Use of new cellular telephony technologies (WAP, SMS)
to remotely monitor and control
wind turbine operation

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ABSTRACT: Remote controlling and monitoring wind turbines is generally done using conventional telephony and custom made programs. Nowadays, new devices appear (mobile telephones supporting WAP protocol, handheld PCs) offering the possibility to be instantly and more efficiently informed, when running critical applications. Moreover, hundreds lines of code can be saved, using a WAP browser, as a communication interface. This paper presents how cellular telephony technologies, like the Short Messages Services (SMS) and the Wireless Application Protocol (WAP), are implemented in the control and monitoring software of a wind farm operation.

Keywords: Wind Farm, Monitor, WAP, SMS, mobile phones

1 INTRODUCTION

The wide and fast spread of the wireless networks (often called *cellular* networks, from the *cells*: sections that divide a geographical region) modifies, slowly but steadily, the way that people communicate. Mobile telephony is already widely used in many countries. The new trend nowadays is the deployment of advanced telephony services and information resources from mobile devices. The aim is to provide users with the ability to have all they could possibly need in a pocket sized devices.

There are two main reasons that people dealing with Wind Energy can benefit from the use of the new cellular telephony technologies: a) wind turbines are often in remote areas without conventional (cabled) telephony facility and b) people want to retrieve data from Wind Farm operation, not only in their workplace, but also discretely, when are travelling or on vacation.

Portable computers is already a solution, for mobile users. However, they present 3 main disadvantages: i) they are quite expensive ii) they have to be powered-on and connected to receive data (not suitable to alarm conditions) and iii) they are not as discrete as mobile phones. Moreover, the trend is that new devices (mobile phones, handheld PCs) become smaller, more powerful, cheaper and people carry around everywhere with them, all day long.

Remotely installed measuring systems is another area of application of the cellular technologies. During long period, non-stop measurement campaigns (*i.e.*: assessment of the load and power performance of a wind turbine) those new mobile devices can instantly communicate the measurement progress and/or any eventual errors occurred.

Two communication protocols are described here: a) the Short Messages Services (SMS) and b) the Wireless Application Protocol (WAP). SMS messages are already very familiar to the mobile phone users (more than a billion were sent during December 2000) mainly because of its cheap price. WAP is intended to provide a common application environment for mobile devices, offering a series of advanced features like: graphical interfaces, true bi-directional connection, security (through server/client authentication, and data encryption) More features are expected to appear, as soon as, the next generation GSM devices (GPRS) become available in the next couple of years, providing more bandwidth and enhanced connectivity.

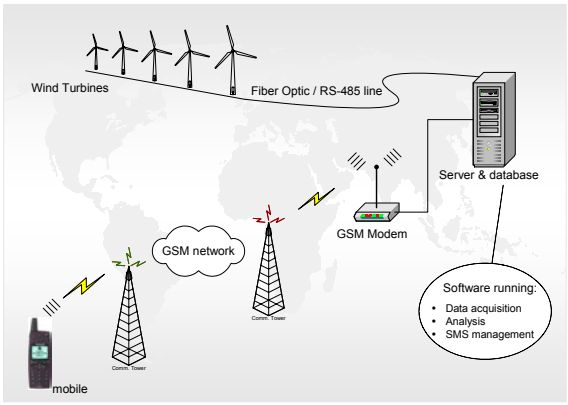

Figure 1: Set-up for communication system with a Wind Farm, using SMS messages.

2 IMPLEMENTATION

The SMS message based set-up, is a built-in feature of the *CRESdaq* software, the data acquisition & on-line analysis tool, for measuring wind turbine power performance, loads and power quality. It is already functioning for 1½year continuously, in different sites in Greece, where measurement campaigns are conducted.

Both communication technologies (SMS, WAP) are currently installed at the CRES 3.7 MW Demonstration Wind Farm & Test Station of wind turbines.

3 WHEN USE *SMS* AND WHEN *WAP*

At this moment the two technologies are complementary. SMS messages are supported by all mobile phones, without any particular configuration. The user, as long as he powers-on his mobile, he can send and receive messages without any additional procedure. This is an advantage over WAP, because under special conditions (alarms, warnings, errors) the user will be notified, providing that his mobile is on.

WAP is a feature incorporated only in the high-end of the mobile phones. However, even if there are powered-on, they need an additional step in order to use WAP. The user has to connect to his GSM Provider in data mode, to start work with WAP. This connection is not permanent and cannot last for long periods due to reasons related to the mobile functionality (battery, extra price for data-mode, simultaneous voice calls, etc). Therefore, today, SMS messages are more suited to monitoring and notification purposes.

On the other side, WAP-enabled phones can display graphics and navigate through menus to select the exact information needed or to perform certain operations. In the near future, the next generation mobile phones, will all support WAP and will be permanently connected in data mode. This will further enhance the mobile phones functionality and range of use.

3 COMMUNICATING WITH SMS MESSAGES

SMS is a standardized and mature technology of the GSM network. As one can guess from its name, an SMS message is short (maximum 160 characters long). However, this is not a an obstacle in most of the cases, as the necessary information can be held in 1 or 2 messages, if arranged in a compressed manner.

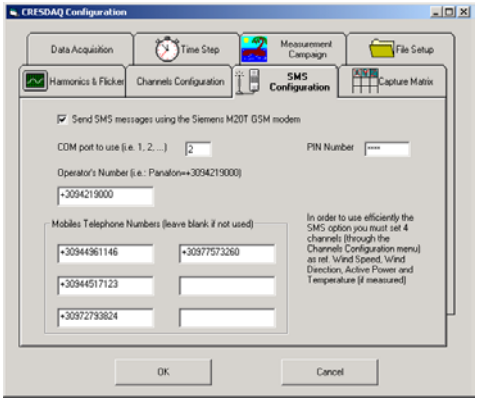

Figure 2: The *CRESdaq* configuration sub-menu, for the automatic SMS message transmission to selected users.

The communication system based on SMS messages is designed to meet the following criteria:

- it should be able to react with a user (by receiving his message and replying accordingly)
- it should periodically, during the day, send the general status
- it should notify the administrator in case of alarms, warnings and errors.

The *general-status* information of the Wind Farm operation is available to the public in order to: a) promote wind energy and the acceptance of the specific wind farm and b) let people monitor weather conditions. It contains the following quantities:

- wind speed
- wind direction
- wind gust
- mean elec. power of each WT
- temperature
- total energy produced since the beginning of the current month and year.

Figure 3 shows an example of the SMS message which is sent every 3 hours –but not during calms- from the measuring system, during a data acquisition campaign for the power performance of a specific wind turbine

CRESdaq is a mixed-language application (front end in Visual Basic, analysis in Fortran, some specific modules in C) running under the Windows NT/2000 operating system. The acquisition system is designed for long-term, non-stop measurement campaigns. Its concept relies on the *circular-buffer* concept, which cyclically fills a buffer with acquired data. The buffer is divided into two equal halves so that, while filling the one half, the other half (already acquired) is being stored, statistically processed and (if predefined criteria are met) its results are transmitted to the users with SMS.

Figure 3: Example of an SMS message automatically sent for the system check status.

4 COMMUNICATING USING WITH *WAP*.

The Wireless Application Protocol (WAP) is also a standard of the cellular networks (GSM, GPRS, 3G). In its first steps it did not have the success of the SMS messages, for reasons which are beyond the scope of this article. However, constantly it gains popularity and nowadays the majority of the mobile phones are WAP-enabled.

WAP is a more advanced technology than the SMS and in the near future will overcome its disadvantage over SMS, concerning the lack of alarm notification support. This will be possible and will be realized via a procedure which is very similar to the *e-mail*.

The functionality of WAP is very similar to that of the Web. In principle, the user enters the URL of a website in his browser (WAP-enabled mobile) and the Web server replies the requested information. The underlying mechanisms of this transaction, of course, are complex, but beyond the scope of this article. If the WAP server is permanently connected to the Internet,

then what one should do is configure his phone according to the settings of his GSM-Provider and access it. When connecting directly to the WAP server (by direct dial call), some intermediate steps are not necessary (*i.e.:* DNS: Domain Name Server address resolving) but some other are additionally required (local WAP Gateway). Figure 4 schematically represents the required set-up for a WAP based communication with a Wind Farm.

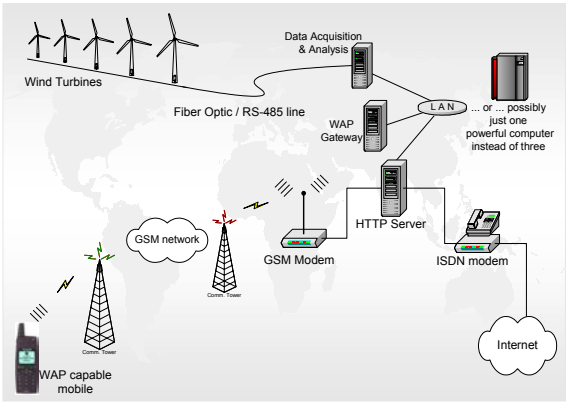

Figure 4: Using WAP to monitor & control a Wind Farm.

When designing an application software for monitoring and controlling a wind farm, WAP offers a wide range of exciting capabilities. Only two of them are discussed here, since there are implemented in the monitor and control software of the CRES wind farm. The first one is the ability of displaying graphical information. The second one is the ability to *navigate* through different menus, in order to choose the exact information needed.

Figure 5 shows a representative sequence of navigation through the menu of the CRES Wind Farm, in order to retrieve information, which is not possible to obtain using SMS messages.

Figure 5: Example of a *navigation* through the menu of the CRES Wind Farm, WAP communication system.

The adopted technology to serve URL pages with a *dynamic* content, is Microsoft's ASP (Active Server Pages). The reason of using pages with dynamic content (instead of static one) is due to the constant change of the wind farm's operation data. The following steps occur during a transaction between the WAP mobile phone and HTTP server, (during a direct-call communication).

- The WAP phone requests a specific Web page (URL).
- The WAP gateway translates the request it receives, to normal HTTP content.
- The HTTP server reads the ASP file, process the code, perform the statistical analysis of the database and sends the updated output.
- The WAP Gateway translates and compresses the answer, in order to save the on-the-air bandwidth and to further reduce the (limited) phone's processing requirements.
- Finally, the WAP browser displays the output to the mobile's screen.

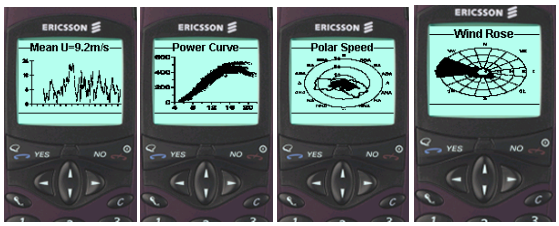

Figure 6: Samples of the information retrieved from the WAP server, for the Wind Farm operation.

Figure 6 shows some examples of the *dynamic* information obtained using WAP. It consists of the result of statistical analysis concerning meteorological data and selected data from the wind farm operation. This is one of the strong points of the WAP technology, since it is evident that a graph contains much more information compared to a text message.

5 CONCLUSIONS

The main outcome from the use of the described technologies is that, it permitted to:

- increase the availability of the wind turbines, due to early error notifications
- construct high quality databases from measurement campaigns (*i.e.*: rotor and tower loads, meteorological data)
- promote wind energy in general, through the a link to the leading edge technologies of today.

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