Whitepaper

NVIDIA® DirectTouch™ Architecture

Table of Contents

Touch Interface Background

Touch is one of the most natural and intuitive ways of interacting with the surrounding environment and is one of the five primary human senses. The use of touch-based user interfaces has led to explosive growth in the mobile device industry. Almost all smartphones and tablets today use touch panels as their primary user interface navigation mechanism, and consumers have become hyper-aware of the responsiveness and performance of touch based user interfaces. Mobile device manufacturers have realized that touch performance is a key feature that influences consumer purchase decisions, and therefore are seeking solutions that deliver outstanding performance, design flexibility, and scalability for increasing performance needs.

Current touch solutions rely on discrete touch modules that interface between the touch panel and the application processor. The touch module includes an Analog to Digital Controller (ADC) and a dedicated touch controller chip. In newer touch controller designs a single chip may include both the controller and the ADC. The touch module is typically bonded to the touch panel and interfaces with the mainboard and the application processor through a flex connector. Figure 1 below illustrates a simplified block diagram of typical touch architectures.

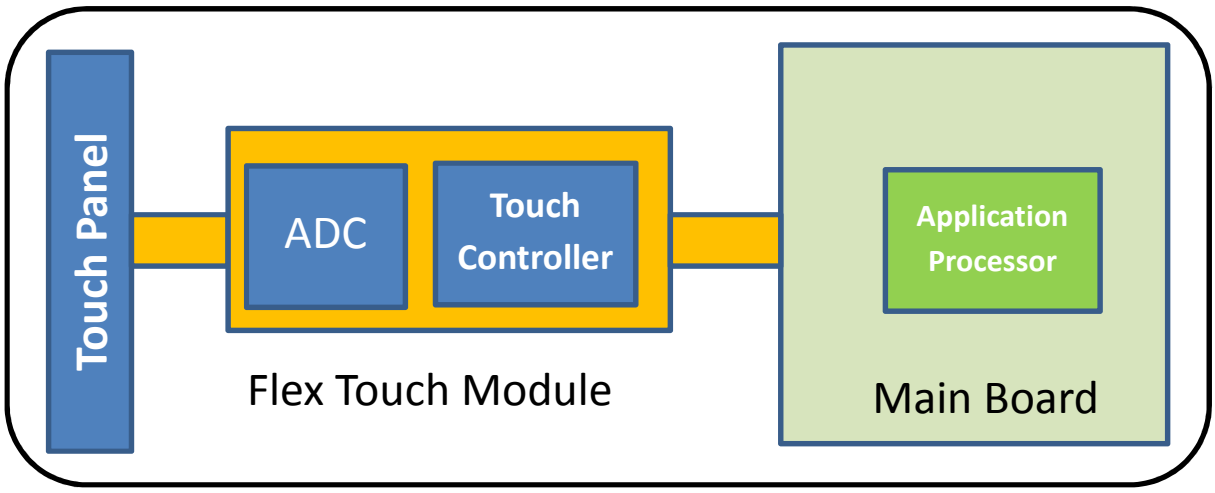

Figure 1 Current Touch Architecture

NVIDIA® DirectTouch™ Architecture

NVIDIA DirectTouch is a patent-pending touch architecture that improves touch responsiveness by offloading some of the touch processing that is typically performed by touch controllers and touch modules onto the NVIDIA® Tegra® 3 application processor. The architecture also simplifies the implementation of touch based hardware and user interfaces, requiring less power while delivering more scalable performance. Figure 2 illustrates a simplified block diagram of the NVIDIA DirectTouch architecture.

In most cases, the DirectTouch architecture uses the low power Companion CPU core on Tegra 3 to handle the touch processing that is typically performed by the touch controller. If applications (such as browsers, apps, and games) running on the mobile processor have activated one or more of the four performance CPU cores, then the touch processing is performed on the main CPU cores to deliver even higher touch performance. For example, when the system is idle or workloads are small, touch processing would be done on the Companion core. But when the system is running performance-intensive applications that require the use of one or more of the main CPU cores, the touch processing would be done on one of the four main cores. The workload for touch processing is a very small fraction of the workload presented by performance intensive applications, and therefore the power consumed for touch processing is negligible compared to the power consumed by the performance intensive applications.

As shown in Figure 2, the DirectTouch architecture also relies on a compatible ADC, which includes additional logic to facilitate the touch interface, sensor scanning, and new interface to Tegra 3.

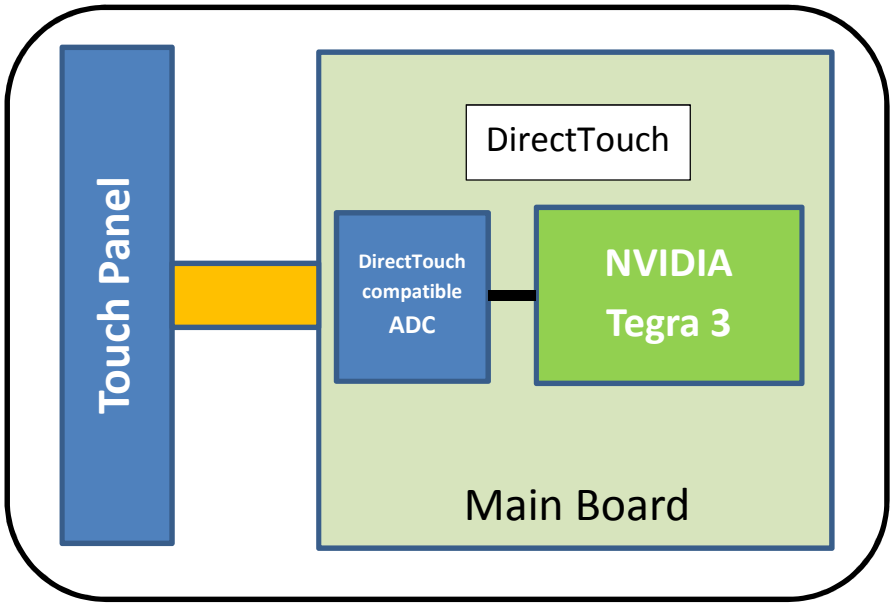

Figure 2 NVIDIA DirectTouch Architecture

Benefits of NVIDIA DirectTouch Architecture

NVIDIA DirectTouch delivers the following benefits:

Higher Performance: Touch controller chips are typically based on function-specific micro-controllers that have limited data processing powers. These controllers use simplified algorithms for noise filtering, perform extensive data filtering resulting in higher touch latency, and do not easily scale up performance due to their limited operating frequency ranges, memory, and

power requirements. DirectTouch architecture delivers improved touch capabilities by using the Companion CPU core in most cases, or a main core in some instances. The ARM CPU cores are capable of running more sophisticated algorithms to filter noise, process touch input, track fingers, reject palms, process pen input, and reduce latency to deliver a superior touch experience with a simpler touch sensor design. The ARM CPU cores on Tegra 3 are capable of operating at much higher frequencies and therefore have sufficient headroom to deliver additional processing power as demands for touch performance increase.

Current Touch Controller	**NVIDIA DirectTouch**
8-bit to 32-bit controller designs	32-bit design
Basic micro-controller ALU	ARM CPU
Fixed cache size	Scalable cache allocation for touch processing in 1MB L2 CPU cache
Up to 40 MHz operating frequency	0 MHz to 1.3+ GHz operating range

Table 1 Performance Capabilities of Existing Touch controller solutions vs. NVIDIA DirectTouch

Simplified Design- DirectTouch architecture allows the touch panel to directly interface with the mainboard instead of going through a flex touch control module. The flash memory, static RAM, power regulators, and the crystal required for the touch controller are reduced or eliminated. The interface between the touch panel and NVIDIA Tegra 3 relies on an ADC chip that handles basic sensor scanning logic and analog to digital conversion. The ADC chip is not required to be on a flex board, and can reside on the mainboard, sharing the same voltage rails, regulators and clocks as the NVIDIA Tegra 3 processor. Any additional analog noise that may be introduced by moving the ADC on to the mainboard can be easily filtered out by the superior noise filtering algorithms that can run on Tegra 3.

Lower Power- Even though DirectTouch uses the Companion CPU core for touch processing in most cases, the power consumption to process touch is in fact lower than that of current touch controller based solutions. In current touch solutions, both the touch controller and ADC need their own set of voltage regulators, power circuitry, and crystal oscillators. Even when the system is idle and there aren't active touch inputs, the controller is in an active state consuming power.

When the mobile device is actively processing touch inputs, the power consumed by an NVIDIA DirectTouch solution will be lower than that of current microcontroller based touch solutions. If a device is processing touch inputs, it means an application requiring touch input is already running on the device, and either the Companion CPU or one or more main CPU cores are active and running the application. The additional power required for touch processing on either the Companion or a main CPU core is lower than an existing touch controller based solution

that requires the microcontroller and its associated circuitry to be powered on, in addition to the CPU core running an application.

Conclusion

Consumers are extremely aware of touch performance on mobile devices and expect immediate responsiveness and sustained performance for both basic UI interactions and advanced touch-based applications and games. In response, mobile device manufacturers are looking for opportunities to improve touch performance without increasing cost or power consumption of touch solutions. NVIDIA DirectTouch is a patent-pending solution that offloads touch processing onto the CPU cores of the NVIDIA Tegra 3 and delivers higher performance, lower power consumption, and lower cost.

In addition to DirectTouch, NVIDIA continues to work in close collaboration with industry leaders to deliver the best touch experience possible.

Document Revision History

Date	Version	Notes
1/23/2012	1.0	First Release