Advanced Planning and Scheduling
in ERP Systems and their classification
in the Czech Market

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Abstract:
ERP systems represent a key software infrastructure for production and logistics management. Their effective application in everyday working practice should however not take place without the use of the corresponding methods and solutions for the planning and management of production and logistics processes. This paper summarises the main observations of the Center for investigations into Information Systems (CVIS) in these fields. It provides an overview of the main results and outcomes of research study investigations into the Czech ERP market with an orientation on the Advanced Planning and Scheduling integrated into the applications logic of ERP systems.

Key words: Enterprise Resource Planning (ERP), Manufacturing Resource Planning (MRP II), Just in Time (JIT), Advanced Planning and Scheduling (APS), Supply Chain Management (SCM), Theory of Constraints (TOC)

1. Research Methodology

The Center for investigations into Information Systems (further only CVIS) has conducted research studies of the Czech ERP market on an annual basis since 2000. CVIS' research methodologies are based upon years of personal experience [1] and observations and knowledge defined in professional literature by authors like Gill, Johnson [2] and Pavlica [3].

General bases for the ERP systems investigation, classification and efficient utilization are formed in pivotal monographic studies of Professors Jiří Volšek [4] and Zdeněk Molnár [5] from the end of nineties, and in significant foreign studies of the renowned research companies such as Accenture [6] and Deloitte [7]. The last two cited works form, together with expert publications of T. H. Davenport [8], T. Stevens [9] and D. L. Olson [10,11], the base of the own ERP systems classification.

The research itself is performed in the following ways and forms:

1. A questionnaire-based research investigation of vendors, in the form of quantitative questions supplemented by qualitative control of the data and information provided by them (e.g. through telephone conversations with customers to verify selected references and the correctness of information about the functionality and other aspects of their ERP solutions).

2. A qualitative control question process of both user and vendors in the form of market research and targeted discussions, which then tend to be elaborated into case studies (more than 50 studies).
The research aims are:

1. To prepare an overview of the Czech ERP market for prestigious Czech publishing houses like Computer Press, Extra Publishing and CCB.
2. To verify the general theories relating to the ERP market and to generate situational and contextual interlinked theories.

<table>
<thead>
<tr>
<th>Year</th>
<th>Main topic</th>
<th>Additional topic</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>ERP systems</td>
<td>-</td>
<td>51</td>
</tr>
<tr>
<td>2001</td>
<td>ERP systems</td>
<td>ASP</td>
<td>45</td>
</tr>
<tr>
<td>2002</td>
<td>ERP systems</td>
<td>IS efficiency, information asymmetry</td>
<td>49</td>
</tr>
<tr>
<td>2003</td>
<td>ERP systems</td>
<td>ASP, ERP projects</td>
<td>53</td>
</tr>
<tr>
<td>2004</td>
<td>ERP systems</td>
<td>System integration, strategic alliance</td>
<td>72</td>
</tr>
<tr>
<td>2004</td>
<td>IS for SME</td>
<td>Trade models</td>
<td>49</td>
</tr>
<tr>
<td>2005</td>
<td>ERP systems</td>
<td>Trade models</td>
<td>80</td>
</tr>
<tr>
<td>2005</td>
<td>IS pro SME</td>
<td>Economical systems</td>
<td>63</td>
</tr>
<tr>
<td>2006</td>
<td>ERP systems</td>
<td>Information asymmetry, services, BI</td>
<td>75</td>
</tr>
<tr>
<td>2006</td>
<td>IS for production</td>
<td>Detailed analysis of APS/SCM functionality</td>
<td>68</td>
</tr>
<tr>
<td>2006</td>
<td>IS for SME</td>
<td>Economical systems, problems with projects</td>
<td>61</td>
</tr>
<tr>
<td>2007</td>
<td>ERP systems</td>
<td>Servicing and trends in ERP market</td>
<td>77</td>
</tr>
<tr>
<td>2007</td>
<td>IS for SME</td>
<td>Economical systems, problems with projects</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>ERP systems</td>
<td>Servicing and trends in ERP market, management of production and logistics processes</td>
<td>80</td>
</tr>
</tbody>
</table>

Table 1: Czech ERP market investigation in form of a written questioning (CVIS 2000-2008)

The authors of this paper use their own previous experience with research studies into the Czech ERP market as the basis for realising individual research study investigations. The selection of the sample group is performed deliberately, and on the basis of the following requirements and principles:

1. To acquire data and information from the maximum possible number of suppliers of all of the information systems on the Czech market equipped with an ERP function - through the use of repeated questioning.
2. To exploit the team’s personal contacts with concrete individuals in positions of responsibility in the managements of the supplier enterprises – in order to inculcate motivation and to evoke interest in taking part in the research endeavour.
3. In the course of creating the sample for the questionnaire-based investigations, emphasis is placed on ensuring that the given sample
corresponds with the base-set, and thus includes all who meet the set criteria – i.e. domestic producers of software in support of ERP systems as well as representatives of world-class software corporations providing their ERP systems in the Czech market.

4. The aim is therefore to ensure the maximalisation of the number of respondents, while at the same time bearing in mind the potential risk of oversimplifying the techniques and a certain level of superficiality in the responses.

5. Previous experience has shown that, in research studies into the ERP market, there is no direct correlation between the size of sample and the simplification of the techniques and thereby also reducing the ability of the questionnaire to provide meaningful responses. Respondents are sufficiently motivated to supply an exhaustive reply by the opportunity to present their products in professional publications, and which is taken and understood to be, in its own way, a certain form of promotion.

The high-quality response ability, validity and reliability of the research study are buttressed by the following principles:

1. Should new questions be integrated into the questionnaire, then a small pilot study is performed on a small sample of respondents in order to verify whether the questions are sufficiently well-formulated and comprehensible to all and thus make the requisite sense.

2. The research sample of respondents is deliberately selected; in 2008 it represented approximately 90% of the basic sample-base – from the perspective of the number of implementations of the ERP systems under study.

3. The information acquired through the questionnaire investigation is verified telephonically, and in selected cases, confronted through discussions with customers and the use of qualitative questioning (e.g. enquiries, and directed discussions).

4. The reliability of the research study is based upon the annual repetition of tried and tested methods and approaches, while at the same time, any eventual deviations in the results over time are tracked and rigorously controlled.

In view of the above-mentioned facts, it is therefore possible to generalise upon the outcomes and conclusions deriving from the written questionnaires and other research methodology.

2. Advanced Planning and Scheduling in ERP Systems

Advanced planning and scheduling is a component of specialised applications that are usually integrated within the context of SCM or supplied independently for the purpose of planning the production process [1]. These systems decidedly do not replace traditional ERP systems; they are either add-ons or directly integral components which create the support mechanism for planning and decision-making at all levels. We can mention the following as being three of the main characteristics of an APS system:
Unified planning of the entire supply chain – from supplier to a single company customer, or to whole networks of companies.

True optimization based on the mathematical models and exact or heuristic algorithms.

Hierarchical planning systems. These optimisation of the planning of whole supply chains as a single system is not possible, since it is broken down into individual parts, which however cannot be resolved independently (since one would lose the optimal aspects). This thus leads to compromises between its ease of implementation and weighing-up the degree of independence of individual planning tasks.

The following table compares the functions of ERP and APS systems in individual fields.

<table>
<thead>
<tr>
<th>Field:</th>
<th>Traditional ERP systems:</th>
<th>APS systems:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Planning for unlimited capacity</td>
<td>Real plans which take the restricted capacity and nature of key resources into consideration</td>
</tr>
<tr>
<td>philosophy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aim:</td>
<td>feasable plans</td>
<td>optimal plans</td>
</tr>
<tr>
<td>“Push” and “pull” systems</td>
<td>Combined systems</td>
<td></td>
</tr>
<tr>
<td>Management field</td>
<td>Production management</td>
<td>Demand satisfaction</td>
</tr>
<tr>
<td>Production type</td>
<td>Primarily discrete production</td>
<td>All industries</td>
</tr>
<tr>
<td>Main orientation</td>
<td>Transaction systems: e.g. finance, controlling, HR, production</td>
<td>Planning demand, production, logistics, supplier chains</td>
</tr>
<tr>
<td>Information flows</td>
<td>One-way</td>
<td>Two-way</td>
</tr>
<tr>
<td>Able to be simulated</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Ability to optimise costs, profits, prices</td>
<td>Minimal</td>
<td>High</td>
</tr>
<tr>
<td>Production duration</td>
<td>Fixed</td>
<td>Flexible</td>
</tr>
<tr>
<td>Progressive Planning</td>
<td>Limited</td>
<td>Available</td>
</tr>
<tr>
<td>Rapid (pre-)Planning</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Data memory capacity for calculations</td>
<td>Database</td>
<td>Memory-resistant</td>
</tr>
</tbody>
</table>

Table 2: Comparison of traditional ERP systems (ERP I) with APS systems [12]
The **Infor ERP SyteLine**, **Infor ERP Visual**, or **IFS Applications** are typical ERP systems that are widely available on the Czech market that make use of integrated APS functionality. Equally, an example of a Czech APS system integrated into the core ERP application is the Czech ERP system **Karat**, even if the functionality of this solution is restricted to some of the most frequently used algorithms (viz more detailed description in the following section).

3. Production planning and management methods in ERP Systems in the Czech Market

The basis for the management of production and logistics processes is the “push” principle. ERP systems exclusively supported by the MRP II method predominate on the Czech market. This is for two main reasons:

1. The diverse product offer available on the Czech market include so-called “small production” ERP systems among others, which are intended for the management of single part or small series production in a single workplace (one machine). This can make do with the use of only the “push” principle (e.g. the **EPASS** ERP system).
2. Other ERP systems are also available on the market that support only certain specialised product types, for instance – for the planning, recording and tracking of production in mills and bakeries (e.g. the **ComSTAR2000** ERP system), which in principle is based upon predicting and setting of plans.

It is also clear from our results of research that the presence of electronic kanban and TOC systems have strengthened their place in ERP systems ever since 2003. This corresponds to the growing need of enterprises to make use of a wider variety of methods (even in principle completely differing ones), this is especially true at the workshop management level.

When selecting concrete methods, then apart from the type and dispositional arrangement of the production process what is decisive is the way and stability the production is moved on to its final user, the structure of production itself – and above all, its ability to support the attainment of the main goals of production and logistics process management, These are:

- Meeting requirements for the delivery of materials and sub-assemblies for completing the production process.
- The optimal planning and exploitation of production and storage capacities.
- Meeting delivery deadline.
The field of advanced planning and scheduling algorithms has seen a marked shift in their integration directly into the core of ERP systems. This shift is exclusively linked to algorithms for forward planning and backward planning, which enable enterprises to promise delivery deadlines on the basis of CTP and ATP. On the basis of the results of our research study and survey of the Czech ERP market, the following classification and commentary relating to the position of ERP solutions with the support of APS functionality is possible.

4. The ERP systems with APS functionality and their classification

4.1 Lower class ERP solutions with APS functionality support

For domestic producers of ERP systems, it is by no means a matter of certainty that advanced planning algorithms are an element of such systems. Despite this fact, it is possible to find a number of positive examples. For instance, the Karat Software Company outsourced the development of this functional feature to its partner organisation (NWT Computer, a division of the Adder Company). They subsequently bought the rights to it and this partnership solution was integrated as a full-value component of their ERP system. The APS solution within the overall framework of the Karat information system supports make-to-order, i.e. non-repetitive single-item production runs and producing inventory stock – these are usually small series, large series or mass production runs. Equally, its functionality
also covers continual assembly-line production runs with a single finished product. It is not oriented on the area of process production runs and on assembly-line production runs with multiple finished products. In view of this conception, its main validation is predominantly in mechanical engineering, metal-working, foundry, plastics-processing, furniture and cabinet-making and other closely related industries.

From the process cycle point-of-view, APS covers everything from purchasing to sales and deliveries. Its basis is founded on the main production plan (i.e. MPS – Master Plan Schedule), and collaterally with the main plan it is possible to create “user” plans. These allow one to carry out simulations that can later be projected onto and integrated into the main plan.

The APS integrated into the Karat ERP system support both of the key algorithms:

1. **CTP (Capable to Promise)** – This is based upon planning operations. In the course of planning, the effort is to optimised the through-put times and customer delivery deadlines. The calculation is performed on the limited capacity of production resources, i.e. on operations, materials, human resources, ancillary tools and equipment, plant and equipment, and workplaces depending upon how busy they actually are.

2. **ATP (Available to Promise)** – This enables enterprises to promise delivery deadlines based on the actual state of inventory, work-in-progress, sales orders (received and accepted orders) and purchase orders at all inventory levels ranging from sales to purchasing.

The advanced planning and scheduling (APS) application in the Karat ERP system lacks an interactive Gantt chart function, which is replaced by a simpler variant that does not enable more complicated and detailed working with individual orders. Equally, support for SCM functionality is also missing in this ERP solution.

We can classify the Karat ERP system as far as its support of APS is concerned as a representative of lower class solutions. In view of its excellent price/quality ratio however, it has found its place above all in smaller manufacturing enterprises. Other domestic producers of ERP solutions have adopted a similar approach to integrating APS into core ERP systems; for example, ABRA Software, K2 amitec and others, despite the fact that each of them is at a differing level of development and ability to make using this functionality a reality at the customer level.

### 4.2 Intermediate class ERP solutions with APS functionality support

The majority of world-class ERP solutions provided on the Czech market not only include the basic planning algorithms, but also other advanced APS functions. Typical examples are Infor ERP Visual or Infor ERP SyteLine.

For example, the Infor ERP SyteLine system plans for individual orders (requirements) according to priorities, and always begins by backward planning. As long as it does not encounter any bottlenecks or restrictions in that day’s data, it performs its planning function. In cases where it encounters that day’s date, it performs forward planning – and then backward plans once again – in order to optimalised the process. It is also possible to set so-called “virtual todays” in the system and to plan to that particular date. This all takes place hidden from the eyes
of the users – in the background. Users of the system do not even receive warnings or other announcements about how far advanced planning is.

Infor ERP SyteLine also respects lean production principles. It takes into consideration not only the availability of capacity, but also of materials and inventory levels at the same time. It is possible to set the planning of certain resources as being a finite state and the rest of the resources as infinite. The system makes use of more advanced controlling concepts than DBR, since it takes bottlenecks into consideration, and in each case it calculates things at all possible levels. Users can also make use of an interactive Gantt chart; the use of which assists in intuitively planning order-processing and production.

![Bar chart showing support for advanced planning and scheduling in ERP systems on the Czech market.](chart.png)

**Figure 2:** Support for Advanced Planning and Scheduling in ERP systems on the Czech market

Equally, the system supports collaborative planning in chains, in the so-called “Multi-Site” regime. Examples of the successful implementation of this solution linking a number of companies or entrepreneurial units within the framework of an SCM exist on the Czech market. A typical example of such a project is the implementation of the SyteLine system in the Grund Company.

Infor ERP SyteLine, thanks to its abilities ranks among the intermediate class systems which support advanced planning and scheduling. In view of the very high-quality of projects implemented by SyteLine’s partner institution for the Czech Republic – the ITeuro Company, this production control and management solution
is a competitor to the SAP solution, linked to the financial and other ancillary support SAP modules, that apart from the production management module some clients have had implemented. Examples of such projects can be found in companies like Česká zbrojovka a. s., Uherský Brod and Strojírny Třinec.

4.1 Top class ERP solutions supported with APS functionality support

The top class of ERP solutions which also support APS functionality includes complex software applications like the SAP Business Suite with its integrated SAP APO modules, or SAP SCM and Oracle E-Business Suite with integrated Oracle Advanced Supply Chain Planning functionality. Their possibilities are extremely extensive and apart from this advanced production and supply chain management functionality also include SCM project planning.

SAP APO and Oracle ASCP also know how to resolve the key problems that tend to occur within the context of the strategic planning of supply chain projects: location-allocation problems and the strategic planning of networks. Location-allocation problems determine the mutual roles of all of the components of a network – that is to say from suppliers to distribution centres, distribution centres to production plants, products to production plants and from stores or suppliers to production plants. In both systems, these relationships are resolved with a view to their geographical nearness, while also taking into consideration capacity restrictions or restrictions to individual elements of the chain, and last but not least in evaluating overall costs, which should be as low as possible. Linear programming models are used for the strategic planning of networks. Strategic planning may be used for changes in supplier chains or in the course of expansions into new areas or fields that lack the requisite infrastructures.

Both solutions find a place for themselves almost exclusively in large-sized organisations and supranational corporations. Smaller enterprises could encounter serious problems with effectively using such solutions and especially with their ability to master the implementation of projects of such demanding and detailed functional applications.

The realisation of more extensive projects linked to APS support and the necessity of resolving collaborative planning solutions in chains, it would seem that it would be better to make use of ERP systems like QAD Enterprise Applications and IFS Applications, which we classify as upper intermediate class systems. These systems find a use for themselves and validation in many Czech enterprises – above all in the automobile, mechanical engineering and food-processing industries.

5. Conclusions

The management and controlling of production processes is an extremely demanding task since it covers a whole range of mutually intermingled as well as mutually independent and differing activities. While for instance, the financial agendas of many organisations tend to be very similar, production is characterised by a whole range of specific features, which are to a significant extent unique to each of these enterprises. For these reasons, the implementation of an information system into an industrial enterprise should primarily be based upon the
technological and organisational conditions in the production and logistics processes. Managements should know how to decide about the choice and implementation of solutions which not only provide the requisite functionality, but also manage to integrate the interlinked or follow-on processes.

This is also the reason that the Center for investigations into Information Systems has undertaken long-term investigations into the Czech ERP market and why it puts together tables providing a clear overview of complex ERP solutions with an orientation on the needs and requirements of production and manufacturing enterprises. The actual individual specialised applications designed for advanced planning and scheduling (APS) – which are sometimes understated and taken to be a “cure-all” for planning production processes, are – in practice useless and unusable, as long as the enterprise in question does not have the corresponding integrated processes within the framework of an ERP system, a unified and consolidated data-base, and an appropriate set of established and standard methods for the management and control of its production and manufacturing processes.

Bibliography