USING NEW REPLICATION FEATURES OF ORACLE 7 IN AN EMERGENCY MANAGEMENT SYSTEM

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Oracle DOE SIG Abstract

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Presentation Title: Using New Replication Features of Oracle7 in an Emergency Management System

Abstract:

Pacific Northwest Laboratory\textsuperscript{1} is developing an application for the Army and the Federal Emergency Management Agency to support emergency management of hazards resulting from the accidental release of chemical agents during their storage or destruction. This application, called the Federal Emergency Management Information System (FEMIS), uses Oracle7.1 in a client/server configuration. At each Army site where FEMIS is deployed, there will be two or more servers and about 25 users on client personal computers (PCs) connected to each server.

The Oracle\textsuperscript{2} Data Base Management System is configured as a multiserver, distributed data base using partitioning to share information between the Oracle instances. The information in the individual partitioned tables is merged by Union operators to form a set of site-wide views. This data base contains more than 180 tables and about 40 additional site views. Oracle snapshot replication was chosen rather than distributed queries in order to achieve autonomous operation and improve failure tolerance.

The presentation will describe this architecture and discuss how the data was partitioned. Some useful techniques for generating the scripts that produce the data base will also be discussed.

\textsuperscript{1}Pacific Northwest Laboratory (PNL) is a multiprogram laboratory operated by Battelle Memorial Institute for the Department of Energy.

\textsuperscript{2}Oracle is the registered trademark of Oracle Corporation.
Using New Replication Features of Oracle7 in an Emergency Management System

1. INTRODUCTION

Pacific Northwest Laboratory is developing an application for the Army and the Federal Emergency Management Agency to support emergency management of hazards resulting from the accidental release of chemical agents during their storage or destruction. Phase I of this application, called the Federal Emergency Management Information System (FEMIS), uses Oracle7.1 in a client/server configuration. The application has been through alpha, beta, and government acceptance testing as of March 1995.

The Phase I system of FEMIS is designed for a single storage site that has multiple Emergency Operations Centers (EOCs). It is also possible to remotely log into an EOC at a different storage site. The capability to automatically share information between remote storage sites will be present in Phase II which will be delivered in 1996.

2. CONFIGURATION DETAILS

FEMIS is a client/server system where much of the application software resides in the client. Each EOC has between five and 25 Personal Computers (PCs) through which users do their jobs. These client PCs are connected via a local area network to servers that provide efficient EOC-wide services. The client software comprises a graphical user interface based on Visual Basic, a government-furnished dispersion model, and commercial, off-the-shelf (COTS) tools such as the Arc View geographic information system (GIS), Microsoft's Project Manager, and GroupWise's electronic mail.

Each EOC has a UNIX server providing services for evacuation modeling, data management, ArcInfo GIS capabilities, and basic file management. A PC electronic mail server is provided to handle electronic messages, and a PC communications server is available to interface with external subsystems. For Phase I, the weather collection system (MET) is the only external subsystem. The EOCs at the site are interconnected via Wide Area Networks using T1 links.

Figure 1 shows a conceptual view of Phase I FEMIS and shows the types of information required. Much of this information is located in the Oracle database management systems (DBMSs). The DBMSs cooperate to share data among EOCs. This allows multiple users to share the information, while maintaining the integrity and persistence of the data. Table 1 summarizes the types of relational data and its general nature.

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The FEMIS program provides automation for the Army's Chemical Stockpile Emergency Preparedness Program (CSEPP) and is funded by the U.S. Army Chemical and Biological Defense Command. This work was done under a Related Services Agreement with the U.S. Department of Energy Contract DE-AC06-76RLO 1830.

ArcView is the registered trademark of Environmental Systems Research Institute, Inc.

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Table 1. Types of Data Managed by the DBMS

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Data Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Data</td>
<td>CSEPP site information including EOC data.</td>
</tr>
<tr>
<td>Work Plan Data</td>
<td>Includes work plans, accident data, the activity log, and case management data.</td>
</tr>
<tr>
<td>Plan Data</td>
<td>Information supporting electronic planning.</td>
</tr>
<tr>
<td>Met Data</td>
<td>Weather conditions and equipment status information.</td>
</tr>
<tr>
<td>Source Data</td>
<td>Chemical agents, munitions, bunkers, events, and casualties.</td>
</tr>
<tr>
<td>Personnel Data</td>
<td>Personal and organizational information along with user control data.</td>
</tr>
<tr>
<td>Facility Data</td>
<td>Information about zones, facilities, and shelters.</td>
</tr>
<tr>
<td>Resource Data</td>
<td>Information about resources and Memorandum of Understandings.</td>
</tr>
<tr>
<td>Population Data</td>
<td>Population information including special care needs.</td>
</tr>
<tr>
<td>Risk Data</td>
<td>Includes information about plumes, wedges, threatened areas, and recommended actions.</td>
</tr>
<tr>
<td>Spatial Data</td>
<td>Relational data supporting the GIS.</td>
</tr>
<tr>
<td>Evac Data</td>
<td>Relational data tables used by the evacuation model.</td>
</tr>
<tr>
<td>D2 Data</td>
<td>Relational data tables used by the dispersion model.</td>
</tr>
</tbody>
</table>
The relational database in FEMIS is managed by Oracle, a commercial DBMS. The distributed processing features of Oracle Version 7 are used to produce a multi-server distributed data architecture. Data replication provides local copies of the shared tables. This is important, since it allows an EOC to operate autonomously in case the links to other EOCs are not operational. Also, performance is enhanced because the local table can be accessed at the LAN bandwidth.

Approximately one half of the tables are empty at installation. These are tables such as the Situation Summary table which contains information about current conditions at the site. As the system is used, data will accumulate in these tables which will become a useful resource. The remaining tables are preset with data as part of system installation.

3. DATA TABLE SHARING

In Phase 1, more than 180 tables comprise the FEMIS relational database. Based on past design efforts and testing results, each relational data base table is local to an EOC, and some are shared with the other EOCs. Data in the local tables can be accessed only by users logged in to that particular EOC, while the data in shared tables is available at several EOCs. Details of data placement are transparent to the FEMIS users, so that the FEMIS data base appears to be a single, unified collection of tables.

Local Tables

Tables that are local are managed by the local Oracle database and can be accessed only by users connected to that server. Local tables provide privacy between EOCs and also are an efficient way to manage general-purpose read-only data such as validation tables. Figure 2 shows an example of a Local FEMIS table.

![Figure 2: Local Tables](image-url)
**Replicated Tables**

These tables are assigned to a single EOC but are shared with the other EOCs via Oracle replication. Whenever the primary table is modified, the remote EOCs will get the updated data in their snapshot table. This type of sharing is useful when all of the write access occurs at the primary EOC. The Work Plan table that contains daily activities is an example of Replicated tables in FEMIS (see Figure 3). A synonym is used to rename the snapshot back to the original name of the primary table in this manner:

```sql
grant select on EOC1.EOC1_Work_Plan to EOC2;
create synonym EOC2.Work_Plan for EOC1.EOC1_Work_Plan;
```

![Figure 3: Replicated Tables](image)

**Site-view Tables**

Site-view tables have local read and write access and are also part of a view that is the Union of the table with local snapshots of the same table from the other EOCs. The Facility table shown in Figure 4 is an example. Each EOC has

![Figure 4: Site-view Tables](image)
its own Facility table and also the view named S_Facility which is defined for EOC One as:

```sql
create view EOC1.S_Facility as
    select * from EOC1.Facility UNION
    select * from EOC2.EOC2_Facility UNION
    select * from EOC3.EOC3_Facility;
```

where EOCn.EOCn_Facility are Oracle snapshots and the site has three EOCs.

4. ORACLE DATA REPLICATION

The individual EOCs in FEMIS are operated rather autonomously by their user organizations. For example, in Utah, the Onpost EOC is the Army's responsibility, while the County EOC is managed by Tooele County and the State EOC is managed by the State of Utah. All EOCs are expected to be in operation when an accident is possible, but there are times when any given EOC is offline.

Oracle replication works well in this kind of situation. If an EOC happens to be unavailable, operations at the other EOCs proceed normally. When the offline EOC becomes operational, all the data changes are propagated to it. Also, if communication links fail at an EOC, operations can continue using the local copies of shared tables.

Oracle replication became possible with Version 7.0, and enhancements are being made with each new release. FEMIS is currently using Version 7.1.4, the latest production release. Tables can be replicated in an asynchronous manner with table-to-table integrity enforced. In the future, added replication features will allow the ownership of the primary table to be passed among Oracle servers and will allow users at the snapshot sites to update data in the snapshots.

The Oracle7.1 snapshots used for data replication are created by first defining a snapshot log at the server that manages the read/write (primary) version of the table. For example, the following would create a log for the Facility table at EOC One:

```sql
create snapshot log on EOC1.Facility;
```

These logs are necessary if the FAST refresh option is used. The FAST option allows the refresh process to send only the changes to the data rather than the complete table, thus saving both communication bandwidth and time.

After the snapshot logs are created, the snapshot objects can be created at the other EOCs. The syntax to create a snapshot of the Facility table from EOC1 at EOC2 is as follows:

```sql
create snapshot EOC2.EOC2_Facility as
    select * from EOC1.Facility@link_to_EOC1;
```

The database link, link_to_EOC1, fetches data from the remote EOC.

Replicating data, while maintaining integrity between related tables, is done using the Oracle DBMS_REFRESH Package. A snapshot group can be defined to replicate two or more tables as a single transaction, so that parent/child relationships are maintained. A group called Fac1 containing the Facility and Shelter snapshots is defined by executing the following stored procedure from the DBMS_REFRESH package:

```sql
EXECUTE DBMS_REFRESH.MAKE('EOC1.Fac1', 'EOC1.EOC1_Facility,' EOC1.EOC1_Shelter', SYSDATE, 'SYSDATE+1/(24*60)', TRUE, TRUE);
```
The parameters name the group, define the snapshots in the group, specify when to begin to refresh, how often to refresh, and how to manage the group. This example causes the refresh to commence immediately and to check for updates every minute. Most of the FEMIS snapshots use the one-minute rate except for several critical tables which are refreshed three times per minute.

5. DATA BASE ADMINISTRATION

Administration of the database with more than 180 tables where 40 of these are shared between three EOCs is complex. Several techniques were developed to automate the SQL script generations that created the various objects in the database. Each table was given a type label to denote how it is shared. The types are:

- **Local** - No Sharing; each EOC has its own table
- **Replicated** - Only Onpost EOC has table; others have snapshot
- **Replicated** - Like Replicated, but shared conditionally
- **Site-view** - Each EOC has table and also a site-wide view
- **Site-view** - Like Site-view, but shared conditionally

Conditional sharing was implemented with a timestamp column in the table and a where clause in the create snapshot statement, for example:

```sql
create snapshot EOC2.EOC2_Facility as
select *
from EOC1.Facility@link
where xmit_flag is not null;
```

A spread-sheet containing the table names and types was prepared. UNIX awk scripts were made that used the spread-sheet to generate the SQL scripts that create the snapshot logs, snapshots, views, and the other objects necessary to configure Oracle in a three-server architecture.

Another configuration was developed where all three EOCs use a common server. To do this, the snapshots were replaced by views managed by a single Oracle instance. Again, the SQL scripts to create this configuration were produced by awk scripts.

6. FEMIS LESSONS

Based on experiences gained over the past year, several tips and lessons learned are offered:

1. Replication works well in situations where all of the Oracle servers are not available 100% of the time. In this situation, distributed queries using 2-phase commits would have required considerable exception processing and error recovery.

2. The one-minute refresh rate creates a CPU load on the servers, but with Sun 1000e servers with 4 CPUs, this was minimal.

3. Due to new replication features being added with each release, the developer must be flexible to incorporate these into the application.

4. The downside of replication is that it can fail unexpectedly. This was infrequent, but still of concern to a developer. One problem is that the failure modes are not well documented. Our solution was to periodically monitor replication, and then drop the failed snapshots and recreate them when necessary. Future releases of Oracle are expected to have more error reporting, so this should be less of a problem.

5. Due to frequent data placement modifications that occur during development, some form of automated SQL script generation is recommended. This bypasses the error prone, manual preparation process that will slow down development.

6. Visual Basic (VB) places some constraints on the Oracle database. The
user_name.table_name convention is not understood by VB, so unique table and view names had to be used. Also, data access performance was slow using VB Dynasets; this is attributed to the Open Data Base Connectivity (ODBC) interface between VB and Oracle.

7. During development and testing, software errors often resulted in dead Oracle client sessions. A process to monitor and remove these orphan sessions was required in order not to exceed the maximum number of users authorized by the licensing.