Equipment Compatibility Problems in Complex Engineering Systems

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Summary
In this work we have considered basic problems of equipment compatibility in complex engineering systems. By the way of concrete example, we are touching upon the situation which is typical for industrial enterprises, which remotely take the readings of the devices or to operate some of own resources by means of automatics. We have given a description of the promising solution of the equipment compatibility problem and/or software compatibility problem with application of modern product in the field of computer science and artificial intelligence , namely in the field of ontology.

Key words:
Compatibility , complex engineering systems ontology.

1. Introduction

Now we can see an increase in the level of automation in various fields of human activity, and conversion to new technologies of automation systems construction. It is largely promoted by use of custom-made built-in object control systems. Thus, the designing of the built-in computing systems became a mass process. Many such systems have higher demands to reliability and operating safety. Despite of existing standards and specifications, very often the manufacturer does not pay much attention to the issues of compatibility of the product and the products by foreign manufacturers. The following fact is even more incomprehensible - the manufacturer can produce various equipment and software for it, but he completely forgets to provide the technologies or means of automatic determination of compatibility of different equipment or the equipment and the software. As a result, the construction of complex engineering systems is always connected to many problems due to selection of the necessary combination of the equipment and the software. For certain the majority of readers have faced this problem of equipment and software compatibility even at the level of "self-made" computer, not to speak of local area network of the enterprise, and they know that sometimes it is very hard to make some things work properly according to the end user demand.

Let's consider this topic more closely by the way of concrete example of telemetering and telecontrol. After that, we shall show new approach to the problem of equipment and/or software in compatibility complex engineering systems based on "ontology" concept.

2. Telemetering and telecontrol system

So, we shall talk about the situation which is typical for industrial enterprises, which remotely take the readings of the devices or to operate some of own resources by means of automatics. We have mentioned, that most convenient way (and further we shall discuss this way) is centralized control of gauges and actuating mechanisms, when they are connected to the multipurpose programmable controller, and the controller is constantly connected to the local area network of the organization – it is made for operational control and scheduling, but there are some other ways of the devices operation, directly from the operator's console.

In order to introduce the resource registration and management system at the objects located far from each other it is necessary to solve the following problems:

- To buy the equipment and the software (SW);
- To organize telemetering and telecontrol at the planned objects;
- To provide compatibility with currently used equipment and SW;
- To start up the remote metering and control center (access center).

Last two items are most interesting for us; therefore we shall consider them further in detail.

2.1 Guaranteeing equipment-SW compatibility and creation of the access center

Let us suppose that all organization works at the objects aimed at telemetering and telecontrol were finished. That is, first of all, installation of the controller and the accompanying equipment, laying of communication channels at the object, connection of gauges and control elements to the controller, configuration of the software and installation of the drivers of the devices, connection of the controller to the local area network of the organization. We strongly recommend to use network closed group of IP-addresses for this purpose, to work with controllers using well-

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defined ports and to not forget about authorization with detailed access journaling.

Actually, all this is usually done by employees of the company- manufacturer of the ordered equipment, not entrusting sometimes untrained personnel of the customer with the installation.

The best way of guaranteeing the equipment-SW compatibility and creation of the access center of remote metering and control over the objects is to make it in parallel, having thought over general engineering policy for these stages. In other words, prior to the stage of the equipment purchasing we should find out, how we shall make it compatible and what hardware-software means we shall use for this purpose, and how it will look like in real life?

One of solutions is a creation of some basic server (we shall call it access center), which compatibility will be our aim at development of user applications and dispatching AW (the automated workplaces). That is this server and its software will be our standard, which will be the basis for all other "incompatible" things, and which will be the center for the software of operators of the access center.

The basic advantage of such approach is: irrespective of control system of the installed equipment, this system will have user interface for every hardware-software platform and in most cases, even several standard interfaces (and hardware-software tools) for data exchange. For example, the controllers often use SQL-compatible databases, web-interfaces for adjustment and for an input/output of the user data. Certainly, at the stage of selection of the equipment it is better to use the hardware which is easily adaptable to our hardware-software basis, and remember of its cost and availability.

We *strongly recommend* to begin projecting of the access center server (select capacity, scalability, software for it and supported communications protocols and even presence of necessary number of COM-ports for connection of specific hardware such as time synchronization device or GPRS-communicator) *prior to the purchase* of other equipment, we think, that our *standard* should be maximally adapted to operation with various types of hardware-software resources. Simply speaking: our server should know maximum number of protocols and standard interfaces for information interchange, it will further facilitate the adjustment of compatibility in the projected system.

Hence, the compatibility problem at *remote metering* by the different equipment can be solved by rather simple way – by writing (or by ordering from the manufacturer of the equipment or software developer for it) of the programs-converters in order to convert the formats of the documents, issued by various controllers, to the database format of our reference server.

It was tested at first hand – these formats are usually simple and standardized (xml, html, sql DB and suchlike), so can be easily analyzed by a machine (probably, in this case it is better to use programmer's phrase «they are subject to parsing»). One-two programmers from IT-department of the organization can write high-quality converter - data replicator in a week, the task of this replicator will be a link between a standard-server and certain controller type. Thus, the task of measuring of remote incompatible controllers can be solved quickly and easily, and the main thing is the fact, that it can be made sequentially, spreading over the period of time! The only reason for updating or writing of a new converter is an occurrence of new type of the equipment which is not compatible with previously installed.

The remote control is more interesting and even easier, especially if the hardware-software configuration of the central server were correctly chosen beforehand. In fact all the remote control devices are nothing but switches, regulators and knife switches (this classification is exaggerated for the purpose of presentation). There are no particular complications of *direct* control over them (both for mechanics and electronics). May be it will be necessary to use the devices, which "know" how to use the network report supported by the controller (or by one of our programs-converters).

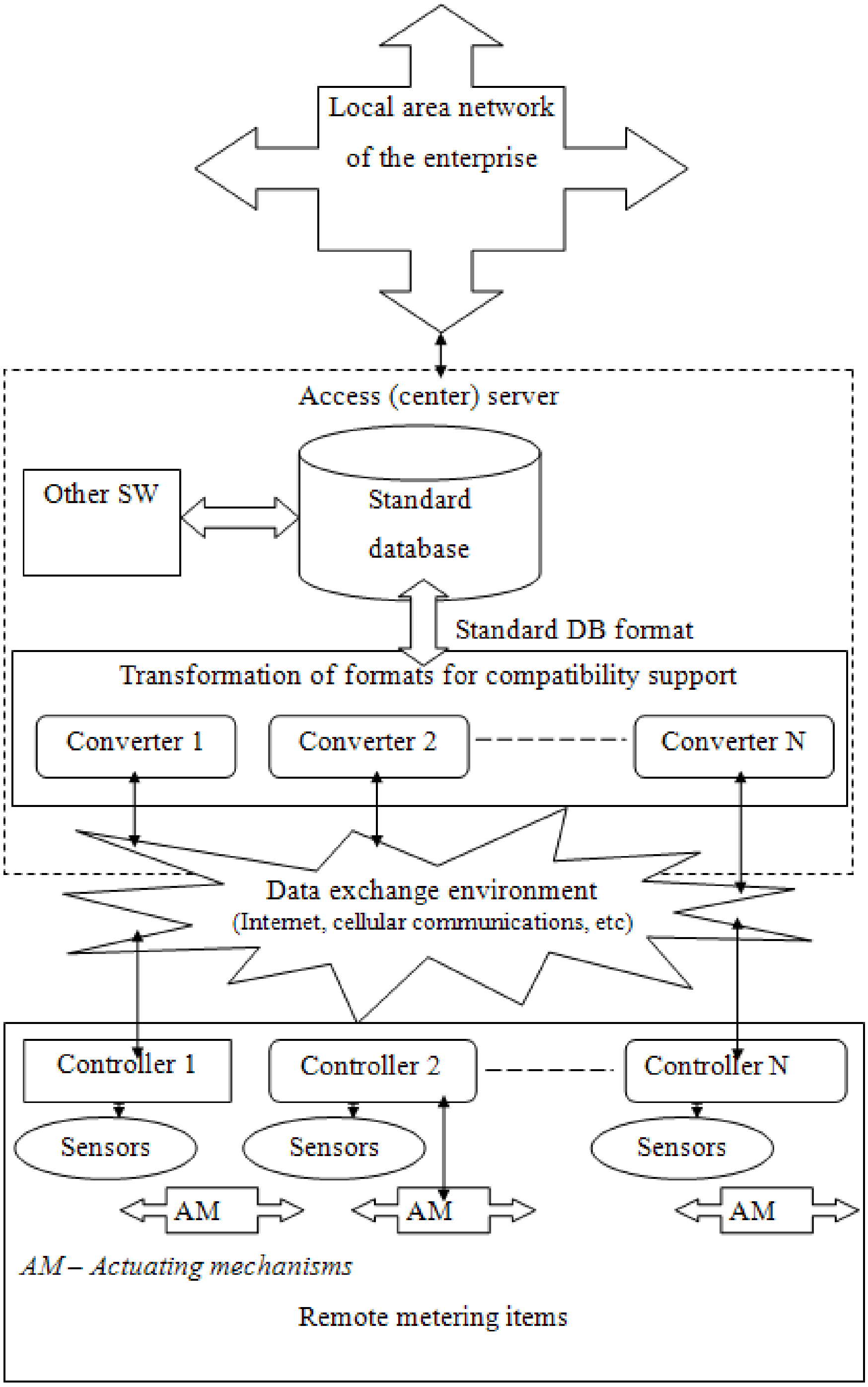
We shall emphasize, that centralized remote control is little bit more complex in comparison with telemetering because of intractable intermediary - the controller which will not give simple access to each device separately. It is possible to parallel it to the operation of web-service on the Internet: reading access will be provided to every interested person, and record and control access will be provided only to elite. That is telecontrol will need authorized access of higher (administrator's) level, and, probably, special software from the factory-manufacturer, which sale and introduction provide a benefit to the factory.

There are two ways out:

- Development (independent or together with the enterprise-manufacturer) of software, which will help to control various types of controllers from the access center. We must say that except for development in this case we shall need periodic modernization of SW for operation of every new controller used at the enterprise objects. The advantages of the product are, first of all, maximum optimization and integration of existing hardware-software complex, and second, low cost of creation and introduction (but not for all possible cases). And the minus can be long-time period of creation of specialized SW - "slowness" at mastering of new devices operation.
- Application of powerful software products of MMI/SCADA class (for example, Pyramid, Power resources, ClearSCADA and suchlike) which

support hundreds of types of actuating devices and controllers and are constantly updated at occurrence of new pieces of equipment. The most obvious and pleasant advantage of SCADA is an opportunity of application of nearly all available actuating devices and controllers and rate of occurrence of the drivers and software updates for support of the latest hardware. The disadvantage of this variant will be rather high cost of the complex, its adjustment according to the needs of the organization and, probably, even updating up to the newest version.

Below there is a model of support of equipment and SW compatibility based on the access center and programs-converters.



The purpose of the converter is determined by its conversion function F, which depends on the input value X.

The conversion function is the ratio power polynomials P (c, X) and Q (c, X) of the parametric influence variable (1).

$$F(c, X) = \frac{P(c, X)}{Q(c, X)} \quad (1)$$

Where c is a vector of real coefficients.

The converting has several kinds of contingencies:

- The orders of polynomials of model numerator and denominator;
- Completeness of spectra of the powers of numerator and denominator polynomials;
- Connection between the coefficients;
- Pole-zero diagram type;
- Introduction of system of equations for the coefficients.

3. Ontology and compatibility problem solving

Ontology is *a formal specification of sharing conceptual model [Studer, 1998]*. Ontology consists of the classes of the subject field entity, properties of these classes, connections between these classes and the statements made of these classes, their properties and connections between them.

The question is, what is the categorical or ontological dimension of complex engineering systems. The first dimension is a dimension of various representations (originally - "prospects"). In this connection we consider telemetering as an object of representation of different experts – computer developers, engineers, businessmen and other. We call this cognitive dimension, as it consists of different knowledge acts, in which the system plan is developed in different ways.

Each concept helps to describe the system using various formal attributes such as compatibility, reliability, self-descriptiveness, composition and many others. The thing is, that it is impossible to speak only about compatibility, reliability and about anything else separately, but it is necessary to speak about everything, that the thing is made of, being a knowledge problem. In case if the estimation is made by a tester, the most important reliability category for him is a testing reliability, if it is made by computer expert, for him it is a stable operation of the programs, if it is made by the engineer – he wants durability of engineering elements. I would name such views formal ontological dimension.

The period of development of complex engineering system comprises time intervals of several stages - idea formations, prototype, then alpha and beta versions and so on. During each of these stages the thing can be disclosed cognitively in different ways, if to consider it from the point of view of formal ontological dimension. Such phenomenon also results in creation of third change which I call progressive dimension.

But it is too early to finish the story about complex engineering systems from the ontological point of view. If you realize, that such system has time-varying current configurations (it is named "temporal object"), we can see, that this development has no direct way, and there are some dead ends, corrections, returns to the start, together with use of new strategy or reinforcements of old strategy with new resources. This dimension which I call evolutionary dimension, is of major practical importance, being a mirror for those interactions that connect the characters to each other. For example, the user or the customer explains to the computer expert the opportunities, which he would like to see in the system. The computer expert will embody these ideas in the computer program language and will show the offers to the customer. Being surprised, he sees, that the received materials are not the materials he expected, in this case the customer can see, that, probably, he did not understand the issue correctly or did not state the idea clearly. He will reject the offers of the computer expert, to describe the demands more precisely and to make new specifications. It, in turn, will result in the following offers of the computer expert and so on. We shall name the customer specifications the ontological wording. They create certain field of ontological space of the system: they can be connected to the certain point of view on the basis of cognitive dimension, with the concept of formal ontological dimension and with the certain stage of progressive dimension. The same as well is related to all the offers of the computer expert. This picture is a display of cooperation which has taken place during development and introduction process.

The question, whether we are able to master all four named dimensions, is an empirical question. Everything, that we try, is ontology which was called into being for realization of certain offer. We should know that four-dimensional ontology shown here is only an abstract circuit. In this respect it is similar to Aristotle's system of categories. Each system can have single determining specificity, corresponding to the system. The sound quality category is determined by the method, which is different from the method for visible thing. In the same way the estimations which apply to the telemetering system are not similar to the estimations which will be given to the transport system.

Such ontology is naturally makes great philosophical sense it is able to explain the necessity for acceptance of the new principle of categories which would help to apply them in complex engineering systems. The technology philosophy will, naturally, fail in case if the technology describes the thing by the thing ontology concepts or with the help of the concepts received during the analysis of the instruments, similar to a hammer. As against a hammer, the complex engineering systems are multisubject objects, because they are made with the help of different fields of knowledge, which are not necessary at all in case of hammer presence. Moreover, they are temporal objects in entity, in the sense in which the objects of the traditional thing category are not such.

Probably it is possible to object to it and to say, that we need a concept of the thing both in the naive engineering design. It is obvious, that a question on the thing category is central in that case also. And the thing always has a set of properties and fortuities. The multidimensional ontology can operate an entity or randomnessly. In case of hammer, for example, we can usually neglect evolutionary dimension. Progressive dimension can be reduced considerably, considering only two stages, namely the stage of development and the stage when we already have a working hammer. And certainly, only this last stage will be essential for us (at least, for all those who are not the manufacturers of the tool). Such reduction will take place in the first dimension which will take into account only that vision, which is known to hammering people. But if you place "Quality" or "Reliability" on the scale of formal-ontological dimension that similarly you will can't do without the first dimension. The hammer can be described as non-temporal, mono-subject (as against multi-subject) thing, manifestative in many cases of own action. In other words, this material/random ontology can be integrated in multivariate ontology. Therefore the material-random ontology can be considered as simplified, not basic ontology.

Multidimensional ontology is also endowed with considerable practical value. It can be used, for example, as a heuristics for development of similar system. Actually this idea is inspired by developmental model, offered by computer researcher Bernd Mahr from technical university of Berlin which, in turn, addresses to the models similar to ISO standard ODP (Open Distributed Processing). Such models will help developers stating necessary questions, because solving of such questions will help to divide the complex problem into the number of simple ones. And what is more important, it will result in cooperation of participants of the project from different fields of activity and having different interests. Thus we can show the straightforwardness of Nietzsche, who was trying to philosophize like a hammer, and study the development of engineering systems with the help of Aristotle and Brentano.

Conclusion

We have considered concrete example of organization of complex engineering system and solving of its compatibility problems. It is shown, that further development could be an improvement technique for solving equipment and/or software compatibility problem with use of modern product in the computer science field and artificial *intelligence*, namely ontology.

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