

A comparative analysis of academic dissertation management systems in China

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Abstract The paper is to do a comparative evaluation on the four major digital theses and dissertations management systems used in the mainland China, which are TRS, TPI, TASI and IDL-ETD. The evaluation analysis is primarily based on the systematic tests on these systems conducted by DUT (Dalian University of Technology) Library. Special focuses are on the distinctive features of each system such as their performance in terms of stability, reliability, openness, capacity of backdating, copyright protection, service monitoring, document conversion and release automation, log management, statistical tabulations, vendor's technical support and so on. In addition, authors provide a statistics on the choice of academic dissertation system of most 985^{a)} colleges and universities in China.

Keywords Academic dissertation management system, Evaluation analysis, Functional analysis, Performance analysis

1 Background

Academic dissertations, being the first-hand and most important research results of teaching and scientific endeavors in every university, as such, they have great value for perpetual preservation and promotion for their accessibility. There are two major modes for constructing dissertation full-text databases in the world today. One is by way of a centralized construction operation. They include such operations as PQDT (The ProQuest Dissertations and Theses) of the UMI in the United States^[1] and a Chinese domestic one known as CDMD (Chinese Doctoral Dissertation & Master's Theses Full-text Database) of CNKI (China National Knowledge Infrastructure)^[2]. The other mode is to build a database based on OAI (Open Archives Initiative) protocol under the distributed environment, such as the United States NDLTD

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^{a)} 985 or 985 project is a project funded by the Ministry of Education, China, aiming to establish China's own world-class universities in the 21st century.



(Network Digital Library of Thesis and Dissertation) developed by the Virginia Tech University^[3].

In September 2003, a major project called CALIS (China Academic Library & Information System) Academic Dissertation Full-text Database was launched in Beijing. Focusing on copyright control and in line with the development of digital libraries in colleges and universities and the trend of distributed digital information environment, CALIS introduced a distributed system framework. It consists of two operational centers; one is dwelled in a central database center and the other is a local system that operates in each individual participating member library. Interoperability and communication between the central database system and the localized library systems were developed in support of a range of standard protocol and interface^[4].

At the beginning of this project, CALIS proposed the aim of building the standard and open dissertation management system, formulated metadata specifications, technological specifications, functional specifications, digital object specifications, etc^[5]. CALIS also provided clear and detailed system requirements to software developers. According to the research findings on the extent of system completion, user satisfaction and the level of after-sales support, the CALIS project team members recommended four systems developed by domestic software companies; namely, TRS-Dpaper, TPI, TASI and IDL-ETD for participating member libraries to choose for subscription. Coordinated library consortia purchase was also recommended in order to obtain the best price, reduce duplicated development, reduce the overall cost of operation and to improve operational efficiency^[6]. As one of the participating member libraries, DUT (Dalian University of Technology) in adhering CALIS' recommendation based on an analysis of their specific electronic resources conditions, subscribed to the TRS-Dpaper system.^[7] DUT began constructing its local dissertation database since September 2004.

In Oct. 2007, TRS unexpectedly announced that it would stop upgrading and developing its system and would limited its services to technical support only in the future. Taking into account this adverse development, DUT was immediately confronted with the difficult issue of switching the current dissertation management system to a different one. In order to resolve this thorny issue more intelligently for the eventual decision to subscribe to a more viable replacement system, we decided to experiment and to compare analytically, first of all, all these four more popular dissertation management systems that are in operation currently at most Chinese universities; namely TRS, TPI^[8], TASI^[9] and IDL-ETD^[10]. This experimentation was designed for a period of six months in order to obtain a clear and definitive answer for our choice of adoption. We began our focused inquisitive experimentation at our own library in November 2007.



2 Evaluation and analysis of systems

CALIS Academic Dissertation Full-text Database provides a centralized search (including the first 16-page full-text search) and a distributed full-text retrieval service. The dissertation management system developed by participating institutions themselves must follow interrelated metadata specifications and provide uniform metadata, autonomous control access to full-text (factoring into consideration of intellectual property rights).

This paper focuses on the functional comparison of the above mentioned four systems, including but not limited to the function of submitting, auditing, cataloging, retrieval, secure distribution, statistical functions, etc. In addition, those users' concerned key practical issues are also analyzed.

2.1 Design requirements for dissertation management system software

- Follow the internationally accepted standards (Such as OAI-PMH (Open Archives Initiative-Protocol for Metadata Harvesting)^[11], METS (Metadata Encoding and Transmission Standard)^[12], OpenURL^[13]).
- Follow the standards set by CALIS (Such as CALIS-OID (Object Identifier)^[14]).
- Follow rules made by project team (Such as file naming rules, core form configuration and etc.^[15]).
- Carry out special functions of system according to characteristics of dissertation itself (Such as DRM (Digital Rights Management)) control on academic dissertation^[16]).

2.2 System evaluation indicators

2.2.1 The system functional evaluation

The main six instruments which could be selectively applied to the evaluation of each of these four dissertation management systems. Their functional details are explained as follow:

- Submitting module Its evaluation functions were mainly involved in submitting metadata of dissertation online, uploading full-text, modifying online, searching online, submitting authority certification, choosing and control of submitting authority, formulating items configuration, free configuration on visualized interface.
- Auditing module Its evaluation functions were mainly involved in auditing metadata, auditing full text, deleting records and etc.
- Cataloging module Its evaluation functions were mainly involved in adding, modifying, deleting cataloged data, authority control and etc.



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- Document standardization module Its evaluation functions mainly involved batch files conversion (such as converting WORD to PDF), limitations of authority, safety control and etc.
- Release and search module Its evaluation functions mainly involved quick search and advanced search, search within results, smart extended search, full-text search, browsing by subject, browsing full-text online and etc. In addition, providing data interface based on OAI and access control based on IP and users^[15].
- Log recording and statistical reporting module Its log recording evaluation components mainly involved various logging operations, such as various access and operations by staff and users, logging database management, etc. The statistical reports evaluation components mainly involve the operations and workload of staff practitioners, user behavior statistics (such as searching, downloading, and statistics based on IP, time-frame, and subject field differentiations).

Other functional evaluation of system involves data backup, user management and retrospective filing.

2.2.2 The system performance evaluation

System performance evaluation is also involved with the assessment of pertinent standards and specifications, level of system support, system platform compatibility, workflow, stability and openness. It also concerns about the extent of technical support. More specifically, the evaluation focuses on the following:

- System platform compatibility It assessed to what the extent that the system supports the deployment of cross-operating system platforms, and the selection of background database.
- System openness It assessed to what the extent that the system supports pertinent standards and specifications that determine system openness. It mainly involved CALIS' unique naming specification for digital object identifiers, OAI record format and release specifications, the interface specification for the inquiry of OAI-DP record number, METS data export specifications^[14].
- Workflow It concerned only with the process of dissertation submitting, auditing, cataloging, document standardization, metadata and full-text data releasing.
- System stability The system's stability was manifested in its concurrent performance when many users simultaneously submitting their dissertations online in a given time framework. The report of testing results from professional software developer of the system was particularly important.



- Technical support It mainly involved fee-based service charge method, service model, response time to users' inquiries and quality of service.

2.3 System evaluation process

TASiv3.5, IDL-ETDv3.1, TPIv4.5 and TPI linking and integration version were installed and configured under windows2003 OS environment successively in our library. According to system requirements made by CALIS and workflow, our staff simulated users to submit papers and then to process information. There were five people in our team; two of them were from technology development department and the other three were from circulation and reading department. They were divided into three different functional spheres; two as system managers, one as an auditing staff and the other two as catalogers, who took different responsibilities in testing the different modules and functions.

The trials for TASiv3.5 and IDL-ETDv3.1 were respectively completed within one month, those for TPIv4.5 and TPI linking and integration version were respectively completed within two months.

Trial data mainly consisted of three parts. The first part was student information, which mainly included students' name, ID, password, department, major and tutor's name. In consideration of the potential needs of similar work in the future, this segment of information totaling 36 thousand items were batch imported into the database by a system manager. Another segment was informational data, which included academic departments, subject major and their corresponding department code and subject major code. They had to be batch imported into the database and also had to have them completed by a process of connecting relevant tables. The last portion of these informational segments was also the most important data, which were the dissertation data including metadata and full-text data. Metadata included Chinese and foreign language titles, abstracts, keywords, pagination, security level, reference and etc. We were particularly concerned about document format (such as how to deal with the mathematical formula and special characters and symbols contained in abstract) and the format requirements and auditing methods for reference. As for full-text data format, the major concerns were on the type of documents, the size of the document and their upload method. It was on the basis of these considerations, we extracted respectively 25 papers from our Institute of Applied Mathematics, Foreign Language Institute, Physics Department, and Institute of Architecture in each of their existing old database as trail data.

Auditing staff were mainly responsible for the testing of the submitted auditing module. They began by simulating themselves as users to submit and modify metadata and full-text data and then they did these data auditing and sent out the



notice of auditing results. They also performed testing on authority control and on the validity of form configuration.

Catalogers were in charge of testing the cataloging module and dissertation backfile module.

System managers were responsible for testing document standardization, release and search modules, log recording and statistics module. The testing related to the document standardization, release and search was mainly concerned with converting document formats as well as their release, inquiries and data browsing. The management of system log and statistical reporting functions was mainly concerned with unprocessed records, unqualified and qualified statistical records in order of student's name, student ID, thesis submission date, department affiliation, etc. In addition, there were also statistical records made about browsing times of single document, rankings for access of academic departments based on IP range. Staff workload assessment included auditing the job performance of each individual staff, their quantitative records of cataloging, auditing, authorizing and retrospective conversion. Besides, system managers were also responsible for testing data backup, user supervision, system's standardization, stability and openness.

2.4 Comparison of evaluation results

2.4.1 Comparison of main functions and performance

Based on our ad hoc trials as well as from our actual hands-on experience, simultaneously referring to the user's manuals^[17-20] and system use instructions^[21], we compared the main distinctive features of these four systems as showed in Table 1.

2.4.2 A comparison of the log and statistical reporting functions

The function of log recording is mainly to monitor various operations of the administrative staff and users on a daily basis. It provides management setup, maintenance operations for log recording and statistics. Based on our practical use experience and in consultation with related references, we found that each system at present was uneven in their statistical and log recording functions as shown in Table 2^[17-20,22].

2.4.3 A comparison of the standard, specification and workflow of the four systems

Under the distributed environment, CALIS adopted automatic harvesting mechanism. It followed OAI-PMH to harvest dissertation metadata collected in participating member libraries. Service provider (CALIS data center) sent the request to the data



Table 1 A comparison of the main functions of the four academic dissertation management systems in China

System	TPI	TASI	IDL-ETD	TRS-Dpaper
System environment	Windows KBase	Windows SQL SERVER	Windows SQL SERVER	Linux, Solaris, Windows TRS+Mysql or SQL SERVER
Script tools and system architecture	IIS+ASP B/S+C/S	IIS+ASP B/S	IIS+ASP B/S+C/S	Apache +JSP B/S
Submitting	Metadata and full-text can be modified repeatedly; HTTP for uploading full-text	Metadata and full-text can be modified repeatedly; HTTP and FTP for uploading full-text	Metadata and full-text can be modified repeatedly, however, full-text need to be re-uploaded each time once modified; HTTP and FTP for uploading full-text	Metadata and full-text can be modified repeatedly; HTTP and FTP for uploading full-text
Reference checking	Don't automatically check the format of reference	Don't automatically check the format of reference	References are attached to the full-text without format checking, and are submitted with full-text uploading.	Automatically check the format of references
Auditing and cataloging	Generate the number of collection item automatically	Add the number of collection item	Add the number of collection item	Add the number of collection item
Searching and linking-integrated service	Not supporting search within the results and extended search; Supporting full-text retrieval;	Not supporting search within the results and extended search; Supporting full-text retrieval;	Not supporting search within the results and extended search; Supporting full-text retrieval, and displaying pages that contain the retrieved words;	Supporting search within the results and extended search; Supporting full-text retrieval and highlighting retrieved terms;
Data standardization	Providing reference linking- integrated service PDF format adopted; automatic release of files with manual operations assisting	Not Providing reference linking- integrated service Double-layer CEB document was generated automatically; completely automatic release of files without any manual operations	Not Providing reference linking- integrated service PDF format adopted; automatic release of files with manual operations assisting	Not Providing reference linking- integrated service PDF format adopted; automatic release of files with manual operations assisting
Platform	KBase full-text retrieval database	Apabi digital resource platform	Skywalker full-text search engine	TRS full-text retrieval database
Dissertation backfiles	Including backfile function	Backfile module need to be purchased separately	Backfile module need to be purchased separately	Not providing backfile function





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Table 2 A comparison on log recording and statistical reporting functions of the four major academic dissertation systems in China

System	TPI	TASI	IDL-ETD	TRS-Dpaper
Log recording	Log recording was designed for administrative staffs to monitor the online audition.	Log recording was designed for administrative staff with very simple functions.	More sophisticated functions of log recording were provided, including IP login, search, auditing, resources making and so on.	Log recording was designed for administrative staff with very simple functions.
Submitting statistics	Providing qualified, unqualified and unprocessed dissertation statistics according to departments	Providing dissertation statistics according to departments, degree-level, time and auditing phases, and forming statistical tables	Providing dissertation statistics according to process situation and auditing phases	Providing qualified, unqualified and unprocessed dissertation statistics according to department
Access statistics	Providing access and download statistics according to time and database	Providing simple access statistics	Providing access statistics according to IP range with rank	Providing access, browsing and downloading statistics according to IP range and department
Workload statistics	Providing workload statistics of each staff's cataloging and auditing; no statistics on the online users.	Providing workload statistics of cataloging, authorization and auditing according to degree-level, department, time and auditing phases, and forming statistic table, not for each staff; no statistics on the online users	Providing workload statistics of each staff's cataloging and auditing according to time range such as year, month or day; with the graphics display; no statistics on the online users.	Providing auditing and cataloging workload statistics of each staff according to time range; no statistics on the online users.

provider (participating member institutions) and then harvested metadata after receiving the response. The first 16 pages of the full-text dissertation were collected based on METS (Metadata Encoding and Transmission Standard) mechanism. At first, user searched the central database for basic information about their desired theses, and then they could link them to full-text database collected in each library by OpenURL and CALIS-OID.

As such operation is an integrated operation of multi-users and multi-systems, it is essential that the system's design, specifications and interface are to be standardized. A comparison of each of the system's standards, protocol, copyright protection mode and basic workflow is shown in Table 3.

As far as the workflow of these four systems is concerned, TRS releases its information data only after information data are cataloged and documents are standardized. This has an advantage in terms of enhanced manipulation for the display of documentary segments. The other three systems adopt a direct release process, which has the advantage of having no time delay for information release. Besides, TASI also comes with an optional authorization function and also with an embedded copyright protection module.

Table 3 A comparison on standard, protocol, copyright protection mode and basic workflow of the four dissertation systems in China

System	Standard and protocol	Copyright protection	Workflow
TPI	CALIS-OID, OAI, METS, OpenURL	Providing DRM interface	D↘ SU→AD→(CO)→R&SE CA↗
TASI	CALIS-OID, OAI, METS, CLRC, OEB	Embedded DRM module	D↘ SU→(AT)→AD→CO→R&SE CA↗
IDL-ETD	CALIS-OID, OAI, METS, OpenURL, Fetch	Providing DRM interface	D↘ SU→AD→(CO)→R&SE CA↗
TRS-DPaper	CALIS-OID,OAI	Not providing copyright protection	SU→AD→CA→R&SE D↗

Note: SU:Submitting; AD:Auditing; D: Document standardization; CA:Cataloging; R: Release; SE:Searching; CO:Copyright protection; AT: Authorization.

2.5 System analysis

From the above comparison, it can be seen that TRS is a multiple compatible system. In addition to the Windows system it is also in compatible with Linux and Solaris, which are possible for them to be deployed across various platforms. It has a relatively high profile of system security. In addition, the TRS system checks



reference format automatically, provides multiple retrieval methods and has relatively a more comprehensive function. On the down side, it does not provide such features as thesis retrospective function nor the interface of DRM. The more important defect is it has no tested OAI interface to provide data to CALIS data center. Users have to complete metadata submission by using the third-party tools. The main advantages of TPI linking and integration version lies in its automatic citation analysis function, reference linkage, similar literatures linkage and integrated services^[23]. TASI is relatively well for automatic data release, authorization and copyright protection while IDL-ETD has a relatively more comprehensive system log recording and statistics functions.

The following is a comparative analysis of some of these four prominent systems' distinctive functional features that are of more interest to the users according to our observations and empirically hands-on experience.

2.5.1 An analysis of four systems' distinctive functional features

- Document standardization, release and copyright protection. With the increasingly enhanced sense of system applications and user's heightened awareness of such system functional features as the range of authorization for information access and for copyright protection, for converting document format, for the automatic display and release of the first 16-page of a given thesis as well as the automatic display and release of its full-length article, more and more users are paying increased attentions to these system features in their actual field practice. We noticed that during the process of getting our data standardized, TASI was capable to generate CEB format file and to release them automatically, with less manual and more automatic operation. For the other three systems, library staff had to use some file conversion tool provided by software developer to convert document to PDF file, and then had to have them copied to appropriate path in order to complete the release. TASI introduced an embedded DRM module and performed relatively better than the other three systems in terms of granting authorization and providing copyright protection.
- Dissertation retrospective files There had been a certain amount theses in print format and also there were numerous digitized academic papers on floppy disks in every university and college library before academic dissertation management system was used. These metadata and full-texts need to be digitized and backdated so as to achieve the completeness of the dissertation database. These are the particular practical concerns of library users. Because our current digitization work is limited only to a number of theses in paper format, it is not a long-range and comprehensive digitization project. Users



will pay more attention to the cost of digitizing paper-format dissertations and the related methods of retrospective data conversion operations. TPI has an embedded backfile module to achieve this part of digitizing function. TASI and IDL-ETD require users to purchase an additional software to complete thesis backdating. TRS does not have such a function.

- **Log recording and statistics** An ideal log management with multifaceted, multi-perspective statistic functions is able to provide a strong basis for a variety of analysis so as to make the whole system a more complete one. Advanced users are more concerned about log recording and statistical reporting functions. As shown in Table 2, both TRS-Dpaper and TASI provide relatively detailed statistical reporting functions, however, a simple log recording function is designed only for administrative staffs to operate. TPI also provides a simple log recording and management tools for staffs; it can monitor the operation of an auditing staff, but unable to monitor the operations of users, nor to count the number of on-line users at the same time. IDL-ETD provides relatively the most detailed system log and statistical functions among the four systems. However, it can only provide statistical records of user's operational behavior, but unable to monitor simultaneously the operation of the administrative staff and the on-line users at the same time. Therefore, none of these four systems, from a management perspective, can give necessary and timely statistical support to the system operation during peak hours.
- **Submitting and auditing** Some details in submitting and auditing process and friendly interface are also the main areas of users' concern. These four systems all can meet the basic requirements of paper submission. With the exception of TRS-Dpaper, the other three systems are unable to check the format of references that attached in the submitted thesis one by one automatically according to preset specifications when theses are submitted. As such, the format of these references might not all be of standard nor can their accuracy be effectively guaranteed. This problem may possible cause the need to check and to test again the stand-conformity issues of each reference work cited in the thesis when the system links to other databases via reference. In addition, all these four systems are not equipped to send email message automatically with full auditing information.

Aside from the above mentioned issues, a requirement of flexibility on the part of system developers in terms of meeting users' customized need is also of paramount importance. For example, libraries assign different call numbers for their theses collection according to their own unique situation. Developers should be concerned about how their users' specific needs can be made satisfactorily.



2.5.2 System stability

Most users are concerned about the concurrent performance of the given system. An ideal concurrent performance depends on many factors, which are mainly related to robustness of application program code application. For example, JVM (Java Virtual Machine) memory embedded in JVM is too small or its program is too imprecise, which might result the appearance of too many junks. Users cannot form a sound judgment to analyze concurrent performance of the applications based only on the concurrent performance of the database and web server. Such sound judgment requires a testing engineer for software performance to use a professional testing tool (e.g. LoadRunder that supporting a wide range protocols) to do the job. Such a tool is specifically used to operate and to analyze server-side CPU utilization and memory occupancy. Furthermore, it simulates the possible impact of a large number of data input on the hard disk and what else need to be taken into account in optimizing a system's performance. Therefore, in addition to system users' own testing result, it is essential for the system developers to provide also a test report on the system's professional performance. All systems should have a monitoring function allowing it to oversee the operation of on-line users so that a timely assessment of system running situation and relevant effective measures could be taken at any prompt time.

Notwithstanding our field experience with the TRS-Dpaper, TASI was the only one among the other three systems, which provided us with a testing report of its system performance via LoadRunner tool. The significance of this reports was that it gave us a reliable reference source about systems concurrent operation performance, so that users themselves were not adequately equipped to run such a test on their own effectively.

Furthermore, in its test report, TASI clearly indicated that they had tested the entire system workflow and softdog software. The test result gave positive indications to their proper functions and the software could be released. At the same time, software developers also passed a series of the tests by using the technical tool of LoadRunner 8.0 to simulate fifty concurrent users, completing metadata, uploading the full-text database in infinite cycles, and also having tested the system stability under a large number of simultaneous operations. These test results showed that IIS (Internet Information Services) would not stop^[24]. It is these authors' opinion that the other three software developers ought to seriously consider to provide professional test report like that mentioned above so as to make useful test data available for users to consult.

Our practical work experience with TRS-Dpaper at DUT may serve as an elucidating case. By the end of Oct. 2009, the number of doctoral students was 3,254



and that of master students was 8,138.^[25] The number of dissertation submitted each year increased substantially and the timeframe of thesis submission was very concentrated. The capability of the concurrent performance of the system was challenged severely during that given period of time. Experience showed that once the concurrent data increased, the speed of system response declined proportionately, service process occupied almost 80–90% of the CPU resources. In some serious cases, system service even shutdown every a few minutes, for example, during the peak hours of the submission.

2.5.3 System openness

With the practical operation of the communication between local databases and central database, it has becoming increasingly the focus of users' attention to a given system's performance evaluation of system to see whether the interface can support OAI, METS, OpenURL and relevant protocols, and whether it follows the criteria of OID unique identifier name, resolution and realization. It is essential that system developers should consider to provide an interface integrated with campus card system, library portal and other authentication system as their next strategic move.

At present, with the only exception of TRS-Dpaper, which cannot provide a mature module in support of metadata and in harvesting the first 16-page full-text document, all the other three systems are able to provide a more complete interface program. Some TRS-Dpaper users are harvesting and submitting their metadata and the first 16-page full-text document with a third-party software. Compared with other 3 systems, the unique advantage of TPI's linking and integration version in openness is to provide reference citation link to CNKI based on OpenURL. It can be seen that TRS-Dpaper is relatively weak in openness on metadata harvesting and citation linking service.

2.5.4 Technical supporting service

Specialized technical support covers a wide range of aspects, including system upgrade and maintenance, technical training, bug handling, etc. TASI and TRS-Dpaper provide free software upgrades and technical support. However, our experience of actual use showed that TRS-Dpaper sometimes failed to process certain issues in a timely manner. TPI and IDL-ETD charged a service fee for software upgrade, maintenance and technical support.

TRS Company was initially successful in attracting more users due to its relatively sophisticated system functionality, such as giving support to cross-platform deployment, high security, better user-friendly interface and persuasive promotional pitch. Its subsequent withdrawal from the dissertation management market resulted in a situation of great uneasiness for its subscribers. Many users who originally



opted for TRS-Dpaper system had to switch to another system. This unpleasant episode taught us a lesson that from now on we should factor whether a system developer can provide long-term effective technical service into one of our paramount considerations in terms of choosing a system. At present, TASI is another system falling behind in this regard.

Although all these four systems adhere to CALIS' prescribed standards, each system has its own database system, data structure, which makes their operation incompatible with one another. A change to a different system will inevitably necessitate the migration of related metadata and full-text data. For example, as of June 2009, our library had collected dissertation metadata and the full-text data totalling 21,024 items including the metadata of the first 16-pages of those theses submitted from 2004 to 2008, which had to be migrated to a new dissertation management^[7]. Therefore, the workload of system switching is just overwhelming and there is a soaring need of adequate technical support to do the job from both the old and the new system vendors.

3 User survey

In June 2009, we accessed the webpage of libraries of 39 universities which were associated with 985 project and sent out email inquiries to library directors and/or responsible persons in charge of technical support to inquire their preferred dissertation management systems. 31 pieces of valid responses were collected representing a valid return of 79.49%. From Table 4, we can see, TPI and TASI took 20% market share. IDL-ETD took an obscure amount of the market share. TRS-Dpaper still had the largest number of subscribers as of date due to its superior overall system functionality, friendly interface and other technical features. However, things are gradually changing ever since 2007, when TRS announced its withdraw from the academic dissertation system business at the Third Meeting of CALIS University and College Academic Dissertation^[26]. As it stands now, TRS-Dpaper will only provide limited technical support on transferring data. Therefore, it is safe to say that in the long run, a majority of TRS-Dpaper subscribers will confront the problem of system conversion.

From the statistics we gathered, there were a few college and universities, which chose to develop their local dissertation management system by themselves. Self-developing such system requires a large amount of human talents, financial and logistical support such as continuous monitoring, upgrading and managing software development. In university libraries, the acute shortage of personnel and the high-rate of exit mobility of high-level system developers make it difficult to ensure the system's normal function, maintenance and upgrade. Moreover, the basic



requirements for dissertation management are generally the same among university libraries despite their slight local differences which are not the primary issues of major concerns. Therefore, those commercial systems that have gone through the process of validation by CALIS have distinct advantage over others in the areas of technical specialization, technology development, upgrading, maintenance and technical support and etc. They are the top choice of most libraries. Because of these technical and maintenance problems, some libraries which initially opted for the development of a home-grown system have subsequently switched to a commercial system after a period of grudging trial and experimentation.

However, the trouble of system conversion caused by software vendors' sudden decision to terminate its services to continue to upgrade and to develop remains a bad experience and a hard lesson for the majority users who happened to choose a business software.

Table 4 Statistics on the choice of academic dissertation system of most 985 colleges and universities in China

System	User's number	College and universities
TPI	7	Renmin University of China, China Agricultural University, East China Normal University, University of Science and Technology of China, Huazhong University of Science and Technology, South China University of Technology, Chongqing University
TRS-Dpaper	12	Tsinghua University, Beijing University of Aeronautics & Astronautics, Beijing Normal University, Nankai University, Dalian University of Technology, Jilin University, Harbin Institute of Technology, Shandong University, Sun Yat-sen University, Xi'an Jiao Tong University, Hunan University, Northwestern Polytechnical University
TASi	6	Peking University, Fudan University, Ocean University of China, University of Electronic Science and Technology of China, Lanzhou University, Northwest A&F University
IDL-ETD	1	Zhejiang University
Self-developed system	5	Beijing Institute of Technology, Xiamen University, Shanghai Jiao Tong University, Nanjing University, Wuhan University

4 Conclusion

Through this evaluative study, we found that all the above mentioned four dissertation management systems, with each of their own distinctive merits, were able to meet the basic requirement stipulated in CALIS guidelines for colleges and universities dissertation database construction and operation. TRS-Dpaper had better compatibility, security and relatively more comprehensive functions. TPI provided unique citation link service, TASi resolved the issue of copyright-protection relatively better, IDL-ETD had more detailed log recording service and statistics functions.



However they also showed different deficiencies. For instance, they all did not provide effective monitoring and managing mechanism against on-line users collectively, which prevented the system from collecting the desired data of simultaneous users during peak hours. In addition, system stability and openness should be further enhanced. With the quickened development of different service systems, dissertation management system need to develop an interface, which is capable of doing authentication work and is also integrated with campus card and library portal. Moreover, system provider should take account of specialized local requirements and customize their system functions to meet those particular information needs of their clientele.

Furthermore, we should pay more attention to the issue of data migration caused by TRS' decision to terminate its subsequent system development and upgrade. Successful system switching needs help from both the old and the newly subscribed system developer. In the future construction of similar management systems, the stability and sustainability of software vendors should be an important factor to be taken into consideration. We should also take into account the problem of system switching if once such problem emerges and its remedial methods should be clearly written into contract. CALIS also should play a greater role, not only just to organize group purchasing but also to provide timely advice to the system upgrading and after-sales technical support services so as to assure its membership to have a good networked work environment.

This paper is a result of our work experience with TRS and our dedicated experimentation with the other three dissertation management systems. There are naturally some limitations in our testing and analysis. For example, the data that we used may not be inadequate in terms of sufficiency and diversity. Our study of system users' behavior may not be thorough and comprehensive enough, which may compromise the objectivity of our study somewhat. The dynamic development of the four dissertation management systems need to be given continuous scrupulous attention. We should also take up an in-depth follow-up study and in a comparative perspective about those more successful dissertation systems abroad especially about their systems' reference linkage, copyright protection, release, retrieval, as well as their statistical functions and so on. We hope this paper would provide some insight into the decision making process of those libraries who are currently facing the system switching issues and issues related to making further improvement of the overall performance of dissertation management systems at the institutions of higher learning in china.



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