Lost Bus

Solving the obsolete PC Bus standards problem in ATE

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***Abstract*— Every 6 to 11 years a new PC peripheral interface standard is developed. As the new interface gains in popularity, the old interfaces that are replaced become obsolete. This poses a challenge for ATE and UUT equipment that rely on the PC peripheral interfaces for testing. The solution for the obsolescence problem in PXI (and similar) systems is to move the interfaces away from the PC and into an instrument. A peripheral instrument would need to include several standard PC interfaces such as Ethernet, USB, SATA, UART, and I2C. By moving the interfaces to an instrument, when the PC and the associated interfaces become obsolete, the instrument can continue to be produced allowing the continued testing of the legacy UUTs. Furthermore, the instrument can maintain software compatibility through multiple OS releases preventing costly rehosts of TPS (Test Program Set).**

Keywords—UUT; Peripheral; ATE; PC;

I. Introduction

The PC industry continues to innovate at a rapid pace and with this innovation comes new standards and bus systems. This rapid pace of innovation leads to buses becoming obsolete faster and is a particular challenge for the test engineer who has to support both the legacy and current bus systems. As the PC industry continues to evolve the test engineer is faced with the following challenges:

- Buses become obsolete when new PC models are introduced.
- Limited slots in motherboards result in limited space for new bus instruments
- Rehosting TPS due to incompatible bus instrument replacements
- Newer Operating Systems' (OS) no longer support older buses

This paper will explore the causes and consequences of the above challenges and will present a solution in the form of the peripheral instrument.

II. Brief history of buses

A. Here come the buses

Over the years a multitude of buses have been introduced to interface peripherals to the PC. This section outlines the history of a few of these buses and how they relate to each other.

B. ISA

One of the first mainstream bus standards introduced was the ISA (Industry Standard Architecture). The bus was created by a team at IBM in 1981, and the term ISA was used by Compaq to replace "PC Compatible". The bus was designed to connect peripheral cards to the motherboard. The initial implementation required users to have knowledge of hardware parameters such as IRQ (Interrupt Request Line) and IO addresses which made configuration difficult and resulted in the dreaded IRQ conflict. The configuration difficulties led to the creation of ISA PnP (plug-n-play) which automatically managed resource allocations.

C. ATA

Based on ISA, the ATA interface (AT Attachment) was developed in 1986 to interface hard drives with the motherboard. Originally hard drives would be integrated on an ISA adapter, but given the clunky nature of the solution the hard drive was eventually moved to a hard drive bay and connected to the ISA slot via a ribbon cable.

D. PCI

Created in 1992, the PCI (Peripheral Component Interconnect) was created to replace the VESA Local Bus. PCI eventually replaced not only VESA (Video Electronics Standards Association) but ISA as well because the PCI slot was 2 inches shorter and the PCI cards were typically less bulky and faster than their ISA equivalents.

E. SATA

In 2003, SATA (Serial AT Attachment) was created as a successor to ATA, which had been renamed PATA (Parallel AT Attachment). SATA introduced a much higher throughput than PATA, and a much more robust and thinner cable to interface the hard drive to the motherboard. Also, it provided features such as hot-swapping and hot-plugging.

F. PCIe

PCIe (Peripheral Component Interconnect Express) was introduced as the serial successor to the parallel PCI standard. PCIe has a much higher throughput than PCI and a smaller footprint and IO count. Furthermore, more robust hot-swapping and hot-plugging support was introduced in the standard along with better error reporting capabilities.

G. RS-232

RS-232 was introduced in 1962 by the Radio Sector of the EIA. RS-232 was originally used to connect together teletypewriters/terminals and modems. In later iterations the bus was used to connect various peripherals such as mice, keyboards, modems, and printers to PCs. Today, RS-232 is commonly used as a debug port and to implement point to point communication protocols.

H. USB

USB (Universal Serial Bus) was designed in 1996 to simplify the connections of external peripherals to the PC. It was meant as a way to eliminate the multitude of connectors that existed such as PS/2, the Parallel Port, and the Serial Port. The advantage of USB is that it supports hot-swapping and hot-plugging and has maintained backwards compatibly with each iteration of the standard.

I. Ethernet

Ethernet was originally developed at Xerox PARC between 1973 and 1974. The DIX (Digital/Intel/Xerox) standard was published on September 30, 1980 and set the foundation for modern computer networks. The bus was primarily created as a low cost solution for interconnecting PCs.

III. THE ATE STRUGGLE

A. Difficulties and Challenges

Modern test systems must support UUTs with a wide array of legacy and current bus standards. This section will explore the unique challenges of the ATE test engineer who must continue to support obsolete bus standards, add testing capability for new bus standards, prevent TPS rehosts, and continue to support both old and new OS releases.

B. Short term usually wins

The fast paced nature of the PC and ATE environment oftentimes puts pressure on test engineers to find a short term solution. When faced with the challenge of creating a test platform for a new or legacy peripheral, the test engineer might decide to directly plug the UUT into the test PC as shown in Fig. 1. Although the buses used in UUTs have become so prevalent because they are commonly found in PCs, using the PC to test the UUT results in several problems.

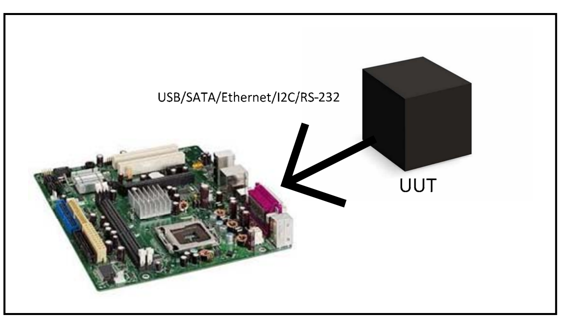

Fig. 1. Example PC test setup

Relying on a PC for testing a UUT PC creates a replacement problem. If the UUT damages a port on the PC, then the PC will need to be repaired. Given the PC is also the test station, this results in downtime since no testing can continue until the PC port is replaced. Potentially the damage may be more severe and can result in data loss, which could result in significant downtime as a new PC is brought up.

C. Obsolescence happens

Motherboards and associated buses will go obsolete, often much more quickly than the lifecycle of a UUT. In situations where a PC is used for testing and the PC motherboard goes obsolete, it is possible that a replacement motherboard will not support the required bus standards. For example, it is now very difficult to find a motherboard with ISA or PCI slots despite their popularity several years ago. In such a case either test coverage for the device is lost, or the test engineer must undergo a lengthy process to try and find an alternative.

D. Compatibility

The test engineer may choose to use an expansion card to add support for the obsolete bus. However, the expansion card may not be compatible with the original set of APIs used in the TPS. As a result, the TPS may need to be rewritten and requalified which is a costly endeavor.

Similarly, the expansion card may not support the older/newer OS being used on the test station PC. In this scenario either support for the older OS needs to be dropped or the system needs to be upgraded to the newer OS. Either decision results in having to rewrite the TPS and requalify the entire system which may not be feasible.

E. Out of Space

If the expansion card approach is taken to support the UUTs, then it is likely that the test engineer will run out of expansion slots on the motherboard due to the large number of buses that need to be supported. Furthermore, expansion cards tend to be bulky and may not fit into smaller 1U and 2U test station PCs. Both situations result in the inability to test the UUT.

F. Reliability

PCs and the associated expansion cards are typically designed for the consumer market. They are not made for constant plugging and unplugging of cables, and the cards and the slots on the motherboards are prone to damage. Furthermore, the motherboard and expansion cards are not intended to support wide temperature, and humidity ranges that ATE hardware may be subjected to. This leads to time lost trying to debug broken test hardware, ports, and cables.

IV. THE PERIPHERAL INSTRUMENT

A. Solution

When testing legacy and current bus standards, a test engineer will run into problems of supporting buses that go obsolete, supporting old and new OS releases, and testing several differing bus standards. One possible solution to these problems is a peripheral instrument which can be seen in Fig. 2.

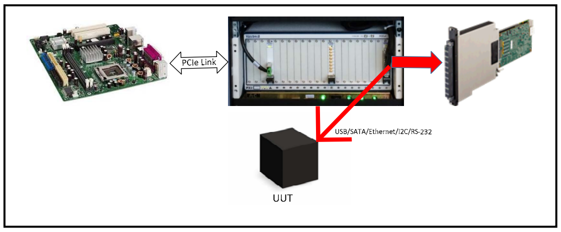

Fig. 2. Example peripheral instrument test setup

The peripheral instrument integrates several bus standards that are found in PCs such as Ethernet, USB, SATA, and RS-232. Communication to the PC is handled via a high speed link such as PCIe, which can be found in a PXIe (PCI eXtensions for Instrumentation Express) chassis. Given the PCIe link, the peripheral instrument is transparent to the PC's OS and the ports on the peripheral instrument appear as if they were directly coming from the PC.

Even though PXIe uses PCIe as the high speed backplane link and PCIe is a bus standard that may eventually go obsolete, it is a good solution for test because PXIe is a test platform. Test platforms have much longer lifetimes then the bus standards on which they are based on. When PCIe and eventually PXIe go obsolete, there will be test solutions which will allow the next standard to interface with existing PXIe platforms.

B. Minimal downtime

A peripheral instrument solves the problem of plugging UUTs into the PC by acting as a buffer between the UUT and the PC. If a port on the peripheral instrument ever gets damaged, the peripheral instrument can be replaced with minimal downtime. Given that the peripheral instrument acts as a buffer, there's no damage which could occur to the PC that will result in a catastrophic loss of data.

C. Long term solution

Managing obsolescence is a major problem for test engineers. New bus standards are developed every 6 to 11 years and oftentimes a newer bus standard will succeed the older standard. Once a new bus standard takes over, the older bus will no longer be supported. At this point it becomes difficult to find replacement motherboards and expansion cards with the older bus.

The peripheral instrument integrates both old and new bus standards and can continue to support the older standards as long as is necessary. If a new standard needs to be supported, it can be added in a new iteration of the peripheral instrument while maintaining support for the older standards.

Utilizing the peripheral instrument, PC obsolescence is easier to deal with since no UUT is dependent on the PC. The PC can be replaced with any model as long as it continues to support the backplane technology utilized in the peripheral instrument, which in the current iteration is most likely to be PCIe.

D. Compatibility

TPS rehosts are very expensive both in time and money. When motherboards and expansion cards go obsolete, even if a replacement exists, oftentimes it is not compatible with the previous motherboard or expansion cards. The time and effort necessary to either rewrite the TPS or try to make the new system work is a difficult process.

With the peripheral instrument, a consistent API is provided for all of the buses. If a new iteration of the peripheral instrument is required, for example to add support for a new bus, the API for the new bus would be consistent with the API for the other bus types. Having a consistent API makes it easier for a TPS developer to develop TPS for the new bus standard.

Furthermore, with a consistent API it is no longer necessary to modify the TPS following a new release of the OS. Even if the underlying code in the OS may change, the API visible to the user and TPS remains unchanged, thus making the transition to the new OS transparent for the developer. If support for an older bus standard is dropped inside the OS, it would still be possible to maintain support for that standard via custom drivers while still exposing the same consistent API to the developer.

E. Space Savings

By separating the support for buses from the PC, the peripheral instrument allows the test engineer to easily expand the number of ports and bus standards that can be supported. If a test engineer requires more ports for a particular bus, they can add an additional peripheral instrument to the chassis and not be limited by the number of slots or height restrictions presented by a motherboard or PC case.

Space savings are realized using the peripheral instrument because multiple bus standards can be supported on a single card. For example, a single peripheral instrument can offer support for Ethernet, USB, SATA, RS-232, and I2C (Inter-Integrated Circuit).

F. Reliability

A peripheral instrument is designed with special consideration for ATE, ensuring that the hardware is robust. Special connectors are used for the hardware to increase the number of supported connection cycles. Also, ATE standard interfaces are used to ensure that the peripheral instrument can be interfaced to existing systems. Care is taken during the design to ensure that environmental and reliability requirements for ATE are met or exceeded.

G. Flexibility

A peripheral instrument provides more flexibility to the test engineer by separating the peripheral interface from the PC. Separating the interface allows the test interface to be brought closer to the UUT. Bringing the test interface closer to the UUT allows the test engineer to eliminate additional equipment such as port repeaters for bus standards that have a limited cabling range such as SATA and USB. This saves cost by eliminating the upkeep of additional equipment that may become obsolete.

V. IMPLEMENTATION

A. Design Options

One potential implementation for a peripheral instrument uses a PXIe chassis. Such an implementation allows the flexibility of using the peripheral instrument in a remote system to get closer to the UUT as well as making the peripheral instrument a seamless extension of the test station PC. To the test station PC, the peripheral instrument and its peripheral buses can appear as an extension of the PC's PCIe bus.

To emulate all of the peripherals, either off the shelf chipsets or FPGAs with custom firmware can be used. Initially the off the shelf chipsets can be used and the functionality can be wrapped in a custom API. When the off the shelf chipsets go obsolete, the design can be transitioned to an FPGA which emulates the obsolete bus standards. All these issues are transparent to the TPS developer, given that all of the functionality has been wrapped into the custom API.

VI. CONCLUSION

TPS developers and test engineers face many challenges in developing and supporting new test systems and instrumentation.

- Modern test systems must support a mix of legacy and modern bus standards
- Test engineers must ensure that they can continue testing older standards even as they go obsolete.
- New OS releases may drop compatibility for legacy buses and/or expansion cards.
- As test systems become more complicated there is a need for more ports which cannot fit into current PC motherboards given the limited number of slots.
- Potential damage to the PC can result in long downtimes and results in the inability to support the testing of equipment.
- Test systems require robust and reliable instruments and interfaces that can sustain years of wear and tear.

A peripheral instrument overcomes many of these challenges. By integrating multiple bus standards, a peripheral instrument can reduce both the number of PC slots required to test equipment as well as the number of instruments. Utilizing a consistent API enables the developer to continue testing even as new versions of an OS are released and buses become obsolete. Implementing a standard backplane such as PXIe enables the easy expansion of the system to support more ports or new buses, and enables the testing of peripherals that may have previously been out of reach. Utilizing industrial grade components enables a peripheral instrument to be reliable and operate in the harsh environments in which ATE equipment may be used. If the instrument is ever damaged, it can easily be swapped out without a lengthy downtime and testing can continue.

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