COMPUTER AIDED PRODUCTION MANAGEMENT IN SMALL AND MEDIUM ENTERPRISES USING SWZ, KBRS AND PROEDIMS SYSTEMS

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Abstract: The paper presents the problems of management in SMEs. It also presents certain part of the activities covered by the research project. It is the method and manner of a formal description of the production processes structure and the way of data exchange between existing IT solutions: ProEDIMS, SWZ and KbRS systems, using XML (Extensible Markup Language - Extensible Markup Language).

Keywords: XML data exchange, computer aided management, scheduling, XML Schema.

1. Introduction

Recently, besides SMEs number increase, an increase in the number of companies known as micro, often family, employing up to 10 workers is observed. They can have the production, trade or service profile. It should be noted that in Poland a low degree of capital concentration can be observed, resulting in the creating of a large number of micro enterprises, which in some cases can evolve in small, medium and large companies. Businesses existing on the market have different forms of production organization, from mass production implemented in a warehouse, production on a synchronized production line, manufacturing of variable series of products performed on behalf of other companies, and production for direct order [13].

Type of the production flow and, associated with this, type of control is usually closely connected with the fact that production is realised on the stock, or addressed directly to the client (Make To Order – MTO) [14]. Recently it is observed a tendency to shift from mass production (at the stock) and the production of synchronized production lines to produce variable performed on behalf of other companies, and production for direct order. Imperfections in the form of losses and delays in production, and thus, great opportunities to improve the operation of systems, are visible at the stage of product design and production organization and management. The competition is regarded as an undertaking that having similar resource is able to organize production in a way that ensures more efficient than it provides a competitor [10]. The advantage of such generators is, i.e., faster decision-making about the possibility of accepting the order and its timely implementation.

Research of the management systems market reveal that the current management system MRP and ERP systems are implemented mainly in large companies. The main reasons of this fact is too wide range of activities for SMEs, the high cost of implementation and the necessity of making changes in the organizational structure [11]. SMEs are looking for management systems in which a greater emphasis is put on technical issues than a business one; it means MES system (Manufacturing Execution System) or SFC (Shop Floor Control).

2. Software systems supporting enterprise management

The analysis of commercially offered software solutions aimed at both large industrial enterprises and enterprises belonging to the segment of SMEs showed that approximately 70% of the implementation of large systems, MRP / ERP does not bring the intended benefits. The reasons for this state of affairs should be sought from both the so-called human factors, as well as the software itself [3].

From the software point of view, the main factors responsible for the failure of implementation are lack of flexibility of the software (the software forcing a rigid structure for the implementation of modifications to the company's organizational structure) and software mismatch between the needs of enterprise-level functionality (functional redundancy occurs on the side of the function administrative control in combination with the lack of full support on the side of the functions of production planning and control). The research project was proposed as the result of the analysis of SMEs needs. This project is thought to develop a scientific methodology for the integration of computer systems supporting the activities of companies in the areas of planning and control of industrial production (in the range of scheduling and production rescheduling), methodology of rapid decision–making on the acceptability of a production order and methodologies of creating a neutral file formats for data exchange between existing author's solutions and commercial solutions [5].

As the result of the project an integrated system-assisted decision making procedures in SMEs will be developed. The authors will modify existing production management and scheduling IT systems: PROEDIMS (Wroclaw University of Technology), KbRS and SWZ (Silesian University of Technology) in such a way that their cooperation will be made possible. In a longer time horizon project authors expect that developed this way, production flow management IT system in SMEs will become an alternative to expensive and very complex MRP/ERP systems, that are practically inaccessible for SMEs [6].

3. Software support of the manufacturing flow management

The manufacturing flow management, planning, scheduling and control is related to the appeal to different behaviours, such as different ways of organizing production, it is clear both from the flexibility necessary to respond to customer expectations and requirements set by the competition. It is obvious that decisions have to be taken in the mode of interaction with computer aided system. Existing solutions are based on different paradigms of production flow management, implemented in various control strategies such as JIT (Just-in-Time), OPT (Optimized Production Technology), LM (Lean Manufacturing), AM (Agile Manufacturing). The manufacturing flow management in a JIT strategy relies on avoiding the execution of the operation which do not give the added value. The essence of strategy OPT [1], is the introduction into the system the production lots in the moments that do not lead to the over limiting, arbitrarily chosen limit.

The JIT strategy puts special emphasis on the elimination of losses and keeping the amount of stock material at the minimum level, so the system is very sensitive to disturbance, while OPT focuses on balancing the flow, reducing the production cycles and ensure timely execution of orders. The LM (Lean Manufacturing) relies also on the systematic reduction of losses in all spheres of business. This is achieved by parallel conducting individual leading of production orders [21]. The AM (Agile Manufacturing) is characterized by a readiness to change, arising from the requirements of a rapidly changing market, the willingness to dynamic allocation of resources (personnel and equipment). This amounts to sharing spare capacity currently available to the company, or to use the resources of other companies [9]. The presented analysis indicates the lack of the universal strategy for management of the production flow. Please note that any decision related to the adoption of the implementation of a production order has to ensure its viability in terms of taking timely and cost of production. Taking into account the specific area of operation in which companies form SME segment operates, it becomes necessary to use IT systems for decision support, in particular, as a support in decision making concerning the possibility of implementation of a production order.

The admissibility of the production flow variants is determined by limitation of a quantitative and qualitative character [7]. Combinatorial nature of the possible variants of organization of production flow causes that it is practically impossible to solve this problem in quantitative terms, it means, that it is not possible to obtain the optimal solution within a reasonable time horizon. For the same reason it is difficult to determine the allowable production flow, for instance solve the problem in terms of quality. This implies a need for the resignation of determining the set of all feasible solutions for the determination of a subset of reachable solutions. Solving such problems is reduced to verify the sequence of arbitrary selected conditions, where each test is to check the condition of local balance. The fulfilment of all conditions (their conjunction) guarantees the execution of the order. The lack of the local balance provides information about the necessary withdrawal of certain conditions of the order, or having to meet the needs associated with an increase in available capacity of manufacturing recourses and workhouse free space etc. [4].

3.1. The Order Verification System – SWZ

This method has been implemented in the "Order Verification System - SWZ 4.0" system. SWZ use data about production system and orders to produce distributed control procedures, which contain quantitative and qualitative indicators of the production system. Production flow control is implemented through, cyclically executed, local resources conflict resolution rules (LLRKZ) [19]. LRRKZ determines the access of order to the resource and provides at least a one execution of operations belonging to each of the processes sharing a resource. Access to resources is regulated according to the mutual exclusion mode. It means that the fixed runs are generated by the sets of LRRKZ assigned to resources. Because work of machines and equipment is carried out according to generated cycle rules, its characteristic feature is that significant production normatives can be set in an algebraic way. It gives the possibility for creating a high level of specific performance indicators of production, such as resource utilization and inventory levels of work in progress. The solution generated by the SWZ system can be used for the production of rhythmic multi-assortment systems, characterized by the simultaneous execution of multiple products, which occurs during regular, steady repetition of the operations of the manufacturing process performed on the resources (machines, crew) of the production system [12].

3.2. The production rescheduling system - KbRS

The KbRS is a production rescheduling system dedicated for non rhythmic, multi-assortment production. The predictive-reactive scheduling and event-driven method is used in the system for preparation and modification of a production schedule. The basis for determining production schedules is the set of technological data (write multi-variant processes) and organizational data of production orders – due dates, priorities, and the volume of production. These data are derived from databases of CAPP and MRP/ERP class IT systems or entered using the data exchange forms [17].

After defining the input parameters the searching of available schedules is executed and resulting obtained set of the best solutions is saved. The ranking list of schedules is created using set of selected criteria. The initial production schedule can be selected directly from the top of the best schedules list, or manually by a planner/dispatcher who in a given situation may apply additional, informal evaluation criteria. Production schedules are presented in form of the Gantt chart, an overview of evaluation indicators and analysis of individual schedules by other reports can be provided. The system structure is shown in Figure 1.

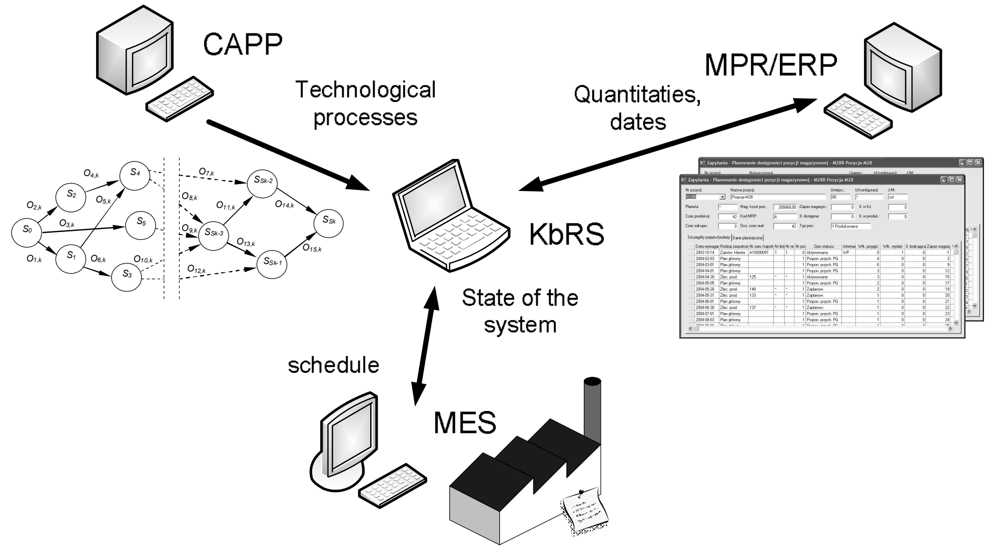

Fig. 1. The KbRS interaction with other production IT systems [18]

3.3. ProEDIMS system

ProEDIMS system (Fig. 2) belongs to a family of products that are used to manage product data and processes in an enterprise. ProEDIMS enables the creation, collection, management and propagation of all data associated with the product throughout the whole product life cycle.

The ProEDIMS supports various areas and activities related to the product and business activities: starting from the conceptual phase, through design and process management, logistics and relationships with customers and suppliers, to the maintenance and servicing of products. The system functionality can be easily modified and adjusted to the needs and requirements of users. This solution provides high flexibility because of its open and modular software architecture. The basic functionality of the ProEDIMS is provided by its main modules, which are responsible for managing the order or whole project, documentation, resources and workflow management. Matching the system to user's needs is done by appending the specialised modules, such as product structure management, design, technology, warehousing, or logistics, monitoring work in progress and others.

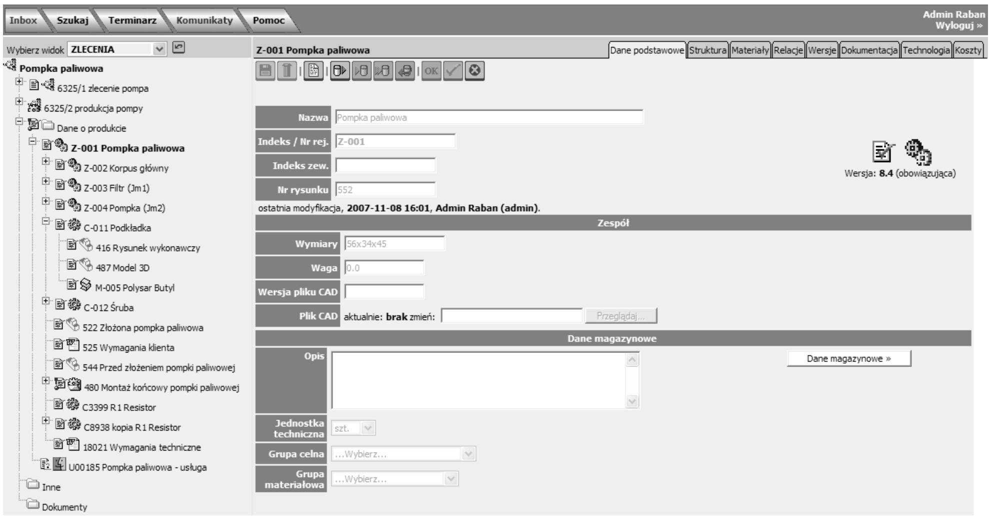

Fig. 2. ProEDIMS system user interface [18]

In cooperation with the KBRS and SWZ systems, with advanced production scheduling and rescheduling projects, production flow and rhythmic production IT systems ProEDIMS creates a complete solution for SMEs.

4. Data exchange between ProEDIMS, SWZ and KbRS systems

The formal methods for description of the structure of production processes and the data exchange between existing solutions (SWZ, ProEDIMS and KbRS systems) were developed. It was decided to use the Extensible Markup Language XML (Extensible Markup Language), intended to represent different kind of data in a structured manner. XML is now commonly used in electronic data interchange systems (EDI) due to its high versatility and convenience [20, 15]. XML specification was defined by the W3C (World Wide Web Consortium) [2]. Originally it was developed as a language for effective information exchange in the World Wide Web, however, due to its advantages, also found application in other fields.

The first step in the implementation of the data description and exchange method was the definition of the structure of an XML document containing data model of production system. Most popular standards for defining XML document structure is Document Type Definition (DTD) developed by the W3C and XML Schema, which is considered the successor to the standard DTD.

It was decided that the structure of the document will be defined using XML Schema due to the fact that:

- XML Schema is also stored in XML format,
- it is more powerful in comparison to the standard DTD,
- it allows to define additional data restrictions.

By applying the XML schema it is also possible to create new definitions of the structure, or to combine information from several schemes, which is important in the process of data acquisition from IT systems. The definition of the XML document structure as a XML Schema provides data determining proper method of preparing of the XML document, including information on, inter alia, data types, attributes and ranges of acceptable values. The XML Scheme is also used to control the correctness of the document (XML validation) during the transformation process of XML documents in applications.

Developed XML Schema, describing structure of the production processes with regard of available resources of the production system, includes a definition of the XML document structure for the data describing the resources that create the manufacturing system, i.e.:

- manufacturing resources, inter-operational buffers, input and output buffers for products which are to be manufactured in the system,
- data on production processes, i.e., routing technology, data about the setup time, execution times of individual operations on the manufacturing resources of the production system,
- data on the scheduling of resources.

Example of a part of XML Schema containing definition of the XML document structure was shown on Figure 3.


```xml
<?xml version="1.0" encoding="UTF-8" ?>
- <root xmlns="http://www.proedims.pl/xsd_schemas/psl" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  - <planowanie>
    - <zlecenie>
        <id>15345</id>
        <status>Rozpoczęte</status>
        <priorytet>1</priorytet>
        <wielkosc_partii>3</wielkosc_partii>
        <data_rejestracji>2009-12-11</data_rejestracji>
        <planowana_data_rozpoczecia>2010-06-24</planowana_data_rozpoczecia>
        <planowana_data_zakonczenia>2010-06-25</planowana_data_zakonczenia>
        <rzeczywista_data_rozpoczecia />
        <rzeczywista_data_zakonczenia />
      - <operacje>
        - <operacja>
            <id>15375</id>
            <nazwa_operacji>Operacja domyślna</nazwa_operacji>
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            <zezwol_nadgodziny>0</zezwol_nadgodziny>
            <harmonogram_reczny>0</harmonogram_reczny>
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            <opoznienie_wykonania_operacji>0.0</opoznienie_wykonania_operacji>
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            <id_zasobu>15359</id_zasobu>
            <id_grupy_zasobow>0</id_grupy_zasobow>
          </operacja>
        </operacje>
      </zlecenie>
```


Fig. 3. Exemplary part of XML Schema as ProEDIMS, KbRS and SWZ interface

The next step is automatic generation of input files in ProEDIMS, KbRS and SWZ systems internal formats based on data stored in the XML documents. For this purpose, was used Extensible Stylesheet Language Transformations (XSLT), which is recommended by the W3C language allowing to transform an XML document into another type of document (eg another XML document, web page, a text document etc.).

XSLT is used in a variety of software (eg web browser, MATLAB), and the implementation process of XSLT document transformation can be conducted using available processors (XMLSpy, Sablotron for C + +, XSLT, PHP).

Presented solutions associated with defining and transformation of the data obtained from ProEDIMS, SWZ and KbRS systems, supporting the enterprise management process, are the basis of the development of methodology of creation of the integrated computer system for supporting the technical and organizational preparation of production [8]. Practically, systems integration is realized by extending SWZ and KbRS with a common interface for data exchange between different modules of integrated planning environment, providing the possibility to save data about system resources and execute orders in XML files, according to developed XML schemas.

The transformation process of XML files based on XSLT documents can be implemented in two ways. The first uses the available software containing XSLT processors (XMLSpy). The second way is based on the newly created authors interface using XSLT processors (Fig. 4).

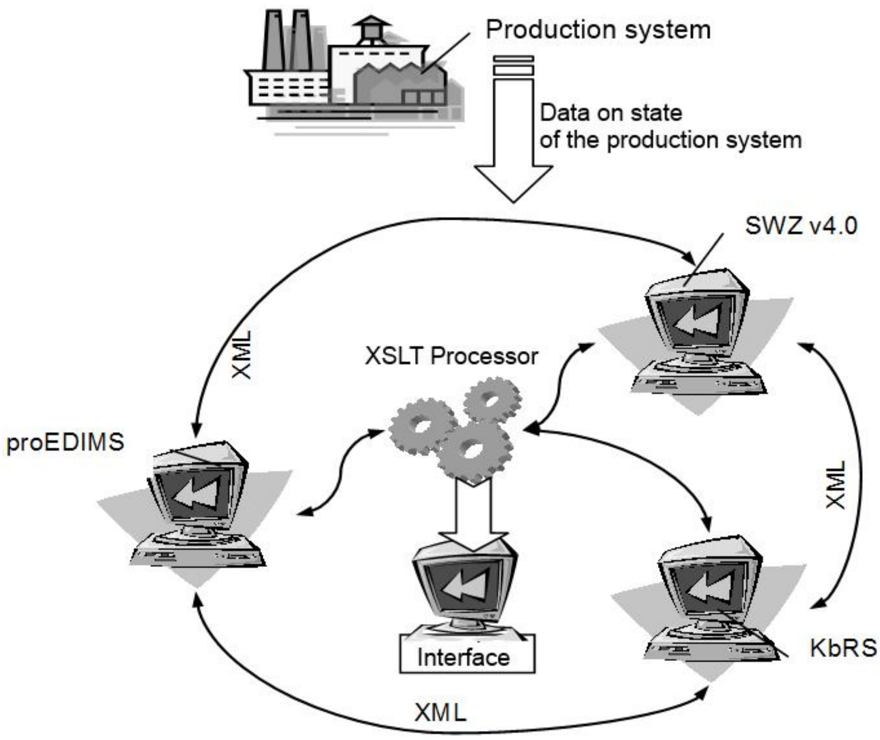

Fig. 4. Data Exchange interface between ProEDIMS, SWZ and KbRS IT systems [16]

5. Summary

Analysis of the current state of knowledge on methods, tools and techniques for integrating the design, planning and production management functions of IT systems carried out by the authors showed that it is advisable to carry out research in this area of scientific consideration, mainly due to the lack of such solutions, both commercial and academic, especially in relation to SME segment companies.

The result of the project is a prototype of management IT system for SMEs, built on the basis of ProEDIMS, KbRS and SWZ systems. Integrated IT system obtained after interfacing the ProEDIMS, KbRS and SWZ systems was successfully implemented in one of the SMEs sector enterprises.

References

1. Blackstone Jr, J.H.: Theory of constraints - a status report. International Journal of Production Research, 2001, Vol.39, No.6, 1053-1080.
2. Bray T., Paoli J., Sperberg-Mcqueen C. M., Maler E., Yergeau F.: Extensible Markup Language (XML) 1.0 (Fifth Edition) W3C Recommendation 2008 http://www.w3.org/TR/2008/REC-xml-20081126/. Acces date: 10.01.2009
3. Ćwikła G.: Methods of manufacturing data acquisition for production management – a review. [in:] Modern Technologies in Industrial Engineering. [Eds:] C. Carausu et al. Advanced Materials Research, vol. 837, 2014, 618-623.
4. Ćwikła G.: The methodology of development of the Manufacturing Information Acquisition System (MIAS) for production management. Applied Mechanics and Materials, vol. 474, 2014, 27-32.
5. Dobrzańska-Danikiewicz A., Krenczyk D.: The method of the production flow synchronisation using the meta-rule conception. Journal of Materials Processing Technology, vol. 164, 2005, 1301-1308.
6. Grabowik C., Kalinowski K., Kempa W., Paprocka I.: A survey on CAPP systems development methods. [in:] Modern Technologies in Industrial Engineering. [Eds:] C. Carausu et al. Advanced Materials Research, vol. 837, 2014, 387-392.
7. Grabowik C., Kalinowski K., Paprocka I., Kempa W.: UML models of design and knowledge representation for technical production preparation needs. [in:] Modern Technologies in Industrial Engineering. [Eds:] C. Carausu et al. Advanced Materials Research, vol. 837, 2014, 369-374.
8. Grabowik C., Krenczyk D., Kalinowski K.: The hybrid method of knowledge representation in a CAPP knowledge based system. Hybrid Artificial Intelligent Systems. vol. 7209, Springer Berlin / Heidelberg 2012, 284-295.
9. Huang H.H.: Integrated production model in Agile Manufacturing Systems. Int.J. Advanced Manufacturing Technology, 20, 2002, 515-525.
10. Kalinowski K, Grabowik C., Kempa W., Paprocka I.: The graph representation of multivariant and complex processes for production scheduling [in:] Modern Technologies in Industrial Engineering. [Eds:] C. Carausu et al. Advanced Materials Research, vol. 837, 2014, 422-427.
11. Kalinowski K., Grabowik C., Paprocka I., Kempa W.: The model of discrete production scheduling system in UML notation - classes diagrams [in:] Modern Technologies in Industrial Engineering. [Eds:] C. Carausu et al. Advanced Materials Research, vol. 837, 2014, 416-421.

12. Kalinowski K.: Multistage decision making process of multicriteria production scheduling. Journal of Machine Engineering vol. 12, 2012, no. 3, 20-33.
13. Krenczyk D., Skołud B.: Production Preparation and Order Verification Systems Integration Using Method Based on Data Transformation and Data Mapping. Hybrid Artificial Intelligent Systems. vol. 6679, Springer, Berlin 2011, 397- 404.
14. Krenczyk D.: Data transformation for production planning and control systems integration. Journal of Machine Engineering, vol. 11, no. ½, 2011, 171-180.
15. Okamoto A, Gen M., Sugawara M.: Integrated data structure and scheduling approach for manufacturing and transportation using hybrid genetic algorithm. Journal of Intelligent Manufacturing, 2006, 17, 411–421.
16. Skołud B., Krenczyk D., Kalinowski K., Ćwikła G., Grabowik C.: Zintegrowany system wspomagania zarządzania produkcją w małych i średnich przedsiębiorstwach. V Konferencja Naukowo-Techniczna nt. Jakość, innowacyjność i transfer technologii w rozwoju przedsiębiorstw INTELTRANS. Wydawnictwo Politechniki Krakowskiej, Kraków 2009, 125–134.
17. Skołud B., Krenczyk D., Kalinowski K., Grabowik C.: Exchange of data in production flow control systems SWZ and KBRS, Automatyzacja Procesów Dyskretnych. [in:] Teoria i Zastosowania (eds: Świerniak A., Krystek J.), Gliwice 2010, 207-214.
18. Skołud B., Krenczyk D., Krenczyk D., Kalinowski K., Grabowik C., Ćwikła G., Chlebus E., Cholewa M., Czajka J.: Zintegrowany system wspomagania zarządzania produkcją w małych i średnich przedsiębiorstwach o zmiennej produkcji wieloasortymentowej na zlecenie. Instytut Automatyzacji Procesów Technologicznych i Zintegrowanych Systemów Wytwarzania, Wydział Mechaniczny Technologiczny, Politechnika Śląska, Gliwice 2012.
19. Skołud B., Krenczyk D.: Flow synchronisation of the production systems – the distributed control approach. Proceedings of the 6th IFAC Workshop on Intelligent Manufacturing Systems IMS 2001, Poznań 2001, 127 – 132.
20. Tao Y., Hong T.; Sun S.: An XML implementation process model for enterprise applications. Computers in Industry, Elsevier Science Publishers B. V., v. 55, 2004, 181–196.
21. Womack, J. P., Jones, D. T.: Lean Thinking- banish waste and create wealth in your corporation. Simon & Schuster, New York 1996.

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