BRIDGE OF KNOWLEDGE: AN INTERNET PLATFORM FOR R2R AND R2B TRANSFER OF KNOWLEDGE AND PROMOTION OF COOPERATION

HENRYK KRAWCZYK[1] AND PAWEŁ LUBOMSKI[2]

*[1]Faculty of Electronics, Telecommunications and Informatics,
Gdansk University of Technology*
Gabriela Narutowicza 11/12, 80–233 Gdansk, Poland, hkrawk@pg.edu.pl

[2]IT Services Centre, Gdansk University of Technology
Gabriela Narutowicza 11/12, 80–233 Gdansk, Poland, lubomski@pg.edu.pl

Abstract: Currently, the European Commission puts emphasis on supporting collaboration between universities and business. There are many possible ways to create a strong relationship between both these parties. Positive results of such cooperation lead to increased competitiveness of the global market and, in consequence, bring significant growth of innovation. The cooperation between research-to-research (R2R) and research-to-business (R2B) is analysed. The paper shows how the IT technology can be used to support and stimulate it. In our University we proposed a two-step strategy. Firstly, we tried to improve collaboration among scientists in order to develop R2R activities. Secondly, we focused on R2B projects that stimulate promising scientists to take part in various innovative activities carried out in cooperation with the industry representatives. Based on some well-known good practices a special Internet platform was designed and implemented to support such a strategy. Its name is the "Bridge of Knowledge". The platform architecture, its functionality and some other aspects of the development process are described. The platform was developed and introduced at the Gdańsk University of Technology. It has been available online for nearly 2 years now and it has been attracting increasing numbers of new visitors and returning users. Several use cases of cooperation between R2R and R2B were analysed and described with the use of advanced analytic tools and on the basis of the organisation's resources. The idea of the Bridge of Knowledge platform is to gather and share resources not only from one university. The architecture of the platform focuses on a wide and easy interoperability. Other universities can share their resources without any additional cost.

Keywords: research to research cooperation, knowlegde to buisness transfer, golden rectangle, science gateways, knowlegde platforms

1. Stages of knowledge development

Taking into account some commercialization processes, where a new product or production method is introduced into the market, four stages of knowledge development can be defined:

1. Information and knowledge coming from pure science, i.e. science-to-know-ledge (S2K) is considered;
2. Knowledge selection from the market needs, where some knowledge-to-business (K2B) is selected;
3. Business activities create a new product or production methods, then business-to-product is performed – the so called business-to-product (B2P) process;
4. Marketing efforts encourage commercial adoption of the product or method, thus, product-to-market (P2M) actions are determined.

In the further consideration we focus on the first two stages. The basic source of knowledge is science which is developed by researches individually or by different project teams. In Fig. 1 we show a simple knowledge generator. It consists of three elements: team, lab and project which create a triangle of knowledge. The team is created according to the project requirements, then the corresponding tasks result from the purpose of the project.
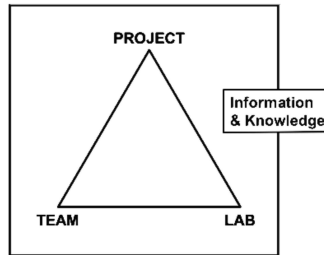

Figure 1. Simple generator of knowledge

Additionally, a specialized laboratory can be built and explored to carry out the required experiments. All the information related to the team activities as well as their main decisions should be registered and selected. First of all, the publications of the team can be registered. Moreover, on the basis of a standard description of such results, some suitable procedures of data mining should be used to discover some new knowledge which can be used in further experiments or considerations. In such a way we obtain different generators of knowledge which are not isolated because different scientific teams are cooperating with one another. Due to IT technologies, generators of knowledge can standardize different sources of knowledge and offer a wide scope of services. In a large sense, such activities can be called research to research (R2R). In the next section we will show different implementations of generators of knowledge which concentrate on some processes related to S2K as the first stage of knowledge development.

The second stage often requires some extra new kinds of knowledge coming from the market in order to evaluate the usability of scientific knowledge (see Fig. 2a). Then, the scientific knowledge can be verified according to the market requirements. Therefore, the main activities depend on knowledge filtering (see Fig. 2b) and its possible enriching. The latter means the return to the R2R phase. General knowledge selection requires tedious work of either some experts (see Fig. 2b) coming from the market or some special organizations that decide about the evaluation and further investment decisions. The deep market knowledge is required to reduce the risk of costly decisions. In many cases a step-wise selection is made, after using some extra evaluation tests. In general, this stage can be called a research-to-business (R2B) approach and it is much more difficult to be supported by IT solutions.
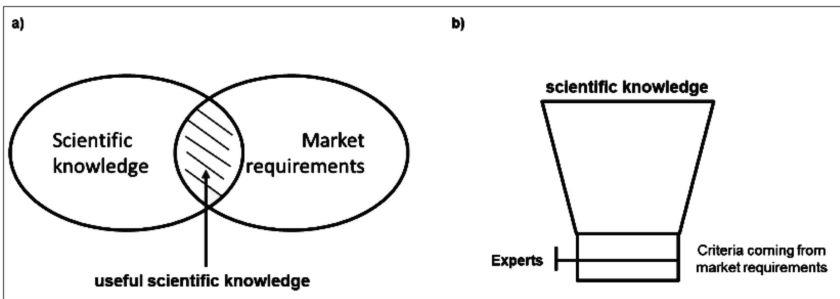

Figure 2. Main stages of knowledge development

The third stage corresponds to some production processes and it is called business-to-product (B2P). In this case the knowledge selected in the second stage should be transformed into a specific product, e.g. by some small or medium enterprises. These activities are not available for everyone and the knowledge about them is very often kept in a deep secret. The last stage is called product-to-market (P2M) where promotion actions are strongly recommended. Then, once again some new kind of knowledge is required and often successfully used. All stages can be divided into parts as shown in Fig. 3. R2R corresponds to the two first stages, R2B to all the following ones.
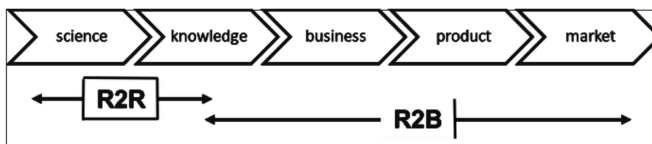

Figure 3. Illustration of knowledge filtering processes

Some suitable conditions should be created for all these stages to stimulate the development of innovative products. They are performed by the so called golden rectangle (see Fig. 4) where proper cooperation among the main items is

required. Administration in this rectangle is responsible for preparing a proper law for the development of R2R and R2B. The university should be an efficient generator of useful knowledge. Business should create real market requirements which would allow formulating suitable criteria for scientific knowledge filtering. Finally, the social organization should monitor the development trends and impact sustainable development. To register and analyse all such processes we need some progress in understanding them and their complex description properly.
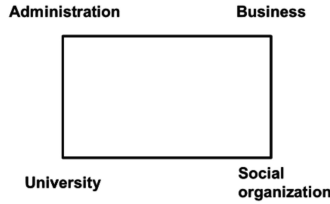
Figure 4. Golden rectangle to support R2R and R2B cooperation

In the next section we describe some IT implementation of R2R and R2B solutions. We concentrate on some IT platforms, but in many cases some special activities offered by different universities and business organizations can speed up such implementations.

2. Science gateways and virtual environments

Fig. 5 shows a basic concept of the so called science gateways which represent some web-based interfaces, where the researcher can connect with scientific instruments and sensor stream data. Then, other tools allow research using advanced computing which is more efficient and more easily accessible.
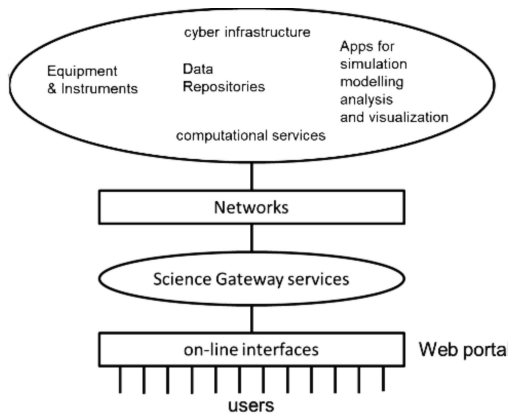
Figure 5. Idea of science gateway portal

The idea of science gateways which can enable citizen science can also be a conduct for course material and computational science in many domains.

Due to NSF activities, the Science Gateways Community Institute (SGCI) has been established for the gateway development. It will invigorate the scientific collaboration across the nation and across all the scientific domains. It will allow evaluating scientific progress and stimulating the creation of additional gateways, making them easier to use for scientists and engineers. Moreover, gateway services will support many scientific activities denoted earlier by R2R.

Another solution are virtual research environments (VRE) for supporting collaboration of scientists working in different disciplines. This interesting solution was developed by the European Program Horizon 2020. A suitable prototype was built based on collecting and analysing the requirements from several research communities and the reference architecture (see Fig. 6). It is a very effective virtual research environment for empowering Innovation and Collaboration (VRE4EIC). It allows preparing interoperable metadata standards (CERI F) for popularizing.
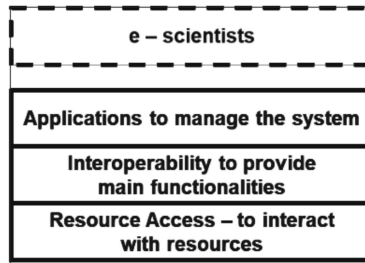

Figure 6. Architectural tiers of VRE

The suitable catalogues link some research actors and outputs. In general, the functionality of a VRE:

- allows researchers to communicate with others and share and use the resources available in the community;
- allows researchers to build some new resources as a result of processing the existing resources with the available tools, and create some complex workflows by combining the available services;
- allows research managers to apply economy models to access and manage the existing resources to ensure the security and privacy of the sustainable environment.

This solution belongs also to the R2R category.

In the further consideration we focus on our own proposition which was designed and implemented at the Gdańsk University of Technology. It is called the "Bridge of Knowledge". The idea of this solution is given in Fig. 7. The main idea is to create a research platform for Polish universities for R2R and R2B activities.
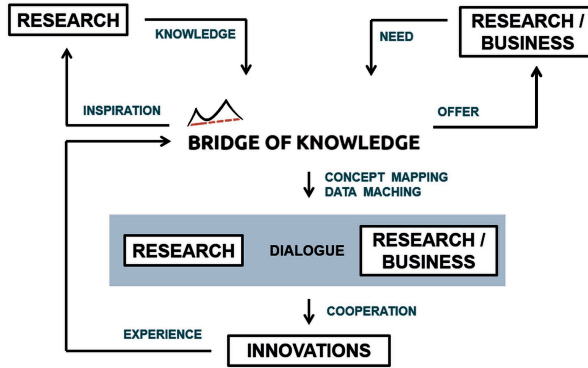
Figure 7. Interaction of R&R and R&B worlds on Bridge of Knowledge platform

3. Open Science implementation

In 2016 the Gdańsk University of Technology started the project called "Multidisciplinary Open System Transferring Knowledge – Bridge of Knowledge". The project has been co-financed by the European Regional Development Fund within the Operational Programme Digital Poland for the years 2014–2020.

The main goal of the "Bridge of Knowledge" project is to implement a platform that integrates data from many databases of the Gdańsk University of Technology, as well as many other universities and research centres. The gathered data and knowledge are easily accessible in public, consistent, and ready for reuse. The resources are accessible to business, the research community and society in an open, clear and simple form. As a result, a specific bridge that connects academic communities among each other and with their economic environment (business, non-profit organisations and citizens) has been created.

The project started also the implementation of the Open Access initiative at the Gdańsk University of Technology. Therefore, the Open Access policy was prepared, which required some changes to the existing university-level legislation and preparation of some new documents. The Open Access policy at the Gdańsk University of Technology is of a depository nature. All publications created by the University are archived. Depositing publications in the institutional repository is based on the principle of self-archiving in the process of the user's research output registration. In this way the Bridge of Knowledge platform has become an institutional repository. By default, all publications should be accessible on an open licence basis. When a publication cannot be made OA due to some legal aspects, it is treated as a "dark deposit" (the publication is made OA automatically when the embargo expires or when there are no other legal restrictions). Besides, the repository makes it possible to take advantage of the "on demand" option. This function enables the user to send the author a request for permission to get a one-time access to a non-OA publication.

The Open Access initiative and all the legal aspects were new and difficult to follow for most of our researchers. Previously, they were focused on publishing

their research output in a wide range of magazines, with as high the impact-factor as possible. They did not pay attention to the aspects of licensing and openness. We organized many meetings, open days and other presentations focused on the benefits of publishing in Open Access. Moreover, we appointed a special team in our University Main Library consisting of Open Access specialists. They support researchers and answer any question regarding this field. The process of becoming open was organized in a way as easy as possible for our researchers. The existing process of registering all the research outputs in our internal database was extended by the step of uploading a full-text and creative commons license optional indication. This is all what a researcher is obligated to do. Specialists from the Main Library check the magazine's open access policy and determine whether the specific manuscript can become accessible on an open basis or not. The form of publication (pre-print, post-print or publisher version) is taken into account. Very often it has to be done in contact with the magazine publisher, especially in cases of a national magazine, when the open access policy has not been published. They also suggest the most suitable license. This process is presented in Fig. 8.
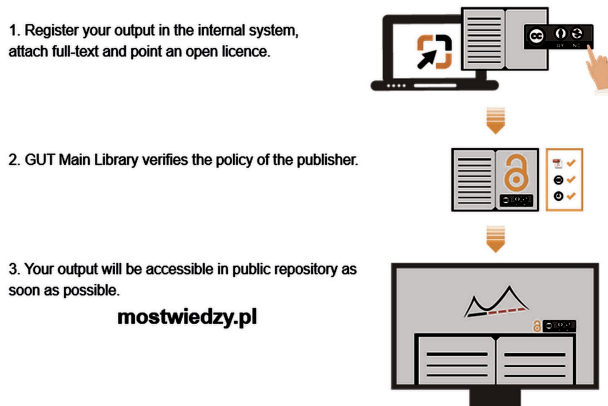

Figure 8. Process of registration and open access verification

Thanks to this approach after 15 months we have over 1000 publications accessible on an open-access basis and almost the some number in the verification process. In this way, in a very short time, the Gdańsk University of Technology became one of the leaders among the universities implementing the Open Access initiative.

4. Bridge of knowledge platform architecture and functionality

In accordance with the trend in software development of producing micro services, the Bridge of Knowledge platform is an e-service system with RESTful services (see Fig. 9). They are accessible by a modern web interface as well as

an open API. The whole platform is deployed on a private cloud developed at the Gdańsk University of Technology. The interface of the portal adapts automatically to different types of devices used and is designed considering disabled people. The key functionality of the system is data searching. Therefore, there are various services supported by the Elastic Search engine. Obviously, there are also closely related services responsible for data processing, storage and indexing. The platform is characterized by high interoperability. The main areas of integration are supplementing databases and social media. The platform also supports services that maintain appropriate concept mapping as well as multidisciplinary data matching. In this way, the platform is a tool and space for establishing cooperation between R2R and R2B. Moreover, the acquired experience provides some additional knowledge for improving the intelligence of the platform and its services.
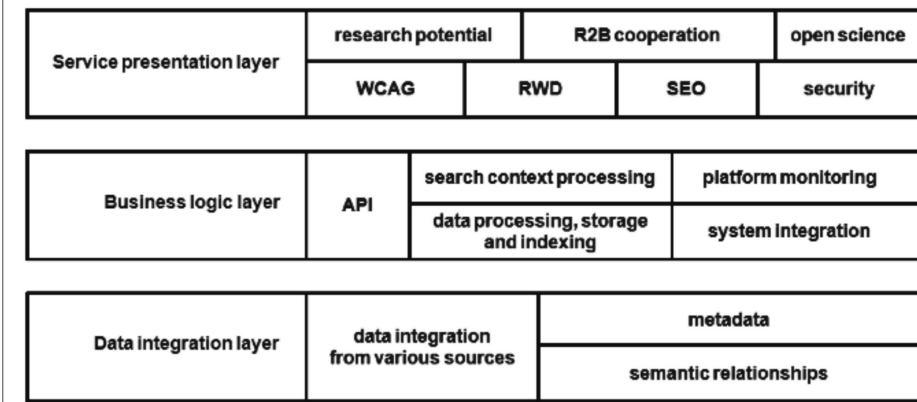
Service presentation layer	research potential		R2B cooperation		open science
	WCAG	RWD		SEO	security

Business logic layer	API	search context processing	platform monitoring
		data processing, storage and indexing	system integration

Data integration layer	data integration from various sources	metadata
		semantic relationships

Figure 9. Logical layers of Bridge of Knowledge platform

The system has a built-in intelligence, so that it suggests 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 automatically detects groups of users and adapts the search results accordingly. In this way, the platform becomes an intelligent consultant.

From the technical point of view the main focus was put on the Search Engine Optimization (SEO). Successful indexation by many search engines such as Google, Google Scholar, Bing and other is the reason why the resources gathered in the platform are very well promoted and very often appear on the first page of the query results. This aspect is under a constant monitoring and improvement process.

All resources are described by metadata understandable for computers and connected with one another. This complies with the RDF standard and the 5 Star Open Data classification.

5. Platform impact, range and openness

The Bridge of Knowledge platform has been available online for nearly 2 years now and it has been attracting increasing numbers of new visitors and returning users. With the use of advanced analytic tools and on the basis of the organisation's resources it can be said that in 2018 the portal had over 100 000 unique visitors and over four times more page views. Those factors are growing rapidly – half of them were achieved in the first 4 months of 2019. Over 20 percent of users come from a referring site. The portal is a good source of publication, as nearly 10 percent of traffic comes from Google Scholar. This is a good result, taking into account the fact that Google Scholar started to index our portal as late as in mid-2018. However, most of the traffic (about 70 percent) comes from organic search. It is the result of our efforts taken in preparing the resources in a very good form for indexing. They are also easy to interpret by machines, thanks to many metadata items and good linking between them. This also influences positively the final rank and position in the query results – if a specific resource is available in the portal, it appears very often on the first page of results.

The Bridge of Knowledge is not only a Polish portal. The user interface is bilingual: Polish and English. Many of the gathered resources are also described at least in English. Thanks to that, 20 percent of visitors are from outside Poland – mainly USA, Germany, India and UK. We can observe that it is growing constantly.

It is very hard and too early to measure the feedback of sharing knowledge in such a form but in many discussions, especially with young researchers, they say that they receive noticeably more invitations to multidisciplinary cooperation, also on an international scale.

The attractiveness of the form of description is very important. The use of multimedia (pictures, videos, etc.) is the reason why users spend three times more time browsing such profiles. That is why we have taken a great effort to prepare some special offers for business in this affordable and attractive form.

The idea of the Bridge of Knowledge platform is to gather and share resources not only from one university. The architecture of the platform focuses on a wide and easy interoperability. Other universities can share their resources without any additional cost. At the moment we are having advanced talks with several universities and scientific organizations in Poland on connecting their databases to our Bridge of Knowledge platform as their institutional repository. There are dozens of external scientific individual profiles, as well.

6. Conclusions

The support and stimulation of cooperation between R2R and R2B with the use of the IT technology is possible and effective. The proposed solutions are flexible and can be implemented in line with the current progress in understanding such processes of cooperation. Many aspects have to be taken into account and consideration when implementing the Bridge of Knowledge platform. There are

many standards to follow. Special emphasis should be also put on ensuring the security and dependability of the platform when designing such a valuable source of information. The success of the project and its completion time encouraged us to prepare and start a new project called "Bridge of Data". The project has also been co-financed by the European Regional Development Fund within the Operational Programme Digital Poland for the years 2014 – 2020. Its main goal is to introduce the full Open Science concept at the Gdańsk University of Technology, including the Open Research Data repository and other e-services supporting the green open access of publishers of magazines and organizers of science conferences. During this new project the team of open access specialists from our Main Library has been expanded to a competence centre that supports all researchers from the whole of Poland. During this project some e-services from the Virtual Research Environment (VRE) category such as a virtual microscope of human tissues and a platform dedicated to running many analysis of Open Research Data on a supercomputer will be implemented.

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