Integrated Platform for R&D Information Systems: A Canadian Experience

Karim Bouzoubaa, Mohammadia School of Engineers, Mohammed V[th] University, Rabat, Morocco, karim.bouzoubaa@emi.ac.ma
Adil Hamdouna, eVision, inc. Québec city, Canada, adilh@evision.ca

Abstract

The "knowledge Economy" is the objective that many countries around the world are targeting in their strategic planning, it is meant to enable social and economical development. For many economists, it is also the sophisticated economy that balances out the dependency on basic commodities as natural resources. Research is the key to creating a "Knowledge Economy"; more and more public and private money goes into funding research around the world. On the other hand, governments and industries are more and more eager to put their hands on practical research results to be applied to solve the ever growing complexity of society issues and needs. This makes Researchers and Research Administrators more accountable. Our target in this paper is to explain how we see the Research Administration Process evolving, and how the Information Technology solutions can help streamlining and standardizing this process.

Keywords: R&D process, Information System, Integrated platform

1. Introduction

Research and Development (R&D) could be defined as a specific type of scientific investigation. This investigation is designed to develop new consumer goods and services, new inputs into production, new methods of producing goods and services, new knowledge, or new ways of operating and managing organizations. There are two types of R&D: basic and applied. R&D may result in ownership of intellectual property such as patents. Research serves National and International interests.

In general, R&D involves many actors: researchers, students, laboratories, research centres, universities, technicians, administrators, etc. One of the key issues to develop and conduct R&D is Money. It is difficult to imagine R&D without it. R&D involves also many processes. We could consider that the most known one is the funding process. Funds come from governmental and private organisations. Funds are provided through grants and contracts after a call for projects and an evaluation procedure. A contract or grant concerns one or multiple projects, and involves one or multiple actors. Many researchers spend more than a trivial amount of their time applying for grants for research funds. Every grant necessitates an administrative, financial and scientific follow up. In Canada and in 2007, almost 29 billion dollars were spent for R&D in total sciences [4]. Therefore, the ideal quest for a funding organisation is to provide money: at the right time, to the right people, for the right project.

In Canada, the federal government remains the largest source of support for university research (47%) [3]. In turn, the share of funding provided by the provinces is (20%) and industry is (17%).

The whole R&D business process is not easy to handle and master. The only funding process is iterated through a long period of time. It is divided in many steps and each step contains sub-steps. For example, the first step necessitates working first of all on the preparation of the call. The call should be given a particular attention because it is supposed to focus on themes and topics that are of interest for the community, the region and even the country. Grants that would be provided are supposed to solve problems that some community or the country is facing such as sustainable development, education or health.

There is evidence that Information and Communication Technology (ICT) would be of great help for all actors to tackle and manage the R&D process, to be updated about the latest project status, to follow up on project expenditures and timelines. This is also known as Electronic Research Administration and is defined as improving administrative processes through the application of technology, particularly computer technology [1]. Electronic Research Administration is one of several factors that is intended to help reduce costs in research organisations and to speed the movement of research ideas from laboratory into products. An ideal IS to manage the whole R&D process is a system that should have, among others, the following features:

- The whole solution should be designed as a set of compatible and complimentary modules. Eeach one corresponding to a single R&D process (e.g. granting, reviewing, awarding, etc.). Such a system would allow organisations to implement following their own priorities and desired level of automation;
- Adapt and customize according to the specific rules and requirements of each organisation;
- Allow all actors to access the same information taking into account their privileges;
- Access and manage the information from almost anywhere;
- Be able to know to whom the money was granted, on what it was spent, and what impact it had: Performance Indicators are key to convincing funders that Research has a direct impact on society
- etc.

Industry has already developed some Information Systems (ISs) dedicated to the R&D business. However, even the importance of R&D for the economy of a country and the importance of using ICT for managing R&D, to our knowledge (i) there is no system capable of managing the whole R&D process and (ii) there is no system that respects all the above criteria. In addition, let us mention that:

- Most of ISs are dedicated to only one specific process (most of the time, it corresponds to a "Finance management system" for granting agencies [5]);
- Most ISs are developed to specific funding organisations and the solutions are difficult to be adapted from one organisation to another (because of business rules aspects and/or technological aspects). Application forms can be very different from one organization to another;
- The development expenses are still high, especially in developed countries. There is still a need to decrease expenses associated with the development and maintenance of such ISs

Hence, there is a need to develop for the R&D community such a system. We have already developed some ISs dedicated to specific R&D processes such as the funding and reviewing processes [9]. This expertise leaded us to think (in terms of modelling, development and technology) about the R&D at large. Our aim is to contribute to the development of an integrated platform that manages the whole R&D process. Objectives of such a system are:

- Offer a better Quality of Service to the scientific community
- Lower the amount and the complexity of administrative work for both administrators and researchers
- Improve the efficiency of R&D organizations
- Increase the capacity for strategic and operational planning
- Facilitate Networking in the research sector

For this purpose, we present in section two our modelling of the R&D business process. The modelling gives an idea about what should be the platform that manages the whole R&D process. In section three, we present our solution in terms of technology, methodology and standards adoption. In section four, we conclude the paper.

2. Modelling the R&D business process

R&D is a complex, multi-business processes. We model it with four main concepts: Actors, Resources, Products and Context.

- An Actor A is every one that acts in the R&D world. We distinguish individual actors IA (who represent persons such as researchers, students, technicians, administrators, etc.) and composed actors CA (who represent organisations such as universities, research centres, ministries, hospitals, etc.). A CA is composed of individual or other sub CAs.
- A Resource R is anything that an actor needs to conduct research. A Resource could be funding, research equipment, laboratory space, etc.
- A Product P is anything the R&D community (IA and CA) may produce such as call for projects, CV, a publication, a brevet, etc.
- A context C is the perspective from which the R&D process is considered. We distinguish:
  - The geographical context: R&D process is considered for a specific geographical area such as a Canadian province, a specific region, a specific city, etc.
  - The type of actor context: R&D process is considered for a specific type of actor such as considering R&D for only researchers, only students, or only research centres, etc.
  - Combined context: combining a geographical context with a type of actor one, e.g. considering R&D for research centres in Ontario province.

In addition to the R&D concepts we have introduced, we need to model the R&D process. We consider basic processes and composed processes. A basic process is a minimalistic scientific action that an actor can perform. The syntax of such a process is:

`Combination(R, P) → Actor → Combination(R, P)`

This is interpreted as: a combination of resources R and products P are given to an actor A that performs some R&D actions to produce another combination of resources R and products P. Here are some examples:

`Money → Researcher → publication`
A researcher uses some money to produce a publication

`Money → Student → Thesis`
A student receives some money (e.g. scholarship) for his(er) thesis

`Money → OICR → Call for projects`
The OICR (Ontario Institute for Cancer Research [11]) receives money (e.g. from the government). To distribute money to the best researchers, it produces first a call for projects.

These basic processes could be combined in a sequence to form more complex and actual R&D processes. For example, the granting process (from the call for projects till the execution of the project) could be modelled as:

1. `Money → OICR → Money & Call for projects`
   Governmental money is given to the OICR that takes part of it and launches a call for projects

2. Call for projects → Researchers → Submissions
   The call is taken by researchers that respond it by producing submissions
3. Submissions → Committee → Decisions
   These submissions are given to a committee for evaluation and to make decisions about who would be granted money for research
4. etc.

The whole R&D process can be viewed as a layered model. The three layers correspond to the three R&D components: actors, resources and products. The image in Figure 1 shows that a CA (represented as a building) contains (dashed lines) multiple IA (represented as a smiley). The work of these actors is to use and provide resources and products (arrows). Thus, any R&D process can be viewed as a continuous process where some actors are consuming resources and produce some R&D products while others are using these products as inputs to provide new resources to other actors.

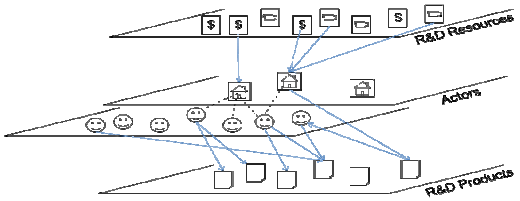

Figure 1: The three layered model of the R&D process

To illustrate the concept of context, let us take two examples. The first part of Figure 2 shows an example of type of actor context.

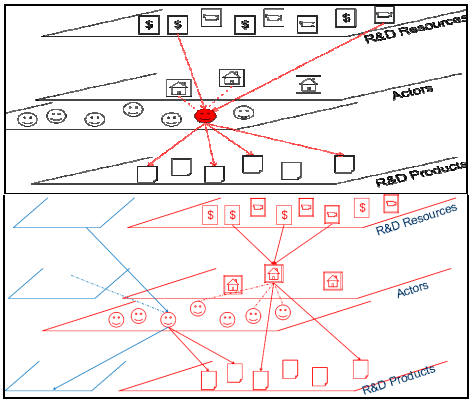

Figure 2: The R&D model in two different contexts

Suppose the selected actor is a researcher. Knowing every information about this researcher means knowing:

- The resources (s)he uses
- The organizations (s)he works for
- The R&D products (articles, patents, etc.) (s)he has produced.

This context corresponds exactly to the CV of the researcher. The second part of Figure 2 shows an example of geographical context. Suppose we concentrate on a specific Canadian province (e.g. Ontarian province), then the three layers are selected. Knowing every information about R&D in this province necessitates knowing almost everything, and even information from other contexts (another province or even another country). For example, some individual actors may use resources and produce elements in these other contexts.

This global R&D modeling shows that, as cited above, using ICT to manage the whole R&D is not an easy task. However, using ICT is the only way to efficiently manage the process since the data and information are huge; the number of actors, resources and products is great.

3. An integrated platform

3.1. Existing Software

Applying ICT to the whole R&D process would be a huge Information System (IS). Computerizing the process in one IS would be too complex. Rather, the R&D process should be implemented as a set of sub-ISs or a set of modules, each one focusing on a specific sub-process or on a specific context. Some of these modules have already been developed[1]. For example, the modules we have identified within the granting process of a typical funding organisation are illustrated in Figure 3. In this figure, we show also for each module the relationships it has with other modules and the kind of actor to whom it should be dedicated:

- Electronic CV: Researchers have all access to a specific form to enter and update their own *interactive electronic CV*. All funding organisations have access at any time to these CVs in case they need some particular experts in a particular domain for example;

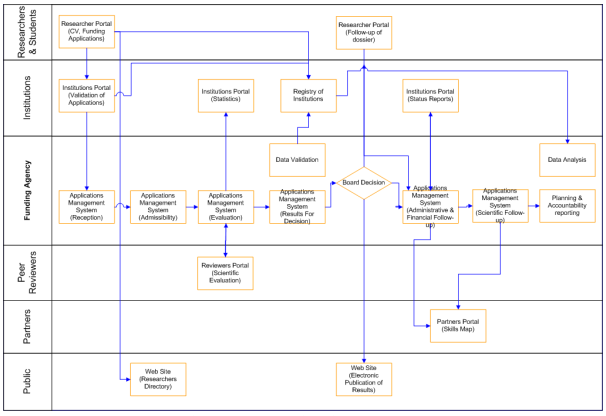

Figure 3: Modules within the business process of a typical funding organisation

- Electronic Grants Management System**:** To launch a call, a funding organisation sends an *electronic*

[1] More details about these modules could be found at www.evision.ca

proposal and researchers use *application web form* to submit for the proposal. A *personalized electronic dossier* per researcher is then created and a *project management system* is used for the *web approval* by academic entities, for *the electronic evaluation* and the *interactive support to committees*. Funding organisations can also make use of graphic representation, summary reports and financial scenarios for the planning of their future activities and decisions. This product presents many advantages such as: saving time for both researchers and funding organisations (one full data entry by researcher followed by continuous updates as required), web access for academic institutions to CVs and projects for their researchers, automatic data transfer to their own corporate databases, and efficiency gains for the funding organisation (e.g. early identification of inadmissible applications, significant time saving for Evaluation and Peer Review Committees);

- Administrative, Financial and Scientific Follow-up: The funding organisation holds a client dossier for every researcher to allow an *administrative follow up* such as the updates of the coordinates, change of laboratory, site or affiliation. The *financial follow up* deals with that payments requests, payment conditions, and financial reports. In the *scientific follow up*, funding organisations have to ensure that researchers produce interim and final reports of their projects;

- Planning and Accountability: The funding organisation stores a *Directory of Researchers* (Who does what?), *Registry of Centres*, including performance indicators (With whom?), and a *multidimensional Informational Catalogues* and Cubes to be able to combine data to make particular decision. This product helps every funding organisation to offer a better transparency on the allocation and use of Public Research funds and more visibility for researchers.

3.2. The integrated view

The previous section detailed the modules for only the granting process of a typical funding organisation. Considering other contexts, other types of actors, and other R&D processes would lead to the identification of another great number of modules. In addition, these modules are not isolated but are interacting between them.

The aim is to provide a software solution that efficiently manages the whole R&D process. Our solution consists of a platform that integrates all R&D modules at the same time in an integrated system [2]. The platform is considered as a shared space where identified modules (and those that would be identified later) have to co-exist.

On another hand, and as we can see in Figure 2, every actor can access the platform via a portal which represents his(er) own perspective of the System. However, every actor has a limited view according to his(er) privileges and place in the system. For example, a student has access only to his own CV. A researcher has access to his(er) CV and own projects. An academic institution has access to the CVs and parts of its own researchers' projects.

For example, figure 4 illustrates the use of the shared space for a specific researcher. John Nach is visualising at the same time in his workspace three different web-applications:

1. his electronic CV application;
2. the EAMS application (Electronic Award-Grant Management System) where the reseacher may fill information to apply for a grant
3. the review application which is an on-line system for the management of the electronic submissions for examination and evaluation

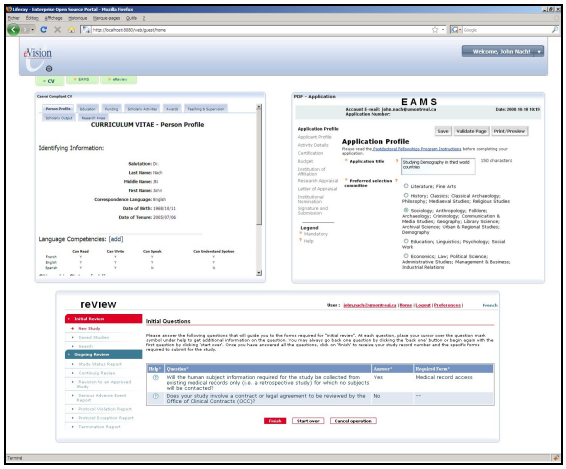

Figure 4: A web-portal containing multiple portlets

3.3. Technological aspect

Our shared space platform comes as a specific portal according to the kind of actor using the system. In all portals, every module is considered as a portlet (Figure 4). Let us recall that portlets are pluggable user interface components that are managed and displayed in a web portal [6]. Portlets produce fragments of markup code that are aggregated into a portal page. Typically, following the desktop metaphor, a portal page is displayed as a collection of non-overlapping portlet windows, where each portlet window displays a portlet. Hence a portlet (or collection of portlets) resembles a web-based application that is hosted in a portal. For example, Figure 4 illustrates a researcher portal where the CV portlet, the grants portlet, and the reviewing portlet are all opened within the same researcher share space.

On another hand, the modules explained in section 3.1 and the R&D modelling show that the management of the business using ICT is mainly considered as an

exchange of documents (Figure 3). In traditional software all data, rules and processes are bundled together in the same software code. This code must be frozen before using it in the business, even the smallest change can break the software unless we re-code and re-test every change. This forces the business into a straight-jacket because of the time and cost associated with any change.

This business vs. technology problem is as old as electronic business itself. The technology we use addresses this problem by introducing an important innovation: *Document-Workflow*. Rather than trapping your data and rules into individual software systems, documents are defined separately by creating standards-based documents definitions. This approach matches what most R&D actors are already used to: CVs, Grant Applications, Progress Reports, Budgets, etc. We think of these as business documents, not software systems. On another hand, rather than trapping your business processes and rules into individual software systems, workflows are defined separately by creating standard based workflow definitions (which include the documents). This approach matches how R&D actors think about getting work done: Apply for a grant, validate a grant application, review a grant application, etc. These are business processes, not software systems.

Our document-workflow solution comes with a collection of pre-configured modules that serve as a starting point for all R&D processes: CV management, Admin review, Prepare/Submit grant applications, etc.

Since our platform has to be implemented for many kinds of clients and actors and since the exchange and share of data is a key issue, technology to use (i) has to respect standardisation; (ii) could be implemented in multi-platforms; and (iii) has to ensure that traffic is not overloaded during the multiple exchange and share of data. Our platform is built around three main components: the j2ee environment, the oracle DBMS and the XML-based technologies.

3.4. Standards

In Canada, the number of research funding organisations is important, containing both federal and provincial ones: FRSQ (Quebec Fund for Heath Research [10]), NSERC (Natural Sciences and Engineering Research Council of Canada, [7]), OICR (Ontario Institute for Cancer Research, [11]). The number of actors (researchers, students, universities, research centres, laboratories, etc.) that may be engaged in a funding project is also high. Thus, for a given project many actors could be involved at the same time. For example, for a medical project the following actors could be engaged:

- The funding organisation
- One researcher as a university member
- One researcher as university member and as a research centre member
- One student as a university member and as a hospital practitioner

The funding organisation has not only to follow up the project but has also to share the information with the involved universities, the research centre and the hospital. Sometimes, one researcher may be funded for the same project by two organisations. On another hand, researchers and students have to fill the CV form every time they want to submit for a project proposal even for the same funding organisation.

For this purpose, most of the Canadian research Administration actors participated in the creation of CASRAI organization (Consortia Advancing Standards in Research Administration Information). CASRAI [8] is dedicated to developing, maintaining and promoting standardized specifications of common research administration business documents to enable reliable electronic business and automated data exchanges between members. Among the objectives of CASRAI, we could mention:

- to remove the risk and cost to members of building & maintaining multiple interchange mechanisms on an ad-hoc basis;
- to make data sharing possible without dependency on specific software, platforms or systems;
- to allow researchers to maintain one copy of their data and to reuse it reliably everywhere;
- reduced costs through shared research, development and testing of an open XML vocabulary for research administration
- access to CASRAI-published whitepapers, articles, best practices and other educational resources authored by international experts and thought-leaders on how to use XML and other open standards optimally in order to reduce operating costs, assure data quality and enhance data management
- documentation, XML schemas, test suites and other version-controlled and non-proprietary outputs of the CASRAI standards process
- improved accuracy, quality, and consistency of shared information
- standards that are technology neutral, have predictable release cycles, and that can be processed internationally

Among the first actions undertaken by CASRAI was the standardisation of the CV which is named the Canadian Common CV.

3.5. Internationalisation

Canada is officially a bilingual country (English and French). Hence, all modules of our platform can be displayed in both languages. This internationalisation is made possible not with the duplication of user interfaces, programs, etc. but with the use of XML files (or in data bases) that stores only the labels and texts that appear in user interfaces and that depend on the

language.

On another hand, in our quest to export the platform to other countries, we plan to export the platform to other languages. This is possible with a very little cost since the only change to make is the addition of all labels and texts of the interfaces inside XML files (or inside the database). However, this idea can be applied only for Roman languages (e.g. Spanish, German, etc.) but could not be applied for scripted languages (e.g. Arabic, Farsi, Hindi, etc.) because in those kind of languages, not only the labels and texts of user interfaces are different but also their orientation and the orientation of the other categories that may appear in the user interfaces such as the menu, the pop-up, the combo boxes, the area texts, etc.

4. Conclusion

We have looked at the different aspects of the Research Administration Process, we have analyzed many Research Admin sub processes that are keys to the success of the research, and this work resulted in a new generation of electronic solutions that bring value to all players:

- Better collaboration tools for Researchers
- Better communication between the Researcher, the Research office and the funding agencies
- Funding Process Streamlined
- Better ethical, scientific and financial follow ups on the ongoing research projects

We have been instrumental in advancing some data standards through CASRAI, which have enabled the development of some performance indicators and impact factors. We're now hoping to be able to compare and analyze the outputs from different research projects without fearing the 'Apples to Oranges" classic mistake. In terms of technology, we have focused on using open and portable platforms, we have relied on XML technologies to implement our document driven architecture.

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