/// Executive Summary

MultiTouch Cornerstone® is a software toolkit for creating bespoke applications for multi-touch displays. MultiTouch Ltd. has a long history of software development to support its own high-end interactive displays. Cornerstone SDK 1.x has been available since 2009 and has already been used in some of the most demanding interactive display applications to date. With Cornerstone 2 MultiTouch has gathered the experience of the past years and improved the usability, performance and introduced many new features. For ultra high resolution applications supporting any number of users, the new open Cornerstone 2 will be the platform of choice. For applications using advanced tracking features such as object recognition or pen use, Cornerstone 2 is unique in the market.

Major change is that for the first time Cornerstone SDK will be free for any developer to use. This gives the customers a free and mature toolkit to match the capabilities of MultiTouch’s MultiTaction Cell displays making it straightforward to get most value from the interactive display installation. The toolkit is supported by extensive documentation and developer forums with MultiTouch offering direct support and training as well.

Another key change is that MultiTouch Cornerstone SDK benefits can now be enjoyed on third party multitouch display hardware. The new open approach means projects done for MultiTaction Cell can be deployed on smaller, lower cost displays, e.g. across retail, making applications reusable and investment in the toolkit learning a easier to manage.

On the technical side, Cornerstone 2 now includes support for Javascript allowing a new much larger worldwide pool of developers use interactive displays to the fullest. Scalability has been improved through more efficient threaded rendering making 50 Megapixel 24 screen applications easy to develop. 4K resolution application are a breeze for Cornerstone 2.

Furthermore, Cornerstone 2 includes built-in support for remote management and control of applications by integration with MultiTaction Site Manager. Operational requirements for interactive display installations are increasing as installations are more and more business critical. Site Manager allows applications to plug into an existing efficient management tool.

Finally, Cornerstone 2 includes a set of ready made demonstration applications which allow partners and customers immediately to see the advanced features and benefits in practice.
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// Overview

Background
MultiTouch Ltd. is the market leader in advanced interactive displays for professional use. Market segments such as corporate, retail, education, digital signage, and museums have adopted interactive displays to address their specific engagement needs. However, application development is often hindered by lack of tools that would support the various needs of application developers and clients.

The development of MultiTouch Cornerstone SDK began in 2007 to support the launch of MultiTouch Cell display in 2008. **MultiTouch Cell** was the first stackable high-definition touch display in the market and required a toolkit that had performance requirements well above ordinary interface toolkits for touchscreens. Ever since, Cornerstone has been developed to support the features of the most advanced interactive displays and fulfill the requirements of the largest multi-touch installations ever built.

Some notable projects done with Cornerstone so far are presented below. These range from ever larger wall setups to object tracking tables and show how Cornerstone SDK already has been used by leading brands to do unprecedented installations.
Siemens Identity Wall consisting of 14 Full HD MultiTouch Cells and developed by uma using Cornerstone SDK.

ABB product demonstrator featuring a live action narrator.

Space Shuttle 30th anniversary application for Houston Space Center.

Muro de Chile. Chilean pavilion at 2010 Shanghai Expo featuring 200 GB of assets and 96 simultaneously playing videos over 8 Full HD MultiTouch Cells.

MultiTouch Microscope by FIMM. Gigapixel scans navigated with multitouch application developed with Cornerstone SDK.

Avatar exhibition by Snibbe Interactive. Application driven by tangible objects.

Executive Brand Suite by engage production running on 24 Full HD MultiTaction Cells
/// MultiTouch Cornerstone 2 Overview and Architecture

Cornerstone SDK is based on C++ in order to maximize performance on any PC hardware. In touch applications immediate and fluid response is key to achieving user acceptance. Performance under multiple users is also uniquely important with the stackable nature of MultiTouch’s displays.

The key features of MultiTouch Cornerstone 2 are:
· The most powerful multi-touch toolkit
· Extendable, high-performance C++ engine
· Easy-to-use JavaScript interface to utilize the C++ engine
· A rich set of UI and gesture components to create applications
· Scalable from single display up to 24 x full-HD displays per computer
· Compatibility for several types of multi-touch hardware, from MultiTouch Ltd. and others
· Support for all major operating systems – Windows 7/8, OS X, Linux
· Support for many different interaction types – fingers, hands, markers, and pens
· Real-time application styling with Cascading Style Sheets (CSS)
· Integration with MultiTaction Site Manager to enable remote control and monitoring of interactive applications
· Support for the full life-cycle of the application development and deployment, including built-in emulator

The main components of Cornerstone 2 are presented below.

Cornerstone 2 is designed to help developers and users throughout the application life-cycle, starting from development to deployment and content updates. This fundamental feature pervades the toolkit design at all levels.
Cornerstone starts from the nuts and bolts of C++ or JavaScript programming. This is the level where application logic is created. This is done using widgets, operators and other components that programmers create to implement the desired application logic.

To speed up application development developers can utilize ready-made components and templates implementing commonly requested features such as background effects (bubbles, ripple, etc.) and basic media presentations (image/video carousels, book widgets, etc.).

Typically graphical assets are designed during project preparation and produced while the application is being developed simultaneously. Because of this, a flexible method for using placeholder assets and easily replacing them is required. To alleviate this, Cornerstone makes it possible to adjust application visuals using Cascading Style Sheets (CSS).

For debugging purposes Cornerstone includes a widget inspector. This tool displays all the components that make up the application. Attributes, such as colors and locations, of the visual elements can be monitored. This helps in debugging and development process by giving developers a real-time view into application state.

The toolkit requirements change once an application is deployed. Instead of adding new features in the development environment, content updates to running installations, and monitoring their state typically take over. For this purpose Cornerstone works together with another tool from MultiTouch: The Site Manager. With Multitaction Site Manager, it is possible to get a remote connection to any Cornerstone application to perform application monitoring and management.
/// Key Features of Cornerstone 2 SDK

Interaction Possibilities

Cornerstone visualizer app showing different input modalities on MultiTaction Cell.

**Different Modalities**

MultiTouch Cornerstone 2 supports a wide range of interactive display input modalities – fingers, hands, markers, basic shapes, and pens. In addition to direct touchscreen input, Cornerstone also accepts input from a keyboard (for text input) and a mouse (for development purposes). As the toolkit provides support for these different input modalities, the developers don’t need to worry about implementing support for them.

**Gestures**

Touchscreen applications rely on gestures for user input. The common gestures range from simply tapping an image or button to multi-touch interactions for scaling, rotating, and moving objects. Cornerstone 2 implements these common gestures for the user and they can be turned on or off with minimal effort.

Users can implement more specialized gestures as needed. All the data from different input modalities is available to the application programmer, so that custom gestures are easy to implement.
C++ Engine for Performance
The core of Cornerstone is implemented with C++, for optimal performance and object-oriented design. Due to this it is possible to write extremely effective code with Cornerstone. High performance enables one to use Cornerstone with rich and captivating applications using commodity computers, even when building large installations.

The C++ engine implements a series of performance optimizations. These optimizations are free to the application programmers, that have less need to worry about fundamental features like image/video loading or text rendering.

Cornerstone utilizes modern C++ features such as smart pointers and lambda functions to increase productivity, programming safety and performance. For the sake of developer learning curve, Cornerstone API can be used even without the latest C++ additions.

JavaScript for Quick Application Development
JavaScript has been adopted as a second language with C++ in Cornerstone 2. It combines a powerful programming language with a large user base. As JavaScript is a fundamental element of modern web development, it is easy to find JavaScript developers who can pick up Multitouch development.

As an interpreted language, there is no need to compile JavaScript applications. This makes iterative development faster as compilation times are removed from the application development. A live connection to an application is possible with an interactive JavaScript terminal that allows the application to be modified on-the-fly by entering JavaScript commands or by executing scripts loaded during runtime.

The JavaScript engine in Cornerstone uses Google’s V8 JavaScript Engine, which is also utilized in Google Chrome web browser. As V8 is an extremely fast JavaScript engine, it can be used to develop high-performance applications. To support JavaScript development, Cornerstone includes the Node.js JavaScript library. The library provides a rich set of basic tools for JavaScript developers.

Cascading Style Sheets for Convenience
While the application logic is typically implemented with C++ or JavaScript, these languages are not very flexible when tweaking the visual appearance of the application.

For this purpose Cornerstone includes a CSS parser that can be used to control the way applications look – just like with web pages. Cornerstone supports CSS 2.1, with some elements from the upcoming CSS 3.0 specification.

Rather than limiting CSS to control just the visual appearance of an application, it can also be used to define the values of any parameters. These parameters can affect the application behaviour, such as how the physics are simulated and how objects are interacted with. This enables designers without programming skills to independently tune the applications to the needs of the customers without needing the help of programmers.
Getting the application look and feel just right is typically a highly iterative task. To make iterations fast, Cornerstone monitors the CSS files that are in use, and updates the application immediately when a CSS file is modified. This removes the need to stop and start an application that is running, and cuts the iteration time significantly as the application can be changed while it is running.

**Simulator**

Cornerstone SDK includes a runtime simulator where you can run the entire application on the desktop while developing. The Simulator can be run in a window on the desktop or in full screen mode. You can simulate any type of inputs, including hands, markers and pens.
Widget Inspector for Interactive Testing and Debugging

Cornerstone includes Widget Inspector, a visual debugging tool, to make application development easier. The inspector can be used to select and visualize widget attributes and change their values while the application is running.
Parallel Renderer for Large Installations
The Cornerstone rendering pipeline uses modern graphics cards to deliver high-performance, hardware accelerated graphics. Cornerstone handles thousands of images, multiple 4k videos and dazzling special effects at the same time.

A high-performance text-rendering engine produces scalable and artifact free text rendering. Text-effects like drop shadows, glow, and stroke effects are all implemented in Cornerstone.

The unique multi-threaded rendering engine in Cornerstone makes it possible for applications to scale with the number of installed graphics cards. This makes it possible to drive massive display walls using a single computer, reducing the costs for hardware and software development.

The rendering engine can be configured to use any number of video outputs which can be arranged flexibly. All display outputs can be adjusted individually, giving a high degree of freedom to installation design ranging from standard rectangular video walls to wild asymmetric setups.

Parallel Rendering

![Parallel Rendering Diagram]
Example of an asymmetric "Oblique Wall" with one Cornerstone application across all displays

Spatial Audio for Large Setups
Usually for large display walls where audio is part of the installation spatial audio playback is desired. Spatial audio is usually implemented using directional speakers. This enables localized sound playback so that audio can be heard only by select users instead of having everyone listen to it. To support these setups, Cornerstone includes a spatial audio engine that supports any number of audio outputs that can be localized in the application coordinates.
Component Collection for Flexible Application Assembly

In addition to basic widgets, such as pictures and videos, Cornerstone also includes a collection of high-level components that can be used to assemble applications with less work. These ready-made components fall into several categories:

- Games
- Visual effects, like ripple and several different background animations
- Web browser framework for embedding web pages into applications
- Presentation templates that can be used to deliver quick applications with minimal programming

These components can be used to create quick demonstrations or they can be combined together to create applications. For example, an application might contain a slideshow as a background, a few carousel-type image and video containers and a ripple effect for eye-candy. The components are included in Cornerstone as plugins that can be dynamically added to any application. Users can also create new components themselves to be shared between in multiple projects.

MultiTaction Site Manager Integration for Installation Control

An important aspect of application life-cycle is maintenance and monitoring operations. For this purpose MultiTouch has developed the MultiTaction Site Manager – a networked tool for managing installations that are in continuous use. Cornerstone integrates with the Site Manager to provide a system with remote management features.

With Site Manager, users can connect remotely to running Cornerstone applications and perform different management tasks, such as:

- Live view of the application for monitoring what it is doing
- Synchronization tool for downloading new content to the application computer via MultiTaction Sync Server
- Possibility to control the application by changing the running plugin set, or by executing JavaScript snippets to control the application

6 x Full HD Cornerstone application with live preview on Site Manager
For more information on the Site Manager, please see MultiTaction Site Manager white paper, available from http://www.multitaction.com.

**Extensive Hardware Support for Installation Flexibility**

A major roll-out of touchscreens can include several types of installations running the same software. For a retail chain this may include small displays for small shops and kiosks, larger displays for flagship stores, and large display walls for corporate headquarters and trade shows. The hardware needs for these different cases are remarkably different and cannot be met by any single touchscreen type.

To support different kinds of hardware, Cornerstone supports the following touchscreen interfaces:

- Cornerstone touch
- TUIO
- Windows touch

Cornerstone touch is the native interface of MultiTaction Cells and is free to use. Third party hardware support using TUIO or Windows Touch is subject to runtime license fee to enable the application to run on the target hardware.

These interfaces cover essentially all touchscreens that are available in the large-scale display market, starting from 10” laptop screens and ending to 20 meter display walls. The use of MultiTouch Cornerstone enables the clients to use the same software on the hardware that is best suited to their needs, depending on the use case.

**Multi-platform Support for Flexible Deployments**

Client needs and preferences regarding the used operating system vary. Because of this, Cornerstone is developed on all major operating systems, including Windows, OS X, and Linux to match these requirements.

Windows systems are often preferred in corporate environments where integration with the existing company IT systems is often crucial. Cornerstone supports Windows 7 and Windows 8.

Linux is often used in high-performance environments, such as display walls, and in academic institutions. Some corporate clients also prefer Linux due to its flexible customization options.

Mac computers running OS X are often used in the field of visual communications where it is the preferred operating system. Clients may opt to deploy there touchscreen setups with OS X in order to work with a familiar system.
/// Conclusion

Cornerstone 2 is industry’s most advanced and best performing toolkit for building large multitouch applications. Its many benefits are summarized in the table below.

Thanks to the open licensing policy any developer can now start using Cornerstone 2 for free to create the world’s most stunning multitouch applications.

<table>
<thead>
<tr>
<th>Unlimited</th>
<th>Scalable</th>
<th>Robust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simultaneously track as many fingers, hands, pens, and objects as you need.</td>
<td>Run up to 24 displays from a single computer.</td>
<td>Track not only fingers, but hands, markers, and objects as well.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Multi-platform</th>
<th>High-performance</th>
<th>Easy</th>
</tr>
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<table>
<thead>
<tr>
<th>Productive</th>
<th>Hardware-independent</th>
<th>Complete</th>
</tr>
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<tbody>
<tr>
<td>Utilize ready-made components and quickly change visuals with CSS.</td>
<td>Develop applications for any hardware that supports Windows Touch or TUIO output.</td>
<td>Maintain and monitor deployed applications with MultiTaction Site Manager.</td>
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/// Resources

To download Cornerstone 2, go to MultiTouch Cornerstone developer site at http://cornerstone.multitouch.fi and register.

To access developer forums, please log in to Cornerstone site.

For commercial details on MultiTaction Cells, SDK support and training options or support for third party hardware, please contact MultiTouch sales at:

- EMEA: sales@multitouch.fi
- Americas: sales-us@multitou.ch
- Asia: sales-asia@multitou.ch

Please visit for further information:

Follow MultiTouch on:
YouTube: http://www.youtube.com/multitaction
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Multiple patents pending.