

The Development of Digital Archives Management Tools for iRODS

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Abstract

The amount of digital data in today's society is both enormous and constantly growing. Unfortunately, existing digital archives are often fragile and susceptible to data loss. Thus, as the amount of digital information continues to grow almost exponentially, it is increasingly important to develop new ways to manipulate this data and minimize the risk of data loss after hardware failures. In this paper, we create an improved data preservation system by working with iRODS, a distributed data management system suitable for data grids, digital libraries, and persistent archives. We develop a user interface, called UrSpace, provide a corresponding Sync Package, and also create a monitoring system (call SIMS) that can check iRODS for errors and monitor the system independently. These tools and system are currently used for the TELDAP program in Taiwan.

Index Keyword Terms—TELDAP, Data Preservation.

1. Introduction

In the digital age, all forms of data such as text, pictures, music and video are available in digital format, and thus the need for storage capacity is constantly growing. When organizations such as the IDC (International Data Corporation) report that the digital universe doubles every 18 months [2], it is certain that data users will face unimaginably large amounts of data in the near future. In order to keep pace with this immense increase in information, it is necessary to create an extensive but manageable data preservation framework that enables people to agilely handle colossal amounts of data.¹

One of the greatest challenges with existing data management is that these archives are fragile, and they are often prone to crash in unexpected ways. Generally, digital archives are stored in some type of electronic storage device, but due to inevitable malfunctions and wear, no existing digital archives can remain operational forever. As a result, there is a continuous need to develop increasingly reliable preservation mechanisms

in order to ensure that data is consistently accessible and robust.

In 2002, a "National Digital Archive Project" (NDAP) was initiated and worked to collect and integrate different kinds of digital archives from institutes, museums and research groups from across Taiwan. Created in 2008, the "Taiwan e-Learning and Digital Archives Program" (TELDAP) [3] continues the work of NDAP. In order to reliably manage all of this data, the Digital Archives Remote-Backup (DARB) project was proposed. Its primary responsibilities include data preservation system development and research. The DARB project also created the Sinica Data Preservation System (SIDPS), which stores digital archives and content from such diverse field as history, biology, ethnology, education and language.

SIDPS follows a distributed framework and manipulates data in multi-level collections. The characteristics of this design are to meet the performance of data preservation in the distributed environment and alleviate the cost of external network deployment. In maintaining SIDPS, DARB works closely with another data management system, specifically designed for working with data grids, called the Integrated Rule-Oriented Data System (iRODS) [4]. Taking advantage of rule-based policy mechanisms, iRODS provides several optimized data transfer functions, and it enables users to more flexibly coordinate data stored within distributed environments. This feature allows the DARB project to use iRODS to manage digital archives stored in different institutes across Taiwan.

Generally, the iRODS team provides several APIs for developers to create their applications. It is true that there are some iRODS user interfaces such as Davis WebDAV [9] and iRODS Explorer for Windows. However, users who aim to preserve digital data need a good interface that is multilingual, a convenient process to make data preservation easier and safer, and a fast data transfer mechanism. Hence, the DARB team takes advantage of iRODS' APIs to develop a user interface called the UrSpace tool, and a corresponding data preservation utility, called the Sync Package. The system status of iRODS is tracked through the Sinica iRODS monitoring System (SIMS), which detects errors that occur within the iRODS system and quickly alerts system administrators of any problems.

¹ Supported in part by National Science Council (Taiwan) Grants NSC99-2631-H-001-024.

The remainder of this paper is organized as follows. We first describe the SIDPS framework, and then outline the designs of the UrSpace interface and the Sync Package utility. Next we introduce SIMS, the monitoring system for iRODS. Lastly, in the final section we present our conclusions.

2. Digital Archives Preservation Cyberinfrastructure

Recently, the number of digital archives stored within SIDPS has grown rapidly. In order to handle this increased data flow, we propose a digital archives support framework that is based on the iRODS system and designed to coordinate the aggregation and preservation of archival data. Its key roles include handling distributed data acquisition, data storage, integration, transformation, and management.

2.1 The Multi-level Digital Archive Collection

The architecture for a multi-level digital archive collection like SIDPS requires a fast data transfer speed, low power consumption, and a disaster recovery mechanism. In regards to data transfer rates, we employ a framework designed to overcome issues related to limited network bandwidth while also improving the cost-effectiveness of data preservation. As Figure 1 demonstrates, this framework can be broadly divided into three levels.

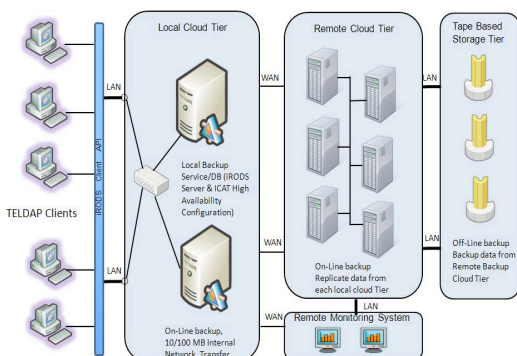


Figure 1 Multi-level Digital Archive Collection

First, the local cloud tier provides a storage buffer. Users are able to upload digital archives to their local storage devices at high speed. Second, the SIDPS located within the remote cloud tier moves digital archives that have not been modified or have been left idle over a period of time to the SIDPS. Lastly, tape servers regularly replicate digital archives from the SIDPS. Overall this multi-level digital archive collection framework shortens data uploading time, because users only need to upload their data through their internal

network, rather than through the much slower external network. This framework also helps reduce power consumption, because backup copies of the data are stored within the internal network on tape, compared to more power-intensive online models such as Hadoop [8] or the google file system [7]. Most of the time, the tape storage system is kept off-line, and is only used during periodic backup sessions or when original data needs to be recovered due to errors within the SIDPS. Throughout this process, the SIMS monitoring system acts as a gatekeeper, serving to monitor each data transaction at each of the different institutes, and to then immediately notify system administrators of errors via e-mail or instant message.

3. The UrSpace Tool

A good user interface ought to match system operations to the real world. Generally speaking, users that join TELDAP program would like to have a good user tool that supports multilingual interface, provides a view of the system status, and provides flexible and efficient functionalities. UrSpace is a Graphical User Interface (GUI) tool based on the iRODS Jargon APIs. The objective of the UrSpace tool is to provide users with a friendly and multilingual interface to manage metadata and upload and download digital archives to and from the iRODS system. The tool itself is compatible with multiple operating systems (unlike the iRODS Explorer for Windows), and performs the following functions: multiple data transfers, resume transfers, export log files to PDF format, edit metadata, and basic searches. UrSpace is also free and can be downloaded from the DARB website [5]. The Davis WebDAV interface [9] is also based on Jargon APIs and includes several convenient functions that help users manipulate data easily. The UrSpace tool is focused on developing useful data manipulation mechanisms and efficient data transfer methods in a multilingual interface. Overall, the UrSpace tool offers users who are not familiar with command-line operations a more approachable alternative.

3.1 UrSpace Features

The UrSpace tool is a multi-function user interface. It is mainly composed of several Java packages and Jargon APIs. The Java Jargon APIs released by the iRODS team contain several data manipulation functions such as file I/O access, GSI authentication modules and metadata operations. This interface itself was designed using the Java Swing Library. As Figure 2 shows, the DARB team uses the Jargon APIs to complete basic data manipulation tasks, such as data uploading, downloading, metadata editing, and MD5 check sum verification. The Java multi-thread library is also used to design the “multiple tasks” processing

function, and the Java security module is used to develop a file encryption mechanism.

UrSpace is dynamically updated software with a steady flow of frequent updates. In order to ensure users have access to the latest version, UrSpace comes equipped with on-line software renew option. This function downloads and installs the latest UrSpace updates from the DARB website.

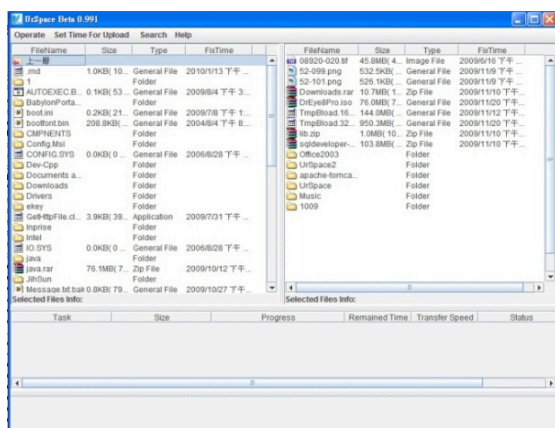


Figure 2: UrSpace Tool Layout

The Scheduler depicted in Figure 3 lets users set their own update schedule, in order to ensure updates do not interfere with personal workload.

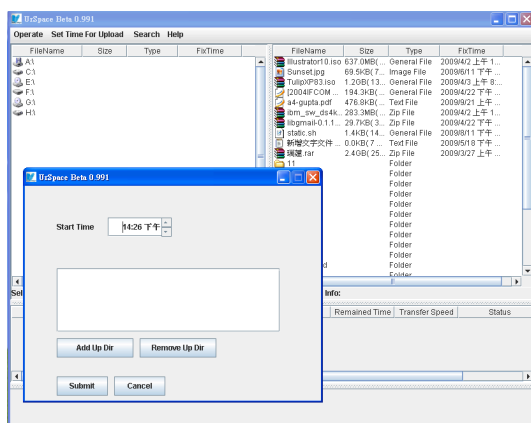


Figure 3: UrSpace Scheduler

3.2 UrSpace Components

In addition to providing some common data management functions, the UrSpace tool also contains various user-friendly features. These designs are made up of several different data manipulation components that are able to help users manage their digital archives more easily. As Figure 4 shows, the UrSpace tool has the following components:

- **Data manipulation** – The UrSpace tool supports several basic data manipulation functions, including

adding common folders, deleting recursive files, and a data viewer function. Users are able to rename their files or directories with multilingual words. UrSpace can also display basic file information such as file size and the number of files in a folder.

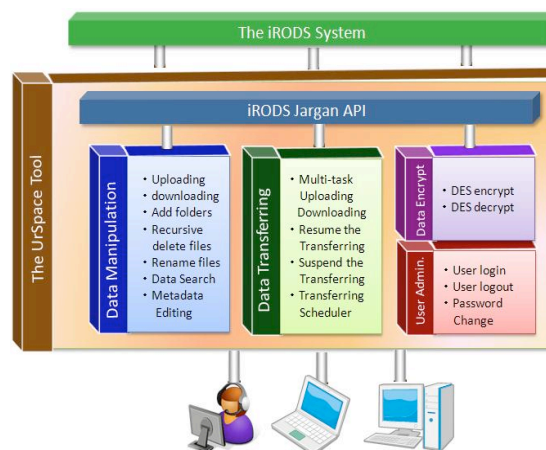


Figure 4: UrSpace Components

- **Data transferring** –The UrSpace tool supports multiple simultaneous data transfers. Users are able to execute several different tasks to upload and download data simultaneously. Moreover, the DARB team designed a mechanism to pause and resume data transfers. This mechanism permits users to suspend their data transfers temporarily.

- **Data encryption** – UrSpace supports the Data Encryption Standard (DES) file encryption. Users can encrypt their digital archives and upload them to the iRODS system. Currently, users are able to download files and decrypt them to a local disk with the UrSpace tool.

- **Data search** – Since the UrSpace tool has a built-in search assistant, users can use file names to search digital archives stored in the iRODS system. The search assistant gives users exact search results including file names, file routes, and file size.

- **Metadata editing** – The iRODS system allows users to register digital archive metadata in an iCAT (iRODS Catalog). Thus, UrSpace provides users with a metadata editing assistant. This assistant lets users browse, add and modify metadata on-line.

4. The Sync Package

The Sync Package provides users with another option for managing their digital archives. It is true that the UrSpace tool includes many data manipulation functions that help users preserve their data more conveniently. However, the Sync Package utility is focused more on developing the automatic data synchronization and efficient data preservation methods.

According to user surveys, many users have several very specific needs. For example, some users need to mass upload large digital archives all at one time, while others would like their archives to upload and backup data automatically. Furthermore, some users need detailed data transfer logs.

In order to meet these needs, the Sync Package was developed. In order to help with mass uploading large digital archives, the package uses parallel I/O techniques to improve data transfer speeds. Moreover, users can operate the Sync Package in coordination with the OS scheduler to synchronize data automatically. The package also makes use of an e-mail dispatcher program that is able to send data synchronization records to users via e-mail. Lastly, the sync package includes file encryption and UTF8 encoding conversion. As a result, the Sync Package gives users another way to manage digital archives more efficiently.

4.1 Sync Package Workflows

Figure 5 below demonstrates how the Sync Package implements the helpful features mentioned above. Overall, the process is fairly straightforward. After first setting the iRODS user environment, users should open the main batch file and enter in the data route for the local and remote sites, and then their e-mail address. Now, users may execute the main batch file, and the digital archives will either be uploaded to the iRODS system or downloaded to a local disk space. Users may also integrate this package into an OS scheduling tool so that data backup is handled automatically.

After executing the batch file, the International Language Transform Service will convert the digital archive file names into UTF8 encoding. Depending on the user's needs, the package will either encrypt or decrypt archives, and then upload or download the assigned task. A data record generator records this process as a log file, which is then sent to the user's mailbox.

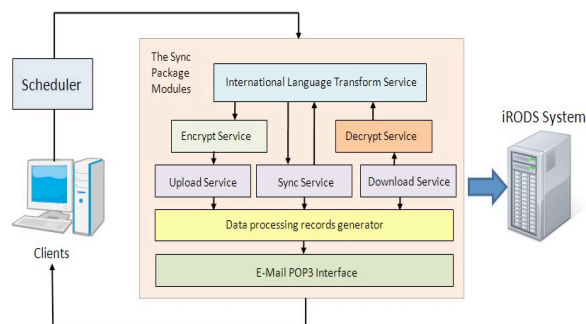


Figure 5 Workflows of the Sync Package

4.2 International Language Support

In order to assist multilingual users, the Sync Package comes equipped with an international language

encoding converter. While Taiwan uses traditional Chinese characters, users sometimes label files with Japanese or simplified Chinese characters. In general, multilingual applications convert language text that originated from different sources into UTF8 encoding. However, the Sync Package operates using a command-line, which does not support UTF8 encoding on the Windows operating system. Furthermore, iRODS i-Commands do not provide UTF8 encoding conversion. Thus, an international language encoding converter is needed.

Because iRODS i-Commands are at the core of the Sync Package, the international language encoding converter was embedded within the iRODS i-Command code. The converter contains several different encoding mapping tables, including "Big5", "GBK" and "Shift-JIS". Also, the Big5 table was extended to support Japanese and simplified Chinese characters, so that users can manipulate different language on the traditional Chinese Windows operating system. As Figure 6 shows, when users upload data to the iRODS system, the converter first detects the OS language setting automatically, and selects a suitable encoding mode. It then converts the files into UTF8, and records the value of the file name into the database management system. In the case where users download data to their local sites, the converter inverts the value of the file names with UTF8 encoding from the database to the encoding format of their local OS language setting.

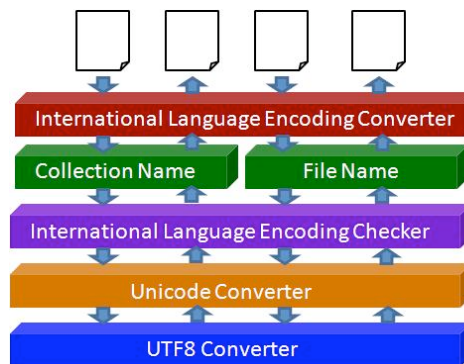


Figure 6 The Workflows of the UTF8 Converter

4.3 Parallel File Encryption

In regards to encryption, the iRODS system uses a GSI security mechanism and constructs a secure data-transferring tunnel. However, the iRODS system does not have a file encryption mechanism, and thus important information from digital archives is vulnerable to theft. In order to protect user data, file encryption was incorporated into the Sync Package. In the beginning, we used a simple symmetric encryption method, called the Data Encryption Standard (DES).

The Sync Package's DES model is the same as the one used within the UrSpace tool, and the DES

algorithm is suitable for working in parallel. We implement the DES algorithm in Electronic Codebook (ECB) mode and use the OpenMP API to upgrade the encryption's performance on multi-core CPUs.

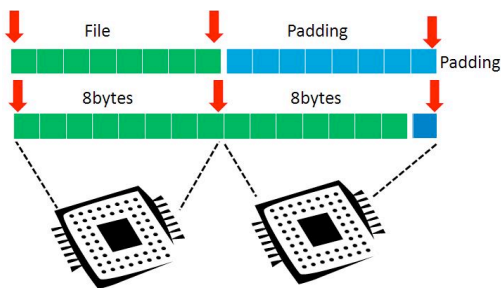


Figure 7 Parallel DES Encryption

As Figure 7 shows, initially, a file is composed of several 8 bytes blocks, and each block is encrypted in parallel. Then, we follow RFC 1423 padding method to affix padding to the encrypted file. Users simply need to fill in their file-encryption password in the main batch file, and then the package encrypts or decrypts their data.

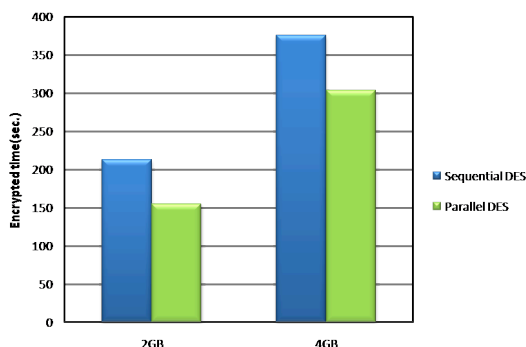


Figure 8 Performance of the Parallel DES encryption

Figure 8 demonstrates that, compared with sequential DES, parallel DES performs on average up to 30% faster on an Intel Duo-Core 3.0GHz CPU.

5. The Monitoring System

The SIMS monitoring system is critical for detecting system problems within iRODS instantly, in order to ensure data loss from disasters is minimal. Developed by the DARB team, SIMS is designed to monitor iRODS as well as the database management system and server operations. After surveying several options, the DARB team settled on Nagios [6] for monitoring distributed environments, largely because it offers several kinds of distributed data management mechanisms. Unfortunately, Nagios does not inherently support the iRODS system, and only provides

notification via e-mail. Consequently, the team extended the use of the Nagios monitoring service to monitor the iRODS system. Here, it is important to note that the SIMS monitoring system works independently of the iRODS system. SIMS records the activities of the server, database, and storage system and then notifies system administrators when an error occurs in the following ways.

5.1 The SIMS Parser

Each iRODS system records its activities in a log file, which keeps track of system processes and error messages. These messages help system administrators troubleshoot and trace problems when errors occur. However, these messages are not always necessary, and thus a parser tool is used to parse messages and identify important communications. For archival purposes, a MySQL database was selected to store records. Overall, the parser helps system administrators receive important messages from a large number of system activities.

5.2 SIMS Notification System

In addition to observing system activities, the monitoring system is supposed to notify system administrators as soon as possible when a system gets into trouble. As mentioned previously, SIMS generally notifies system administrators via e-mail or instant message when receiving an error message. However, for different urgent levels of error messages, the notification mechanisms should not be the same. SIMS utilizes a heartbeat mode to detect if the iRODS system is up and running. In the event that the system is down, SIMS dispatches an urgent message to the system administrators' cell phone. In addition to serious error messages, system administrators are still able to receive error messages from e-mail or instant message.

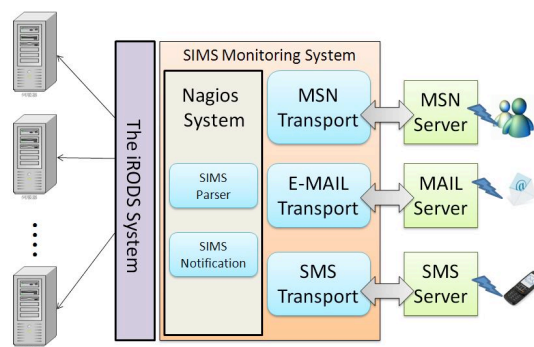


Figure 9 SIMS Notification System

6. Conclusions

Our everyday lives are surrounded by digital data – nearly everything we watch, hear, or read is digital. As the sheer volume of this data continues to grow, users

will increasingly encounter problems with storage capacity, data authentication, data integrity, and metadata management. The iRODS system contains several optimized data management mechanisms that address these issues and help users manage digital archives flexibly. While iRODS has its disadvantages, namely the lack of support for UTF8 encoding and file encryption in i-Commands and the absence of a good Jargon API-based multi-function user interface for Chinese, these problems are ameliorated by the inclusion of the UrSpace tool and Sync Package developed by the DARB team. Furthermore, the DARB team will continue to develop these tools, with an emphasis on data management, stability and security.

7. References

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