White Paper

The Future of Wireless Technology is Here:
Introducing “Truly Wireless” with wPCle™

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Abstract

To date, wireless mobility has traditionally referred solely to network / Internet connectivity through a wireless interface such as Wi-Fi. By this definition, wireless technology has eliminated only a single cable from the mobile computing device – Ethernet. Mobile computing devices must still bear the cost, footprint and power burden of a multitude of additional interfaces to physically connect to displays, printers, multimedia devices, external storage devices and more.

The next stage in the wireless evolution will enable any computing platform to completely break free of its physical boundaries. Wilocity’s breakthrough wireless PCI Express (wPCIe™) technology was designed to create an entirely new mobile computing experience. Leveraging 60 GHz connectivity, wPCIe delivers the industry’s first truly wireless bus that breaks the cycle of cable replacement and frees the mobile computing device from its physical size constraints. Mobile device manufacturers will be able to deliver the thin and light platforms that consumers want without sacrificing the performance and functionality that consumers need.

Wireless Technology Today

Since the late 1990s, the development of wireless technologies has focused on eliminating a particular cable connected to a mobile device, such as a notebook to a peripheral. One of the most successful wireless interfaces to date is Wireless LAN, also known as Wi-Fi. While Wi-Fi is essentially an Ethernet cable replacement, the widespread availability of private and public access points has enabled consumers to connect their notebooks to the Internet from effectively anywhere in urban areas. This has transformed notebooks from relatively static devices into highly flexible, mobile platforms.

Additional wireless technologies have appeared on the market to replace specific cables. Bluetooth, for example, was designed to untether keyboards, mice, speakers and headphones, while simultaneously enabling transfer of small files between notebooks and handheld or portable devices, such as cell phones. Alternatively, WAN mini cards, express cards and USB dongles can connect notebooks with the cellular network (i.e., HSPDA, WCDMA, WiMAX) or serve as Digital TV receivers. (see Table 1).

<table>
<thead>
<tr>
<th>Application</th>
<th>Wired</th>
<th>Wireless</th>
<th>Next-Gen</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN</td>
<td>Ethernet (10/100 or 1000)</td>
<td>Wi-Fi (up to 300 Mbps, no wireless equivalent for GbE)</td>
<td>wPCIe</td>
</tr>
<tr>
<td>Human-Machine Interface (HMI) Devices</td>
<td>USB, PS2, Audio</td>
<td>Bluetooth</td>
<td>wPCIe</td>
</tr>
<tr>
<td>Voice</td>
<td>Phone</td>
<td>Wi-Fi, WAN</td>
<td>wPCIe</td>
</tr>
<tr>
<td>Video</td>
<td>VGA, DVI, HDMI, USB</td>
<td>wUSB</td>
<td>wPCIe</td>
</tr>
<tr>
<td>Storage</td>
<td>USB, SATA, FireWire</td>
<td>None</td>
<td>wPCIe</td>
</tr>
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<td>Docking Stations</td>
<td>USB, PCIe, Proprietary Interface</td>
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<td>wPCIe</td>
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<tr>
<td>Cellular Network</td>
<td>None</td>
<td>WAN cards</td>
<td>wPCIe</td>
</tr>
<tr>
<td>TV</td>
<td>None</td>
<td>Terrestrial TV cards</td>
<td>wPCIe</td>
</tr>
</tbody>
</table>

Table 1 - Wireless Evolution in Notebooks
In general, each of these wireless interfaces in effect cuts the wires at the edge of the platform. However, each of these wireless technologies requires a unique radio within the device while typically replacing only a single cable. The addition of multiple radios to a mobile device introduces potential interference issues that can significantly increase system cost and complexity.

PCs and notebooks also have a variety of application-specific interfaces that do not yet have wireless equivalents, such as those used for video (VGA, DVI, HDMI and DisplayPort), storage (SATA and FireWire), and high-speed network access (GbE). These interfaces are still tethered primarily due to the lack of a wireless interface with enough bandwidth and low enough power consumption to be feasible for battery-powered notebooks. Clearly, today’s notebooks have not yet achieved a “truly wireless” experience.

Wilocity’s Wireless PCI Express (wPCIe) technology, robustly overcomes the weaknesses inherent in today’s wireless technologies. Unlike other wireless technologies that eliminate only a single cable, wPCIe technology can eliminate all cables, relocating the interfaces from the mobile device to a remote platform called the DockingZone™. Additionally, by leveraging 60 GHz bandwidth, Wilocity solutions enable truly multi-gigabit wireless for a wide range of applications from I/O to networking to video. This game changing 60 GHz solution enables full performance of all supported interfaces without compromise, unlike other wired and wireless docking solutions that severely limit the performance of the interfaces they support.

**Distributed Computing in Notebook Architectures**

To understand how wPCIe works, we first need to look at the general underlying architecture of today’s modern computing platforms (see Figure 1).

The heart of the system, the Central Processor Unit (CPU), is connected through a Front Side Bus (FSB) to the Memory Control Hub (MCH). The MCH is often referred to as the “North Bridge.” In some implementations, a Quick Path Interconnect is used instead of an FSB or the North Bridge is directly integrated on the CPU.

Typically, the role of the North Bridge is to manage communications between the CPU, system memory, graphics processor, and other interfaces managed by the I/C Controller Hub (ICH), also referred to as the Platform Control Hub (PCH) or “South Bridge.”

In most PC architectures, the North Bridge communicates with the graphics processor across 16 lanes of PCI Express and directly connects and controls system memory using a double data rate (DDR)-based interface. The North Bridge may integrate the graphics processor while supporting access to an external graphics processor as an upgrade option. In this case, the North Bridge is often called the Graphics MCH (GMCH) and video interfaces are directly exposed from the motherboard (e.g. VGA, DVI, DisplayPort and HDMI).

The South Bridge manages a wide range of system interfaces, including Ethernet, Wi-Fi, WiMAX and Bluetooth, as well as interfaces for managing internal power, timing, keyboard, mouse and even access to hard disk drives.

The South Bridge also exposes external interfaces, including multiple USB ports, multiple SATA ports, high-definition audio interfaces, and multiple general-purpose, single-lane PCI Express ports.
The PCI Express Bus

The common factor shared by the interfaces exposed by the South Bridge is that they are all "driven" by PCI Express logic. PCI Express (Peripheral Component Interconnect Express), officially abbreviated as PCIe, was designed to replace older PCI, PCI-X and AGP specifications. PCIe serves in consumer, server and industrial applications both as an internal and external interface.

PCIe topology is based on point-to-point serial links, with packets communicating information between components. Packets are formed in the Transaction and Data Link Layers and, as they flow through the other layers, they are extended with the additional information needed to handle packets at those layers. At the receiving side, packets are transformed from their Physical Layer representation to their Data Link Layer representation and finally (for Transaction Layer Packets) to a form that can be processed by the Transaction Layer of the receiving device. Figure 2 shows the conceptual flow of transaction-level packet information between layers.

PCIe devices communicate via a logical connection called an interconnect or link. Each link is a point-to-point communication channel between two PCIe ports, allowing both to send and receive ordinary PCI requests (configuration read/write, I/O read/write, memory read/write) and interrupts (INTx, MSI, MSI-X).

At the physical level, a link comprises one or more PCIe lanes. The maximum throughput for a single-lane is 2.5 Gbps, with overhead of 20% from 8B/10B encoding, resulting in a theoretical data rate up to 2 Gbps. Throughput for a 16-lane bus is up to 32 Gbps.

Relatively low-speed peripherals, such as an 802.11n Wi-Fi card, use a single-lane link to communicate with the South Bridge while a higher speed device, such as a graphics adapter, typically uses a wider 16-lane link to connect to the North Bridge.

wPCIe: Enabling True Wireless Mobility

The traditional computing architecture consolidates a computing platform’s external interfaces at the South Bridge and passes them to the North Bridge over PCIe. Unlike other wireless technologies that attempt to replace these cables and external ports one at a time, wPCIe elegantly exploits this consolidation to eliminate all cables and ports, relocating the interfaces from a mobile device to a remote docking station, the DockingZone™.

Figure 3 illustrates the distributed model that wPCIe enables. The DockingZone derives the various application-specific interfaces allowing the notebook to then become a local device with its peripherals and interfaces implemented or distributed remotely.
The result is a thin and light mobile computing device, driving a distributed dock that is much lighter, power efficient, and less expensive than a comparable notebook with all of the processing power and interfaces integrated within its chassis.

How It Works

wPCIe defines a split implementation of a PCI Express Switch with the upstream port (near-end) on the mobile device side and the downstream port (far-end) on the remote side (the DockingZone).

A PCI Express Switch is defined as a logical assembly of multiple virtual PCI-to-PCI Bridge devices (see Figure 4) by the PCI Express specification. The switch has a single upstream facing port and any number of downstream facing ports. Figure 4 shows a typical 1-to-3 PCI Express switch structure.

In a wPCIe implementation, the two parts of the switch are connected by a wireless system. The MAC and PHY sub-layers supply services to the wPCIe adaptation layer and switch. To the PCI Express layers, the switch appears as if it is co-located in a single location. Therefore, the software used to configure and manage the switch is identical to that of legacy switches/bridges. Even the operating system (OS) is not aware of the wireless split, and the far-end devices appear in the OS device manager as if they were locally connected.

A wPCIe implementation can define any number of downstream ports, each of which can be located either in the near-end or far-end. Figure 5 shows a 1-to-3 implementation where one downstream port is located in the near-end. Figure 6 shows an application using a far-end downstream port.

Because the switch is distributed over a wireless channel, once an air-link has been established, both sides of the link negotiate basic parameters including number of ports, configuration, size of buffers, etc. After a link is established, a set of messages carry both interface and management data between the two ends. External messages (upstream port and far-end downstream) are mostly standard PCIe messages while internal messages (upstream port and far-end internal, near end-internal and far-end internal) are modified messages.

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A reliable wPCIe connection can be maintained with a relatively low data rate channel. However, to achieve meaningful performance between local and remote devices, the data rate needs to be on the order of 2 Gbps, or that of a single lane of PCIe. The only practical wireless channel that can support this capacity is 60 GHz.

Wilocity’s wPCIe technology operates in the 60 GHz unlicensed band which is supported worldwide, provides seven to nine GHz of spectrum and can deliver date rates over four gigabits per second.

wPCIe: Truly Wireless Applications
The benefits of Wilocity’s wPCIe solutions to users are tremendous. True mobility – where all cables are eliminated – is now possible. By expanding the functionality, enhancing the performance and extending the usability of traditional mobile computing devices, Wilocity enables mobile device manufacturers to deliver the thin and light platforms that consumers want without sacrificing the performance and functionality that consumers need.

Expand the Functionality
Wilocity’s wPCIe technology expands the functionality of the thin and light computing platform through the addition of new interfaces and capabilities to the DockingZone, which the mobile computing device does not natively support.

Specifically, users can now have wireless Gigabit Ethernet, FireWire and eSATA, enabling gigabit wireless access to networks, multimedia peripherals and external storage devices from a low power netbook. In each case, these and other interfaces will be supported as if they were natively implemented on the mobile computing device.

For example, many of the next generation netbooks or small notebook PCs feature a single USB 2.0 port, one video port, and power, creating even thinner and lighter portable devices. With wPCIe, these devices can connect wirelessly to a DockingZone that supports interfaces such as Gigabit Ethernet, eSATA, USB 3.0 and more. Therefore, by wirelessly distributing the functionality to the DockingZone, netbook and notebook consumers will have access to extensive functionality and peripherals previously available only to much more powerful and expensive computing platforms.

Enhance the Performance
Wilocity’s innovative wPCIe multi-gigabit wireless technology enables the full performance of all supported interfaces without compromise. By overcoming the physical limitations of notebook architectures, wPCIe technology enhances a mobile computing device’s performance by supplementing the native mobile computing device with additional remote processing.

For example, notebooks currently on the market can only offer graphics capabilities based on their internal graphics processor. With wPCIe, notebook graphics can be enhanced with a more powerful graphics processor implemented remotely in the DockingZone or integrated into a high performance monitor, thus greatly improving the native video performance.

Extend the Usability
wPCIe extends the usability of traditional mobile computing devices by enabling a simple upgrade path for consumers, creating return on investment. Interfaces that were not available at the time the notebook was purchased – USB 3.0, for example – can be added to the DockingZone, providing a simple upgrade path equivalent to those of desktop systems, without requiring the purchase of a new notebook to get the needed functionality.
Summary
Wilocity is creating an entirely new category of wireless technology, not just another cable replacement technology. Its wPCIe technology breaks the cycle of cable replacement and frees the notebook from its physical size constraints. Unlike today’s wireless technologies that eliminate only a single cable, wPCIe can eliminate all cables, relocating the interfaces to the DockingZone. Ultimately, the DockingZone will give way to direct connections to a multitude of wPCIe-enabled devices, creating a new and entirely mobile wireless computing experience. Wilocity’s wPCIe technology paves the way for a truly wireless computing experience, allowing mobile device manufacturers to deliver thin and light platforms that consumers want without sacrificing performance and functionality.

About Wilocity
Founded in March 2007, by a core team of executives and engineers from Intel’s Wi-Fi Centrino® group, Wilocity is developing next-generation 60 GHz wireless chipsets for both the notebook and peripheral markets that will enable mobile device manufacturers to deliver the thin and light platforms that consumers want without sacrificing the performance and functionality that consumers need. Based on the recently announced Wireless Gigabit Alliance (WiGig) specification, Wilocity’s wPCIe technology will enable truly multi-gigabit wireless for a wide range of applications from I/O to networking to video.