A Holistic View of Touch

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by Geoff Walker

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Trying to form a clear picture of the entire touch industry is a little like trying to herd cats – it's pretty difficult. Most of what's written about touch concerns a single technology, a single application or a single supplier. This article attempts to fit the various pieces together into a holistic view. However, it must be noted that it's a *personal* holistic view. The opinions (and interpretation of history) offered in this article are the author's, along with the responsibility for any errors or misconceptions.

Two Basic Segments: Touch can be classified into two basic segments: (a) "transparent" (touch used with a display) and (b) "opaque" (touch used on devices other than displays). The latter is dominated by the controller chip suppliers, including Cypress, Synaptics, Quantum, Alps and EtherTouch. Notebook touchpads are the high-volume application in this segment; an example of another well-known application is the scroll wheel on the iPod. The technology used in opaque touch is almost totally projected capacitive, with sensors varying from simple electrode pads to two-layer X-Y grids of conductive traces. The chip suppliers have attempted to gain some traction in the transparent touch market, for example, by demonstrating how standard chips can be used to control four-wire resistive touch screens (Cypress), and by producing transparent notebook touchpads (Synaptics), but they've met with very limited success.

In contrast, the transparent touch segment is dominated by the sensor manufacturers, of which there are at least 50 worldwide. The remainder of this article focuses only on transparent touch. This article also excludes consideration of pen-based user interfaces, which can also be classified into two basic segments: electromagnetic (Wacom, FinePoint Innovations, UC-Logic, ACECAD and Hanwang) and electrostatic (N-trig).

Touch Technologies: There are seven touch technologies in current use, as follows:

- Analog resistive
- Surface capacitive
- Surface acoustic wave (SAW)
- Infrared (IR)
- Projected capacitive
- Optical (camera-based)
- Bending wave (APR & DST)

Analyzing the touch world by technology is convenient but somewhat misleading, since there is a large disparity between the technologies in terms of revenue. The author's independent estimate of the total transparent touch market size is around $1 billion in 2006. (Note that this is quite consistent with Venture Development Corporation's (VDC's) estimate of $1,013M, just published in their 3/21/07 market research report on touch screens.) The author believes that the $1B can be broken down into three basic chunks: analog resistive (70%), surface capacitive (17%) and other (13%). Resistive and capacitive therefore represent the great majority of the mainstream touch market, while "other" represents a mixture of established minor technologies and emerging technologies.

Analog Resistive

Analog resistive touch is the lowest cost technology and therefore has the widest range of applications. However, it has two primary limitations: (a) susceptibility to damage because of its PET top surface, and (b) relatively low transmissivity (typically 80% - 85%). Elo TouchSystems invented the basic concept of resistive touch around 1982, so it's not covered by patent protection any longer. As a result, there are a large number of suppliers –

roughly two-thirds of the 50+ worldwide touch suppliers offer some form of resistive touch. Resistive touch comes in three basic types: 4-wire (lowest cost), 5/6/7-wire (longest life) and 8-wire (4-wire with less calibration drift and temperature sensitivity). Five-wire is the dominant type. Within each type there are various constructions such as film-glass, film-film, film-plastic, etc. There is also a wide variety of available options, such as surface armoring, dual-force touch, low-reflectivity/high-transmissivity, rugged substrate, palm rejection (stylus support), narrow border, sunlight readability, anti-smudge coating, EMI shielding, anti-bacterial coating, heated (anti-fog), etc.

Digital resistive touch (also called "matrix" touch) is not considered in this article because it's not generally used with displays. It competes with other opaque touch technologies and with non-touch technologies such as membrane switches.

The most significant recent change in the analog-resistive market landscape was 3M's (MicroTouch brand) exit from the market in the middle of 2006, which set off a scramble among competitors to offer plug-compatible products and to supply 3M's customers. Now that 3M's gone, the market leaders include Elo TouchSystems, Fujitsu, Gunze, J Touch, Nissha Printing, Panasonic, SMK, Touch International and Young Fast.

Surface Capacitive

Surface capacitive touch eliminates resistive touch's two primary limitations, while adding three new limitations: (a) roughly double the cost for the same sensor size, (b) finger-only touch and (c) difficulty adapting to mobile applications due to EMI considerations. Surface capacitive is sometimes called "4-corner capacitive" because the technique that's used to determine the touch location is based on measuring the current flow from each corner of the sensor. Surface capacitive comes in only one type, although there are some available options such as more durable top coating, rugged substrate, EMI shielding on the back, etc.

The most significant recent change in the surface-capacitive market landscape was the expiration in the last few years of 3M's basic patents on surface capacitive technology (these are commonly referred to as the "Pepper" patents). Previously 3M basically had a monopoly on the technology; now more than 30% of the 50+ worldwide touch suppliers say they're supplying surface-capacitive touch screens. In actual fact, less than half of those suppliers are actually shipping product. Many of them are still learning how to successfully manufacture surface capacitive – it's much harder than resistive. As a result, the market leaders are still 3M and Elo TouchSystems. However, as the price of surface capacitive continues to drop due to increasing competition, there is some speculation that 3M will exit the business in the next year or two, perhaps by selling off their entire operation to an Asian competitor.

Surface Acoustic Wave (SAW)

As previously noted, analog resistive and surface capacitive account for about 87% of the transparent touch market. What's left can be grouped into three established minor technologies (surface acoustic wave, infrared and projected capacitive) and two emerging technologies (optical and bending wave). Of the three established technologies, SAW has the most penetration, probably because its application has been aggressively pursued by Elo TouchSystems since they purchased the technology from Zenith in 1987.

SAW's major strength is that its substrate is clear glass with no coatings, providing the highest possible transmissivity (92%) of any touch technology that requires a substrate. Note, however, that although the substrate is "clear" glass, it isn't "plain" glass because it includes reflective arrays made of powdered glass (frit) that are screen-printed along all four edges. SAW allows slightly more flexibility in touch activation than surface capacitive, since it reacts to anything that's soft enough to absorb acoustic energy – fingers, gloves or a soft stylus. SAW's major weakness is that it's very sensitive to surface contamination from dust, oil or grease – although scratches in the substrate don't affect it. SAW comes in only one type with a small number of options including a rugged substrate and surface treatments such as AR and AG.

In the past there was another acoustic-wave-based touch technology called "guided acoustic wave" (sometimes abbreviated as WAV). This technology, invented by Carroll Touch sometime in the 1980s and supplied only by them, was basically the same as SAW except that the acoustic waves were propagated within the substrate rather than on the surface of the substrate. When Elo TouchSystems acquired Carroll Touch in 1999, Elo let the technology die because they were already invested in SAW.

The most significant recent change in the SAW market landscape was the expiration of Elo TouchSystem's patent on SAW technology in 2005. The most aggressive new competitor in the newly expanded SAW market is General Touch, established in 2000 in Sichuan, China. In addition, there are five other touch suppliers (all in Taiwan and China) currently claiming to be supplying SAW touch screens. It seems likely that this market will expand further.

Infrared (IR)

Infrared was the "original" touchscreen. Invented by Carroll Touch in the 1970s, it was revolutionary at the time. Infrared is the only touch technology that doesn't require a substrate. Although this can provide a significant advantage in terms of image quality, it's also a disadvantage because it means that infrared doesn't require a physical touch. A touch is sensed by breaking the IR light beam with any opaque object larger than about 5 mm. Depending on how far above the display or substrate surface the IR light beam is located, significant "pre-touch activation" and parallax problems can result. In addition, dust, oil or grease buildup on the touch screen frame can block the IR light beam, causing malfunction. However, a side-benefit of not requiring a substrate is that infrared touch screens can be made quite large fairly easily; the largest publicly disclosed size is 150" (10 feet x 7.5 feet), applied to a rear-projection video wall. Like SAW, infrared touch comes in only one type. There are a moderate number of options including rugged or no substrate, dust-proofing, surface treatments such as AR and AG, IP65 sealing, etc.

The usability issues described above, combined with the high cost of IR LEDs in the 1990s and rapidly growing competition from other touch technologies, caused infrared to significantly decline in popularity by the time Elo TouchSystems acquired Carroll Touch in 1999. Elo did little to reverse this trend after the acquisition, apparently preferring to concentrate on other technologies.

In 2002, IRTouch Systems was incorporated in China to leverage the development started in 1993 by Hui Tian Laboratories, a pioneering infrared touch-technology developer. In the last five years, IRTouch Systems has become the largest infrared touch screen manufacturer in China (and probably the world), with a 70% market share in the Chinese banking industry (i.e., ATMs). IRTouch Systems has already expanded into Korea, Japan and Europe, and is just beginning to expand into the USA. In addition to IRTouch Systems and Elo TouchSystems, there are five other suppliers of infrared touch technology (two in Taiwan, one in China, one in Germany and one in the USA). While this isn't as strong a growth pattern as is occurring with SAW, it's not trivial.

Projected Capacitive

The primary advantage of projected capacitive is that the sensor can be placed behind a sheet of plain glass and therefore can be totally protected from users and the elements. The typical field-projection distance is around 20 mm, which is enough for even very thick sheets of plain glass. Gloves don't significantly affect projected capacitive touch because they just slightly increase the projection distance. The major weakness of projected capacitive has been high cost, although the two leading vendors seem to have made significant recent advances in cost reduction. Another weakness has been the visibility of the conductive traces in the sensor.

There are two basic types of projected capacitive sensors. The first type, developed by MicroTouch in the mid-1990s and originally called "Thru Glass", is based on a two-layer, patterned X-Y grid of transparent ITO conductors on a glass substrate. When 3M acquired MicroTouch in 2000, they renamed the technology "Near Field Imaging" (NFI). In 2005, 3M announced a second generation of the technology, called "MicroTouch Interactive Surface Technology" (IST), based on a flexible substrate, but it was never commercialized. 3M exited the

projected capacitive touch market in mid-2006, citing technical difficulties and insufficient revenue.
The second type of projected capacitive sensor, developed by Zytronic in 2001 and called "ZyTouch", is based on parallel rows of 10-micron wires (an X-Y grid) on a sheet of polyethylene laminated between two sheets of glass. Zytronic has continued to put significant effort into developing and marketing this technology; their worldwide touch screen sales in 2006 were approximately $12M. Zytronic also licenses the technology to Elo TouchSystems, who integrates it into a few of their own LCD monitors.

TouchKO claims to have developed a third type of projected capacitive sensor based on a continuous (non-patterned) ITO coating. However, there are no published patent applications on it and TouchKO is extremely secretive about their technology, so the author is hesitant to count it as an official third type until more information is known.

Other than 3M exiting the market in 2006 (which had no perceptible effect), there haven't been any recent significant changes in the projected-capacitive market landscape. The three current suppliers (Zytronic, Touch International and TouchKO) are all growing, but even combined they don't have much critical mass.

However, the wild card in this picture (and it's a *big* one) is the Apple iPhone's projected-capacitive touch screen. If Apple meets their stated goal of 10M units sold in 2008, it will have a major impact on the touch market. Ten million units at $15 per unit (half of the initial estimated cost of $30) is $150M – that's 15% of the 2006 total touch market! Strategy Analytics, a market research and consulting firm, recently predicted that sales of capacitive touchscreen-only phones would reach 115M units within two years. If reality turns out to be even a small fraction of this forecast, the projected capacitive touch market will be drastically altered.

Optical (Camera-Based)

Optical touch technology uses line-scanning cameras to track the movement of any object close to the surface of a substrate by detecting the interruption of an infrared light source. The light is emitted across the surface of the substrate either by infrared LEDs or by special reflective surfaces. Optical touch shares some of the advantages and disadvantages of infrared touch, such as a touch registering just before the finger or object actually touches the substrate surface. However, optical touch's most significant advantages include lower incremental cost as size increases, and substantially higher resolution and data rate, which translate into much better drag-and-drop performance.

Optical touch is available in two basic configurations, (a) overlays that touch-enable existing large flat-panel displays, and (b) discrete hardware for integration into manufacturer's products. There are only two significant suppliers, NextWindow in New Zealand and Smart Technologies in Canada, both of whom have been producing optical touch screens since 2003. A limited number of options are available, including a rugged substrate and surface treatments such as AR and AG.

The most significant recent change in the optical market landscape was NextWindow's selection as the supplier of the touch technology in HP's new TouchSmart all-in-one "family PC", launched in January 2007 at CES. This is the first time optical touch technology has been used in a mass-market product. The TouchSmart PC uses a 19-inch wide-format (16:10 aspect ratio) LCD; reviews of the touch portion of the product have been very favorable. NextWindow expects to announce at least two more similar mass-market product design-wins during 2007; this is likely to establish optical touch as a serious competitor in the "system control and office automation" (desktop LCD) touch-screen market.

Bending Wave (APR & DST)

Bending-wave is the newest touch technology, and it's just beginning to emerge. As of March 2007, there is only one product shipping with this technology, a 15-inch desktop touch-monitor from Elo TouchSystems that's targeted at retail point-of-sale applications.

Bending-wave touch technology provides the touch-activation flexibility of resistive (finger, glove, pen, credit-card, etc.) with the plain-glass-substrate simplicity and durability of infrared or optical. It can be scaled easily from PDA-size (3 inches) to large-TV-size (60 inches) with no increase in cost other than the cost of the larger plain-glass substrate. It's inherently simpler than SAW and projected-capacitive touch. Its primary limitation is that touch-and-hold or drag-and-hold aren't possible because bending waves aren't created in the hold position.

Bending-wave touch technology actually seems to combine the best of all the touch technologies. However, because it's so new, and because both of the initial suppliers are very conservative and slow-moving, it's going to be a while before it's known if bending-wave technology will have a significant impact on the touch industry.

Bending-wave technology is available in two forms, (a) lookup-table based, called "acoustic pulse recognition" (APR) from Elo TouchSystems, and (b) real-time signal-processing based, called "dispersive signal technology" (DST) from 3M. The two forms use almost exactly the same sensor construction (plain glass with four piezoelectric sensors attached to the back); the difference is mostly in the controller. 3M is focused on the digital-signage market, with the intent of offering DST touch screens of 30" and larger. Elo is focused on the company's traditional market segments, including retail, industrial, hospitality, medical, etc., with the intent of offering APR touch screens in the 3.5" to 42" size range.

The most significant recent change in the bending-wave market landscape is 3M's planned re-launch of their DST product. 3M initially announced the DST technology in 2004, and then announced shipment of the product in 2005. After some field experience with the product, 3M withdrew it from the market at the beginning of 2006 and began development of a second generation. 3M is re-launching the improved product at the KioskCom Self-Service Expo in April 2007, with Richardson Electronics' Pixelink division as the primary systems integrator.

Making Sense Out of All of It

Technologies: From a technology point of view, the touch industry can be summarized as follows:

- Two dominant technologies (resistive & surface capacitive)
- Three established minor technologies (SAW, infrared & projected capacitive)
- Two emerging technologies (optical & bending wave)

Geographies: From a geographic point of view, the touch industry can be summarized as shown in Table 1.

Looking at touch in terms of an East-West split can be informative. As shown in Table 1, 32% of the suppliers are in Western countries, while 68% of the suppliers are in Eastern countries (this is the number of companies, not the revenue). The only two published touch market-research reports of which the author is aware also happen to reflect an East-West split. In Fuji Chimera's 2007 FPD Materials Report, five of the top six resistive touch suppliers are reported to be located in Japan (the sixth is in Taiwan). In Venture Development Corporation's 3/21/07 Touch Screen Global Market Demand Analysis report, *all* of the six leading touch suppliers (including resistive, surface capacitive, SAW and infrared) are reported to be located in the West. This dichotomy suggests that it's very difficult for market research firms to form a clear picture of the portion of the touch industry that's outside of their native geography.

Country	Suppliers
Canada	2
China	6+
Germany	1
Japan	7
Korea	3
New Zealand	1
Taiwan	18
United Kingdom	1
USA	11
TOTAL	**50+**

Table 1: Touch technology suppliers by country

Suppliers: From a supplier point of view, the touch industry can be summarized as follows:

- 27 suppliers offering 1 technology
- 18 suppliers offering 2 technologies
- 4 suppliers offering 3 technologies
- 1 supplier offering 6 technologies (Elo TouchSystems)

Technology	Leading Suppliers (alphabetical order)
Resistive	Elo TouchSystems, Fujitsu, Gunze, J Touch, Nissha, Panasonic, SMK, Touch International, Young Fast
Surface Capacitive	3M, Elo TouchSystems
Surface Acoustic Wave	Elo TouchSystems, General Touch
Infrared	IRTouch Systems
Projected Capacitive	Touch International, Zytronic
Optical	NextWindow, Smart Technologies
Bending Wave	3M, Elo TouchSystems

Table 2: Leading touch suppliers by technology

It's clear that Elo TouchSystems is the 800-pound gorilla of the touch industry. Elo is the only supplier that offers six of the seven technologies (they don't offer optical), and Elo is a leading supplier in four of those six technologies (they've been overtaken by IRTouch Systems in infrared, and they simply integrate Zytronic's projected capacitive in a few of their touch monitors).

Applications: From an applications point of view, the touch industry can be summarized as shown in Table 3.

Touch Application Category	Examples
Amusement gaming	Bartop entertainment device
ATM	ATM
Cellphone	Smartphone
Commercial aircraft	In-flight entertainment device
Education	Public-sector education device
Healthcare	Patient information terminal
Industrial control	Nuclear power plant control; process control
Kiosk – commerce	Digital photo printing; airline check-in
Kiosk – point of information (POI)	Shopping center information display
Kiosk – ruggedized	Subway ticket dispenser; gas pump
Legal gaming	Casino video game
Medical equipment	Portable medical instrument
Military fixed & mobile	Submarine console; ruggedized PDA
PDA	PDA
Point of sale (POS)	Restaurant ordering; home-center check-out
Portable entertainment	Handheld game device
Securities trading	Trading terminal
Semiconductor	Cleanroom production-control panel
Systems control & office automation	Desktop monitor; building lighting control panel
Training	Private-sector training device
Whiteboarding & conferencing	Large conference-room monitor

Table 3: Touch application categories

There is no industry-wide standard or agreement on how to categorize touch applications. Each touch supplier has their own list of applications that reflects their particular customers and/or prospects. The 21 touch application categories in Table 3 on the previous page were originally suggested by Steve Atwood of Capstone Visual Product Development and then refined by the author. Note that these are application categories, not market segments. While the two terms are often used interchangeably in the touch industry, this article tries to make a clear distinction between them.

Market Segments: The 21 touch application categories in Table 3 on the previous page can also be mapped into market segments as shown in Table 4. There is somewhat more industry agreement on touch market segments. The 10 segments shown in Table 4 are fairly representative of current touch industry usage – although no single supplier (not even Elo) addresses all 10 segments.

Touch Market Segment	Common Touch Application
Retail	Kiosk – commerce
Hospitality	Point of sale (POS)
Industrial	Industrial control
Medical	Patient information
Entertainment & gaming	Legal gaming
Transportation	Kiosk – commerce
Government	Military fixed & mobile
Education & training	Training
Finance & banking	ATM
Consumer electronics	PDA

Table 4: Touch market segments

Technology Selection: Each of the touch application categories in Table 3 on the previous page can also be mapped into one or more of the seven touch technologies. However, this isn't a particularly useful exercise, since there are relatively few application categories that map into only one or two technologies. For example, kiosk POI applications are split between five of the seven technologies; industrial control applications are split between four of the seven; and ATMs are split between three of the seven. As examples of narrow mapping, legal gaming applications are almost exclusively surface capacitive, while PDAs are almost exclusively resistive.

It's more useful to examine why some applications are split across multiple touch technologies. Some of the reasons include the following:

1. Accurate, detailed & complete information about the characteristics and performance of touch technologies may not be readily available, particularly when comparing technologies. Some touch suppliers publish technology comparison charts, but often the charts are subtly biased by minimizing or completely omitting the supplier's strongest competition. Or, the charts rely on (or intentionally propagate) out-of-date information, such as stating that the only available configuration for projected capacitance sensors is wires embedded in glass. The touch industry is very secretive. Touch suppliers publish very little information about the details of their technologies or their new developments. Some touch suppliers don't even submit patent applications in order to guard their trade secrets. The result is that touch technology selection may be made on the basis of incomplete or inaccurate information.

2. Supplier dominance in a country may cause a bias towards a specific technology in that country. For example, ATMs in China mostly use infrared because of the dominance of IRTouch Systems in China. ATMs in the USA are much more likely to use SAW, surface capacitive or projected capacitive than infrared because of the lack of a strong infrared supplier in the USA.

3. Many touch applications are implemented by value-added resellers (VARs) or systems integrators (SIs). Many of these channel companies have close relationships with selected touch suppliers; the result may be a bias towards selection of one technology over another by the VAR or SI.

4. How well each touch supplier markets themselves to the channel can have a strong effect on the selection rate of a technology in a given application. In fact, marketing (and marketing hype) probably have a stronger effect on the selection of touch technology than the technical details in the majority of cases. Because of the relatively high degree of secrecy in the touch industry, and because of the lack of a clear global view of touch technologies and suppliers, it's a relatively imperfect market.

5. For any specific technology limitation, there's always at least one supplier that claims to have found a way to eliminate the limitation. For example, General Touch claims to have made SAW dustproof, allowing it to be used in outdoor applications such as point-of-information kiosks. This tends to have the effect of leveling the playing field between technologies. Another example of the same principal occurs when the options of armoring and a rugged substrate are applied to resistive touch. The result is a touch screen that can be hit with a hammer (as AD Metro often demonstrates) and is just as durable as surface capacitive. So which technology is better? There is no right answer, just as there is no perfect touch technology.

Conclusions

1. Analog resistive is the lowest-cost touch technology, which is the reason it dominates the $1B transparent touch market. Resistive technology is relatively mature and stable.

2. The remaining four established technologies (surface capacitive, SAW, infrared and projected capacitive) are more directly competitive than is generally believed, especially when options and "limitation-eliminating" supplier claims are considered. Supplier and/or channel relationships and geographic availability of a technology are often more significant in the selection of a touch technology for a specific application than specifications or performance differences in the technologies.

3. Surface capacitive and SAW are undergoing rapid market share growth due to the recent elimination of IP restrictions. Infrared is undergoing some degree of resurgence, and projected capacitive could explode it if takes hold in the mobile handset market. All four of these technologies will take share from resistive as well as compete with each other.

4. Optical touch is on the verge of going mainstream and becoming directly competitive with the five established touch technologies. Bending-wave touch has the potential of becoming an exceptionally competitive technology, but it will be several years before its impact is really known. Elo TouchSystems' version (APR) is likely to have a much larger market impact than 3M's version (DST), but Elo is likely to limit APR's growth because it has the potential of significantly reducing Elo's revenue from sales of established touch technologies.

5. Touch has applications in more than 20 distinct categories spread across 10 market segments. Most application categories are growing, especially mobile devices (8.4" and smaller) and kiosk applications (15" and larger).

6. Touch sensors and controllers are sold in two fundamentally different ways: (a) through direct sales or manufacturers' reps to product manufacturers (OEMs) for incorporation into high-volume products such as PDAs and ATMs, and (b) through value-added resellers and system integrators (VARs & SIs) for incorporation into lower-volume, more-specialized products such as kiosks and in-flight entertainment systems. Traditional distribution doesn't have much influence on touch hardware sales.

7. Touch is a global industry, with 50+ suppliers spread across 9 countries. However, the touch market doesn't behave as a global market due to a number of factors, including suppliers' reluctance to publish technical information, supplier technology dominance in some countries, a geographically focused channel system and a lack of globally-based touch market research data.

Company	URL	Company	URL
3M	http://www.3mtouch.com	NextWindow	http://www.nextwindow.com
ACECAD	http://www.acecad.com.tw	Nissha Printing	http://www.nissha.co.jp
AD Metro	http://www.admetro.com	N-trig	http://www.n-trig.com
Alps	http://www.alps.com	Panasonic	http://industrial.panasonic.com
Apple	http://www.apple.com	Quantum	http://www.qprox.com
Cypress	http://www.cypress.com	Richardson Electronics	http://www.rell.com
Elo TouchSystems	http://www.elotouch.com	Smart Technologies	http://smarttech.com
EtherTouch	http://www.ethertouch.com	SMK	http://www.smk.co.jp
FinePoint	http://www.finepointinnovations.com	Strategy Analytics	http://www.strategyanalytics.com
Fuji Chimera Research	http://www.fpdonline.com http://www.fcr.co.jp	Synaptics	http://www.synaptics.com
Fujitsu	http://www.fujitsu.com	Touch International	http://www.touchinternational.com
General Touch	http://www.generaltouch.com	TouchKO	http://www.touchko.com
Gunze	http://www.gunze.co.jp http://www.gunzeusa.com	UC-Logic	http://www.uc-logic.com
Hanwang	http://www.hanwang.com.cn	Venture Development	http://www.vdc-corp.com
HP	http://www.hp.com	Wacom	http://www.wacom-components.com
IRTouch Systems	http://www.irtouch.com	Young Fast	http://www.efast.com.tw
J Touch	http://www.jtouch.com.tw	Zytronic	http://www.zytronic.co.uk

Table 5: Companies mentioned in this article