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Smart Water Utilities

COMPLEXITY MADE SIMPLE

IWA PUBLISHING

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INTRODUCTION

TODAY

The challenges with which water utilities are faced today call for smarter control and management of our water resources.

The world population is growing; more people need fresh water as well as food, energy, products, etc. All of these goods require increasing amounts of clean water. Urbanisation in many regions is happening faster than the growth of water infrastructure and the establishment of good water reservoirs to supply the cities. The increasing standard of living further raises the expectations for sufficient amounts of clean water and seamless wastewater handling. This increases the pressure for a safe and clean natural environment and nature. As if nature for nature's own sake were not enough, we also need nature as a source of life as well as for recreational purposes. We need the nature, and nature increasingly needs us to collaborate.

Unsustainable water extraction and wastewater handling can take place for a while, but at some point water needs to be managed in a way that is sustainable long term. When more water is pumped out of the ground than is replenished, the water table drops and at some point it will be impossible to extract sufficient water or water of a sufficient quality from that resource. As a result of this process, the lakes and rivers may run dry. Where water has not been handled carefully, where rivers have been used to carry away waste streams, the problems of getting access to clean water become challenging – sooner or later. Like overspending on a bank account, sooner or later we will need to deal with unsustainable actions.

Emerging climate change further increases the pressure on the water infrastructure. This happens by changes of the pattern of the rainfall – the primary source for fresh water for all purposes. In that sense,the climate change challenges are mostly appearing as water availability. The changes will cause increasing incidents of water scarcity as well as increasing frequency of flooding events. Both situations lead to serious challenges for all people affected.

These challenges further increase the requirements to manage and control the water quantity and quality intelligently. From top to bottom we need to take better decisions to obtain sustainability and provide good water service to all. We need to handle water utilities "smarter".

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SAMPLE MATERIAL

TOMORROW

So the challenge is clear. And happily new and effective tools and technologies are at the same time becoming available at an affordable cost.

New water treatment technologies are steadily changing the water infrastructure options. With current water treatment technologies, we are able to treat any quality of dirty water into any quality of clean water. This means that the old paradigm of one water type for all purposes change – purpose-sufficient water quality is enough. It also means that recycling of water may become a viable option economically as well as in regard to water quality and safety.

Sensors are becoming available for an ever increasing number of parameters. The quality and robustness are increasing rapidly and the required service is diminishing. This means that the sensors become more reliable and hence can be relied upon to a much greater extent for automatically handling critical processes. Online and real-time control means safer and more effective operation.

The combination of better sensors and new water treatment technologies is a strong enabler for decentralised and diversified water treatment. Plants can be run with a minimum of personnel attendance. Whereas earlier we had tens of sensors we will in the future have thousands of sensors in the water utility cycle to handle all the complexity in an effective way.

So what is the difference between having tens and having thousands of sensors?

The main difference is that we need some kind of automation to bring the thousands of data points into useful and actionable information. As an operator or a water consumer, I should not have to worry about all this complexity. As with the telephone network, for the most part, of the couplings should be handled "behind the curtain". The caller should just know whom he wants to call.

So the challenge is clear.

COMPLEXITY MADE SIMPLE

It is not possible to effectively manage and control systems and processes that are not well understood.

Whether the dynamics are fast (seconds or minutes), medium (hours) or long (days, weeks or months), we need data to make good decisions. Data from sensors, measurements, laboratory analysis, and observations. From short to long timescale processes and from water catchment to wastewater effluent, we need real-time and online data to measure what is going on.

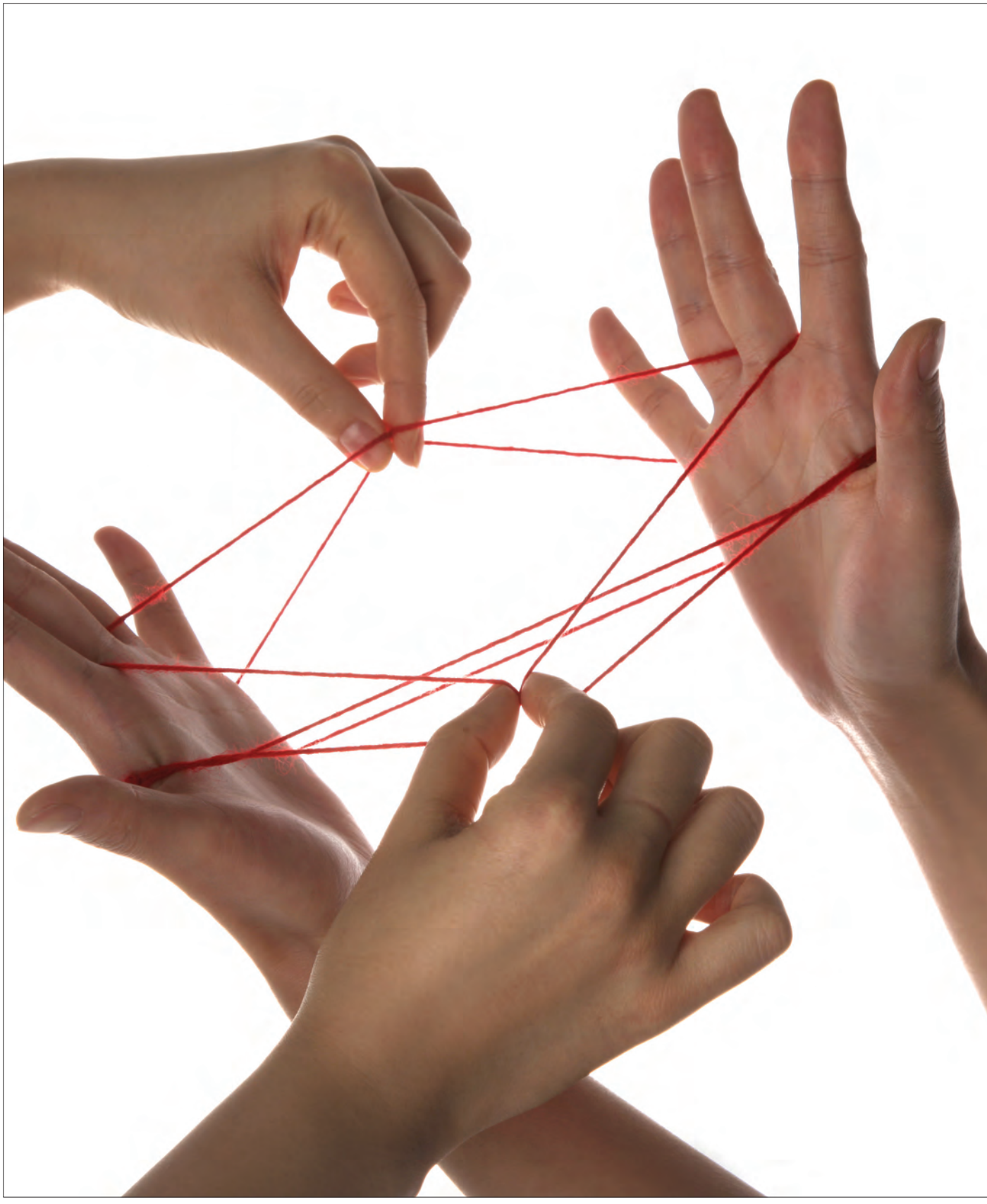
However the enormous amounts of data continuously streaming in from a variety of sensors in a multitude of positions, together with all the other types of data is bound to be confusing unless a structured analytical system is set up to transform data into information.

The information has to be easily comprehensible, ideally green or red light indications – and in case of red light followed by an array of possible reasons for the malfunction and its correction. The information needs to be tailored to the many decisions that should be taken in the water cycle. From automatic decisions taking place in controllers, operational decisions about choice of critical set point, tactical decisions on how to replace or redesign the system and strategic decisions on the higher goals of the utility and its collaboration and interaction with the world around it.

A framework for Smart Water utilities based on a M-A-D approach (Measurement-Analysis-Decision) is proposed and elaborated upon in this book. This framework organises the ”Smart” in a comprehensible way, which gives a good starting point for implementing ”Smart” in a water utility by providing an overview of supporting technologies and methods. A tool box for all water challenges.

A tool box for all water challenges.

SAMPLE MATERIAL



THE AUTHORS' MOTIVATION

Water is a resource essential for all life. This perspective should penetrate all our handling of water. The challenges of water in a modern society are in many cases rooted in its apparent abundance. Traditionally, to the extent that water could be claimed and moved to the location of usage, the water problem was solved. However, as the population and cities have grown, industries are adding to the pressure on water resources; climate change is further adding to the stress; the former robust relationship between water in nature and water in society has become, or is at the verge of becoming, out of balance.

The rules have changed. Today the approach of 'every man for himself' cannot work. There needs to be some kind of water stewardship that ensures that the urban and the natural water cycles work together seamlessly and without destroying values in either place.

It will be possible to achieve this through intelligent water stewardship, and the water utilities hand in hand with the authorities at different levels are in charge of solving this task. The authorities set the requirements at the interfaces and the utilities should strive towards excellence in managing the water accordingly.

While water requirements today are quite crude and based mainly on maximum concentrations, future requirements will be based on the ecological quality of the recipients and reservoirs. Hence utilities need to acquire a deeper understanding of the urban water systems as well as the natural water system. Through an improved understanding better control can be achieved – and hence a better result. The solution is both technical and behavioural – but most of all we believe it is intelligent – and achievable by applying "Smart Water Utility" technologies.

While the mounting pressure from the demand pulls this area forward, the technology opens up new possibilities and creates a push effect.

DEMAND PULL

Regulatory requirements, economics and efficiency are significant driving forces for any utility manager and for any water operation, small or large. The quality has to be satisfied at all times in the various parts of the urban water cycle, for the consumer of drinking water as well as for the lake or river receiving the treated wastewater. The quality requirement will become increasingly stringent and will have to be monitored around the clock. Of course this sets tremendous demands on instrumentation and frequent measurements of many different variables, but also on our ability to interpret an ever increasing torrent of information. It is apparent that this cannot be done manually. Instead, we have to trust that automatic systems can take care of most of the operational challenges, some in a very fast time scale, others appearing very slow, in periods of months and years.

Energy is usually the single largest operating expense in water operations so it makes economic sense to reduce those costs where possible through good control. The vision of zero or even positive energy plants has already been realised in some cases. Furthermore, wastewater is not waste, it is a resource, containing thermal energy, organic substances, phosphorus and many other interesting and valuable components. Therefore any wastewater treatment is nothing more than a water resource recovery process.

TECHNOLOGY PUSH

To measure is to know and obtaining reliable measurements is the fundamental condition for any good operation. In any plant operation, small or large, the primary goal is to (hopefully automatically) make sure that the equipment – pumps, motors, valves, etc. – are operating adequately. The next level of information is about water quality. The development of online sensors has been remarkable and it is logical that all water operations should take advantage of this.

There is a risk with having lots of data available, whereby we may become data-rich but information poor. Therefore it becomes increasingly important to exhaust the measurement data and make meaningful information out of it. With the computing power today, any computation effort is almost for free. Our challenge is to make the maximum use of the measurement and computational resources.

Still another crucial development is the revolution in communication. The “internet of things” makes it realistic to monitor any instrument wherever we are. It also means that competent people such as operators and process engineers do not have to be physically present at a process or a plant. The “death of distance” makes them available for operations of any scale and size.

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THIS BOOK IS FOR YOU!

This book is addressed to the entire water industry: managers, engineers and operators of water and wastewater utilities, consultants, designers of water infrastructure, researchers in university and industry, innovators, manufacturers of equipment,– and policy makers.

The concept of "Smart Water Utilities" extends by borrowing the use of "Smart" from the electrical energy arena (e.g. Smart Grid) to water. The book is about the full water cycle and how to manage and control it in an intelligent way by the use of online real-time data. A very simple model is proposed, called M-A-D: Measure–Analyse–Decide. So, basically:

1. Make sure you get the data you need, preferably in real time;

2. Make sure you analyse the data both correctly and creatively; and

3. Apply the results to take better decisions.

This is about decisions at all levels, from automatic control to management of the full water cycle and the organisation to handle it. Besides from presenting the M-A-D framework there is a number of interesting case stories from people working with Smart Water Utility concepts. The book ends with a number of visions, reflections and views into the future of Smart Water Utilities covering areas of management, technology and innovation, presented by leaders in the profession.

Basically our view is that today you can treat any kind of poor water source and convert it to any kind of high water quality you wish. It is all a matter of the cost and complexity of the treatment. Especially, it is about the energy that you put into the process as well as the required capital investment.

Energy and capital are the two main restraints keeping the world from reaching the grand water vision. But we know that in water laboratories all over the world, scientists and engineers are spending work-hours and night-hours pushing the technological limits to provide water smarter, and at a lower cost, both in terms of treating it and transporting it.

This book is about all these water innovations and how they can be used in the real world to benefit all. Part of the water industry is mature and water and wastewater are handled consistently and with few hiccups and have been for decades. But there is also an emerging area in which new-comers and visionaries tenaciously develop new water technologies and frameworks for how to handle the water more intelligently.

We can all contribute and have a role in creating the new and improved water utility: the water utility 2.0. It will require a lot of effort from all of the industry.

Having picked up this book and read this far, we welcome and encourage you to take part and join us on this travel into new and emerging possibilities.

WATER UTILITY MANAGER

You have been entrusted with a very important and valuable asset of your community. The decisions that you make while managing will have to be lived with by water utility managers for the next 50–100 years. But they are not the only ones to enjoy your legacy. The economic and social developments of your community are also greatly influenced by your decisions for many years to come. And even if we don't talk a lot about it, the nature around us is also affected. Remembering back when you chose this path of career was not nature an important personal driver?

WATER UTILITY ENGINEER

There are so many things to understand about the urban water cycle and so many options to make your footprint clear. Be it automation and control, construction, treatment processes, models, asset management, water cycle wide integration or any other field, your utility relies on your ability to make the effort to really go deep into understanding what is going on and how it could be made to work optimally. In the day to day hassle of making things and collaboration relationships work, it might be difficult to find time to think out of the box – but try to make time. You might be closer to a great solution than you think.

WATER UTILITY DIRECTOR

Dear Director, this is important! You need to understand what Smart Technology makes available to you. You can set the direction and paint the future of your utility. Please paint it to be smart. Not just for the sake of your employees, the politicians that rely on you, your customers and stake holders – but also for yourself. By making the water utility smarter your doubts and fears about catastrophes looming on the horizon can be reduced. You can sleep soundly at night knowing that the smallest problem on the horizon will be picked up and that you can defend all of your actions to a potential sudden angry political reality. Just browsing through this book will give you an idea of what can be done. Then you may give the book to your engineers and see what happens.

CONSULTANT

So you are working in a water company – new or mature. Well, this is as you probably noticed neither the fastest, most glamorous nor the easiest industry. But it makes good moral sense and as an engineer you do get some street-credit for "saving the world". We hope to give you a better overview – outside of your particular choice of specialty. This can enable you to collaborate better with other businesses and provide new solutions to your customers. Additionally, understanding world trends and the world of your customers will also benefit your company. Please be patient but persistent with the industry.

DESIGNER

We know the dilemma: make it smart or make it the conventional low-risk way. But please if you don't invest the time in understanding how smart this could all be – now, then the industry will never change for the better. So muster the courage and the dedication to sell a good solution, talk to the client, suggest something better, and educate him as well. Design the plants and the networks for flexibility and make sure that sensors are specified as well. Coordinate with the engineers in automation and control; they will be happy to help you and show you where flexibility counts. Remember, it is profitable to become smart!

RESEARCHER

You are still up? This late at night? We know! We are up with you. We imagine you are doing experiments in laboratories and in front of computers trying to wring out the secrets of how to treat water even better, how to transport it even cheaper, how to detect that substance that is still undetectable, how to control the process even better without compromising process stability. In the breaks from your experiments read this and make sure that your research really counts on the big problems. We need your intelligence, persistence and concentration to work on the real-world problems. Above all, make sure that you not only solve the problems right, but also solve the right problems.

A TOOL BOX FOR ALL WATER CHALLENGES

Water challenges around the world take different forms, depending on factors such as climate, water availability and wealth of nations.

Some countries, such as Canada and Norway, have tremendous water resources. Norway can supply 100% of its electric power using hydropower. There is a temptation when having so much water to consider it infinite.

Lack of water is a major reason for the Middle East crisis. The Gaza strip will be completely dried out in a few years due to over-abstraction of its aquifer. The aquifer under the West Bank is primarily used by the Israelis, leaving far too little for the Palestinians.

Northern China is dry, while the South is wet. The North includes not only major cities such as Beijing but also huge water requirements for the agriculture, for energy generation, for other industries and for a rapidly increasing population. The Chinese solution is to build a huge south–north waterway from the Yangtze River.

The west and south west of the USA is a dry country, creating a water supply challenge for millions of people. There is also a serious conflict between oil exploration using hydraulic fracturing and agriculture that depends on irrigation using groundwater.

Our huge need for oil is causing terrible suffering for many people. In Nigeria, the livelihood of some 30 million people has been destroyed by leakages from the oil exploration in the Niger Delta. This used to be one of the most valuable wetlands in the world.

Every country, region and city has its own water challenges. Smart Water utilities provide a toolbox that is useful across all challenges and conditions. The tools will not always solve the problems but will provide a framework and relevant data to make the problems solvable.

This book will present you with a toolbox and an introduction to methods and tools, providing a perspective of what can and could in the future be achieved by intelligently managing the water. And that means managing water at all levels, from national politics, local politics, and utility leadership down to the concrete physical layer of controllers operating to treat and transport the water.