Babylon in Industry

by

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As is well known, the construction of the Tower of Babel described in the Bible failed - in addition to divine wrath at the project's skyrocketing presumption - because of the diversity of the workers employed and their languages. Similarly, in factory automation there is a Babylonian confusion of languages between the drives and controls of the various equipment manufacturers. Increasingly, however, the OPC UA architecture is emerging as an open solution standard for the intelligent factory - at least in Europe.

The Fraunhofer Institute IOSB-INA has built a model factory for this purpose in Lemgo, Westphalia. In my opinion, OPC UA-standardisation is the most important step in the German and European digitisation strategy. The industrial competitiveness of our economy is at stake.

I therefore visited the model factory in Lemgo and had the experts there explain the problem to me.

The German debates on digitisation policy revolve mainly around the complaint that there are no European providers who can compete with Google, Facebook or Amazon. And in the Corona epidemic, the lack of digitisation in schools and public administration was alarmingly noted. These omissions are painful, but the digital sustainability of our economy is still not decided in these areas. For Germany as an industrialised country, the decisive digital race is taking place in the factories, namely in the competition for standards in the automation of production processes.

The background and causal problem are the different control systems that each manufacturer of sensors, handling devices and industrial robots uses for its plants. For manufacturing companies who want to build up a production process from their combination, the equipment zoo has so far been an endlessly laborious and costly tinkering with the equipment. It is not only a matter of data exchange between the individual components that is regulated at all, but also of time-critical data processing and temporary control of the "flow": Which component, for example, needs to be the first to be informed that the workpiece currently being processed has overheated and needs to cool down before the production process can be continued? And since the available transmission channels are finite: via which data string is this information routed? With every change to the production object or the production plant, the IT puzzle also largely begins anew. Data security has now also become a crucial system issue, as have the connection of networked locations to the Internet and fast data transmission with the new mobile phone standards. Dr.-Ing. Olaf Sauer from the Fraunhofer Institute describes the challenges facing modern production processes better than I can put it here in brief: https://www.iosb.fraunhofer.de/servlet/is/51316/

With the MAP Machine Automation Protocol developed at General Motors in the USA, a solution to the communication problem seemed to be within reach in the 1980s. However, the practical experience was sobering: MAP-controlled spraying robots did not paint the new cars, but painted each other. It soon became clear that a long way was still needed to solve the problems, and years of "field bus wars" followed, in which various consortia and user organisations wrestled with each other to tie as many customers and customer groups as possible to their systems and to establish their group solutions as a standard at the IEC International Electronic Commission or other international bodies.

Organisations and process of national and international standardisation

Standardisation can take place at national, supranational and international level: The following explanations in Times font are unaltered quotations from Wikipedia.

The **International Organization for Standardization - ISO for** short (from Greek ἴσος *isos*, German 'gleich'[1]) - is the international association of standards organizations and develops international standards in all fields except electrical and electronic engineering, for which the International Electrotechnical Commission (IEC) is responsible, and telecommunications, for which the International Telecommunication Union (ITU) is responsible. Together these three organisations form the WSC (World Standards Cooperation).

ISO and IEC are associations under Swiss law (Art. 60 ZGB). Both closely cooperating organisations are based in Geneva. In the meantime (August 2020) 165 countries are represented in the ISO. Each member represents one country, although there is only one member from each country. The German Institute for Standardization (DIN) has been a member of ISO for the Federal Republic of Germany since 1951.

DIN is also a registered association which is supported by the private sector and is financed to over 90% by its own resources. The association works by consensus and is not bound by any government directives. However, it is supported in its European and international standardization activities by the Federal Republic of Germany as the only national standards organization.

In legal terms, the standardisation bodies are therefore private associations of experts. They have to agree unanimously on recommendations, but these are not more than recommendations for the time being. Political influence results mainly from the filling of the positions of executive boards and the chairmen of technical committees and working groups.
As in any association, the filling of these elected positions is likely to depend above all on the active commitment of the respective member. It remains unclear to the public whether special financial commitment can also bring influence. For example, the statutes of the German Institute for Standardization e.V. state

„7. Members' contributions
7.1 Members are required to pay membership fees, the amount and method of payment of which shall be determined by the Bureau.
7.2 Special contributions may be levied, the fixing of which is also decided by the Presidium. "

The ISO standardisation process is a multi-step process.

Level		Name	Acronym
00 preliminary stage	Preliminary project	*Preliminary Work Item*	PWI
10 Proposal	Standards application	New Work Item Proposal	NWIP
20 Preparation	Working Paper	*Working Draft*	WD
30 Committee phase	Committee draft	*Committee Draft*	CD
40 Exam	draft	*Draft International Standard*	DIS
50 Approval	Final draft	*Final Draft International Standard*	FDIS
60 Publication	International standard	*International Standard*	IS
90 Review		*Review*	
95 Retreat		*Withdrawal*	

Some standards are developed and published in cooperation with other international standardisation organisations, such as the International Electrotechnical Commission (IEC). In the names of these standards, the organisations involved are separated by a slash, e.g. "ISO/IEC 8859".

Furthermore, ISO cooperates with CEN *(Comité Européen de Normalisation)*, which as the European Standards Organisation transfers a large part of the ISO standards into the European Standards System. However, while the transposition of ISO standards into the respective national standardisation system is voluntary, all European Standards have to be implemented by the CEN members as national standards. In addition to CEN, there are the European standardisation bodies CENELEC (European Committee for Electrotechnical Standardisation) and ETSI (European Telecommunications Standards Institute).

European standards **(EN standards)** are the standards that are binding at European level and partly replace national standards, such as the **DIN standards** in Germany. European standards must be incorporated into the national body of standards (for Germany, for example, DIN, which is then marked DIN-EN). Conflicting national standards must be withdrawn.

However, European standards are not yet binding per se in the sense that they have direct legal effect. Rather, they only support European legal acts, i.e. certain laws or regulations can refer to a European standard, e.g. when determining limit values. Despite their prominent role, CEN and CENELEC are private non-profit bodies. Only about 30% of their standards have been made mandatory by EU legislation.

In 2012 a European Regulation on European standardisation (1025/2012 / https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32012R1025&from=EN) entered into force, creating a new political framework and a clear legal basis for European standardisation. On this basis, the three recognised bodies of the European Standardisation System CEN, CENELEC and ETSI have prepared a draft for the European Standardisation Strategy 2020.

(ftp://ftp.cencenelec.eu/EN/AboutUs/Mission/CEN_CENELEC_Ambitions2020.pdf)

The draft emphasises the role of CEN and CENELEC as a network of competence and a sustainable system and the possibility of promoting European growth and innovation through norms and standards.
This strategy is controversial. Although the "Ambitions2020" speak of a "private-public network", which is to be strengthened, it is not clear how this strategy will be implemented. But at least the industry association BITKOM probably has the impression that the standards created by this network will then be official European-wide guidelines and no longer voluntary rules to be followed: https://www.bitkom.org/sites/default/files/file/import/Position-paper-on-CEN-CENELEC-ETSI-draft-European-standardisation-strategy-2020.pdf

The process of international standardisation is thus a laborious one, which is beyond the direct influence of governments. In the context of international standardisation of industrial automation processes, the IEC should be kept in mind in particular:

IEC Organization Chart: https://www.iec.ch/dyn/www/f?p=103:63:0##ref=menu

Since 1 January 2020, the President of the IEC has been the Chinese Dr. Yinbiao Shu, who has been directly responsible for standardisation work since 2012. He is also chairman of the Chinese Huaneng Group. China Huaneng Group (CHNG) is an electricity generator which is state-owned by the Chinese central government. The company's performance is subject to the supervision of the *State-owned Assets Supervision and Administration Commission* (*SASAC*), a special commission directly subordinate to the State Council of the People's Republic of China.
One of the closest members of the management team as one of the vice-presidents is the German Dr. Ralph Sporer. He has worked for Siemens AG since 1996. Both there and now at the IEC, he is responsible for standardisation management. Kazuhiko Tsutsumi, another influential vice president responsible for technical standards, currently comes from Japan. He has worked for the Mitsubishi Electric Corporation for 35 years.

One of the many institutions trying to influence ISO and IEC is the **OPC Foundation** (official abbreviation for "Object Linking and Embedding for Process Control", but now only Open Platform Communication for short), an international industrial consortium founded in 1994, which creates standards for open connectivity of industrial automation devices and systems between sensors, instruments, controllers, software systems and notification devices.

The OPC has developed a whole range of standardisation proposals, including most recently the OPC UA (United Architecture) for industrial production processes. These will be discussed below.

Battle of the superpowers for the future industry standard

As "Standard IEC/DIN EN 63 62541", the OPC UA is now finding more and more users in machine and plant construction. The German Fraunhofer Institute has made a significant contribution to this. In the "smartfactoryOWL" the Fraunhofer IOSB-INA tests and develops the application of the standard for real industrial processes together with the Technical University of East Westphalia.

Machines, components, sensors and controllers equipped with OPC UA interfaces can be combined with each other with little effort and "understand" each other, even if they come from different manufacturers. Even older and even analogue devices can be made OPC UA-compatible at a later date. The advantage of standardisation is not only lower installation costs or reduced energy consumption due to optimised, fast processes. Nissin Arbesun Perez, an engineer at the Fraunhofer smartfactory, cites a particularly impressive example of possible applications: "Imagine a company that has factories in several countries or continents. The factory in country A gets a production order, say for the manufacture of vaccines. But a later repeat order exceeds the capacities there. Practically at the push of a button, capacities in countries B, C and D can then be switched on to carry out the order with the same quality". This is a huge step forward, especially in view of the diversification of supply chains, which proved to be important during the corona epidemic.

But will factories all over the world be equipped with a uniform OPC-United Architecture in the future? Unfortunately not at all!

Understanding this means that the unified OPC architecture is based on the ISO/OSI standard, which distributes machine communication over seven "layers" - just as the Tower of Babylon was once constructed. **Since then, the battle between China, the USA and Europe for technological leadership in the factory has taken place in the finest ramifications of these layers.**

The **OSI model** (*Open Systems Interconnection model*) is a reference model for network protocols as a layer architecture. It has been published as a standard by the InternationalTelecommunicationUnion (ITU) since 1983 and by the InternationalOrganizationforStandardization (ISO) since 1984. Its development started in 1977.

The purpose of the OSI model is to enable communication across different technical systems and to promote further development. For this purpose, this model defines seven successive *layers*, each with narrowly defined tasks. Network protocols defined in the same layer with clear interfaces are easily interchangeable, even if they have a central function like the Internet Protocol. The TCP/IP protocol family is mainly used in the private and commercial sector. The TCP/IP reference model is very specifically tailored to the interconnection of networks *(internetworking).*

However, TCP/IP (**Transmission Control Protocol/Internet Protocol), on which the Internet is based,** is now a special feature of the standards structure. It developed from work carried out by the DARPA **Defense Advanced Research Projects Agency, an agency of the US Department of Defense** in the early 1970s. In March 1982, the US Department of Defence declared TCP/IP to be the standard for any military computer network. Later, the development work was divided into a military MILNET and a private commercial research ARPANET, both of which naturally continued to develop. However, both branches are in a close communicative exchange. In practice it probably means that the US Department of Defense has "the last word" in the further development of the TCP/IP standard.

The TCP/IP protocol plays a decisive role in the development of the IoT Internet of Things. Around the ARPANET the OMG Open Management Group, founded in 1989, was formed as a private user consortium, from which, among others, the IIC Industrial Internet Consortium and the Industry IoT Consortium emerged.

The network protocols developed according to the OSI reference model have in common with the TCP/IP protocol family that they are hierarchical models. However, there are essential conceptual differences: OSI precisely defines the services that each layer has to provide for the next higher layer. TCP/IP has no such strict layer concept as OSI. Neither the functions of the layers nor the services are precisely defined. It is allowed that a lower layer is used directly by a higher layer, bypassing intermediate layers. TCP/IP is therefore much more efficient than the OSI protocols. The disadvantage of TCP/IP is that there is a separate network protocol for many small and very small services. OSI, on the other hand, has defined a large scope of services for each of its protocols, which has many options.

TCP/IP works on the third and fourth layer of the ISO/OSI model and is therefore more "basic", but also less specific and less related to concrete applications. For a better understanding it is worth to have a look at the layer scheme of the ISO/OSI model:

https://de.wikipedia.org/wiki/OSI-Modell#cite

In business practice, TCP/IP-based solutions (foreseeable) are mainly used for fast data communication, e.g. for the transmission of mobile phone data or fast data transfer from cars in motion. The protocol developed for this purpose is called MQTT (Message Queue Telemetry Transport) and is now considered the basis for the Internet of Things (IoT Internet of Things). However, a statement that MQTT is only useful for mobile data communication is only tendentially true,- as is the statement that OPC UA is only suitable for controlling industrial processes.

The OPC UA, on the other hand, works in the top seventh ISO/OSI layer, which is intended for specific applications. For the configuration of recurring manufacturing processes of a similar kind, "information models" are created and stored in this layer. In the smartfactory-OWL, this is done in close cooperation with the VDMA, the German Engineering Federation and a whole range of individual industrial companies such as digicolor Gesellschaft für Kunststoffmaschinentechnik mbH.

In the USA, on the other hand, machinery and plant manufacturers are following the research strategy of the six scientific national CESMII institutes set up just a few years ago. These institutes pursue standardisation on the basis of TCP/IP and MQTT. It may be assumed that, in addition to the special suitability for mobile communication in the background, the influence of the US Department of Defense and the interests of MILNET described above also play a role here. Although Tom Burke, Strategic Marketing Officer of the OPC Foundation, promised at a first presentation of the "CESMII-Smart Manufacturing Platform" in 2019 that CESMII developments should have the possibility to dock to OPC UA, the OPC Foundation has not promised to dock to OPC UA. In fact, however, these are two different developments that are trying to set the pace for each other. Dr. Christian Mosch, the VDMA expert for the digital standardization of production processes, is therefore not very reassuring: "There is already the possibility of a divergence in development, but we are in a constructive dialogue with the Americans. But not everything is always transparent. Institutions have a life of their own". To the outsider the impression is forced upon him that a truly common transatlantic standardisation strategy can only be achieved with the involvement of NATO and defence ministers.

The actual lack of interest of US scientists and US engineers in the OPC UA standard is also reflected in the low number of American visitors to the smartfactory in Lemgo. Far more numerous are visitors from Asia. However, Dr. Mosch observes a significant difference between the Japanese and Chinese. "Within the framework of the Japanese >RRI Robot Revolution & Industrial IoT Initiative< we have an excellent cooperation with the Japanese at OPCUA". It is different with the Chinese, Dr. Mosch reports: "Here the mentality is to adopt OPC UA as a standard on the one hand, but then to make changes in details in the last instance, and then it is just another application again. The Federal Ministry of Economics and Technology is therefore preparing a draft Memorandum of Understanding which should enable "fair competition" with the Chinese. The text states that "the good rules of standardisation should be respected, e.g. in the case of OPC UA". However, the Memorandum also addresses numerous other issues such as market entry barriers or visa policy. There is certainly no "pressure" on the Chinese to adhere to those standards developed by the IEC as a body whose chairman is a Chinese. And in the meantime, the Chinese may well have become even more "pressure-insensitive": In the context of the new Asian Free Trade Agreement (RCEP - Regional Comprehensive Economic Partnership), the 15 signatory states - including Japan - also want to talk explicitly to each other about standardisation.

Germany and the EU thus find themselves in a complicated dilemma in the existentially important field of industrial automation: while it is difficult, if at all, to reach agreements with the USA, a tug-of-war is beginning in Asia between Japan and China. Even if the Japanese prevail over China and establish OPC-UA as a quasi-binding standard in Asia, Europe will be increasingly drawn into the maelstrom of Asian markets. If China succeeds in spreading OPC UA with Chinese deviations in Asia, Europeans will suffer disadvantages in both America and ASEAN.

Rapid agreement between the EU and the US at a high political and technical level is therefore essential. This could then also strengthen the Japanese and thus actually establish a global industrial standard that allows all nations industrial compatibility and fair competition. Otherwise, the world threatens to further disintegrate into the spheres of influence of three major blocs at the economic level.

Used sources:

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Personal telephone calls with Dr. Christian Mosch, VDMA on 08. 06. and 03.11.2020

Personal visit to the smartfactory OWL on 02. 06. 2020 with discussion partners M.A. M. Eng. Nissin Arbesun Perez and M.Sc. Florian Pethig, Group Manager Fraunhofer IOSB-INA

Dr.-Ing. Olaf Sauer

https://www.iosb.fraunhofer.de/servlet/is/51316/

Functions of production-related IT or manufacturing execution systems are and will remain indispensable in Industry 4.0, but:

The ICT architecture is changing: it is becoming apparent that the previous levels of the familiar automation pyramid are dissolving and a new information model for Industry 4.0 is required. The following basic technologies, among others, are responsible for this:

1. Internet of Things, Cyber-Physical Systems and Embedded Systems,
2. Big Data and main memory databases,
3. IP-based communication.

Service orientation: MES systems, which until now have appeared rather monolithic, are changing towards service-oriented architectures. New providers of production-related IT systems on the market are developing their tools directly according to the paradigm of service orientation. The following architectural components can be roughly distinguished:

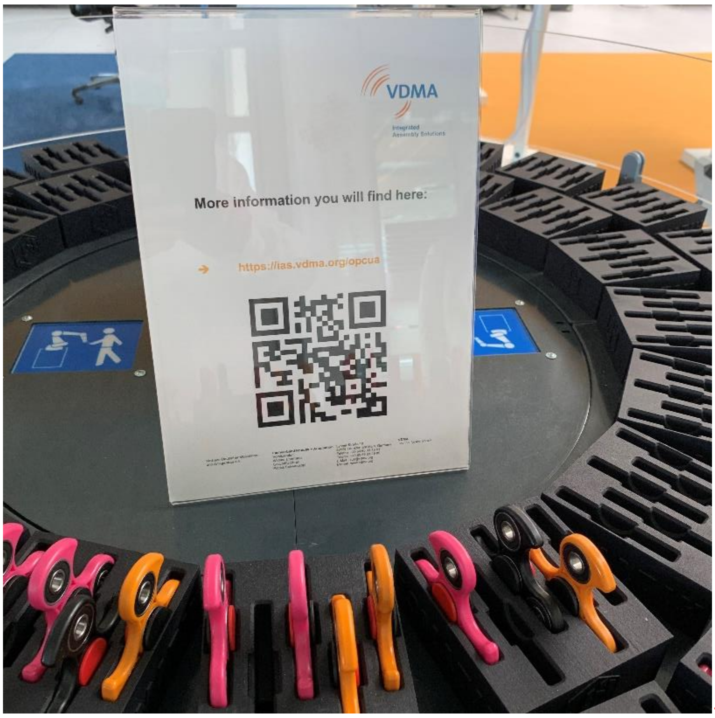
- APPs: Applications with their own user interface, but no or only very limited own data storage, which can be used on a mobile device.
- MES services: In the following, we understand a service to be a unit with a concrete function and clear input and output parameters.
- Manufacturing Service Bus: The services communicate with each other via this bus.
- Integration services: these services are absolutely necessary to create the link between MES service and the machines, plants and other facilities of the factory.

Cloud computing: The basic approach of cloud computing is that computing power, ICT systems and their functionalities are not installed locally at the user's premises, but are sourced from an external data centre as required.

Interoperability and plug-and-work capability: Industry 4.0 promotes the vision of flexible, adaptive production. Intelligent components 'know' their capabilities and 'know' in which plants they can be installed. If necessary, they change configuration settings independently to adapt to the production task and also to the plant in which they are installed.

Condition monitoring and MES are merging: Instead of simple corrective maintenance, the trend is moving towards systems that already make foresighted maintenance and further action suggestions. On the basis of the machine data acquisition function that is already available today, it can be assumed that MES systems will in future offer condition monitoring functions, diagnostic functions and decision-support functions so that machine operators can quickly and specifically maintain the availability of machines and plants.

New technologies for interaction between man and machine: Instead of screen, keyboard and mouse, gesture interaction, speech recognition and other new technologies will be used in the factory in the future, thus dissolving today's fixed points in production, which are provided, for example, by terminals for reporting work processes, for reporting quality results or for displaying machine statuses.



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