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A technologic water corridor

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Abstract. A modern methodology has been developed by a team of Autovie Venete technicians and engineers in order to monitor a motorway wastewater purification system and ensure its regular functioning. Initially designed for "section 28" (Sacile Ovest-Godega di Sant'Urbano) of the A28 motorway conecting Portogruaro (Venezia) to Conegliano (Treviso), the purification and monitoring system was later expanded to include "section 29" between Godega di Sant'Urbano and the A27 junction near Conegliano. Completely designed and developed by Autovie Venete Systems Engineering Department, the system has taken one year of work and an investment of € 650,000. The added benefit of this system lies in the fact that it is possible to further strengthen the network infrastructure without making adjustments to its system architecture.

Key-words. Optical network, stations, oil skimmer, optic fibers, SCADA, PLC master.

1. Introduction. To reduce motorway pollution at a minimum level, motorway operator Autovie Venete has built a technologic water corridor located along the edges of the carriageways of the A28 motorway, between Sacile (province of Pordenone) and the A27 junction at Conegliano (province of Treviso) (Figure 1). Composed of ditches, whose structure consists of various layers of waterproof materials as well as settling tanks and oil skimmers, the purification system follows a three-stage procedure: the liquid poisons harvesting (water, oil and grease); the decantation of light materials (water, oil, grease) from the heavy ones (sand, stones, branches); the oil-water separation. The complexity of this system

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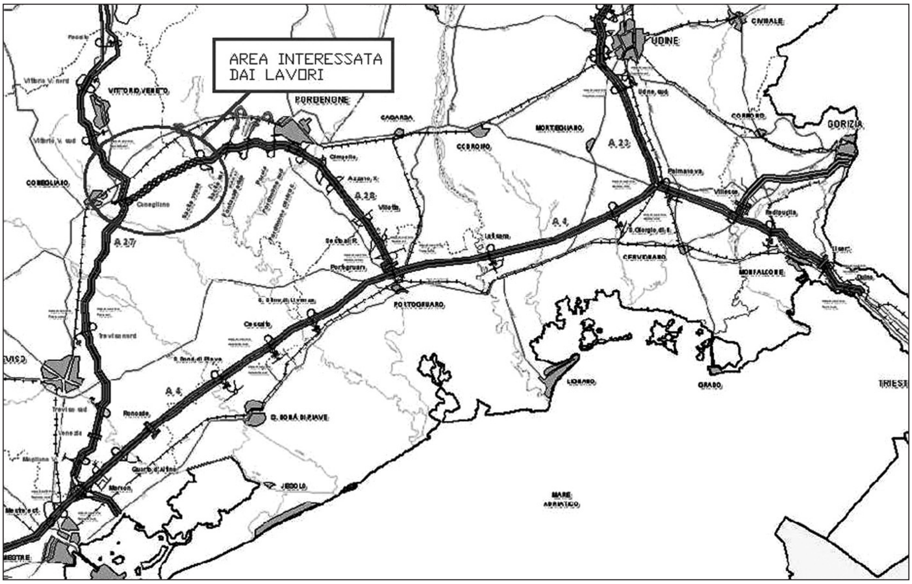

Figure 1. Area of intervention.

requires a continuous "surveillance and cleaning" of its infrastructures, so an accurate and well-timed maintenance is fundamental.

To meet this need, a team of Autovie Venete technicians and engineers dealing with system designs has developed a modern project so as to monitor and ensure the regular functioning of the system. The project consists of a sophisticated and widespread optical network which allows centralizing and remotizing any information obtained from sensor nodes so as to enable a real-time monitoring of each station as well as the automatic throwing of warning signals which, in case of critical situations, are sent to the Maintenance Unit. All data acquired from the network sensors are gathered, processed and memorized on a management server to which remote clients equipped with GUI "user-friendly" and the Maintenance Unit Operators of Palmanova (province of Udine) may log on.

2. The purification stations. The purification network consists of 93 stations (Figure 2). Each of them is a system composed of interconnected passive/active components which filter and clean the water. The stations receive wastewaters from the ditches. The liquid, then, is stored and treated in huge three-section settling tanks (Figure 3). The third section is equipped with a submersible pump which recovers the fluid and sends it to the oil skimmer (second tank). A passive filter, the oil skimmer, recovers the fluid from the settling tank pump and, thanks to a coalescing filter, separates "cleaned" water from oily substances which are stored up to the maximum capacity (Figure 4). Owing to gravity, "cleaned" water comes out of the oil skimmer and is sent to the territorial rainwater harvesting systems. The submersible pump is statically monitored by a sensor network which is located inside the settling tank and the oil skimmer. The logical combination of sensors allows the activation of the settling tank pump and the outflow of liquids into the oil skimmer. The condition of the tanks and of the pump is constantly monitored by sensors. The collected data are the necessary information to feed the networking system which, by processing any signal, allows the remote operators to verify the regular functioning of each station.

3. The telecommunication infrastructure. An efficient and reliable network architecture allows accessing all the purification stations, supports the transmission protocols of the stations' data acquisition/transfer apparatus, regardless of their collocation in the territory (Figures 5-6). The network is a ring-based backbone which has a maximum transmission speed of 1 Gb per second. It uses TCP/IP protocol stacks whose fundamental parameters have been evaluated during design stage (recovery time, transmission speed, physical connection parameters used by the stations and physical parameters related to the network "degree of importance" inherent in the service supplied). Thanks to a physical rings network, which is

Figure 2. Purification station.

Figure 3. Settling tanks.

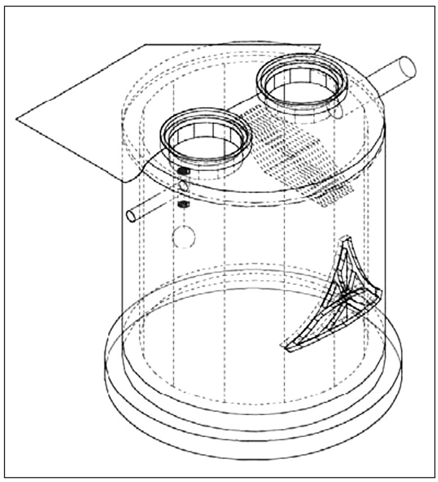

Figure 4. Oil skimmer.

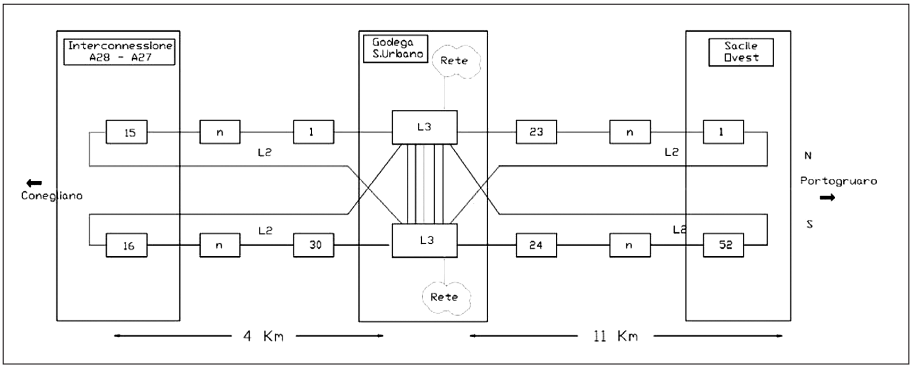

Figure 5. Network architecture at completion of work.

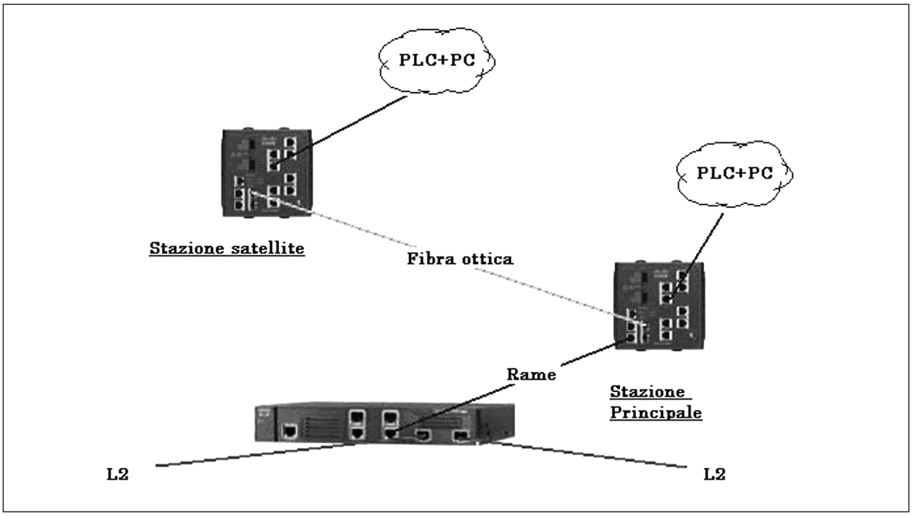

Figure 6. Satellite station network with switch.

managed by the link layer (L2) of TCP/IP stack, a master configuration has been obtained. Implemented with a series of point-to-point links between the stations, the rings network depends on a distribution panel which is managed by the network layer (L3) of TCP/IP stack. Overall, the network architecture consists of: 94 purification stations; 1 data collection site which allows intranet network access; 18 satellite purification stations, downstream of some of the 76 L2-layers.

4. The network devices management. The management of switch equipments, as provided for by Autovie Venete's corporate standard, allows any maintenance and failure prevention. A software has been used so as to allow the management and the monitoring of the connected switch equipments: CiscoWorks LAN Management Solution. This computer program allows building a dynamic network topology, verifying the regular functioning of the systems and configuring devices. If failure occurs, then a wide range of tools enables the operator to perform failure investigations. The application allows configuring multiple user profiles in accordance with the activity of the operators managing the software. To perform the network discovery, the operators mainly use 2 protocols: SNMP (Simple Network Management Protocol) and CDP (Cisco Discovery Protocol). The former is a standard protocol which supports different operating systems. The latter protocol is designed by Cisco System. It allows verifying any contiguous network connection so as to create the physical path (by showing all interfaces for data flowing).

5. Fiber-optic vector. Essential elements of the network are the backbone and the shunt optic fibers (8 SM/single-mode fibers) which include an optic nucleus composed of loose unitubes with dielectric armour. The doped silica optic fibers (matched-cladding type) are cladded by coloured material so as to clearly distinguish between the different kinds of cables. The internal armoured loose unitube, on the other hand, is made of polybutylene terephthalate (PBT) which guarantees high mechanical protection.

6. The management control system. The MCS (Figure 7) has a three-layer structure: 1) supervision and client operating system. The heart of the supervision system consists of a single configuration SCADA server which is predisposed for Hot-Standby configuration as well; 2) data collection system (PLC Master). This layer consists of a PLC which gathers data from the "third layer" PLC Slave (single-PLC configuration and dual Network Interface Card). This PLC is intended for the installation of a second CPU (as it is in the case of the SCADA server) so as to be configured in a Hot-Standby modality (HSB) without adding further components; 3) PLC Slave Units. The supervision system can be connected to external systems through high-performance drivers which perfectly guarantee communication among the software applications.

7. Mainframe. The mainframe oversees system features and supplies the connected operators with adequate software visualizations. Some mainframe tools enable the data storage and the software management, while others allow software visualization and the issuance of commands. The SCADA database, which is suited to support a client-server architecture, has been bought in a modular form (Figure 8). As a matter of fact, sizes can be increased by simply buying an upgrade, and the number of clients

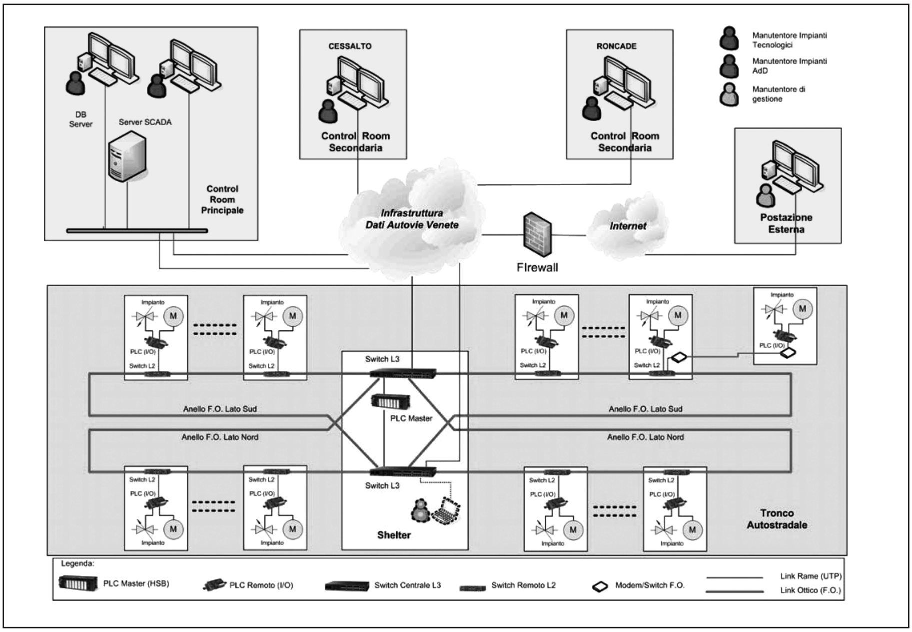

Figure 7. System architecture.

can be easily increased as well. Client Access Licenses are both "fixed" (locked to a particular PC client – e.g. the Control Room) and "floating" (Web based). Floating licenses are installed on a server which supports dissolvable clients connectivity, even from multiple workstations.

8. Warning device. The alarms raised by the controlled network systems, the pumps and the actuators can be of any type. They are managed by the SCADA system according to the typical modalities of supervision network systems. There is no limit to the number of simultaneous alarms. The system detects each alarm onset/clear event both with and without alarm acknowledgement. The operator can acknowledge the alarm, clear the acknowledgement and suppress the alarm. Moreover, the system is able to manage the severity of the alarm events by classifying them according to a cause-effect logic. For example, when a PLC activates an alert, the whole system managed by it will not have to raise any alarm. Each controlled component recognizes three conditions: normal (green light); alarm (red light); undefined (yellow light).

9. User profiles. The user profiles are managed in specific ways in order to allow access to different parts of the network system (the same applies to alarm events and alarm acknowledge-

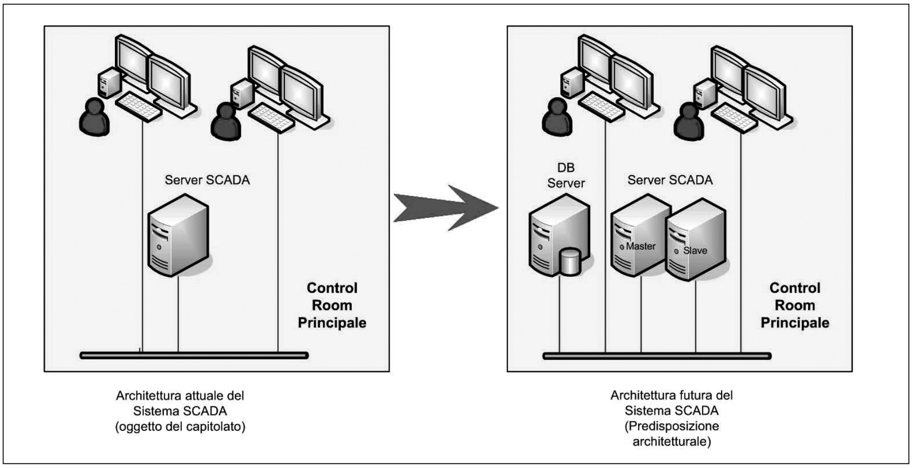

Figure 8. System opening with the addition of a DB server.

ment). The user profiles, then, are structured according to a sort of "functional insulation" which consists of the operator identification through a profile intended to enable both visualization and command features. The Network Administrator is the only user who can create a user profile and has the power to perform any operation in the network system. The user profiles can be modified during run-time without stopping the SCADA system.

10. Remote System. The basic unit for the remote management of the whole purification system is "the motorway section" (identified as a sector). Each management sector is equipped with a PLC Master (single-PLC configuration, expandable to HSB configuration) which controls the PLCs of every single purification station. Therefore, from a functional point of view, the SCADA system manages the PLC Master which, by checking all PLC Slaves, oversees supervision on the motorway sector (the PLC Slaves are set along the motorway and each of them controls a single purification station) (Figure 9).

The whole system is designed to guarantee high performances. It allows managing more than 700 simultaneous alarm events. The maximum execution time is less than one second after the operator command issue. The maximum update time of pages, then, is less than one second after the operator command issue, while the maximum PLC cycle time is less than 50 seconds. Moreover, thanks to SCADA server licenses, it is possible to manage an unlimited number of I/O and variables.

11. Conclusions. In this article an integrated purification and monitoring

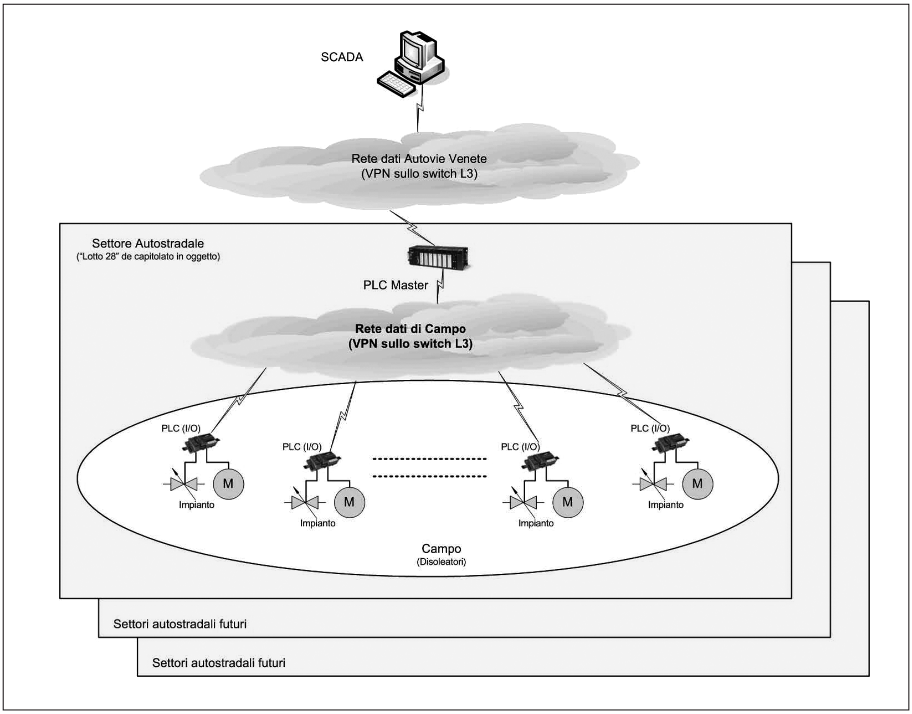

Figure 9. Remote control system.

system has been described for the control of motorway wastewater pollution. The system has been implemented by motorway operator Autovie Venete on the new A28 motorway between Sacile and Conegliano. The system is based on a widespread optical network, uses advanced data management methods and enables real-time monitoring of each purification station. Autovie Venete network purification system has been recognized as one of the most innovative ideas in the field and has recently won the European *Innovation Award at Cisco Live 2010*, a prestigious award for network environmental technologies.