Reflective Memory in Action

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Reflective **Memory**

What is REFLECTIVE MEMORY?

A Reflective Memory network is a special type of shared memory system designed to enable multiple, separate computers to share a common set of data.

Reflective memory networks place an independent copy of the entire shared memory set in each attached system. Each attached system has dull, unrestricted rights to access and change this set of local data at the full speed of writing to local memory.

When data is written to the local copy of Reflective Memory, high speed logic simultaneously sends it to the next node on the ring network. Each subsequent node simultaneously writes this new data to its local copy and sends it on to the next node on the ring. When the message arrives back at the originating node, it is removed from the network and, depending on the specific hardware and number or nodes, every computer on the network has the same data at the same address within a few microseconds.

Local processors can read this data at any time without a network access. In this scheme, each computer always has an up to date copy of the shared memory set. In the four-node example shown, it takes 2.1 µs for all computer to receive the data that was written to Reflective Memory.*

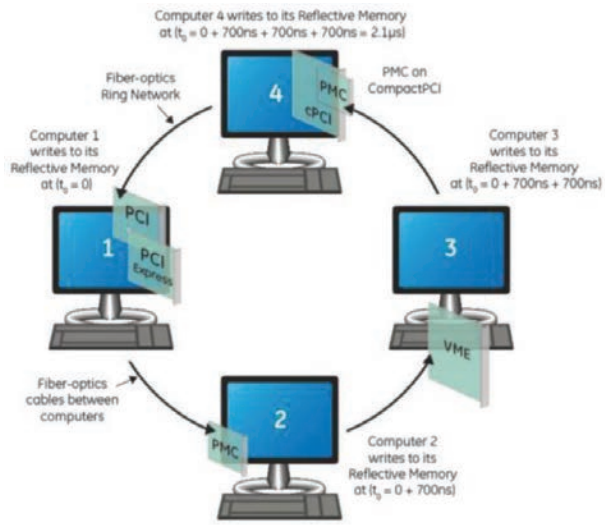

***Figure 1** Reflective Memory provides very low latency between nodes.*

** This latency is calculated assuming no network traffic, short cable lengths and the largest packet size is possible. Cable length and network traffic can cause the latency to increase, but as long as the bandwidth of the network is not exceeded, the latency should not increase significantly.*

WHERE DO I USE REFLECTIVE MEMORY?

Reflective Memory may be used in any application that uses Ethernet, Fiber Channel, or other serial networks to connect computers or Programmable Logic Controllers (PLCs) together, but it is not ideal for all applications. Reflective Memory is most relevant in systems where interaction in real time is a primary concern. In systems where determinism, low latency, and high-speed communication are necessary, Reflective Memory boards, while typically more expensive than lower performance hardware, provide a huge return in performance with the added benefit of ease of use.

WHO USES REFLECTIVE MEMORY?

Reflective Memory is used in hundreds of applications, including the following:

- Aircraft simulators
- Automated testing systems
- Power plant simulators
- Engine test stands
- Industrial process control
- High speed data acquisition
- Over-the-horizon radar
- PLC users
- Ship & submarine simulators
- Aluminum rolling mill control/monitoring

Application EXAMPLES

WHY WOULD I CHOOSE REFLECTIVE MEMORY?

Reflective Memory LANs or Real-time Networks are usually constructed because the designer has needs or problems that are solved by one or more of the following Reflective Memory board characteristics:

- Deterministic data transfers
- High-speed performance
- Ease of use
- Operating system & processor independence
- Economics and available time-to-build systems
- Advantages over Standard LAN Technologies

APPLICATION EXAMPLES

FLIGHT SIMULATION

One example that shows the importance of low-latency performance is an interactive combat flight simulator where multiple participants participate as independent variables in a combined synthetic environment. In this type of simulation, each separate computing system may be responsible for generating a display, managing individual participants' inputs into the simulation, generating terrain or other environmental aspects, managing weapons systems, or any of a variety of other functions. Because multiple independent participants are performing highly-dynamic movements at extremely high speeds, it becomes imperative that the system updates frequently enough to represent an accurate and lifelike simulation of reality.

In the J-Squared Reflective Memory network, any memory writes placed on the Reflective Memory network, is available for the next computer to receive as data in less than 700 nanoseconds. This is measured from the time it was written into local RAM and transmitted to the next Reflective Memory board.

Let us assume that two simulated F-22 aircraft are traveling at their cruising speed of 1,070 mph. If one pilot in the simulation makes a radical maneuver that forces the other pilot to take evasive action, it must be quickly represented in the simulation or the realism of the simulation will be lost.

By minimizing update latency, Reflective Memory ensures the integrity of the simulation. The speed of the network enables the simulation to withstand the scrutiny of the sensory perceptions of the human participants and it meets higher requirements for serving electronic "participants" such as each aircraft's weapons, control and navigation systems.

Application EXAMPLES

ALUMINUM ROLLING MILL

The Reflective Memory real-time network was used to enhance a PLC-controlled Aluminum Rolling Mill operation. Distributed PLCs were used to monitor and control a 3,500 ft/min rolling mill. The PLC control loop had a resolution response that allowed 2 to 3 feet of aluminum to pass through before actuators could respond. These actuators were responding to apply/release pressure on the aluminum to vary the thickness.

Using Reflective Memory, a system of communication between separate VME-based systems was developed to reduce this response time. The 2 to 3-foot resolution was reduced to 4 inches, resulting in tremendous waste reduction and quality improvement in the final product. Data relating to the mill was imported to the PLC which immediately wrote it into Reflective Memory's memory, thereby sending it to a separate VME computer system to transfer complex control algorithms.

The system sends the output control data back to the PLC by simple write commands to its Reflective Memory. In this application, data appears in local Reflective Memory in an almost instantaneous fashion on the PLC. The data transfers are fast and the computations are so fast that the PLC runs its control loop with no delays. Thus, the PLC operates at its maximum scan rate because it is only reading/writing the plant's control devices and Reflective Memory's memory.

Application EXAMPLES

ROCKET ENGINE TEST STAND

Distributed computing, which tightly couples multiple microprocessors, is growing in popularity because distributed systems are economical to build and use. At the same time, a distributed approach is often simply the most practical choice. Most distributed applications are broken down into pieces, with specialized computers each handling specific independent tasks. This makes even very complicated tasks easier to partition and code. The designer is also able to place computers strategically or place them to fit within existing space constraints.

For instance, a rocket engine test stand uses hundreds of transducers to measure various parameters. Operators need a lag-free connection to the testing, but for safety reasons, the instrumentation/viewing center may be located 3,000 meters away. By distributing the implementation, the designer is able to install a computer at the test stand that digitizes and preprocesses the data. Then, instead of hundreds of discrete wires spanning the 3,000 meters, one high speed Reflective Memory network link is all that is required to send the data back to the main computer in the control room. This distant computer then analyzes, archives, formats and displays the data on monitors for viewing by the test operators.

By using a high-speed Reflective Memory link, operators can observe and react to changes as they occur, with minimal delays imposed by the connection. By placing the control staff and core processing computers at a safe distance from the volatile testing, operators are able to minimize risks to personnel and equipment with no degradation of test performance.

Application EXAMPLES

NUCLEAR POWER PLANT SIMULATOR

Nuclear power plant simulators are representative of a growing class of complex applications that require significant amounts of distributed computing power, sometimes spread over quite large distances, and that need to share large arrays of volatile data in real time. Many of these applications are turning to Reflective Memory because it is a highly scalable, simple solution that offers much lower latency and a higher degree of determinism than alternative solutions, making systems both faster and more robust.

Reflective Memory is the technology chosen for training some 2,000 students in Germany who must develop an understanding of, and learn to operate, power plants under all possible conditions on 13 simulators. Simulator training is a significant component in obtaining and permanently retaining the necessary, and also legally-required, specialist skills needed by operators, making an important contribution to the safe operation of Germany's nuclear power plants.

The simulator sees up to 27,000 I/Os managed in real time. Three VME Intelligent I/O Controller (IIOC) systems are coupled together and linked to a VME Data Communications Controller via a VME fiber optic Reflective Memory Interface. The Reflective Memory interface moves data to and from the Data Communications Controller and the IIOCs at a rate of 170 Mbytes/s. Each IIOC contains processor and firmware to support I/O scanning and updating, power-up, real-time, and off-line diagnostics. The Data Communications Controller communicates with the host computer via a Reflective Memory interface. The system supports parallel processing of I/O data concurrently with the transfer of data to and from the host computer, with the IIOC allowing off-loading many I/O-related tasks from the host.

SYNCHROTRON RADIATION FACILITY

Advanced experimental science routinely works at a 'sub-nanometer' level such as probing the structure of matter in electronics. A key technology for working at this level of miniaturization is synchrotron light, a form of electromagnetic radiation. Synchrotron light is an ideal tool for many types of research and industry, such as crystallography of proteins, tomography, photolithography, X-rays and residual stress analysis and has applications in the life sciences, medicine, material science, molecular environmental science, petrochemical and chemical industries.

Reflective Memory is being used in synchrotron applications to provide quick feedback to control particle jitter in the synchrotron's storage ring. The particles will jitter while they are in motion due to minor changes in magnetic forces in the orbit. Reflective Memory is used in the system that controls jitter to ensure the particles are always orbiting. The particles move at very high speed, so the system must be real-time and respond quickly.

Comparison

OFF-THE-SHELF NETWORKING TECHNOLOGIES

SUMMARY

Reflective Memory is an optimal way to share data in time- critical applications ranging from data acquisition and process control to advanced simulation. Reflective Memory networks provide a real-time networking capability that surpasses most communications technologies for low latency and deterministic performance. Reflective Memory networks connect systems with minimal update delays and no access restrictions, to enable multiple, remotely located nodes to share a single data set in real time.

Reflective Memory Network Characteristics	5565/ 5565RC 5565PIORC	10/100 Ethernet	Gigabit Ethernet
Transmission Speed	2.1 GBaud/s	10/100 Mbit/s	1000 Mbit/s
Data Transfer Speed	170 MB/s	1/10 MB/s	100 MB/s
Endian Data Conversion	Yes	No	No
Software Transparent	Yes	No	No
Media	Fiber Optic	Coax, UTP	Fiber Optic
Topology	Ring	Ring, Hub	Ring
Network Data Transmission/ Reception Is Deterministic?	Yes	No	No
Network Transfer Scheme	Data Insertion	Carrier Sense Multiple Access/ Collision Detect	Token Passing
Memory Mapped Access to Shared Data?	Yes	No - Messaging Application Application Must Be Built	No - Messaging Application Must Be Built
Application Must Be Constructed to Share Data?	No	Yes - Messaging Application	Yes - Messaging Application
Application Must Encode/Decode Messages?	No	Yes	Yes
Application Must Perform Error Check/Handling Retransmits, etc.?	No	Yes	Yes
CPU Overhead to Support Shared Data Functionality?	No	Yes	Yes
CPU Overhead Required at Transmission Hardware Interface?	No	Yes	Yes

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