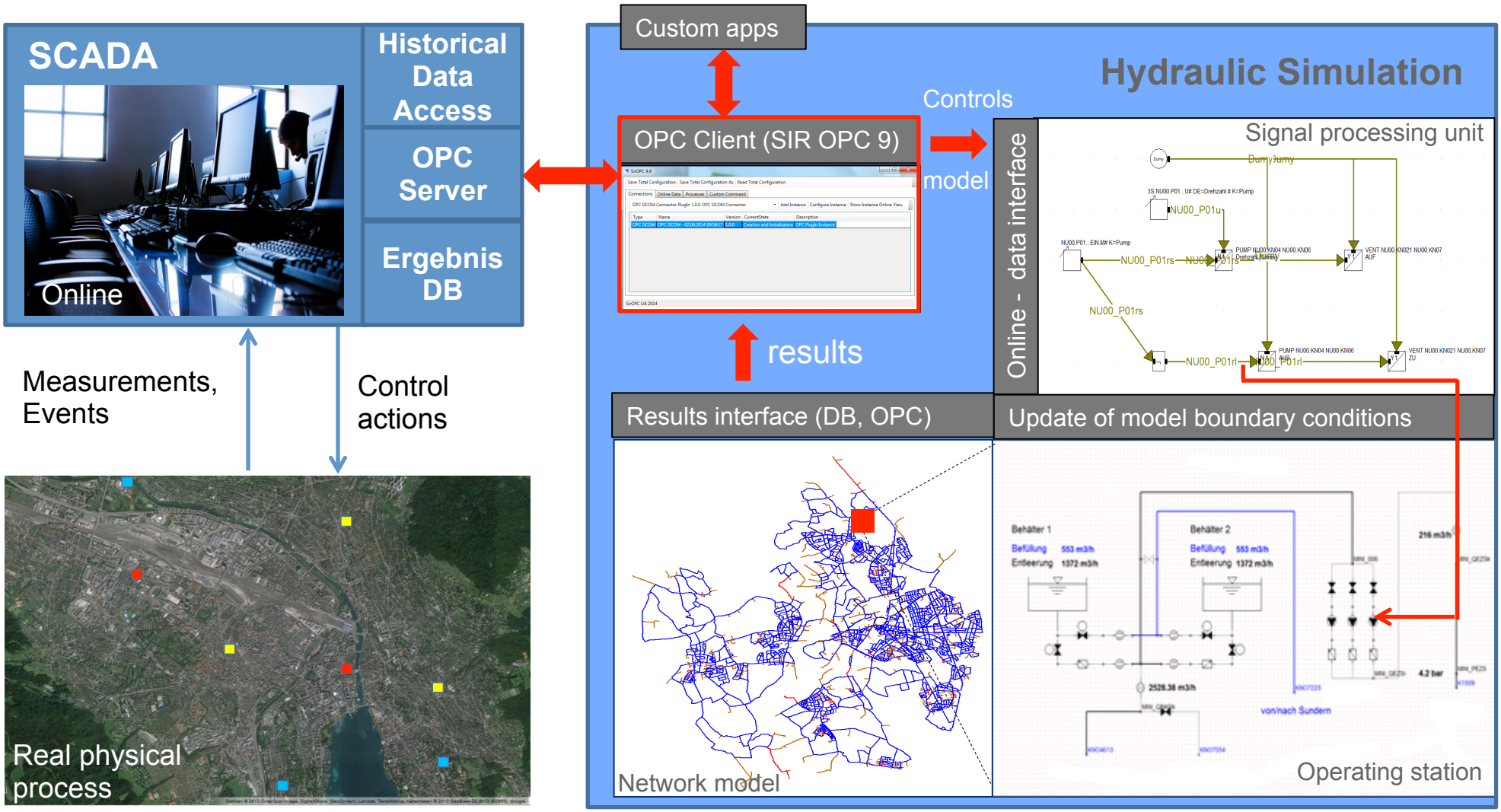
-> Current state of the network at **any time** and **any place** in (near) real-time

(Existing) Hydraulic simulation software

Understanding

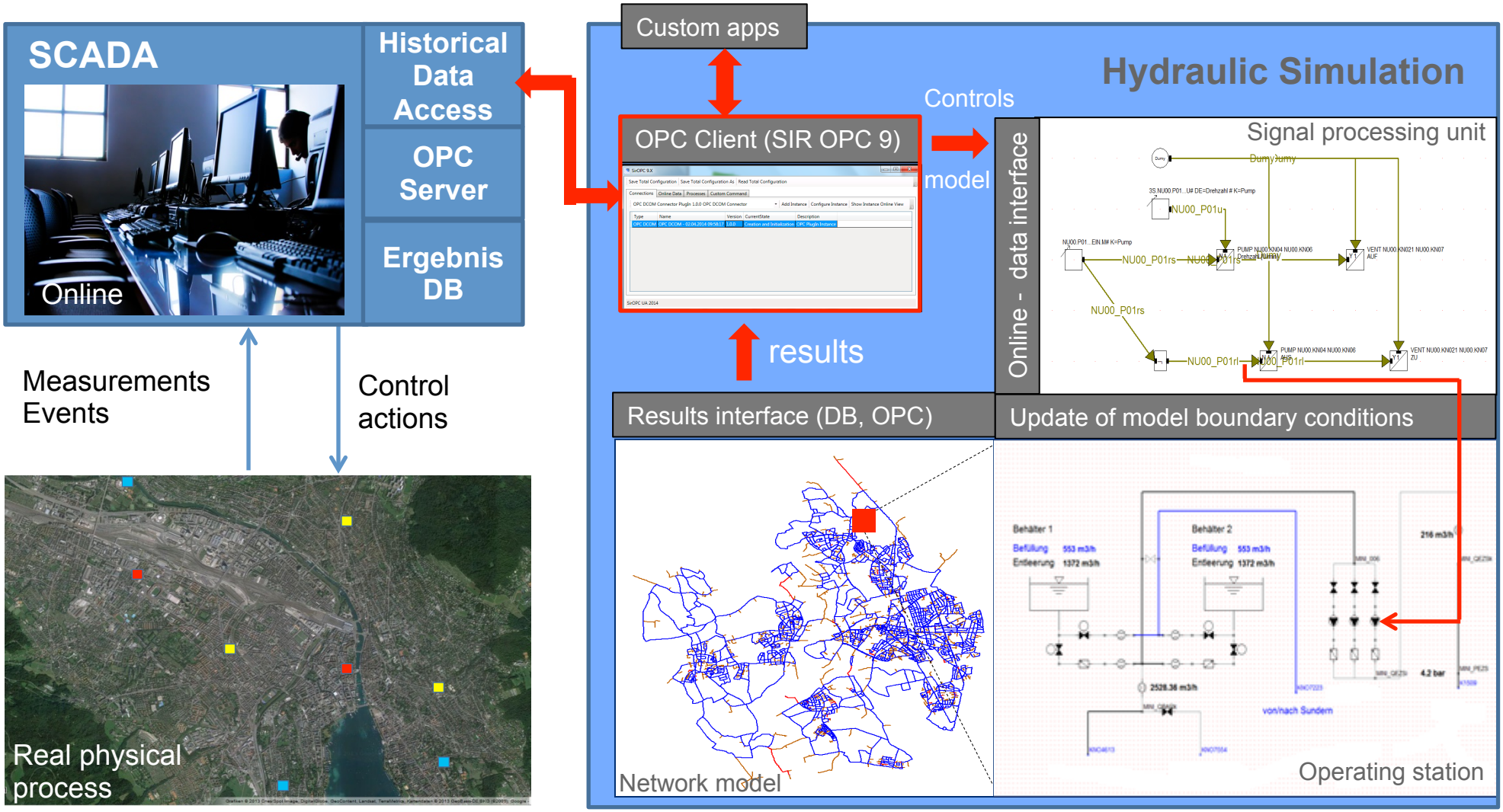
Online-Simulation – real-time use case

Connecting (near) real-time data of SCADA system with simulation software



Online-Simulation – „quasi-online use-case“

Connecting historical data of SCADA system with simulation software -> **Replay mode**



Main research issues and development in SMaRT-Online^{WDN}

1.) Development of online software SIR OPC 9 for online integration of different software components necessary for the project (3S)

2.) Adaptive Modeling, simplification and enhanced calculation (3S, Irstea)

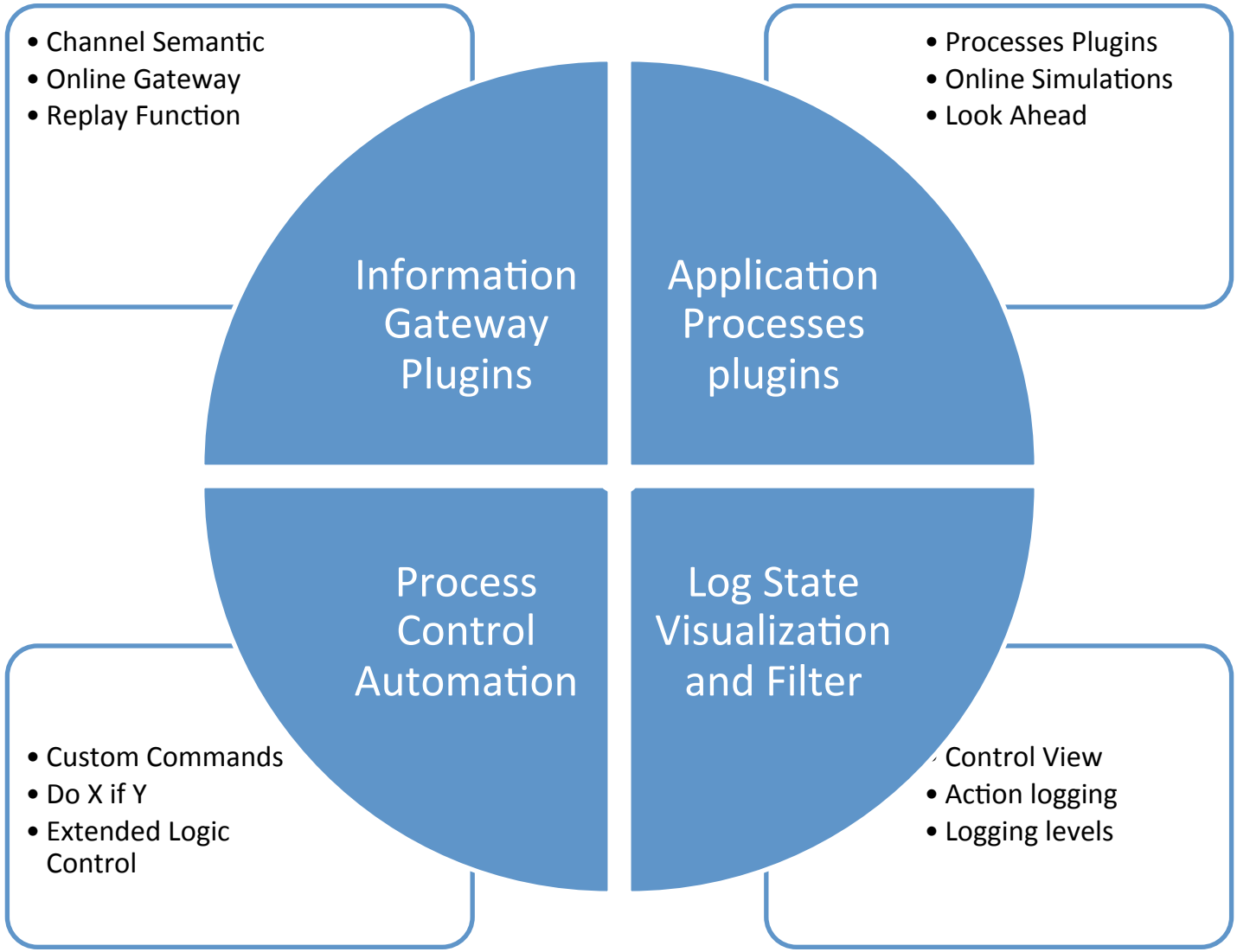
3.) Concept for parameterization of the online model (data updates, frequency, attainable accuracy) (3S, Irstea)

4.) Online calibration of demands (Irstea, IOSB, 3S)

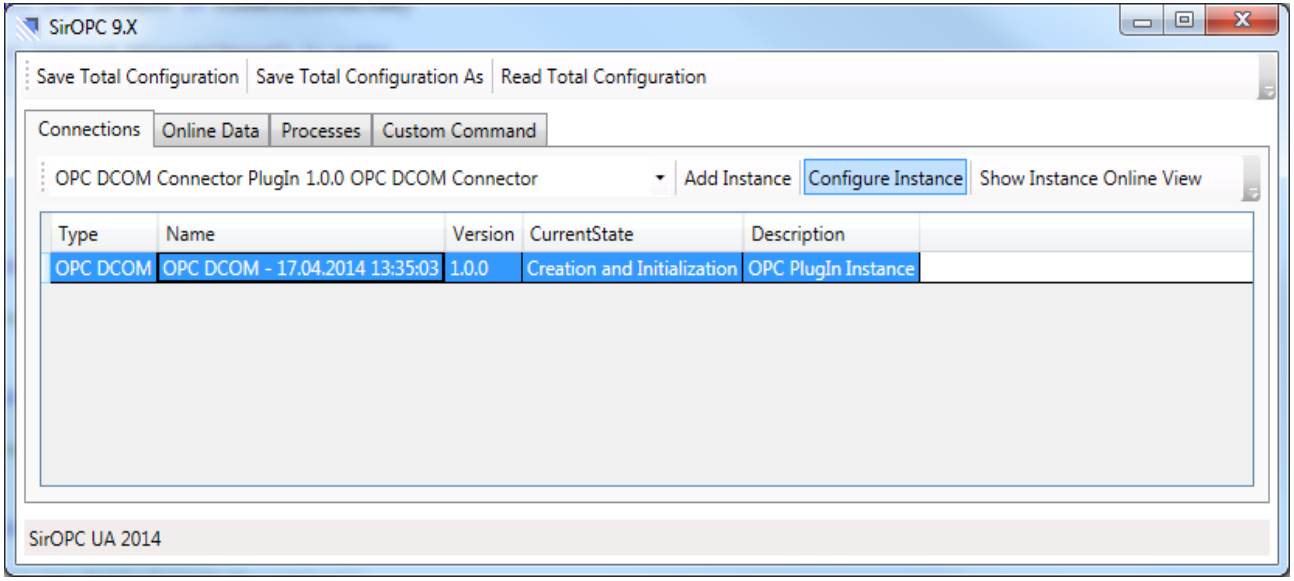
5.) Demand forecast software (IOSB)

6.) Pilot applications (all partners)

Online integration of data and applications



SIR OPC 9 (Online framework)



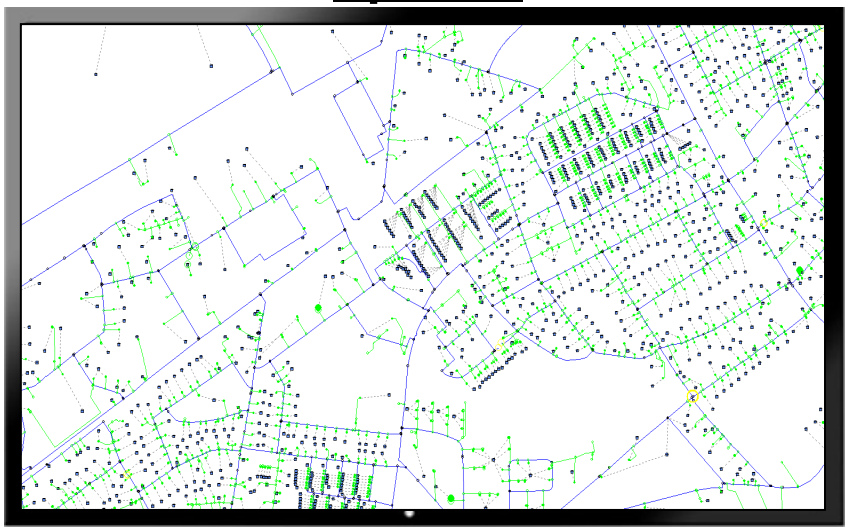
Requirements:

- Extensible framework
- Flexibility
- Performance
- Usability

Connections:	Connect with different data sources (PLC or database)
Online Data:	mapping of data items for communication between components
Process:	Online applications like símulation or source identification
Custom Command:	State machine (Petri net) for application integration

Adaptive modelling = efficient modelling

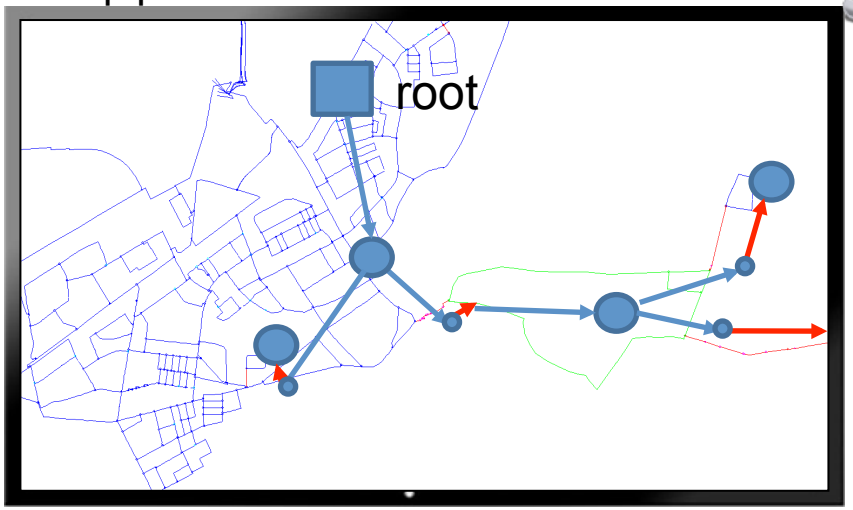
Selection of **optimal** level of detail dependent on problem to solve



all pipe model

switch between different views

aggregated – forest removed



block graph tree

on the same system

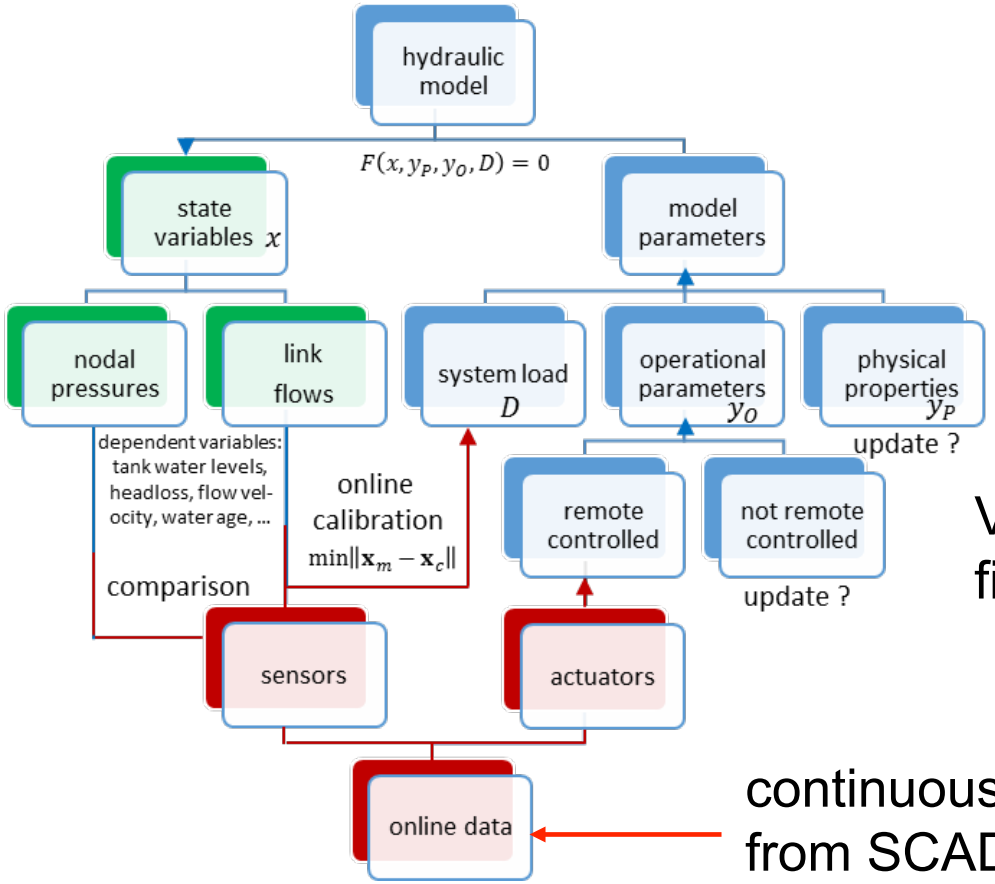
„super-graph“ – topological minor

Adaptive modelling – application example

Model level	#nodes	#pipes
All pipe model	231.120	235.792
Service connections removed	61.204	65.876
Network core	47.174	51.846
Core aggregation 1	31.210	35.882
Core aggregation 2	15.989	20.661
Supergraph	9.557	14.229

Parameterization of the online model

- Integration of different data sources: modelling point of view



GIS, SAP, …

Valves: update from field operations

continuous update from SCADA

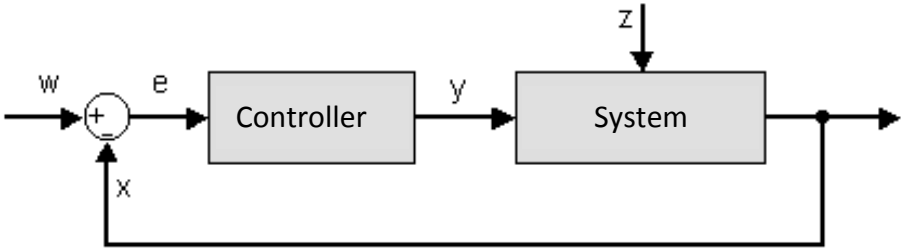
- Major challenges: Estimation of actual demands and valves states

Online calibration of nodal demands

- Basic requirements: fast, stable, easy to combine with hydraulic solver
- Three great classes of solving algorithms:
  - Gradient-type that uses derivatives and intend to solve the normal equations (Irstea)

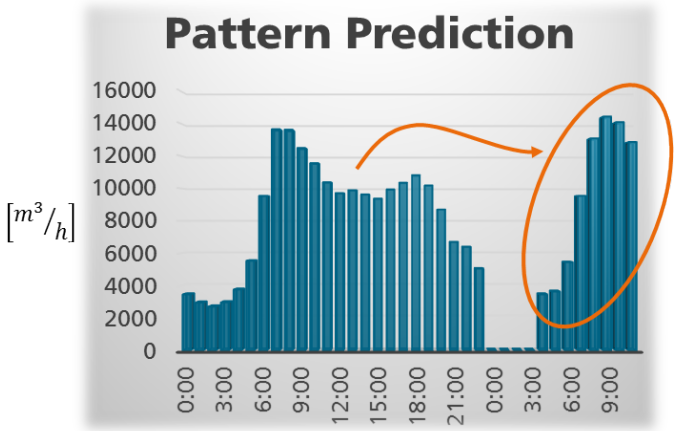
$$\mathbf{x}_{n+1} = \mathbf{x}_n - \mathbf{P}_n \mathbf{H}(x_n)^{-1} \nabla g(\mathbf{x}_n)$$

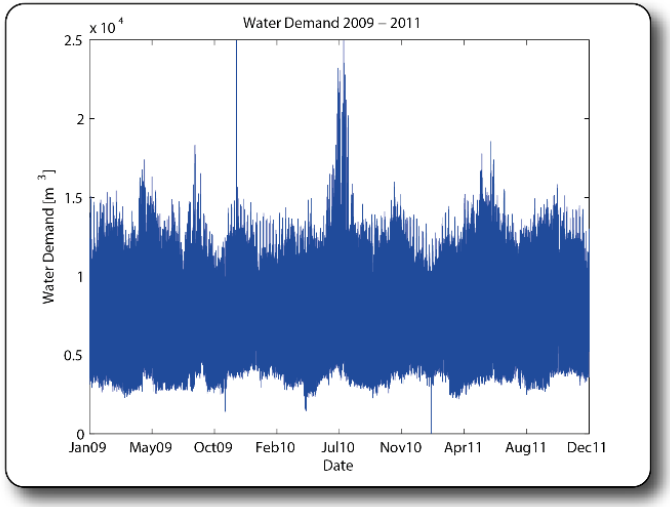
    - May be trapped by local minima and optimum
    - But fast if the criterion is strictly convex
  - Heuristics like GA, multi-agent… (3S)
    - Robust and global research
    - More Significant CPU time
  - Control theory approach (IOSB)
    - Very fast
    - Potentially less robust than the 2 others

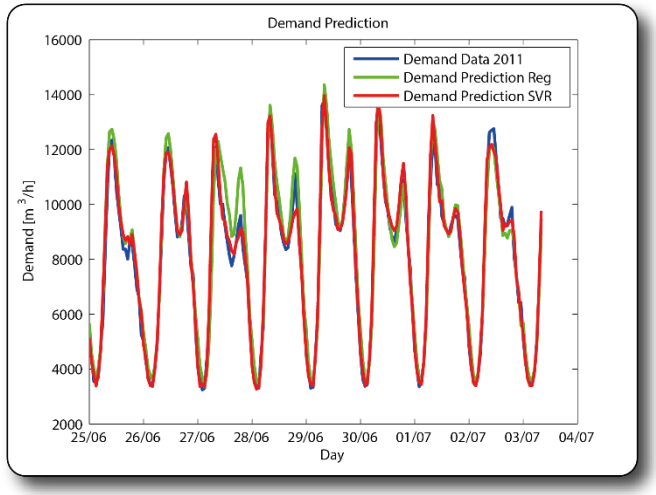


Demand forecast software

- Prediction is modeled on the balance of the flow data at the connection points to the Berlin network
- Prediction models based on ARIMA time series modelling and Support Vector Machines
- Prediction models are able to predict the demand for Network calibration and diurnal demand patterns for scenario simulations
- Demand Prediction for ca. one week in summer 2011
- Comparison of Autoregressive Model, Support Vector Regression and the actual demand data

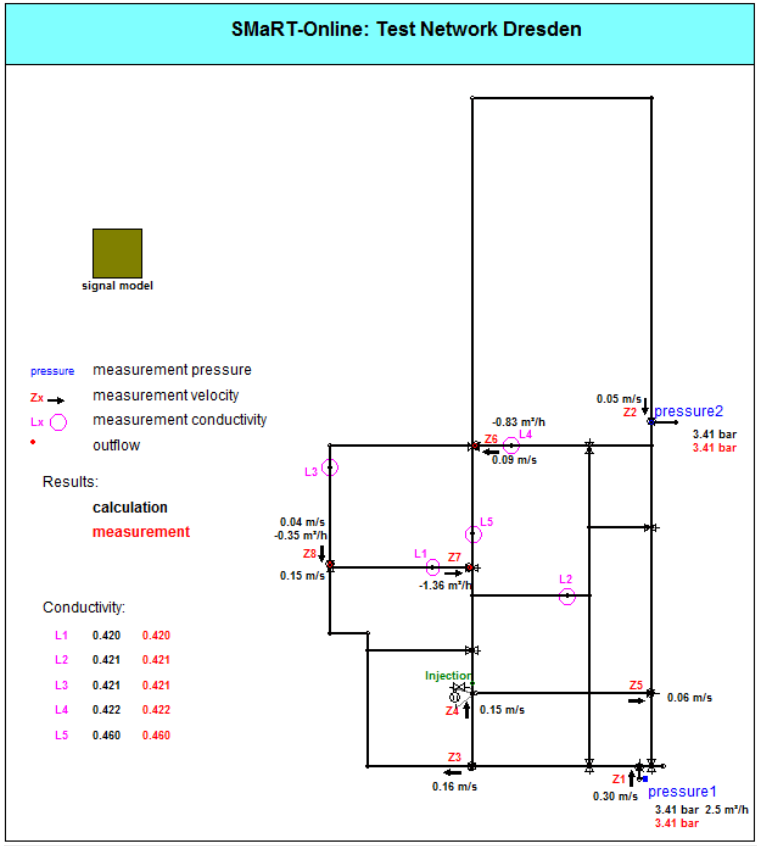






Example networks studied (pilot scale and large scale)

Dresden Testnetwork



Real world applications:

- BWB: large model (one third of BWB supply area)
- BWB: small model
- CUS Strasbourg
- Veolia Eau d'Ile-de-France Sedif networks

Summary and Conclusions

- Comprehensive framework for online simulation and integration of custom software components has been developed.
- Progress has been made in estimation and tuning of model parameters in real-time.
- Replay mode has been proven to be very useful for studying network behavior
- Network simplification that was originally developed for enhanced simulations is useful for many applications such as sensor placement and calibration.
- The quality of the simulation results is strongly dependent on the quality of model data including both offline data and real-time data.

Thank you for your attention
Any questions?

http://SMaRT-OnlineWDN.eu