Design and Implementation of a Home Network System Bus Using a Serial Switched Bus

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Abstract: - In this paper, we present the design of a Home Network System Bus using a Serial Switched Bus Technology. We describe the features of StarFabric, a Serial Switched Bus Technology. The Home Network System Bus, which is newly designed, consists of a Switch Board and a Bridge Board. For their verification, we compose a Home Network environment and measure the performance of a Serial Switched Bus by the designed Switch Board and Bridge Board. Finally, the suitability of the Serial Switched Bus to a Home Network System is discussed.

Key-Words: - Switched Bus, Home Network, Interconnection Networks

1 Introduction
The PCI bus developed in the early 1990s was an epoch-making standard bus that overcame several shortcomings of a local bus such as an ISA bus. This bus can exchange data mutually by a PCI standard irrespectively to the kind of I/O device or CPU. With the advent of high speed semiconductor technology and increased amount of information, the PCI bus has advanced accordingly. In order to solve the problem of bandwidth, buses such as AGP and PCI-X have been developed. Because several I/O devices consist of a parallel bus that share buses, a bottle-neck problem occurs in the case of several host CPUs.

Presently, PCI buses are utilized in various applications such as set top boxes, communication systems, real-time systems, factory automation systems, and PCs. Also, the PCI bus can be used in Home Network Systems. To exchange high-capacity data such as multimedia data at high speed in a Home Network system, a higher speed bus is required.

A serial switched bus can solve the problems of a parallel bus such as a PCI. Because a Serial Switched Bus exchanges data into the switching, it does not suffer from a decline in speed. Fig. 1 displays the most recently developed interconnection technologies. While RapidIO and PCI Express are switched buses, they can be used within a system[1,2]. On the other hand, StarFabric can extend to several meters by a LVDS signal because it can maintain distance physically to networks between several systems. In this paper, we present the design and verification of a Home Network System using StarFabric, a type of Serial Switched Bus.

2. Features of StarFabric
StarFabric, a kind of Serial Switched Bus, is a powerful technology that will be applicable to a distributed embedded system. Because PCI is a shared parallel bus, it inherently entails a decrease of efficiency. Fig. 2 shows the current PCI bus architecture. In contrast, StarFabric guarantees a bandwidth in each I/O device by use of switching architecture, as illustrated in Fig.3[3,4]. Fig. 4 presents a StarFabric sample system.

StarFabric significantly raises both scalability and bandwidth. Because it supports class of traffic, it also raises flexibility and intelligence. New systems such as Home Network Systems need higher performance and scalability. StarFabric is the best solution that supports these requirements. StarFabric supports...
numerous traffic types regardless of protocol of devices such as PCI and H.110 while a Class of Service algorithm can control multi-type traffic.

3. Design of StarFabric Switch Board
Fig. 5 presents a hardware block diagram of the designed StarFabric Switch Board. The Switch Board is composed of a Switch Part, a LVDS Interface Part and a Power Part. A packet with a LVDS interface is transmitted to the destination port through the routing method of the StarFabric Switch. In order to compose 16 StarFabric links, 4 SG1010 Switch Chips are used. High-speed switching is possible by two links between the switch chip.

3.1 Switch Part
The Switch Part is composed of four SG1010 StarGen Switch Chips. As Fig. 6 shows, the StarGen SG1010 StarFabric Switch facilitates the design of high-performance and reliable StarFabric based switching systems. System designers can develop high performance systems that deliver voice, video, and data. The SG1010, a single-chip solution, offers six 2.5Gbps full duplex serial links, which deliver 30Gbps of aggregate, non-blocking, full duplex switching capacity[5,6].

Along with its high performance, the SG1010 can handle content-rich traffic through its extensive
functionality and quality of service (QoS) support. The SG1010 supports 4 classes of service along with three routing methods, which provide added flexibility. The SG1010 is designed to work with other StarFabric devices and supports bridge products that employ protocols such as PCI. System designers can build system architectures that combine control, voice, cell and packet data.

The SG1010 allows PCI based designs to be easily migrated to StarFabric, yet maintain their investments in software and applications. The SG1010 supports two addressing models, a StarFabric address model and a PCI address model. In the StarFabric address model, the SG1010 switches path-routed and multicast frames. To support the PCI address model, the SG1010 appears as a PCI-to-PCI bridge to PCI configuration software. The SG1010 includes a PCI-compliant type1 header for 100% compatibility with existing PCI BIOS, drivers, application SW, and operating systems.

The SG1010 allows system designers to cost effectively engineer highly reliable and available systems. SG1010 system designs can include redundant data paths, so if a particular path fails, traffic can be rerouted over an alternate path. The SG1010 supports detection and notification of link status changes, as well as Hot-pluggable links. Path notification messages alert operations personnel to replace faulty components and through hot swap, the offending boards can be replaced without affecting the rest of the system. The 2.5 Gbps links also tolerate failure of up to three of the four differential pairs in a link. The re-striping of data is done automatically in silicon when differential pairs fail.

### 3.2 LVDS Interface Part

As Fig. 7 shows, the Physical Layer of StarFabric is 622Mbps LVDS. The SG1010 utilizes 622Mbps low voltage differential signaling (LVDS), a technology that is widely applied and thoroughly understood by industry professionals. Four transmit and receive differential pairs create a single 2.5Gbps full duplex link with 5Gbps of total bandwidth. StarFabric designs can span from chip-to-chip to room area networks. Inexpensive twisted pair copper cable can yield distances greater than 10 meters[5].

The serial transmitters and receivers used in StarGen devices are compatible with the TIA/EIA-644 and IEEE 1596.3 LVDS specifications. They transfer data at a 622Mbps rate with a loop current between 2.5mA and 4.5mA. Each transmitter has on-chip termination to minimize reflections and improve signal integrity across backplanes and connectors. Each receiver has an internal 100Ω nominal resistor that provides the required impedance to produce a voltage across the receiver. This voltage is typically 400mV with a center point at +1.2V. The receiver provides +/- 100mV sensitivity over a common-mode range of 0V to 2.4V and compensates for skew between differential pairs for proper detection. The LVDS pairs may be AC coupled. If they are, a Vcommon recovery circuit is required at the receiver end to properly restore the DC value.

- Four differential pairs in each direction
- 622Mbps
- 2.5Gbps
- 5Gbps port
- 2.5Gbps

**Fig.7. LVDS physical layer**

The following list summarizes the LVDS routing recommendations:

- The distance between differential pairs should be a minimum of 2S, 20 mil separation or more is recommended.
- The LVDS portion/layers of the circuit board must be constructed with a controlled transmission line impedance of 50Ω (100Ω differential).
- Trace impedance should be controlled within +/-10%, but +/- 5% control is recommended.
- A minimum distance of ~30 mils should be maintained between the digital signals and the LVDS signals.
- The maximum recommended skew between the + and - signals within each differential pair should be no more than 25ps.
- There should be a maximum time skew of 300ps between the four differential pairs that comprise an SG1010 link.
- LVDS routing should be completed before digital CMOS and TTL routing.

The LVDS emits electromagnetic interference because the LVDS has over 622 MHz frequencies. Hence, a Common Mode Choke should be installed in the output of the LVDS interface. For suppressing EMI we used Murata DLW21HN900SQ2L.
3.3 Power Part

A POLA (Point-of-Load Alliance) DCDC converter (Artesyn PTH05060) is used in the Power Part to supply low voltage power. This DCDC converter is part of the “Point-of-Load Alliance” (POLA), which ensures compatible footprint, interoperability, and true second sourcing for customer design flexibility. The POLA is a collaboration between Artesyn Technologies, Astec Power, and Texas Instruments to offer customers advanced non-isolated modules that provide the same functionality and form factor. Fig. 8 is a picture of PTH05060.

Fig. 8. Artesyn PTH05060

3.4 Designed Switch Board

Fig. 9 represents an experimental prototype of a Switch Board for switching 16 StarFabric links.

Fig. 9. Designed Switch Board

4. Design of Bridge Board

Fig. 10 shows a hardware block diagram of the implemented StarFabric Bridge Board. The Bridge Board is composed of a SG2010 Bridge Chip Part, a LVDS Interface Part, and a PCI Interface Part. As Fig.10 shows, a StarGen SG2010 PCI-to-StarFabric Bridge provides an interface between the PCI and StarFabric[5,7]. The bridge translates PCI traffic into a serial frame format for transmission across StarFabric. By connecting the bridge’s serial interfaces to other bridges, or to StarGen StarFabric switches, designers can design flexible topologies with increased bandwidth, reliability, and number of endpoints or slots. PCI buses can be 32 or 64 bits, and can operate at 33 or 66 MHz. The PCI-to-StarFabric Bridge supports legacy address-routed traffic with full compatibility to existing PCI software, including configuration, BIOS, OS, and drivers. With the SG2010 Bridge’s gateway function, it supports StarFabric-native path and multicast routing capability along with other enhanced features. Fig. 12 represents an experimental prototype of a Bridge Board for bridging StarFabric to the PCI.

Fig. 10. Bridge Board hardware block diagram

5. Experiment

We tested the implemented Switch Board and Bridge Board using four personal computers. In order to verify the performance of the Serial Switched Bus, we installed a Bridge Board in the PC and transmitted
maximum traffic. Bridge Boards should be installed in four PCs first, and then the StarFabric driver software is installed so as to allow the OS to recognize Bridge Boards. The Bridge Board is connected to the Switch Board with Category-5 cable. The bridge mode function of the Bridge Board is disabled, because of CPU-to-CPU communication. The Bridge Board supports path routing only in pure gateway mode. We built custom software using StarGen API and transmitted and received user data. We transmitted random packets and measured transmit throughput.

Fig. 13. Result (2 PCs)

![Graph showing throughput vs. data length for PC1-PC2 (2 PCs)](image)

StarFabric data payloads can be up to 128 bytes per frame and there is a link overhead between a 12 bytes header and frame. Therefore, the speed of one physical StarFabric link is 2.5Gbps. To transmit 128 byte data frames, the real throughput is about 1.77 Gbps because of link overhead and header. Fig. 13 shows the result of a throughput test between two PCs. Fig. 14 is the result of a throughput test using four PCs. There is no difference in throughput between the two PCs test and the four PCs test. These results show the characteristics of the switch fabric architecture.

Fig. 14. Result (4 PCs)

![Graph showing throughput vs. data length for PC1-PC2 and PC3-PC4 (4 PCs)](image)

6. Conclusion

In this paper, we proposed a Serial Switched Bus as a high-speed Home Network System and an evaluation method for testing the implemented system. The proposed Serial Switched Bus is designed using StarFabric. In order to evaluate performance, the Switch Board and Bridge Board designed and implemented herein were tested by transmitting high-speed Ethernet traffic.

It was verified that the Serial Switched Bus is more suitable than a Parallel Bus such as PCI for construction of a high-speed Home Network System. The designed Serial Switched Bus is not compatible with other switching technologies such as RapidIO and PCI express, and only supports StarFabric technology.

The Home Network System should be more compact and embedded. In this paper, we used custom packets for testing functionality. Currently, we are designing a PC-based packet converting device. In the near future, various Home Network Devices of embedded style will be required.

References: