MECHANICAL AND PROCESS ENGINEERING

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

IoT.H2O - IoT for Supervision and Control of Water Systems

Harald Roclawski
Martin Böhle
Thomas Krätzig
Aloysio Saliba
Laurent Vercouter
Benjamin Dewals

SAM

INSTITUTE OF FLUID MECHANICS AND FLUID MACHINERY

PROF. DR.-ING. M. BÖHLE

Water JPI

2017 JOINT CALL

SPONSORED BY THE
Federal Ministry of Education and Research

Consortium – IoT.H2O

- Technical University of Kaiserslautern (Germany), Institute for Fluid Mechanics and Fluid Machinery (SAM)
- Dr. Krätzig Ingenieurgesellschaft mbH (KI), Aachen, Germany
- Federal University of Minas Gerais, Brazil (CPH), Centro de Pesquisas Hidráulicas e Recursos Hídricos
- Liege University, Research group Hydraulics in Environmental and Civil Engineering (HECE), Belgium
- Institut national des sciences appliquées de Rouen, LITIS LAB, MIND Group, France

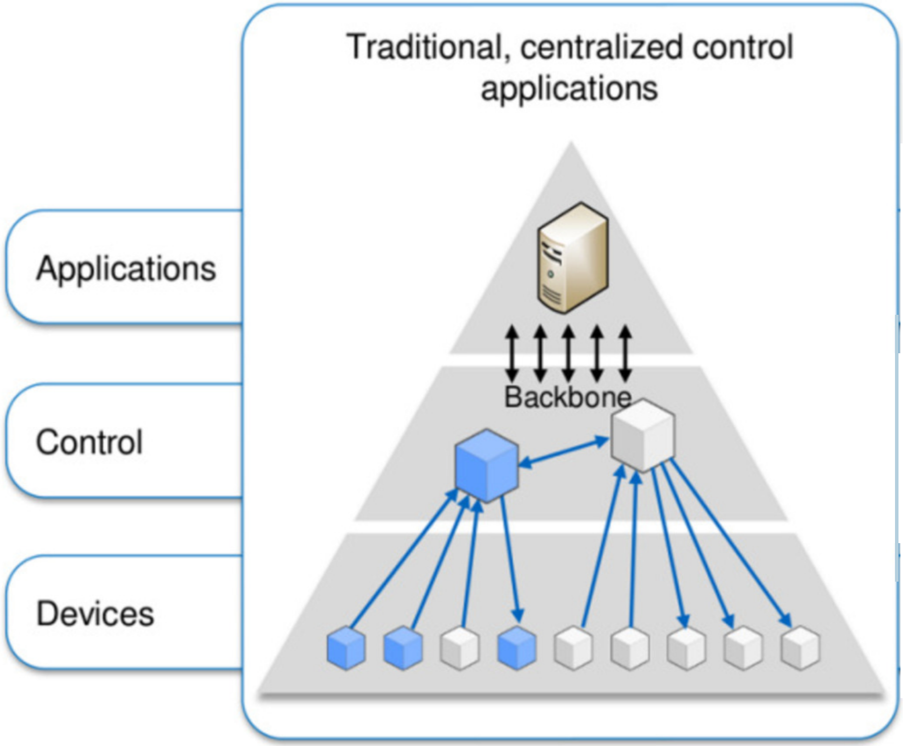
Contribution to IC4Water call and UN SDG

- Challenge 2, Sub-topic-2.a: Developing systems for universal and equitable access to safe and affordable drinking water for all:
  - Assessing the impact of water scarcity on safe drinking water in an increasing demography context:
  - Developing low cost, low maintenance technology for the water management sector in developed and developing countries.

- UN Sustainable Development Goal 6:
  - “substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity”
  - “expand international cooperation and capacitybuilding support to developing countries in water- and sanitation-related activities … including … water efficiency

Motivation – Supervision and Control of water systems

- SCADA (Supervisory Control and Data Acquisition) systems are used for data acquisition, process control and visualization of water systems
- Centralized, hierarchical structure
- Inclusion of additional sensors require software adaptions in the central computer



Motivation - Drawbacks of SCADA systems

SCADA systems:

- expensive installation of remote sensors and actuators (often restricted to main operating data)
- number of measuring devices are limited
- significant parts of the network remain “invisible”
- long term observation and big data analysis not possible
- mostly proprietary and manufacturer specific
- restricted communication and interaction with other systems
- high investment cost and technically complex
- …

⇒ SCADA systems are very often not achievable for small water utilities
Small water systems or peripheral districts of larger systems are often operated manually or with a very low level of automation

Example: Pump operation

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
2		Neu			Neu			Neu			Neu			Neu		
3		Brunnen G			Bunnen S 1			Brunnen S 2			Brunnen H			Brunnen S 4		
4	Förderhöhe, m	11,00			65,00			57,00			10,00			75,00		
5	Fördermenge, l/s	24,00			24,00			40,00			22,00			15,00		
6	Fördermenge, m³/h	86,40			86,40			144,00			79,20			54,00		
7	Fördermenge jährlich, m³/a	100.000,00			500.000,00			700.000,00			100.000,00			300.000,00		
8	Laufzeit jährlich, h/a	1.157,41			5.787,04			4.861,11			1.262,63			5.555,56		
9																
10	Bieter	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
11	Motorleistung, kW	5,50	5,50	7,50	37,00	45,00	26,00	37,00	45,00	37,00	4,00	5,50	7,50	22,00	26,00	26,00
12	Kabelquerschnitt	4 x 4²	4 x 2,5²	4 x 6²	4 x 16²	4 x 10²	4 x 10²	4 x 16²	4 x 10²	2 x 2 x 10²	4 x 4²	4 x 2,5²	4 x 4²	4 x 16²	4 x 16²	4 x 25²
13	Gesamtwirkungsgrad															
14	aufgenommene Leistun, kW															16,04
15	spez. Energiebedarf, kWh/m³															0,297
16	Energiebedarf jährlich, kWh/a															89.106
17	Energiekosten, EUR/kWh															0,30 €
18	Energiekosten jährlich, EUR/a															26.731,67 €
19	Beobachtungszeitraum, a															10
20	Energiekosten für Beobachtungszeitraum, EUR															267.316,67 €
21	Montagekosten															1.500,00 €
22	Kosten E-Technik															15.000,00 €
23	Preis Pumpe															7.561,27 €
24	**Gesamtpreis**															**291.377,94 €**
25	Laufrad/Anmerkung															

Energy savings up to 75% are possible!

Premise: continuous monitoring of operating data

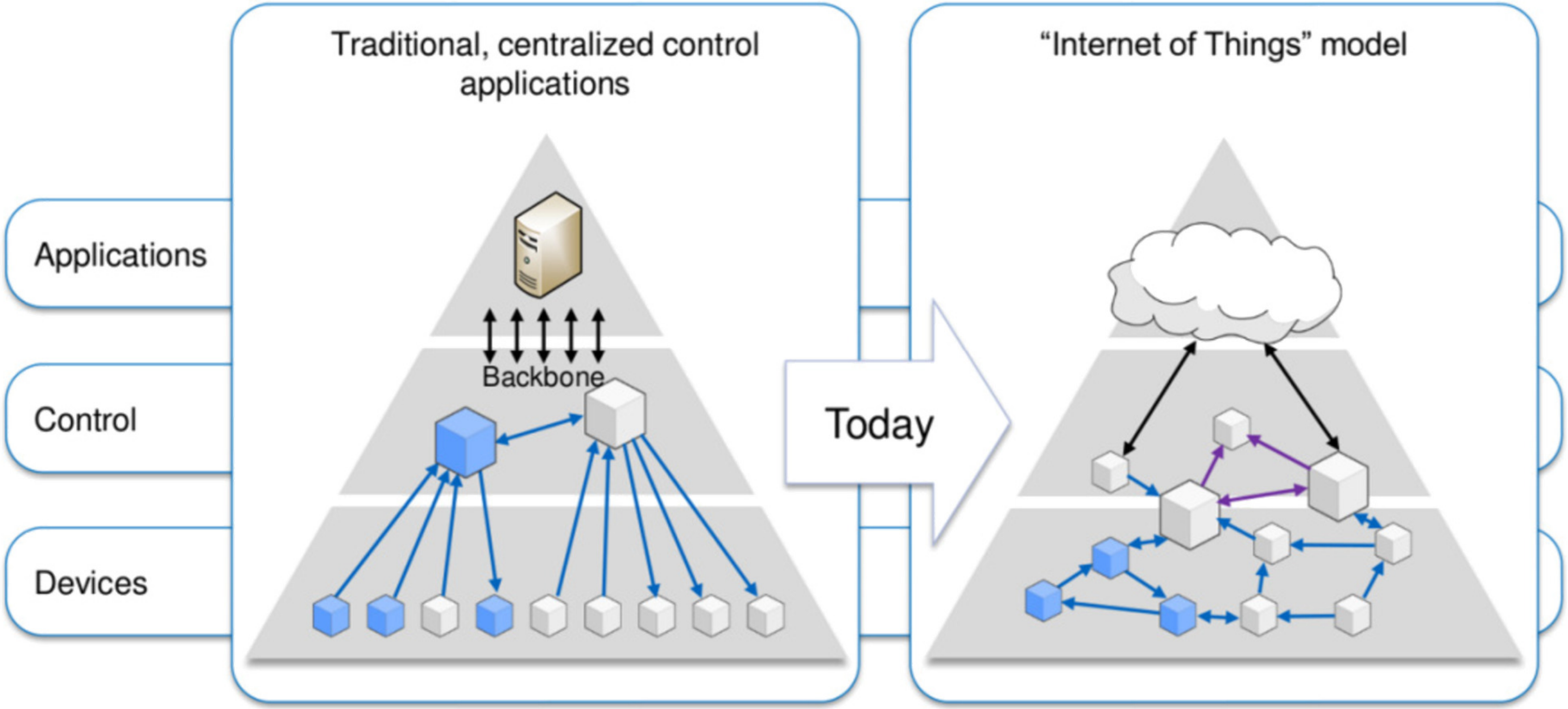
30						
31		Bestand	Bestand	Bestand	Bestand	Bestand
32		Brunnen G	Brunnen S 1	Brunnen S 2	Brunnen H	Brunnen S 4
33	spez. Energiebedarf, kWh/m³	0,153	0,287	0,328	0,179	0,57
34	Energiebedarf järlich	15.300,00	143.500,00	229.600,00	17.900,00	171.000,00
35	Energiekosten, EUR/kWh	0,30 €	0,30 €	0,30 €	0,30 €	0,30 €
36	Energiekosten jährlich, EUR/a	4.590,00 €	43.050,00 €	68.880,00 €	5.370,00 €	51.300,00 €
37	Beobachtungszeitraum, a	10	10	10	10	10
38	Energiekosten für Beobachtungszeitraum, EUR	45.900,00 €	430.500,00 €	688.800,00 €	53.700,00 €	513.000,00 €
39	Einsparung Energiekosten	67,19%	12,97%	33,18%	74,61%	47,89%
40	**Gewinn über 10 Jahre** (Energiekosten für Beobachtungszeitraum (Bestand) - Gesamtpreis (neu)	**9.586,90 €**	**30.224,65 €**	**199.765,00 €**	**18.876,37 €**	**221.622,06 €**
41	**Empfehlung**	**Pumpe erneuern**	**Pumpe erneuern**	**Pumpe erneuern**	**Pumpe erneuern**	**Pumpe erneuern**
42						

Objectives – IoT for supervision and control of water systems

- Explore the potential of the Internet of Things (IoT) model for monitoring and operating small water utilities
- low-cost hard- and software
- manufacturer independent computer platforms
- sensors and actuators with digital interfaces
- free or open-source visualization technologies
- digital hydraulic water system modelling and artificial intelligence implementations
- digital twin technology for prototyping and testing and as an operational support tool

➡ Cheap but powerful control and supervision system for water utilities

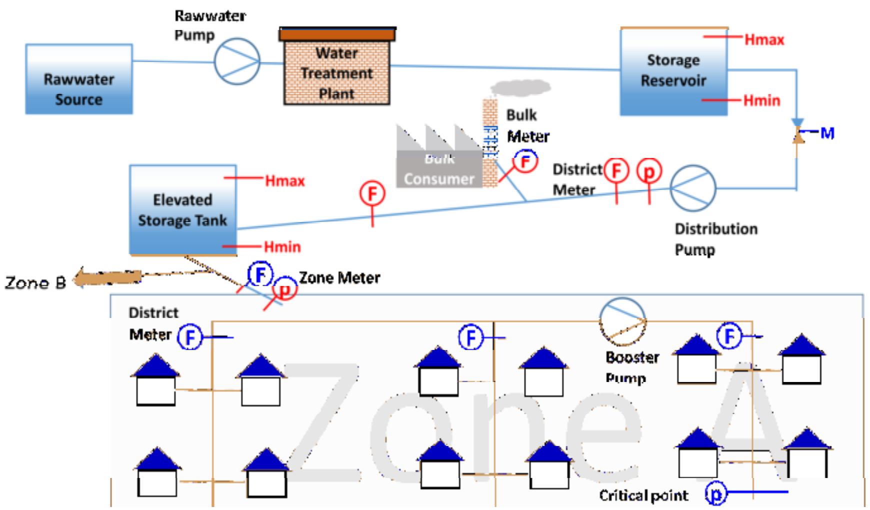
SCADA vs. Internet of Things model



IoT: decentralized interconnected field devices : additional sensors can „easily" be added

IoT.H2O water system

Field layer (Devices / Gateways)



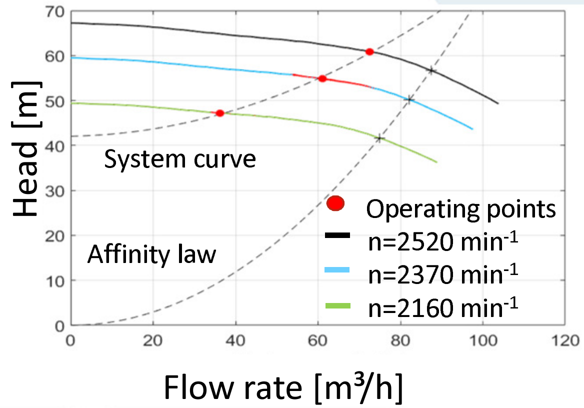
Network layer

- Network service provider (Ethernet, cellular data networks (2G/3G/4G/5G), LoRaWAN, …)
- Gateway administration

Application layer

- Physical objects are mapped to objects in the information world
- User Front-End
- Applications for visualization of water network operation
- Big data analysis
- Time series processing
- Predictive maintenance for pumps and valves
- Operational optimization
- …

Work packages



Detailed Hydraulic modelling (WP1 and WP2)

Fast hydraulic models for real-time control (WP3)

Condition Monitoring of Pumps (WP3)

Definition of IoT Sensor Positions (WP2)

IoT Sensor Development (WP5)

Multiagent technology for decentralized AI (WP4)

Field Test (WP6)

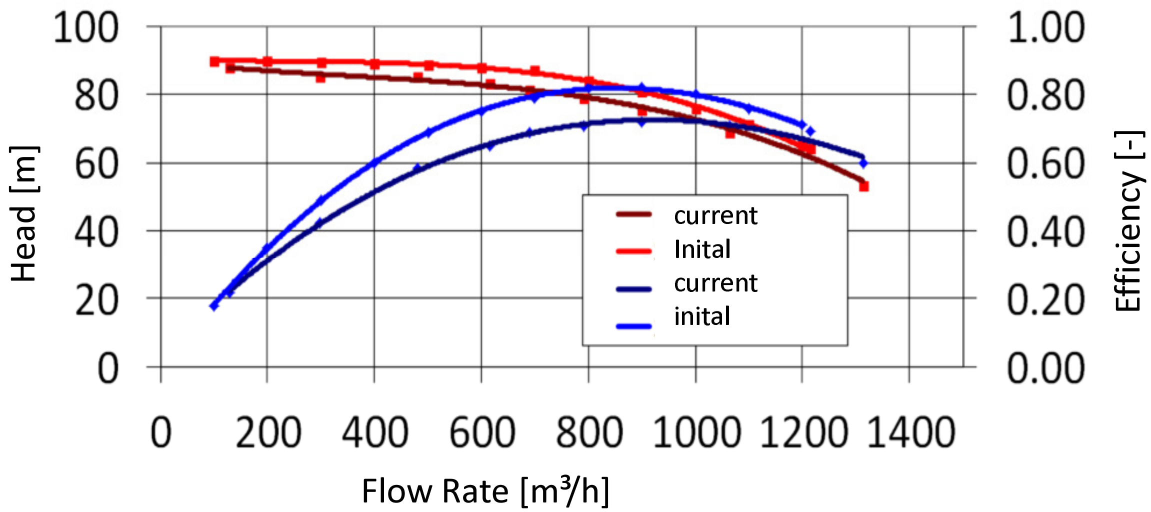
Improved and sustainable management of water distribution systems

Multiagent Technology

- Artificial intelligence decision on water network components and implementation in IoT nodes.
- Examples:
  - incident recognition (pipe bursts, situation adapted generation of alarms)
  - optimization strategies including demand driven water network optimization
  - condition monitoring for enhanced maintenance strategies

Multiagent Technology – Example: Pumps

- Vibration measurements -> preventive maintenance
- Degradation of pump performance over time
  - Regular comparison of operating data to characteristic curve



- Detection of inefficient pump operation
- Cavitation detection
- …

Expected outputs

- IoT-System in laboratory scale
- Pilot installations in real water utilities in Germany, Brazil and Belgium
- Front-end applications for data storage, data processing, hydraulic modelling
- Visualization and system operation by use of personal computers, tablet computers or smartphones
- Virtual twins of the water systems for testing of system components and their interaction
- IoT-system will contribute to water loss reduction, reduce impacts of water scarcity, simpler maintenance strategies and strengthening of water systems resilience

MECHANICAL AND PROCESS ENGINEERING

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

Thank you very much for your attention!

SAM

INSTITUTE OF FLUID MECHANICS AND FLUID MACHINERY

PROF. DR.-ING. M. BÖHLE

Water JPI

2017 JOINT CALL

SPONSORED BY THE

Federal Ministry of Education and Research