FTI FORUM per la TECNOLOGIA della INFORMAZIONE

ENEA

Interoperability for digital engineering systems

edited by
Anna Moreno

Foreword by
Luigi Nicolais

FrancoAngeli

Informazioni per il lettore

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Foreword

Luigi Nicolais[1]

The contents of this book can be considered as “drops of wisdom” provided by the main experts of the standards for interoperability of hardware and software. The acknowledgement of this technology by a larger community will make any engineering data produced by any appropriate software application able to be read by any relevant other software application now and in the future. The benefit is that anyone and therefore all the industrial society, could take advantage of a better exchange of technical data during the entire life cycle of any product, as simple as a mobile phone or as complex as a building, a ship, an aircraft, etc..

This technology has been already applied in many fields such as aerospace, automotive, oil & gas, building, ship building, etc. and can be used in many other fields where data are managed by computer.

It is well known that International Standards bring technological, economic and societal benefits and help to harmonize technical specifications of products and services; making industry more efficient and breaking down barriers to international trade. Although these are beneficial effects, the interoperability standards are facing many difficulties to be universally adopted in every industry. This has a very high social cost which can be evaluated, in some cases, to go up to the 10-25% of the cost of the products due to longer time to produce them, higher human resources employed for redesigning and data entry, rectification of mistakes due to misleading or lack of information, etc. Even if such a cost is so high, that is the cost of non-interoperability, only a few operators have come to consider it as a driver for change. These costs are mainly borne by the purchasers of the products who, therefore, will have either a worst product for the same amount of money or will have to face an increase of price for the planned product.

But even if the actual cost is borne by the buyers, the benefit of interoperability will positively increase not only the profit of the manufacturers of the products due to a better organization of work and competitive returns but also the profit of

[1] President of National Research Council (CNR) Italy.

software vendors who will have the advantage of working with the same information models with all the customers and therefore reducing the cost of software development.

Consequently, to embrace interoperable software the team members should consider interoperability issues when making technology purchases. The ability of the technology to exchange data across software and platform should be weighed among the primary factors for investment. Even if those benefits will not be realized today, they are of emerging importance and could come into play in the near future. Metrics and improved education will help to promote this solution.

Anna Moreno was one of my students at Naples engineering university and I felt very proud when I knew she had been awarded with the gold winner recognition for education by the European Women Inventors and Innovators Network (EUWIIN). The latest products of her scientific activity in this book are meant mainly to promote scientific and technical knowledge to the "external world". She believes that scientific knowledge is "kept prisoner" by the few domain experts and it seems to have very hard time to reach the rest of the world.

I'm sure this book, which gathers the experience of the most established experts in this domain, will contribute to increasing the spreading this knowledge within universities and research centers which are preparing human resources and among operators which will need to take the first step to suggest to their customers to make a better use of this technology.

Therefore we wish that the effort made by Anna Moreno to collect these authoritative contributes will make a step forward for interoperability standards dissemination and implementation.

Preface

The extension of the global economy and supply chains with the corresponding need to share and exchange computerized product information among many different partners and customers has led to the search for solutions to enable this data to be exchanged and shared easily so that companies can perform efficiently and effectively in response to global market opportunities. Information technology is the backbone of modern manufacturing industry and managing the computerised information produced by this technology is the second business of every manufacturing company. However the difficulty that does emerge in the exchange of computerised technical information and data between collaborating companies is the problem due to the incompatibility of the various internal data representation structures used by different engineering software systems. The problem of exchanging data between different software systems automatically and in digital format can provide a barrier to collaboration and leads to inefficiencies, the costs of rework and extra system costs.

The answer to this problem has been found by creating common models for the engineering information that is to be exchanged. The ensemble of these models is known as Product Data Technology (PDT) and the specifications of these models are a series of International Standards. It is the modern equivalent of the standardisation of the description of screw threads and nuts and bolts in the 19th Century.

This book is intended as an introduction to the use of these standards to enable interoperability and intercommunication by the representation and exchange of engineering product data. It should be of interest and value to industrial organisations who want to improve the efficiency of computer-to-computer communication in their supply chains and with their customers and want to reduce the costs of the management of their computer systems and software.

The first part of the book provides examples of the application of product data technology to a selection of industrial situations and should be of interest to managers and executives to stimulate their strategic planning.

The second part of the book provides some insight into the details of some of the standards that comprise the technology and will be of value to engineers and software developers who want to implement the technology in their operations.

The overall aims of the book are to extend the awareness of this technology, widely used in some of the largest companies, to smaller companies in their supply chain and to those industrial sectors that do not currently use the benefits of this technology.

The scope and the details of these standards are extensive and they represent the efforts of many hundreds of engineers from many industrial nations over a period of nearly thirty years. It is not possible to do full justice to this great intellectual achievement in a volume of this size but an attempt has been made to provide an insight into some of the results of this achievement in the hope that this will stimulate a closer inspection of these standards and the benefits that they can provide for advanced manufacturing.

Acknowledgements

The Editors wish to express their thanks to their colleagues from ISO TC184/SC4 for their contributions to this volume and for the happy times that their friendship had brought over the many years of our collaboration.

Particular thanks are due to Musadaq Hanandi, who suggested the compilation of this book and contributed to the early versions, and Anna Amato, who contributed to the final compilation.

Part I: Examples of the application of product data technology to a selection of industrial situations

1. Introduction: Communicating engineering data

Norman Swindells[1]

Abstract

The industrial requirements for a more efficient way of communicating engineering data within companies and across the global supply chain were recognized by several industrial nations in the 1980's. An impressive international collaboration, involving several hundred engineers from most of the world's industrial sectors, has developed a series of International Standards that provide a comprehensive solution to the representation of computerized engineering information, independent from proprietary software, suitable for communications in current operations and for archiving for future use. This Chapter describes the fundamental basis of the solution to this industrial requirement.

1. Introduction

Readers may be familiar with the use of standards for the communication of computerised data such as using the JPEG standard to communicate the content of digital visual images from one computer to many other computers. A mobile phone can transfer the content of an audio message to other phone systems without needing to reveal the standards that make this possible. When a threaded bolt is purchased from one supplier and a nut from another supplier there is confidence that they will fit together provided that both suppliers have used the same specification and then there is also a standardised spanner that will fit the nut and bolt.

The situation with the computer representation of engineering product data is completely different. Engineering data for products are now almost always created and processed in software systems and the flow of product information, represented by data, throughout the life cycle of the product will require the transfer of this data between many different systems within and between many different enterprises each

[1] Ferroday Limited, United Kingdom.

with different methods of working. Each engineering software system has its own internal method of representing the data for the product or process that it deals with. Direct transfer of data between two different engineering software systems is therefore impossible without two extra software pairs for two-way translation between the two representations: often this translation is either not complete or not accurate. Communication of engineering data to different software systems therefore requires some method of ensuring that the data representation in the message can be understood, without ambiguity, by the receiving software system. Furthermore, the lifetime of engineering software systems is often less than the lifetime of many engineered products. There is therefore an additional requirement to ensure that, if the product data are to be retained in a computer-processable form for future access and use, then they must still be computer-understandable in this form many years after the computer system in which they originated is obsolete or no longer available. This has implications for the integrity of company records and for the resolution of company responsibilities for product liability.

The global project to develop a solution these problems was started in ISO committee TC184/SC4 in 1984 and has benefited from the efforts and expert knowledge of several hundred engineers from all of the main industrial countries and from most industry sectors since then. The application of this technology, called Product Data Technology, has created a series of specifications for the computer representation of engineering data – based on computer-understandable information models – that are independent from proprietary software and able to describe or represent all computerised engineering data by a standard method: the 21st Century equivalent to standardising the description of screw threads. Alternative strategies for the communication of engineering data are illustrated in Figure 1.

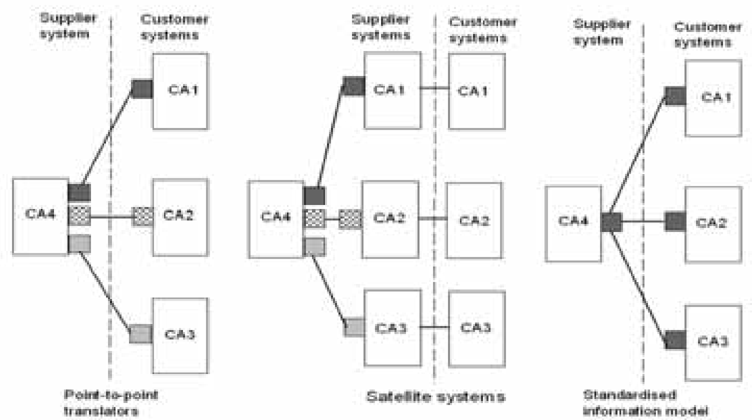

Fig.1. Alternative strategies for the communication of engineering data

2. The international dimension

The problem of communication between different engineering computer systems was first recognized with the widespread introduction of computer-aided methods for product design and analysis in the 1980's and three nations developed their own methods of solving the particular problem of the representation of data from computer-aided design (CAD) systems: the USA developed IGES for its aerospace industry; Germany developed V-DAFS for their automotive industry; France developed SET for their automotive sector. It was soon recognized that these different methods were only local solutions for specific application to CAD data and they could not solve international communications between those companies who had adopted their national methods. There was also the need to expand the requirements for communication to many other aspects of computer-aided engineering: to engineering analysis for example.

3. The solution

To solve the problem of communication of computerized engineering data on an international scale the International Organization for Standards (ISO) Technical Committee 184 (Automation systems and integration) established Subcommittee 4 (Industrial Data) - ISO TC184/SC4 in 1984. The current membership of ISO TC184/SC4 has 19 participating countries and 22 observers. The solution adopted by ISO TC184/SC4 was to develop a collection of standards that defined the representation of an engineered *product* and all of the other engineering information needed to support this description. This description was specified in a new computer language, EXPRESS, which was also defined in the collection.

This solution was based on the fundamental requirements for any communication process, including that of communication by human language. For communication to be understandable without ambiguity there are three requirements for the representation of the information:

- The data items that encode the information – e.g. words in a natural language;
- A formal structure to define the locations of the data items and their roles – a sentence in a natural language and the numerical representation of a calendar data are examples of the use of formal structures to represent and to convey information;
- A dictionary to define the meaning of the data items.

To ensure that the information can be understood without ambiguity it is essential that all of the parties in a communication process use the same information structure and the same dictionary.

The information structure is called an *information model,* defined as: *A formal description of types of ideas, facts and processes which together form a model of a portion of interest of the real world* and *which provides an* explicit *set of rules for its interpretation* (Shenck & Wilson, 1994).

When the information model is written in EXPRESS, or any other computer-sensible representation, then, it has the additional quality of being computer processable. To communicate a particular piece of information, putting relevant data items into their appropriate places in the model creates an *instance* of the information model. It is clear that, as in the example of a natural language, an information model can be reused many times as different instances of the same structure populated with appropriate data items depending on the requirement.

The information models and their supporting technologies are defined in the family of standards developed by ISO TC184/SC4. The whole collection of standards and the technology that it specifies is called *Product Data Technology*. The standards are developed by a very rigorous, formal procedure, subject to extensive validity checks, quality control procedures and approved by international ballots.

Product Data Technology is therefore an engineering approach to the problems created by software engineers, who develop individual and unique internal representations of data structures in their application software. ISO TC184/SC4 provides standard engineering specifications for engineering data, just as standard engineering product specifications are the bed-rock of communications for any engineered product. Interfaces to output and input data representations that conform to ISO TC184/SC4 standards are already incorporated in many commercial CAE software systems. A flow chart to adopt the use of these standards for other situations is illustrated in Figure 2.

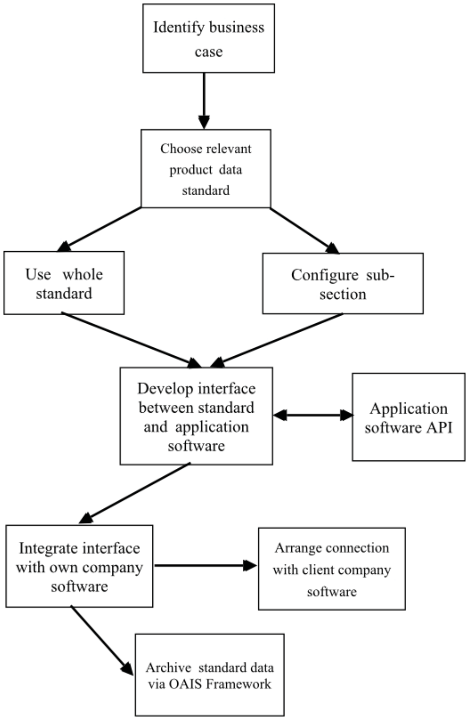

Figure 2. Flow chart for the implementation of standard data representations

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