A REM White Paper

Smart Systems
For
Smart Meters
1. The Challenge

A UK wide domestic Smart Metering rollout presents many challenges; one of these challenges is to deliver a resilient, scalable “Smart System” capable of communicating with and processing all the messages from a large mixed Smart Meter estate within a finite processing window.

It is generally accepted that in order to realise some of the benefits of Smart Metering that half hourly time of use data will need to be acquired, processed, securely stored and made available to consumers in a timely manner. Having this information available enables the consumer to be informed about how they are using energy and with suitable help, information and financial incentives they can be encouraged to use less energy or to shift some of their energy usage to a time of day when both the demand and the carbon intensity of the grid is lower. This implies that the “Smart System” implemented must be capable of processing daily time of use messages from all domestic energy consumers in an overnight processing window.

The solution is also expected to process high volume “spikes” of messages generated from communication intensive business processes such as network outage notification, tariff updates, firmware updates or when large numbers of messages require processing after the recovery from system or network problems. The solution must be capable of responding to these communication spikes and should prevent these spikes from causing a noticeable drop in message transaction rates.

In the recent UK smart metering consultation process (1) three market model options are considered:
1. A Centralised Market Model;
2. A Competitive Market Model;
3. A Central Communication Model.

In the context of this paper option 1 and option 3 are identical as they both require a central smart system to manage the communications with the national meter estate of around 47 million meters. In the competitive model each energy supplier is required to implement their own solution.

A large UK energy supplier may have 10 million customer accounts and will need a smart system capable of receiving and processing at least 10 million daily messages; each message will contain as a minimum the energy consumption measured in each of the 48 half hourly periods of the day. It is not unreasonable to expect that all communication takes place overnight and the resulting messages must be processed in a finite processing window between 12 midnight and 6am. The implied system processing requirements are 463 messages processed per second, every second, throughout the six hour processing window. In this example a total over 480 million separate data items have to be parsed, verified, validated and securely stored during this nightly process.

We define this requirement to process 463 messages per second as the Supplier Benchmark. Similarly we define the requirement to process 2176 messages per second as the National Benchmark.

2. Our Solution

REM’s Smart Metering Operations Suite (SMOS) provides a complete and scalable enterprise smart metering solution. SMOS has been designed and developed in the UK by REM based upon experience gained with the UK’s largest domestic smart meter trial and experience gained from several larger scale smart metering projects in the United States. SMOS is a complete meter, data and transaction management system for smart metering operations. It provides a single solution to manage a mixed meter estate and supports a wide range of on-demand business processes.

- SMOS is built upon Oracle Enterprise 10g and Oracle TimesTen in memory database technology
- SMOS delivers high levels of security;
- SMOS is meter agnostic, network agnostic and communication protocol agnostic;
- SMOS Functionality, Performance and Scalability at Lowest Cost:

The Smart Metering Operations Suite (SMOS) developed by REM includes an optional Oracle TimesTen database component embedded within the system architecture. In this option known as SMOS In Memory an in memory database is used to process in real time, messages from remote metering devices.

Remote meters deliver messages via a load balanced architecture to incoming message queues within the SMOS In Memory node; multi-threaded processes concurrently dequeue and process messages from the queues. Each message is parsed (broken down into its individual data items) and transformed into a metrology data structure before the virtual meter data model is updated to reflect the contents of the message. Within SMOS each real meter is modelled as a virtual meter, the virtual meter data model contains both the current snapshot and the complete history of a real meter. After the message has been processed the data is replicated into the main SMOS Oracle database from where the data can be accessed via the SMOS user interface.

3. IN MEMORY DATABASE TECHNOLOGY

In memory database technology is not new; it is widely deployed in enterprise wide Supervisory, Control And Data Acquisition (SCADA) systems and is in extensive use in telecommunications and financial systems. Some mobile phone operators use systems containing in memory database technology to maintain a real time picture of their mobile network so that calls can be routed correctly in real time. In a Pay AS You GO application, in memory technology is used to resolve real time requests to check a customer’s prepay balance prior to enabling or barring the customer from making a mobile phone call. Some financial systems use the simple linear scalability of the in memory technology to ensure that an order is processed before a stock price changes; all orders for a stock are processed within a consistent time frame regardless of the number of orders being placed. Typically these applications are deployed on off the shelf hardware in a resilient, dual redundant, hot standby configuration.
Oracle’s TimesTen database resides entirely in memory; an advantage of this architecture is that it does not have to perform some of the tasks a conventional enterprise database typically performs such as writing data to disk and managing buffer caches. This results in a simpler technical architecture that requires fewer CPU instructions to process the same amount of data as a conventional relational database, this manifests itself as faster processing times for the same number of transactions. In our SMOS In Memory implementation we optimise a combination of performance and resilience, we ensure the TimesTen transactions are persistent and recoverable; data is always available in memory even after hardware failure. To achieve this we sacrifice some performance by periodically writing log files containing all the relevant transactions to disk.

SMOS In Memory supports load balancing and hot standby, it is fully integrated with bi-directional data replication to and from our meter data management Oracle database.

4. Benchmark Testing In Collaboration with Oracle UK

REM is an Oracle technology partner and has recently participated in the TimesTen 11g Beta Programme. Following the completion of the development programme and the general release of TimesTen 11g; REM completed the development of its SMOS In Memory product and arranged with Oracle to execute a Smart Meter Message Processing benchmark test. The testing was performed jointly by technical teams from both REM and Oracle at the Oracle UK Enterprise Technology Centre in July 2009.

The benchmark testing was conducted on two identical HP Proliant servers; each with 4 dual cores AMD Opteron CPU’s and 16GB of RAM. Redhat Enterprise Linux 4 (64 bit) operating system was used on both nodes. SMOS and Oracle are Operating system independent.

SMOS In Memory including Oracle TimesTen 11.2.1.2.0; 64-bit; was installed on one node with the log files residing on a RAID-0 SAN. SMOS including Oracle 10.2.0.4.0 64-bit Enterprise Edition was installed on the second node with the data files residing on a RAID-0 SAN. The nodes were connected to the SAN via a fibre channel connecter each node formed part of a private Gigabit LAN.

Prior to commencing the Smart Meter Message Processing benchmark tests, to gain an understanding of the performance limits imposed by this hardware configuration, the standard TimesTen Online Transaction Processing (OLTP) benchmark tests were executed. These standard tests contain a combination of selects and updates and were run against a table containing 1 million rows of data with the following results:

- for queries a peak of over 1.1 million selects per second was achieved;
- for 30% updates a peak of over 450k committed updates per second was achieved (updated per transaction);
- for 50% updates a peak of over 380k committed updates was achieved;
- for 100% updates a peak of over 200k committed updates per second was achieved.

As shown in Figure 2 below the tests were repeated with up to 7 concurrent connections before the I/O capacity of the SAN began to cause contention.

*Figure 2 TimesTen OLTP Benchmark*
The SMOS In Memory and the SMOS Standard Edition nodes were tested in exactly the same way. Each node stored the Meta Data for 0.5 million meters and had 0.5 million daily messages queued ready for processing; each message included the total active positive energy, the total credit (to simulate prepayment meters) and 48 half hourly time of use consumption records; resulting in a total message size of approximately 100 bytes.

Each SMOS configuration was tested with a variety of concurrent processes until the best message processing rate for each configuration was obtained. Performance tuning to remove contention, hot spots and bottlenecks was performed between each run to improve the results. Memory usage for SMOS Standard Edition never exceeded 7GB and the memory usage for SMOS In Memory never exceeded 6GB.

The following message processing rates were achieved:

- **The Supplier Benchmark Requirement**
  - To process 10 million messages in 6 hours, a minimum of 463 messages per second.

- **The National Benchmark Requirement**
  - To process 47 million messages in 6 hours, a minimum of 2176 messages per second.

- **SMOS**
  - A maximum of 200 messages processed per second;
  - A maximum of 720,000 messages processed per hour;
  - This configuration would take 13.8 hours to process 10 million messages;
  - A cluster of three of these server nodes would be required to achieve the Supplier Benchmark;
  - This configuration would take 66.7 hours to process 47 million messages;
  - A cluster of a minimum of twelve server nodes would be required to achieve the National Benchmark.

- **SMOS In Memory**
  - A maximum of 1555 messages processed per second;
  - A maximum of 5.6 million messages processed per hour;
  - This configuration would take 1.7 hours to process 10 million messages;
  - A single SMOS In Memory node would exceed the Supplier Benchmark;
  - This configuration would take 8.4 hours to process 47 million messages;
  - Two load balanced SMOS In Memory Nodes would exceed the National Benchmark.

*Figure 3 Benchmark Testing Results*
5. Conclusions

A UK wide domestic Smart Metering rollout presents many challenges; one of these challenges is to deliver a resilient; scalable “Smart System” capable of communicating with and processing all the messages from a large mixed Smart Meter estate within a finite processing window.

In response to the processing challenge resulting from this requirement Remote Energy Monitoring has designed SMOS In Memory to provide best of breed performance for this type of application.

In this paper we have deduced and defined two smart meter message processing performance benchmarks which we have called the Supplier Benchmark and the National Benchmark.

With the help and support of our technology partner Oracle, we have tested and quantified the message processing performance of SMOS In Memory and compared that to the performance of SMOS, the Supplier Benchmark and the National Benchmark.

Our conclusions are:

1. Different technology stacks (hardware & operating system) will produce different values for the number of messages processed per second. However the conclusions to be drawn from this type of testing will remain the same;

2. When installed on relatively inexpensive server hardware (less than £5,000 each) SMOS In Memory demonstrated a message processing capability that exceeded the Supplier Benchmark;

3. SMOS In Memory demonstrated a 7 fold increase in message processing capability compared with our standard product SMOS which uses conventional Oracle database technology;

4. A small cluster of three of the same low cost servers running SMOS In Memory would exceed the National Benchmark;

5. To deliver the National Benchmark the SMOS In Memory solution costs approximately 75% less in hardware and 50% less in software licensing costs than a conventional Oracle database technology solution;

6. SMOS In Memory provides a low cost solution to the smart metering message processing challenge;

7. SMOS In Memory delivers high message processing capabilities and linear scalability.

REM offers its products via a flexible business model which gives customers a choice of:

- A fully managed and operated service in which REM just deliver data and data access to the customer for an agreed service charge;
- A “black box” solution remotely operated by REM but with the “black box” within a customer’s data centre. REM can provide a full “black box” solution, an operational solution delivered on appropriate hardware, complete with technology stack and technology licenses.
- A complete in-house solution where REM receives a license fee for the SMOS software and the customer provides the complete technology stack and the operational staff to deliver the service;

Customers are free to choose the operational model which best suits their business. REM will deliver the required level of service, training and support.

SMOS is an enterprise architecture that is scalable and can be delivered as a dual redundant, load balanced, solution with automatic failover and recovery. This architecture delivers a fault tolerant solution with full disaster recovery capability.

SMOS In Memory and SMOS are available today, please contact REM to initiate further discussions of your operational requirements.