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Multipurpose computer platform supporting the transfer of innovations to business practice

K e y   w o r d s

Transfer of research findings, innovativeness, computer systems, virtual institutional cluster.

S ł o w a   k l u c z o w e

Transfer wyników badań naukowych, innowacyjność, systemy informatyczne, wirtualny klaster instytucjonalny.

S u m m a r y

The paper presents a novel, multipurpose and heterogeneous computer platform that includes digital, application, and hardware resources essential for the proper functioning of a virtual institutional cluster. The cluster is oriented at the transfer of innovative process and product technologies that are an exemplification of scientific research and implementation works into business practice. Moreover, the following elements of the multilayer structure of the platform are presented: integrated computer systems for data fusion and processing, information and specialised knowledge used in systemic and process structural analyses that are performed with, among others, Business Intelligence models used by interdisciplinary research teams undertaking innovative challenges. Furthermore, the author presents the functional capabilities of the platform linked to e-service and e-science, and original and innovative IT solutions developed to meet the requirements of the platform.

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Introduction

Modern research and business organisations look for new structures of functioning, and new methods and models that support innovative processes in order to improve their competitiveness on the global market in sustainable development conditions [12]. One of the most efficient mechanisms that influences development of these trends is the integration of organisational activity and the creation of network-based structures or institutional clusters. Because of the fact that they share the infrastructure (human resources and knowledge), they are able to decidedly accelerate the market recognition. This enables them to identify needs and technological niches in order to make decisions oriented at the development, application, and commercialisation of products that are notably innovative [4]. However, an innovative product does not guarantee a competitive advantage, especially when information concerning the product is accessible to a limited number of potential clients or they are aimed at clients who are not interested in the product [13]. Experience gained from a numerous projects realised within the Framework of Innovative Economy Operational Programme, the Multi-Year Programme PW-004 "Development of innovative systems of manufacturing and maintenance 2004–2008" [17] and the Strategic Programme "Innovative Systems of Technical Support for Sustainable Development of Economy" show that innovative processes realised by consortia, networks or clusters have to be supported by modern information technologies and IT applications [2]. As practical experiences show, that this is essentially important in the area of construction and exploitation of machines [13], where the development of a conception, and designing and manufacturing of an innovative product requires the following, among others:

- Stable cooperation between research units, research institutes and business units within an interdisciplinary research team, where members are geographically dispersed and have to regularly communicate in order to solve current, often very complex technical problems;
- Systematic exchange of information concerning a state of the advancement of a innovative product development;
- Accessibility to results of research that is performed in various research laboratories and making the results integrated within engineering databases or knowledge bases, available to other members of a institutional cluster through the Internet;
- Optimisation of investment on specialised, often very expensive software for designing with the most advanced methods of engineering design;
- Dispersion of information concerning an innovative product to a certain groups of clients;
- Cooperation between research units and business units in the stage of a products application and training of operators;

– Generating new ideas for the development of an innovative product, especially related to mechanical solutions, control systems and computer applications; and,
– Accessibility to the content of databases that support the protection of intellectual property rights.

Shortening the time of market analysis, specialised computer platforms [5] might be used for a generation of new conceptions of product and process technologies optimised in eco-effectiveness criteria [9, 10, 14], increasing the efficiency of innovative, application and commercialisation processes. Therefore, there have been works undertaken in order to develop and implement a multipurpose computer platform that enables data flow, fusion and sharing of digital resources necessary to run virtual organisation supporting processes of the transformation of innovative solutions to business practice in the area of construction and exploitation of machines.

Critical assessment of existing solutions in the area of the construction and exploitation of machines

The first step before the project of the platform was developed was analysing computer technologies and information resources of databases and web sites used in processes of technology transfer, especially in innovation promotion and the dissemination of information concerning innovative enterprises, technologies, services, and products. The research consisted in analysing over 40 international, national, regional, sectional, and institutional databases and over 400 thematic portals [11, 12]. Fundamental conclusions from the analysis indicate the following:
– Web portals or specialised databases are popularly used as computer solutions for the support of the process of the transfer of innovative product and process technologies.
– The thematic scope of databases depends on their purpose, and databases frequently contain information concerning the innovation of a particular sector and information about offers, technological needs, enterprises, and experts.
– Information resources are usually systematically supplemented when research projects and projects in the Framework of Innovative Economy Operational Programme are carried out or financed from structural funds; whereas, after projects are terminated, investment in databases updating and maintaining is limited.
– Data acquisition is performed mostly with the use of classical methods based on paper questionnaires or electronic forms that have stiff structures and cannot be modified by the user.

– Available solutions are directed at the gathering and dissemination of data, not at the gathering, integration and sharing of knowledge, for instance, as a result of the analyses of data and the market that indicate the real market demand.

A distribution of information is a notable restriction, as well as the lack of close connections between existing portals and databases, and between patent bases and bases with scientific publications concerning, among others, issues such as the efficiency of mechanisms and structures of knowledge transformation. It should be recalled that available applications are not equipped with integrated computer systems that support cooperation in solving problems in the area of innovativeness, also taking into account issues of knowledge transformation and technology transfer.

Structure and capabilities of the multipurpose computer platform

The platform was designed in accordance with proposals from performer analyses, and it is based on the priority research directions in the subject matter, especially in reference to using the knowledge as a medium for the creation and management of virtual structures that influence real relations between institutions that elaborate innovative solutions in the area of construction and the exploitation of machines. It was assumed that the specialised computer platform used in the area of the construction and exploitation of machines should support an efficient solving of the following problems [2, 6, 7, 8]:
– Gathering, processing and selectively orientated dissemination of information concerning processes of knowledge transformation, technology transfer, and innovative product and process technologies, for instance, technologically advanced machines or research apparatus;
– Aggregation of data obtained from various sources available through the Internet, for instance, data concerning components and subassemblies used in the construction of machines, results of R&D in the area of construction and exploitation of machines, legal instruments, founding sources, technical parameters, patents, standards, and the like, in order to integrate and process to build ontologies, perform efficient contextual search of information, management of logistics of manufacturing processes and correct presentation and interpretation of analyses results;
– Exploration of knowledge from gathered data that could be the trigger for new innovations or could be useful when developing innovative solutions, which are particularly important in technical sciences and engineering;
– Performing research in the area of innovativeness, market demand, research potential of research organisations, and the like, with the use of advanced methods, for instance CAWI (*Computer Assisted Web Interviews*);

– Ensuring effective and efficient verbal and visual communication between members of interdisciplinary research teams that enables fast exchange of data, information and knowledge;
– Stimulating the creative generation of ideas in the area of construction and exploitation of machines with the use of unconventional, heuristic and behavioural operational methods, for instance, a brainstorming method;
– Improving cooperation between different users in updating and maintaining thematic portals of the platform with the standardised CMS system (*Content Management System*);
– Managing services, including support services involving promoted innovative solutions, e-science services, marketing services, an electronic document flows with the CRM (*Customer Relationship Management*) system based on the SaaS (*Software as a Service*) model and SOA (*Service-Oriented Architecture*) conceptions.

The project was developed, and implementational tasks concerning the dynamic, scalable, scalable and virtual platform have been undertaken. The platform is intended for efficient communication, dissemination and information processing, and selective fusion of knowledge resources of corporations, research institutes, research units and advisers, and experts that aim at developing innovative technical solutions and technologies. The platform has a heterogeneous and multilayer architecture (Fig. 1) including digital, application and hardware resources that enable the functioning of a virtual institutional cluster directed at knowledge transformation and transfer of innovative product and process technologies. The platform integrates the following layers: physical, communication, operational, application, and information (Fig. 1).
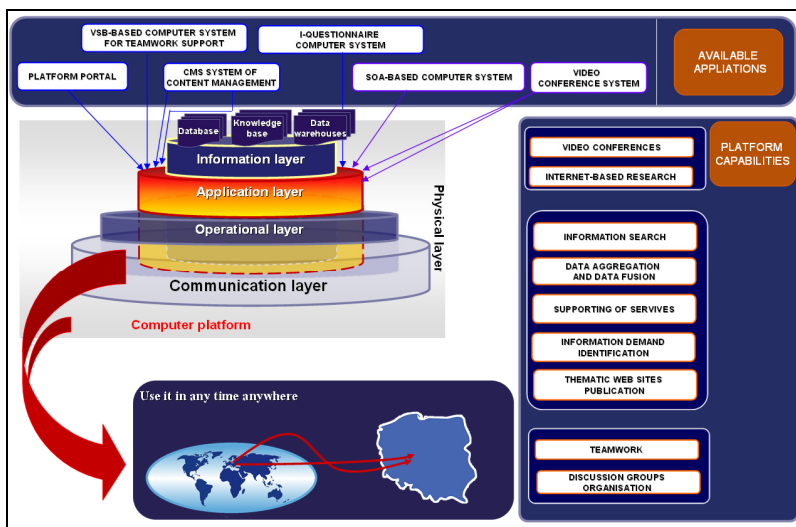

Fig. 1. A multilayer structure of the computer platform
Rys. 1. Wielowarstwowa struktura platformy informatycznej

The physical layer includes hardware equipment that is necessary for using all offered functions of the platform. Distributed hardware solutions that were used enable one to treat each application of the platform as an individual service with its own program and hardware interface. Services are run in the computational cloud. It enables one to achieve numerous benefits crucial to the functioning of the platform, in particular, the elimination of peer-to-peer connections, the isolation of individual computer systems through program interfaces and strict control over communication processes between users. Moreover, all adaptive devices, mediation devices, network devices (hardware servers, switches, and routers), hardware firewalls, hubs, workstations and a data transmission network are located in the physical layer.

The communication layer ensures electronic, digital contact between external and internal users and the platform applications. In the communication layer, the exchange of data and other information is performed with the use of teleinformatic technologies and TCP/IP (Ethernet) HTTP, FTP, and GMS/GPRS protocols. The distribution of hardware resources enables the gradual development of the platform, as well as a replacement of devices without any disturbances in the platform's operation. The applied structure of the physical layer meets the requirements of the SOA and enables one to implement a conception of a corporate portal. It guarantees storing and selective availability of gathered knowledge between a cluster's nodes (the platform shareholders) and enables one to implement requirements concerning conformity of hardware interfaces and to provide e-services and e-science.

The operational layer is a virtual institutional cluster that is a copy of an organisational network of business and research units that participate in the generation, design, implementation or commercialisation of innovative solutions based on research findings. The essential task of the operational layer is to realise a loop of systemic processes concerning knowledge transformation (Fig. 2).

Because of the fact that the operational layer is a virtual copy of a real organisational network, it is possible to implement a methodology of system engineering including the following operational procedures (Fig. 2):

– Gathering of data, information and knowledge (*searching, monitoring, exploring*);
– Analysing with the use of various method of knowledge representation and synthesis for, among others, an ontology construction and inference (*systemic analysis and synthesis*);
– Explaining and justifying (*systemic fusion and integration of information and knowledge*);
– Selective disseminating of gathered data, information and knowledge for users of the platform (*transformation of knowledge, distribution of information and knowledge*); and,
– Verifying of gathered knowledge (*evaluation*).

The knowledge is provided by experts, documents, or electronic sources, and then it is transformed into a digital resource with the use of transformation and mapping methods. The knowledge provided and registered in this way is then assessed and verified.
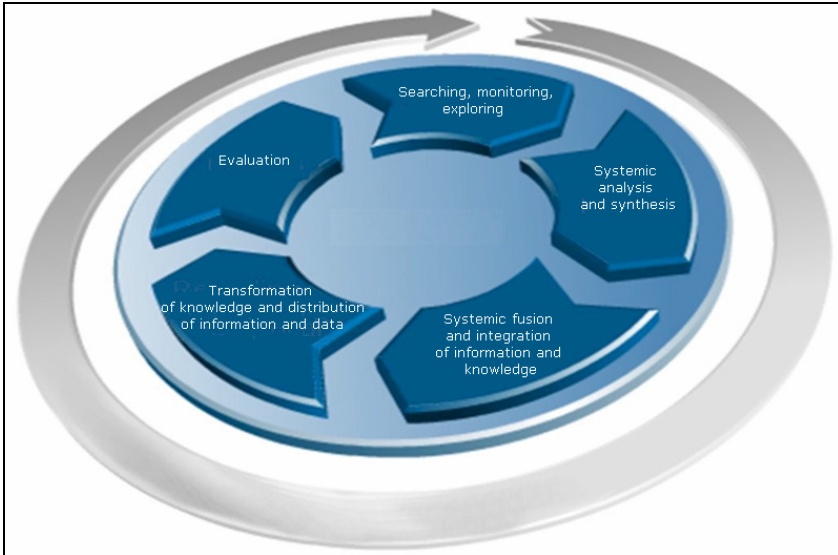

Fig. 2. A loop of system processes in the operational layer
Rys. 2. Pętla procesów systemowych w warstwie operacyjnej

On this basis inference, explanations, predictions (prognoses), and simulation, models were prepared.

The application layer contains computer applications for knowledge management, multidimensional analyses of processes of knowledge transfer to business practice, intelligent gathering of distributed information (for instance from the Internet) and applications for the protection of the platform resources. The following computer systems function in the application layer on the present stage of the platform development:

– The Internet portal, which is an equivalent to a corporate portal, including common information for the whole platform (Fig. 3);
– The content management system (CMS) designed with the use of the Joomla libraries which were adapted, modified and extended for algorithmic models in accordance with the platform requirements, in particular, for tasks concerning an integration of virtual users and other applications of the platform;
– The original computer SOA-based system, including a selection of organisational and technical methods that enable a precise integration of business models with computer resources (The system modules contain

computer services supporting small-to-medium enterprises (SME) or
research institutes in taking strategic actions in client service, product selling
and marketing strategies. This enables one to join SOA-based systems with
CRM requirements);
– The VBS computer system for supporting brainstorming sessions;
– The I-Questionnaire computer system intended for performing CAWI based
   research; and,
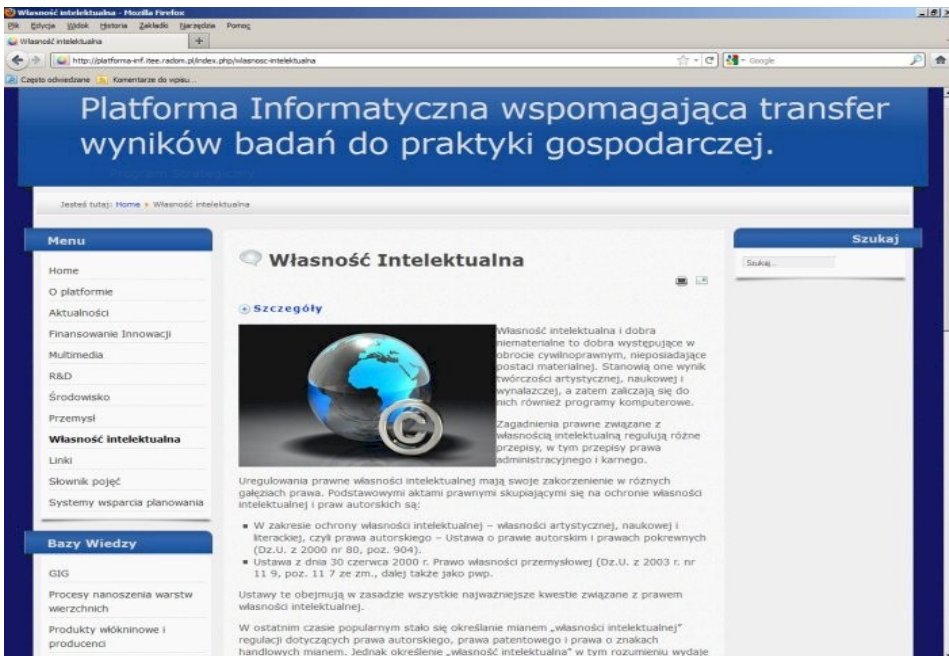– The system for videoconferences and video seminars.

Fig. 3. User interface of the platform portal
Rys. 3. Interfejs użytkownika portalu platformy

The application layer includes original applications of systems intended for
knowledge management in accordance with requirements of knowledge
engineering and for intelligent integration of data and information. The
application is equipped with applications for dynamic generation of ontologies
and semantic processing with the use of neuro-linguistic programming (NLP)
[15]. This group also contains interactive decision support systems and expert
systems that are used in planning and decision making, which enables one to
obtain selected, condensed and analysed information and facilitates taking
innovative decisions. There are numerical OLAP procedures and original
applications developed with methods of data mining and knowledge exploration
used in multidimensional analysis [17]. Applications for DAI-based (distributed
artificial intelligence) tasks are also very important. They include a set of

agents, so-called Internet agents, and dynamically generated web pages that are available on the designed portal, which ensures a fusion of information from all data resources from the virtual institutional cluster in one digital space. The main goal of Internet agents is to automate the process of information and knowledge gathering, as well as to ensure effective resource sharing by users. In the application layer, a transfer of knowledge into business practice is managed by computer systems of e-services, including mobile services, modules of teamwork, management of documents, and content. A protection of the platform resources, apart from hardware solutions, is ensured by firewalls and an original application for management of profiles and user entitlements.

The information layer of the platform contains a set of distributed, logically ordered structures such as databases, knowledge bases, and data warehouses. These structures in the information layer are the centre of data for systemic processes. MySql and Oracle relational databases were applied. Data warehouses are complementary repositories that contain data from various resources. The data is processed and used to create reports and system analyses that provide information necessary for a rational justification of decisions which are crucial for strategic analyses in processes of the transfer of research results used in innovative solutions. Within the development of the platform, databases and data warehouses will be integrated with rule-based knowledge bases and also knowledge bases where knowledge is represented by facts and frames.

Application of the platform for solving the problems in the area of the construction and exploitation of machines

The classification of issues in the area of the construction and exploitation of machines that the designed platform could be used is presented (Fig. 4).

Practical experiences of the author show that the specialised computer platform efficiently supports solving problems in the area of the construction and exploitation of machines, especially in cases when a cooperation of geographically distributed interdisciplinary research teams is required. One of the most functional qualities of the platform is the obtaining, gathering, and processing of knowledge from various sources. Its heterogeneous, distributed structure enables one to include new data and knowledge bases, for instance, engineering bases used for designing in accordance with defined needs. The application based on the brainstorming method is an effective tool for stimulation of the processes of creating innovative ideas in the area of the construction and exploitation of machines and supports teamwork in solving conceptual and project problems. It could be used in relatively new research, called quality engineering, that focuses on testing product technology quality. Applications available within the platform enable one to verbally and visually

communicate with team members, which improves the processes of manufacturing and supporting.
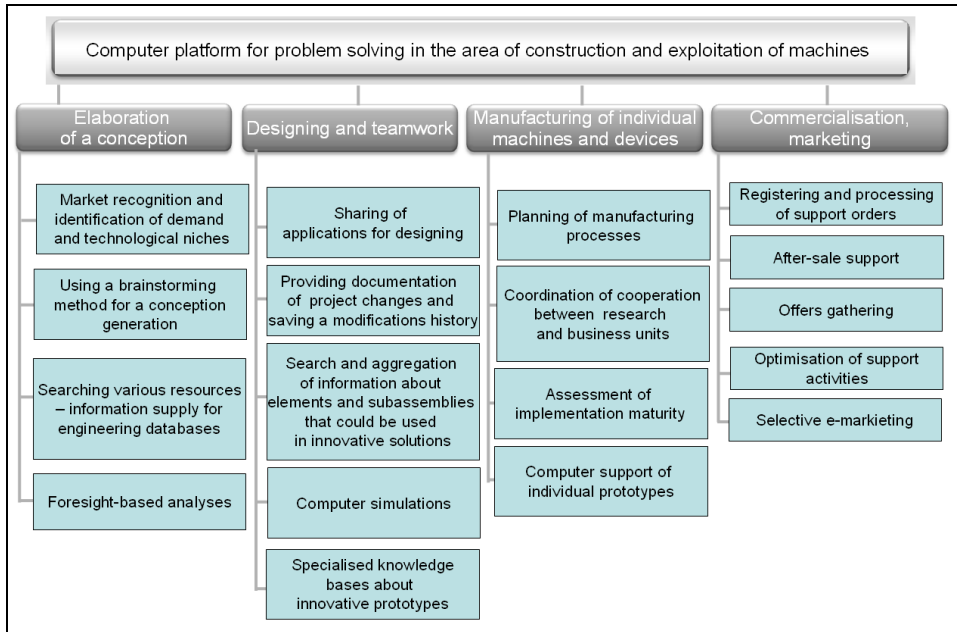

Fig. 4. The application of the computer-aided platform for solving problems
in the area of the construction and exploitation of machines
Rys. 4. Zastosowania platformy do komputerowego wspomagania rozwiązywania
zagadnień z obszaru budowy eksploatacji maszyn

Summary

Solutions and computer technologies applied in the platform under construction enable one to classify it to a group of knowledge management systems of the forth generation, which are currently investigated within research conducted throughout the world by the most significant manufacturers and providers of computer software. An issue of a special importance is a multilayer platform architecture that supports an exploration and creative application of knowledge in solving complex problems in the area of the construction and exploitation of machines and the functioning of e-services and e-science for a virtual institutional cluster needs. The most remarkable features of the platform that distinguish it from existing solutions are the following:
– Multitasking of the platform, in particular, in gathering and data processing for specialised analyses that support decision making in processes of the transformation of scientific results of research to business practice;

- The capabilities of gathering and exchange of knowledge between members of a institutional cluster;
- A knowledge base that contains information about over 300 innovative solutions in the area of the construction and exploitation of machines that were developed within the Multi-Year Programme PW-004 "Development of innovative systems of manufacturing and maintenance 2004–2008" [17] and the Strategic Programme "Innovative Systems of Technical Support for Sustainable Development of Economy";
- Capabilities of knowledge exploration from gathered data that could be useful in developing innovative solutions;
- Capabilities of the support of the creative approach to solving complex technical and technological problems with both research findings and unconventional methods, for instance, brainstorming;
- Capabilities of a contextual information search from various data sources located in the Internet, as well as in databases, data warehouses and knowledge bases that exist in the platform structure;
- The application of original heuristic, behavioural and algorithmic models that are used in multidimensional quantitative and qualitative analyses; and,
- Capabilities of using computer systems with various functions that work in a computational cloud.

The construction of the platform consisted in using the latest findings of modelling, research and application results of IT, particularly, business intelligence, technology intelligence, object business and artificial intelligence, e.g., in an ontology generation for a database contextual search. The designed platform, by using the most advanced IT technologies, integrates business and research units; therefore, it should be systematically updated and developed. Furthermore, because of its multitasking and scalability, the platform could be used in long-term support of research, development, and implementation activities in the area of the construction and exploitation of machines.

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Wielozadaniowa platforma informatyczna wspomagająca transfer rozwiązań innowacyjnych do praktyki gospodarczej

Streszczenie

W artykule przedstawiono nowoczesną, wielozadaniową i heterogeniczną platformę informatyczną zawierającą zasoby cyfrowe, aplikacyjne i sprzętowe niezbędne dla funkcjonowania wirtualnego klastra instytucjonalnego ukierunkowanego na dystrybucję do praktyki gospodarczej innowacyjnych technologii produktowych i procesowych będących egzemplifikacją wyników prac badawczych i rozwojowych prowadzonych w obszarze budowy i eksploatacji maszyn. Zaprezentowano wielowarstwową strukturę platformy, w szczególności zintegrowane ze sobą systemy informatyczne przeznaczone do gromadzenia, fuzji i przetwarzania danych, informacji oraz specjalistycznej wiedzy wykorzystywanej w realizacji systemowych analiz strukturalnych i procesowych prowadzonych między innymi z wykorzystaniem modeli sztucznej inteligencji przez interdyscyplinarne zespoły badawcze podejmujące przedsięwzięcia o charakterze innowacyjnym. Wskazano możliwości funkcjonalne platformy w zakresie świadczenia e-usług oraz realizacji e-science. Przedstawiono oryginalne i innowacyjne rozwiązania informatyczne opracowane na potrzeby funkcjonowania platformy