1. Introduction

Water, a vital resource for human activity, must be drawn off, treated, transported and after it is used, returned to Nature clean. This process, now automated, is subject to very demanding quality, environmental and productivity constraints. The stakeholders responsible for producing and distributing water are looking for automation partners capable of taking charge of all the systems and proposing solutions that encompass all of the phases from installation and operation to maintenance.

Water treatment process

Most of the time, water sources are far away from consumption points, so to guarantee dependable water supply in all seasons, it is necessary to multiply the supply points. This results in processes that utilize extended infrastructures and create specific water business needs. Figure 1 illustrates the water cycle, which comprises two phases, often independent:
- Production of clean, drinking water
- Recycling of waste water

Constraints of the water treatment process on automation

Without getting into a detailed analysis of the specific needs of each customer, we can outline the constraints that determine the automation architecture. Table 1 summarizes the main constraints:

<table>
<thead>
<tr>
<th>Type of constraint</th>
<th>Constraint</th>
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<tbody>
<tr>
<td>Environmental</td>
<td>- Water quality and monitoring of parameters</td>
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<td></td>
<td>- Traceability</td>
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| Continuity of service with possible redundancy and fall–back in the event of failure |
| Security, including access control for remote sites and intrusion detection |

| Legal |
| Transparency with respect to local communities and the public: |
| Types and quantities of generated waste |
| Height of ground water |
| Level of reservoirs, etc. |
| Conservation of historical data |

| Economic |
| Total cost including installation, maintenance, updating and revamping |
| Follow–up of operating costs, material and energy consumption costs |
| Follow–up of historical data, archiving |
| Management of on–call duty |

Table 1

The process typology guides the choice of the architecture, which will be different for the two phases of water treatment:

- **Production of clean water**
  
  At all stages, from catchment and purification, through transportation and storage, to consumption, water must be monitored and bacterial proliferation must be regulated by the use of additives (chlorine). The complexity of the system arises from the large volume of information to be processed – resulting from multiple check points – and from the regulation needed throughout process. The various process units are independent to some extent but monitoring of all the units must be centralized. The connections between units are often temporary, lasting only the time it takes for the required information to be exchanged.

- **Recycling of waste water**
  
  In this stage, automation is concentrated in the treatment stations. Waste water collection and disposal are seldom supervised by automation. The automation profile at this point is similar to that of industrial processes.

Two architecture profiles fulfil all of the needs mentioned above:

**Systems structured around a central process.** A portion of the infrastructure units are permanently connected, generally via the public network or a proprietary network. The other part of the infrastructure is intermittently linked and this involves telemetry. The design of the central system, similar to those found in industry, must take this point into account.

**Telemetry systems.** All of the links between remote sites are periodic and characterized by exchanges which may be triggered by cyclical polling of the central system, or at the operator’s request, or by the transmission of data from a site to the central supervisory system upon the occurrence of an event.
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The rest of this article will emphasize the specific problems relating to this type of system.

2. Telemetry

Independent units, little human presence on the sites and large distances are determining factors for the systems, which are generally structured in three levels (see Figure 2):

- **Centralized control**, whereby the different sites may be remotely supervised and monitored via a central SCADA (Supervisory Control and Data Acquisition) system and, as an option, other units and maintenance people may be informed.

- **Links**. The system must store information locally, establish communication, either cyclical or event-driven, and transmit the information. According to the criticality of the data to be transmitted, it is sometimes necessary to provide media redundancy to deal with communication contingencies or to differentiate the receivers. The maintenance specialist is informed by GSM, whereas process follow-up data are sent via a public STN (Switched Telephone Network) line at the operator’s request. Since connections are cyclical, the SCADA used must manage the modems and communications. Time-tagging of events must be done at the source and the data must be stored, waiting to be read. The modems need to be capable of operating in both master/slave\(^1\) and master/master mode.

- **Local control-monitoring** provides all of the automation, electrical distribution and protection functions required for the operation of the process. The system must be capable of supplying the information required for control. In the event of a failure, it must not only inform, but also ensure a minimum of continuity of service (downgraded mode).

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1. **Main functions expected**

Without being all-inclusive, the list of the functions below represents the majority of the needs encountered:

- Data acquisition (status, measurements, counting....)
- Time-tagging of events
- Processing of events
- Automatic transmission of events to the SCADA and maintenance operator
- Publication in logs, curves, mimic diagrams and reports.
- Transmission of information on incidents
- Remote monitoring of the process and installation
- Management of maintenance crew operations at the SCADA or front-end communication level or even via a system embedded in the product
- Reduction of maintenance time and costs remote diagnosis of the components (variable speed drives, PLCs, protection relays, instrumentation, etc.)
- Updating of the application software or automation software
- Access supervision and authorization (badge readers)

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\(^1\) In master/slave mode, the terminals only reply when polled, whereas in master/master mode, they can transmit data upon the occurrence of events
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- **Specific features of the links**

  Each installation configuration entails specific constraints relating to operation and also to the types of communication available and the regulations in effect. Like any other type of communication system, telemetry utilizes the transmission media available and standard protocols according to needs.

  Communication transmission media currently used:
  - STN (Switched Telephone Network) lines or proprietary lines, with a rate of 64 Kbits
  - Analog wireless links with or without a user license
  - Digital wireless with a rate of 1.2 Kbits
  - "GSM data" at 9.6 Kbits, which is not available in all countries
  - GPRS, which uses a dynamic IP address system, requires a particular type of management to fit requirements
  - Fiber optics, ADSL and carrier current

  Ten or so protocols are used around the world:
  - Modbus is the best known. It represents 25% of the network protocols used worldwide and covers industrial, electrical distribution and infrastructures applications.
  - IEC 870-5-10x protocol, defined by the international standardization committee for electrical distribution and used in water treatment
  - DNP3 protocol used mainly in USA, GB, Asia and South America.

- **A global need**

  Faced with the need to optimize the solution, decision-makers must deal with very different cost and environment related constraints spanning the complete installation usage cycle, including design, investment, installation, operation, maintenance and sustainability. These constraints naturally lead to seek support from partners who can deal with the matter as a whole and are capable of working with contractors and integrators. Preference is given to a sole provider to guarantee the consistency and maintainability of the chosen solutions.

3. **Schneider Electric's telemetry offering**

  Schneider Electric's expertise and international base in industrial automation, electrical distribution and network monitoring make it, together with its partners, one of the few players capable of offering a range of products and services that covers the automation needs of the water business worldwide, including the selection, implementation, operation and maintenance of the solution. According to its policy, Schneider Electric collaborates with a large number of integrators and has created the Alliance partners' network. This singular feature offers customers the power of a major group combined with the flexibility and proximity of a specialist, enabling tailored turnkey solutions using the finest technologies.

  2 Each unit does not have a fixed address; the address is assigned to each connection automatically by the Web server.
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To both facilitate selection and offer optimized solutions, the offering is structured in the three levels described above and shown in the diagram in Figure 2.

- **Control** is ensured by SCADA software, supervising either a group of independent stations, or integrated in a master process which controls the satellite sites.
- **Links.** They are managed by telemetry modules in the w@de³ range which perform multiple functions such as communication, archiving and automation monitoring. The range of configuration products and software are integrated in the architectures presented in the following section. Schneider Electric advocates the use of Modbus. This widely-used communication protocol is well-suited to electronic messaging needs. It has been implemented in TCP/IP, giving the equipment total transparency. Time-tagging functions are included to meet specific water treatment needs.
- **Control–monitoring** includes, for each station, products such as PLCs, contactors, variable speed drives, circuit breakers, protection relays, sensors and monitoring systems. To help customers select, Schneider Electric has optimized some "preferred architectures". The figure below gives a succinct illustration of three examples. Reader are invited to refer to specialized documents or contact Schneider Electric for a fuller understanding of the solutions proposed.

³ Water @pplication Distributed Equipment
The objective is to propose consistent, interoperable and suitable solutions to cover all specific water treatment needs. Based on industrial standards and acquired experience, each "preferred" architecture has been designed to optimize investments and reduce operating and maintenance costs. Existing installations may therefore be easily updated without requiring major modifications or revisions of the architecture. Implementation does not require any specific training or particular knowledge, and the solutions may be easily implemented or modified.

In the event of a problem, given the simplicity of the architecture and the possibility of real time fault information, the causes can be quickly identified without having to call in highly qualified engineers. All of the data used in the application can be easily configured and saved in a non-proprietary data database that can be utilized by other software.

As a partial illustration of the offering, three "preferred" architectures are presented in Figure 2:

- **P1 architecture – Compact solution**: This architecture is structured around a W320I module which includes a mini-PLC and communication and data storage functions. A W502 configuration
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software tool, operating with Windows, is used to easily configure the product. This architecture is very simple to implement and is well-suited to small lifting stations.

- **P2 architecture – Optimized solution** – An Altivar 61 variable speed drive including a "Controller Inside" PLC board is the heart of this solution. With this system, several pumps can be managed by a single variable speed drive. Ready-to-use software applications are proposed. This architecture is specially dedicated to multi-pumps systems such as pumping and booster stations.

- **P3 architecture – Modular solution** – This architecture, capable of handling the most complex local applications is based on the Premium range of PLCs, its panel of software tools and interoperability among the various components such as W@de telemetry modules, user interfaces, variable speed drives and video monitoring, which allows digital recording from the supervision station. This architecture supports the "Transparent Ready" concept which offers total transparency between the products, the supervisory system, and even the automation systems of other stations.

These architectures are found in real applications that Schneider Electric has produced for its customers in conjunction with its partners.

4. Application of telemetry to drilling stations in Tunisia

- **Origin**
  The project consists of providing a telemetry system for the regulation of six drilling stations connected to the same reservoir.

- **Solutions implemented**
  The system architecture (Figure 3) consists of 6 pumping stations. Each one comprises a W320I telemetry module including a PLC, a W320i module for the reservoir and a micro-PLC for supervision linked to a G500 wireless communication interface. The clusters are started and stopped in a specific order according to the flow rate and pressure measurements transmitted by each one.
Since the reservoir site has no 220V network, the W320I is powered by a battery charged by a solar panel. The sizing of the source provides 3 to 4 days backup without any sun, at any time of the year.

- **Customer benefits**

  The automation of the structures and total self-regulation of the drinking water supply network works without any human intervention. For the operators, the grouping all the alarms on a single site (supervisory system) improves the installation's effectiveness and availability. Simple access to data such as events, alarms and measurements reduces operating and maintenance costs.

5. **Application to Générale des Eaux booster stations**

- **Stakes**

  Générale Des Eaux (GDE) is the delegated operator of Veolia Environnement in France. It serves 26 million people in French districts and local communities, providing both drinking water and waste water treatment services. By contract, it must guarantee distribution under constant pressure, whatever the required flow rate.

  It is important for GdE to find a compromise between quality of service and energy savings, and avoid pressure shocks as much as possible.

  With the number of booster stations on the rise, the economic factor is essential and a choice has to be made between the building of new reservoirs and the extension of existing reservoirs height-wise. Since the number of pumps used in this type of structure varies from 2 to 5, the solution chosen will not depend on the number of pumps.
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Générale des Eaux and Schneider Electric have worked together to find a solution that meets the functional specifications for this type of structure, including the development of a standard booster application software tool and the validation of all of the components in the electrical panel.

Solution implemented

Schneider Electric has developed the 3S control solution\(^4\) which includes:
- A selection guide used to build an electrical panel according to hydraulic data and the number of pumps
- Commissioning, operation and maintenance documents
- The electrical panel (Figure 5), comprising motor starters, protection units and customer options, including Altivar 38 variable speed drives and their "Controller Inside" boards and the "Booster" installation management software in Magelis XBT operator panels.

The Menilles site shown in Figure 4 is one of GdE's references.

Figure 4
The main technical features are:
- 60 m hydraulic head
- Output of 22 m\(^3\) per pump
- Distributed, redundant control–monitoring by variable speed drives
- Integrated operator terminal
- Connection to the remote transmission station by Jbus links

Figure 5

Customer benefits

This competitive solution meets the following criteria:

\(^4\) 3S: "Solution Surpression Schneider", meaning "Schneider Booster Solution".
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- Improvement of pressure regulation in the pipes (response time and accuracy)
- Dependability of the installation (independent pumps, integrated mutual backup, integrated fallback mode, redundancy)
- Optimized economic efficiency of the installation (speed drive performance during peak consumption, switching to economy mode during low-consumption periods, pump changeover)
- Total visibility of operation (local access to operating modes, remote access by GdE agency)

6. Application to the Grenoble water utility

Eurosystem, a system integrator, has conducted in partnership with Schneider Electric the revamping of the city's water treatment system.

- **Origin**
  The utility has been in existence for 120 years and manages a 220 km network of pipes distributing 160 million m3 of water to cover the needs of the city's 163,000 inhabitants. The Rochefort site is made up of 5 wells, two reservoirs with a capacity of 40,000 m3 and 3,500 m3 respectively and a backflow station. The automation system dates back to 1985 and needed to be revamped.

- **Customer's objectives**
  To modernize the installations and make them sustainable by implemented new technologies to make operation and maintenance simple and secure.
  To increase installation availability and track information.

- **Solutions implemented**
  The diagram in Figure 6 presents the installation structured around two redundant networks, one fiber optics, and the other using the STN (Switched Telephone Network) system, with the whole assembly connecting the various sites to the supervision stations.
Site supervision

All the data coming from the various sites are centralized in one location. Supervision is done using PcVue software published by the Arc Informatique company (Figure 7) equipped with bi–screens, offering users the required ergonomics.

The availability of the application is ensured by redundant servers.
The system remains easy to operate thanks to the use of a single control environment, including the supervision of local systems and remote systems on the same workstation via telemetry.
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- Communication architecture

Ethernet TCP/IP Modbus is the backbone of the system. This well-known network meets the requirements for performance, interoperability and simple connection. Availability is guaranteed by the use of a fiber optic ring.

- Telemetry

It is ensured by W@de modules which meet the specifications. Availability is increased by the use of two W@de 330 modules which share the flows of calls on TCP/IP. Connectivity is ensured with the Twido PLCs – used for decentralized processing – at the same time as the transparency of communications for diagnosis, programming and downloading. Maintenance is optimized by the choice of the same type of telemetry module for the entire installation and the use of the embedded Web server.

- Automation

The brain of the installation is a TSX Premium PLC and remote Advantys STB modules. These products, which have proven their reliability in industrial environments, offer easy maintenance by the hot swapping (on-load changing) of input/output boards and integrated diagnosis. The availability and upgrading capability of the offering guarantee sustainability and maintainability.

- Customer's point of view

All of the players got involved and shared their competencies:
  - Operator: their knowledge of the installations
  - The integrator: their knowledge of the business and nearby service
  - The manufacturer: their product and solution expertise

Teamwork made it possible to develop this application and provide innovative solutions to meet all of the customer's expectations.