



Design and development of institutional repositories: A case study[☆]

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Summary Institutional repositories (IR) are digital collections that capture, collect, manage, disseminate, and preserve scholarly work created by the constituent members in individual institutions. They are born out of problems with the current scholarly communication model developed by commercial publishers and vendors. The establishment of IR in the developing countries ensures that their national research becomes mainstream and contributes on an equal footing to the global knowledge pool. This paper presents the results of an effort to develop an IR of publications of the Indian Institute of Science (IISc), Bangalore, India. Since self-archiving is extremely sporadic, this repository is compiled from several identified, authentic sources by extracting metadata by constructing a suitable search strategy. The extracted metadata are standardized and duplicate publications are removed. The database is updated periodically and publications can be added and edited through the add publication module. The search module allows users to search by specific publication type. Links to full text are given wherever possible. The repository, named "PRABHAVI", is web-enabled using Greenstone Digital Library software and can be accessed at: <http://vidya-mapak.ncsi.iisc.ernet.in/cgi-bin/library>

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Introduction

An institutional repository (IR) is a new method for capturing, collecting, managing, disseminating, and preserving scholarly works created in digital form by the constituent members of an institution (Chang, 2003). In a position paper, The Scholarly Publishing and Academic Resources Coalition (SPARC) examined the strategic roles IR play and outlined the viability and long-term impact of institution-based digital collections that preserve

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the research and scholarship of an institution (Crow, 2002). The paper asserts that IR is a natural extension of an academic institution's role as a generator of primary research and lists the four essential characteristics of an IR as: (1) Institutionally defined, (2) Scholarly content, (3) Cumulative and perpetual and (4) Interoperability and open access. An effective IR of necessity represents collaboration among researchers, librarians, information technologists, archivists, records managers, administrators and policymakers.

IR answers two challenges currently facing academic institutions. First, they reform scholarly communication by stimulating innovation in a disaggregated publishing structure. Second, they serve as tangible indicators of an institution's quality, thus increasing its visibility, prestige, and public value (Crow, 2002). Thus, establishment of IR especially in the developing countries ensures that their national research becomes mainstream and contributes on an equal footing to the global knowledge pool. In fact, IR is one of the two routes viz., Open Access Journals/Publishing and Open Access Archiving, recommended by the Soros supported Budapest Open Access Initiative, which aim to free research literature from crippling access tolls and promoting the research output of all contributing institutes (<http://www.soros.org/openaccess/read.shtml>).

Open access archiving: E-print archives and IR

Open access archiving can be either discipline-based, as in the case of e-print archives, or institution-based, which are defined as IRs. Preprints in digital format are known as e-prints and the online databases from which they are distributed are called e-print archives (Lawal, 2002). The physics community has a long history of using preprints and established ArXiv, an e-print archive at Los Alamos National Laboratory in 1991 (<http://www.lanl.gov>). Recently other disciplines have also established e-print archives. The rapidly increasing subscription rates and the growing ranks of journals has forced libraries to look at e-print archives as a possible way to relieve the cost (Odlyzko, 2004).

Though e-print archives offer very positive advantages in terms of rapidity of scientific and scholarly exchange and access to information, it raises important issues regarding intellectual property rights, peer review, the integrity of data and the storage and archiving of material (Tennant, 2002). Also, the success of the early subject-based

repositories has not been repeated in other disciplines. Chemists and biomedical researchers seem to fear the clinical or social consequences of the publication of non-peer-reviewed preprints, and scholars in humanities often are concerned of the risks of plagiarism (Ware, 2004b). The same is observed in the case of IR also. According to a survey of 45 IRs, the average number of documents per archive is just 1256, most of which were theses or gray literature such as technical reports and working papers (Ware, 2004a). This is because self-archiving is extremely sporadic. Authors are unlikely to adopt entirely new and untested methods of communication in the short term and worry that it will be difficult to assess the impact of their research if it is not published in peer-reviewed journals. But many are unaware of the advantages of gaining greater visibility and are reluctant to make the effort to post their articles on archives. However, authors can continue to publish in their preferred refereed journals, merely archiving the preprints of the already published papers in their institutional archives, simultaneously or subsequently.

In order to establish a comprehensive IR, as an effective intermediate step, one would need at least (a) many more authors, in a range of disciplines, to participate, (b) many more (especially not-for-profit) journals to permit the practice and (c) much better coordination among repositories to ensure the best possible cross-institutional access. More importantly, universities and research institutions have to officially commit themselves to implementing a systematic policy of open-access provision for their own peer-reviewed research output (<http://www.eprints.org/signup/sign.php>).

In the absence of systematic official legislature and given the sporadic nature of authors for self-archiving, an effort is made here to design and develop a comprehensive and effective IR taking Indian Institute of Science (IISc) publications as a case study, based on several authentic, published sources. Started in 1909, by J.N. Tata, IISc (www.iisc.ernet.in) is a premier institution of advanced research and teaching, with more than 2000 active researchers working in almost all frontier areas of science and technology. The repository, named 'PRABHAVI' (PRAkatan: Publications; BHARateya Vlgiana mandira: Indian Institute of Science), is an abbreviation for IISc publications. It is compiled by identifying, extracting metadata from several authentic, published sources by constructing a suitable search strategy. The extracted metadata are standardized and duplicate records are removed. The database provides access to journal articles, conference publications,

patents, technical reports, theses, books and book chapters. PRABHAVI is web-enabled using Greenstone (www.greenstone.org).

The main objective of the study is to design and develop an IR with the following functions:

- To publish and archive scholarly work of an institution locally, using authentic information sources
- To enable long-term preservation of scholarly work
- To facilitate constituent members of an institution an easy and rapid way to publish and archive their research locally
- To provide an integrated view of and act as a single entry point to scholarly work of an institution
- To provide wider accessibility, visibility and distribution of the scholarly work of an institution
- To act as a self-evaluation tool for the management.

In the paragraph below, salient features of PRABHAVI are described.

Methodology

This preliminary study concentrates on compilation of repository of IISc research publications based on several international databases subscribed by IISc and freely available resources on the Net. For theses sample collection, the metadata are extracted from IISc library OPAC for the theses submitted during 1985–1995.

The following are the broad steps involved:

Identify different external sources

Despite the proliferation of electronic databases and the facilities to search multiple databases, not very much is known about how information on a particular topic is distributed throughout different databases. Additionally, despite the tools provided by some on-line hosts for searching over multiple databases or for discovering which databases are most productive for particular search statements, more needs to be known about the distribution of records for a particular topic across many databases. There has been very little work done on how information on a particular topic is distributed among the many available databases in stark contrast to the plethora of work done on analyzing the distribution of articles on a topic in different

journals. The work on the distribution of articles in journals does not translate directly to articles in databases, because journals and databases are quite different entities. Two characteristics in particular are quite different: databases typically have many more records than journals have articles; and articles typically appear in only one journal, whereas records of articles in journals may appear in many databases (Hood & Wilson, 1999).

To identify the distribution of IISc publications among the many available bibliographic databases, a profile of IISc research activities is constructed, based on the research carried out at about 37 different departments in IISc. This is matched against the scope and coverage of different databases. Since the databases are available on different platforms and through different service providers, an analysis of retrieval software and database accessibility is also carried out while selecting the databases. This analysis resulted in about 10 core databases, which include IISc publications.

Search strategy formulation

When conducting a search on databases, a searcher enters one or more terms, gets a response from the system, and iteratively modifies the terms until satisfied with the results. The iteration in the search formulation and reformulation process can be considered a search move. A set of moves that are temporally and semantically related can be a search tactic. An efficient search strategy requires both domain knowledge (searchers knowledge of the search subjects) and knowledge of searching techniques (Bates, 1979; Fidel, 1985; Wildemuth, 2004).

For the present study, IISc publications are defined as those publications, which has either 'IISc' or its variant forms in the author affiliation. Since the databases are accessed using different publisher/vendor software, depending on the search and retrieval feature of the software, a search strategy is constructed and iteratively modified to retrieve all the records pertaining to IISc. Most of the retrieval software facilitate search by author affiliation. In the absence of searches by author affiliation, a general search for the institution name is carried out and manually the records are checked for affiliation.

Heterogeneous resources integration

Building such a repository based on highly heterogeneous and distributed systems poses problems at

the technical level (such as different operating systems and user interfaces) and at the conceptual level (such as same objects are named using different terms and represented in different ways). One substantive approach to Meta search (search across heterogeneous data) is to create a new application that integrates multiple search requests into a union search platform. This is done in two ways: core metadata-based method (CMB) and web-based method (WBM).

In CMB (Fig. 1), the metadata records of all available heterogeneous databases are harvested into a new database. The search is then performed on this database. Because of the diverse types of metadata, the new database must have a core metadata set as the transform standard in order to integrate the different types of metadata forms into the new harvested database.

In WBM (Fig. 2), an application is employed to accept and distribute the request. This application plays the role of an intermediary. If the source database search system is web based, it can be added into the application as an option. Unlike CMB, WBM maps a query between multiple database search systems (Lin Fang, 2004; Li Yongwen & Zhang Xiaolin, 2002; Powell & Fox, 1998).

PRABHAVI is constructed based on the CMB method because the databases searched are not only web based but also are available in other media such as CD-ROMs and floppy disks. Since each database gives metadata in a different format and classifies the publication in a different way, a list of metadata to be included in the harvested database along with the format for different types of publications is created (Table 1). The records pertaining to IISc are extracted and converted to this format and stored in a MySQL database.

Standardization of metadata fields

Since PRABHAVI is compiled from several sources, the metadata extracted are not in a standard form. Besides this, there are also typographical errors in the extracted metadata. For accurate retrieval of relevant information and effective indexing of the database, the extracted metadata, especially author and author affiliation, have to be standardized.

In the case of author names, for example, Mehta Indra Kumar occurs in the compiled database in the following variant forms: Indra Kumar Mehta; Mehta, Indra Kumar; Mehta, I.K.; I.K., Mehta; Mehta IK. The framing of the rule for standardization of author names is governed by the fact that if none of the databases provides the full name of the author, it is not possible to know what the initials stand for. Hence the standard form for author should comprise only initials. Also, users find it easy to type the author name without using commas or dots. Because of these reasons, the standardized author name is rendered as: <Second name> <Initials without dots>. Hence, all the variants of Indra Kumar Mehta listed above is replaced by one standard form, viz, Mehta IK

Similarly, author affiliation is not rendered properly because: the institute and department names have been given in variant forms; in case of multiple authors multiple addresses have not been delimited properly; project or laboratory name is provided instead of department name; and the department name is not given at all in many cases. Also, the institute name, viz, Indian Institute of Science is rendered in different ways. Hence while standardizing author affiliation, first the string 'Indian Institute of Science' is standardized and later the department names are standardized by going through a standard synonym list prepared using the author affiliation as given by different databases for department names.



Figure 1 Core metadata-based method.

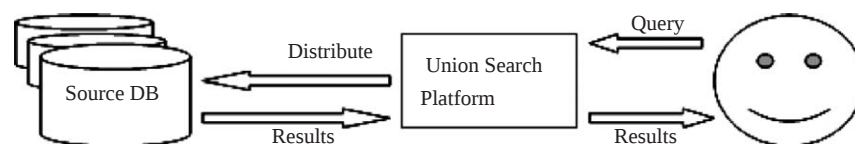


Figure 2 Web-based method.

Table 1 List of metadata fields identified for different types of publications.

Field names/doc types	Journal	Conf proc	Book— whole	Book— chap	Report	Patents	Thesis
Title, primary; chapter title	*	*	*	* Chap title	*	*	*
Authors, primary	*	*	*	*	*	*	*
Date, primary	*	*	*	*	*	*	*
Start page	*	*	*	*	*	*	*
End page	*	*	*	*	*	*	*
Periodical (1)	*	NU	NU	NU	NU	NU	NU
Periodical (2); edition	*	NU	*	NU	* (Rep no)	*	NU
Vol no; application no	*	*	*	NU	NU	*	NU
Title (sec); book title	NU	NU	NU	* (Book title)	NU	NU	NU
Authors (sec); editors; assignees	NU	*	*	* (Editors)	NU	*	* (Guide)
Issue no; edition; chap no; patent no	*	*	*	*(Chap no)	NU	*	NU
Publication place/date; patent country	NU	*	NU	*	NU	*	* (Department)
Publisher	NU	*	*	*	*	NU	NU
References	*	NU	NU	NU	NU	*	NU
Series title	NU	*	*	*	NU	NU	NU
Series author; series editors	NU	NU	*	*	NU	NU	NU
Abstract	*	*	NU	*	*	NU	*
ISSN/ISBN	*	NU	*	*	NU	NU	NU
Availability	*	NU	NU	*	NU	NU	NU
Date (sec), date filed	NU	NU	NU	NU	NU	*	NU
Class code (intl); type	NU	NU	NU	NU	* (Type)	*	UDC class number
Class code (US)	NU	NU	NU	NU	NU	*	NU
Address	*	*	NU	*	*	NU	NU
Web, URLs	*	*	*	*	*	*	NU

NU, not used; *, available.

Remove duplicate records

Bibliographic databases typically overlap to a large extent in their coverage of the source literature. When searching for records in bibliographic databases, records are considered as duplicates when they are surrogates for the same source article. This may happen even though the record may look quite different in different databases and even within the same database. For example, representations of authors may be different, field structure may vary, and title, abstracts may be different. When determining the distribution of records in databases, duplicate records need to be taken into consideration (Hood & Wilson, 1999).

It is difficult to come up with a reliable duplicate detection algorithm because (a) databases use quite different representations for bibliographic records (e.g., the way authors are treated), (b) there are many errors in the databases and (c) the databases often have unparsed fields with many subfields that are difficult to accurately analyze algorithmically.

Many commercial vendors have used a duplicate detection algorithm in their retrieval software. Ingwersen and Christensen (1997) note that the duplicate removal algorithm used by DIALOG is not completely reliable. Records can either be wrongly identified as duplicates or not correctly identified as duplicates. Miller (1990) indicates that the DIALOG algorithm checks for first author and title but not source or publication year. Errors in author or title fields can result in duplicates being missed; articles with the same author and title, such as a conference paper later appearing as a journal article are wrongly tagged as duplicate. In general, the large number of errors (or variations in representation of records) in bibliographic databases will cause errors in the duplicate detection algorithm. Due to these problems in duplicate record detection, it is better to use the algorithm for identifying the duplicate records and manually check that all proposed duplicates are real duplicates because missed duplicates are much harder (or infeasible) to detect.

Table 2 Number of records in the database before and after removing the duplicates.

Year	Records after removing duplicates	Total records from different sources	Percentage of removal
2004 (January–May)	717	1390	48.42
2003	2055	3750	45.20
2002	1439	2796	48.53
2001	1473	2797	47.34
2000	1478	2451	39.70
1999	1418	2236	36.58
1998	1316	2213	40.53
1997	1363	2281	40.24
1996	1470	2469	40.46
1995	1326	2244	40.90
1994	1399	2259	38.06
1993	1235	1989	37.91

To identify duplicate records in PRABHAVI, an algorithm is developed, which identifies duplicate records based on publication title and ISSN/ISBN numbers. After removing stop words and white spaces in the title, the first 250 characters are converted to upper case. This string along with the ISSN/ISBN number is used for identifying the duplicate records. The duplicate record removal is done manually taking other metadata fields such as publication type, author name and volume number into consideration. Appendix A gives a few examples of duplicate publications. Table 2 gives the number of records from all the databases and the number of records in the repository after removing the duplicates for the last 10 years. This table indicates that about 48% duplicate records were identified and removed from the compiled database.

Identify different publication categories and metadata details

Metadata is the Internet-age term for structured data about data. Typical examples are library catalog records and bibliographic headers in Web pages. Different user communities define and use metadata for different purposes. Publishers and other content providers are seeking agreements on standards to enable new forms of electronic commerce. Since there is an overlap in the categorization of different types of publication among different databases, depending on the publication type and metadata description given in each database, the publications are classified as journal article, conference publication, technical

report, patent, book and book chapter and thesis. Table 1 gives metadata details of different types of publications covered in the repository. These metadata details are decided based on the details given for each type of publication on different databases.

Link to sources, which provide full text access

PRABHAVI works on the reference linking, which allows the user to click on a reference and be taken directly to the target content. The scientific and scholarly community prefers clickable links, which provides navigational ease at the desktop. Reference linking provides users with context-sensitive linking to services that the institution has defined and customized on the basis of its e-collections and policies. It improves linkages between metadata and the resources and services that are available over the intranet and Internet. By providing links, which are truly persistent, usage to acquired resources is increased and access to content not owned is expanded.

The implementation of reference linking is a step forward in meeting users' expectations for the digital environment.

Reference linking in PRABHAVI is viewed in two ways: Access to old publications for which there is no online access available and access to new publications for which online access is available and access is given through linkages.

Old publications, which are not available in e-form publications, are scanned if it is not copyrighted; otherwise, location details are given. This

is demonstrated for four journal publications authored by Kolhatkar GB in 1914; Sudborough JJ in 1916; Cadre ST and Sudborough JJ in 1916; Watson HE and Pal G in 1916 and two Indian patents numbered IN 170691, IN 43403. For other publications it has to be carried out in the future. However, for journal publications a few selection criteria such as Societal publications, Journals with emphasis on basic research and theory, Editorial policies and citation practices followed by the journals, Journals citation rate and impact factor can be used for considering a particular journal publication for converting to e-form.

For recent publications the following linkages are demonstrated in PRABHAVI for a few publications:

- DOIs (Digital Object Identifiers), which are tagged to article metadata supplied by the participating publishers. A DOI allows for persistent linking, because once material has been given a DOI it never changes, unlike a URL which becomes obsolete when it is moved. The end result is an efficient, scalable linking system.
- Open archive journals whose publishers allow self-archiving (as given on <http://www.ecs.soton.ac.uk/~harnad/Temp/Romeo/romeo.html>).
- Journals subscribed by the IISc library.
- Since IISc is a member of Indian National Digital Library in Science and Technology consortium (INDEST), providing link to INDEST subscribed full text journals will help other INDEST members to access the full text journals.
- Freely available online journals.
- European and US patents.
- Author details such as email address, department, phone number.

Web enabling the database

The Open archives Forum lists about 40 software packages for creating OAI compliant databases (<http://www.oaforum.org/index.php>). PRABHAVI is web enabled using open-source, multilingual, full text indexing software, Greenstone (<http://www.greenstone.org>), a suite of software for building, publishing and distributing digital library collections, either on the Internet or on CD-ROM. These features of Greenstone make it a very good selection for building IR. It is produced by the New Zealand Digital Library Project at the University of Waikato, and developed and distributed in cooperation with UNESCO and the Human Info NGO.

To web enable the database using Greenstone, all the records from MySQL database are converted to html format and placed in the import directory of

Greenstone. The html plug-in is used for building the collection. For full text references the files are kept in pdf format and a pdf plug-in is used for indexing the full text records.

Since the records are entered in different databases at different points of time and depending on the metadata description, a record from a particular database is retained in PRABHAVI. Hence, batch conversion is carried out whenever the database is updated. As Greenstone does not give a 'persistent resource identifier' unlike other OAI compliant software, batch conversion is quite easy in Greenstone. When the database is updated, the import directory is emptied and an html file is again created for all the records and the database is built again.

Greenstone does not support an OAI Repository; instead the Greenstone collection can be built from the recorded OAI data provider. This is one of the major drawbacks of using Greenstone for IR. However, the Greenstone development group has promised to make it OAI compliant in the next release.

PRABHAVI: Publications of IISc

According to this preliminary study, in recent years, the IISc publishes about 1800–2000 publications including journal articles, conference publications, patents, technical reports, books and book chapters, spread over 10 databases. There are about 36,393 journal articles, 1818 conference publications, 92 reports, 77 patents and 51 books and book chapters in the database. The oldest publication in the database dates back to 1913 authored by Sudborough JJ and was published in Proceedings of Chemical Society. About 900 bibliographical details of the theses submitted during 1985–1995 are also available, which were taken from the IISc library Online Public Access Catalogue. For about 200 theses scanned abstracts are included in the database.

'The database has five modules viz., 'About', 'Search', 'Recent publications', 'Add publications', 'Administration' and 'Suggestions'. 'About' module gives a brief description of the database. 'Search' module is designed using 'super collection-sub collection' concept of Greenstone. Six different publication types viz., journal, conference publication, report, patent, and thesis and are identified as sub collections. For each collection type associated metadata fields for both searching and browsing are identified. The database is updated periodically. Newly added publications can be

browsed and searched through 'Recent publications' module. Since PRABHAVI is not comprehensive, if any publication is not included, through 'Add Publications' module, the constituent members can submit publication details or send the details through email. This module gives the details of what, when, where and why publications have to be added to the database. 'Administration' module gives access to log files and facilitates remote collection building for the Greenstone administrator. Suggestions can be sent through 'Suggestions' module. Appendix B gives a few screen shots of search interface of PRABHAVI.'

Conclusions

The compilation of an institutional repository can be viewed in two ways: compilation of prospective scholarly work and compilation of retrospective scholarly work. Articulating appropriate legislature and motivating the present constituent members of the institute to submit details of their scholarly work to the repository will compile prospective work. But retrospective work has to be compiled based on authentic external sources, if scholarly work is not preserved.

This study had the motivation to design and develop institutional repository taking the IISc publications as a case study, based on several authentic external information sources. The problem of defining metadata for different types of publications, standardization of metadata values and removal of duplicate records is addressed quite satisfactorily while compiling this database. It is observed that such a repository would help in preserving and archiving an institutional research locally and give wide accessibility and visibility to the research work carried out in an institution. Though it is compiled without expecting self-archiving to be done by authors, it facilitates authors to submit articles either pre print or post print version, in case it is not included in the database. In this preliminary work, access to IISc research work as reported in several external sources is provided. It needs to be expanded to include internal sources of information.

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Appendix A. Three sample publication details, which show the problem in duplicate detection

1. Author(s), Affiliation, Title and Journal name are same

Pub Type: JOURNAL ARTICLE
 Title: ELECTRON-SPIN-RESONANCE STUDIES OF PHASE-TRANSITIONS IN DOUBLE PRO-PIONATES
 Author(s): Bhat, S.V.; Dhar, V.; Srinivasan, R.
 Affiliation: INDIAN INST SCI, DEPT PHYS, BANGALORE 560012, INDIA
 Year: 1981
 Start Page: 1167
 End Page: 1167
 Journal: Ferroelectrics
 Volume no: 39
 Issue no: 1-4

Pub Type: JOURNAL ARTICLE
 Title: ELECTRON-SPIN-RESONANCE STUDIES OF PHASE-TRANSITIONS IN DOUBLE PRO-PIONATES
 Author(s): Bhat, S.V.; Dhar, V.; Srinivasan, R.
 Affiliation: INDIAN INST SCI, DEPT PHYS, BANGALORE 560012, INDIA
 Year: 1982
 Start Page: 49
 End Page: 52
 Journal: Ferroelectrics
 Volume no: 40
 Issue no: 1-2

2. Same publication assigned as journal article and conference publication by different databases. Conference publication has detailed metadata fields.

Pub Type: JOURNAL ARTICLE
 Title: Dielectric behavior of castor oil impregnated paper polypropylene systems
 Author(s): Ramu, T.S.; Rao, Y. Narayana
 Affiliation: Indian Inst. Sci., Bangalore, India
 Year: 1979
 Start Page: 37
 End Page: 40
 Journal: IEE Conference Publication
 Volume no: 177

Issue no: Int. Conf. Dielectr. Mater., Meas. Appl., 3rd

Pub Type: CONFERENCE PAPER

Title: Dielectric behaviour of castor oil impregnated paper polypropylene systems

Author(s): Ramu, T.S.; Narayana Rao, Y.

Affiliation: Indian Inst. of Sci., Bangalore, India

Year: 1979

Start Page: 37

End Page: 40

City: Birmingham, UK

Publisher: IEE

Conf Title: Third International Conference on Dielectric Materials, Measurements and Applications

3. Same publication with different Title representation

Pub Type: JOURNAL ARTICLE

Title: Surface barrier effects in non-resonant microwave absorption by thin superconducting films of $YBa_2Cu_3O_{7-\delta}$

Author: Rastogi, Amit; Srinivasu, V.V.; Hegde, M.S.; Bhat, S.V.

Affiliation: Indian Inst of Science, Bangalore, India

Year: 1994

Start Page: 229

End Page: 231

Journal: Physica C: Superconductivity

Volume no: 234

Issue no: 3-4

Pub Type: JOURNAL ARTICLE

Title: Surface barrier effects in non-resonant microwave absorption by superconducting thin films of $YBa_2Cu_3O_{7-d}$

Author: Rastogi, Amit; Srinivasu, V.V.; Hegde, M.S.; Bhat, S.V.

Affiliation: Department of Physics, Indian Institute of Science, Bangalore, India

Year: 1994

Start Page: 2056

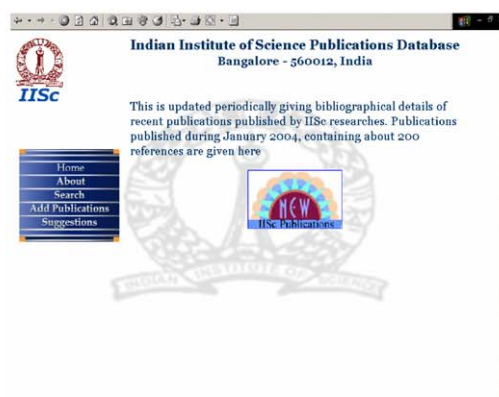
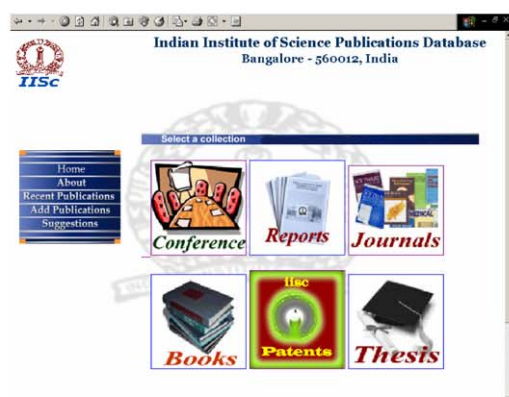
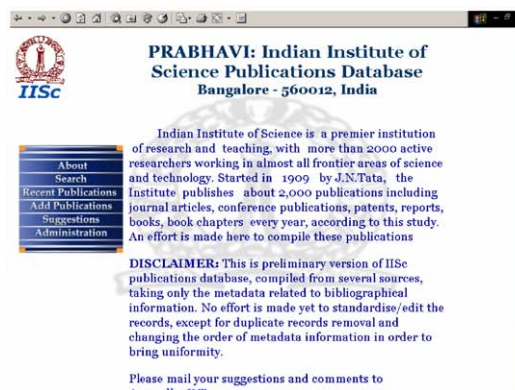
End Page: 2057

Journal: Physica C: Superconductivity (Amsterdam)

Volume no: 235-240

Issue no: Pt. 3

Appendix B. Screen shots of PRABHAVI database



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