A HEALTH INFORMATION SYSTEM IN FIJI
Discussion on the Implementation of a National Health Number and the Methodology of Synchronizing a Number of Remote Databases

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Abstract

This paper is based on experience with the design and implementation of the Patient Information System (patient based) (PATIS) that is being implemented across medical facilities in Fiji with the financial assistance of the Australian Government Overseas Aid Agency (AusAID) and the Government of Fiji.

The paper initially outlines the scope and technical infrastructure of the PATIS in Fiji before focusing on two fundamental areas of the system.

The implementation of a National Health Number (NHN) is discussed in detail outlining the objectives, production, implementation strategies, problems encountered and solutions applied.

To implement an NHN it was necessary to design a reliable, but affordable, methodology to synchronise the medical information across multiple facilities on a nightly basis. The paper discusses the innovative use of “off the shelf” products to effectively synchronise multiple databases, how the system is structured and monitored and various issues that have arisen since implementation.

1. Introduction

The Fiji Patient Information System (PATIS) is a component of the Fiji Health Management Reform Project, jointly funded by the Government of Australia and the Fiji Islands and implemented by Aus Health International Pty Ltd. PATIS is based on a Health Information System developed in Samoa (HIS) under a project initiated by the Australian Agency for International Development (AusAID) in 1997. A copy of the Samoan HIS was taken to Fiji and, with significant improvements to functionality and reporting, adapted for use in Fiji. The original development, and subsequent redevelopment, of the application was undertaken by Spherion Technologies Solutions (Canberra, Australia) under contract to AusAID. Significant improvements have been made to the PATIS application over the last 18 months based on observation and user feedback.

The success of the implementation to date is due in part to the continued support of both AusAID and the Government of Fiji.

The population of Fiji is approximately 820,000 and geographically consists of two main islands and a large number of smaller outlying islands. Medically the country is split into three divisions (Central/Eastern, Western and Northern). Fiji’s principal medical facilities consist of 3 divisional hospitals (200, 300 and 450 bed), 19 sub-divisional (20-80 bed), 3 specialty hospitals, 75 health centres and 100 nursing stations. It is proposed to implement PATIS in the majority of the hospitals and selected major health centres.

Figure 1. Map of Fiji

By the end of 2003 PATIS will be running in nine hospitals (including the three divisional hospitals), four health centres, three divisional health offices, the Ministry...
of Health Central Office (CO) and the Central Government Pharmacy Office. The first hospital was implemented in February 2001.

2. Patient Information System Overview

PATIS principally supports the inpatient process, pharmacy, radiology, dental and the outpatient departments. Laboratory will be included in November 2003. Monitoring public health staff utilisation and surveillance in remote areas is catered for by a paper-based system with timely entry into the nearest computer system.

2.1. Technical Infrastructure

A Local Area Network (LAN) is installed at each facility where PATIS is running. The minimum requirement for each network is a server, personal computers, printers, label printers (National Health Card production and pharmacy) and a modem. The transmission media for the networks is principally twisted pair cabling (CAT 5 – 100Mbps) but fibre-optic and wireless communication is installed where required. A wide area network is being established between the major centres which will assist in communications and maintenance.

Hardware comprises standard commercially available “name brand” (Dell, Compaq) personal computers, servers and printers that carry a three year parts and labour warranty. The server operating system is MS Windows 2000. Desktop PCs run MS Windows 2000 or XP operating system. The number of PCs installed varies from 8 in the smaller hospitals (25 bed) to 50+ in the larger hospitals. Computers are placed in most wards, radiology, pharmacy, dental, laboratory, clinics, outpatients, dietician and management. Printers are located at strategic points. Servers are all multi-disc running Redundant Array of Inexpensive Disks (RAID Level 5) for faster access and reliability with redundant power supplies and automated tape backup.

The PATIS application has been developed with MS Access 2000, utilizing Visual Basic for Applications (VBA) and Data Access Objects (DAO). DAO is defined as “The objects that represent the structure of the database and the data it contains”. From VBA you can use DAO objects to create or change tables or queries, secure the database, manipulate the data and access data from external data sources. VBA and DAO also form the basis of the data replication application.

MS SQL Server V7.0 is used as the data base management system. Communication with the database is via Open Database Connectivity (ODBC). The SQL Server database structure has been kept relatively simple principally to alleviate the need for a specialist Database Administrator. Use is made of database views, functions and triggers. Complex data integrity checks are programmed into the PATIS application. SQL Server Agent is used to automatically backup (dump) the data to a file on a daily basis, that is subsequently backed up to tape. Virtually all data in each database is synchronized (replicated) on a nightly basis. How this is done is described in Section 4.

The structure of the database and the PATIS application is identical at every installation. A “control” table is customised at each site to indicate the hospital name, identification code and number, set primary key counters and other operational information. Every potential installation has a predefined identification code and number (eg Lautoka hospital Code: LAU, Installation number: 32). The predefined number for the installation precedes all primary key counters. For example the counter for the primary key value for the admission table at Lautoka would be initially set to 320000001. A custom function reads the next available number when required and increments the number appropriately. This system ensures that all primary key and related values are unique enabling data from all installations to be combined. The initial two digits also indicate where the data originated.

3. National Health Number (NHN)/National Health Card (NHC)

When a person (including children) first presents at a hospital running PATIS they are registered on the system and issued with a unique NHN. To avoid the possibility of more than one person having the same number the system prevents a number ever being issued more than once. The number is automatically assigned by the system. Each patient is then issued with a NHC depicted in Figure 2. Issue of cards to children is optional. Children can be linked to parents and tracked via their parent’s number.

![Figure 2: National Health Card](image)

Production of the card is reasonably simple. A “label” is produced (Zebra/Eltron Thermal Transfer Printer-TLP 2844 ~ $AUD1,200) which is subsequently stuck onto a backing card and laminated. The process takes about a minute to complete. A record is kept in the database of when and how many cards have been issued to a patient.
For operational reasons, a patient can only be issued with a maximum of three cards without intervention of a unit manager. Identical cards are used for the production of labels for drugs dispensed to patients. By bulk-buying cost of cards (cards, laminating pouches, labels, ink rolls) is approximately $AUD10 per hundred.

The NHN is a nine-digit number (99999 99 99). The initial two digits indicate the hospital where the patient was registered (e.g., 32001 12 76 where 32 indicates Lautoka Hospital). The NHN can be used for sequential or terminal digit (utilising the last four digits) filing of physical medical records.

Virtually all new, changed and deleted data at each installation is distributed automatically overnight to all other installations. This enables patients to use only one identifying number, the NHN, throughout the country where PATIS is installed. The number is used for all services in the hospital (radiology, clinics, dental) streamlining medical records and patient tracking in and between hospitals. A review and reorganisation of medical records is inherent in all PATIS implementations. PATIS has also created the opportunity to standardise data collection throughout the country.

Note that the NHN is not a “National ID number”. It can be thought of as a master health number, or master medical record number.

3.1. Issues with the National Health Number

Duplicate Registration

Duplicate registration of patients, while not a major problem, is still a problem. A large effort is applied to reduce duplicates in addition to running regular checks to identify and merge duplicates that have occurred. The identified duplicates are examined to try and ascertain probable reasons for the duplicate entry, which in turn identifies areas that may need attention or refinement. By August 2003 about 350,000 people had been registered on PATIS. Of these, approximately 5,000 or 1.4% have been identified as duplicate registrations. While a number of factors contribute to persons being registered more than once on the system the principal factors have been shown to be:

- Inadequate supervision of staff,
- Attentiveness of staff,
- Inadequate initial training of staff,
- Lack of adequate and appropriate training of new staff members after PATIS is implemented,
- Programmatic inefficiencies (eg too many people returned when search criteria entered), and
- Misunderstanding by patients of the meaning and use of the NHC/NHN and/or embarrassment to admit they have lost their card or left their card at home.

A routine, run on a monthly basis, has been included in PATIS to retrieve all registrations that may be duplicates. After examination results are relayed back to the various centres for appropriate action where required (training, increased supervision or general staffing issues). Any identified duplicates are “merged” retaining only one NHN (principal NHN) for the patient and making the duplicate NHN read-only. Details of the principal NHN can be viewed from the duplicate NHN’s Patient Master Index screen enabling users to access the correct details efficiently.

The following actions are in place in an effort to improve the registration process.

Training

A series of “PATIS Train the Trainer” courses have been run to build up a group of experienced PATIS trainers. Participants have been selected from around the country and from all disciplines, including nursing. The courses were initially facilitated by a Samoan National who had built up a wealth of experience and knowledge on the original Samoan HIS while working for the Samoa Department of Health. Component trainers within the Fiji Ministry of Health (MoH) now facilitate the courses. The courses have produced a select number of capable trainers.

User training has been structured to emphasize not only the “how” of PATIS but also the importance of the data, data accuracy and effect it has at all levels and how the data is to be used. For users who attend to the public, the training also includes a session on public relations and “interview” techniques specific to patient registration and/or their particular task. Use of the registration equipment (label printers and laminators) is an integral part of the training. Refresher training courses are run in facilities if the need is identified.

For users who have little or no previous experience with computers an “Introduction to Computers” course is run immediately prior to the specific PATIS training. The course is of one or two days duration depending on the level of experience of the users and covers the basics of computers (hardware, turning on and off, keyboards, mice…) and an introduction to MS Windows. The courses have been very successful in making users comfortable with computers and have increased the productivity of the PATIS training.

Initially new staff at a facility were given a very brief introduction to PATIS by a resident staff member then “thrown in at the deep end” with little or no supervision and limited understanding of what they were doing. This has been addressed by identifying competent users at each facility who also possess the skill to train individuals. The selected users have been given the task of training and subsequently supervising new staff that have not undergone initial PATIS training.

Search Parameters

Before registering a person on PATIS a search must be carried out on the database to ascertain if the individual has been previously registered. It is not possible to by-
pass the search routine if the NHN of the person is unknown. During training it is stressed vigorously that staff must perform the search rigorously every time because, for various reasons (lack of understanding, embarrassment) many patients do not inform staff that they already possess a NHC.

Search criteria have been refined over time and now include surname (mandatory), given name, sex, age and race. The surname is converted to a “soundex” equivalent to retrieve all names in the database that sound like the name entered (alleviating incidence of spelling mistakes). If a given name is entered (encouraged) the first letter of the entered name is extracted in order to refine the search. If an age is entered the search will search for all persons with an age entered +/- three years (the age span parameter is adjustable). The age criterion is used with caution as information supplied is often unreliable. Sex and race are further criteria used to refine the search. The most important criterion (apart from surname) is the given name. After careful study of results it was ascertained that in the vast majority (95%) of duplicate entries the first two letters of the given names are consistent although there are many errors in the final spelling of the given names. An example of variations of one of the more common names entered is “Mohammed”, “Mohmmed”, “Moh’d” or variations of these names combined with a second name. For common surnames, for example “Wati”, the given name is virtually essential to reduce the search results. As of May 2003 there are approximately 12,000 registered on the database under the name Wati. Virtually all (99%) persons registered as Wati are female and Indo-Fijian. Entering a given name can reduce the search result from 10,000 to a couple of hundred thus reducing the time taken to retrieve the results and reducing the error rate of missing an entry when scanning the results.

The search result screen displays all the criteria entered and a listing of all patients who match the search criteria. Pertinent patient information (e.g. Fathers name – necessary for Indo-Fijians, village of residence, date of birth), already registered is displayed to enable users to make an informed decision regarding the patient presenting. The initial training covers the above topics in detail including the various traps that users may find. The awareness of operators is improving over time and with experience.

**Direct Duplicate Error Check**

On initial examination of duplicates entered it was noticed that about 70% of duplicates were an exact match on surname, sex, date of birth or age and the first two letters of the given name. While this had implications in regard to training and user awareness, the program was modified to scan the database prior to adding the person to check if there is an entry already existing with the exact details as above. If a match is found a screen is displayed detailing the result and allowing the user the option to proceed with the registration, due to the fact that there are many people with matching details, or to check if the person was missed in the initial search. This modification has reduced the incidence of direct duplicates significantly although at times the check is ignored and the patient added again (user training).

**Public Awareness**

A large effort has been put into trying to increase public awareness of the NHC and NHN. Specific training is given to users in explaining the use and purpose of the NHC and NHN and how to interact with the public.

A3 size posters and double-sided A5 leaflets have been produced to assist in the awareness campaign. Posters are displayed in prominent positions throughout hospitals and various public places (e.g. government building, shops). Radio sessions have been organized to discuss the NHN and NHN. In Fiji the use of bank cards for accessing accounts is now wide spread. The analogy of the NHN and NHN is one method used to explain the NHN and NHN.

**4. Data Replication**

**4.1. Background**

The replication or data synchronisation process currently used in Fiji was adapted from the system designed and used in the Samoa HIS project to synchronise two databases. The original installation in Samoa used MS SQL Server V6.5 as the database management system but MS SQL Server V6.5 allows only one-way replication. A “simple” but cheap methodology was required to synchronise the databases utilising relatively basic communication facilities available at the time. The replication system was modified and refined to enable it to be used in Fiji to synchronise a number of remote databases.

**4.2. Replication Overview**

Replication is the process whereby data in each installation of PATIS is synchronised with data from all other installations of PATIS. Additions, modifications and deletions of data at any given installation are applied to the other PATIS installations using an automated nightly replication process.

The process is controlled from the Ministry of Health Central Office (CO) server. (Hospital, health centre and divisional office installations are referred to as HHC in the following text).

All additions, changes and deletions to all data (PMI, admissions, pharmacy...), with the exception of some system and installation specific tables, at each HHC installation are “replicated” to CO. This process is known as “One-Way” replication. All the data from the HHCCs is then consolidated on the CO database, extracted and

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subsequently dispatched to all installations that are on-line. **This process is known as “Two-Way” replication.** At the completion of the nightly replication process all installations are synchronised. The various elements of the process are described below.

### 4.3. Directory Structure

Each server is partitioned to have C (system and application files), D (data files) and E (SQL Server data files) drives. For ease of installation identical replication directory structures are setup on the D drive of each server. The names of the principal directories are kept to eight characters, as the communicating package (BLAST – section 4.6) is a DOS based program.

**Figure 3. Replication Directory Structure**

**Directory Definitions**

- **Archive directories**: Files in the archive directories (excluding Archive\blast) are deleted when greater than 21 days old. The period is adjustable.
- **\Archive\Blast**: Stores a copy of the previous periods (1-15th or 16th -end of month) Blast log.
- **\Archive\Input**: At CO stores copies of all hospital extraction files. At HHCs stores copies of Two-Way input files.
- **\Archive\Output**: At CO stores copies of Two-Way consolidated files. At HHCs stores copies of extraction files.
- **\Archive\Reports\AllDivisionFiles**: At CO stores copies of all process and status text files from each HHC.
- **\Archive\Reports\OneWay**: At CO stores copies of the One-Way Load text files. At HHCs stores copies of the Extraction process text files.
- **\Archive\Reports\TwoWay**: At CO stores copies of the Two-Way Extraction text files. At HHCs stores copies of the Two-Way Load process text files.
- **Blast**: Stores the current period Blast log (CO only).
- **\Input\OneWay**: Stores One-Way Extraction files awaiting processing (CO only).
- **\Input\TwoWay**: Stores Two-Way Load files awaiting processing (HHCs only).
- **Master**: Stores the replication programs/utilities.
- **\Output\OneWay**: Stores extraction files at each HHC awaiting transfer to CO.
- **\Output\TwoWay**: Stores a copy of the Two-Way extraction files in the relevant installation directory at CO awaiting transfer to the respective installations.
- **Reports**: Stores status report files awaiting processing (CO) or awaiting transfer to CO at HHCs.

### 4.4. Nightly Replication Process Overview

Outlined below are the principal actions undertaken by the replication process and the timing in place at present. Further explanation of each process, where required, follows.

1) **7:00 pm**: **Replication Extraction (HHCs)**

The replication extraction process (MS Access application **RepExtr.mde**) runs at each HHC depositing a compressed data file in the **Output\OneWay** directory. The file is named with the convention YYYYMMDD.xxx where xxx is the abbreviation for the specific installation (e.g. LAU for Lautoka, SAV for Savusavu) and YYYYMMDD indicates the year, month and day the file was created. (*This convention is used used throughout the remainder of the document*). A text file is created in the **Reports** directory detailing information in regard to the “extraction” process. The files are named ExpxxMMDD.txt.

2) **7:15 pm**: **Get Hospital One-Way Files (CO)**

The CO server dials each HHC (using Blast Communications Package and batch file **GetHospitalOneWay.bat**) in turn and retrieves all files located in the HHCs **Output\OneWay** directory. The files are placed in the **Input\OneWay** directory on the CO Server. After successful transmission to CO the files are deleted from the respective HHC servers. A text file is created in the **Reports** directory detailing information in regard to the “Get” transmission process for each installation (GxxxMMDD.txt).

3) **9:00pm**: **Replication One-Way Load and Two-Way Extraction (CO)**

Part A: The replication One-Way Load process (MS Access application **RepLoad1.mde**) runs at CO loading, in chronological order, all data from the HHC files located in the **Input\OneWay** directory. After successful transmission to CO loading, in chronological order, all data from the HHC files located in the **Input\OneWay** directory.

Part B: After completion of the One-Way load the
The replication application logs on to the database as "RepUser". The database triggers are only activated if the replication application logs on to the database as "RepUser". The database triggers are only activated if the replication has a field called strRecordStatus. When a record is added or changed, a trigger is executed in MS SQL Server on the relevant table that updates the strRecordStatus field of the record to indicate the action. An example of a record status value is C14N. The value is made up of 3 parts. The first character is either A or C, representing Add or Change respectively. The second and third characters identify the installation. The fourth character identifies the division to which the installation belongs. The flag is not updated if a record is changed and an “A” flag is present in the strRecordStatus field. When a record is deleted, a trigger will record the unique identifier of the deleted record and the relevant table name in the server table tblREP_DELETIONS. All records with a value in the record status field are extracted from the database by the replication extraction process detailed in section 4.7.

The SQL Server PATIS database has two application users assigned: “AppUser” and “RepUser”. When the PATIS application is started the user is automatically logged on to the database using “AppUser”. The replication application logs on to the database as “RepUser”. The database triggers are only activated if “AppUser” is logged on.

**Database Tables**

There are a number of database tables that play a role in the overall replication process.

- **Installation Table (tlkp_INSTALLATION)**

  The Installation table lists all the potential facilities where PATIS could be installed in Fiji. Information contained in the lookup table includes the facility name, abbreviation, the type of installation (e.g. CO), the division where the facility is located, whether the facility is on-line and the facility code number. The facility code number is a unique number assigned to the facility to ensure all data entered has a unique ID ensuring data can
be consolidated at all other facilities. This code is cross-referenced in the control table. The replication process uses information from this table to determine which facilities are on-line.

- **Control Table (tlkp_SYS_Control)**
  The Control table is used to store system control values such as the hospital name, identifier and unique key values.

- **Table Names Table (tblRepTableNames)**
  The Table Names table lists all tables in the database detailing the name and data type of the primary key and whether the table is to be included in the one-way replication and two-way replication processes.

- **Deletion Table (tblRepDeletions)**
  When a record is deleted a database trigger records the unique identifier of the deleted record and the relevant table name in the Deletions table for processing at other installations.

- **Status Report Table (tblStatus Report)**
  The Status Report table stores information in regard to the status of all of the replication processes. Data is extracted from this table to produce the daily “Replication Status” report at CO.

### 4.6. Communications

A third party communication program called “Blast Professional for DOS (BLAST)” and “BHOST” (produced by Blast, Inc. (North Carolina, USA)) is used for all the communication and file transfers between CO and all other installations. BLAST is installed on the CO server and is activated as required by DOS batch files and MS Windows 2000 Scheduler. BHOST is a remote control host program that is resident on all other servers, monitoring the communications port invisibly in the background. Dedicated telephone lines and modems are installed at each facility. BLAST and BHOST are DOS based programs. DOS based programs were used instead of the 32 Bit versions now available because of the superior script programming available (specifically in regard to error trapping). BLAST/BHOST cost $AUD250/ $AUD150 respectively.

The BLAST set-up at CO has three main components: 1) BLAST Set-up files for each installation, 2) DOS Batch files to initiate BLAST for communication with each installation and 3) Generic scripts to get/send files.

The One-Way file transfer takes from 4-6 minutes (280kb file). The Two-Way file transfer takes from 5-7 minutes (650kb file). BLAST can be run interactively.

#### Set-Up Files

The BLAST application is used to create the set-up files. The set-up files are named using the abbreviation assigned to the hospital (e.g. LAU.SU for Lautoka Hospital) and contain basic information regarding communication (phone number, modem type, baud rate). Baud rates are set at 56k bits per second (bps) but due to poor line quality most communication is between 28k and 36kbps.

### DOS Batch Files

Simple DOS batch files are initiated by the MS Windows 2000 scheduler to start BLAST. Depending on the task (sending or getting files) various parameters and variable values are passed to BLAST via the batch file. In brief BLAST is initiated using the installation set-up data that contains the appropriate telephone number and running a BLAST script file to get or send files. The hospital abbreviation (and division indicator for Two-Way replication) is passed to the script for reporting purposes and/or determining a directory path (Two-Way). BLAST is re-initiated for each installation via the batch file.

#### Scripts

As each installation has an identical directory structures and the files being transferred are named with the same format (YYYYMMDD.xxx or *.txt), generic scripts have been developed for sending/getting files to or from the installations. The scripts consist of two parts, a “Master” and a “Slave”.

**Master Script:** The “Master” scripts (e.g. sGetSDMst.scr) initialise variables (e.g. Installation Name) and error trapping. The “Master” script then calls the “Slave” script. At the completion of the “Slave” script controls returns to the “Master “ which tests the error value returned by the “Slave”. If no error has been detected BLAST is closed and control returned to the Batch file. If an error is detected, and the maximum number of tries to contact the installation (currently 2) has not been reached, the “Slave” script is re-called after a period of 2m30s (allowing time for the remote modem to reset).

**Slave Script:** The “Slave” scripts perform the following functions:

- Dialling the remote server.
- Transferring the appropriate files either from the remote server to the CO server (Get) or from the CO server to the remote server (Put).
- Deleting the transferred files from the appropriate server after successful transfer. If the transfer is unsuccessful (bad line conditions, no connection) the files remain in the output directory and are transferred the next time reliable communications is established.
- Writing a transmission status text file. The text file is placed in the Report directory and is named PxxxxMMDD.txt or GxxxxMMDD.txt for the “Put” or “Get” processes respectively. The file contains the date of the transfer, “Y” indicating success or “N” failure, the installation abbreviation and the relevant process. For example: “10/05/2003”, “Y”, “CWM Put Transmission”.
- Extensive error trapping is built into the scripts to ensure files are transferred reliably.

#### BLAST Log File

BLAST Log File
A log file is maintained by BLAST that records all actions undertaken by BLAST, and selected processes from the scripts, during a session. The log file is referred to when troubleshooting.

4.7. Extraction, Load and Maintenance Programs

The extraction, load and maintenance programs have been developed using “MS Access 2000”. All communication with the database and subsequent data manipulation utilises VBA and DAO (refer section 2.1).

Replication Extraction and Load Program Files

A number of program files have been created to perform the replication process. All the program files are placed in the Master directory of each server.

1) Replicate.MDB

For ease of maintenance, one application or program has been developed containing all the code to perform the extraction, one-way load and two-way load processes (generically named Replicate.MDB). The base application is compiled, copied and subsequently renamed to indicate the relevant process it is to perform. When the relevant application is initiated via MS Windows 2000 Scheduler the application captures the current file name in order to determine which function or process to carry out. Note: Un-compiled MS Access files have an “.mdb” extension, compiled versions have an “.mde” extension.

The three versions of the Replicate.MDE file are:

- RepExtr.mde: Initiates the “Replication One-Way Extraction” process on HHC servers.
- RepLoad1.mde: Initiates the “Replication One-Way Load” process on the CO server. After completion of the One-Way load the “Replication Two-Way Extraction” process is initiated.
- RepLoad2.mde: Initiates the “Replication Two-Way Load” process at HHC.

Although the One-Way and Two-Way load coding is very similar they are also very complex. For ease of maintenance the functions have been coded separately.

2) RepData.MDB

The RepData.mdb file is an MS Access database containing the exact table structure of all PATIS database tables. The replication extraction files are created using this file. If the PATIS database structure changes, the RepData.mdb is replaced at each installation. A script has been programmed to create this database as required.

3) Utility Files

- PKZIP.EXE, PKUNZIP.EXE: DOS based compression programs to compress or uncompress files.
- Zip.BAT, UnZip.BAT: Simple DOS batch files called from the Replicate.MDE application to compress or uncompress files utilising PKZIP.EXE or PKUNZIP.EXE respectively.

4) RepMaint.MDE

The RepMaint.mde file is a MS Access 2000 database installed at all installations to perform maintenance tasks.

The maintenance program is discussed in section 4.10.

4.8. Replication Extraction Process

The replication extraction process creates an output file per calendar day at each installation that the process is run. The extraction file is created in the Output\Oneway directory named EXTRMMDD.xxx. On successful completion of the process the files are compressed using PKZIP.EXE and are named with the format YYYYMMDD.xxx. The EXTRMMDD.xxx file is then deleted. A copy of the compressed file is placed in the Archive\Output directory. At CO copies are distributed to the relevant Output\Twoway directories for installations that are on-line and the file is removed from the Output\Oneway directory. If the extraction process is run more than once on a given day the Archive\Output directory is checked to see if a file exists for that day. If yes then the archived file is uncompressed and subsequently appended to and distributed as above. This ensures that no data is lost.

At the completion of the extraction process a record is saved in the Status Report table indicating the status (Successful “Y” or Failure “N”) for the current date and installation.

The principal tasks performed by the extraction process are:

1) Current installation ID, name, abbreviation and type are ascertained from the Control and Installation tables.
2) A text file, (ExxxMMDD.txt) is created in the Reports directory. This file is written to throughout the extraction process reporting various details (e.g. number of records extracted from a table, errors). The current process being undertaken by the extraction program is also displayed on the status bar of the MS Access window.
3) If no extraction file exists for the current date a copy of the RepData.MDB file is placed in the Output\Oneway directory and renamed with the format EXTRMMDD.xxx.
4) A snapshot (read-only) “recordset” (copy of a set of records from a database table) is created from the Table Names table for all tables flagged for One-Way replication (HHC) or Two-Way replication (CO).
5) For each table in the Table Names recordset the PATIS MS SQL Server database is queried to establish if there are any records that have an “A” or “C” flag in the strRecordStatus field. If one or more records match the criterion, the records are extracted and inserted into the equivalent table in the EXTRMMDD.xxx database. The strRecordStatus field for all affected records on the server database is then set to Null.
6) Any records in the server Deletions table are extracted and placed in the EXTRMMDD.xxx database Deletions table.
7) If the extraction is successful the EXTRMMDD.xxx
file is compressed and renamed YYYYMMDD.xxx. The EXTRMMDD.xxx file is deleted. A copy of the compressed file is placed in the archive directory. At CO a copy of the compressed file is placed in the appropriate Output/Twoway directory for on-line facilities.

The extraction process is under "transaction" control so in the event an error occurs the process is "rollbacked" ensuring no data is updated on the server maintaining data integrity. Details of the error encountered are written to the reporting text file. The application is thoroughly error-trapped but to date has proved remarkably reliable, fast and efficient. The extraction process takes from 2-3 minutes to run. 5,000+ pharmacy and 1,500 PMI records could be extracted on any given day from CO.

4.9. Replication Load Process

The replication load process is responsible for loading extracted data from one database into another database. There are two versions of the load process, One-Way and Two-way. Both functions are fundamentally the same. The One-Way load function is initiated at CO. The Two-Way load function is initiated at all other facilities. The load functions are comprehensively error trapped to ensure data integrity is maintained. The errors trapped are split into two categories, fatal (extremely rare) and non-fatal. Fatal errors (e.g. ODBC failure) cause the process to halt. Non-fatal error details are recorded in the load text file before resuming the load process. Non-fatal errors encountered are duplicate key violations (when an attempt is made to add a record that already exists) and records not located in the database when an attempt is made to change or delete the record. These errors are noted as "Exceptions".

At the completion of the load process a record is saved in the Status Report table indicating the "Load Status" (Successful “Y”, Successful (with Exceptions) “Yx”, Failure “N” or No File to Process “NF”) for the current date and installation.

Files to be loaded are sorted in ascending alphabetic order. Due to the file naming convention (YYYYMMDD.xxx) the files are effectively sorted in ascending date order. This is important due to the possibility that file transfer may fail on any given night to or from an installation resulting in two or more files being transferred when communication is next established. It is imperative that the oldest files are processed first to ensure all data is added in the correct sequence and/or changes are processed in the correct order.

The principal processes performed by the load programs are:
1) Current installation ID, name, abbreviation and type are ascertained from the Control and Installation tables.
2) A text file (LxxxMMDD.txt) is created in the Reports directory. This file is written to throughout the load process reporting various details (e.g. number of records added, changed, deleted and exceptions from a table, errors). The current process being undertaken by the load program is also displayed on the status bar of the MS Access window.
3) The names of extraction files present in the input directory (CO - \ Input\Oneway, HHCs - \ Input\Twoway) are placed in an array and sorted in date order.
4) A snapshot recordset is created from the Table Names table for all tables flagged for One-Way (CO) or Two-Way replication (HHC).
5) The file(s) in the input directory are processed. After each file is processed successfully the changes are committed to the database. If a “fatal” error occurs while processing a file the process will halt. All files processed, prior to the file with the error, are not affected. Each file is uncompressed (PKUNZIP.EXE) and a link is established with the resulting EXTRMMDD.xxx file (Input File). At the completion of the load a copy of the input file is archived and then deleted from the input directory.
6) For each table in the Table Names recordset, the corresponding table (and the Deletions table) in the “Input File” is interrogated to ascertain if there are any records to be added, changed or deleted. If there are records to be processed a recordset is created from the Server table (“Output” recordset) containing all records marked for change or deletion. A recordset is also created from the “Input File” (“Input” Recordset) containing all the records to be processed for the selected table. The “Input” recordset is then processed in the following order – deletions/additions/changes. The strRecordStatus field determines the action required for the additions/changes. For deletions/changes the corresponding record in the “Output” recordset is located and subsequently deleted or changed. If a record is not located an exception is recorded. Additions are added directly to the database. With the exception of CO the record status field is set to “Null” after successful addition/updating of the record. At CO, only records flagged for “One-Way” replication have the record status field set to “Null”. The “Two-Way” extraction process at CO resets the status flags as required. Records that originated from the current facility are bypassed. The code is “generic” where the table field names are determined from the properties of the recordsets enabling just the tables names to be passed to a common routine for updating of records. A table is bypassed if there are no records to be processed.

To date the load process has proved remarkably reliable, extremely fast and efficient. On average the load process takes 3-4 minutes to run

4.10. Maintenance/Reporting (RepMaint.MDE)

The replication maintenance program deletes “old” data files, provides data for reporting on the extraction and load processes and produces the “Replication Report”
(CO). The program is scheduled to run every day.

File and Status Table Maintenance

To ensure archive directories do not become cluttered with files, but also to maintain a reasonable backup of data and reporting files, the maintenance program cleans directories as described in section 4.4 point 6 and 8.

Replication Report

As mentioned the extraction and load programs write a record to Status Report table at each installation indicating “status” of each process run. At all installations, except CO, the maintenance program extracts the current data to text file (SxxxMMDD.txt), which is subsequently transferred to CO. At CO the maintenance program re-loads the files into the Status Report table and then runs a predefined Replication Status report. The report is viewed by staff each working day and can quickly give an indication if there were any problems with the replication process. The reports list the success or failure of the “Get” and “Put” transmissions to each installation and the status of the Extraction and Load processes at each installation. There are five indicators reporting the status of the processes – Y (success), N (failure), Yx (success with exceptions), NF (no file) and blank (unknown).

When the status is “NF” or blank this generally indicates that there was a problem with communication. The failure (“N”) and exceptions (“Yx”) flags require immediate attention to ascertain the reason and subsequently remedy the situation as required.

Load and Extraction Reports

The load and extraction reports provide information on the respective processes. The reports have a secondary purpose in providing a quick indication of the workload of each facility (e.g. pharmacy prescriptions processed).

4.11. Issues

While the replication process is generally very reliable it does require constant monitoring to ensure that any problems are attended to immediately. If left for a period of time small issues can become large and require more effort to remedy.

- The most common problem encountered to date has been the telecommunication infrastructure and related equipment. The reliability and the quality of the telephone lines has been an issue over time. The modems originally installed also appeared to be problematic with sporadic failures and/or degradation in performance. Occasional interruptions to the communications network have been due to non-payment of accounts and misuse of telephone lines. In January 2003 a cyclone passed over Fiji directly affecting communication with five installations for a number of days. The communication network is “down” for 2 or more days contingency measures are put in place to ensure data is transferred and updated. These measures often include transferring files manually by disk and courier (MoH staff, pilots, friends, public transport) or by email.

- Another problem has been with intermittent power supply to some of the more remote locations. On occasions the timing of the replication processes are adjusted for a particular hospital to ensure data is extracted and loaded when the power supply is most likely to be available or the process is initiated manually.

- Telecommunication charges in Fiji are extremely high when compared with many Pacific Island and neighbouring countries. In addition there is no off-peak rate available for national calls. Negotiations are being conducted with Telecom Fiji seeking a reduced rate for all calls associated the replication process.

- The extraction, load and maintenance programs have been remarkably reliable with only a handful of minor bugs identified during the initial PATIS implementation. The only limitation, of note but of minor consequence, identified to date has been with the load function. It is only possible to load in the vicinity of 2,500 records flagged for “changing” per table during the load process. As mentioned the load function creates a recordset from the server database containing all records flagged for “change”. This is achieved by building a SQL statement in memory with a “WHERE” clause containing the primary keys of each record to be updated. After approximately 2,500 unique identifiers there is simply insufficient memory allocation in MS Access VBA to compile a string long enough to contain all identifiers, resulting in an incomplete SQL statement. This causes a “fatal” error if the load is attempted. This situation has only occurred once in practice during the two and a half years PATIS has been running in Fiji and that was due to “extraordinary” circumstances. A concerted effort was made by one hospitals to update backlogged data for clinic bookings resulting in 3,500 records being updated from one table. Under normal circumstances a maximum of 300 records would be flagged for “change” on any one table on a given day. Splitting the specific tables contents into two files and re-running the load rectified the problem. The vast majority of data is added.

- Minor problems have concerned the BLAST/BHOST package. Initially BLAST, on occasions, was found to “freeze” halting any further communications for the night. After investigation it was found that BHOST on the remote server was “dropping” the connection during file transfer. Additional error trapping was written into the scripts to alleviate the problem.

- Occasionally BHOST, for reasons yet to be determined, loses its “connection” to the communications port and fails to detect BLAST attempting to communicate. This is remedied by restarting the server to re-establish the connection.