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Automated Meter Reading For Water Demand Forecast And Hydraulic Modelling Of The Municipal Water Distribution System In Mikołów, Poland

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AUTOMATED METER READING FOR THE WATER DEMAND FORECAST AND HYDRAULIC MODELLING OF THE MUNICIPAL WATER DISTRIBUTION SYSTEM IN MIKOŁÓW, POLAND: A PRELIMINARY INVESTIGATION

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This paper presents preliminary results of a project aimed at utilising an automated meter reading (AMR) system for water demand forecasting and hydraulic modelling of the Mikołów (Poland) water distribution system.

INTRODUCTION

This paper presents the preliminary results of a project aimed at employing an automated meter reading (AMR) system for water demand forecasting and hydraulic modelling of the Mikołów (Poland) water distribution system [1]. This system will allow for the near-real time collection of hydraulic data used for the purpose of an integrated ICT system. This system will combine GIS, CIS, data acquisition system, hydraulic model and optimisation algorithms into one integrated decision support tool for the management of the water distribution network in Mikołów.

The accurate estimation and prediction of demand patterns of the customers is a crucial element affecting the accuracy of the hydraulic model. The AMR system will be used to analyse the behaviour of individual household-based water consumption. Calibration and validation of the model will be conducted by combining the data acquisition system (SCADA) with temporary measurement points placed during the measurement campaign.

WATER DISTRIBUTION SYSTEM IN MIKOŁÓW

Mikołów is a city located in Silesia, in the southern part of Poland and borders the Silesian Metropolis. The relief of Mikołów is diversified; terrain elevations vary from about 285 m to 345 m. The water distribution system serves about 40 000 people and covers an area that is about 6 km long and 5 km wide (approx. 30 km^2).

The total length of the water distribution system in Mikołów (pop. 40 000) is about 310 km, with 117 km of service pipelines (2013). The net water demand is about 7500 m^3/d during an

average day. Water is supplied to over 7600 individual clients and bulk (industrial) customers. Water for Mikołów is supplied from the main water distribution system of the Upper Silesian Waterworks PLC (approx. 65%) and from two groundwater intakes located in the northwest section of the city. The water supply system does not contain any storage tanks. An overview of the Mikołów water network is shown in Figure 1.

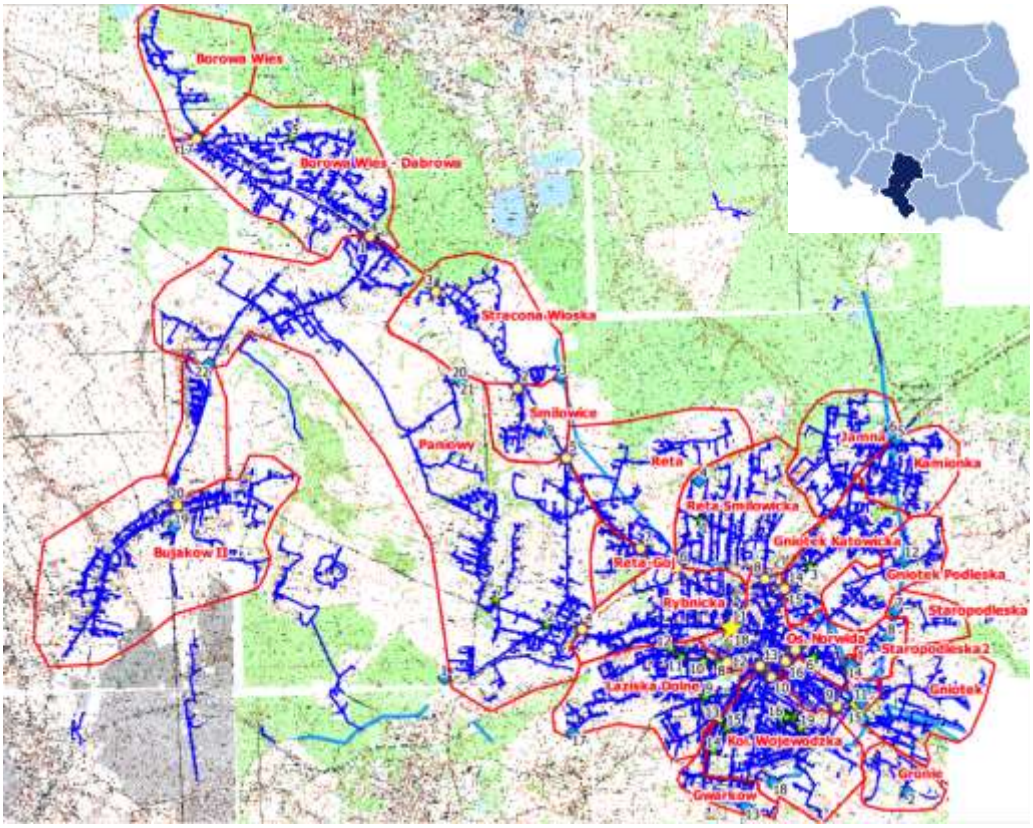

Figure 1. Overview of the water distribution system in Mikołów

THE ICT SYSTEM FOR MIKOŁÓW

The ICT system developed for the water supply system in Mikołów is built in modular form and consists of the following components (Figure 2):

- GIS – for designing the numerical maps of the water network investigated,
- SCADA – for monitoring the water network parameters, i.e. the flow and pressure values,
- CIS – for managing the data of the water amounts consumed by the end users of the water network,
- Hydraulic model of the water network – for calculating the water flows and pressures in all pipes and nodes of the water network,
- Programs and routines with algorithms for mathematical modelling, optimization, approximation, control and planning.

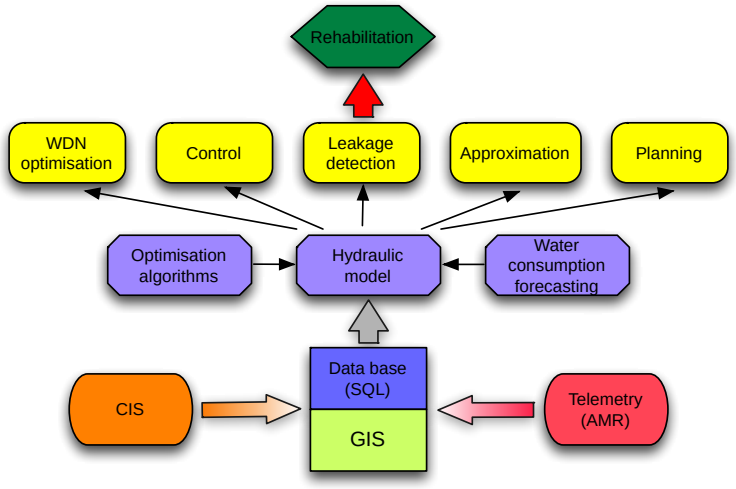

Figure 2. Block diagram of the IT system for water network management

The components GIS, SCADA and CIS are adopted from commercially available software packages (e.g. Intergraph G/Water, TelWin SCADA). They are integrated with custom routines and programs to create the optimized system that is composed of three modules used for the analyses and decision support tool for the water distribution system management tasks. They include (1) custom hydraulic modelling software and optimization algorithms – MOSUW module (Figure 3), (2) approximation algorithms and (3) algorithms for mathematical modelling – kriging applications and objects identification modules (Figure 4).

Figure 3. Module MOSUW of the ICT system

Programs in the MOSUW module interact with the hydraulic model. A multi criteria optimization algorithm is used for tasks such as model calibration, water network optimization and planning, pump scheduling and control as well as the planning of sensor placement for the telemetry system (SCADA) [3]. For the solution of simple tasks, only multiple simulations of the hydraulic model under different conditions of the water network are executed.

Programs included in the kriging application module employ kriging approximation algorithms that enable the graphical presentation of value distributions for various parameters in connection with the water network layout and its operation [4].

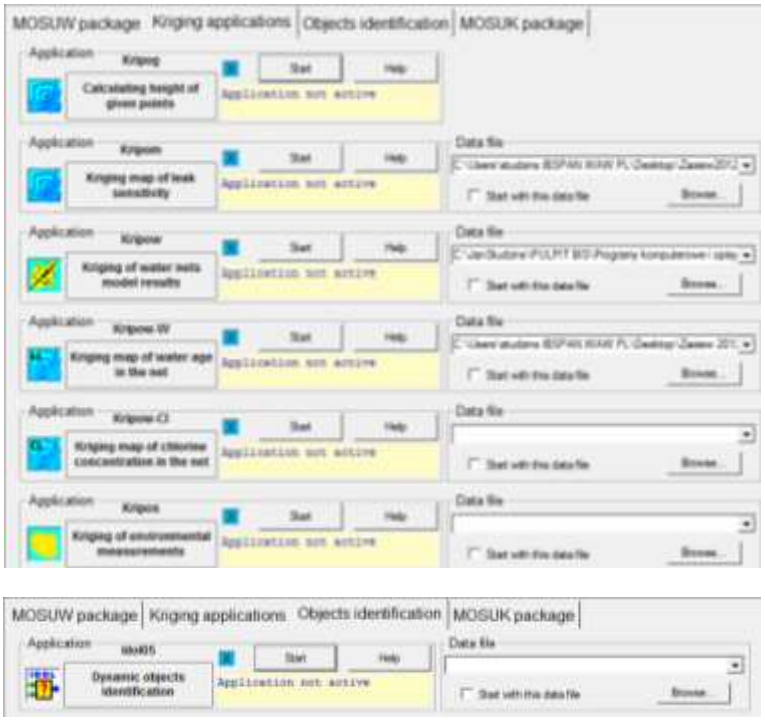

Figure 4. Kriging applications and objects identification modules of the ICT system

In the objects identification module several programs are collected for the mathematical modelling of dynamic processes by means of the time series methods with the least squares algorithms such as Kalman's, Clarke's, maximum likelihood or linear and nonlinear regression algorithms [2].

The developed ICT system consists of more than 20 programs cooperating with each other in different combinations depending on the tasks to be solved. Through this cooperation, a synergy effect arises that increases the efficiency of the running programs.

TELEMETRY AND AMR SYSTEMS FOR MIKOŁÓW

All customers will be equipped with an automated meter and incorporated into the existing monitoring system. A hybrid AMR system will be used combining the local reading of meters by two-way RF units with telemetry stations sending signals using a mobile network (GSM) to the main database server. This server contains a database of water consumption readings for individual customers (Figure 5).

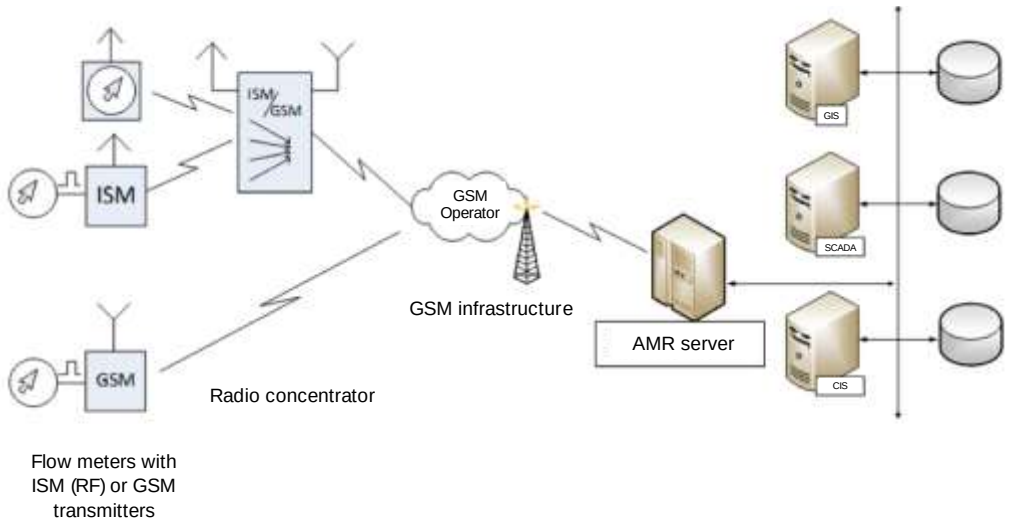

Figure 5. The automated meter reading system for Mikołów

To take advantage of the AMR system a detailed hydraulic model of the Mikołów water distribution network was built. The hydraulic model will be later coupled with an integrated ICT system for the comprehensive management of the water distribution network. The seamless connection between model and GIS, CIS and SCADA modules will allow for the network topology update, automatic re-calibration as well as water demand reading and forecasting.

The SCADA system in Mikołów contains in total 39 telemetry stations where flow rate (39 sensors) and pressure (93 sensors) are measured in the critical areas of the water distribution system.

HYDRAULIC MODEL OF THE WATER NETWORK

The detailed hydraulic model of the water distribution system was built to take advantage of the developed AMR system. The total length of the skeletonized network is approximately 300 km. The network consists of pipes with different materials and diameters ranging from DN 90 to DN 800. All water sources have been modelled. The water supply system in Mikołów is connected to the Upper Silesian Waterworks PLC main water distribution network at 19 points situated in the city along the main DN 1400 pipeline. Along this pipeline the flow rate and pressure are monitored by the online telemetry system. In addition two groundwater intakes (Bujaków and Śmiłowice) have been included in the monitoring system as well as a local booster station.

The water network is divided into several pressure zones by 20 remotely operated flow control valves. The 100 meter difference in topography causes lower elevation areas to have pressures in excess of 60 m. Remotely operated pressure reducing valves (12 pcs.) are installed in these areas on selected pipelines where needed.

Water demands have been grouped in the streets according to data from the AMR system. The total number of metered water nodes was 8432 (including temporary water consumption) and 7387 will be included in the AMR system. Water consumption data will be geocoded and

aggregated with the use of the GIS system. The layout of the hydraulic model is shown in Figure 6.

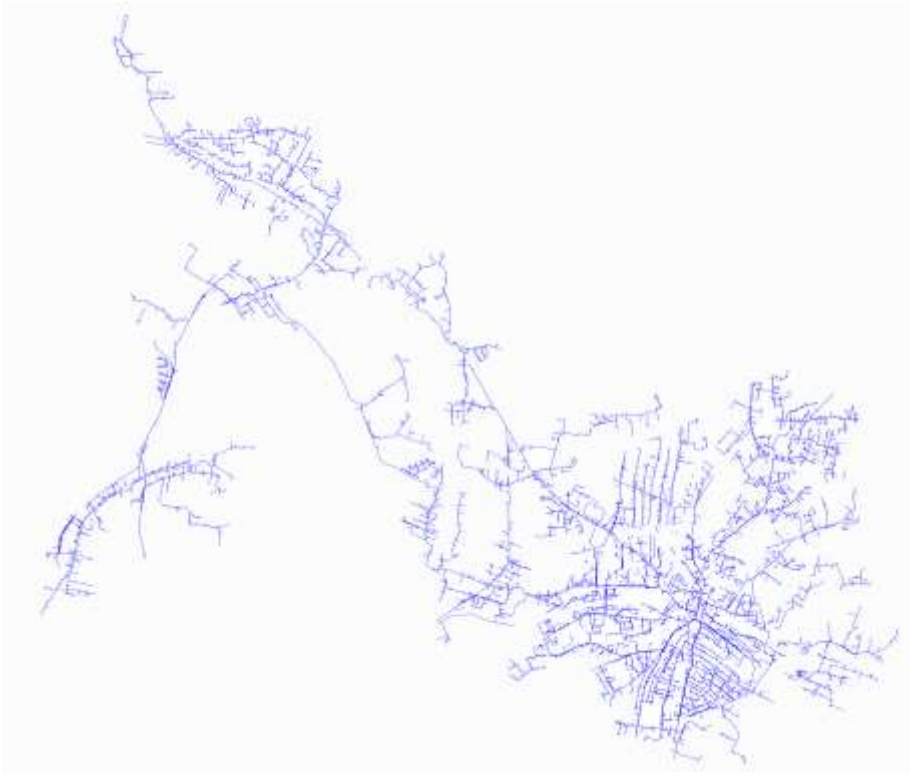

Figure 6. Layout of the Mikołów hydraulic model

CONCLUSIONS

In this case study the automated meter reading system for the Mikołów water distribution system has been presented. Recent investment in the AMR system has provided the unique opportunity to use the Mikołów water supply network for testing various approaches to water consumption forecasting, real-time data management and calibration. Special focus was given to the application of the measurement database from the extensive telemetry system and the AMR for the hydraulic simulation model and multi-criteria optimization modules in the integrated ICT system.

At this early stage of the project, assumptions, challenges and requirements have been identified. The development of the integrated ICT system for Mikołów will provide a tool that can offer significant operational benefits. It will allow for better managing staff as well as let network operators take an active approach to water supply management.

ACKNOWLEDGMENTS

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