

# Scientific Publication Life-Cycle Model (SPLC)

A deliverable of the project  
Open, self organising repository for scientific information exchange (SciX)  
EC fifth framework programme, Information Society Technologies (IST)  
Contract no: IST-2002-33127

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Version 2.0  
October 31, 2002

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## **ABSTRACT**

The scientific publishing process has during the past few years undergone considerable changes, due to the possibilities offered by the Internet for fast delivery and interlinking of publications which refer to each other. The socio-economic structures have, however, not changed much, and many academics and librarians view the current situation as suboptimal and highly unsatisfactory. This has triggered a number of initiatives to set up e-print repositories and electronic peer reviewed journals, which usually offer the full text for free on the web. The label *Open Access* is gaining popularity for describing such efforts, in line with the Open Source term used in the software development community. Despite the obvious advantages it offers, Open Access hasn't become as wide-spread as expected, and there is a need for both successful demonstrator projects and serious research studying the way the scholarly communication system is affected by the Internet.

As a part of the EU funded SciX project the cost implications of different publishing models are being studied. A basis for the cost studies is the formal process model of the scientific publishing process which is presented in this paper. The model has been developed using the IDEF0 modelling method, a method which allows the breaking up of a process into its parts connected by output and input arrows. The *Scientific Publication Life-Cycle Model* models the life cycle of the single publication, in particular the refereed journal article, from the research leading to it and writing it into it being read by other researchers years later or used as an impulse for practical implementation. The paper presents the 22 hierarchical diagrams of the model including 64 separate activities. Conclusions are drawn about the usefulness of the modelling methodology for this particular purpose as well as of future uses of the model itself. In addition to providing a basis for cost studies the model could function as a road map for different types of Open Access initiatives.

### **Key Words**

Scientific Publication, Open Access, IDEF0, Process modelling

## 1. Introduction

A breakdown of the costs of producing and delivering a typical refereed journal paper indicates that perhaps as much as 90 % of the cost consists of the actual research work preceding the writing of the paper. The research work is usually financed by public bodies and the costs are in no way recuperated through the sales of the publications (as would be the case for commercial products such as books, music CDs, movies etc). Even if we look only at just the costs of preparing, reviewing, distributing, archiving and retrieving scientific articles, thus excluding the actual production costs of the knowledge reported on, almost all the costs are in the end born by the universities, public libraries etc. Because of the commercial interests of one group of stakeholders, the journal publishers, which incur a very small fraction of the total life-cycle cost, the access to scientific publications is highly restricted and expensive and the process as a whole is highly inefficient [for a recent overview cf. Guédon 2001]. Publishing parallel electronic versions restricted to subscribers only partly remedies the situation and leaves much of the potential of the Internet untapped.

The dilemma is that it would be in the interest of the researchers and the public to have all this information published for free on the Internet, facilitating global access and hyper-linking of research publications. Nevertheless it is in the legitimate interest of the publishers to make a profit from selling this information, which leads to restricted circulation, pass-word protection schemes for digital versions of traditional journals, bundling of electronic subscriptions to so called “big deals” with library consortia.

Pioneering work to try out new methods of scientific publishing has already been started, usually by enthusiasts from subgroups in the scientific community. Examples include preprint repositories, open access scholarly journals and journals offering a review process where the readers perform the peer review after a manuscript has been posted on the web. There are, however, many psychological, legal and institutional barriers to change the process and these have been underestimated by the pioneers and enthusiasts. Consequently only a small part of the overall volume of the scientific communication process has so far been affected by isolated efforts involving e-journals and preprint archives. A recent study made at the Swedish School of Economics and business studies indicates that only about 0,7 % of peer reviewed journals offer open access on the web.

The SciX (Open, self organising repository for scientific information exchange) project, which is financed through the IST programme of the European Commission, aims at demonstrating that the Internet enables new business models for the scientific publishing process which are much more cost and time efficient to the scientific community than the current practice [SciX 2002]. The SciX project group will create services on the Web that will enable scientists as well as practitioners from the fields of architecture and construction easy and free access to relevant research publications. In addition existing publishing practices will be analyzed systematically and business models for re-engineering the scientific publishing process will be developed, taking into account also the legal, social and psychological barriers to change. The model presented in this paper is one of the deliverables of the theoretical work done within the SciX project.

## 2. Aim and scope of the modelling effort

The aim of the modelling is to help us understand the scientific publishing process and how it is affected by the Internet, in order to provide a basis for a cost and performance analysis of various alternative ways of organizing it. The model can also work as a roadmap for positioning various new initiatives, such as e-print repositories and harvesting tools, within the overall system of scholarly communication.

The model explicitly includes the activities of all the stakeholders involved in this system, including the activities of the:

- **Researchers** who perform the research and write the publications
- **Publishers** who manage and carry out the actual publication process
- **Academics** who participate in the process as editors and reviewers
- **Libraries** that archive the publications and provide access to the them
- **Bibliographic services** which facilitate the identification and retrieval of publications
- **Readers** who search for, retrieve and read publications
- **Practitioners** who implement the research results directly or indirectly

In the model the unit of observation is the single publication, how it is written, edited, printed, distributed, archived, retrieved and read, and how eventually it may affect practice. The viewpoint taken is life-cycle cost per publication. Thus at later stages all cost and time data which is collected will be translated to a per publication basis.

The aim is to clarify the process and to find a way of measuring the total life-cycle cost of a publication, since the objective of the reengineering efforts in the SciX project is to try to investigate business models that minimise the total life-cycle costs, rather than the cost of some particular stage. This is clearly in the interest of the public authorities that finance research as well as the researchers who are primary end users. Another aim of the modelling effort is to try to clarify the functions that the demonstrator parts of SciX try to make more effective.

The model depicts publishing and value added services using both paper and electronic formats. Pure electronic or pure paper-based publishing could be described by subsets of the model. The same goes for free publishing on the web (“open access”), which resembles traditional publishing, but where certain activities such as negotiating, keeping track of and invoicing subscriptions can be almost entirely left out.

The current version of the model has some limitations, which should be kept in mind. It only includes the publication and dissemination of research results in the form of publications that in the end can be printed out and studied on paper (irrespective of whether the publications are distributed on paper or electronically). Thus forms of communication such as oral communication, unstructured use of email and multimedia, sharing of data sets and models, which all are essential parts of the scientific communication process, are out of scope. These could be added at a later stage, but would also add to the complexity of the model.

The model includes some activities, which would be typical for a scientific publisher publishing several journals, allowing for economies of scale. The activities of single-journal publishers could be described by a subset. The reason for including activities such as the general activities of a publisher is that these significantly influence the cost of running individual journals in the form of the general overhead costs that publishers add to the subscription prices.

How easier access to scientific publications might influence the quality of later research and industrial practice, which use these publications as input, is clearly also an important issue, but such qualitative effects of a more efficient process are very difficult to model and even more difficult to measure, and have not been attempted in this model. The same applies for the effect of the publishing on the careers of the authors, which is an important aspect for the choice of where to publish and has created a very strong barrier for change to pure electronic journals from established “brand name” journals.

### 3. Modelling methodology

Formal process modelling techniques are frequently used in process re-engineering efforts to clarify a process and propose changes in it. Using a formalized tool helps in communicating about the process. The IDEF0 method was originally developed in the 1970s for the US Army to help them in large procurement projects. In order to read the model the reader needs some familiarity with the IDEF0 modelling methodology. IDEF0 stands for Integration Definition for Function Modelling [NIST 1993]. The IDEF0 method is a formal graphical modelling method. (Figure 1).

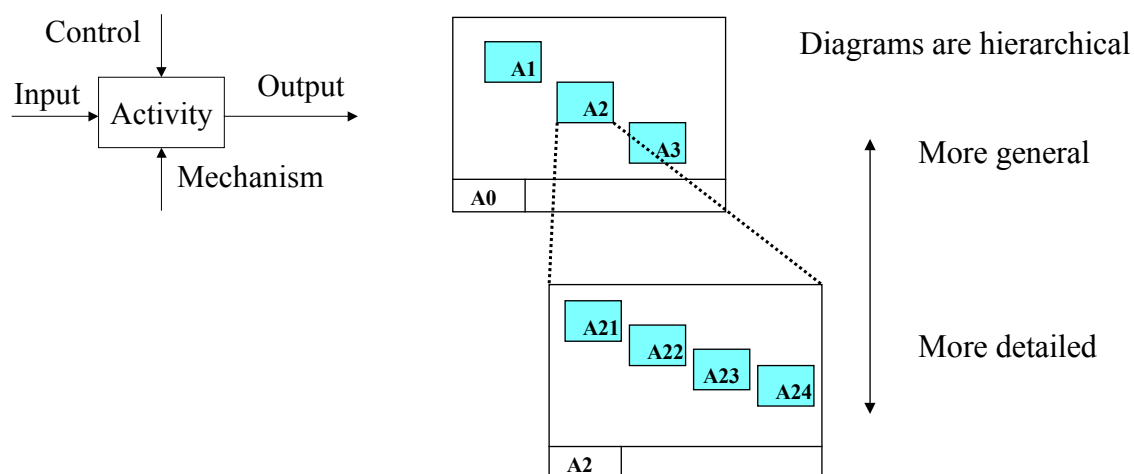


Figure 1. The basic concepts of the IDEF0 method [Karhu 2000].

The main concepts are the activity and the flow. The flow can be used as input, output, control or mechanism. An input represents something which in an activity is consumed to produce an output. Typical inputs could be raw materials, energy, human labor, but also information when the purpose of the activity is to transform the information to provide added value. Outputs can be reused as inputs to further activities, and feedback loops are possible. Activities are controlled by controls. Typical examples could be laws, guidelines and instructions for carrying out an activity etc. Mechanisms, which point at activities from below, are persons, organisations, machines, software etc. which carry out the activities. The presentation of the IDEF0 diagrams is hierarchical in that diagrams on lower levels provide detailed breakdowns of the those from the higher ones, Figure 1.

In the SciX project HANKEN has used a particular software tool called BPwin for making and editing the IDEF0 model. Compared to a simple drafting tool BPwin enhances the speed and consistency of the modelling work, especially for larger models and when changes are needed.

#### **4. Overall organization of the model**

The current version of the SPLC-model includes 22 separate diagrams, arranged in a hierarchy up to seven levels deep. There are typically three activity boxes on each diagram, although there are a couple of diagrams with more activities and some with only two. Although official IDEFO guidelines recommend using up to six activities per diagram, it was felt that models with three activities are easier to read and understand. There are altogether 64 activity boxes and around 200 arrows.

The overall hierarchical breakdown of the model is shown below in table 1. Only the separate diagrams are shown. Some diagrams are further broken down into separate activities.

In the following each diagram is explained separately. The diagrams are numbered using the standard IDEF0 numbering scheme, which helps keeping track of the hierarchical position of each diagram.

## A-0 Context Diagram

A0 Do Research, Publish, Study and Exploit the Results

A1 Perform the Research

A2 Publish the Results

A21 Write Manuscript

A22 Perform Publishing Activities

A221 Publish as Monograph

A222 Publish as Conference Paper

A223 Publish as Scholarly Journal Article

A2231 Do General Publisher's Activities

A2232 Do Journal Specific Activities

A2233 Do Article and Issue Specific Activities

A22331 Article Specific Activities

A22332 Prepare Issue

A22333 Publish Article

A224 Publish in Miscellaneous Form

A23 Archive and Index

A231 Make Publication Available

A2311 Secure Access Rights and Subscription

A2312 Make Paper Publication Available

A2313 Make Electronic Copy Available

A2314 Integrate Meta Data into Search Services

A232 Perform Value-Adding Services

A233 Archive Securely

A3 Study the Results

A31 Find out about Publication

A311 Search for Publication

A312 Be Alerted to Publication

A32 Retrieve Publication

A33 Read Publication

A4 Implement the Results

*Table 1. Hierarchical breakdown of the model, only the diagrams are shown*

## 5. Model walk-through

### ***A-0 Do Research, Publish, study and Implement the Results - Context Diagram***

This is the diagram for depicting the overall model, which traditionally is the starting node of all IDEF0 models, and which contains only one activity describing the overall process. The philosophy of this diagram is to show how science can help in solving problems of everyday life by a combination of research (which creates scientific knowledge) with publishing, dissemination and exploitation activities (which ensure that results help in the advance of our collective body of knowledge). The main stakeholders in the process are shown as mechanism arrows coming into the activity box from below, and the main drivers controlling the behavior of the stakeholders are shown coming in from above. Note that from an academic viewpoint the main result is *new scientific knowledge*. From the viewpoint of society that funds research the most important outcome is *improved productivity and quality of life*.

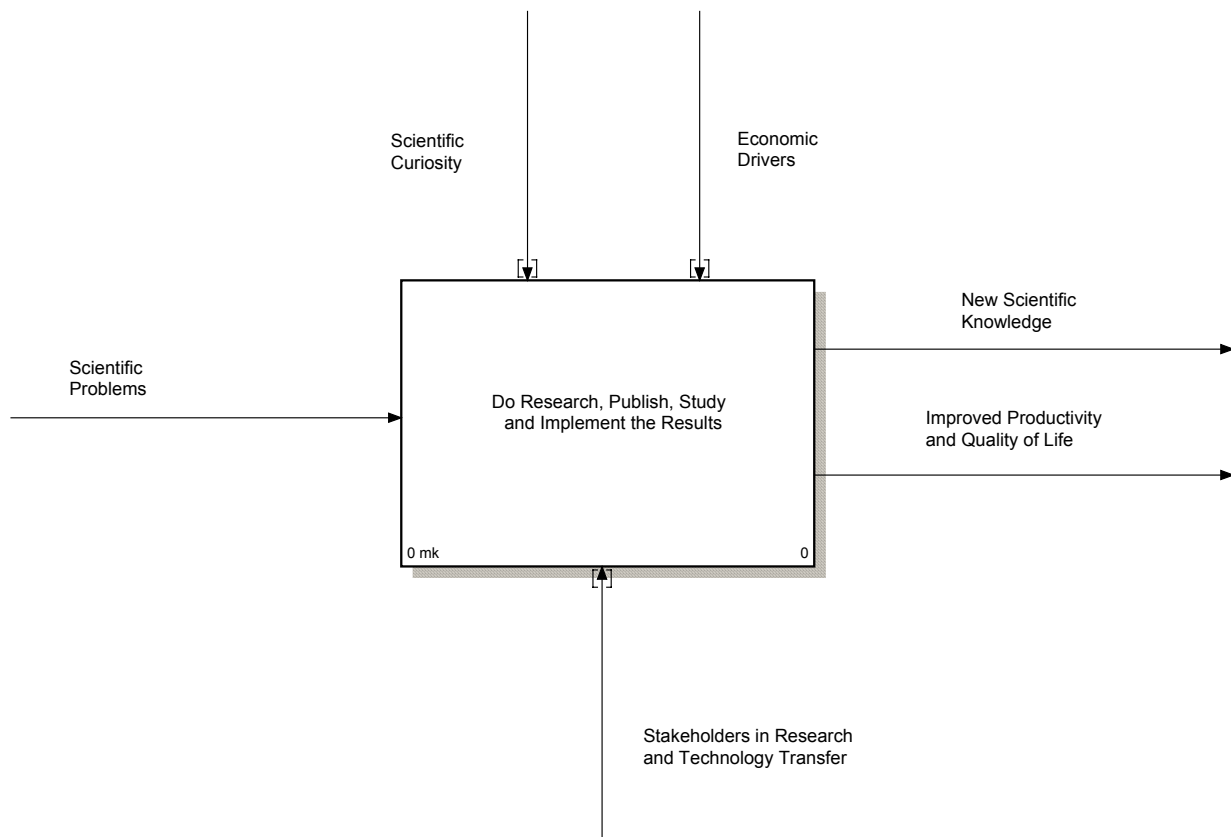


Diagram A-O Do Research. Publish, Study and Exploit the Results, Context Diagram



## A0 Do Research, Publish, Study and Implement the Results - breakdown

This diagram is crucial for understanding the life-cycle view adopted in this modelling effort. The whole life-cycle is seen as consisting of four separate stages. The *do the research* stage is probably the most expensive part, usually consisting of several man-months of work effort per resulting publication, but the one least affected by the reengineering efforts facilitated by the Internet (at least directly, indirectly the effect can be substantial in terms of better quality of the research). The *publish the results* and *study the results* stages constitute the main object of study in this project. This part of the model tries to clarify the dual nature of the publication process. From the perspective of the public bodies that to a large part finance research it is the efficiency of the total process, including both the production and “consumption” of publications, that should be optimized. The important thing is that in a life cycle analysis, the cost and efficiency of both the publish the results activity and the study the results activity are important. Optimizing only one of these may lead to a sub optimal solution for the total process. Here Internet has changed the situation dramatically, as it has for any information goods that can be delivered in a digital format.

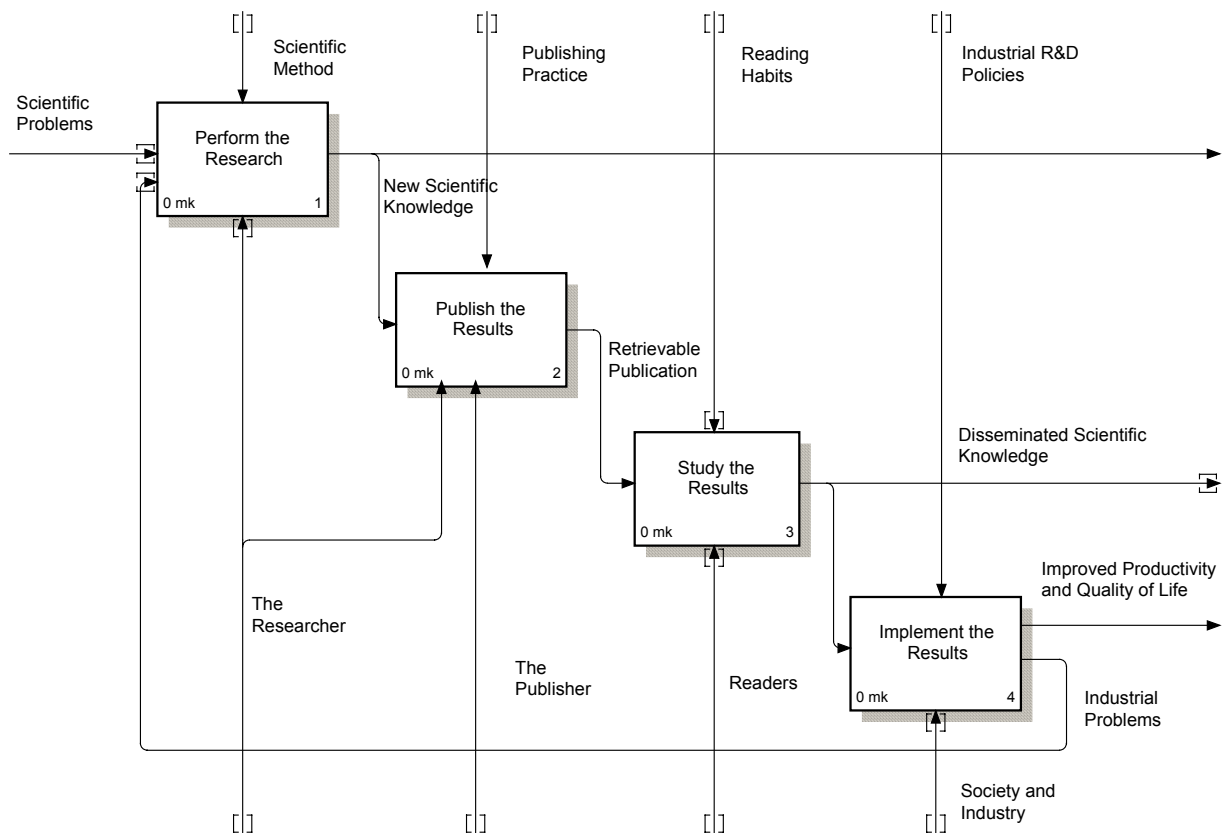


Diagram A0 Do Research. Publish, Study and Apply the Results, Breakdown

The end result of these two stages is called *disseminated scientific knowledge*, reflecting the viewpoint that scientific results which have been published, but which are not read by the intended readers are rather useless. In the last stage, *implement the results*, the *disseminated scientific knowledge* is transformed to an improved performance of society and industry.

## A1 Perform the Research

This diagram shows a highly simplified view of a typical research project. Note that one important feature of IDEF0 diagrams is that the consecutive activity boxes do not necessarily imply a strict order in time as in scheduling methods. Thus the activity *study earlier research* can go on after the other two activities have started. The important thing is that it provides input to these. Clearly this is only one possible way of looking at the research process. The reason for choosing this view is that it clearly distinguishes the study earlier research activity, which also is part of a later stage of the whole model. Here it is seen as providing input to the research that produces a publication, whereas the later stages of the model show how other researchers utilize the results for their own separate research projects. If this activity can be made more efficient, the overall productivity of the research can be increased.

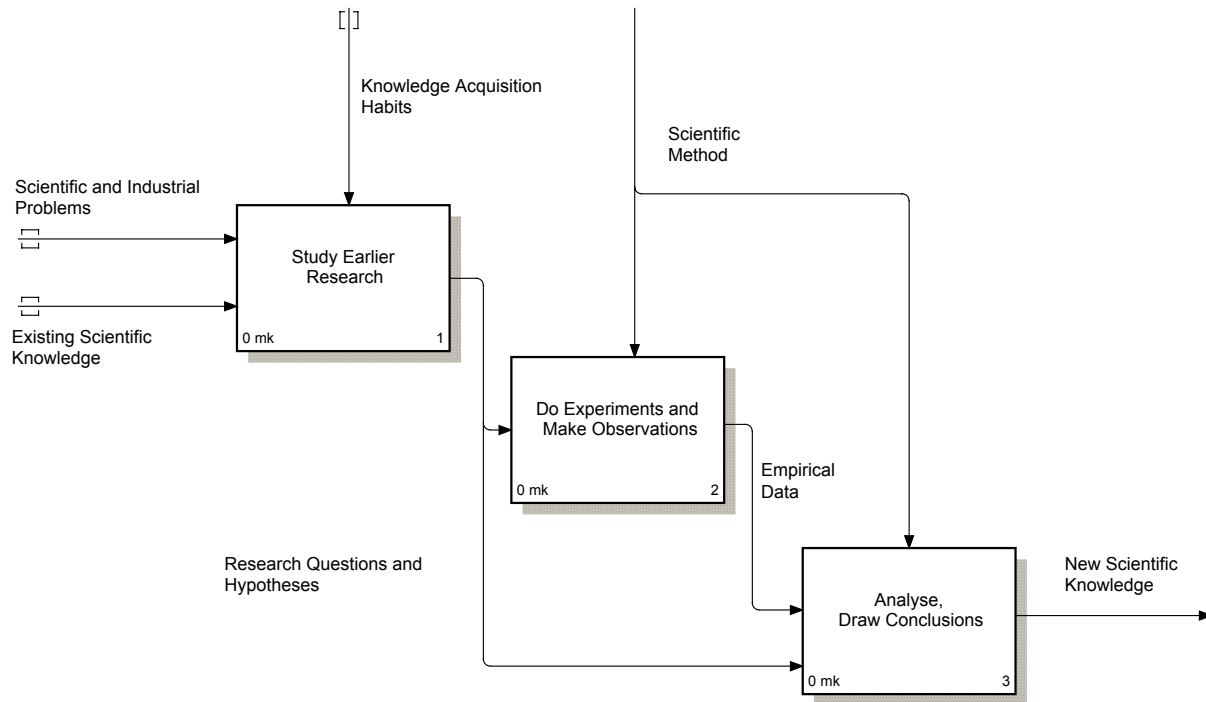


Diagram A1 Perform the Research

## A2 Publish the Results

This part of the model has been split up into three distinct activities, which to a large extent are carried out by different stakeholders. Based on the results of the research, the researcher writes a manuscript, which then in the next stage through a number of transformations is changed into a *publication* (on paper or electronic). The last activity is extremely important from a life-cycle viewpoint and involves the activities of libraries, bibliographic services etc. to make the publication easily available to researchers and practitioners worldwide.

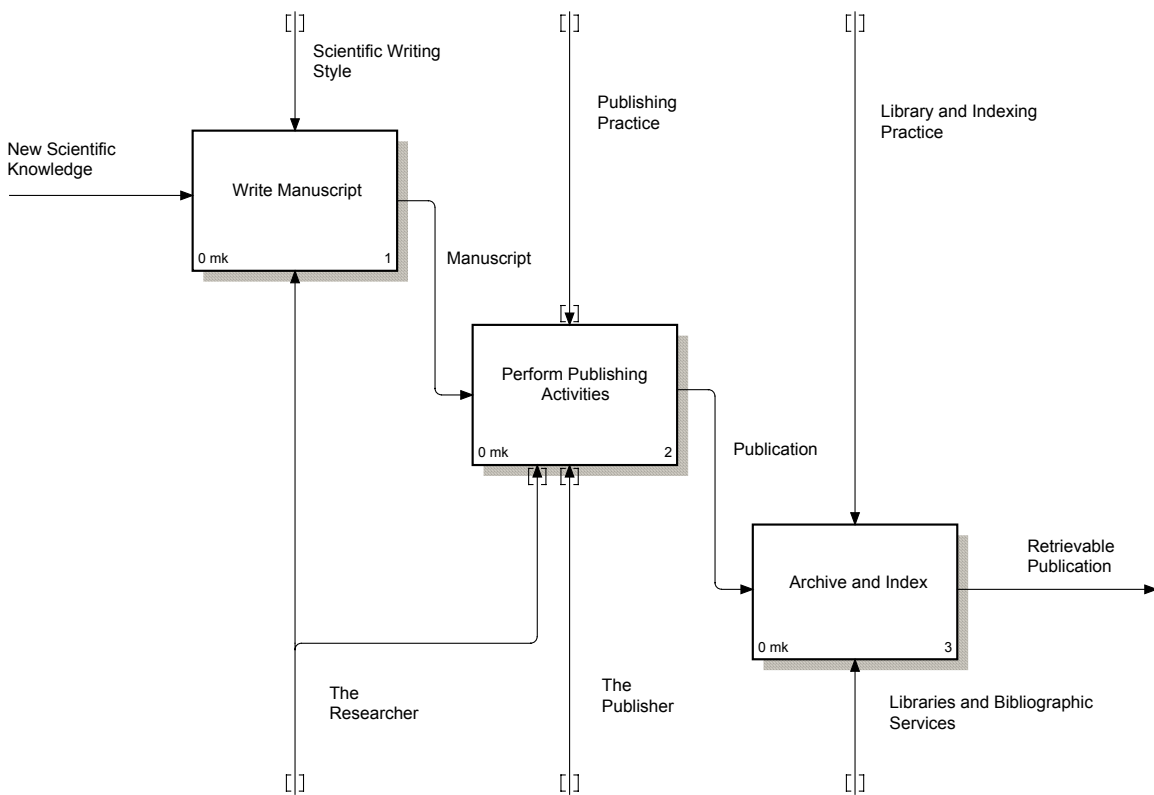


Diagram A21 Publish the Results

## A22 Perform Publishing Activities

At this stage the model is split into four parallel tracks which all take the generic “*Manuscript*” as input. The term *monograph* is in library science used to denote scientific publications which usually are published by the university of the researcher and which are not part of a scientific periodical journal or conference proceedings. Typical examples include working papers, research reports and Ph.D. theses. Conference papers are subjected to some sort of external review either for the abstract or the full paper, and are usually presented orally in addition to the printed version. Conference proceedings are published as one-off books or typically annually. Articles in scientific periodicals are subjected to rigorous peer review. It is important to note that periodicals articles have a much higher likelihood of being referenced in bibliographical services than the other types. Also journals are usually available by subscription whereas the access to monographs and conference proceedings is predominantly acquired on an individual basis. The fourth track involves publication of all other types, for instance as popularized articles targeted for an audience of non-academics, self-publishing of multi-media content etc.

Of these four only the publish as journal article has at this stage been further detailed. This is because of its relative importance in scientific publishing and also because the cost modelling effort will be concentrated there.

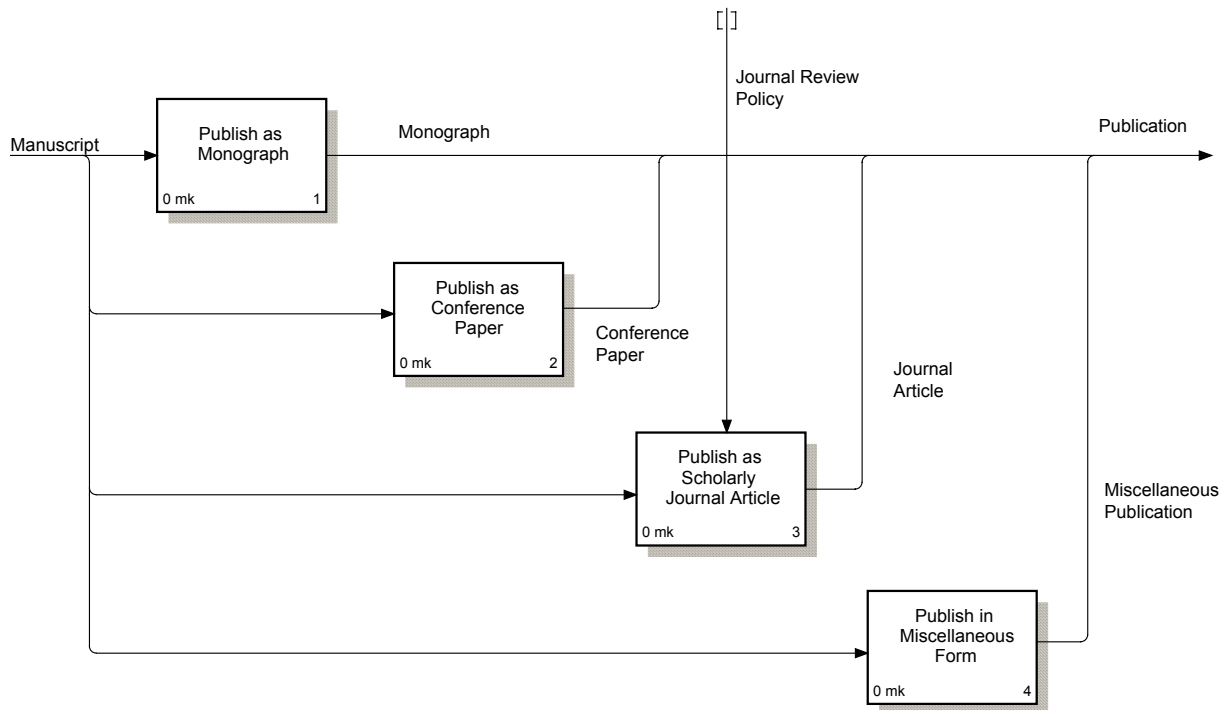


Diagram A22 Perform Publishing Activities

## A223 Publish as Scholarly Journal Article

This diagram may at first sight be difficult to understand. The idea is to show all the activities which are carried out by the publishing organization, and thus have a direct cost implication for them. This is the reason for separating activities such as *do general publisher's activities*, *do journal specific activities*. Both of these demand resources, which cause overhead costs, which then are added on top of the basic variable costs caused by the processing of each individual article ( in the activity *do article specific activities*). For instance setting up and maintaining the IT-technical infrastructure for a portfolio of journals could be such an overhead causing item.

The main pipeline in the model is, however, the input arrow *manuscript*, which directly enters the activity *do article and issue specific activities*.

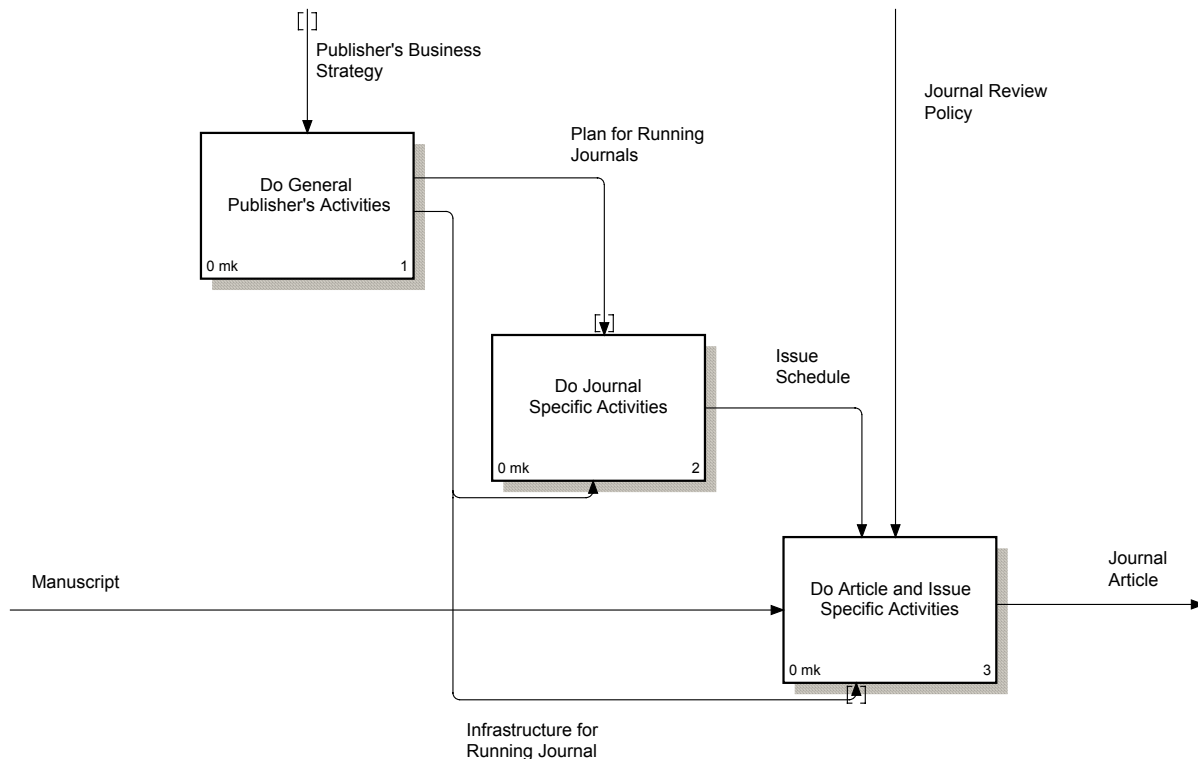
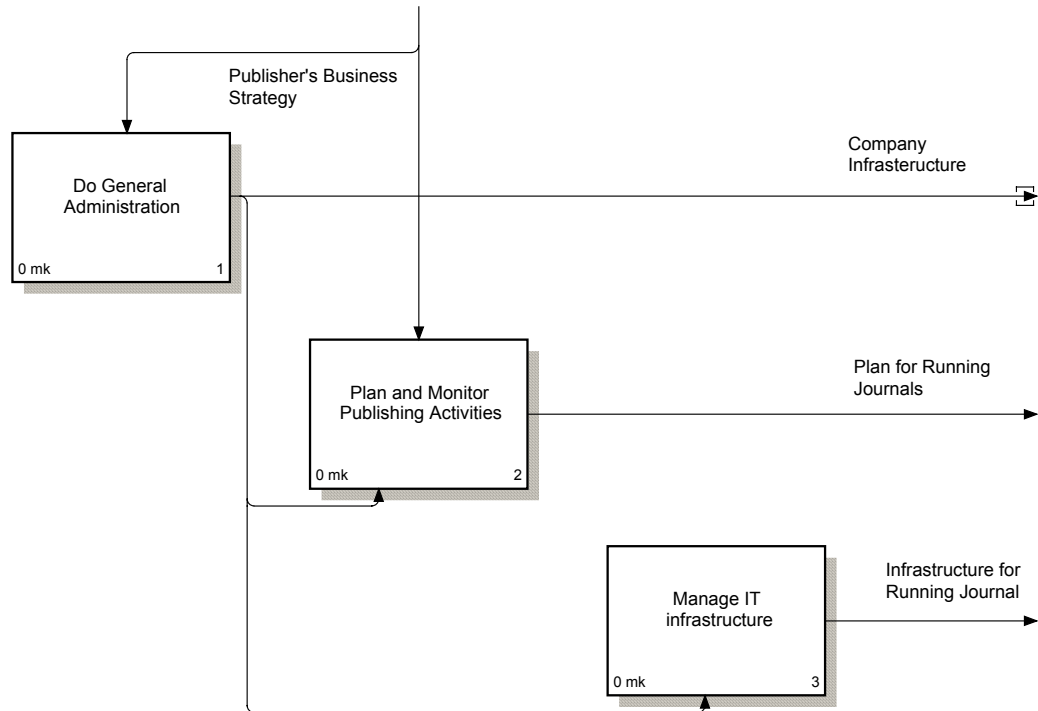


Diagram A223 Publish as Scholarly Journal Article

### A 2231 Do General Publisher's Activities

General publishing activities are typical for most commercial publishers and such professional associations which publish several journals. Activities can include general management and financial functions as well as the setting up of the IT-technical structure for the production of journals (both on paper and the web). Typically such infrastructures are shared for a number of journals because of the savings due to the economies of scale.



*Diagram A2231 Do General Publishing Activities*

## A2232 Do Journal-Specific Activities

Like many of the diagrams in this model, this model represents a choice of viewpoint. Here an important aspect is that commercial journals may spend a lot of money on marketing, and also on the management of subscribers (invoicing, setting up ways of checking access to electronic versions). For open access electronic journals, the latter activity is almost non-existent. Note the output arrow *issue schedule*, which is later used as a control of issue-specific activities.

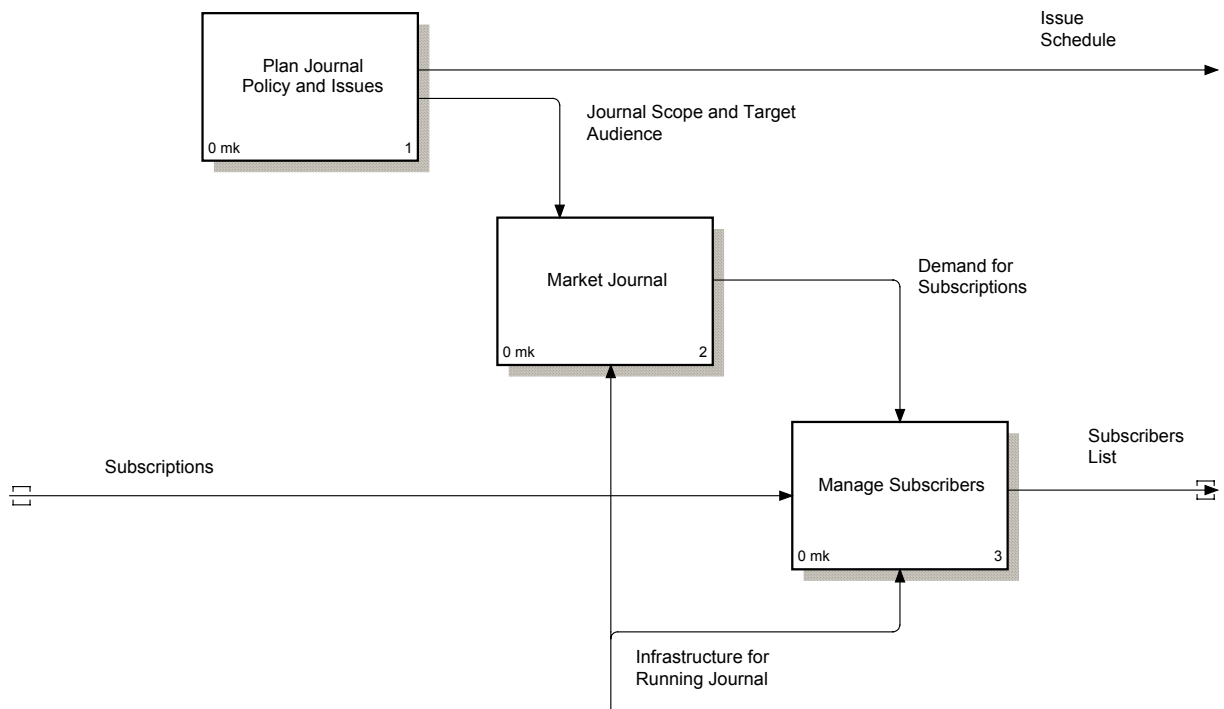
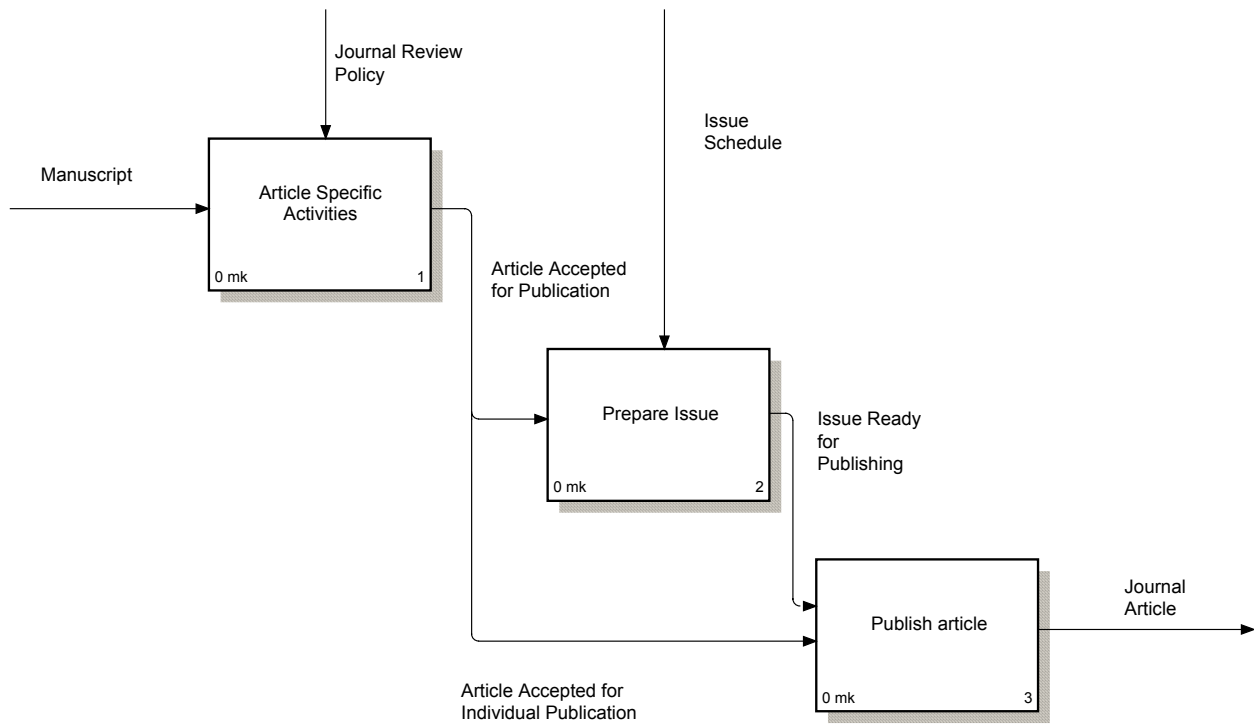


Diagram A2232 Do Journal-Specific Activities

### ***A 2233 Do Article and Issue Specific Activities***

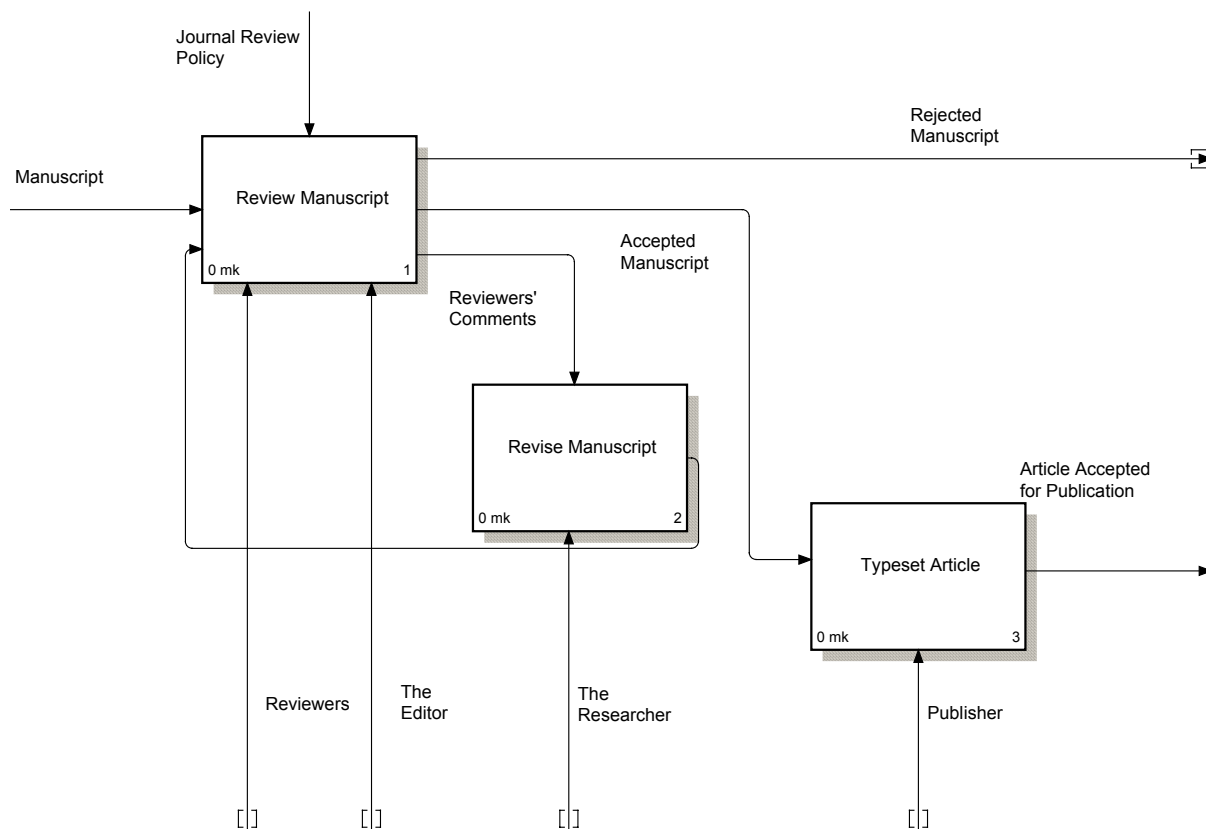
This diagram shows the two major modes for publishing scientific journals. In the paper-based world prior to 1990 articles were as a rule bundled into issues and had to wait for publishing until the whole issue was ready. Electronic publishing does however provide the possibility to publish each article as soon as it is ready. Today many journals are printed in both print and electronic formats but still retain the issue-based structure.



*Diagram A2233 Do Article and Issue Specific Activities*

### A 22331 Do Article Specific Activities

This part of the model depicts the activities carried out during the peer-review process as well as after the peer review to technically format the paper for printing. Note the use of a feedback mechanism, where the *reviewers' comments* become a control of the subsequent *revise manuscript* activity, and where the revised manuscript is feed back into the review process. Before the advent of personal computing the typesetting activity used to be an activity incurring considerable cost, but nowadays most researchers produce text which already is formatted according to the needs of the journal. Also the actual final typesetting is much easier since almost all information is acquired in a digital format.



A22331 Do Article Specific Activities

## A22332 Prepare Issue

This diagram includes a very significant activity which might escape modelling in many modelling exercises, which focus solely on cost or the publisher's activities. Once an article is accepted for publishing, it enters an activity called *queue for publishing*, which typically takes from half a year to a year for traditional issue&paper-based journals (the worst case this author has experienced was three years). Waiting does not imply a direct cost, but there may be an important opportunity cost involved from the viewpoint of the researcher and society, since the results are poorly spread before the actual publishing. This opportunity cost is different for different domains of science. It might be low for the humanities but is usually higher in the STM (science, technology and medicine) domain. In particular this is the case for IT research, where developments are extremely fast.

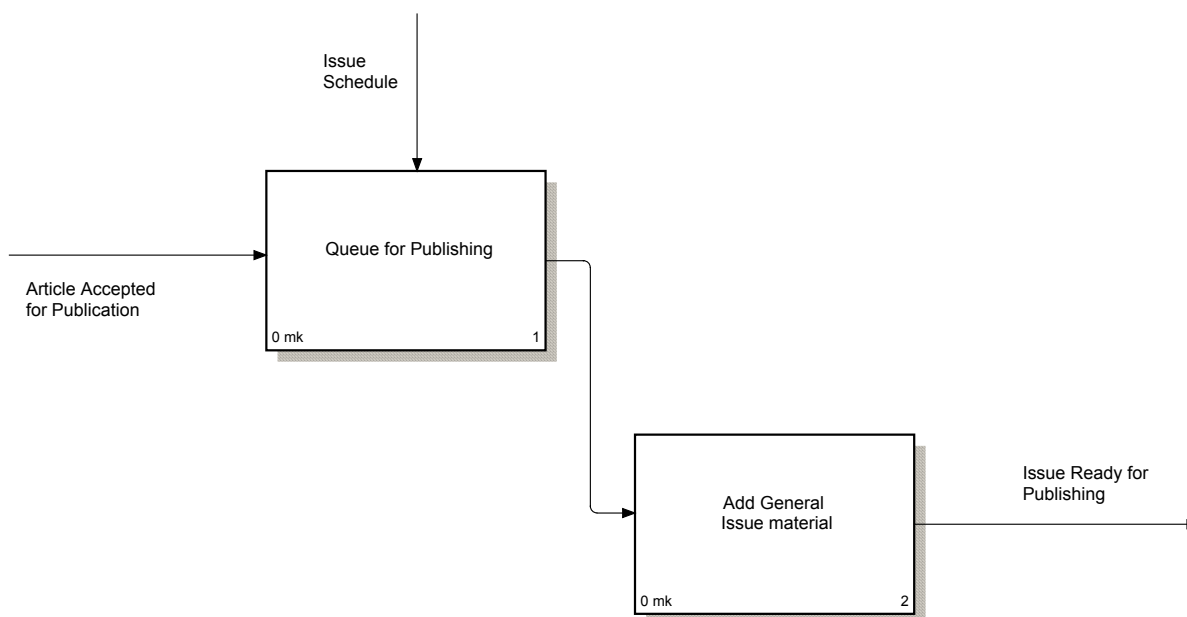


Diagram A22332 Prepare Issue

## A23 Archive and Index

This is the part of the overall process which traditionally to a large part has been handled by research libraries, with public funding. Note also that from a cost viewpoint, hundreds of libraries from all over the world have been performing the same archiving function for each paper version of an article. The primary activity is here *make publication available*, which secures that a publication is available either in print or electronically within a particular organization (such as a university), as well as that the publication can be found in different bibliographical search services. In the *perform value-adding services* a third party analyzes the data to calculate citation indexes, impact factors etc., or writes news bulletins about research results that practitioners can digest more easily. The *archive securely* activity is currently receiving increasing attention, since the archiving of electronic versions of journals for decades implies a number of difficult problems.

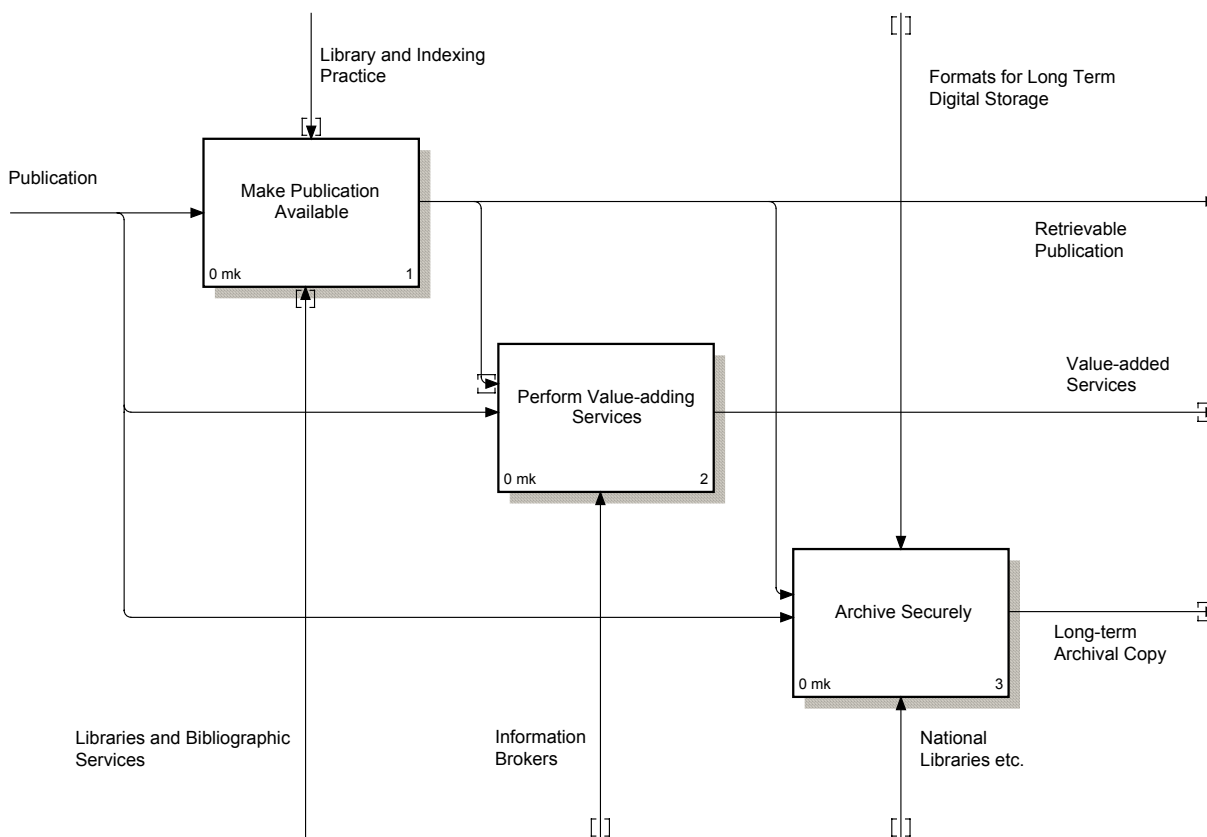


Diagram A213 Archive and Index

### A231 *Make Publication available*

This diagram includes both the activity of making the paper publication available (placing it in the shelves of the library) and making the electronic version available. In both cases this is preceded by the longer term activity of securing subscriptions and access rights to the material, an activity which is even more visible today due to the large library consortia that negotiate “bit deals” with the large publishers. An additional value adding activity is the integration of the meta data about the publication in data bases which facilitates finding out about the existence of the publication.

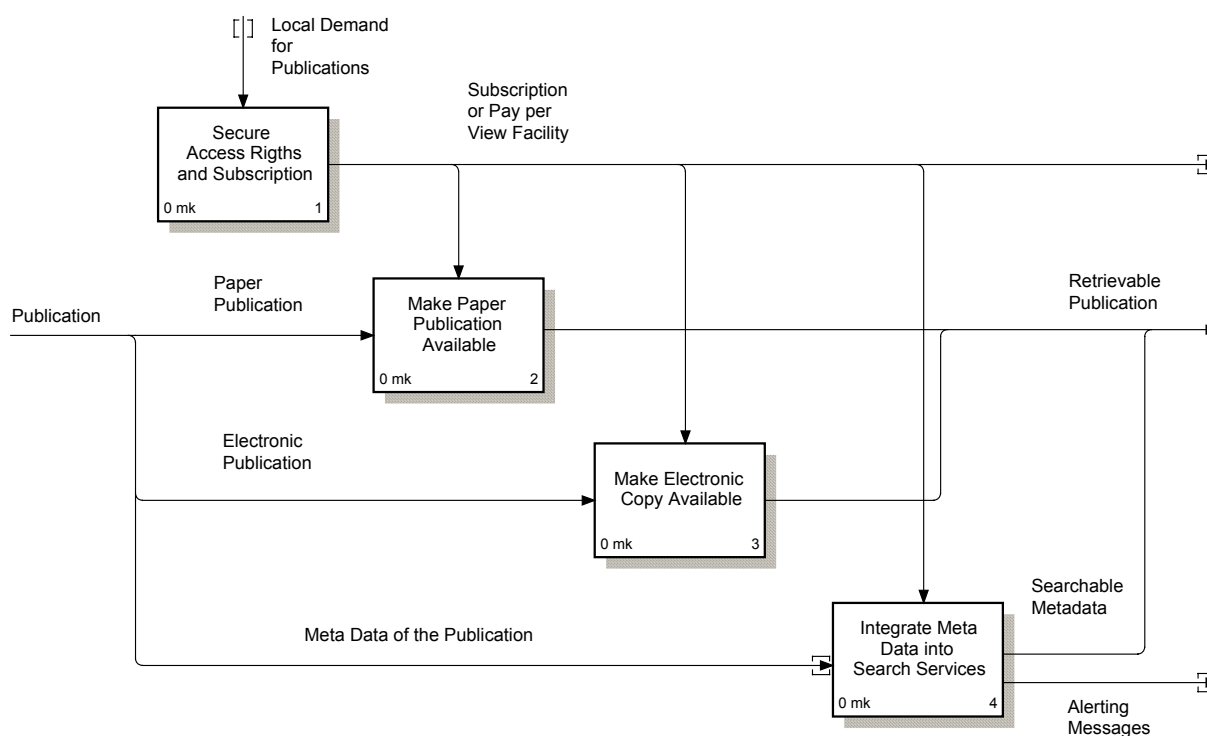
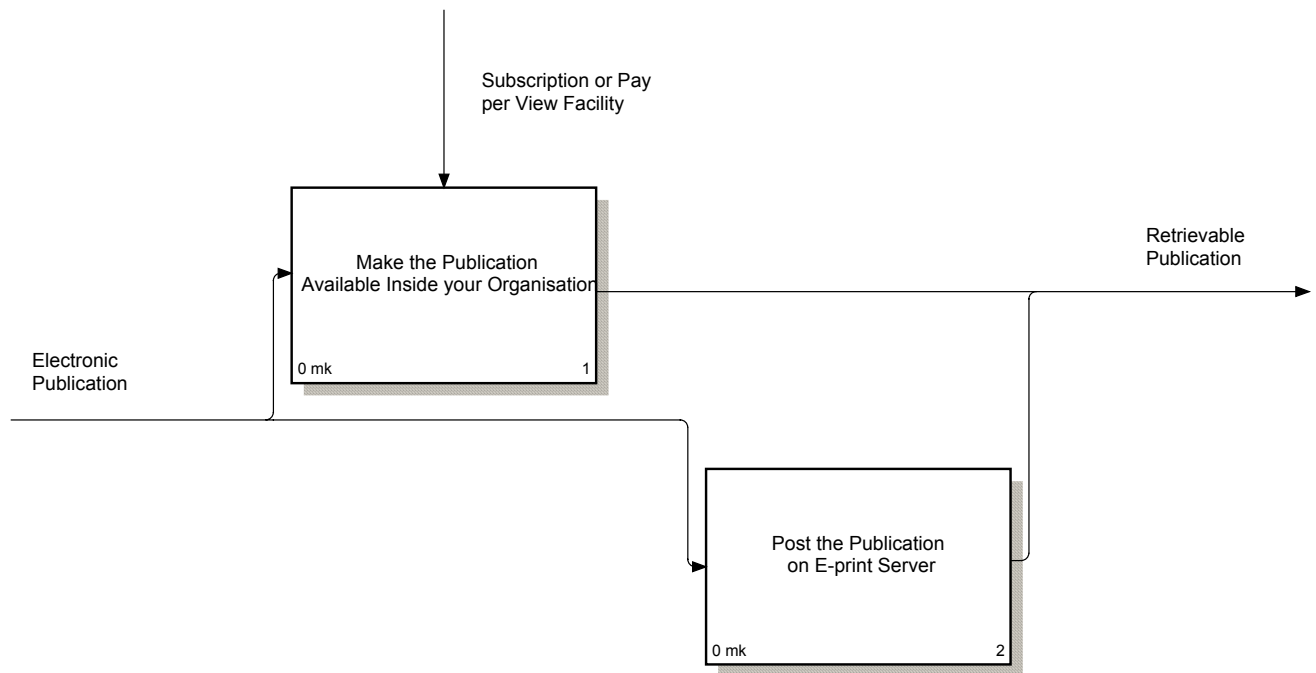


Figure A231 *Make Publication Available*

### **A2313 Make Electronic Copy available**

There are at least two major mechanisms for making an electronic copy of a publication available doing this. Firstly this can be done through standard commercial services, which necessitate that the reader or normally the local university library has secured a subscription and makes the publication visible via the university intranet. A second possibility which partly bypasses this is if the author has sent a copy of the publication to an open access e-prints repository as exemplified by the Los Alamos preprints server for physics



*Figure 2313 Make Electronic Copy Available*

### A2314 Integrate Meta Data into Search Services

Traditionally commercial indexing services have dominated this function and libraries have paid subscriptions to them. Over the past years researchers have increasingly started to use general web search engines for trying to identify interesting publications. An effort to overcome the quality problems related to this is the definition of the Open Archives Initiative standard for tagging scientific content material on the web, which will enable dedicated harvesting search engines to maintain a much more focused data base of links to relevant publications.

A byproduct of the heavy use of IT for these purposes is the possibility or readers to subscribe to services, which based on the interest profiles they define, can send them alerting email messages when something they might be interested in is published.

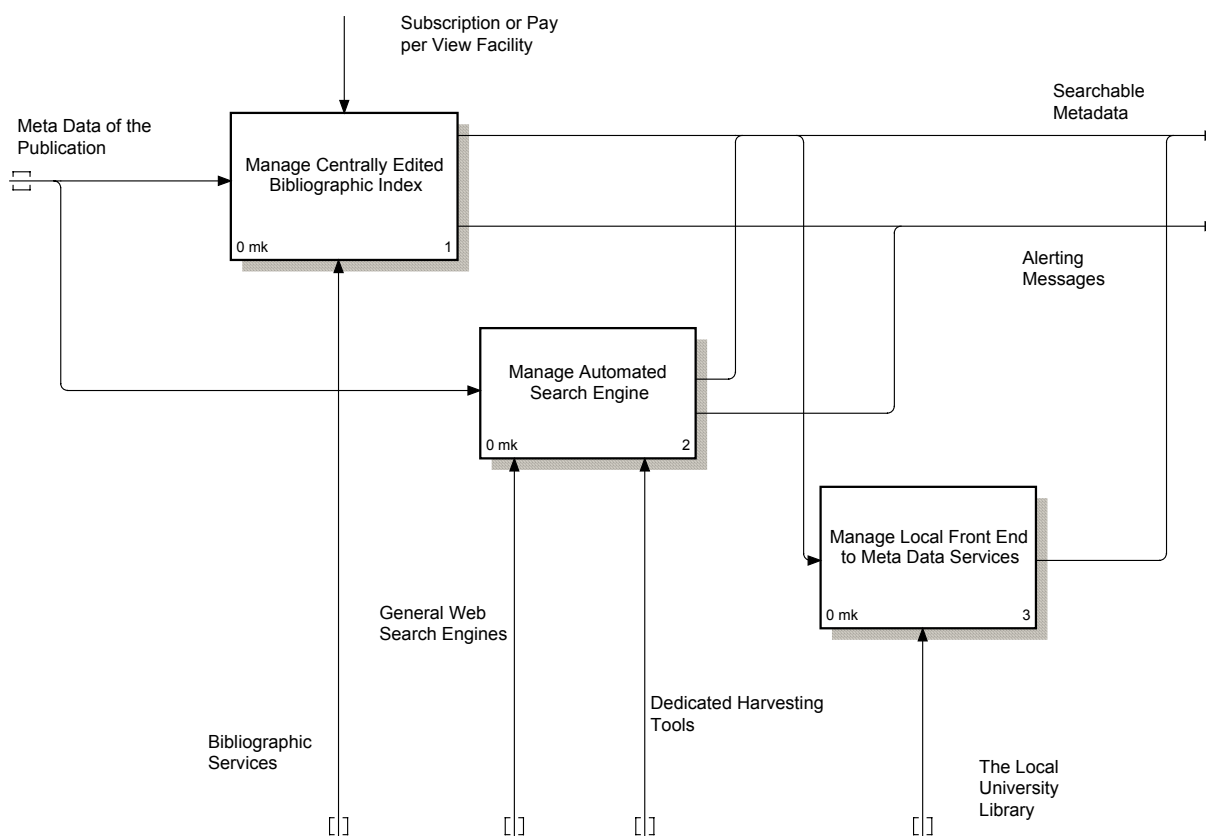


Figure 2314 Integrate Meta Data into Search Services

## A232 Perform Value Adding Services

In this overall category some party analyses the data to calculate citation indexes, impact factors etc., or write news bulletins about research results that practitioners can digest more easily. The three categories are not exclusive and just given here as examples.

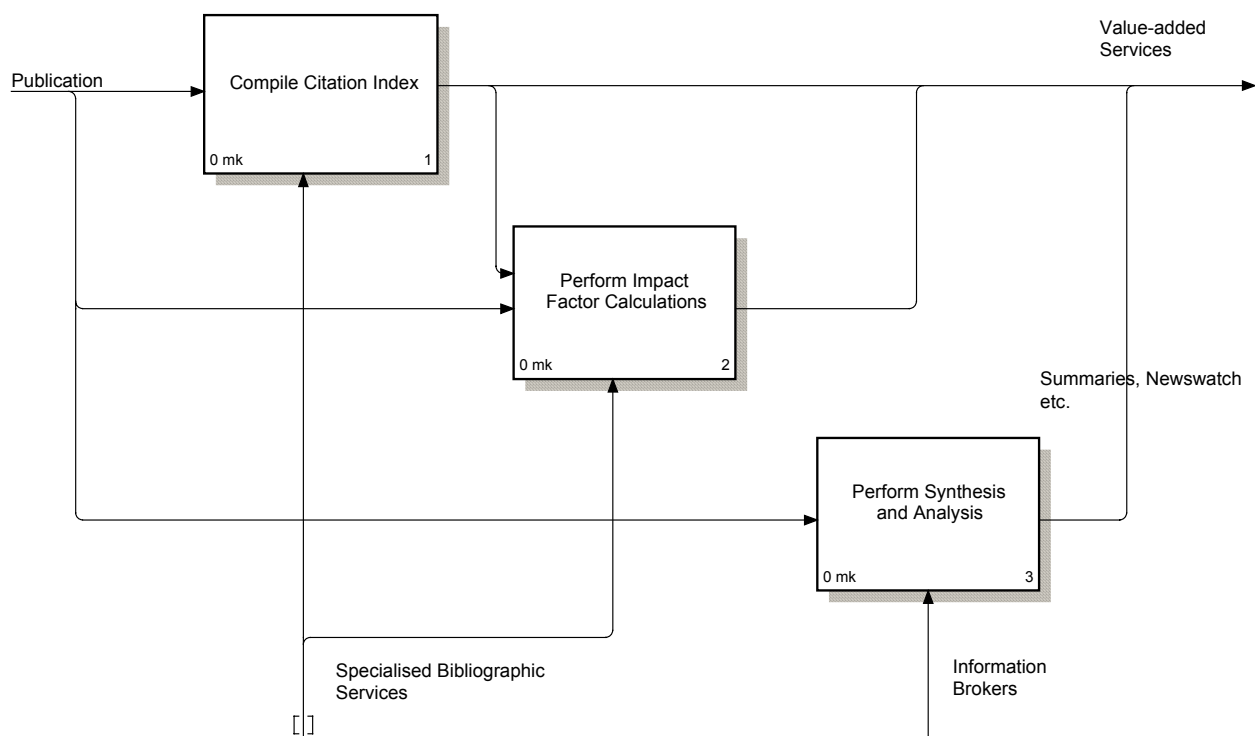


Diagram A2133 Perform Value-adding services

### A3 Study the Results

This diagram structures the activities of the readers of scientific activities. Note again that from a cost per publication the activities of individual readers all over the world and in different time periods should be summed up. *The find out about publication activity results in the output metadata of interesting publication (including the location from which a paper or electronic version can be retrieved). This output is used as the control of the retrieve publication activity. Finally the publication is read and the scientific information in question has been disseminated.* Note that as a rule researchers self-archive interesting publications they have read either as paper copies or today increasingly as bookmarks or in a data base.

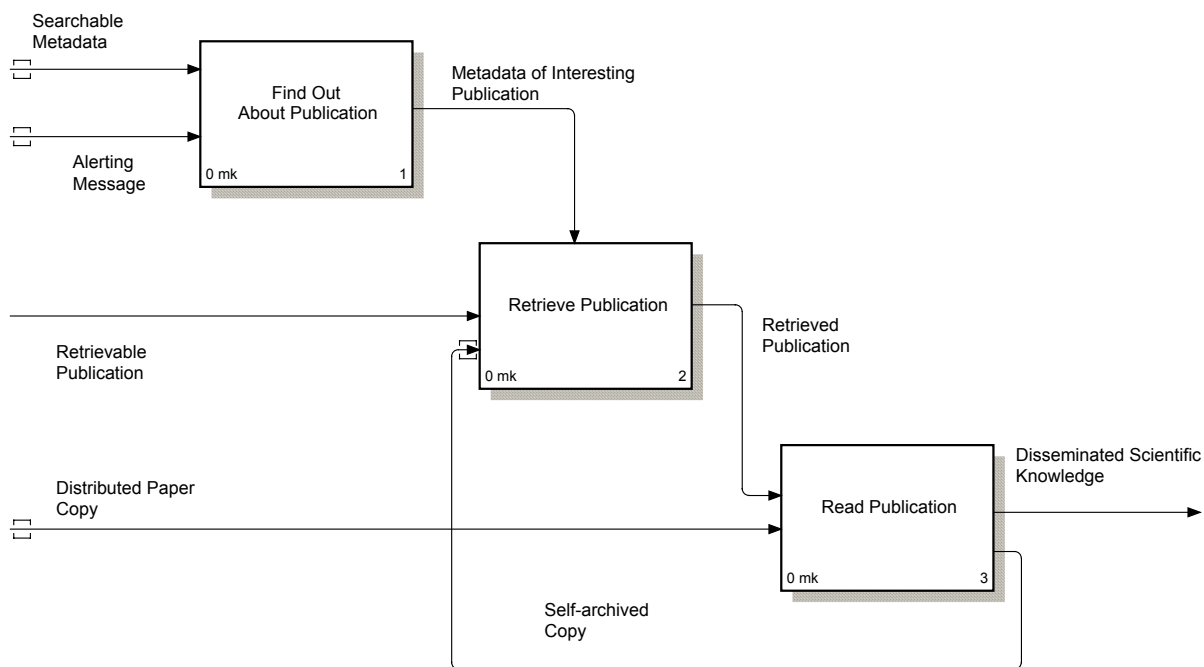
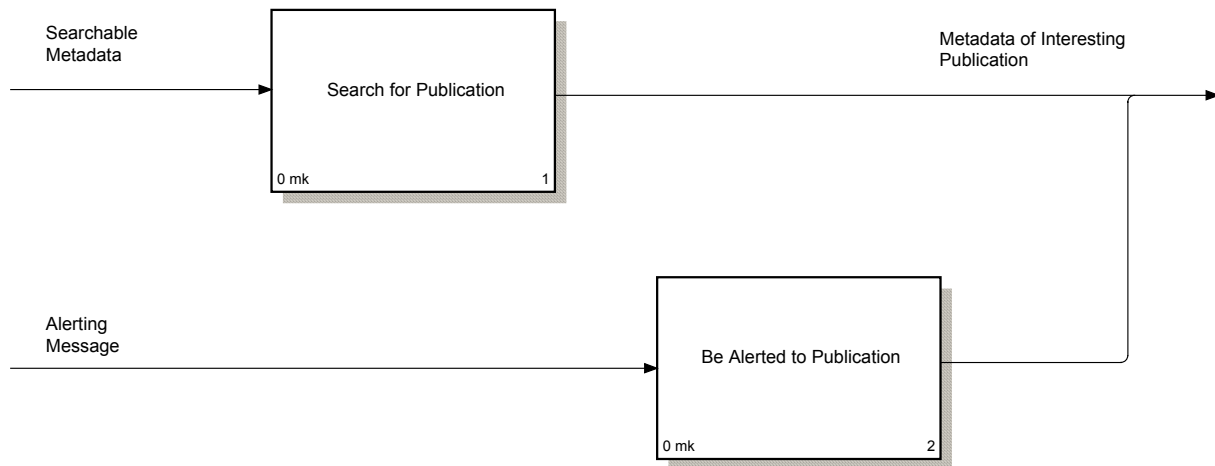


Diagram A3 Study the Results

### **A31 Find Out about Publication**

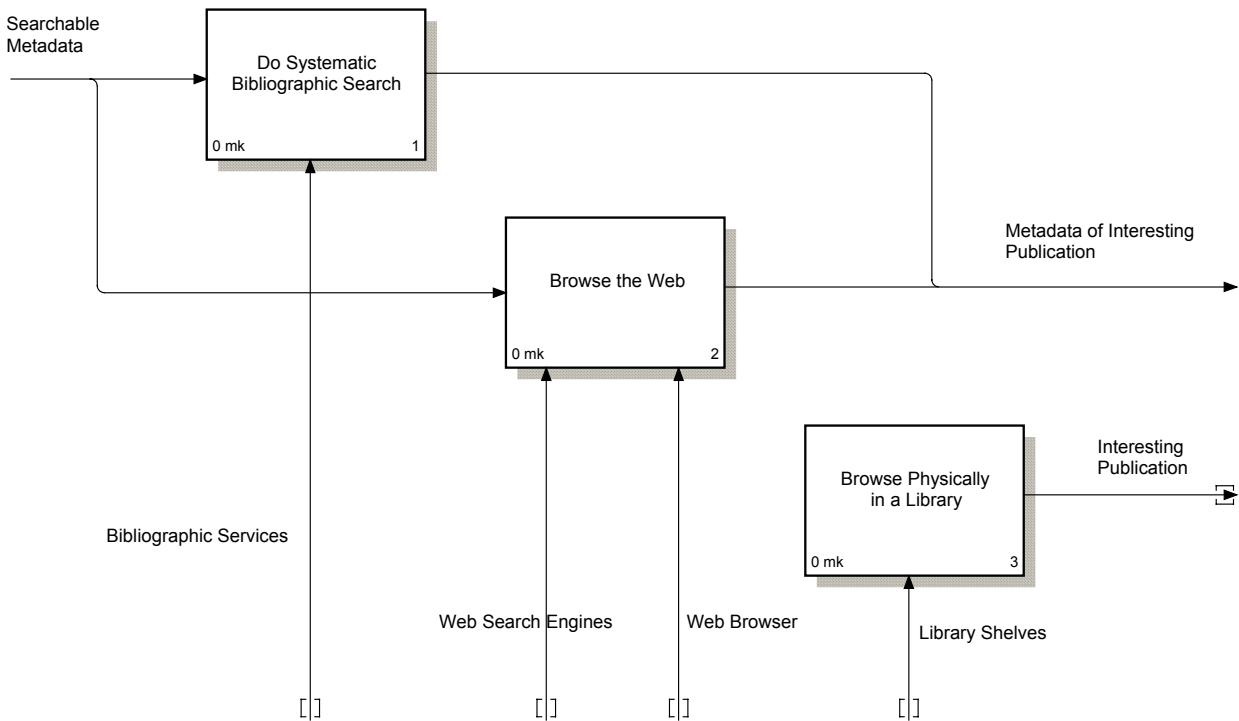
This activity is rather difficult to split up into alternative parallel options (for each identified article one of these is used ). On this first level there is a split into two generic categories. The first one is active search where the reader is “pulling” for information. The other option is push, where the reader receives a notification through some mechanism that something interesting has been published.



*Diagram A31 Find Out About Publication*

### A311 Search for Publication

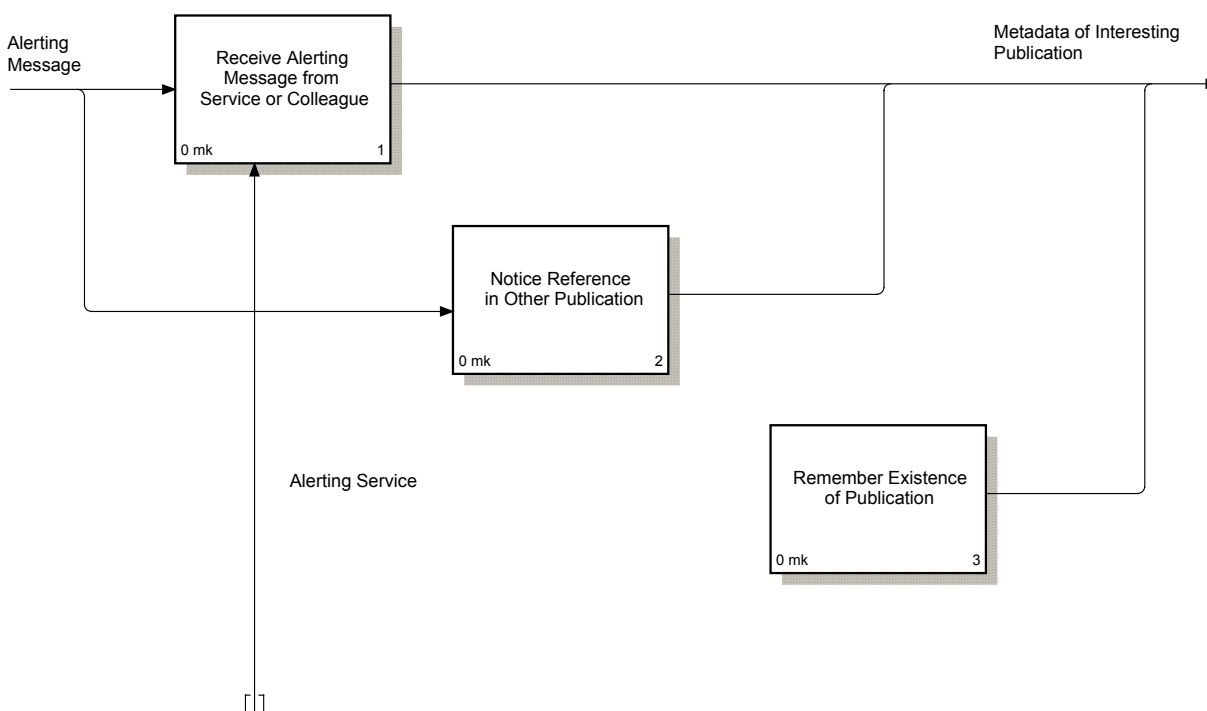
The first modeled option of the pull variety is a traditional bibliographic data base search, for instance using key words. Other possibilities include more unstructured web searches using a general search engine or just browsing from one hyperlink to the other. Less and less the traditional method of physically browsing in library bookshelves is used.



*Diagram A311 Search for Publication*

### A312 Be alerted to publication

Receiving a hint from a third party could be a hint from a colleague or a supervisor, or in today's world a hint from a software based alerting service. The important distinction is that the bibliographic search is triggered by the researcher himself (pull) whereas the hint is coming from the outside (push). *Notice reference in other publication* is a very common way of finding out about an interesting publication. This is where it would be so convenient if all publications were for free on the Internet, because the retrieval would then only entail pressing a hyperlink. The last option *remember existence of publication* is less evident.



**Diagram A312 Be alerted to publication**



## A4 Apply the Results

In the same way as the breakdown of A1, Do Research, this diagram is more of a contextual nature, since no further breakdown of the technology transfer process is attempted. It tries to show how disseminated scientific knowledge can be transferred by several parallel mechanisms into better industrial performance, new products and services and eventually a better quality of life. One of these mechanisms is education and training, which results in better trained professionals who go out into working life (i.e. medical doctors and engineers). There is a rather straightforward link between research and especially university education. A second mechanism is through commercial development work which translates research results into new products, services and working methods. A third mechanism is where practitioners read research publications and are directly affected by them.

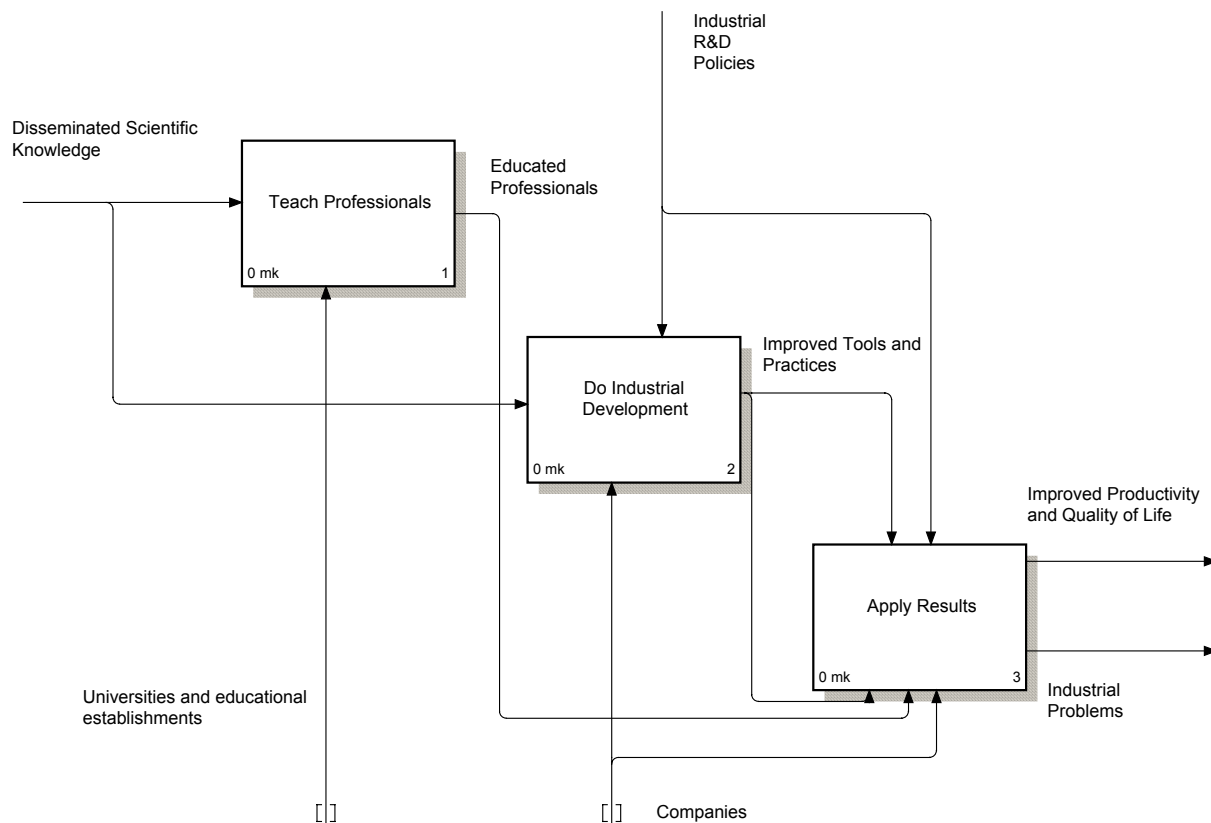


Diagram A4. Apply the Results

## 6. Conclusions

The use of a formal process modelling language for a purpose such as this was motivated by the personal experience of the main researcher, having earlier used this type of methodology for the modelling of the construction process as well as having led an international project investigating innovative process modelling methodologies. The initial experiences have been very positive. The studied process is by its very nature rather linear (contrary to for instance architectural design), which makes the modelling easier than for processes involving a lot of networking or iterative procedures. Also colleagues to whom the model has been shown have quite easily grasped the fundamentals of the IDEF0-notation and have been able to follow the logic of the model.

The model in its current shape is not yet validated in its details, but has been discussed with a number of domain experts (publishers, librarians) with encouraging feedback. Based on these discussions and on the extensive literature review done as part of the SciX project it is the conclusion of the authors that this is the first time a formal process modelling methodology is used in this comprehensive way to model the system of scholarly communication. Publishers employ methods of a similar nature to study the workflows within their organizations, but the point here is to study the whole process, including the activities of libraries and readers, and to use the process model as a basis for determining the activities which will be studied more in detail as a part of the cost modelling.

The cost modeling will be a synthesis task of data from several different sources. To some extent web surveys will be used, in particular concerning the economics of open access journals and repositories and reader behavior. Research work of other researchers concerning the cost of certain activities in the model will also be used [for example Tenopir and King 1998, Odlyzko 1998]. The common denominator will be the to study costs per publication flowing through the system. In addition to the cost modelling the model could also prove useful in providing a roadmap showing the place of a number of different initiatives for increasing access to scientific publications, within the overall system of scholarly communication.

### ***Acknowledgements:***

The presented work has been conducted in the context of the SciX project, funded by the European Commission under the contract IST-2001-33127. The opinions expressed in this paper are that of the authors and do not necessarily represent the opinions of their employers, of the SciX Consortium or of the European Commission. Note that the version of the model presented in this paper is the second first draft (version 2.0) and that the model is continuously evolving based on the feedback we receive. The latest updated version of the model can be found on the SciX website (<http://www.scix.net/>), which interested readers are advised to consult.

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