ENERGY CONSUMPTION METERING IN PRODUCTION PLANT (MĚŘENÍ SPOTŘEBY ENERGIÍ VE VÝROBNÍM ZÁVODU)

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Abstract: Recherche of energy metering sensors, communication standards and systems for data storage. From acquired knowledge data flow architecture from metering devices to SQL database was designed.

Keywords: PowerMeter, Energy, Communication standards, Ethernet/IP, Modbus, PROFIBUS, PROFINET, Database, SQL, NoSQL, Operational Historian, System architecture, Data flow

Abstrakt: Rešerše sensorů měření energie, komunikačních standardů a systémů pro archivaci dat. Z nabytých znalostí byla navrhnuta architektura toku dat z měřících zařízení do SQL databáze.

Klíčová slova: PowerMeter, Energie, Komunikační standardy, Ethernet/IP, Modbus, PROFIBUS, PROFINET, Databáze, SQL, NoSQL, Operační Historian, Architektura systému, Tok dat

1 Introduction

Information technologies are becoming more connected with operation technologies. This opens new windows of opportunities. One of them is energy consumption metering and monitoring. This document serves as a quick overview of what it takes to choose the right metering device and set up a data flow architecture.

2 Energy meters

There are many energy meters producers. In the figure below can be seen the overview of electricity meters series with the most important properties such as output resolution and communication interface.

Measurement instrument: Brand, series/type	Installation	Measurands*	Output resolution*	Communication interface*
IME, NEMO 96	Fixed type	V, A, W, VA, PF, THD	60 s	RS485, Impulse
Siemens, SIMEAS	Fixed type	V, A, W, VAR, VA, PF, THD	< 1s	Profibus, RS485
Schneider, Electrics, PM	Fixed type	V, A, W, VA, PF, THD	60 s	RS485, Impulse
Simpson, GIMA1000	Fixed type	V, A, W, VAR, VA, PF	1 s	RS485, Impulse
Yokogawa,	Fixed type	V, A, W, VAR, VA, PF	<1 s	Ethernet, RS485, Pulse
AccuEnergy, Acuvim	Fixed type	V, A, W, VAR, VA, PF, THD	<1 s	Ethernet, Profibus, RS485, Impulse
Janitza Electronics, UMG 604	Fixed type	V, A, W, VAR, VA, PF, THD	<1 s	Ethernet, Profibus, Impulse
Chauvin Arnoux, C.A.8335	Mobile type	V, A, W, VAR, VA, PF, THD	1 s	USB
Fluke, 434	Mobile type	V, A, W, VAR, VA, PF, THD	0.5 s	USB
Voltech, PM3000	Mobile type	V, A, W, VAR, VA, PF, THD	<10 ms	RS232, IEEE488
Load Controls, PPC	Mobile type	W	15 ms	Analogue 0-10 volts or 4-20 milliampere
National Instruments, cDAQ*	Mobile type	V, A	<1 s	USB

*the listed features are retrieved from the datasheets of the devices and are due to change in future instrument revisions

Figure 1: Overview of electricity meters [1]

In the production plant it was chosen to use PowerMeter series from Schneider Electric brand. These meters satisfy the desired output resolution and provide information about all measurands needed. Schneider Electric offers variety of meters starting from basic one phase energy metering using Acti 9 iEM2000, continuing with three phase multi-function metering using PowerMeter 3000 and ending with high-end meters such as PowerMeter 5000.

Figure 2: PowerMeter 5560 [2]

3 Industrial communication standards

With the rise of Industrial Internet of Things (IIoT) and Industry 4.0, Industrial Ethernet standards are flourishing. In year 2019 Industrial Ethernet solutions were representing 59 % of newly installed nodes compared to Fieldbus solutions being at 35 %. The most used communication protocol over Industrial Ethernet is EtherNet/IP, which managed and developed by ODVA (Open DeviceNet Vendors Association). It is widely used by Rockwell and most of IIoT devices. The second most popular is PROFINET (Process Field Net) utilizing Industrial Ethernet and it even has its counterpart using Fieldbus technology PROFIBUS. These protocols are mainly used by Siemens products. Another example, which is using both Fieldbus and Industrial Ethernet interfaces, was developed by Schneider Electric and it is called Modbus. Modbus protocol can be communicated over RS485, Industrial Ethernet or RS232. [3]

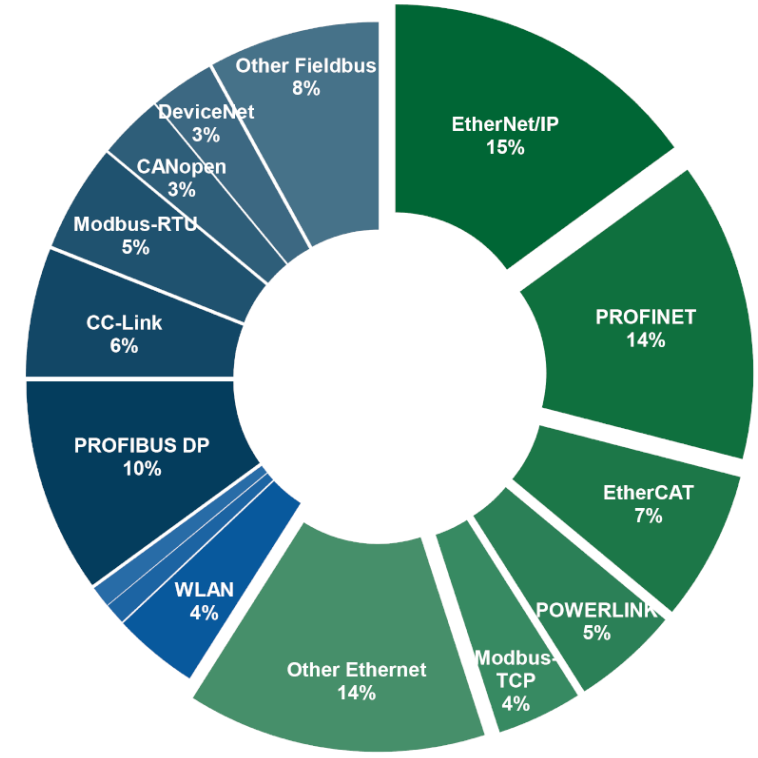

Figure 3: Industrial communication protocols [3]

4 Data storage

Relational databases are popular choice for various systems. It is a set of multiple tables, that are linked through relations. Each table consists of tuples (rows) and attributes (columns). This database type is usually queried and written using Structured Query Language (SQL). It has become so popular, that relation databases are usually referred to as SQL Databases.

The other type is NoSQL database, which refers to Non-SQL or Non-Relational database. The data structure of NoSQL databases is much simpler as it sometimes only stores the key and its value. The simplicity allows some queries to be executed faster than using traditional relational database.

Operational Historian is a time-series database system, which stores industrial process data. In order to do that, it must be able to access Programmable Logic Controllers (PLCs) values. Some Operational Historians have SQL interfaces and therefore they can be accessed via SQL queries (e.g. Historian developed by Wonderware). Others can be accessed via dedicated Application Programming Interfaces (API), which can make it harder to connect it with

SQL databases, but easier for cloud solutions (e.g. Historian developed by GE).

5 Proposed Data Flow Architecture

In order to read the data from energy meters in SQL database, the correct data flow architecture has to be set up. In the factory there are 2 types of meters in terms of communication interface:

1) Impulse

These devices should be connected to PLC Modicon M258, where the pulses shall be counted. This data should be later communicated through Modbus TCP/IP protocol.

2) RS485

Meters, which are communicating over serial bus RS485 should be connected to Gateway EGX100. These meters should act as slaves and the gateway as master using Modbus over RS485 protocol. The data is then translated to Modbus over TCP/IP.

Figure 4: Proposed Data Flow Architecture

Both Modicon and EGX100 should be communicating with PLC Micro850 and it translates the data to Ethernet/IP protocol, which can be accessed by Wonderware Historian. As this type of historian has SQL interface, it can be queried directly from SQL database in order to fill the database.

6 Conclusion

The goal of this project was to do the research of energy metering devices, communication standards and data storage systems. With newly gained knowledge I proposed data flow architecture, which utilizes protocols communicated over both Fieldbus and Industrial Ethernet technology. The data gets first to Wonderware Historian and then through SQL interface it is written into relational database, where it is ready for further analysis.

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