Di-Plast Data Infrastructure Wiki

14 December 2022

Preface

The following guideline is meant to give a roadmap for all decisions to be made when setting up a data acquisition infrastructure for a production plant in the plastics industry. To achieve this goal several strategies can be used, each with its own different advantages and disadvantages. While there is no perfect solution this wiki will try to illustrate the necessary steps, decisions and their consequences from the point of view of a typical plastics processing company based on the experience from the pilot projects and other real-world examples. Since many of the described topics are interlinked, the given order is just a recommendation and can be adapted according to personal preferences.

Information Security

One of the first questions that has to be taken into account is the general topic of information security. Since this wiki is focussing on the production environment (shopfloor) not every possible aspect can be considered. Highest priority is always to make sure that your data cannot be stolen and that your network is safe from intruders. To ensure the latter, most companies are separating the production network from the office and/or server network via a firewall, to make it harder for potential attacks to reach critical company data from the shopfloor network, which is more prone to attacks. The process data gathered on the shopfloor level is far more difficult to protect. An intruder within the shopfloor network will most likely be able to steal data from machines or connected systems (i.e., databases). The value of the raw real-time data is often quite low and since there are no correlations with other data describing material or business processes a loss of this data is not critical if it only happens for a limited time. To protect the data within the databases those can be moved to the server infrastructure in a different network cluster or onto a cloud storage, making the network architecture moreresilient against attacks. Since information security is a complex and specific topic, it is highly recommended to design systems guided by an expert. The following sections will focus solely on the technical aspects of shopfloor data acquisition, leaving out the context of information security.

Interfaces

Digital interfaces for data acquisition are crucial for a working digital infrastructure. During the last decades many different interfaces were used to establish communication between machines, between sensors and machines or from machines to different software infrastructures. Within the last years there was a focus on implementing standardised interfaces for production environments. One of the most widely used standards, the OPC-UA standard, has been developed to cover a wide range of different machine types and industries.

Details on the OPC UA standard and different companion specifications can be found here: [Home Page - OPC Foundation]

To implement and use the OPC UA standard in the plastics industry the European Plastics and Rubber Machinery Association has defined the so called EUROMAP standards. These standards, based on OPC UA, are developed for several kinds of plastic conversion machines. Many more so-called companion specifications for additional equipment like pelletizers, drying and conveying equipment or dosing units are available or under development.

More information on the EUROMAP standards can be found here: [EUROMAP]

Apart from these new standards, there are plenty of other interfaces for Data acquisition: The older and quite unsafe OPC-DA standard, all kinds of MODBUS types, proprietary interfaces and approximately 20 different fieldbus systems.
Thus, one of the most challenging tasks in setting up a good data acquisition system is dealing with all the different interfaces and converting them to a few key protocols. We recommend to define a target configuration and then make a roadmap for every single machine to reach that target. These target configurations may vary between different machine types and the importance of the data they deliver. For example, it can make sense to upgrade all injection moulding machines and extruders to OPC UA while all energy measurement equipment stays on MODBUS. The overall goal should

be to limit the variety of interfaces to a maximum of 5, with exceptions when necessary. To change or adapt the interfaces several technical alternatives are available that will be described now.

1.1 Retrofitting

Machines vary extremely in age and feature set, within any production environment. Since older machines often don't have suitable interfaces for data acquisition, there is no alternative to retrofitting old machines. In many production environments, machines as old as 40 years can be found. Often even newer machines below 5 years of age are lacking digital interfaces, as this feature was not specified when the machine was purchased. There are two options for retrofitting. Newer machines often only need an upgrade to the firmware to unlock data interfaces. This is usually a rather fast, simple and affordable process with costs usually below 10.000 EUR, needing a minimum of downtime. In comparison the hardware of older machines is often incapable of running up-to-date software as the machine control systems were not designed to run a multithreaded operating system. In this case, most of the hardware needs to be overhauled or completely replaced, making this a far more costly process. Depending on the individual machine, costs can range from 25.000 EUR up to 50.000 EUR and even above. As a result of a retrofit, the machine is equipped with an up-to-date software interface that can quite easily be used to acquire process data.

Retrofitting is usually carried out by the machine manufacturers themselves. If the manufacturer is not willing or able to retrofit the machine hardware, companies specialized in retrofitting are also an option. However, the costs can be much higher since those companies are often not familiar with the individual machine.

Some companies have specialised on retrofitting plastics processing machines. They can be found here (examples, no complete list):

Main Page - SHS plus GmbH (shs-plus.de)

I4.0 retrofit for recording machine data | SICK

Kistler introduces new process monitoring system ComoScout | Kistler

1.2 Edge Devices

As an alternative to retrofitting, the use of so-called edge devices is a common strategy. An edge device is basically a computer that is connected to the machine control system and to the data acquisition network. It acquires the data from the machine via the machine specific protocol or individual analogue or digital signals and relays it to the data acquisition system via a standardised interface/protocol like OPC UA or MQTT. Edge devices are usually a cheap alternative to retrofitting, with prices starting below 1.000 EUR but installation and connection to the machine can be challenging. Nevertheless, some companies are offering process digitalisation based completely on installing edge devices for each production line. This has the advantage that machines do not have to be altered in any way and in the event of an edge device failing the machine stays in production. The disadvantages are, that there is another device in the data acquisition pipeline that has additional energy consumption, needs to be serviced, updated regarding security issues and is a potential source of errors.

Providers of edge devices that are familiar with the plastics industry can be found here (examples, no complete list):

Measurement Systems for Industry and Energy - iba (iba-ag.com)

Home - ENLYZE

Perinet

1.3 Middleware

Another alternative to set up a data infrastructure on the shopfloor are software middleware products. A middleware in this context can be understood as a translator and aggregator of data, connecting data interfaces and data storage. This approach provides a high flexibility but at the cost of rather complicated implementation. Most available solutions require IT experts to set up and maintain. A Middleware can run on a server on premise (own servers) or on a cloud system. On premise systems need significant invest in a server system which is redundant and provides fail-safe operation, to guarantee a high availability. The software costs are depending on the respective license model, as shown below. Good middleware solutions are compatible with many interfaces and thus reduce the need for edge devices or retrofitting. In a typical shopfloor environment, a combination of all three approaches is a common solution.

As for many other types of software, middleware products are available with different licensing models (examples, no complete list):

Perpetual license and service charge:
Kepware | Software for Industrial Automation and IoT

Software as a service:
Home | Cybus.io

Open Source:
Eclipse BaSyx

Sensoring

In addition to the sensors in production machines, additional sensors for in-line quality assurance or automation are widely used. To connect those sensors to the data acquisition system three options can be used. First, in lots of cases it is possible to connect the sensors directly to the machine control, connecting them via the machine interface to the data acquisition system. Second, many sensors can be operated as stand-alone systems. Those sensors, often called “smart sensors”, provide a data interface to connect to the data acquisition network via a standard protocol or middleware. If there is a higher level of automation, e. g. quality control of a product with several sensors and actors after the production step, an additional control unit for the automation is used to aggregate sensor data. This unit is connected to the data acquisition network via a standard data interface. Either way, the additional information can be relayed to the data acquisition system.

To find suitable sensors for different processes the Di-Plast Sensoring Tool can be used:
Di-Plast-Wiki: Sensor Tool (uos.de)

Databases

After the data acquisition is set up, the next step is to take care of data storage. Different databases could be necessary to store data from the different sources appropriately.
The exact data volume and retention period is highly debatable. But since the costs for data storage are extremely low it is an acceptable approach to store all numeric data. Regarding image data, the decision is not that simple, as images can be quite large. An often-used approach is to save pictures only for a limited time and only store analysis results that are derived from the pictures (usually numeric data) in long-term storage. Generally speaking, storage of numeric data or short strings (words) is extremely efficient and needs only very little storage capacity. Data in the form of different files or attachments on the other hand take up lots of space. To set up a useful data storage one should initially define what data types are available and what databases are the best fit for those data.

For the distinct tasks different types of databases can be used (examples, no complete list):

Time series data:
InfluxDB Times Series Data Platform | InfluxData | InfluxData

Relational data:
PostgreSQL: The world's most advanced open source database

Non-relational data:
MongoDB: The Developer Data Platform | MongoDB

Cloud Systems

As already mentioned under "information security" there is always the decision whether to run systems on premise or in a cloud infrastructure. While cloud is becoming more and more popular there are still good reasons to host critical data on premise, for example low latency data acquisition and retrieval. Typically, a modern setup is a combination of on premise systems enabling low latency and good accessibility and cloud storage providing high volume data storage and good scalability.

Data Usage

After handling the above-mentioned topics and setting up a data acquisition infrastructure as well as a data storage infrastructure, the use of the available data is the desired reward. There are many possible applications that can be realized by using production data:

- Reporting within the company or towards customers
- Predictive Maintenance
- Logistic optimisation
- Process optimisation regarding quality or resources
- Autonomous operation of production lines with AI
- …

For validating and analysing data several Di-Plast tools are available:

Di-Plast-Wiki: Data Validation (uos.de)

Di-Plast-Wiki: Data Analytics (uos.de)

Other Guidelines

For the above-described topics there are several other guidelines and standards available. A collection of links can be found here (no complete list):

VDI/VDE 3714 Blatt 1 - 2022-09 - Beuth.de (link leads to part 1, parts 2 to 7 also available)

VDI/VDE-MT 3714 - 2022-11 - Beuth.de (necessary qualification to carry out the VDI/VDE 3714)

VDI/VDE 3715 on “Data as an asset - identifying, analysing, measuring and evaluating business data capital” is under development