

Automatic Meter Reading (AMR) System and Application of Esenboga Airport

*Özge Baykara Sezgin, M.Cengiz Taplamacıoğlu and Nursel Akçam
Gazi University, Maltepe, Ankara, Turkey
Faculty of Engineering, Department of Electrical and Electronics Engineering
Haluk Gözde
University of National Defense, Çankaya, Ankara, Turkey
Turkish Military Academy, Department of Electronics Engineering

Abstract :

Automatic meter reading (AMR) system which has been in use for many years was carried out at the end of each month by calculating the consumption information. The system uses the first and last index information of a tasker by scrolling through the individual counters, then multiplying by the tariff coefficient and calculating the biller. Considering today's conditions, this practice is insufficient, so a single point reading system is essential. When this system is installed, both time saving and easy access will be provided to the desired time. In this study, the concept and the general structure of AMR system are investigated and then the application of Esenboga airport is presented.

Key words: Automatic meter reading, Energy saving, Communication, Airports

1. Introduction

Considering the requirements for today, the one-point reading system is necessary because the existing meter-taking applications are insufficient. In the campuses where there are many meters such as shopping malls, business centers, sites, industrial districts or factories, making the meter information and control with classical methods brings various difficulties in terms of user and operators. These difficulties are; billing, invoice/counter payment/loading, illegal use, detection of meter failure status, usage information graphic and documentation. Automatic meter reading system is not only superior to these problems, it also saves time for operations performed by users and operators with its features such as counter control via WEB, e-mail or SMS, and billing information. In addition to this, system ensures stable operation and correct and reliable communication with read meter.

The developments on AMR system are investigated in the survey prepared by Mohassel et al. [1]. When the general structure is examined, it can be seen that the meters are connected to the interfaces called modules by serial communication protocol. Approximately 32 meters can be connected to one module. Modules can be connected to the server through different communication protocols. These include GPRS, RF, Ethernet, PSTN, PLC and so on. When the GPRS communication protocol is used, meter reading is performed via the SIM card on the module. The SIM card can be owned by any GSM operator. Once the meter is introduced to the server, data can be read frequently as desired by the operator. In addition, users can monitor the

*Corresponding author: Address: Faculty of Engineering, Department of Electrical and Electronics Engineering
Gazi University, 06500, Ankara TURKEY. E-mail address: ozgebaykara@gmail.com

latest status of meters by logging into the system via WEB. The GPRS connection is terminated when it is requested to read the meters and then by closing the communication line after the reading process is finished. This operation is an application for the operator to have the communication fee reflected by the GSM operators at the lowest level. By using communication units such as AMR, PLC, SMS, RF, telephone line, the data in any electronic meter can be defined as reading system without going to the meter. These systems should be regarded only as a reading system. Electronic Electricity Meters include many processes such as charging their own situation with these systems, interrupting the charging of electricity to meters in pre-paid systems or charging credit from the central unit. The AMR system is capable of expanding the services offered by the customer by increasing the productivity of all kinds of electronic meters and service providers, reducing the cost of reading meters and enabling critical information to be immediately reported to the center [2, 3].

AMR applications vary according to the communication units desired to be used. Communication units are the most important parts of AMR applications. If it is healthy and successful until the communication unit; The AMR application is also parallel to that. Communication units are an important factor in determining the cost of AMR applications. Automatic meter reading system is a technology that enables billing, problem solving, or analysis through the use of energy meters (electricity, gas, water meters), automatic consumption information collection, diagnosis and status data, This technology also avoids the time, labor and cost of reading caused by service providers in the field. AMR technologies can be implemented with hands-free devices, mobile phone based communication, radio frequency communication or energy line transmission [4].

In this study, the general structure of AMR system is examined in terms of software and hardware. The main software is reviewed. Then, the hardware implementation of AMR and advantages are also reviewed. Following, the real application of Esenboğa airport is briefly presented.

2. Automatic Meter Reading System

AMR System, which has been in use for years, is carried out at the end of every month by calculating the consumption information by calculating the consumption information according to the first and last index information of a tasker by visiting individual meters and then multiplying by the tariff coefficient. The AMR application has a single point reading system is inadequate considering the requirement for today's conditions. Meters used in AMR systems vary according to user region and application. Meters transfer reading information to the central station via communication modules located in certain areas. All desired data can be monitored and reported via central software instantly. If necessary, the difference can be compared with the data of the previous year. Likewise, electricity consumption can be estimated for the following year. The software and hardware structure of AMR system is presented below.

2.1. AMR Software

Customers are kept of the counter information of the subscriber and the subscriber is the system

that made invoicing. Software customer base is the key to the singular "Subscriber Number" is used. Between the main AMR software "Index Service" what is the last month in subscriber numbers may be transferred by the AMR system should provide the index. In the software;

- Subscriber numbers in some subscribers and counter information is kept,
- Invoicing process is done,
- Enables home AMR will transfer the index data of each main AMR meters from the software or software to transmit itself to the index information of each counter. The general software structure of AMR system is depicted in Fig.1.

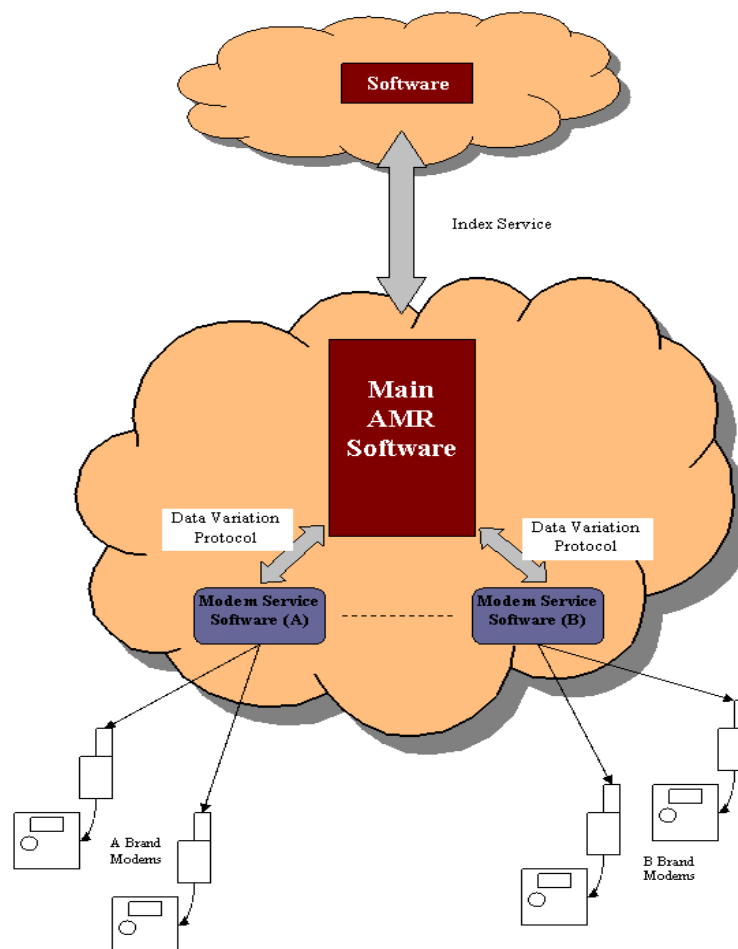


Figure 1. Software of Automatic Reading System [5]

2.1.1. Main Software

AMR will be established by the Administration exited the company has won the tender, the database stores data from the counter, offering data in reporting and web interfaces, system for creating various alarms. This system belonging to his company modems can read smoothly without any integration. However, to be able to include different brands of modem systems of

different manufacturers, each modem manufacturer to establish the "Modem Service Software" class "Modem Data Exchange Protocol" must communicate using nude.

- To collect data from a different brand of modem, Software Modem Service is used,
- The modem service software "Data Exchange Protocol" meter reading may request and receive data read using the nude,
- It is necessary to match Subscriber number, the serial number counter and the counter brand code in the system.

2.1.2. Modem Service Software

Each manufacturer will establish a modem and "Data Exchange Protocol" is the software support services. This service software so the upper part of the "Main AMR Software" which evaluates read requests received from within its own.

- Each of the modems software modem service companies are read using their own logic and algorithm,
- If the data read by the upper side of the raw data format "Data Exchange Protocol" should offer using the nude,
- At least to be able to transfer data from the modem to connect the counter, there is a need the counter brand code (Flag Code), meter serial number, modem IMEI number and key information such as the modem phone number. In addition, this information by the main AMR Software "Data Exchange Protocol" should be introduced using it once.

2.1.3. Data Variation Protocol

This protocol is an XML-based language provides communication between Main AMR software with Software Modem Service. Main AMR Software creates the desire to read the language in accordance with the Modem Service Software. Modem Service software reads the data in the desired counter about connecting to the modem itself. Main AMR software takes the raw data to read using the same language from the Modem Service Software. Later works by dissolving the raw data into their database.

- It determines the format of communication between Main AMR Software Modem Service Software. This format TCP / IP is working on XML-based language,
- Modem service software opens TCP server socket. Main AMR software is as TCP client process, makes connection to the modem service,
- All process (all process that can be done on both sides) between main AMR software and Modem Service Software must be defined in this protocol and the service software must comply with it.

2.1.4. Index Service

This service serves to transfer the meter index between main AMR software and MCC and can use web services. Main AMR Software transmits the index information that is remotely read through this service via MCC or the opposite way MCC receives Main AMR software from subscriber numbers queries based on this data at any time.

- Main AMR Software -> MCC or MCC -> It is a service that allows the transfer of data in

the Main AMR Software direction index, so that;

- Data is transferred on the basis of subscriber numbers. Therefore, subscriber numbers in each counter in the main AMR software and MCCs should overlap.

The biggest factor of maximizing the efficiency is the communication. To read the data coming from different points and collect them in one common center, the most effective method is to establish an IT infrastructure together with virtual server. Within this coverage, a virtual server is supposed to be set. Virtual server is designed for the purpose of minimizing the investment costs and energy consumption quantities, saving time and avoiding data loss in case of any disaster. Operating cost is getting increased if the set communication connection has a different type of license. At this point, the most common technology is TCP/IP basis IP connection.

For the purpose of minimizing the communication costs and strengthening TCP/IP infrastructure, the most efficient operating systems are being used. IP technology is proper here and keeps the operational costs at minimum level. As a result of this, TCP/IP is preferred in order to obtain a communication via RS-485 port. The electricity meter used in this study converts the data at the RS-485 to TCP/IP. As per the ISO standards, TCP/IP communication protocol is selected as an IT infrastructure. Within IT protocol, the main point is to be under the terms of international standards. The base of this model is called OSI. OSI is the first term of interface connection model of open systems. Its ISO standard depends on ISO 7498. OSI terms are being revised and upgraded from time to time. There are seven layers in use at defining this communication as per the recent parameters. The AMR software, as TCP client, is connected to the TCP server port provided by the modem service. Port number and IP address of the modem service should be given [5].

- Modem definitions: If not previously defined, the AMR software uses the data exchange protocol to define the IP numbers of the newly defined modems to the modem service.

- Counter definitions: If not previously defined, the AMR software uses the data exchange protocol for the modem service to specify the serial number of the newly defined counters, the brand code, the IP address of the associated Modem. 32 counters can be defined in one IP number. Since the subscriber number does not have access to the counters, the AMR software provides the mapping of the subscriber numbers and serial numbers of the counters. This is not done by modem services. For the modem service, the counter serial number is sufficient. Counter serial number and brand flag string can be combined. For example, ABC12345678. Here the ABC counter brand flag code is 12345678 serial numbers.

- Counter reading and modem reading operations: it is only necessary to provide the counter number and the mark for counter reading operations. The modem service software can find out which modem the meter is on from previous definitions and read the requested information. For modem operations, only the IP number is sufficient.

Classification of the parameters required for reading parameters;

- Subscriber number
- Counter number and brand code
- IP number
- Phone number

Required parameters for modem service

- Counter number and brand code
- IP number
- Telephone number (for wake up operations etc.)

Parameters required for AMR software

- Subscriber number
- Counter number and brand code
- IP number
- Phone number

Parameters required for MCC software

- Subscriber number
- Counter number & brand code

2.2. AMR Hardware

Architecture is planned as back up and load sharing structure; but it can be used with the different formats. In the all servers, there are virtual machines. Server 1 and server 2 are working as mirrors. For sharing load structure, server 3 and server 4 are working as back up of server 1 and server 2. Four virtual machines in each server will be found. These ones;

- Modem application server
- Web server
- Test server
- SQL server database server.

The general hardware structure of AMR system is depicted in Fig.2.

3. Advantages of AMR System

The advantages of the AMR system are as follows:

- Quick and accurate billing of counter information without the need to go to the subscriber location,
- Shortening of reading and billing time,
- Reduced operational costs,
- Instant detection of unauthorized interventions,
- Follow-up of sudden changes in consumption,
- Comparing the consumption values between the line and the users and determining the loss and leakage rates,
- Determination of infrastructure needs with the consumption data analysis of the region, planning of investments,
- Automatic meter on/off possibility,
- Instant follow-up of the electricity consumption at the facilities where the subscriptions are dispersed on the site,
- Taking retrospective reports, forecasting for the future and making plans

- Prevention of unwanted penalties by subscriber warning mechanism,
- Efficient management of rapidly depleted energy resources [6].

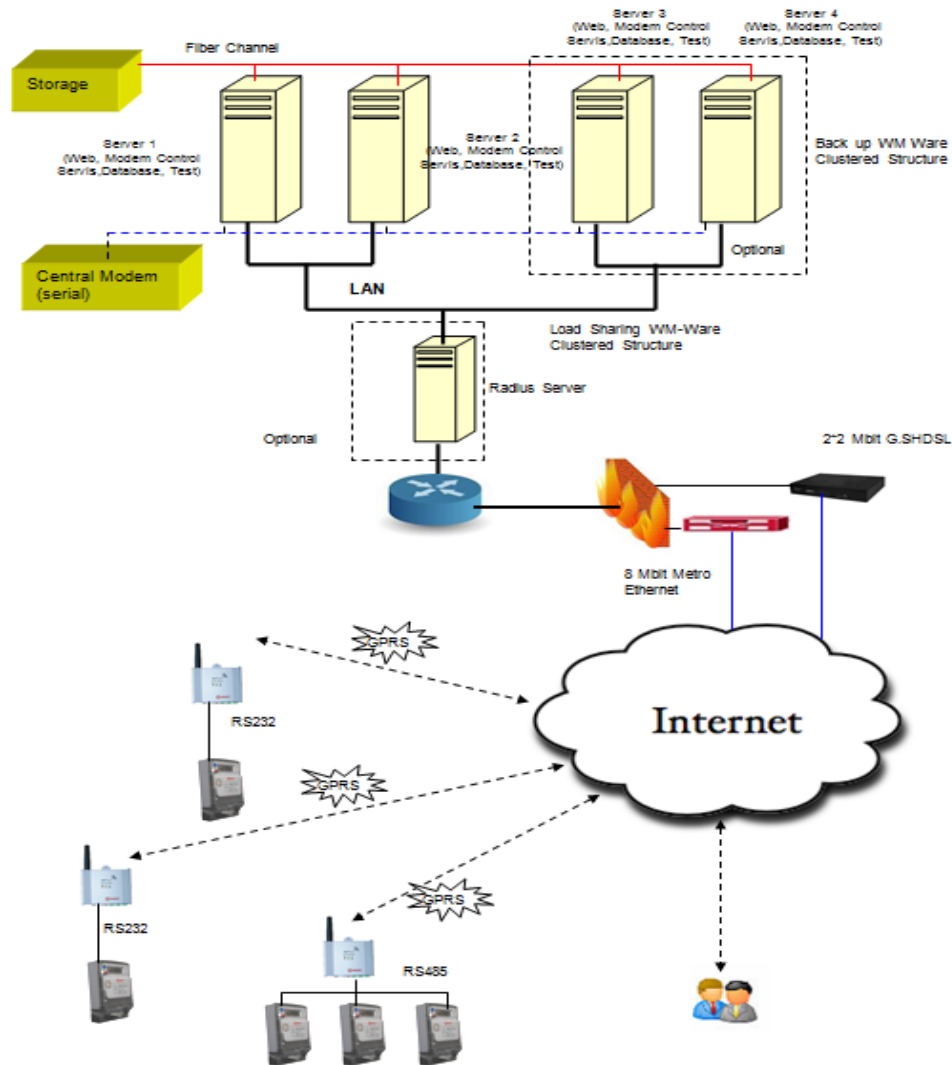


Figure 2. Hardware of Automatic Reading System [6];

4. Application of Esenboğa Airport

Esenboğa Airport is composed of administrative, financial, operational and technical departments. Technical department involves mechanical systems, constructional maintenance & repair, mechanical installation, electronics & electrical works, logistics and contracts department, H&S and architectural departments. Operational departments especially deal with services for planes and passengers. Technical specifications for Ankara Esenboga Airport can be listed as below [7];

Capacity	:	10.000.000 passenger per year
Terminal Area	:	182.000 m ²
Car park Area	:	108.000 m ²
Duty Free Area	:	2.390 m ²
Food Court	:	5.200 m ²
Car park Capacity	:	4.069 vehicles
Passenger Boarding Bridges	:	23 units (18 units gate, 4 units bus gate, 1 unit CIP)
Check-in Desks	:	138 units (26 units self-check-in)
Passport Desks	:	36 units (18 departure + 18 arrival)
Baggage Handling System	:	8.000 baggage per hour
Carousels	:	9 units
Elevators	:	33 units
Escalators	:	38 units
Travellators	:	210 m

The design of the Automatic Meter Reading System has been taken into assessment at Esenboga Airport within the principle of being able to measure at as many points as possible by the installed system coverage. Separate modules of system components are located into electrical rooms. Communication is done via network line laid in the electrical rooms by using TCP/IP. All client users are able to access to the system via username and password through integrated computers.

Within coverage of infrastructure, Cat-6 cable is used between cabinet and modules for communication and 2×1.5 inch cabling is laid between modules and electricity meters. Distance between modules and electricity meters are designed by not exceeding 800 m. While the design studies, optimization is taken into consideration by trying to spend minimum budget with a maximum energy efficiency gain.

A package of 31 units in total of module is used within the terminal area. 32 units of electricity meter connection are applicable to one module. In order to have vacancy in case of any additional meter needs in the future, enough free connection is spared at the modules. In total, system comprises 506 electricity meters.

Since the system is flexible and appropriate to add extra electricity meters, it can be adjusted and upgraded in accordance with future needs. By means of using electricity meter, human resources could be minimized while work efficiency could be conveyed to other work points. For the easy control upon electricity meter, communication infrastructure is supposed to be composed at the beginning.

With the establishment of the AMR system at Esenboğa Airport, productivity has been achieved in the workforce. In addition, leakages of the missing are identified and necessary interventions are made in those areas. Within the scope of energy efficiency, all systems have been either activated or deactivated according to the need and need of monitoring the system instantaneously. With this strict follow-up, energy consumption is seriously reduced and energy efficiency is

ensured. Along with ensuring energy efficiency, there have been significant reductions in carbon emissions.

The establishment of the AMR system in these areas, where the energy consumption is high, such as all airports, shopping malls, campuses, hospitals, schools, etc., will provide enormous energy efficiency and allow our country to reduce energy costs.

Conclusions

The effect of automatic meter reading system upon the energy efficiency is investigated in this paper. As an example of implementation; Automatic Meter Reading system installed at Esenboga Airport is analysed in details herein. Following those analyses, a remarkable positive impact is observed in case of an automatic meter reading system exists. At full reconstruction existing or at building of electricity transmissions 0.4 kV in rural electric networks it is necessary to pass to other systems of an electrical supply reducing influence of asymmetry, improving quality of electric energy and reducing power losses. Automatic Meter Reading system is also preventing power losses for the system [7]. System is working and communicating through TCP/IP internet protocol via Ethernet. The reason of the selection of this communication protocol is to protect the system from other external harmful sources.

For the future studies, by inserting GPRS module, an external instantaneous monitoring via internet may also be possible. In terms of this facility, all energy consumptions could be monitored and be controlled at any time. In case of an increase detected at any energy consumption point, it can be controlled and resolved/corrected/fixed by being informed via this beneficial system.

In addition; by the evaluation of the data collected by Automatic Meter Reading System, the future plan could be assessed and composed accordingly. An “artificial intelligence” module could be integrated into automatic meter reading system which enables the user to realize any variation beyond the tolerance between any two compared figures. This would make the system much more efficient as well.

The installed automatic meter reading system is supposed to be easy and understandable for the client users. Otherwise, analyses could not be done properly.

The importance of the energy efficiency is getting increased day by day in Turkey. The first step of energy efficiency program is, for sure, to measure the energy consumption and to take it under the full control. Once any quantity is measured, then it will become automatically controllable.

With the developing economy of Turkey, energy consumption is increasing from time to time rapidly. In case of a huge demand amount, sometimes, established generation power capacity becomes insufficient to meet with the total demand when also leakage losses become an additional load beside. Because of this as well, such automatic mechanisms should be on board in order to be able to overcome these problems.

Acknowledgements

This study is conducted by M.Sc. thesis of corresponding author under the supervision of Prof. Dr. M. Cengiz Taplamacıoğlu in Gazi University and the work is carried out within the knowledge of Esenboğa Airport senior management.

References

- [1] R.R. Mohassel , A. Fung , F. Mohammadi , K. Raahemifar, “A Survey on Advanced Metering Infrastructure”, International Journal of Electrical Power & Energy Systems, vol.63, pp.473–484, 2014.
- [2] T. Khalifa, K. Naik, A. Nayak, "A Survey of Communication Protocols for Automatic Meter Reading Applications" IEEE Communications Surveys & Tutorial , vol.13, no.2, pp.168 - 182, 2011.
- [3] C. Wei, J. Yang, “Implementation of Automatic Meter Reading System Using PLC and GPRS”, Journal of Information&Computational Science, vol.8, no.16, pp.4343-4350, 2011.
- [4] T. Jamil, “Design and Implementation of a Wireless Automatic Meter Reading System”, Proceedings of the World Congress on Engineering (WCE 2008), vol.1, July 2-4, London, U.K., 2008.
- [5] MAKEL Electrical Materials Industry and Trade Inc.
- [6] T. KARALÜRT, Facility Magazine, 03.11.2012.
- [7] <http://www.esenbogaairport.com/en-EN/abouttav/Pages/TerminalFeatures.aspx>