SMaRT-Online\textsuperscript{WDN}: Online Security Management and Reliability Toolkit for Water Distribution Networks

Thomas Bernard, Mathias Braun, Fraunhofer Institute IOSB
Olivier Piller, Denis Gilbert, IRSTEA
Jochen Deuerlein, 3S Consult GmbH
Andreas Korth, Reik Nitsche, DVGW-Technologiezentrum Wasser
Marie Maurel, Veolia Environnement
Anne-Claire Sandraz, Veolia Eau d’Ile de France
Fereshte Sedehizade, Berliner Wasserbetriebe
Jean-Marc Weber, Communauté Urbaine de Strasbourg

ISCRAM, Baden-Baden, Germany, May 14, 2013
Online Monitoring of Drinking Water Networks

Water supply networks are constantly exposed to deliberate or accidental contamination.

→ An **online security management system** should support the water supplier in planning countermeasures effectively and in short time:

- Where is the source of the contamination?
- What impact will the contamination have on the water distribution network?
- Which measures are needed to contain the harm?
Decision Support Tasks of SMaRT-Online

- **Monitoring**
  - OPC Server (online data)
  - SCADA

- **Understanding**
  - Database (offline data)

- **Acting**
  - Reference scenario (past) (source identification)
  - What if scenario (past & future) (check actions like flushing)
  - Look ahead scenario (future) (e.g., spread of contaminant)

- **Tools & Sensors**
  - Toxicity sensors
  - Hydraulic and quality sensors
  - Hydraulic stations (tanks, pumps, valves)

- **Data Types**
  - Online (near real-time) data
  - Offline data
  - Activities
Project Partners

Water Utilities
Berliner Wasserbetriebe
Communauté Urbaine de Strasbourg
Veolia Eau d’Ile-de-France

Industry
3S Consult GmbH (Germany)

Research Institutes
IRSTEA (France)
DVGW-Technologiezentrum Wasser (Germany)
Fraunhofer Institute IOSB (Germany)
Veolia Environment (France)

Sponsored by

Federal Ministry of Education and Research

ANR

Project Funded by the ANR
Overview

- System architecture
- Optimal Sensor Placement
- Alarm Generation Module
- Online Simulation Model
- Online Source Identification
- Risk Analysis and Impact Assessment
- Real and Test Networks
System architecture of **SMaRT-Online**

- **Water Distribution Network**
  - water pipe
  - sensor for hydraulic, physical and/or chemical parameters
  - sensor for water quality (detection of toxic ingredients)

- **SCADA system**
  - sensor information
  - Simulation of hydraulic and water quality parameters
  - Information about contaminant source
  - Prediction of dissemination

- **Alarm Generation**
  - Plausibility check of alarms
  - Qualified alarm

- **Online Simulation**

- **Online Source Identification**
Optimal Sensor Placement

- Software tool for **optimal placement of sensors** in the drinking water network
Optimal Sensor Placement

- Multi-Objective Optimization Problem
- Priorization of the partly conflicting performance criteria by water utilities
Alarm Generation Module

• Aim: Detection of contaminations from various sensor information without false alarm
Alarm Generation Module

- Training from historical data (method: PCA)
- Software module with GUI developed
Online Simulation Model

- State estimation
- “Look-ahead-Simulations” as decision support tool for planning of counter measures
Online Simulation Model

Berlin (östliche Hochstadt)

After aggregation (no house connection pipes):
- 59,158 nodes
- 63,824 pipes (length ~ 1,960 km)
- 52,811 demands (~ 4,400 m³/h / 38,544,000 m³/a)

Stations:
- 1 water treatment plant
- 2 transfer points
- 1 booster pumping station
- 3 valves with connections to other network parts
- 5 online measuring devices
- 38 measuring devices, that are not online
Transport Model at Junctions and Crossings

- In most simulation software simplified assumptions regarding mixing at crossings and T-junctions are implemented (e.g. complete mixing, Bulk advective mixing)
- Especially for laminar flow (slow velocities) mixing is not perfect!
- **Approach:** Extract more accurate mixing models from 2D-/3D CFD simulations
Transport Model – Result for T-Junction

- For $v_{rel} \sim 0.25$ and $\sim 0.75$ no ideal mixing!

\[ \frac{v_{rel}}{v_{in}} = \frac{v_{out1}}{v_{in}} = 0 \ldots 1 \]

\[ v_{in} = 0.01 \text{ [m/s]} \]
\[ L = 0.5 \text{ [m]} \]
Online Source Identification

- Information about Contamination Source
- Prediction of dissemination
Risk Analysis and Impact Assessment

- Real impacts and perceived ones are performed for the three aspects of sustainability:
  - environmental
  - social
  - economical, combined with technical innovation

RISK ASSESSMENT
- Likelihood VS Vulnerability VS Consequences

RISK MANAGEMENT: MITIGATION AND COMMUNICATION
- Scenarios and actions for risk management
- Cost-Benefit analysis of risk management actions VS Risk aversion

Feedback
Real Networks investigated in the Project
Test Network at Berliner Wasserbetriebe

Length: approx. 600 m;
Material: cast iron
Age: approx. 90 years
out of service since but in use: 2000
Test Network at TZW Dresden
Thanks for your Attention!

SMaRT-Online<sub>WDN</sub>

www.smart-onlinewdn.eu