MULTIDISCIPLINARY OPEN SYSTEM TRANSFERRING KNOWLEDGE FOR R2B DEVELOPMENT

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Abstract: Despite many efforts, there is still a serious problem in transferring knowledge from research to business. The problem is especially visible in Poland – the cooperation of R2B is ineffective. We are trying to solve this problem using some IT support. The manuscript presents some solutions developed at the Gdańsk University of Technology. In particular, the platform called "MOST Knowledge" is deeply described. Its layer architecture, and some new services which it offers are shown. A new interdisciplinary approach is proposed to communicate and support the cooperation of these different worlds. Summarizing, a short comparison with other available platforms is included and discussed.

Keywords: Open Science, innovations, knowledge transfer, R2B cooperation, R2B supporting portals

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1. R2B cooperation problems

Currently the research and business (R2B) cooperation is strongly desirable and recommended because it stimulates significant progress in innovation [1]. There are three main activities in this area extensively promoted by universities:

1. The education role of universities is changing towards critical thinking, creativity, and higher communication skills. For instance, a new subject related to the team project design has been included into the curricula of all fields of study in our university.
2. Different kinds of technology transfer centers, incubators or startups, supporting and/or accelerating research commercialization are largely implemented.

In this way not only new ideas but also ready practical solutions can be brought to the market.

3. Due to some innovative EU programs, numerous university projects are prepared in order to initialize or improve research to business (R2B) cooperation. In consequence, some IT platforms are being developed, and largely used, to support innovative initiatives.

In spite of developing the above solutions, and discovering angel and venture funding, there still exist some internal (inside universities) and external (outside universities) obstacles. The most important barriers are as follows:

- lack of real models to analyze real problems,
- low motivation of people to make innovations,
- risk intolerance in research,
- lack of curricula directly linked to career success,
- high cost of investments required to have modern resources,
- global competition in the world.

To eliminate the above-mentioned barriers, strong cooperation between universities and the industry should be developed, and some opportunities to find new solutions should be created. In the paper, three different solutions referring to our university are presented. It is assumed that each R2B cooperation can be implemented in four steps, as is shown in Figure 1: recognition of possibilities, verification, venture definition and implementation. Each step consists of some detailed activities that allow collecting some kind of knowledge, and moving on to the next steps. Below we show how some of such activities can be realized using the proposed platforms and centers. First of all, we present the "MOST Knowledge" project [2], which is currently under development. Moreover, we compare this solution with previous and future ones, also implemented or prepared in our university.

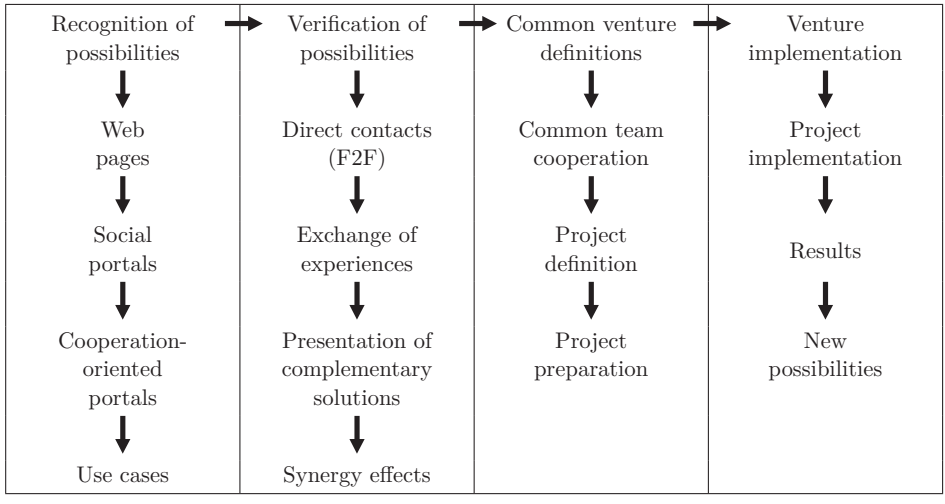

Figure 1. R2B cooperation steps and their basic actions

2. Different innovation approaches

In general, a lot of money is required to achieve useful research results. Therefore, different innovations are considered to improve the previous solution, and reduce the cost of its implementation. The areas where we may meet many innovations are as follows:

- Technology – where such disruptive technologies as Cloud Computing, Big Data and Internet of Things are presently still under development [3];
- Business – where a wide spread of electronic services are generated and proposed for society *i.e.* AaaS (Anything as a Service) [4];
- Marketing, where some parts of society are engaged in brainstorming or crowdsourcing, to improve the functions or quality of products, or also to define new products better satisfying user needs [5];
- Organization – where ecosystems are concentrated with both startups and longer existing innovative companies in order to receive support from investors and other intermediaries. The best example is the Silicon Valley where disruptive technologies are often born [6];
- Administration, where the rules and law are simplified to some extent to encourage, or to stimulate, different companies to be truly innovative [7].

As has been suggested, the means which create innovation ecosystems are the following:

- Venture funds, which means the need for collaboration with venture investors;
- Incubators, where potential solutions for future real problems are developed by teams consisting of research and business people;
- Accelerators – extra means providing seed funding and other resources to support incubators;
- R&D centers – whose main purpose is to capitalize on local technologies and human talents to spur corporate innovations.

A Technology and Knowledge Transfer Center is operating at our university. Its main tasks are related to help in understanding the definitions of intellectual properties, or to support negotiations in order to obtain agreements (contracts) acceptable from the university's point of view. Additionally, other Centers are also active and open for different kinds of cooperation. One of such Centers is the Center of Excellence of Novel Infrastructure for Workable Applications (C2 NIWA [8]), which was co-financed by the European Regional Development Fund within the Operational Programme Innovative Economy for the years 2007–2013. It main task is to create project teams to prepare prototypes of some IT platforms supporting research activities. Besides, it has shown how to transform a working team into an innovative team. Such teams are called "knowledge generators" (see Figure 2 (a) which can provide some solutions to the market. Forms and structures of knowledge related to research achievements are considered in the MOST project. Knowledge, represented in a suitable way, can be easily available for business partners looking for new cooperation ventures. Some matching algorithms to

fit scientific knowledge to the business needs are also considered. In a project proposed lately, a proposition of the STOS (Smart Transdisciplinary knOwledge Services) Centre of Competence is determined, and the implementation of smart services is assumed. Such services refer to three disruptive technologies: cloud computing, big data and Internet of things. They allow organizing and executing different enterprise scenarios that can also support different variants of R2B cooperation. Figures 2 (b) and (c) explain the idea of the above shortly-described projects.

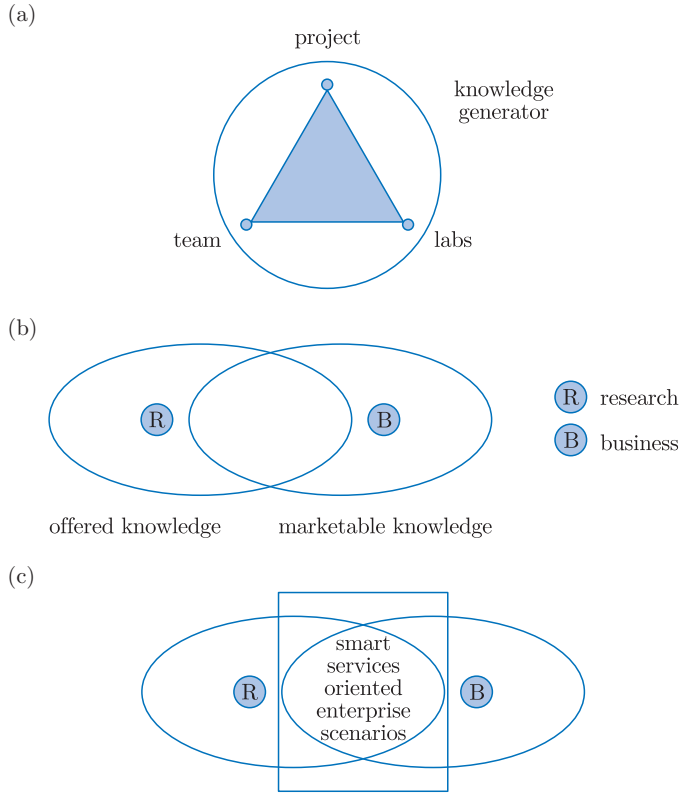

Figure 2. Visualisation of described projects related to R2B. A basic source of knowledge – coming from project teams (a). Two kinds of knowledge: offered and marketable (b). Smart – services oriented R2B scenarios (c).

3. Objectives and architecture of MOST Knowledge portal

In 2016 the Gdańsk University of Technology started the project called "Multidisciplinary Open System Transferring Knowledge – "MOST Knowledge" the acronym of which means "bridge of knowledge" in Polish. The project is co-financed by the European Regional Development Fund within the Operational Programme Digital Poland for the years 2014–2020.

The project is a continuation of some actions performed during two earlier projects implemented at the Gdańsk University of Technology. The first one was a project called "e-University – design and deployment of a platform at the Gdańsk University of Technology offering e-services for the Pomerania region society" [9]. The Project was co-financed by the European Regional Development Fund within the Regional Operational Programme for the Pomeranian Region for the years 2007–2013. The second project was C2 NIWA, mentioned above.

The main goal of the "MOST Knowledge" project is the implementation of a platform that integrates data from many databases of the Gdańsk University of Technology, as well as many other universities and research centers. The gathered data and knowledge will be easily accessible in public, consistent, and ready for reuse. The resources will be accessible to business, the research community and society, in an open, clear and simple form. As a result, a specific bridge that connects the academic community with its economic environment (business, non-profit organizations and citizens) will be created.

During the project a platform of the same name will be developed. The "MOST Knowledge" platform is a distributed web-based system that offers multidisciplinary e-services, located in the private cloud of the Gdańsk University of Technology. The architecture of the platform includes three logical layers:

(1) service presentation layer,
(2) business logic layer,
(3) data integration layer.

Figure 3 presents the main components of each layer. The lowest logical layer is responsible for correct data integration from various sources. It is one of the most important elements of the platform. Each object processed by the system is described by metadata according to many standards (*e.g.* Dublin Core Metadata Initiative (DCMI) Metadata Terms, RDF and SPARQL [10]). Moreover, objects are linked together with the use of semantic relationships. Thanks to that, the gathered knowledge is understandable for other systems, and easy to navigate from one object to another for systems as well as humans. Furthermore, the system supports full-text search for each part of objects with grammatical and synonym tolerance. A big challenge is to ensure the consistency of the data while it is stored and processed in multiple forms in order to provide high performance of the system and quick access to knowledge.

The business logic layer is the core of the system. In accordance with the trend in the software development of producing microservices, the "MOST Knowledge" platform business logic consists of RESTful services. They are stateless, very granular, and organized in functional groups. As mentioned earlier, the key functionality of the system is data searching. Therefore, there are various services supported by the Elastic Search. Of course, there are also closely related services responsible for data processing, storage and indexing.

The system will have a built-in intelligence, so that it will suggest the content on the basis of the search history. There are some search context processing

mechanisms that work on context acquisition and analysis. The aim is to offer selected data which is really expected by the user. The system must automatically detect groups of users, and adapt the search results accordingly. In this way the platform will become an intelligent consultant.

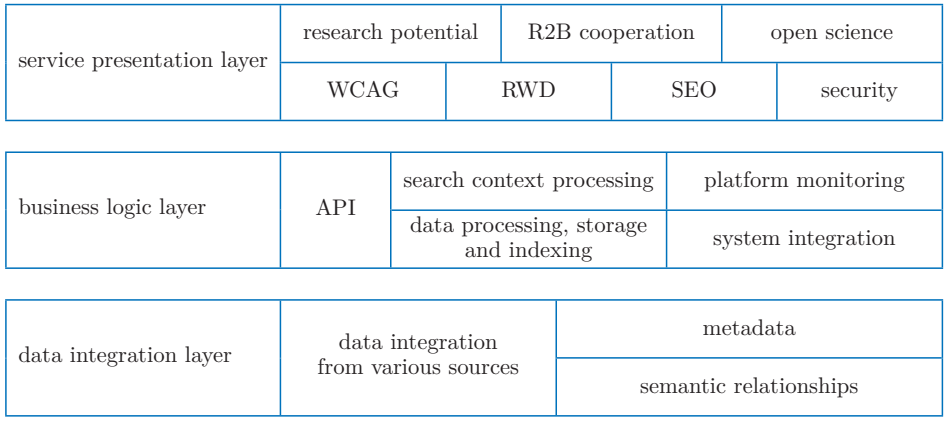

Figure 3. Logical layers of the "MOST Knowledge" platform

Wide accessibility and interoperability enforce the presence of the open application programming interface (API). There are different kinds of API. Firstly, there is an API for data import from various university systems. Besides, repository exploration can be done using an API on the system level, as well as an API that is dedicated to nesting in resultant web pages. There is also an API dedicated to the service presentation layer of the platform associated with its functionality.

The "MOST Knowledge" platform will be characterized by high interoperability. The key areas of integration are the supplementing databases and social media. The former are various citation databases such as Scopus, Web of Science, Cross Ref, Altmetic. There are also DOI and other full-text-paper repositories. On the other hand, at the moment there are some social media dedicated to researchers such as Mendeley, Research Gate, Orcid. Proper integration with them, as well as other most popular media, like Facebook and Twitter, should result in adequate promotion of the collected resources.

Each activity in the system is a source of various statistics. They are collected in order to indicate the most popular resources and areas of interest. Extended profiles of users allow serving content dedicated to them.

The dependability aspect of the platform is one of the key issues. The current load analysis is crucial for correct load-balancing and horizontal automatic scaling of the whole platform.

There are many functionalities of the platform described later. The human interface of the system is a web page accessible through any web browser. The interface is designed to support all types of devices – from traditional PCs to mobile smartphones and tablets. The displayed page is adapted to any device

with the use of an RWD (responsive web design) framework called Bootstrap. The portal is accessible to disabled people – it meets the requirements of WCAG 2.0 (Web Content Accessibility Guidelines) standard [11]. For higher overall security, the HTTPS protocol is the only one allowed to be used while connecting with the portal.

4. Intelligent services supporting the portal

Some smaller areas can be distinguished in the whole functionality of the portal there. The first one is promotion of researchers, innovative results of their work, as well as the research potential of the university and its teams. The second one is dedicated establishing cooperation with business. Figure 4 presents the interaction of two different worlds: research and business. They are using different conceptual and vocabulary collections, so there is a need to associate them intelligently. The presented research knowledge should be translated into offers, use cases, and successful stories. On the other hand, the business needs should have influence on the current navigation in the portal as well as the inspiration for future research areas.

The "MOST Knowledge" platform supports services that maintain appropriate concept mapping and multidisciplinary data matching. It is a tool, and space, for establishing R2B cooperation. Moreover, the acquired experience provides some additional knowledge for improving the intelligence of the platform and its services.

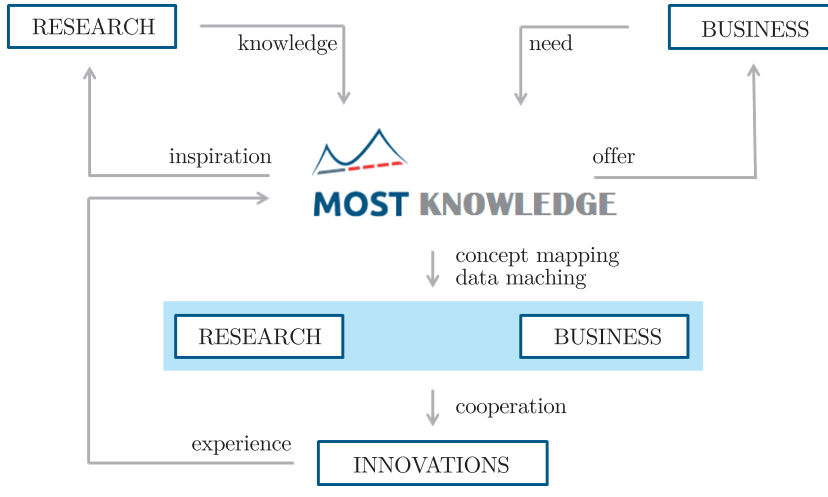

Figure 4. Interaction of R&B worlds within the "MOST Knowledge" platform

There are also services dedicated to effective search engines optimization (SEO) mechanisms and techniques. Thanks to that, the links to the "MOST Knowledge" portal are expected to appear on the first page of search results in Google. Other services support the proper administration of the system, on the

technical as well as data maintaining level. The multilevel status monitoring of different parts of the platform is necessary for assuring a high level of security, availability and dependability. Helpful and intuitive user support is obligatory.

We can assume that we have contacts with two kinds of knowledge. One is available from the research side, and the second one represents marketable knowledge, which is needed by the business side (see Figure 2 (b). These two kinds of knowledge can be given in as different e-documents, which can be expressed in different forms. To check the possibilities of cooperation between R&B sides, we can find consistency aspects in such pairs of documents corresponding to them.

We assume three levels of consistency of such pairs of documents:

- identity, which means that both documents belonging to a pair are similar in every detail;
- similarity, where two such documents are satisfying some evaluation criteria;
- correspondence, where both such documents are close to satisfying the assumed similarity criteria.

In practice, the identity of such documents is rather never achieved. Therefore, we concentrate on the two remaining cases, and in accordance with the forms and contents of such documents, we try to find the most suitable pattern matching algorithm to determine the level of similarity or the level of correspondence [12].

5. Conclusions

The idea of R2B cooperation was presented in the manuscript on the basis of our own experience. Three solutions were taken into account: C2 NIWA, MOST Knowledge [2], and also the new proposition CC STOS. In Table 1 the main differences among them are presented and analyzed. The first two projects were accepted and funded by EU programs. The third one is in the phase of evaluation. All of them create together an example of step-wise progress in implementation of R2B cooperation: from effective team working rules, through partial knowledge transfer, to integration of modern technologies into smart services. Next steps of implementations, and obtained results, will be presented in the upcoming years.

Acknowledgements

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Table 1. Comparison of three different solutions supporting R2B cooperation

Solutions / Approaches	Centre of Excellence NIWA (Novel Infrastructure for Workable Applications)	MOST Knowledge (Multidisciplinary Open System Transferring Knowledge)	Centre of Competence STOS (Smart Transdisciplinary knOwledge Services)
Data	DSpace platform that supports building of open digital repositories for the general purpose of IT team cooperation	Dedicated platform to present basic knowledge coming from the university for supporting R2B activities	Hadoop open source software frameworks used for distributed storage and processing of big data sets running on computer clusters
Information	– Digital formats of texts – Project descriptions – Open-source code of applications and services – Teaching resources	Categories of disciplines and specializations oriented on university research and education	Historical, transdisciplinary data representing well-known or open problems, and corresponding, solutions or propositions
Knowledge	General principles about team organization, motivation and reconstruction in order to improve competition in the global world	General relations among multidisciplinary objects (*e.g.* scientific papers, researchers and projects) showing possibilities to solve new problems	General rules to develop, improve and integrate three main IT areas: Cloud Computing, Internet of Things and Big Data
Models	– Quality evolution of IT teams – SOSE – Services Oriented Software Engineering	Research knowledge description and transfer	– Goal-oriented thinking (learning and design) – Smart services – concepts & implementation
Approaches	Innovative team creation, monitoring and quality analysis	Matching algorithms for examination of similarity or consistency	Knowledge analysis of transdisciplinary data; simplicity, scalability and dependability
Remarks	Project shelf-time	Project in the implementation phase	Project in the evaluation phase

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