

## **From Data Processing to the Internet of Things**

### **and enterprise integration and standardisation**

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#### **Introduction**

The USA Census in 1890 has been the first machine technology supported data collection in history. To enable semi automation data input and large scale data manipulation, the technology required already some application related, but only local standardisation of the card layout (a common understanding of location and size of the input fields) - the first standardisation in information technology. Rather soon, punched cards have been used for data collection, manipulation and storage for business application as well.

The advent of the electronic computer in the 1930s replaced punched cards (rather slowly) and brought forward new technologies for data storage (e.g. magnetic disks, - tapes and - cores) and manipulation (programming languages, graphic representation). These new means enabled new business applications like business operation modelling, - simulation, - monitoring and -control. But to make these applications generally applicable, international standards had to be made available that could be easily interpreted and understood by people involved in businesses operation and their processes. In addition, standardisation of data formats lead to more efficient operation of the enterprise, enabling use of data across the enterprise operation - integrating the enterprise.

#### **Standardisation – State of the Art**

Both ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) as well as industry consortia have developed relevant standards for business applications: standards concerned with business organisation and business modelling in the areas of:

Enterprise architecting: concerned with structuring the business for efficiency and ease of operation, control and monitoring

and business process modelling (with the main objectives) to :

- a. Acquire explicit knowledge about the business processes of the enterprise operation
- b. Exploit this knowledge in business process engineering and reengineering projects to optimise the operation
- c. Support the decision making activities of the enterprise
- d. Ease interoperability of the business processes

Both European and international standards organisations address the subject at very different levels of abstraction, providing architectures, frameworks and explicit standards for different application areas. Standards on enterprise engineering and integration from ISO and IEC on the international level as well as CEN on the European level have produced a set of relevant standards. In addition standardisation is required in the area of business co-operations as well.

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Figure 1 identifies three categories of standards, which relate to the requirements for enterprise reference architectures specified in ISO 15704 using the structure defined in GERAM (Generalised Reference Architecture and Methodologies) developed by the IFAC/IFIP Task Force.

<b>Architecture Requirements</b>	<b>Description</b>
IFAC/IFIP GERAM, Generalised Enterprise Reference Architecture and Methodology	Defines a tool-kit of concepts for designing and maintaining enterprises for their entire lifetime and -history.
ISO 15704, Requirements for enterprise-reference architectures and methodologies	Defines a three-dimensional organisational structure with seven life cycle phases, three levels of genericity and a minimum set of four model views. (derived from GERAM)
<b>Architecture standards</b>	
ISO/IEC 42010, Systems and software engineering - Architecture description	Defines on the description of system, software and enterprise architectures.
ISO/IEC 42020, Architecture processes	Defines requirements on the description of architectural processes
ISO/IEC 42030, Systems and software engineering — Architecture evaluation	Defines requirements on the evaluation of enterprise architectures
ISO/IEC 15288, Information Technology - Life Cycle Management - System Life Cycle Processes	Defines a common framework of process descriptions for describing the life cycle of systems created by humans; identifying a set of processes and associated terminology from an engineering viewpoint.
<b>Modelling standards</b>	
ISO 14258, Concepts and rules for enterprise models	Defines concepts and rules for enterprise models (elements for enterprise models, concepts for life-cycle phases, and descriptions for hierarchy, structure, and behavior.
ISO 19439, Framework for Enterprise Modelling	Defines the generic concepts that are required to enable the creation of enterprise models for industrial businesses and to provide support for the use of frameworks by industrial enterprises.
ISO 19440, Constructs for Enterprise Modelling	Defines language constructs for enterprise modelling, supporting the enterprise model life cycle phases, view and genericity dimensions defined in EN/ISO DIS 19439.
IEC 62264-1, Enterprise-control system integration – Part 1: Models and terminology	Describes the manufacturing operations management domain (Level 3) and its activities, and the interface content and associated transactions within Level 3 and between Level 3 and Level 4.
IEC 62264-2, Enterprise-control system integration - Part 2: Model object attributes	
<b>Interoperability standards</b>	
ISO 11354, Requirements for establishing manufacturing enterprise process interoperability Part 1: Framework for enterprise interoperability	Specifies a Framework for Enterprise Interoperability (FEI) that establishes dimensions and viewpoints to address interoperability barriers, their potential solutions, and the relationships between them.
Part 2: Maturity model for assessing enterprise interoperability	Specifies capability levels of an enterprise to interoperate with other enterprises; Identifies measures for assessing the capability of an enterprise to interoperate with other enterprises; Defines a method for representing concern and barrier overall assessments in a graphical
Part 3: Verification and validation of interoperability among capability units (under development)	Identifies and defines normative requirements that are specific to ICT-based enterprise interoperability for each level of interoperability maturity specified in Part 2.

Table 1: Standards related efforts in Enterprise Engineering and Integration

### **Standardisation – future needs**

With the advent of inter-organisational collaboration, its success depends heavily on the interoperability of business processes and their models. Only if the business process models of collaborating organisations can be linked into a model of the envisioned enterprise can the TO-BE operation be analysed and be optimised. The same is true for the concept of Internet of Things [1] and the German initiative of Industry 4.0 [2].

Standardisation will provide the base for the very much needed interoperability. More research is still required to improve enterprise interoperability between enterprises [3].

#### References:

[1] Internet of things, [https://en.wikipedia.org/wiki/Internet\\_of\\_things](https://en.wikipedia.org/wiki/Internet_of_things)

[2] Industry 4.0, [https://en.wikipedia.org/wiki/Industry\\_4.0](https://en.wikipedia.org/wiki/Industry_4.0)

[3] *Means to enable enterprise interoperation: CIMOSA Object Capability Profiles and CIMOSA Collaboration View*, K. Kosanke, F. Vernadat, M. Zelm, IFAC Annual Review in Control, Vol. 39, pp 94-101