BACKPLANE CHARACTERIZATION FOR THE NEXT GENERATION TELECOMMUNICATION SYSTEMS ARCHITECTURE

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Articolul de față prezintă caracteristicile arhitecturii Advanced Telecom Computing Architecture (AdvancedTCA), un nou standard de telecomunicație definit de către PCI Industrial Computer Manufacturers Group (PICMG). Pe lângă caracteristicile generale ale arhitecturii, accentul este pus pe interconexiunile de înaltă-viteză implementate prin intermediul backplane-ului de una dintre interfețele standardului. Lucrarea prezintă, de asemenea, proiectarea unui generator de trafic 10Gigabit Ethernet, capabil să populeze simultan cu trafic Ethernet controlabil fiecare interconexiune de înaltă-viteză existentă pe backplane-ul AdvancedTCA. Acest sistem a fost construit si utilizat pentru a caracteriza backplane-ul AdvancedTCA, iar rezultate şi concluzii ale acestui studiu sunt incluse în acest articol.

The paper presents the overall characteristics of the Advanced Telecom Computing Architecture (AdvancedTCA), the new telecom standard for chassis-based modular systems, in the history of PCI Manufacturers Group (PICMG). Beside the general characteristics of this standard, the focus is on the high-speed interconnection delivered by the switching fabric implemented on the AdvancedTCA backplane. We present a practical design of a 10Gigabit Ethernet traffic generator able to run traffic on every link of the AdvancedTCA switching backplane simultaneously. This system has been built and used to characterize the AdvancedTCA backplane. Results and conclusions of this characterization study are hereby included.

Keywords: Advanced TCA, telecom, high-speed, backplane, 10Gigabit Ethernet, traffic, PRBS, Jitter.

Introduction

The telecommunications industry is facing increasingly competitive pressure to support more applications, reliability and availability of services. The main market in telecom is for scalable solutions in terms of chassis-based systems.

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In the context of telecommunication systems, a backplane is a high-speed circuit board containing connectors into which other circuit boards (modules) are plugged in. The backplane assures, via high-speed communication lines, the interconnection between those individual modules plugged into its connectors.

The need for an improved standardized solution to be employed in the design of the telecom systems was strongly existent when a new family of PCI Industrial Computer Manufacturers Group (PICMG) [10] standards was defined, by 2002, under the name of the Advanced Telecom Computer Architecture (AdvancedTCA or ATCA) [11]. Very soon after its release, manufacturers of chassis and components decided to adopt this standard and so did as well most of the telecom systems designers and manufacturers. The AdvancedTCA architecture has been also chosen by us for the design of a 10 Gigabit Ethernet switch [13]. As the majority of telecom systems which adopted the standard immediately after the release were new prototypes, as well as the AdvancedTCA standard itself, it was very important to be sure that the backplane works correctly and that it delivers in practice the advertised performances. We looked therefore into testing the AdvancedTCA backplane but very soon found out that high-speed traffic generators available on the market were extremely expensive and did not allow testing of more than a few high-speed lines of the backplane.

In this context, we decided to build ourselves a high-quality traffic generator which answers the need of over-loading with 10 Gigabit Ethernet traffic all the lines of the backplane. We could use this system to characterize the complete functionality of the AdvancedTCA backplane through high-speed measurements. Practical measurements for a fully loaded backplane were not available at that time and when some work in this direction was presented (e.g. [7]), the transmission quality was quantified only for a couple of lines running across the backplane. This was far away from being satisfactory for us as our concerns were related to how it works or, if still works, an AdvancedTCA backplane fully loaded with 10 Gigabit Ethernet traffic.

The present paper will start with an overview of the AdvancedTCA standard. Based on the AdvancedTCA standard specifications, we designed and built a traffic generator system which will be used to give an estimation of the quality of the backplane defined by the AdvancedTCA standard.

1. The AdvancedTCA standard

The AdvancedTCA standard describes a high bandwidth, high connectivity, chassis based architecture designed principally to appeal to the telecommunications industry. The main goal of the AdvancedTCA standard was to enable building telecom systems of higher capacity which offer the ability to mix variety types of modules and technologies in one platform.

The AdvancedTCA specifications define the mechanical form factor, power and cooling parameters, backplane interconnects and the system management architecture necessary to construct a compliant backplane, chassis and plug-in boards. The chassis width depends on the host rack which could be either a 19” instrumentation rack or 23” which is more common for telecom racks. In the first case there are 14 slots per chassis/backplane and in the second there can be either 14 or 16 slots. A major departure from previous instrumentation chassis implementations is the power distribution which is dual redundant -48V. The cooling is designed to support up to 200W of power per slot.

The speeds supported by the AdvancedTCA backplane interconnects are directly dependent on the transmission technology of use by the AdvancedTCA switching fabric, which can be Ethernet, Infiniband, PCI Express, Fiber Channel, Rapid IO etc. The only thing in common between all these is the use of 100Ohm balanced differential pairs for the transmission lines. By providing enough of these pairs by the mean of different interfaces implemented in the AdvancedTCA backplane the PICMG group hopes to offer an infrastructure that will attract all of these technologies.

The AdvancedTCA backplane carries the interconnects and defines five different types of interfaces such as Shelf Management (1), Synchronisation Clock Interface (2), Update channel Interface (3), Base Interface (4) and Fabric Interface (5).

1) Shelf Management. Management of the chassis is a major part of the specification since equipments from various vendors are inserted inside the same chassis. Not all of those modules have compatible I/O and therefore needs to be verified before power is applied. This is achieved over an I2C bus.

2.) Synchronisation Clock Interface. There are three clocks that are bussed across each slot inside the ADVANCEDTCA chassis, two of them are Sonet/SDH clocks at 8Khz and 19.44Mhz. The third is user definable.

3.) Update channel Interface. Each board has 10 differential pairs connecting it to its neighbor. These are expected to be used with proprietary protocols.

Before explaining the Base (4) and the Fabric interface (5) it should be noted that among the 14 or 16 slots of the AdvancedTCA chassis, two of them represent redundant copies of each other and are the central point of control for the switching fabric. These are the logical slots 1 and 2 and their physical position is not defined by the standard. Common practice puts them adjacent to each other, either at the centre or extreme left of the backplane.

4.) Base Interface. It dedicates the logical slots 1 and 2 as redundant hubs boards for a dual star interface using a 10/100/1000 BASE-T Ethernet interconnect to every other slot containing Node boards of the system. The base interface offers a medium speed control path and implements a switching fabric architecture in parallel to the higher speed Fabric Interface.

5.) Fabric Interface. The Fabric Interface defines the switching fabric which represents the 'hearth' of the system which assures the transport of all the high-speed traffic between the different modules. The AdvancedTCA standard defines two different transport architectures and variants on the theme for special purposes. The first is the Dual Star and the second the Full mesh. In the Dual Star every Node slot, N, supports one fabric channel (four pairs in each direction) to each of two Hub slots, H. In a Full Mesh all slots, N, are equal peers and provide one channel to every other board in the backplane. It is also possible to have Dual-Dual Star configuration, which is preferred from redundancy point of view. The mesh and the dual-star topologies are shown graphically in Fig. 1.

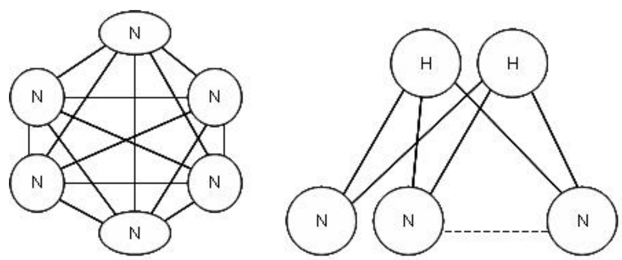

Fig. 1. Mesh and Dual-star topologies

2. A practical implementation for the AdvancedTCA

We developed a system able to generate controllable Ethernet traffic at 10Gigabit over every connection simultaneously in the dual-star topology of the AdvancedTCA fabric interface. This system is a 10Gigabit Ethernet [8] active traffic generator [1], [2] and contains 14 modules to be plugged into the AdvancedTCA backplane slots. Two of these modules are central switching modules (defined as hub boards) and the rest of 12 are Node modules.

The 10Gigabit Ethernet compliant traffic is distributed across the AdvancedTCA dual-star fabric interface on four differential pairs per direction. Eight pairs are used for a full-duplex connection, each of them carrying signals which run at 3.125Gbps with 8B/10B encoding [8]. On a 14 slots AdvancedTCA backplane, there are a total of 200 such differential pairs, on which our traffic generator is able to simultaneously generate 10Gbps Ethernet traffic in terms of pseudo-random bit sequence (PRBS), random or deterministic jitter.

The 10Gbps transceivers used in the system are the Alaska 88X2040 Serdes devices from Marvell [9]. They are located on each module of the traffic generator system and they are connected via the point-to-point links of the dual-star fabric interface on the AdvancedTCA backplane. These Serdes devices can be programmed to auto-generate 10Gbps Ethernet traffic and to adjust the levels of amplitude and pre-emphasis of their corresponding transmitted high-speed signals.

The control of the traffic generator system is achieved from a single point of control on Hub1 in logical slot1 from where it is distributed by using the single star topology of the base interface on all the other slots of the AdvancedTCA backplane. All the control responsible for the traffic generation on the backplane is achieved from a single microcontroller - Lantronix DSTni-LX-001 [12] -. However, the user interacts with the traffic generator via an external PC, which is connected to the Hub1 via the Ethernet interface. The control software application is therefore distributed between the microcontroller in the system and the PC and it is based on the client-server model [3].

Fig.2 shows a 14 slots AdvancedTCA backplane into which the 10 Gigabit Ethernet traffic generator modules are inserted. It can be seen the Hub1 placed at the extreme left and a star connection (represented in black) having the starting point from there. For simplicity reasons, the redundant star connection having the starting point in Hub2 is not shown in Fig.2.

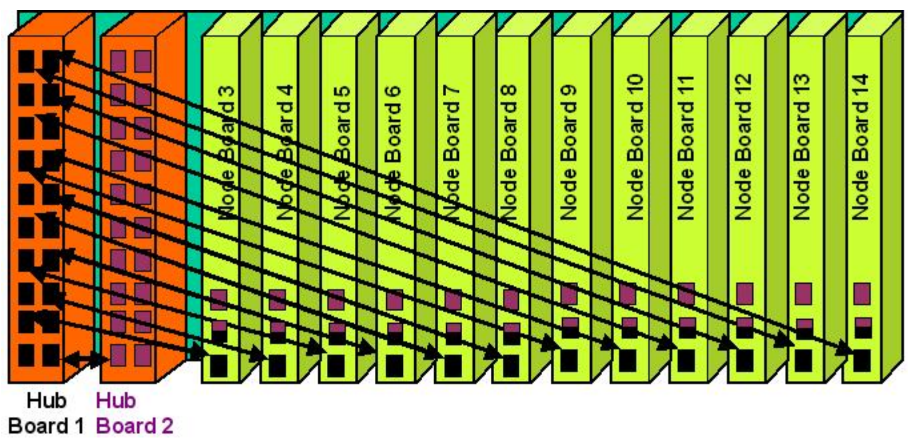

Fig. 2. 10 Gigabit Ethernet traffic generator’s modules inserted into the AdvancedTCA backplane

Hub1, the main switching module of the traffic generator is shown in Fig. 3.

Fig. 3. View of the central switching module Hub1of the 10Gbps Ethernet traffic generator

The connectors corresponding to the AdvancedTCA backplane can be seen in the back-side extremity. The board contains 20 Alaska 88X2040 devices for the traffic generation, the Lantronix microcontroller with its corresponding infrastructure (RAM, serial and parallel flash, Ethernet controller etc.) and has two serial interfaces and an Ethernet interface for the connection to the exterior.

3. Quality estimation of the AdvancedTCA backplane

We used of the 10 Gigabit traffic generator, previously described to determine a qualitative estimate of the transmission quality across the AdvancedTCA backplane.

As mentioned in the previous section, a client-server application has been developed by us to assure the control of the whole traffic generator system. The client application is running on the remote PC connected via Ethernet to the Hub1. Any user of the traffic generator interacts directly with this PC, by defining in a graphical user interface the high-speed lines to be tested (loaded with high-speed traffic) on the AdvancedTCA backplane. The test specifications are transmitted in real-time to the server application running on Hub1, the main point of control of the traffic generator. The server takes care of setting up all the issues related to the traffic generation and to monitoring of the selected high-speed lines. The results (such as high-speed links status and number and erroneous bits) are returned in real time by the server to the client, respectively the user.

In the context of the present article, we did not focus on the software measurements and their results interpretation. We have chosen to show instead a set of high-speed measurements of the 3.125Gbps signals passing across the longest path on the backplane (from logical slot1 to logical slot 14). These measurements were performed at the receiver Serdes device on the module inserted in the slot 14 of the AdvancedTCA backplane, by using a 5 GHz Serial Data Analyser (Lecroy SDA5000A) with a 6 GHz differential probe (WaveLink

D600A-AT). However, we should note that in order to realize those measurements, the traffic generation on the backplane was setup via software as described in the paragraph above. A simplified graphical representation of the measurement setup is shown in Fig.4.

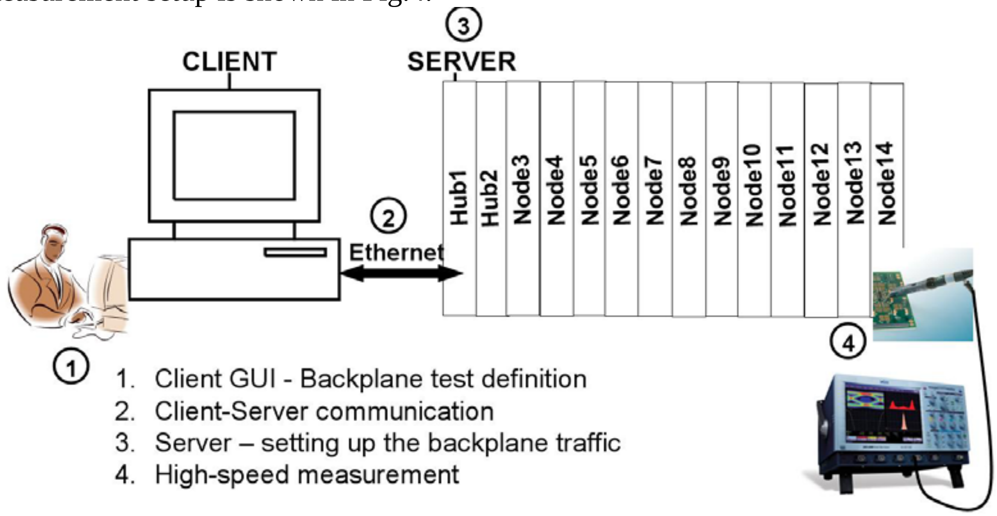

Fig. 4. Graphical representation of the measurement setup

In the measurements we considered the influence of different values of amplitude and pre-emphasis on the overall signal quality. Pre-emphasis is the preferred method of signal conditioning in the backplane applications and operates by boosting the high-frequency components of a transmitted signal and this way compensating for the low-pass filter effect introduced by the transmission channel [4], [5], [6]. The measurements were taken in terms of statistical eye-diagrams, whose minimum eye openings, as specified by the template in the 10Gigabit Ethernet standard, are of 400mV.

First improvements in the transmission quality were achieved by increasing the amplitude of the transmitted signal at the Alaska from the minimum of 700mV, up to its maximum value of 1.1V. The opening of the eye-diagram, measured in slot14 of the AdvancedTCA backplane was increased from 690mV to 1V (Fig. 5).

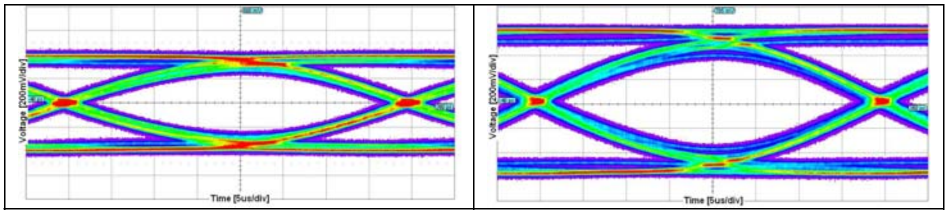

Fig. 5. AdvancedTCA Backplane Measurements (Amplitude benefits)

a.) Transmitted amplitude=700mV
Pre-emphasis=0%
Eye-opening=510 mV
Eye-amplitude=690 mV

b.) Transmitted amplitude=1100mV
Pre-emphasis=0%
Eye-opening=740 mV
Eye-amplitude=1 V

These measurements showed that the AdvancedCA backplane has a good quality and allows good transmission characteristics even when the original transmitted signal has minimum amplitude. To determine if the transmission quality over the AdvancedTCA backplane could be further improved, we considered the influence of different amounts of pre-emphasis on the transmitted signal. Further improvements indeed were achieved when we added an amount of 60% pre-emphasis on the original transmitted signal (Fig. 6).

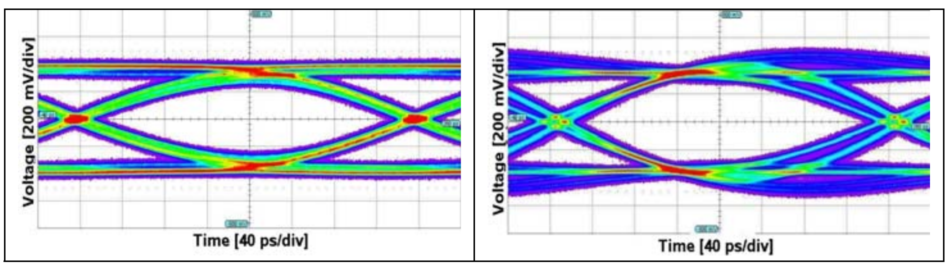

Fig. 6. AdvancedTCA Backplane Measurements (Pre-Emhasis benefits)

a.) Transmitted amplitude=700mV
Pre-emphasis=0%
Eye-opening=510 mV
Eye-amplitude=690 mV

b.) Transmitted amplitude=1100mV
Pre-emphasis=60%
Eye-opening=600 mV
Eye-amplitude=720 mV

We could still see in Fig. 4 to the right some overshoots at the receiver due to the pre-emphasis effect originally added, but the eye opening was superior by 15% when compared to the results achieved in the transmission of the corresponding signal with no pre-emphasis. We proved this way, that if needed and necessary, further improvement of the transmission quality across the AdvancedTCA backplane can be still achieved by using the pre-emphasis conditioning effect.

Conclusions

We have developed a system able to generate 10 Gigabit Ethernet traffic simultaneously over every single connection in the dual-star fabric interface of the AdvancedTCA Backplane. By using this system, we performed high-speed measurements and assessed the quality of the AdvancedTCA backplane. The results obtained show that the AdvancedTCA backplane under test was well engineered and could sustain a good signal quality over the longest distance in the AdvancedTCA chassis even for a transmitted signal with minimum pre-emphasis and amplitude. We demonstrated so, that the AdvancedTCA backplane can deliver the specified cross-sectional bandwidth defined by the standard.

To obtain a further improvement of the transmission quality on the AdvancedTCA backplane, we demonstrated that the pre-emphasis circuitry implemented by the Serdes technology in the Alaska 88X2040 device, can be used if necessary.

We could conclude that the traffic generator we developed completely fulfill its requirements as an instrument for quality control of the AdvancedTCA backplane. Such a system can be used by any AdvancedTCA backplane manufacturer as an instrument of control of their products or even by telecom systems manufacturers employing the AdvancedTCA architecture for their products.

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