



WIRELESS METER READING SYSTEM

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Abstract: This paper is intended to describe system for wireless electrical meter reading. System consists of a hardware module attached to a set of electrical meters, and a remote server. Hardware module reads meters (active and reactive energy consumed, and optionally other parameters such as voltage and current levels per phases, power consumption per phases, etc). After meters are read, data is being sent to a remote server via GPRS module. Server, after data reception, stores data into a database. Data stored in a database is becoming available to many clients over the internet. Client application is also developed in order to provide user friendly interpretation of records from the database.

Key Words: Power and energy consumption, AVR microcontrollers, current loop, GPRS, database server, GUI application.

1. INTRODUCTION

As mentioned in the abstract, Wireless Meter Reading System (WMR) performs remote monitoring of power (energy) consumption. The need for the system like that is obvious:

- First, wireless meter reading (WMR) system greatly reduces cost of meter reading procedure which is currently performed manually.
- Second, WMR system registers malfunction of any kind. Thus, as soon as one of the meters becomes not readable (for any reason), information about that emerges in the control centre.
- At the end, future improvements of the system are possible, so the system would be able not only for monitoring of power (energy) consumption, but also for advanced control such as disconnecting single power consumer, rate changing, etc.

Automated wireless meter reading is a first step during implementation of completely automated system for meter control and automated billing system.

2. SYSTEM DESCRIPTION

WMR system consists of a *concentrator unit* and *server unit*. Client application might be considered as a third module of the system since it allows distant user to interpret data collected during meter readout.

Concentrator unit

Concentrator unit is implemented as an embedded system based on Atmel's AVR microcontroller. Block diagram of a concentrator unit with interface to a set of electrical meters is presented in Figure 1. Since the system has been developed for electrical meters that provide communication interface through the current loop, concentrator unit is connected to meters as presented in Figure 1.

Current loop is only one of the interfaces presented by electrical meters manufacturers. Some manufacturers feature other communication protocols but the current loop is certainly one of the most popular and most often used. Furthermore, meter manufacturers are allowing user to read meter through IEC communication protocol. Although, every manufacturer implements communication protocol to the extent that differs from manufacturer to manufacturer, almost all meters allow user to perform complete readout of meters data. It is sometimes inconvenient, though, to collect large amount of data that is not needed, since during meter readout mode, meter usually bursts all data from internal registers. Modern electrical meters measure not only energy consumption but plenty of other physical values (voltages, currents, frequencies, temperatures, powers per phases, time, etc). Fortunately, original software from meter manufacturer allows user to select values that are going to be read during data readout mode, so only data that is needed can be selected in order to improve system performance. Since meters are being read sequentially, speed of the communication is very important and it depends mostly on amount of data to be read.

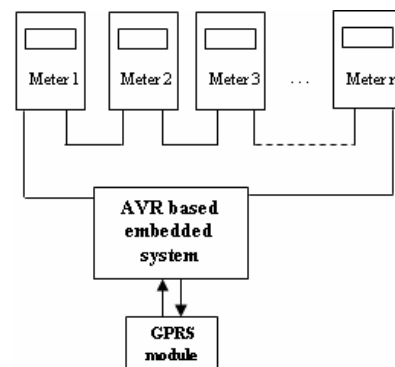


Figure 1: Concentrator unit

Concentrator unit consists of an embedded system based on AVR microcontroller and GPRS module. Concentrator unit supports up to 32 meters. According to that, $n \leq 32$ (Figure 1). Problem of initial system was serial connection from meter to meter. Thus, if one of the meters becomes unreadable, all the meters will also be unreadable. Beside that, if one of the meters becomes unreadable it is not possible to detect which one it is. Because of that, modification of the system is performed as presented in Figure 2. Concentrator unit has not been modified, but **switch module** has been inserted between meters and concentrator unit.

Switch module performs mechanical switching so concentrator unit is always connected only with one electrical meter at the moment. According to that, none of the readable meters is going to be affected by the failure of the one that becomes unreadable. Even more, new topology allows user to detect which meter wasn't able to communicate. Smart electronics controls switch module in a way that it activates one switch module output, waits while meter is being read, then deactivates that output, and activates next one. That sequence continues until all outputs have been activated, that is all meters have been read.

Implementation of a switch module solves one problem – failure of one meter operation doesn't affect other meters. Unfortunately, there is one more problem that exists during meter reading – synchronization. If the system is going to be used for billing it is very important that all meters are being read at exact same time. That time is a moment when minute number of current time is dividable by 15 (x:00; x:15; x:30; x:45 where x represents number of hours). Topology explained above wouldn't allow that, since certain time period is needed to read a single meter and meters are going to be read one after another. Reading of a meter lasts around 2-3 seconds. According to that whole sequence of reading lasts approximately 1.5 minutes (if maximum number of 32 meters is connected to the concentrator unit). Synchronous readout of the meters would require the same number of microcontrollers as the number of meters, or maybe half of the meters number if microcontroller with two communication channels is used. That would significantly increase the total cost of the system and since WMR is intended for meter reading only, unsynchronized reading is acceptable.

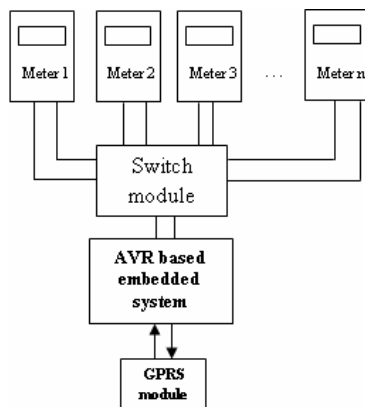


Figure 2: Modification of initial system

Server unit

Server unit is implemented on a PC with GPRS module connected to it. Concentrator unit sends data packets to the server unit via GPRS. Server unit collects data and stores it into a database. Server also implements interface to a client application over internet. Remote client application is able to connect to a database server and to collect data. Functionality of the server unit is presented in Figure 3.

Client application

Client application has also been developed in order to provide user friendly interface. Client application displays graphs of energy consumption for different users of electrical energy like presented in figure 4.

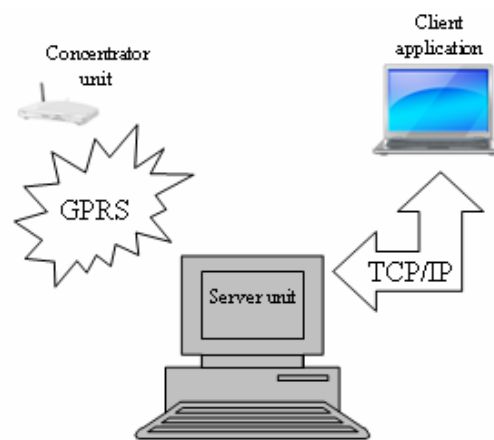


Figure 3: Data flow from concentrator unit to client application

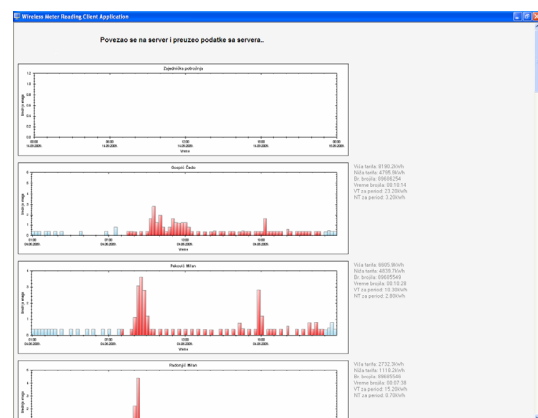


Figure 4: Electrical energy consumption for several users

After starting application, client connects to server and collects data. Server recognizes client application and checks data in a database to retrieve last date of data collection by that particular client. After that, all the data that has not been sent previously to a client is being sent. Client application interprets data received and creates graphical energy consumption overview. Figure 5 shows energy consumption for one energy consumer.

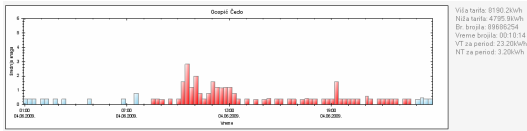


Figure 5: Energy consumption for a single consumer

Bars representing energy consumption for an energy consumer during current month with 15 minute steps can be noticed. Bars are red or blue according to current energy rate at that particular 15 minute interval. Red bars represent rate 1, while blue represent rate 2. Number of rates and time intervals corresponding to each rate could be selected in software. Since graph shows energy consumption during whole month, software user is allowed to move across the graph in order to observe consumption during period of interest.

On the right side of the graph information read from the meter is being displayed, such as total energy consumption per rates, serial number of a meter, time read from the meter, etc. Data read from the meter may be very useful. For example, if the time read from the meter is incorrect, appropriate measures could be taken if internal clock is used for rate switching. Such a situation could also be noticed from the graph itself since red (or blue) bars would appear at wrong positions on a graph (wrong 15 minute intervals).

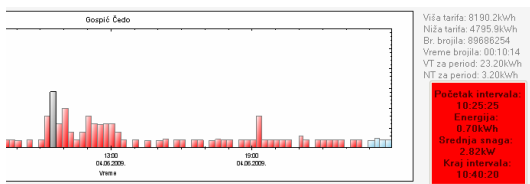


Figure 6: Selecting single bar

Figure 6 shows how information about a bar selected by software user is being displayed. On the left side of the graph red area appears in the lower right corner with information regarding selected bar. Information contains start of interval of interest, end of interval of interest energy quantity consumed during that interval and average power during interval. Figure 7 shows same situation but with selected bar corresponding to rate 2. If the selected bar corresponds to another rate, color of information area in the lower right corner is blue.

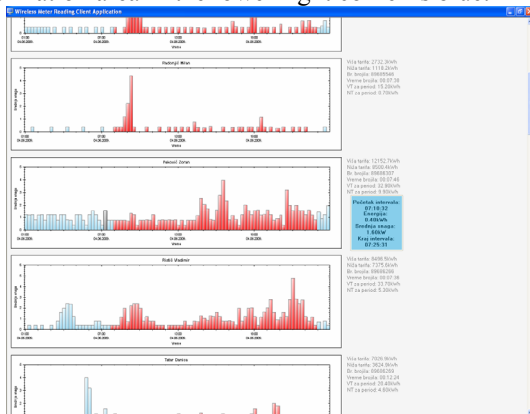


Figure 7: Selecting bar from rate 2

Since client application always shows data from current month, when first hour of the first day of new

month starts, graph is cleared and new bars are being drawn as new data arrives. Client application has a mode where user is allowed to select period from previous months for display. That mode is denoted as overview mode while mode in which data is received from server is called monitoring mode. In overview mode connection to server is not established and in order to receive new data application mode must be changed back to monitoring mode. Period for display is chosen through the form shown in figure 8.

Figure 8: Form for period selection in overview mode

3. CONCLUSION

WMR system provides remote monitoring of power (energy) consumption. Since quantity of energy consumption is recorded during intervals of 15 minutes, WMR system could be used for billing, with some hardware modifications. WMR system reduces expenses of a power distribution infrastructure, and provides better control and monitoring. Any malfunction of the electrical meter is going to be noticed by WMR system so administrator could perform adequate measures.

Further improvements of the system are possible. One of the system modifications might include another communication link between concentrator unit and server unit. So far, GPRS communication has been used, considering the fact that mobile networks provide good signal coverage. However, data transfer via GPRS becomes quite expensive considering the fact that large amount of data is being transferred. Thus, further system improvements should take that fact into consideration. Also, problem with current system is the fact that there is no data storage capacity on the concentrator unit. If there is no connection between concentrator unit and remote server at the moment when data is ready to be sent and during the period until new data packet is ready (after 15 minutes), data will be lost. This problem could be solved by addition of a memory module. Memory module with relatively small capacity would make system much more robust since temporary network problems (which, unfortunately, may occur frequently) will not cause data loss. Server would be able to collect data from concentrator unit when internet connection is established. Another problem, as mentioned before, is unsynchronized meter readout due to one-CPU-several-meters connection topology. Such a topology doesn't allow simultaneous meter readout since a meter readout can start when previous one has been read, not before. Synchronous readout would be required if WMR system is to be used for billing, but since it is intended for energy consumption monitoring only, its functionality is acceptable.

WMR system implementation, as mentioned before, is just one step made during development of a completely automated system for monitoring and control of electrical meters. By adding some hardware components to the concentrator unit, several automated actions might be accomplished remotely. These include remote rate switching, switching on/off single electrical energy consumer, detection of any illegal action performed by the owner of the electrical meter, etc..

Remote rate switching is extremely important considering the cost of the rate change performed manually. Beside the cost, changing rate remotely is performed momentarily, while manual rate change requires plenty of time.

Electrical energy consumers that have not fulfilled their financial obligations (or for any other reason) might be disconnected from the electrical network remotely. This could be done using WMR system by sending

command which concentrator unit would recognize and perform switching off. Concentrator unit could also perform switching on, when needed.

Finally, any kind of illegal action performed on an electrical meter (such as disconnecting meter from power supply or taking the lid off) could be recorded by the concentrator unit and reported to the server unit. Further appropriate actions could then be taken in order to decrease electrical energy loss.

4. REFERENCES

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