The development of aCurve - a Rich Internet Application for process analysis at Käppala WWTP

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Abstract
In modern wastewater treatment plants (WWTP) the demand for advanced process control is a prerequisite for a smooth and energy efficient operation of the plant. Most large WWTPs have distributed control systems (DCS) and advanced supervisory control and data acquisition (SCADA) systems installed for operation and supervision of the plant. Normally the DCS is sufficient for the operators to run the plant efficiently. However, data is also often wanted by others than the operators (e.g. research engineers, students, scientists or consultants) for analysis and reporting or to perform different calculations. At Käppala a new web based program, aCurve, has been developed to meet such needs. The program is a so-called Rich Internet Application (RIA) and is accessible via internet and requires no desktop installation. The main features of the program are rapid presentation of graphs, easy zoom, changing resolution, performing calculations and plotting the results and simple statistics (e.g. mean values, integration, maximum and minimum values). If advanced calculations are acquired, the data is easily exported as an xlsx-file for use in Microsoft Excel or other software capable of reading the Office Open XML SpreadsheetML File format. aCurve can also produce automatically updated reports that are built in Microsoft Excel. This makes the reporting function flexible and any user with Excel knowledge can create and edit a report with a professional result. The reports can easily be shared throughout the organization. The program has replaced other expensive and complex desktop application that were previously used at the Käppala WWTP. Process and laboratory data that can be used for follow up of plant performance has now become available for a greater part of the staff which improve the quality assurance of reported data to authorities and researchers.

Keywords
Rich Internet Application; Data Acquisition; Process reports; aCurve

INTRODUCTION

The Käppala Association

The Käppala WWTP treats wastewater from approximately 640 000 people equivalents (p e). The Käppala Association is the owner of and operates the Käppala WWTP, the connecting tunnel system, pumping stations and flow measurement stations, Figure 1. The Käppala Association was formed in 1957 as a cooperation between nine municipalities to solve the problems with heavily polluted waters in the Stockholm archipelago. The association now consists of eleven municipalities and more municipalities are waiting to be connected.

The Käppala WWTP is a conventional activated sludge plant situated underground with eleven parallel treatment trains. Wastewater is treated in preliminary, primary, secondary and tertiary treatment steps and achieves a high removal rate of nitrogen (80%), phosphorous (98%) and BOD_7 (99%). The nitrogen removal is performed with preanoxic denitrification. Phosphorous is removed by addition of ferrous sulphate in the secondary treatment or with enhanced biological phosphorous removal (EBPR) according to a UCT-configuration (Tchobanoglous et al., 2004). Tertiary treatment is accomplished with 30 dual media down-stream sand filters. Ferrous sulphate is added as precipitant. Primary and waste activated sludge (WAS) is digested anaerobically in two digesters and the produced biosolids are used for agriculture. All biogas is upgraded to vehicle fuel quality and used in buses for public transport. For further information about Käppala WWTP see www.kappala.se.

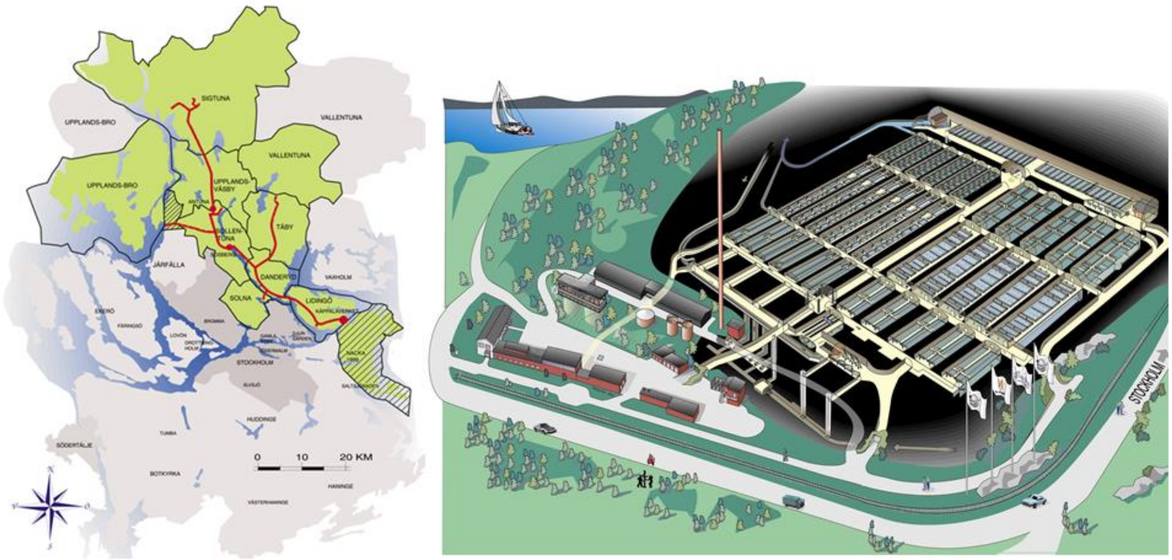

Figure 1. The connected municipalities of the Käppala Association with the tunnel system and the Käppala WWTP.

Control system and data handling

All equipment (e.g. pumps, valves, actuators, gauges, screws etc.) is controlled by a DCS from ABB (800xA 5.1, Figure 2). The level of automation is very high in all parts of the system. With few manual duties the operators only need to be on-site during office hours. During nights and weekends operators are on-call with sms alarms from the DCS and can connect with a laptop computer via remote access. All process data from the DCS is stored in a database which is part of the Power Generation Information Manager (PGIM) from ABB.

The accredited laboratory at Käppala WWTP enables the association to report the treatment results directly to the regulatory authorities, e.g. the county administrative board, and also this data is transferred to the same database via a Laboratory Information Manager System (LIMS).

The quick DCS is enough for the operators to run the plant efficiently since no extra handling of the data is normally required. But as soon as some kind of calculation is needed the DCS is insufficient and data must be transferred to some other application.

Figure 2. Example of the DCS 800xA 5.1 controlling all equipment at the Käppala WWTP and surrounding facilities.

A large number of people need access to the data in the PGIM database for different reasons and in different ways. Process engineers need to be able to access large number of both laboratory and process data rapidly for plotting and to perform simple calculations for process follow up. Sometimes more advanced calculations are needed by process engineers, students scientists or consultants in different research projects. A large number of infrequent users are interested in easy access to different kinds of compressed or ready to use data (e.g. staff outside the operations unit, summary reports for managers or for information to the public). For an application to meet these demands the following specifications must be met;

i. Rapid presentation of large number of data from both laboratory analysis and on-line process data in graphs. Graphical features such as zoom functions, changing resolution, hiding and showing graphs, changing scale etc. is required.
ii. The ability to perform simple calculations (e.g. addition, subtraction, multiplication) rapidly and presenting the results in new graphs.
iii. Statistical operations. Simple statistics should be presented easily, advanced calculations can be performed in other programs.
iv. The possibility to export data to other programs.
v. The ability to build reports that are automatically updated.
vi. Simplicity. The application must be easy to use, for infrequent users a too advanced program will not be used.
vii. Cost effective. For many and infrequent users to be possible, installation and maintenance costs must be low.

The existing market, between the years 2005 and 2010, could not produce a program with the above specifications. Many advanced statistical programs were available on the market but the complexity and costs were too large to meet the demands for low simplicity and cost effectiveness, i.e. the number of users would be limited to a few experts. As a result the Käppala Association decided to build a new program with help of Gemit Solutions according to the above specifications.

METHODS

Agile system development

In most development projects the first task is to produce a comprehensive technical specification that can be used as a tendering document in a procurement process. This technical specification follows the project through program design and testing and finally the program is handed over to operation. This procedure is often referred to as the waterfall principle (Figure 3). There may be many additional phases in the project but this model always enforces moving to the next phase only after completion of the previous phase. This model was however developed in the production industry and is not suitable for software development. The main reason to this is that the waterfall model lacks flexibility for different adjustments, which makes it difficult for programmers to follow. Normally several iterations are required before an optimal solution can be found. Because of this Gemit Solutions and the Käppala Association decided to use agile system development methods as illustrated in Figure 3, to build the application aCurve. There are many different agile methods but they are all based on the principles of adaptive planning, continuous improvement and a flexible response to change. The four basic values of agile development are;

i. Individuals and interactions over processes and tools
ii. Working software over comprehensive documentation
iii. Customer collaboration over contract negotiation
iv. Responding to change over following a plan

The main idea of agile methods is that all development should take place in a close cooperation with the client (Beck et al., 2001). This cooperation is carried out with frequent meetings between system developers and end users. The development should be incremental and iterative meaning that new releases will be frequent. The product is constantly evaluated with respect to new functions and new ideas can easily be implemented and old ideas rejected if needed. This process enables the programmer to constantly be updated with what the user wants and to create a desirable product.

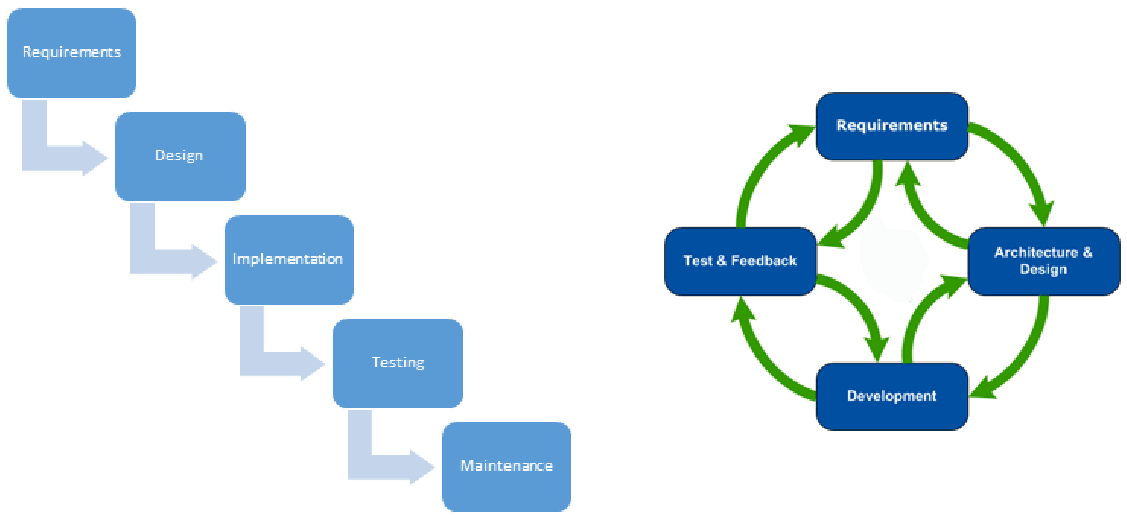

Figure 3. Project management according to the waterfall principle (left) and agile methods (right).

RESULTS

The agile system development has resulted in the program aCurve. The development cost has been a fraction of that of similar system development projects at Käppala WWTP where the waterfall principle has been used. aCurve is a web application (i.e. accessible via internet) or a so-called Rich Internet Application (RIA) that has many of the characteristics of a traditional desktop application for process analysis but requires no installations as a traditional desktop application. Google trends shows that plug-in based frameworks such as Adobe Flash, Microsoft Silverlight and others are in the process of being replaced by HTML5/JavaScript based alternatives. The application aCurve is a perfect example of a new RIA, based on the latest web development technologies. It is applicable in all main internet browsers of today (i.e. Internet Explorer, Firefox and Google Chrome) and is suitable to be used with a smartphone or a tablet computer which adds extra freedom of usability. Plant operators, scientists, and process engineers can easily access all data in the PGIM server on any device with an internet browser, Figure 4.

Figure 4. aCurve can be used on any device with an internet browser.

There are several advantages to use a RIA instead of a traditional desktop application. At first there is no need to install any other software framework on the client. The second advantage is that an upgrade of the software is done simply by updating files on the server, which will affect all users simultaneously. An unlimited number of users can use the RIA and the maintenance cost is a fraction of that of a desktop application.

The main features of aCurve, Figure 5, are rapid presentation of graphs, easy zoom, changing resolution, performing calculations and plotting the results and simple statistics (e.g. mean values, integration, maximum and minimum values). If advanced calculations are required, the data is easily exported as an xlsx-file for use in Microsoft Excel or other software capable of reading the Office Open XML SpreadsheetML File format.

Figure 5. Screenshot of aCurve with graphs and simple statistics in the web browser Firefox.

Besides rapid presentation and easy access to process and laboratory data, automatically updated reports are often required. Traditional reporting software are known to be inflexible and demand expertise to change or create new reports. To avoid this aCurve use a module on the server side to create Microsoft Excel reports. This makes the reporting function flexible and any user with Excel knowledge can create and edit a report with a professional result, Figure 6. The reports can then easily be shared throughout the organization and automatically updated. Since the program is a web application data from the PGIM server can be reached in a secure manner from places outside Käppala WWTP and with no other program than a web browser installed.

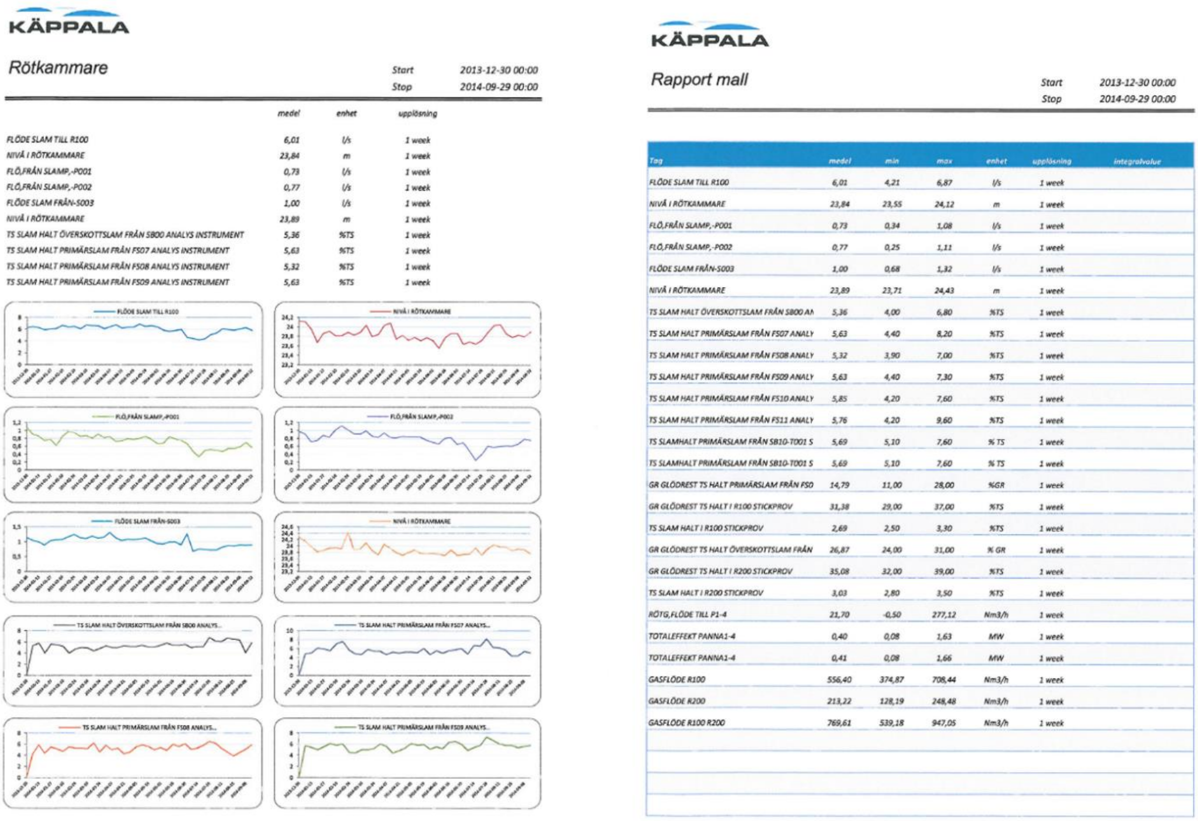

Figure 6. Automatically updated Microsoft Excel reports created by aCurve.

CONCLUSIONS

Thanks to an agile system development approach the RIA aCurve has been developed to meet the needs of many different profiles in the organization at the Käppala WWTP. An unlimited number of users can access the data in the PGIM server thanks to the web based approach. The maintenance costs are negligible compared to traditional desktop applications. Engineers, scientists, and operators can use the application on any device for rapid presentation of graphs and statistics or export data to other programs if advanced calculations are acquired. Automatic reports can easily be built in Microsoft Excel and provides staff outside the operation unit to follow up process performance. The data assurance procedure for reporting to authorities has since the implementation of aCurve improved thanks to the accessibility of data and reports.

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