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# Hype Cycle for Mobile Device Technologies, 2011

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This Hype Cycle examines the status of, and prospects for, various mobile device technologies. It advises handset vendors, mobile operators, application providers and others on the maturity of these technologies and their use.

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# What You Need to Know

Technology advancements and improved design have driven consumers to become new mobile users and to regularly replace their devices. Apple's iPhone and iPad have shown users that design and technology are meaningful only when paired with good underlying device usability. The mobile device landscape has changed as a result. The product spectrum is widening, and the key differentiator is no longer singularly focused on hardware or software alone. It is the combination of hardware and software and the underlying ecosystem that will determine success. Device manufacturers need to continue to focus on those technologies that deliver the highest return on investment by enriching the user's overall experience to the point that users will pay a premium for them. Advances in key technologies — such as manufacturing processes, radio technologies, chip fabrication, processors, memory, displays and user interfaces (UIs) — will dramatically change the size, shape and capability of mobile devices during the next 10 years.

# The Hype Cycle

As the traditional mobile phone market evolves, manufacturers have been reinventing the mobile phone and extending mobility beyond these devices. Smartphones have become full-fledged consumer electronic devices that keep users entertained and up to date with information as well as with friends and family, while also boosting their productivity. Devices such as tablets, portable media players and even handheld gaming consoles have become richer, more full-featured devices — becoming multipurpose devices more capable of interacting in an ecosystem instead of being stand-alone hardware. This has allowed consumers to do more outside the home and office in both their personal and professional lives. This Hype Cycle (see Figure 1) is a window into the innovations we will see in this industry that will enable this continuous metamorphosis of mobility.

Trends in UIs, display technologies and power consumption continue to be at the forefront of this market. Progress continues to be made in terms of UI, display and positioning technology. Although power source technology is reaching its limits, advancements continue to be made to improve efficiency of consumption while improving performance.

## Wireless Trends

The growing trend in multipurpose devices interacting within an ecosystem has highlighted the need for wireless technologies that provide a seamless customer experience. Technologies such as cellular to Wi-Fi authentication allow consumers to move freely between Wi-Fi and cellular networks for their voice and data calls. Furthermore, the strong interest in mobility and video has driven the need for and standardization of wireless video technologies — which can be used over the public spectrum, but also in the home or enterprise as a video cable replacement and video mirroring solution (as in the simultaneous display of the same image on two devices) as well. Technologies such as Wi-Fi Direct allow these wireless-enabled devices to act as access points, allowing peer-to-peer connectivity or numerous devices to connect in a mesh topology. If any of the devices are connected to the Internet, it allows all the other devices to connect as well — otherwise, it will be a local, wireless connection.

## Power and Battery Trends

Current battery technology has reached an efficiency plateau. Regardless, wireless devices continue to become more capable and demand more power. Displays are an essential component to multipurpose wireless devices, as well as one of the most taxing elements on

power supplies. In light of current battery technology limitations, vendors have introduced numerous power-efficient solutions to address these issues. Solutions such as electrowetting and reflective displays promise to deliver equivalent or better performance than current solutions, while consuming less power.

Vendors are also working on alternative power sources to alleviate the issue. One such option is micro fuel cells. Although they are not as effective as primary batteries, their capacity (potentially 10 times that of lithium) and instantaneous recharging make them useful for recharging primary batteries.

## Display Trends

This is a rapidly evolving area for mobile devices and consumer electronics in general. With displays being the most prominent feature on mobile devices, vendors demand the most robust displays to showcase their "halo" devices. Moreover, displays continue to have a significant drain on battery life. Advancements in current technologies, as well as new display technologies, are focused on addressing these key issues. Samsung's investment in Liquavista's electrowetting solution is just one example of vendors' ongoing search for robust, low-power-consuming display technology.

Vendors are also "upping the ante" beyond just having the sharpest screens with large color palettes. The popularity of 3D in cinema has also spilled into the mobile world. Earlier in the year, Nintendo introduced its latest handheld gaming device (the 3DS), which incorporates autostereoscopic 3D technology. LG also introduced a mobile phone with 3D (the Optimus 3D) at Mobile World Congress.

## User Interface Trends

As more devices with touchscreens come to market, vendors need to up their game and deliver a much-richer UI that truly benefits from touch — and multitouch, in particular. Features such as Swype and capacitive pens have been added to provide alternative input methods and to leverage the multitouch experience.

The transition to open operating systems is also forcing manufacturers to focus more on UIs as a way to differentiate their offering. A user's ability to naturally communicate with a computing device through a gesture interface and a speech-recognition interface, such as a multitouch display or an optical-input system, is still largely an emerging capability. However, in the past year we have seen multitouch and haptic technology improve both in quality and adoption. Although haptics help improve the touch experience by adding a level of depth when you touch a key on your screen, there is more that can be done. Pressure-sensing technology is an area that will allow touch interfaces to gain a higher level of precision. Technologies such as solutions from Senseg and Pacinian allow for haptics without using motors. This enhances performance by localizing tactile response while limiting power consumption. Quantum Tunnelling Composite (QTC) is another example, although commercial implementations of QTC are still limited. Samsung has included QTC technology in the trackpad, where the degree of pressure applied on the keypad determines how quickly the menu scrolls.

Furthermore, motion processing through the use of accelerometers, gyroscopes and camera-based recognition has added a third dimension to UIs. But UI improvement does not have to be limited by the design of the physical hardware. Bio-acoustic sensing technology will allow the skin to be used as an input surface. Technology such as Skinput will certainly take UIs to a totally different level where UIs will not be constrained by the physical design of the hardware.

## Positioning and Location Trends

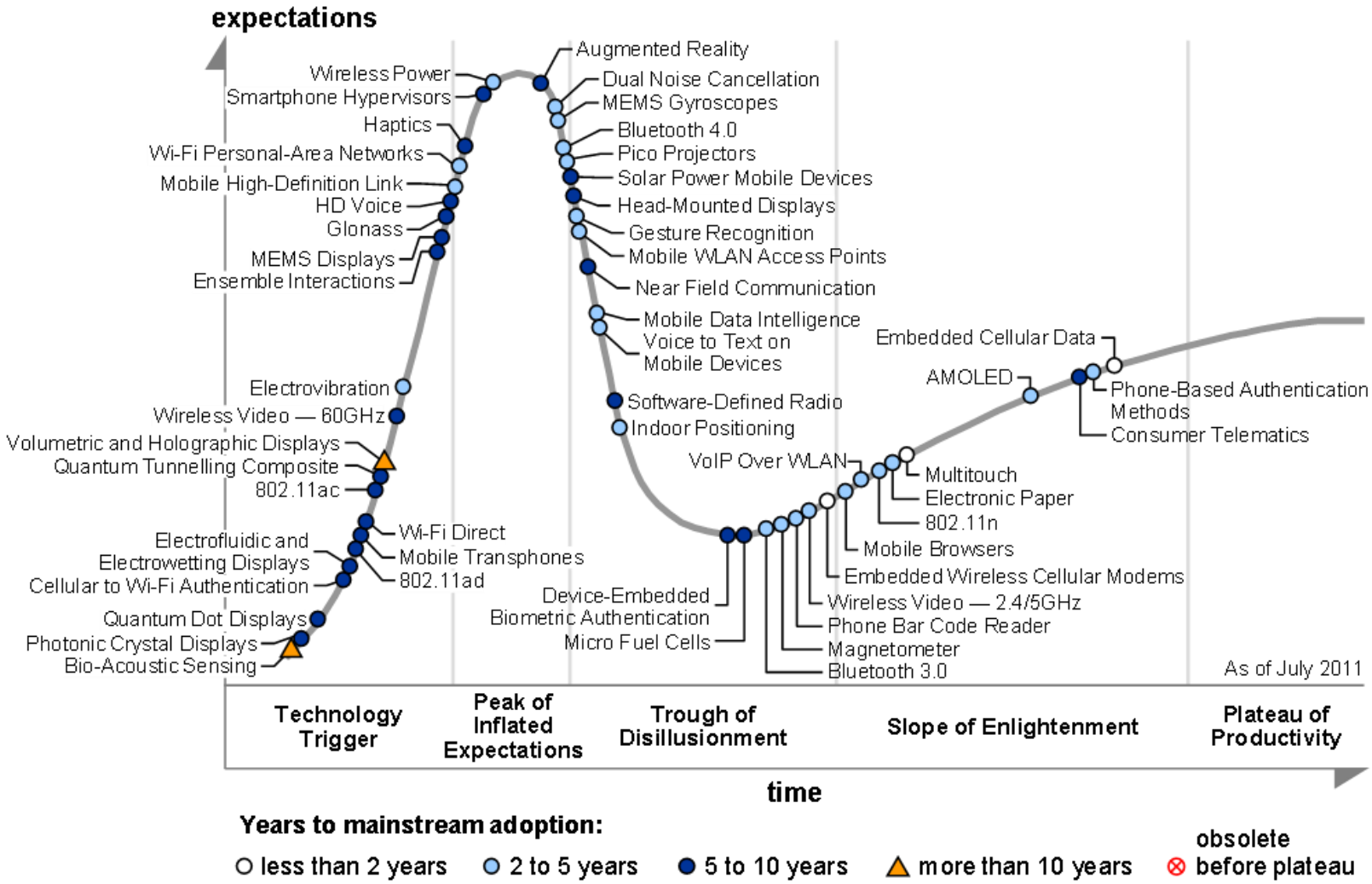
Positioning technology has moved well beyond the popularity of simply offering location and driving directions. GPS has matured and moved off the Hype Cycle. All the main handset vendors have adopted GPS in their portfolios. Furthermore, Gartner estimates that more than 90% of premium communications devices currently sold have integrated GPS. By 2015, we expect all premium communications to have this feature.

Enhancements to GPS, such as gyroscopes, magnetometers, indoor positioning, barometers and Near Field Communication (NFC), as well as parallel satellite positioning technologies (Russia's Glonass and Europe's Galileo), will all serve to improve positioning technology. Gyroscopes have received a significant amount of industry attention lately due to their functionality beyond providing more-accurate locations — such as gesture-based interfaces, gaming and motion sensing.

Mobility continues to develop and expand beyond its traditional roots. In turn, we have added new technologies to this Hype Cycle to reflect this evolution:

- Wireless video — 2.4/5GHz (previously "wireless remote display")
- Wireless video — 60GHz (previously "wireless remote display")
- Wi-Fi Direct
- Embedded cellular data
- Wi-Fi personal-area networks
- Electrovibration
- Phone-based authentication methods
- Consumer telematics
- Electronic paper
- Micro fuel cells
- Cellular to Wi-Fi authentication
- 802.11

**Figure 1. Hype Cycle for Mobile Device Technologies, 2011**




**Source: Gartner (July 2011)**





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## The Priority Matrix

Technologies providing a moderate to high impact on the market are the ones with applications that improve the consumer's experience. The growing convergence of features and functionalities of handsets and other portable consumer electronics devices has opened up opportunities for innovation, with vendors leveraging these technologies across multiple devices to improve the consumer experience. Technology for the sake of technology will have a short-lived impact on the success of the devices that are showcasing it, as well as on the overall industry.

Technologies such as active matrix organic light-emitting diode (AMOLED) have this potential. As a high-performance, lower-power-consuming alternative to LCDs, AMOLED provides benefits to consumers — alleviating the aforementioned power consumption issues, while providing high display quality. Electrovibration improves the customer experience in a different way. It enhances traditional haptics through the use of electrical charges and provides a more natural and intuitive interaction for flat surfaces by mimicking texture and contours, giving them a more-3D tactile effect. Indoor positioning further improves the consumer experience by extending location-based services indoors. It can be used to improve mapping and location when consumers walk to their destination, as well as when consumers are navigating through places like shopping malls, museums and airports.

There are many more technologies that affect the mobile device market than the ones we are showing on this Hype Cycle. Here, we have intentionally focused on those technologies that are at the early stages of development so we can follow them through to their maturity.

As shown in Figure 2, multitouch is the only technology on the Hype Cycle that we see as transformational for the industry in the near team (less than two years). Its rapid progress and adoption has moved this technology quickly off the Hype Cycle. Its application continues to be augmented by numerous technologies currently on the Hype Cycle. Technologies such as haptics will provide a more interactive feel through tactile feedback, while gesture recognition will further complement the interface by adding an intuitive dimension to the equation.

The importance of display-related technology is reflected by the number of its profiles on this Hype Cycle. This technology is the foundation for multitouch and is arguably the most easily identifiable feature for consumers. These solutions range from less demanding applications (such as mirasol's solution for e-readers) to robust solutions for higher-end devices (such as quantum dots and electrofluidic display technology). Regardless, all upcoming display solutions have all prioritized power consumption and aim to be more efficient than current LCD technology.

Although GPS has also moved off the Hype Cycle, a number of technologies currently progressing through the Hype Cycle will further enhance location capabilities. Indoor positioning and multiaxis motion processing (combining micro-electromechanical systems [MEMS] gyroscopes, accelerometers and magnetometers) will all improve accuracy, while augmented reality (AR) will leverage all these capabilities to allow consumers to optimize location experiences. AR takes the concept of location-based services to the next level, combining cutting-edge hardware, software and data to create value for users. Much of the hype and enthusiasm seen for AR last year (2010) has subsided. The components of the ecosystem (browsing, location data, hardware requirements and so forth) still need time to mature. We predict that AR will take several years to reach mainstream use and will coexist with current browsers and maps. Once the initial interface issues are resolved, data availability will be the biggest factor in the success of an AR service.

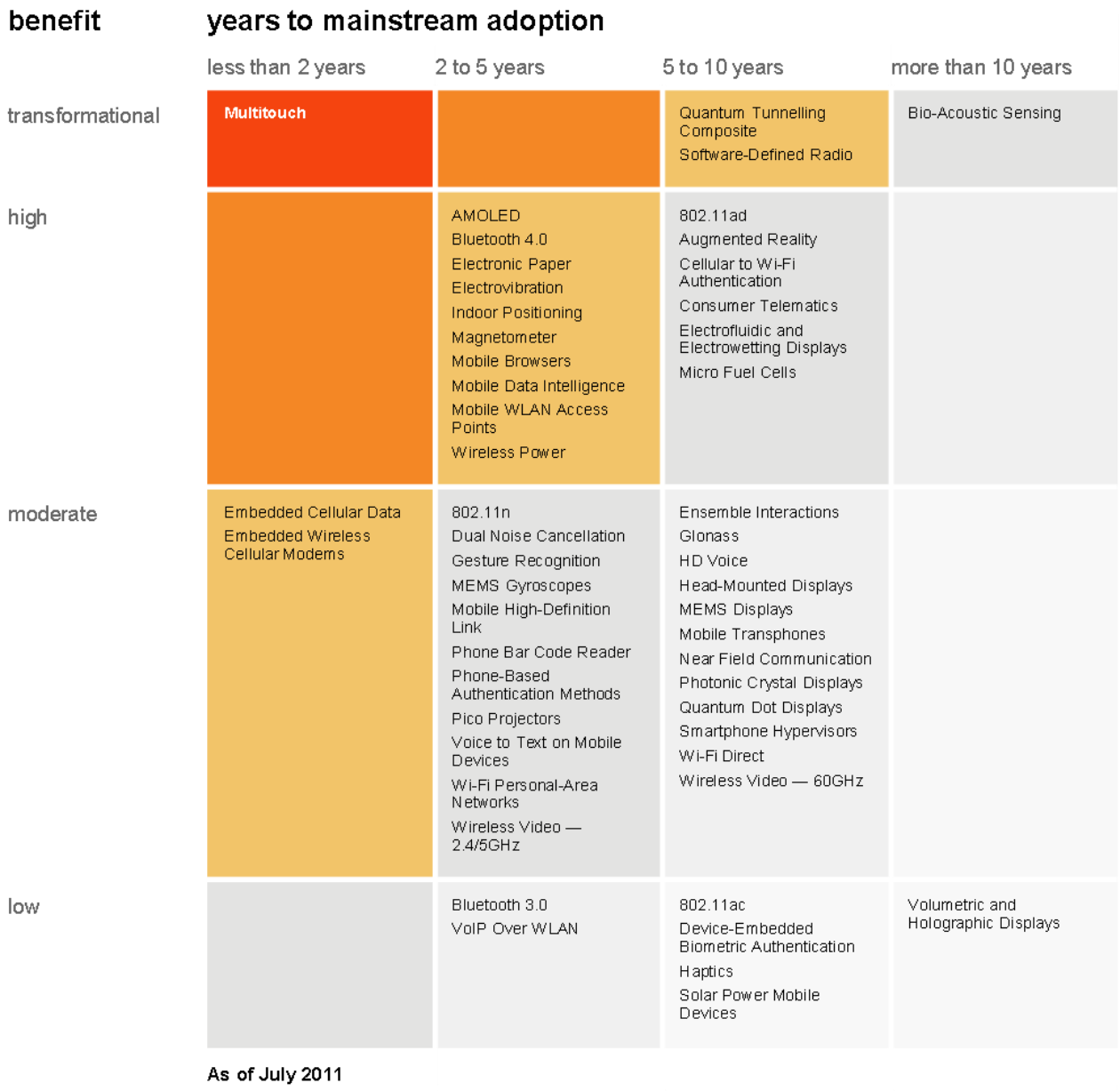
While browsers on mobile phones, in general, are relatively mature, the technology has been poorly adopted due to the user experience it delivered. However, with the most recent crop of smartphones (Android devices and the iPhone), the browser experience is greatly improved,

including graphics and enhanced user experiences. Gartner believes that during the next three years, with the adoption of HTML5 by many browsers and the standardization of resource (location, camera, accelerometer) access on smartphones, the adoption of mobile browsers, for both application access and content delivery, will increase dramatically.

A number of technologies have also moved through the Hype Cycle faster than expected. Bluetooth 3.0 has moved quickly from the peak to the trough in the past year, with its adoption potentially stifled by Wi-Fi Direct. On the other hand, smartphone hypervisors have moved to the peak. Among other things, this has been driven by the general growth of smartphones, as well as increasing enterprise security concerns and interest in cloud computing. Full smartphone OS vendor support for this technology is not expected to occur before 2013; therefore, mainstream adoption will be five to 10 years out.

There were also some technologies that did not show much movement over the year. Although we expect it to be a transformational technology, software-defined radio remains in the pre-trough position, with five to 10 years until technology maturity. It has the potential to reduce device cost and complexity, but it currently consumes too much power for most handsets. Similar to other technologies on this Hype Cycle, software-defined radio is seeing significant progress being made to reduce its power consumption. Gesture recognition has also remained in the same position near the peak due to high-profile launches, such as Kinect. Despite this technology's lack of movement, the hype around such launches has matured the technology from emerging to adolescent.

**Figure 2. Priority Matrix for Mobile Device Technologies, 2011**




**Source: Gartner (July 2011)**

## Off The Hype Cycle

GPS has reached the Plateau of Productivity and moved off the Hype Cycle. Mobile widgets have also moved off the Hype Cycle because they have become obsolete before the plateau (due to advancements in other technologies, such as HTML5).

# On the Rise

## Bio-Acoustic Sensing

***Analysis By:*** Roberta Cozza

***Definition:*** Skinput provides a new input technique based on bio-acoustic sensing technology that allows the skin to be used as a finger input surface. When a finger taps on the skin, the impact creates acoustic signals, which can be captured by a bio-acoustic sensing device.

Variations in bone density, size and the different filtering effects created by soft tissues and joints, create distinct acoustic locations of signals, which are sensed, processed and classified by software. Interactive capabilities can be linked to different locations on the body.

***Position and Adoption Speed Justification:*** This technology is being developed by researchers for Microsoft and the Human-Computer Interaction Institute of Carnegie Mellon University in Pittsburgh. In a prototype system, researchers focused on touch inputs on the arm and hand and created an armband device for sensing. They evaluated different input locations, such as the fingertips and along the forearm.

The technology can also be integrated to augment the experience with a Pico projector that projects dynamic graphical interfaces onto the hand or forearm. For example, a telephone keypad can be projected onto the palm of the hand, allowing real-time dialing without the use of a mobile phone.

Researchers also developed a scrolling interface for projection onto the forearm. Users tap the top or bottom of the user interface (UI) to scroll up or down or go back one level in the user interface (UI) hierarchy. Users can perform a simple, pinching gesture with their thumb and fingers. Accuracy of 95.5% for five input locations on the whole arm has been demonstrated.

The technology is in the early stages of development and future efforts will need to improve on the non-invasiveness of wearable bio-acoustic sensor devices and the disturbance from acoustic signals coming from other motions of the body will need to be reduced, particularly in walking or jogging scenarios (such as operating an MP3 player using Skinput while running).

The input method is limited to quick skin taps, which in its current form does not permit more elaborate common gestures like sliding or dragging. Additionally, body mass index fluctuations can decrease sensing accuracy and there is a high "learning curve" in setting up the solution.

***User Advice:*** Advances in this technology should be monitored and considered in scenarios where users can benefit from always-available and easily-accessible input without direct access to the keypad on a device, such as a mobile phone or portable music player.

***Business Impact:*** Using the human body as an input surface is an interesting concept for UIs. It could enable consumers to use larger and easily accessible additional input surface areas for interaction, compared with the small surface areas offered by the touchscreens on handsets.

Users could benefit by having large extra surfaces for input without needing to carry extra items. In addition, this type of input would allow accurate "eyes free" touch interactions, because of our natural sense of body configuration (proprioception), unlike other external input devices, most interactions could be performed without looking at the surface of a device. Experiments have also demonstrated a good level of accuracy in the input. Other external input approaches, such as smart fabrics or wearable computing, typically require an input device to be built into a piece of clothing, which is more complex.

***Benefit Rating:*** Transformational

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Microsoft

## Photonic Crystal Displays

***Analysis By:*** Roberta Cozza

***Definition:*** Photonic crystal displays are reflective displays made of photonic crystalline materials that can be constructed and designed to manipulate the propagation of light (photons).

***Position and Adoption Speed Justification:*** As a display technology, photonic crystals are currently being used in laboratories to create full-color flexible electronic paper displays, outdoor advertising displays or small reflective screens for mobile devices and consumer electronics. In such displays the spacing between the photonic crystals can be controlled so that they can reflect colors across the entire visible spectrum when an external stimulus is applied, like electrical voltage or a magnetic field.

The whole spectrum of colors can be produced using only incident light. As a result, expensive color filters (like those found in most of the display technologies on the market) are no longer needed. As the displays are reflective, no additional power consumption is needed for backlighting, unlike transflective displays.

At present, the most visible use of photonic crystals in display technology comes from Canadian company Opalux, which uses photonic crystals with the potential to produce color-flexible electronic paper displays through its P-Ink technology. Commercialization of such displays is expected to be at least five years away and significant work is still needed in photonic crystal display research to improve viewing angles for each color, control single pixel saturation and color intensity.

Pixel switching speed is another key area requiring major improvement, as current switching times are still too long to support video. Alternative color display technologies will also increase competitive pressure among manufacturers. Some (like Samsung/Liquavista and Qualcomms' micro-electromechanical systems [MEMS] displays) are incorporating electrowetting technology (where small electrical charges are used to move colored oil within each pixel).

More competition will also come from LCD manufacturers improving color support for devices like media tablets and smartphones, where enhanced e-book content can be consumed.

***User Advice:*** Research and development in photonic crystals used as a display technology is in its very early stages of development. Consumer device vendors should monitor research in this area to identify future opportunities.

***Business Impact:*** Displays using photonic crystals can offer the competitive advantage of enabling less power consumption, as they require no backlighting. In addition, the color generated in each pixel can be maintained for a long time (days) without requiring additional power. With no backlight, high contrast and reflectivity, outdoor viewing quality is greatly improved.

Additionally, there is no need for expensive color filters, as found in most display technologies, which reduces costs. Ultimately, the fact that a single material can be used to produce the entire spectrum of colors can simplify the manufacturing processes.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Opalux

## Quantum Dot Displays

***Analysis By:*** Roberta Cozza

***Definition:*** Quantum dots are nanocrystals made from types of semiconductors that emit colored light. They are very small, with a diameter ranging from two to 10 nanometers. The different colors emitted can be finely tuned by changing the size of the quantum dot and manipulating their chemical composition.

***Position and Adoption Speed Justification:*** As with organic light-emitting diode (OLED) screens, the light in quantum dot displays is self-emitted, meaning that they do not require backlights and color filters like LCD displays.

When quantum dots are used in existing display technology, such as the LEDs in LCD backlights, they can improve power efficiency by reducing the number of diodes required to achieve similar levels of brightness. As quantum dots can be tuned very precisely to emit specific colors, they also improve the overall purity of colors and color rendering, compared with OLED screens, for example.

The composition of these quantum particles means they are soluble, which allows greater manufacturing flexibility, as they can be used with solution processing techniques, such as spin coating, roll-to-roll processes and printing on large areas and flexible substrates.

In contrast, OLED screen manufacturing involves more complex techniques. Quantum dot displays are in the research and development phase and at least five to 10 years away from commercial availability as stand-alone products. Adoption to complement or supplement existing LED and LCD technology is more mature in comparison.

Some companies, such as QD Vision, have produced prototypes and quantum-dot-based solutions to improve existing OLED technology with their quantum dot LED products. More recently, Samsung researchers showed a color four-inch quantum dot prototype panel. Quantum-dot-based displays are still expensive to manufacture compared with other display technologies like OLEDs and LCDs. Most quantum dots that are produced are made of elements like cadmium, which are highly toxic, making their presence in future commercial applications problematic. Some companies, like Nanoco Group, are developing quantum dots that are free of heavy metals.

***User Advice:*** Research and development into quantum dots used as a display technology is at the prototype stage. Device vendors should monitor research in this area to identify future opportunities to use quantum dot applications to improve existing display technologies.

***Business Impact:*** Displays are an essential part of the user experience for mobile devices and smartphones. As video, Web browsing, gaming and navigation applications become more sophisticated on mobile phones, display performance considerations play a key role, especially related to the high demands they place on the battery.

Quantum-dot-based displays promise key advantages over existing display technologies (such as LCDs and OLEDs), with improved power consumption over LCDs, better color rendering and more flexible manufacturing processes. Research and development into quantum dots is vast and

companies have developed some commercial quantum dot solutions, mostly around LEDs, lighting and security applications.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Evident Technologies; LG Display; QD Vision; Samsung

## Cellular to Wi-Fi Authentication

***Analysis By:*** Tim Zimmerman; Michael J. King

***Definition:*** Cellular to Wi-Fi authentication provides a foundational component for dual-mode smartphones to move freely between cellular and Wi-Fi connectivity for voice and data applications. This multivendor and multiple physical layer authentication allows cellular connections to be transferred to Wi-Fi, as well as among multiple Wi-Fi vendors from one installation to another, whether it is a hot spot or, ultimately, within an enterprise. Mobile users, whose devices can move between 3G and Wi-Fi networks at a low level using a 802.21 handoff, also need a unified and reliable way to authorize their access to all of those networks. 802.11u provides a common abstraction that all networks, regardless of protocol, can use to provide a common authentication experience.

***Position and Adoption Speed Justification:*** The ratification of 802.11u, which provides the necessary functionality for internetwork communication such as network discovery and selection, has boosted the momentum for initiatives such as the Wi-Fi Alliance's Next-Generation Hotspot or Hotspot 2.0. Initial vendor testing is just beginning with the Wireless Broadband Alliance and will begin in the fall of 2011 for the Wi-Fi Alliance. Vendor trials will show the ability to authenticate, but vendors will still need to negotiate roaming agreements and to facilitate rolling out the necessary hardware and software for the end-to-end solution for all components of the multivendor solution.

***User Advice:*** Users should expect that once the functionality has been agreed upon by the industry it will take time for the necessary hardware and software to be implemented. They should also expect issues with initial implementations of multiple vendor solutions in hot spots, as well as within the network infrastructure. Enterprises looking to use the technology to additionally provide a migration strategy for roaming among Wi-Fi vendors will have more initial success, since they control the end-to-end solution.

***Business Impact:*** The ability to seamlessly roam from cellular to Wi-Fi will be huge as Wi-Fi continues to provide a 450 Mbps connectivity through a single access point architecturally capable of over 1 gigabyte of Wi-Fi connectivity through layering and load balancing using multiple access points. The offloading ability will provide a solution for density-rich environments, such as stadiums, metropolitan areas or university classrooms.

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Aruba Networks; AT&T; Cisco; Verizon

## Electrofluidic and Electrowetting Displays

***Analysis By:*** Hugues J. De La Vergne

***Definition:*** Electrowetting displays use an electrical charge applied to a water interface to move a colored oil interface, to either show color (no voltage), or become partly transparent. Electrofluidic displays are a variation of electrowetting that uses voltage to pull pigment in and out of a reservoir and spreads it as a film behind the viewing substrate.

***Position and Adoption Speed Justification:*** As new introductions to the display landscape, these technologies are at a precommercial stage. Initially, they are being proposed as a color alternative to black and white displays, which have dominated e-readers until the recent launch of color displays by competitors. The technology offers a low-power, compact solution that delivers a brighter and higher-contrast display (versus reflective LCD) that is fast enough to display video content at high frequencies. This feature set opens up the potential market for this technology to other consumer electronic device applications, such as status screens, keypads and larger displays. Furthermore, electrowetting leverages existing LCD fabs, meaning that displays can be produced in refurbished LCD production facilities, thus lowering the cost and risk associated with bringing a new technology to market. Samsung acquired Liquavista earlier in the year to expand its presence in this space and potentially expand it throughout its vast display portfolio, including mobile phones and larger displays, such as televisions, which is a key reason Gartner has moved the technology further in the Hype Cycle. Pricing is expected to be better than organic light-emitting diodes and will need to be competitive with LCDs in a few years' time to be adopted as a mass-market technology. Time to market will be critical, as the biggest challenge for electrowetting will be competitive technologies. Multiple vendors offering different technologies are going after this segment. E Ink, which currently dominates the e-reader display market, has recently introduced color displays, and micro-electromechanical systems display vendors, such as Qualcomm, have launched products such as Mirasol to try to expand into this space. Other vendors include:

- Electrowetting (Samsung-Liquavista, ADT)
- Electrofluidic technology (Gamma Dynamics)

***User Advice:*** E-reader and consumer electronics vendors should closely monitor developments in this nascent technology. It provides improvements over traditional e-ink by adding an element of color and support of full-motion video, as well as performance improvements that can be adapted to larger-scale displays.

***Business Impact:*** This technology will compete with other technologies to bring a color alternative for product categories that currently use e-ink displays.

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Advanced Display Technologies (ADT); Gamma Dynamics; Liquavista

## 802.11ad

***Analysis By:*** Mark Hung

***Definition:*** 802.11ad is an in-room wireless technology standard that will promise higher throughput than 802.11ac/802.11n at shorter range. It will be part of the widely popular set of Wi-Fi standards.

After 802.11n, the standard bifurcates into two new parts:

- 802.11ac: Supports a maximum throughput of 1 Gbps in the sub-6GHz spectrum
- 802.11ad: Supports a maximum throughput of 7 Gbps in the 60GHz spectrum

Both of these standards are expected to be approved in the second half of 2012.

802.11ad is intended to have a reach of 30 feet or less, unlike 802.11ac and previous generations of 802.11, which can have a coverage radius of up to 300 feet or more.

***Position and Adoption Speed Justification:*** Because of 802.11ad's high throughput and limited reach, it is targeted at applications that require high data consumption and are in close proximity to each other. These include the following:

- Wireless video
- Wireless docking
- Wireless storage
- Medical imaging
- In-room gaming
- Wireless projection

The first standards-compliant products, initially targeted at consumer applications, will be on the market toward the end of 2012. The key to driving the technology down the cost curve and increasing market adoption is to have a competitive market for the enabling semiconductor vendors. Given the dearth of product announcements from this group thus far (other than from a few startup companies), we believe that it will be a few years before 802.11ad sees greater adoption, whether it is by the consumer or enterprise market.

***User Advice:*** Designers of computing and consumer electronics devices should consider which of their platforms can best benefit from 802.11ad's target use cases. Although the range of technology suppliers is currently limited, it is expected that eventually most of the major wireless LAN semiconductor suppliers will have offerings in this space.

***Business Impact:***

- For mobile computing platforms, 802.11ad can reduce the number of wired ports required (e.g., HDMI, USB, eSATA and DVI) and thus provide both a better user experience and lower product cost.
- For mobile communications platforms, 802.11ad can provide higher bandwidth to enable in-room video streaming and data transfer applications.

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** SiBeam; Wilocity

## Mobile Transphones

***Analysis By:*** Monica Basso

***Definition:*** Mobile transphones are mobile device products with an innovative and/or adaptive form factor that users can modify dynamically, based on their specific contexts and needs. Some products are still at the conceptual model stage (such as Nokia Morph), while others are already commercially available. Nokia Morph is based on the notion that, at some point, there will be innovative materials (possibly based on nanotechnologies) to enable a flexible, foldable, stretchable design, thus enabling users to transform their mobile devices into radically different shapes. Modu's Modu Mobile uses a modular, Lego-like approach, based on building blocks, to assemble and create the most appropriate form factor for a user at a given time.

***Position and Adoption Speed Justification:*** Despite the hundreds of mobile devices and models available on the market, personalization is limited. Personalization is mostly about aesthetics and cosmetics — covers in fancy colors and materials, themes with images and ring tones, and accessories such as hanging items and holders. Normally, it does not concern functionality and the form factor, which are rigidly assigned to a device, depending on the target market segment. Mobile devices come with a range of capabilities and functions, but their form factors tend to be optimized on a primary function — for example, email capabilities, as in BlackBerry 88xx devices; camera and multimedia capabilities, as in Nokia N95; and Internet browsing, as in the iPhone.

Most smartphones accumulate a range of capabilities (the "Swiss Army knife" concept), without form factor optimization for most of them. As a result, people tend to adopt a combination of devices to meet their needs. Personalization can be more than that. People will be able to get what they need at a certain point in time, depending on the context, and their roles and needs. Mobile devices will increasingly gain a context-adaptive form factor that provides more personalization and optimization of use.

This evolutionary process for mobile devices will develop through stages. Today's stage is (as in Modu Mobile) based on pluggable, wired, inflexible components. The next stage is likely to be based on wireless, inflexible components, as well as wireless interconnections, such as Bluetooth and, especially, Bluetooth LE (beginning around 2011). This will enable new types of peripherals, such as intelligent jewelry, that can talk to the mobile phone. Flexible is likely to start with simple flexible components talking to an inflexible handset core (for example, a flexible wrist screen talking wirelessly to more-conventional inflexible handset electronics). Before 2015, some handsets will offer separate components, such as a secondary screen and keypad. Wireless video will become a common feature, driven by the Wi-Fi Alliance's standardization efforts.

Due to the preliminary stage of the market, Modu went bankrupt in early 2011; however, its patents have been bought by Google. Interesting adaptations of the transphone model have been launched in 2011 by notebook and smartphone vendors — for example, Asus Padphone, a tablet that embeds a smartphone, and Atrix, a notebook that embeds a smartphone.

***User Advice:*** Organizations should monitor future innovations that will drive more personalization of mobile devices. This will enable them to better meet the needs and expectations of different user groups (per demographics and gender) in their employee and client bases. Handset manufacturers not yet active in this area should investigate people's expectations and plan to deploy one or two transphone products to judge user acceptance.

***Business Impact:*** Mobile transformer products will not significantly affect businesses until similar products become available, and they become a priority for anyone involved in the mobile device ecosystem, such as mobile operators, service providers and application developers. We do not expect this market shift to happen before 2015.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Asus; Google; LG; Nokia

***Recommended Reading:*** "Social Trends Are Influencing the Adoption of Mobile and Web Technology"

"Emerging Technology Analysis: Mobile Transphones, Mobile Device Technologies, 2009"

"Device Portability Is Subjective and Contextual"

"Future Technology: The Plastic, Flexible Gigabit Phone"

## Wi-Fi Direct

***Analysis By:*** Mark Hung

***Definition:*** Wi-Fi Direct is a technology that allows either two devices to connect in a peer-to-peer (P2P) mode or many devices to connect in a mesh topology, all using Wi-Fi as the underlying networking technology. In both cases, a Wi-Fi router, access point (AP) or repeater is not required; thus, the name for the technology: "Direct." This is accomplished by embedding a software-based Wi-Fi AP, or soft AP, in each of the client devices. To connect the devices together, the Wi-Fi Protected Setup (WPS) protocol is used. If any of the devices is connected to the Internet, then all the other devices can access the Internet as well through that device. If not, the devices will be locally connected to each other but not to the Internet.

***Position and Adoption Speed Justification:*** Wi-Fi Direct was ratified as a standard in October 2010, and it is intended to challenge Bluetooth's dominance in the personal-area networking (PAN) space. It has the following advantages over Bluetooth:

- Throughput: A typical Wi-Fi connection using 802.11n has a maximum throughput of 300 Mbps. Bluetooth 3.0/4.0 + HS currently has a maximum throughput of 24 Mbps.
- Range: Wi-Fi usually has a range of 100 to 300 feet, an order of magnitude higher than Bluetooth's 30 feet.

However, Bluetooth currently has a major advantage over Wi-Fi Direct: its plethora of software profiles. When two Bluetooth devices support the same profile, it is a straightforward process of setting up the connection. Currently, the only imminent application that Wi-Fi Alliance is developing to utilize Wi-Fi Direct is Wi-Fi Display, so it will be a while before it catches up to Bluetooth in terms of the richness of the set of applications.

Besides audio and video streaming, Wi-Fi Direct is also targeting low-power applications, such as sensor networks, health monitoring, fitness and PC peripherals. HP introduced a Wi-Fi Direct-enabled mouse earlier this year that takes advantage of a PC's built-in Wi-Fi, so that Bluetooth or a proprietary 2.4GHz radio is not required.

Most of the major wireless LAN semiconductor vendors, including Broadcom, Qualcomm Atheros, Texas Instruments and Ralink, support Wi-Fi Direct in their latest product offerings. In addition, Ozmo Devices and GainSpan have chipsets in production that support Wi-Fi Direct for the low-power use cases.

***User Advice:*** Given the expected prevalence of Wi-Fi Direct technology in chipsets, electronic equipment manufacturers (EEMs) should make this feature a required checklist item when

evaluating vendors. Despite its promise to supplant Bluetooth, though, EEMs should consider carefully whether to use it as a complementary or replacement technology for Bluetooth, as application support for Wi-Fi Direct is still in its nascent stages.

***Business Impact:*** With the increasing amounts of data being moved between devices, whether it is for media streaming or data synchronization, direct connection technologies such as Wi-Fi Direct will provide an improved consumer user experience with its increased throughput and ease of use. As the technology becomes more prevalent in the enabling chipsets, adoption will accelerate in consumer devices, whether they are mobile phones, media tablets, PCs or TVs.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Broadcom; GainSpan; Ozmo Devices; Qualcomm Atheros; Ralink; Texas Instruments

## 802.11ac

***Analysis By:*** Tim Zimmerman

***Definition:*** 802.11ac is one of two next-generation higher-speed wireless LAN (WLAN) standards developed by the Institute of Electrical and Electronics Engineers (IEEE). The working group is looking to provide improvements in the technology to further expand the throughput at 5GHz. The goal is a multistation aggregate throughput of at least 1 gigabit, and a single station link of at least 500 Mbps. Current proposals are looking at utilizing a single eight-antenna access point to service four two-antenna stations operating on 160MHz channels that provides aggregate throughput of 6.93 Gbps. 802.11ac will operate in the 5GHz spectrum to enable backward compatibility with 802.11a/n standards and deployed solutions in the market today.

***Position and Adoption Speed Justification:*** Targeted for conference rooms and home multimedia, future users can have multiple high-definition (HD) video streams and gaming streams active across a house and within a room. Approval of the standard by the IEEE is targeted for late 2012.

***User Advice:*** Consumers and corporations should continue to monitor the progress of 802.11ac. The scalability of 802.11n and the backward-compatibility requirement will limit the available target market, as well keep costs above those for expected implementations of 802.11ad. However, no further action is necessary at this time because of the immaturity of 802.11ac.

***Business Impact:*** 802.11ac will increase the top-end throughput within a coverage area that can address applications requiring large file transfers, such as computer-aided design (CAD) drawings, media unloading from digital cameras, or multiple, simultaneous HD data streams needed for telepresence or in home entertainment. The new performance will be achieved while maintaining the backward compatibility, coverage, functionality and expectations of current Wi-Fi solutions. We expect that there will be an issue with the requirement to integrate eight antennas into devices such as laptops to achieve the desired throughput, because vendors are pushing back on the more than one needed to fully utilize the benefits of 802.11n. 802.11ac faces direct competition from the 802.11ad standards that will operate at 60GHz, and will look to provide multiple-gigabit, point-to-point in-room connection with a potentially lower price point.

***Benefit Rating:*** Low

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Broadcom; Intel; Qualcomm; Samsung

## Quantum Tunnelling Composite

***Analysis By:*** Roberta Cozza

***Definition:*** Quantum tunneling composite (QTC) is a flexible electrically conductive material, developed by British company Peratech, which enables pressure switching and sensing. This is a printable polymer that changes its electrical conductivity with an applied force. The technology uses quantum tunneling to enable conductivity under pressure, which results in better pressure resolution than standard resistive techniques.

***Position and Adoption Speed Justification:*** QTC can be used to enable pressure-sensitive touchscreens in mobile phones and new types of pressure-sensitive controls, switches and sensors for a wide range of consumer electronics. Peratech has licensed its technology to Samsung Electro Mechanics (electronic components), QIO (smart clothing and luggage) and Nissha (for touchscreens).

Currently, commercial implementations of this technology are available but still limited. It has been used in robotics, having been adopted by NASA's Robonaut and recently the Massachusetts Institute of Technology commissioned Peratech to develop a tactile skin based on the technology to enable robotic devices to interact by detecting touch and intensity of touch.

Nissha is planning to integrate the technology in the perimeter of handset screens and Samsung has included QTC technology in the trackpad of a Samsung qwerty handset model, where the degree of the pressure applied on the keypad determines how quickly the menu scrolls. Similarly, several more immediate applications will need increased pressure applied, for example, when zooming into a Web page or for e-book readers to flip through pages of an e-book faster by applying more pressure.

Pressure sensing in controls is attractive for gaming applications where it becomes an additional form of input. QTC can enable sensitive gesturing that can produce lines with varying degrees of thickness which are useful for writing Asian language characters on touchscreens. Other pressure touch-sensitive technology is available in the market, but the QTC material has advantages in terms of cost, flexibility and robustness.

Peratech has developed a transparent version of the QTC material called QTC Clear. This see-through layer is six to eight microns thick and features a transparency thickness similar to existing touchscreen technology. The new QTC material could be used to replace current resistive touch technology or enhance capacitive screens. QTC Clear has been licensed to a top touchscreen manufacturer.

***User Advice:*** Handset vendors and consumer electronics manufacturers should investigate the opportunities enabled by pressure-sensitive QTC technology to drive further product differentiation and improvements in the user touch-interface experience.

***Business Impact:*** QTC is a low-cost flexible material that can be incorporated in a wide range of different products from clothing to credit cards, as well as switches and controls of consumer electronics. Switches based on QTC material can be as thin as 75 microns, which makes this technology suitable for integration into very thin electronic designs.

QTC technology can be used on small screens and scaled to large touch surfaces. The technology can be implemented on existing display technology like organic light-emitting diodes

and LCDs. In addition, QTC-based interfaces do not use power when there is no pressure applied, unlike optical pads that draw electricity and need a constant charge.

The flexibility and low cost of the technology opens up a broad potential for applications beyond integration in handsets and consumer electronics and into fields like sport healthcare, automotives, robotics and industrial applications, opening up new and more refined ways of human-machine interactions based on force sensing (for details, see www.peratech.com).

***Benefit Rating:*** Transformational

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Peratech

## Volumetric and Holographic Displays

***Analysis By:*** Stephen Prentice

***Definition:*** Volumetric displays create visual representations of objects in three dimensions, with an almost 360-degree spherical viewing angle in which the image changes as the viewer moves around. Unlike most 3D planar displays, which create the illusion of depth through visual techniques (stereoscopic or autostereoscopic), volumetric displays create lifelike images in 3D space.

Holographic displays can create reasonable illusions of volumetric displays, but technically, they are not true volumetric displays.

True volumetric displays fall into two categories: swept volume displays and static volume displays. *Swept volume displays* use the persistence of human vision to recreate volumetric images from rapidly projected 2D "slices." One approach is to project images onto a rapidly rotating mirror inside a protective enclosure (to protect the viewer from injury, should he or she attempt to touch the images). *Static volume displays* use no major moving parts to display images, but rather, rely on a 3D volume of active elements (volumetric picture elements, or voxels) that change color (or transparency) to display a solid option. Low-resolution displays may use transparent elements such as light-emitting diodes (LEDs), but practical higher-resolution displays use techniques such as pulsed lasers that are directed by scanning mirrors to create balls of glowing plasma at the location of each voxel.

Holograms can be deployed to create a realistic volumetric display, but with a more restricted viewing angle. At present, this is the only way to create a large image (that is, more than about one cubic meter).

***Position and Adoption Speed Justification:*** Volumetric displays have barely emerged from the laboratory, and developments remain in the very early stages, with little movement on the Hype Cycle during the past 12 months. At Siggraph 2010, Sony demonstrated its RayModeler device (a cylindrical autostereoscopic display), but this, like most others, remains firmly in the lab environment. Several companies, including InnoVision Labs and Realfiction, demonstrated 3D holographic images generated from their projectors, but none of them has been commercialized yet. The use of holographic techniques is, by far, the most advanced, but due to the intensive computing calculations required to generate the holographic image, the cost of generating the display image is one of the hurdles toward real-life adoption. Simpler and much lower-cost solutions would be required for mass adoption, and the growing availability of 3D displays is likely to divert demand for less-specialized applications (such as marketing and retail displays) toward these less-challenging technologies.

Swept and static volumetric displays suffer from the significant dangers of rapidly moving parts or ionized particles in the vicinity of people, especially because the volumetric nature of the generated image convinces the brain that it is solid and "real" and, therefore, can be touched. In all cases, the volume of data required to generate a volumetric image is considerable — typically on the order of 1,000 times more to create a 24-bit voxel image (1,024 layers on the z-axis) than the corresponding 2D image. In all cases, the amount of CPU processing required is equally significant compared with creating a 2D image.

***User Advice:*** Outside of specialized areas, where budgets are not significant constraints, this technology remains firmly in the lab rather than in commercial applications. The rapid growth and continuing development of 3D televisions in the mainstream markets threaten to overwhelm the continuing development of volumetric and holographic displays outside of specialized markets.

***Business Impact:*** General applications are not well-developed for business use. To date, simple applications in marketing have been deployed — usually targeted at high-end retail environments, and there are some specialized applications for geospatial imaging to enhance 2D maps, and for use in architectural rendering. However, most of these can be achieved at much lower costs using other more-advanced technologies, such as 3D displays (which have developed rapidly during the past 12 months) and virtual worlds. Potential application areas include medical imaging, entertainment, gaming and design, but costs will need to fall dramatically for these to be viable for using true volumetric displays.

***Benefit Rating:*** Low

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Holografika; InnoVision Labs; Optics for Hire; Quince; Realfiction; Sony; viZoo; Zebra Imaging

## Wireless Video — 60GHz

***Analysis By:*** Mark Hung; Jon Erensen

***Definition:*** Wireless video may be broadly defined as any over-the-air video transmission, whether it is broadcast (one-to-all), multicast (one-to-many), or unicast (one-to-one). This video stream can be transmitted either over the public spectrum (i.e., broadcast frequencies or WAN), or inside a home or enterprise using unlicensed spectrum (i.e., wireless LAN [WLAN]). We are limiting the definition of this technology to wireless video transmission using the 60GHz band in a WLAN setting. Applications include video cable replacement and video display mirroring (e.g., simultaneous display of the same image on two devices).

***Position and Adoption Speed Justification:*** Wireless video technologies can be categorized along several different axes:

- Spectrum: 2.4GHz, 5GHz, or 60GHz.
- Standards-based or proprietary: Wi-Fi (IEEE 802.11) is the most popular physical layer standard for WLAN.
- Network topology: Star (with a wireless router or access point in the middle) or peer-to-peer (P2P).
- Throughput: This is largely a function of the underlying physical layer standard, although the use of compression at a higher layer can increase the overall throughput.

In the 60GHz band, there were primarily two groups vying for the leadership position:

- Wireless HD: This was one of the earliest proprietary wireless video implementations, promoted by SiBEAM and several Asian consumer electronics (CE) companies. This was also the first use of the 60GHz spectrum for video transmission. With the range limitations inherent at 60GHz, this was designed primarily to be a P2P network supporting 4 to 7 Gbps of throughput.

- WiGig: Although it is not a wireless video-only standard, WiGig was formed to compete against WirelessHD, with most of the existing Wi-Fi semiconductor vendors as its members.

The two groups have since come together to combine their efforts for the 802.11ad standard. One of two next-generation 802.11 standards (the other being 802.11ac), 802.11ad is designed to support up to 7 Gbps of throughput in the 60GHz range. 7 Gbps was the design target to provide sufficient overhead for transmitting uncompressed 1080p high-definition (HD) video at 60 frames per second (fps), which would require 3 Gbps of bandwidth. It is designed to mostly operate in the P2P mode. Whereas previously there was a lack of certainty as to how the competing 60GHz standards would be sorted out, the path to technology maturation is clearer now that they have coalesced around 802.11ad. The specification is expected to be ratified by the end of 2012, and prestandard products are already on the market today. Although the first standards-based products are expected to be available for the 2012 shopping season, it will be several years before we see broader penetration of the technology in CE devices.

At the application layer, the new Wi-Fi Display standard is expected to be the transport mechanism adopted by the computing, communications, and CE equipment manufacturers for P2P video streaming. This will enable these devices to interoperate more easily with each other.

***User Advice:*** Electronic equipment manufacturers should focus on delivering standards-based products (802.11ad, Wi-Fi Display) to ensure interoperability and a better user experience, which would grow the overall market and broaden the technology's adoption.

Consumers who would like to have the ability to stream uncompressed HD video should wait until 802.11ad-based products are on the market, as they would ensure compatibility with future standards-based products.

***Business Impact:*** Wireless video using 60GHz will have a wider impact in the consumer market rather than the enterprise market. For the former, the components in a home theater system (the AV receiver, TV, set-top box and Blu-ray player) can all benefit from the inclusion of this technology. For the latter, the targeted markets for this technology are wireless projectors and videoconferencing equipment, although adoption in these two platforms is expected to be muted.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Apple; Broadcom; Intel; Qualcomm Atheros; Samsung Electronics; Sony

***Recommended Reading:*** "Emerging Technology Analysis: Consumer Electronics Technologies, Wireless High-Definition Multimedia Interface Cable Replacement"

## Electrovibration

***Analysis By:*** Roberta Cozza

***Definition:*** Electrovibration technology is based on an effect in which touch receptors in the skin can be duped into perceiving texture. Electrical charges simulate the feeling of localized vibration and friction, mimicking shapes, textures and contours (such as the feel of a keyboard key or a button) on touchscreens and an array of other mobile devices or product surfaces.

No electrical charge passes through the skin with this technology (unlike electrocutaneous displays), as the charge is created through movement over a conductive surface. A periodic electrostatic force is created, which "deforms" the skin on users' fingers.

***Position and Adoption Speed Justification:*** Many research groups are developing different types of electrovibration techniques to enhance touch display experience with tactile sensation. The most notable work comes from researchers from Disney Research in Pittsburgh, Carnegie Mellon University and the University of Paris-Sud, which used and developed an electrovibration technique called TeslaTouch, where electrovibration was used to control electrostatic friction between a touch panel (a commercial touch capacitive panel was modified from 3M) and a user's fingers.

A Finnish company, Senseg generates tactile feedback by using a solution called E-Sense, which charges a conductive film on a touch panel to create an electric field, which causes vibration on the skin. E-Sense is based on independent tactile elements ("tixels") providing localized sensations (specifically, different textures for each finger or different area of a surface) and in this solution tactile sensations can be felt both with moving or still fingers.

Senseg's solution is not available in commercial products. However, the company is working with three top OEMs in Asia, planning to take the technology to a commercial level by 2011. Toshiba has shown prototypes based on E-Sense. High profile partners will be of key importance to companies like Senseg. Challenges in adoption are also linked to user acceptance and reliability needs to be proven in real-world deployments.

***User Advice:*** Touch interfaces are key elements driving rich user experiences across many categories of devices. Consumer electronics, smartphones and media tablet manufacturers should explore the opportunities provided by electrovibration techniques for new forms of tactile feedback for touchscreens and other surfaces that can differentiate and enhance user experiences.

***Business Impact:*** On-screen touch experiences are evolving and becoming more complex. Mechanical solutions are limited in their ability to differentiate and provide rich experiences based on multitouch and new gestures. Electrovibration solutions can considerably enhance the touch feedback currently delivered by mechanical vibration used in common haptic implementations. These use moving parts that wear out over time and have motors that drain battery life, generate noise and cause excessive vibration of the entire device.

Electrovibration solutions could greatly impact the way users interact with touch interfaces and screens on media tablets, smartphones, gaming handheld devices, advanced in-vehicle controls and other consumer and industrial products.

Different levels of friction can augment the manipulation of icons, files and other "dragable" items by applying simulated friction in drawing/painting applications (in the TeslaTouch experiment, various levels of friction were associated to file size when files were dragged to a folder or when items needed to be aligned).

Different textures can be applied to virtual objects and applications can be implemented for blind or visually impaired consumers (current touchscreens still largely require users to locate objects visually on the screen).

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Senseg

***Recommended Reading:*** "Cool Vendors in Imaging and Display Devices, 2011"

## Ensemble Interactions

***Analysis By:*** Nick Jones

***Definition:*** Ensemble interactions are user experiences that involve multiple linked devices or that dynamically cross two or more personal devices. An early example that has already been demonstrated is video calls that shift automatically from a mobile handheld device to a large-screen TV as the user walks into a room and uses gestural controls that "throw" a video from a mobile device to a larger monitor. In the long term, as more consumer electronics and home appliances become networked and increasingly "intelligent," the number and complexity of ensemble interactions are likely to increase. For example, a TV shopping experience could involve simultaneous interactions on a smartphone and an Internet Protocol (IP)-enabled TV. If the input complexity demands it, then user interactions could jump from a small-screen device to one with a keyboard. If they were in the vicinity, then simple devices could call on the services of more-complex devices — for example, to perform speech recognition for data entry.

***Position and Adoption Speed Justification:*** Although a few demonstrations of the concept have been shown, this technology is still immature and is the subject of academic research. User expectations about how multiple devices should collaborate in delivering an experience are undefined and uncertain, and the number of domestic devices that could participate in interactions is limited. The growth in IP-enabled TVs, and the increasing availability of wireless networking in computing and entertainment devices, suggests that home media will be an early area of adoption of ensemble interactions. Emerging technologies (e.g., wireless video interfaces) will facilitate rapid shifting among display devices. However, one technological foundation that is still immature is short-range, in-room positioning services to reliably detect the locations of devices in the vicinity.

***User Advice:*** User organizations should monitor this technology because, as it emerges, it could further complicate assumptions about what device an interaction is taking place on. This is because the device might change during the interaction. Organizations conducting business in situations where two or more smart devices are in the same vicinity (such as TV shopping or in-store retail experiences) should pilot ensemble interactions implemented using communications applications.

***Business Impact:*** Vendors in areas such as mobile devices and consumer electronics should monitor and sponsor research into ensemble interactions. Vendors that manufacture a wide range of consumer electronics (for example, in the mobile and home entertainment markets) should explore this technology as a way to add value when consumers purchase more than one product from the same company.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Embryonic

***Sample Vendors:*** Microsoft; Motorola

## MEMS Displays

***Analysis By:*** Tuong Huy Nguyen

***Definition:*** "MEMS display" refers to the use of micro-electromechanical systems (MEMS) technology in display technology by controlling the emission of light.

***Position and Adoption Speed Justification:*** MEMS technology used for low-powered displays for mobile devices is still a relatively new technology, and deployment remains limited. There are a number of different, competing display solutions available, primarily based on either transmissive or reflective technology. These include:

- Qualcomm's mirasol solution — a reflective display technology based on interferometric modulation (IMOD) technology with MEMS structure at its core. Qualcomm's IMOD display solution operates by using spatial multiplexing mirrors to generate color using interference and the reflection of ambient light. Qualcomm's mirasol solution is the first low-power, color, video-capable and sunlight-viewable display that has proven commercially available solutions, including a connected wideband code division multiple access camera monitoring device, a stereo Bluetooth headset and an entry-level handset. The 5.7-inch e-reader solution originally planned for 2H10 has been delayed and is expect by the end of 2011. This solution is initially positioned to challenge electronic ink in the e-reader market. Not only does this reflective technology claim the lowest energy consumption and "greenest" footprint of any display technology, but it improves on electronic ink by providing color, as well as being able to show video/multimedia. Despite this, as a reflective technology, the color aesthetic is softer than that of standard displays because of the natural-light source. Furthermore, Qualcomm has recently demonstrated an embedded front light with light-emitting diodes (LEDs) that's controlled by an ambient light sensor in the e-reader solution — to improve overall usability. Although the upcoming 5.7-inch e-reader solution is an impressive increase in size over the 2.6-inch display available in 2009, in the near term (one to two years) it will still be better-suited to the small- to midsize-display market.

- The Pixtronix solution combines the sequencing of microshutters and LEDs, as a backlight, to modulate the light. The technology claims lower power consumption and greater brightness, contrast, ambient viewability, and color depth for stills and video than traditional LCDs, partly because the liquid crystals, filters and polarizers are replaced with MEMS shutters. As of 2Q11, the company has developed small- and midsize-form-factor prototypes with Hitachi Displays, Chimei Innolux and Samsung Electronics. Commercial production is expected in 2013.

- UniPixel's solution uses LEDs mounted on the edge of panel glass as a light source. The solution uses total internal reflection and time multiplexing of shutters to modulate the light (and eliminates the backlight, polarizers and filters), using the panel glass as a light guide. UniPixel's solution also outperforms current handset display solutions in terms of power consumption and image quality. The company does not currently have a commercially available solution.

***User Advice:*** Consumer electronics vendors should implement these solutions only if doing so improves the cost structure of devices. This is especially true for lower-end devices targeted at developing markets. As a low-power solution, this is applicable for handset vendors as a green solution, for developing markets (where access to electricity is limited), and as a solution to extend battery life (still a key concern for consumers). Furthermore, depending on the solution used, it can also provide a higher-performance display than traditional LCDs. Consumer electronics vendors can also consider applications beyond the main screens on mobile phones,

such as "status" screens found on consumer electronics products, on accessories such as headsets, or on secondary displays on phones.

***Business Impact:*** MEMS displays in connected portable devices are expected to be a more-energy-efficient display technology than current LCD screens and decrease costs (as they scale). This technology currently lacks scale (and requires infrastructure investment), so the benefits are offset by the added price. Moreover, it is in its early stages, with a limited number of commercially available products. With the only commercially available MEMS display solutions, Qualcomm is best-positioned for current adoption of these technology offerings. Its superior performance over the current e-reader solutions makes it a viable solution for vendors to implement. Adoption is further affected by its ability to meet demand. Qualcomm hopes to address supply issues with its planned (2012) Taiwan fabrication plant. Although the display quality and power consumption efficiency of the solutions of UniPixel and Pixtronix exceed those of current LCD technology, current lack of commercial solutions brings their market viability into question.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Pixtronix; Qualcomm; Texas Instruments; UniPixel

***Recommended Reading:*** "Emerging Technology Analysis: MEMS Displays Cut Mobile Device Power Consumption"

## Glonass

***Analysis By:*** Annette Zimmermann

***Definition:*** Glonass is a global satellite positioning system run by the Russian Ministry of Defence. It runs parallel to the U.S. GPS system and the planned Galileo system in Europe, and its signals can be reached by any user of a Glonass receiver globally (once all satellites are available).

***Position and Adoption Speed Justification:*** The initial development of Glonass goes back about four decades, and the system officially began operations in 1993. During the past few years, the Russian government has invested in the modernization of the system. In December 2010, three new satellites were to be added to achieve global coverage; however, due to a calculation error the mission failed. Nevertheless, the Russian government is said to be investing 1.4 billion euros in Glonass over the next decade, and global functioning of the system is now expected by the end of 2011. Currently, the system covers 100% of Russian territory and 98% of worldwide territories.

There are only a few vendors currently supporting this technology. Mobile operator MTS started selling Russia's first Glonass- and GPS-enabled cellular phone in May 2011, the MTS Glonass 945 — an Android-based device manufactured by ZTE. The Glonass/GPS chipset is developed by Qualcomm. MTS is using the hype surrounding this new technology to promote its location-based services (LBSs); the device features the MTS Navigator and the MTS Locator, for example. MTS states that it currently has around 1.2 million active LBS subscribers in its network, and the number continues to grow steadily. Another semiconductor vendor known for its GPS chipsets, u-blox, announced its first GPS/Glonass chipset during 2Q11, and first devices should be on the market during 2H11. Most recently, operator SkyLink introduced the Xpad, an Android-based 7-inch media tablet that is GPS/Glonass-enabled.

For the consumer, the main advantage of a Glonass/GPS combination in a handset is the increased performance — due to the availability of twice as many satellites. However, the main drawback (which has also persisted for GPS during the past few years) — severe battery drain — needs to be monitored by chipset and device vendors.

The Russian Government has a lot of interest in spurring adoption of the technology and the Ministry for Transportation has announced that, in future, vehicles need to be equipped with navigation units that support Glonass. Moreover, the government has been debating, during the past year, whether to impose the requirement for device vendors to integrate Glonass chipsets into all phones to be sold on the Russian market.

***User Advice:*** Monitor the developments in Russian legislation, because the requirements for devices to be sold on the Russian market could experience a drastic change.

***Business Impact:*** The two debates regarding the requirements for vehicle and device manufacturers (mentioned above) have strong implications for the automotive and handset industries. Depending on the outcome of these discussions, mobile device vendors could be forced to integrate Glonass chipsets across their product portfolio, and vendors who fail to do so could find themselves excluded from one of the largest device markets in Europe.

Another short-term consequence could be the rise of the black market in Russia.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Qualcomm; U-blox; ZTE

***Recommended Reading:*** "Cool Vendors in Consumer Mobile Services, 2011"

"Cool Vendors in Consumer Applications, 2011"

"Cool Vendors in Context-Aware Computing, 2011"

## HD Voice

***Analysis By:*** Anshul Gupta; Neha Gupta

***Definition:*** High-definition (HD) voice is also known as wideband voice. Compared to traditional telephony voice over public switched telephone networks (PSTNs) and cellular, HD voice uses double the sampling rate, reproducing a much larger sound frequency and delivering all, or most, of the frequencies of a user's voice. HD voice's major advantage is the ability to communicate with clearer audio and have improved and more intelligible conversations over fixed line, cellular networks and voice over Internet Protocol (VoIP).

***Position and Adoption Speed Justification:*** HD voice makes significant voice quality improvements over traditional telephony and enables an improved user experience. That is, listeners can clearly differentiate between similar sounding words or the speaker can be heard clearly, even when in a noisy environment.

HD voice quality over telephony conversation would require both HD-capable networks along with compatible devices. HD VoIP has been around since 2006 along with HD-capable IP telephone devices. Most large organizations have moved or are moving to IP telephony systems and most new IP phones come with G.722, the baseline HD voice codec for desk phones, built in.

HD voice can be implemented in cellular networks and currently supports Global System for Mobile Communications (GSM), wideband code division multiple access (WCDMA)/Universal Mobile Telecommunications System (UMTS) and LTE networks. HD voice over cellular networks is yet to come to the mainstream. Orange Moldova was among the first cellular providers to launch an HD voice-capable network in 2009, with HD-capable mobile devices. As of April 2011, HD voice services were available on 16 cellular networks across 15 markets worldwide — according to the Global mobile Suppliers Association (GSA). Telstra Australia launched the world's largest HD-capable network in June 2011. Similar to cellular networks, HD-capable mobile devices are not yet a mainstream technology. Ericsson has successfully demonstrated HD voice on CDMA technology, but HD voice over CDMA networks is yet to be commercially launched.

HD voice will help communications service providers (CSPs) to differentiate their offerings and provide high-quality services to voice-dependent businesses like call center services, information services, emergency services and so on. HD voice is also ideal for conference calls and can contribute to a reduction in business travel and improvement in productivity, while reducing the environmental impact. HD voice also helps people hear better in noisy environments. In future, HD voice will allow voice recognition systems to understand a larger vocabulary of words and become an integral part of real-time communication language translation. HD voice will also reduce bandwidth requirements, as it requires a bandwidth of just 32 kbps instead of the 64 kbps required for traditional voice.

Mass deployment of mass HD voice is still many years away. The greatest commercial hurdle is that the handsets and networks will have to be upgraded to deliver HD voice, which will require significant investment without any return as the service providers will not be able to charge extra. Rather, they will only be able to use it to differentiate themselves from competitors. And as more providers offer it, the less it will differentiate.

***User Advice:*** CSPs should ensure HD voice fits into their service plan, as it will add to the cost of infrastructure and devices. HD-enabled mobile devices, cordless phones and headsets will come at a premium and this additional cost should be factored in when deploying HD voice solutions. GSA indicates that as of April 2011 there were approximately 45 HD-capable mobile devices selling in the market; however, they were all high-end devices. Some HD-capable devices include: Nokia's C7 and N8; Sony Ericsson's Xperia Mini, Acro and Play, Samsung's Galaxy Ace and Pro B7350; HTC's Desire HD; and LG's A310. CSPs can include HD voice in premium packages together with higher quality of service to entice high-end consumers and enterprise users. CSPs can also conduct studies for enterprise users to assess demand. Consumer VoIP has been sold as a cheaper alternative to PSTN lines and with HD voice, it will become a premium service. In the consumer market, the home gateway will work with cordless phones to provide an HD voice experience. Equally, in the future, the gateway can be the central voice processing hub for man-machine voice interfaces.

***Business Impact:*** The early benefits of HD voice can be enjoyed in a closed environment where the technology can be controlled; for example, teleconferencing, Web conferencing, dedicated call center services, emergency services and consumer telepresence. Consumer telepresence is about feeling that you are effectively with the person you are communicating with; HD voice will provide the audio component. Next, as fixed-line carriers move their PSTN networks to a broadband VoIP environment, they will start to consider implementing HD voice as a premium product. Mobile operators in a fourth-generation environment will quickly follow suit and form a very similar perspective.

The greatest benefit from HD voice will be longer in coming and will be in HD voice's contribution in the area of real-time communication language translation, which could aid globalization.

HD voice's greatest benefit in the home will be its contribution to using voice as a man-machine interface.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Cisco; Ericsson; Nokia; Polycom; Texas Instruments

## Mobile High-Definition Link

***Analysis By:*** Jon Erensen

***Definition:*** Mobile High-Definition Link (MHL) is a mobile audio/video interface standard for directly connecting mobile phones, digital still cameras, digital camcorders and other portable consumer electronics devices to high-definition TVs (HDTVs) and displays. It is a five-pin, low-power interface capable of 1080p quality and supporting high-bandwidth digital content protection (HDCP), High-Definition Multimedia Interface (HDMI). Consumer Electronic Control (CEC), and digital audio. It allows for a single cable to connect to the display and, at the same time, provide power for the mobile device. MHL can be converted to HDMI-compliant signals for connection to a digital TV using an active cable or dock with a conversion chip. MHL can utilize established connectors — including mini-USB — that are currently found in many mobile phones and portable consumer electronics products. Using existing connectors is cost-effective, saves space for small form factors, and allows consumers to get more functionality from a single connector.

***Position and Adoption Speed Justification:*** The technology behind MHL was developed by Silicon Image. Silicon Image was also the leading company behind HDMI, which has become the standard interface for connecting HD audio/video components in the home. The HDMI connector was too large for small form factor mobile devices, and so MHL was developed as an alternative that would still be compatible with the installed base of devices with HDMI connections. Products with MHL were originally expected to be on the market in 2009, but that was delayed to the second half of 2010, and then delayed again to the first half of 2011. The first product shipping with MHL, the Samsung Galaxy S II smartphone was announced at Mobile World Congress in February 2011 and has begun shipping.

Silicon Image, along with Nokia, Samsung, Toshiba and Sony formed the MHL Consortium in April 2010, and they released the 1.0 specification in June 2010. MHL initially will be found on high-end media-centric smartphones, portable media players, and digital still cameras/camcorders before spreading to midrange devices. As more HD content is stored on portable consumer electronics and smartphones, MHL represents a simple way to display this content on a larger screen. Some companies have tried to use wireless technologies, mostly Wi-Fi, to display content stored on a mobile device on a larger display, but the quality, ease of setup and the lack of a standard to perform this task will slow adoption. This is expected to change with Wi-Fi Direct and proprietary implementations, including Apple's AirPlay.

In the interim, MHL has an opportunity to become a wired option for connecting mobile devices to HD displays. The main competition for MHL will come from mini-HDMI, which has become the standard wired connection, although it requires a larger, separate connection and is not designed to provide power. However, in order to be powered, the phone will need an MHL connection, and there are currently no displays or docks with embedded MHL connections, although this should change as such products are introduced in the next year. The repeated delays in introducing MHL-equipped devices has put the success of the standard in jeopardy, especially as mini-HDMI has gained more traction.

***User Advice:*** Device manufacturers should closely follow the MHL Consortium's progress in creating the MHL standard and be prepared to use this as a simple, wired connection for media-centric portable devices. It will be important before wireless standards are set; and even when they are, MHL will still complement wireless solutions.

***Business Impact:*** The impact of widespread MHL adoption is that users will be able to rely on their smartphone in more situations and not need to travel with heavier notebook PCs. Consumers will be able to share content stored and captured on their mobile phone on larger displays.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Nokia; Samsung Electronics; Silicon Image; Sony; Toshiba

# At the Peak

## Wi-Fi Personal-Area Networks

***Analysis By:*** Van L. Baker

***Definition:*** Wi-Fi personal-area networks (PANs) are highly localized networks implemented via Wi-Fi technology to facilitate the synchronization of personal content between multiple devices, and the discovery of devices and services available to users via their PCs and personal devices. The Wi-Fi PAN will accommodate the synchronization of content across a range of devices, including smartphones, connected media players, set-top boxes and personal computers. Additionally, the technology will facilitate peripheral connections for PCs and handheld devices. Initial implementations were done via Bluetooth, but the Wi-Fi implementation should gain traction as Wi-Fi proliferates among consumer electronics manufacturers.

***Position and Adoption Speed Justification:*** As the use of multiple personal electronic devices grows in the consumer market, manufacturers of these devices need to facilitate the updating and sharing of content between devices, as well as the delivery of services to these devices. Additionally, the proliferation of Wi-Fi in consumer homes has become the norm. We initially expected the market to consolidate on a Wi-Fi implementation of PAN technology by 2012; however, the technology has been slower to take hold than we anticipated, partially due to Apple's continued use of cables for synchronization. As a result, we now believe that the maturity of this technology will take some time. Additionally, device manufacturers and media owners continue to be far from agreement on content portability standards, further delaying easy synchronization of content across devices. While Wi-Fi personal-area networking will gain traction in the market, it will not completely displace Bluetooth technology, where power must be kept to a minimum. In devices where Wi-Fi is already present, it is likely that Wi-Fi PANs will be implemented at the expense of Bluetooth. The addition of cloud-based synchronization services will add to the appeal of this technology.

***User Advice:*** Consumer electronics, personal computer and networking equipment manufacturers should monitor the development of Wi-Fi-based PAN technologies and standards and should move to incorporate these into future products if and when the technology begins to gain additional momentum. If this has not happened within the next two years, the technology may fade. Any consumer electronics manufacturer that incorporates Wi-Fi connectivity into its products should consider support for Wi-Fi-based PANs, assuming the technology gains

momentum. Use of the technology in conjunction with cloud-based synchronization should help create consumer appeal in mature markets.

***Business Impact:*** Wi-Fi PAN technologies will affect personal computers, consumer electronics and peripheral devices, as well as networking equipment manufacturers. Wi-Fi PANs should also simplify synchronization between devices, resulting in an increased demand for content, especially when combined with cloud-based services.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Dell; HP; Nokia; Samsung; Sony

## Haptics

***Analysis By:*** Jackie Fenn; Tuong Huy Nguyen

***Definition:*** Haptics is the use of tactile interfaces (for example, vibration or pressure) to provide touch or force feedback as part of the user interface.

***Position and Adoption Speed Justification:*** Tactile haptic feedback on mobile handsets has been around for a while and is mainly used to complement ring tones. Adoption into other applications stagnated until the recent trend in touchscreen displays. The growing popularity of touchscreen displays in mobile phones has led handset vendors to implement haptic feedback on touch devices to further improve usability to remain competitive. Haptics in mobile devices is much further along the Hype Cycle than other applications. Although it is currently nearing the plateau, we expect it to remain in this position for two to five years — until subsequent developments advance functionality beyond a tactile feedback for enhancing the touch experience. Motorless solutions from vendors such as Pacinian and Senseg will add more immersive dimensions to tactile feedback, while minimizing power consumption — helping advance the technology into the Plateau of Productivity.

On the higher end of the market, there are force-feedback solutions that provide a more realistic touch experience. Adoption is primarily in vertical-specific uses in the medical, surgical and dental fields, design, sculpting, computer-aided design (CAD)/computer-aided manufacturing (CAM), and training/simulation. Although the technology is available, we have not seen significant movement since 2010. We do not expect to see mass adoption of force feedback in connected consumer electronics devices during the next five years. Broader interest and adoption by enterprises as a general-purpose user interface technology (for example, to speed item selection by providing tactile feedback when an icon is selected) will depend on seamless and simple inclusion in standard interface components (such as touch pads, mice or 3D gesture controllers).

Lower-end applications include entertainment and gaming, where the use of haptic feedback in joysticks is well-established. The automotive industry continues to explore the use of haptics for driver information management applications that go beyond traditional means of communication in a vehicle (for example, visual and audible alerts).

***User Advice:*** All connected consumer electronics devices that integrate a touchscreen interface need to have some degree of haptic feedback. Devices lacking this will be put at a severe competitive disadvantage.

Enterprises aiming to improve the design process for 3D modeling and simulation applications should evaluate today's haptic devices. In most other cases, users should wait until the technology is embedded in mainstream devices.

***Business Impact:*** Haptic feedback offers potential improvements in speed and quality for 3D design and teleoperations, as well as an improved user experience in gaming, virtual world, training and simulation environments.

The growing trend in touchscreen phones has spurred demand for tactile haptic feedback on devices. Haptic feedback greatly enhances the user experience for touchscreen devices by providing a tactile response to acknowledge user actions.

***Benefit Rating:*** Low

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Force Dimension; Haption; Immersion; Moog; Novint Technologies; Pacinian; Sensable Technologies; Senseg

## Smartphone Hypervisors

***Analysis By:*** Monica Basso

***Definition:*** Smartphone hypervisors are thin layers of virtualization software running directly on smartphone hardware that define one or more processing environments. Initially, they are being used to reduce the number of discrete processors by defining multiple virtual processors on a single, physical die. As the technology evolves, it will be used to improve the standardization, manageability and security of the application environment.

***Position and Adoption Speed Justification:*** Business drivers for the adoption of hypervisor technology in smartphones include:

- Improves the time to market for new products and contains costs — for handset manufacturers.
- Addresses the security challenges posed to networks by an increasing number of intelligent mobile devices and third-party applications — for mobile operators.
- Exploits new capabilities offered by cloud computing on mobile devices — for service providers, in general.
- Enforces IT security and management policies on personal-owned devices — for enterprises.
- Enables cross-platform application portability (e.g., .NET applications to Android devices) — for enterprises.

Smartphone hypervisors appeared in 2006, and first shipped in production smartphone models from HTC and Toshiba in late 2007. Development efforts increased significantly during 2007 and 2008, resulting in heightened interest from smartphone vendors and suppliers of smartphone microprocessors. VMware's acquisition of Trango Virtual Processors (November 2008), and Citrix Systems' investments and partnership with Open Kernel Labs (January 2009), validate market interest. Market developments started in 2010, with ARM's new Cortex-A class microprocessor designs that have TrustZone, a standard mechanism to enforce hardware virtualization that can be exploited to create separate virtual machines to make applications more trustable. Due to the

presence of ARM's TrustZone capabilities, more than 50% of smartphones shipped during 2010 had hardware virtualization features. By the end of 2012, this figure will rise to 90%. By 2013, all smartphone OSs will introduce support for virtualization functions and the potential standardization, manageability and security benefits of hypervisors. Hypervisors will help drive standardization for each OS, but are unlikely to improve interoperability among different OSs.

One issue is the processing overhead imposed on the application environment, which is already performance-constrained. Improvements in processing capability and the gradual integration of virtualization technology into smartphone processors will make hypervisor functions more appealing.

***User Advice:*** Monitor developments in smartphone processors for signs of when and how virtualization technology will be added to smartphones and other mobile devices. Once smartphones with hardware-assisted virtualization capabilities appear in the market, plan for the approach to become mainstream within two years.

***Business Impact:*** Smartphone hypervisors will not deliver improvements in the manageability and security of smartphones until smartphone OS vendors also embrace and fully support them, which is unlikely to occur before 2013. Through 2012, continue to pursue established management and security initiatives.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** ARM; Open Kernel Labs; VirtualLogix; VMware

***Recommended Reading:*** "Smartphone Virtualization: Making Mobile Applications More Trustable"

"The Emerging Market for Smartphone Hypervisors"

"Cost Reduction Drive Will Bring Hardware Virtualization to Smartphones"

"Virtualization Will Simplify Smartphone Deployment"

## Wireless Power

***Analysis By:*** Jim Tully; Steve Ohr

***Definition:*** A wireless power supply facilitates the charging or direct powering of electrical and electronic equipment using inductive or radio frequency (RF) energy transfer. Inductive systems are preferred for short-range wireless power transfer (a few centimeters) and can provide very high levels of power of several thousand watts or more. Some electric trams and trains utilize this form of power transfer.

RF power transfer operates over longer distances (tens or hundreds of meters or more) and provides more modest levels of power (a few milliwatts or less). Therefore, inductive systems are more suited for PCs and the fast charging of mobile devices, while RF power is more applicable to remote sensor networks and trickle-charging of mobile phones. A combination of induction and RF is used in Near Field Communication (NFC), used for medium/short range (typically up to around 20 cm), but is dependent on the frequency used. The NFC Forum has specified a version of the technology that operates at 13.56 MHz with an operating distance up to about 4 cm.

In its most basic forms, inductive power has been in use for many years — for example, in electric toothbrushes. The focus now is on more flexible, efficient and addressable forms of the technology using resonance techniques. Most users of mobile electronic devices find battery charging to be a real annoyance. It is inconvenient and different chargers are required for different types of equipment.

The idea of wireless charging is clearly attractive and several solutions have recently been demonstrated. For example, wireless charging schemes are being designed for use in tabletop surfaces and similar environments that will charge a mobile device when it is placed onto the surface.

***Position and Adoption Speed Justification:*** Adoption of the technology for mobile devices or PCs requires a degree of standardization. The Wireless Power Consortium is addressing this issue and considerable progress is being made. A bigger obstacle is the question of why mobile equipment makers (such as handset vendors) should be interested in this technology.

Mobile phone makers have recently agreed a set of standards for chargers and this could set back the aspirations of wireless power vendors in this area. Much prominent discussion continues about this technology and we receive many requests from clients for information. Therefore, we have advanced the technology slightly along the Hype Cycle this year.

***User Advice:*** Technology planners in organizations with many users of mobile devices should evaluate the benefits of this technology as it becomes available. Vendors of mobile devices, batteries and power infrastructure (such as chargers) should evaluate the alternatives and decide on their position in relation to this technology. Users should investigate this if they need small levels of "trickle" charging for equipment where it is difficult or impossible to connect a physical supply — for example, sensor networks and Bluetooth low-energy devices.

***Business Impact:*** The technology is applicable to a wide range of business and consumer situations. Some environments require mobile devices to be charged at all times and wireless charging is particularly suited to these situations. It also offers advantages of less clutter and reduced e-waste of old chargers. Efficiency is somewhat lower than wired power and this will need to be factored into any decision.

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Fulton Innovation; MIT; Nokia; Powercast

## Augmented Reality

***Analysis By:*** CK Lu; Tuong Huy Nguyen

***Definition:*** Augmented reality (AR) is a technology that superimposes graphics, audio and other virtual enhancements on a live view of the real world. It is this "real world" element that differentiates AR from virtual reality. AR aims to enhance users' interaction with the environment, rather than separating them from it. The term has existed since the early 1990s, when it originated in aerospace manufacturing.

***Position and Adoption Speed Justification:*** The maturity of a number of mobile technologies — such as GPS, digital cameras, accelerometers, digital compasses, broadband, image processing and face/object recognition software — has made AR a viable technology on mobile devices. As all these technologies converge in maturity, AR has also benefited from a growing

number of open OSs (promoting native development), the increasing popularity of application stores (increasing awareness and availability of applications), and the rising availability of overlay data such as databases, online maps and Wikipedia. The combination of these features and technologies also allows AR to be used in a number of different applications, including enhancing user interfaces (UIs), providing consumers with information and education, offering potential for marketing and advertising, and augmenting games and entertainment applications. We also believe that AR will play a role in mobile contextual interactions, and will be particularly powerful for:

- Exploration — Finding things in the vicinity.
- Suggestion — Indicating real-world objects of interest.
- Direction — Indicating where a user should go.

In 2010, AR had reached the peak of its hype, as many vendors exploited this technology to differentiate their products — both services and hardware. For example, AR browser vendor Layar boasts more than 700,000 active users. The vendor is working with LG (to preload its application on new Android devices) and Samsung (to be supported on bada). This year, we observed that the hype surrounding AR has slowed down. Nevertheless, its uses are still being explored. Panasonic provides the Viera AR Setup Simulator (as a promotional tool) to help the consumer feel how their TV will fit into a room. World Lens developed an AR translation application allowing users to translate one language to another; for example, by pointing a camera at a traffic sign. Nintendo 3DS also uses AR as a differentiator to enrich gaming experiences on its 3D display.

Despite the hype and potential, a number of factors will slow adoption of AR:

- Device requirements for AR in mobile devices are rigorous; so, although mobile services provide a great use case for this technology, it will be restricted to higher-end devices. Mobile devices have smaller screens than other consumer electronics devices such as laptops and even handheld gaming consoles, restricting the information that can be conveyed to the end user. The interface (a small handheld device that needs to be held in front of you) limits usage to bursts, rather than continued interaction with the real world. GPS technology also lacks the precision to provide perfect location data, but can be enhanced by hardware such as accelerometers, gyroscopes or magnetometers.
- As with other location-based services (LBSs), privacy is a potential concern and a hindrance to adoption.
- As a newer solution, there are also issues with compatibility: competing AR browsers are using proprietary APIs and data structure, making the AR information from one vendor's browser incompatible with that from other browsers.

***User Advice:***

- **Communications service providers (CSPs):** Examine whether AR would enhance the user experience of your existing services. Compile a list of AR developers with which you could partner, rather than building your own AR from the ground up. Provide end-to-end professional services for specific vertical markets, including schools, healthcare institutions and real-estate agencies, in which AR could offer significant value. A controlled hardware and software stack from database to device will ensure a quality user experience for these groups. Educate consumers about the impact of AR on their bandwidth, to avoid being blamed for users going over their data allowance.

- **Mobile device manufacturers:** Recognize that AR provides an innovative interface for your mobile devices. Open discussions with developers about the possibility of preinstalling application clients on your devices, and document how developers can access device features. Build up alliances with AR database owners and game developers to provide exclusive AR applications and services for your devices. Secure preloading agreements and examine how you could integrate AR into your UIs or OSs.
- **AR developers:** Take a close look at whether your business model is sustainable, and consider working with CSPs or device manufacturers to expand your user base; perhaps by offering white-label versions of your products. Integrate AR with existing tools, such as browsers or maps, to provide an uninterrupted user experience. Build up your own databases to provide exclusive services through AR applications. Extend your AR application as a platform that individual users and third-party providers can use to create their own content. Explore how to apply AR, through different applications and services, to improve the user experience — with the aim of predicting what information users need in different contexts.
- **Providers of search engines and other Web services:** Get into AR as an extension of your search business. AR is a natural way to display search results in many contexts.
- **Mapping vendors:** Add AR to your 3D map visualizations.
- **Early adopters:** Examine how AR can bring value to your organization and your customers by offering branded information overlays. For workers who are mobile (including factory, warehousing, maintenance, emergency response, queue-busting or medical staff), identify how AR could deliver context-specific information at the point of need or decision.

***Business Impact:*** AR browsers and applications will be the focus of innovation and differentiation for players in the mobile device market in 2011. There are interesting branding opportunities for companies and businesses. Points of interest can be branded with a "favicon" (that is, a favorites or website icon) that appears when the point of interest is selected. Companies such as Mobilizy are offering white-label solutions that allow core Wikitude functionality to be customized. AR products such as Wikitude can lead to numerous LBS advertising opportunities.

CSPs and their brand partners can leverage AR's ability to enhance the user experience within their LBS offerings. This can provide revenue via set charges, recurring subscription fees or advertising. Handset vendors can incorporate AR to enhance UIs, and use it as a competitive differentiator in their device portfolio. The growing popularity of AR opens up a market opportunity for application developers, Web service providers and mapping vendors to provide value and content to partners in the value chain, as well as an opportunity for CSPs, handset vendors, brands and advertisers.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** GeoVector; Google; Layar; Mobilizy; Tonchidot

***Recommended Reading:*** "Emerging Technology Analysis: Augmented Reality Shows What Mobile Devices Can Do"

"Contextual Smartphone Applications Will Exploit Augmented Reality"

## NFC

***Analysis By:*** Mark Hung

***Definition:*** Near Field Communication (NFC) is a wireless technology that enables a variety of contactless and proximity-based applications, such as payments, information retrieval, mobile marketing and device pairing. It has an operating range of 10 cm or less using the 13.56MHz frequency band. There are currently three user modes defined for NFC operation:

- Card emulation
- Tag reading
- Peer-to-peer (P2P)

These modes are based on several ISO/IEC standards, including ISO 14443 A/B, ISO 15693 and ISO 18092. The NFC Forum is the industry group that specifies the use of these standards. It has launched a logo certification program to ensure interoperability between devices from different chipset vendors and equipment manufacturers.

***Position and Adoption Speed Justification:*** For the past decade, NFC has been a technology looking for a solution. Originally intended as the foundation for next-generation payment systems using smart cards, it never caught on due to the lack of a compelling value proposition. As mobile phones became more prevalent globally, Nokia tried to push the technology in this new platform. However, the ROI was still unclear for financial institutions, payment processors, credit card issuers and most importantly, merchants. Nokia itself introduced it on only one feature phone, the 6131.

In November 2010, Google breathed new life into NFC by embedding it into its latest smartphone, the Google Nexus S. This became the first widely available smartphone with built-in NFC. During the next several months, Google enhanced the Android OS to eventually support all three modes specified by the NFC Forum — another first. In the first half of 2011, all the major smartphone OS vendors, with the notable exception of Apple, announced support for NFC by the end of 2011. They include the following:

- Android: Samsung, HTC, LG, ZTE, Huawei
- RIM: BlackBerry Bold
- Symbian: Nokia
- Windows Phone 7: Nokia

By embedding NFC into the smartphone platform, the hardware and software companies hope to move beyond payments and provide the developer community with another tool to foster innovative applications, such as:

- Gaming: Rovio has introduced a version of "Angry Birds" that will allow NFC-enabled phones to unlock unique levels of play.
- Social networking: Poken has pioneered the use of NFC to allow people to exchange not only contact information, but also profiles from various social networking sites, to build out their social network. This network can then be used to share coupons, offers and virtual goods.

- Information retrieval: NFC tags can provide a richer experience at museums by providing the user with more information about the display. Additional use cases include real-time schedule information at transit stops and smart advertising.

- Device pairing: NFC can serve as the setup channel for connecting two devices together, such as a Bluetooth headset with a phone or a wireless printer with a PC.

- Access control: Instead of providing a guest with a key card, a hotel can download the key to the guest's handset at check-in and deactivate it upon check-out.

- Location-based services: Foursquare has started an NFC pilot by installing NFC tags at local merchants to facilitate the check-in process.

Progress has also been made in the NFC payment segment. ISIS, a consortium of mobile carriers in the United States that includes Verizon Wireless, AT&T and T-Mobile, decided to drop its initial plans for forming a new payment network and to instead work cooperatively with the existing financial institutions. Google, on the other hand, introduced the Google Wallet, which has the support of some of the leading players in the mobile payment ecosystem, including Citi, MasterCard, First Data and Sprint. Most notably, Google is not sharing in the transaction fee structure that's been established between the existing players, opting instead to monetize this platform via offers and advertising. The Google Offers product that was introduced with Google Wallet allows users to transfer online coupons onto the wallet to be used in brick-and-mortar stores.

For the next few years, growth of NFC will be primarily in smartphones and the surrounding digital ecosystem devices, such as tablets, PCs, printers and TVs. For NFC to take off in payments, it remains to be seen whether a compelling case can be made for the merchants and the financial ecosystem to invest in the necessary infrastructure.

***User Advice:***

- Electronic equipment manufacturers should examine carefully NFC's possible use cases and determine which of their mobile, computing, communications and consumer electronics devices can benefit from its inclusion.

- Software developers should explore the combination of NFC with a smartphone's other capabilities to bring about innovative applications that can bridge the online and physical worlds.

- Wireless connectivity semiconductor vendors should re-examine their product road map and decide how to offer this capability to their customers, whether it is through a partnership, acquisition or organic development. This will become a checkbox item for connectivity on smartphones within two to three years.

***Business Impact:*** NFC can bring about heretofore unrealized applications by embedding identity into a multifunction computing and communications platform, such as the smartphone. Although this will at first have the most impact at the consumer level, it may eventually have a strong influence on context-aware computing and security control in many different industries and enterprises.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Broadcom; Google; Inside Secure; Nokia; NXP Semiconductors; RIM; Samsung

## Dual Noise Cancellation

***Analysis By:*** Anshul Gupta

***Definition:*** Dual noise cancellation capability helps to:

- Separate background noise at the microphone, so that only the speaker's clear voice enters the communication channel and the person on the other end of the call receives the same clarity of voice.
- Reduce the amount of background noise entering the speaker's ear, by using noise-reduction technology in the headphones.

***Position and Adoption Speed Justification:*** Noise cancellation in headsets and consumer devices is achieved with two microphones: one close to the mouth to pick up higher-intensity human voice, and the other further away to pick up ambient noise. An electronic circuit is then used to separate ambient noise from the mix, so that a pure, refined human voice enters the communication channel.

Such headsets, most commonly hands-free Bluetooth headsets, have been available for use with mobile phones for some years now. Over time, technological improvements have made them very efficient. Headsets are available from vendors such as UmeVoice, Sennheiser and Audio-Technica. We are seeing mobile devices based around touch user interfaces becoming popular. Some users tend to keep their heads away from touch devices, leading to more disturbance and unclear voice at the other end. Noise cancellation using two microphones on the device is a good way to avoid ambient noise getting into the voice channel. Dual microphones are already being directly integrated into mobile devices to achieve active noise cancellation. The Nexus One and the Motorola Droid were among the first devices with dual microphones; however, the technology is now seen in most high-end devices, such as HTC's Touch Pro2 and Nokia's E7 and C7. Dual microphones are now also being deployed in media tablets such as the Dell Streak and Cisco's Cius.

Reducing ambient noise at the listener's end can be achieved by using passive (traditional) methods of reducing the noise entering the ear, by using special material in the earcups, or by designing earbud-type headsets, which mechanically block noise from entering the ear. However, headsets with active noise cancellation using electronic circuits are also available in the market. These types of headsets generate an anti-noise sound wave of opposite polarity to that of the surrounding sound. Such headsets have been on the market for more than a decade. Headsets (available from Sony and Bose) that use traditional or active noise cancellation are commonly used with music players, to allow users to listen to music in a noisy environment, such as a plane or train.

There are few headsets available in the market that uses noise cancellation technology to produce noise-free voice and reduce the noise from the human voice that enters the communication channel. This market is at an early stage, but there are clearly more use cases for such a product. It will enable those in noisy environments to hear, and be heard, properly.

***User Advice:*** Headsets using active noise-reduction methods (with electronic circuits) are effective in reducing low-frequency sounds, but not very effective in reducing inconsistent high-frequency sounds. An additional consideration for headsets using electronic circuits is that they require a battery. This renders them bulky and power-dependent — the absence of a battery will cause the entire unit (not just the noise cancellation element) to shut down completely.

Headsets using passive (traditional) noise-reduction methods are effective for reducing high-frequency inconsistent sound, but their prolonged use (especially earbud-type headsets) could cause discomfort.

Noise-cancelling, microphone-enabled headsets are very useful when the user is in a noisy environment. Callers can keep a conversation relatively private by speaking quietly, while the person on the other end can still hear clearly. These headsets are premium products priced at approximately $100, but they enhance the user experience greatly. Bluetooth headsets with dual noise cancellation are available at the lower price of about $40 (the Motorola H17, for example).

Dual noise cancellation technology would be very useful for users in noisy environments (such as call center workers and airport ground staff), as well as in public places, or at events, conferences or shows.

***Business Impact:*** The impact of this technology is limited to users who are constantly on the move, or those based in noisy environments who spend most of their time on the phone. Products with dual noise cancellation will allow them to:

- Get improved voice quality on mobile devices.
- Speak quietly in noisy environments, allowing them to keep their conversations private, yet still be heard clearly.
- Hear the other speaker properly.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Audience; Cisco; Dell; Motorola; Nokia; Plantronics

## MEMS Gyroscopes

***Analysis By:*** Tuong Huy Nguyen

***Definition:*** A gyroscope is a device to measure rotation (pitch, roll and yaw) in a three-dimensional space. Micro-electromechanical systems (MEMS) gyroscopes leverage the original idea of the technology, and have adapted it to a much smaller scale using MEMS as the driving mass.

***Position and Adoption Speed Justification:*** The use of MEMS gyroscopes is growing. When used with accelerometers, gyroscopes provide enhanced spatial precision data for numerous applications — improving the user experience. They can also be used as an alternative to a multiple accelerometer solution, or accelerometer and magnetometer solution.

Initial adoption will be in higher-end devices with accelerometers. Demand for more accurate location, enhanced interactive experiences, and improved functionality and usability will drive growth in MEMS gyroscopes. Growth will also be driven by benefits across numerous applications, such as GPS, location, navigation, safety, healthcare, gaming and imaging. They are already being used in numerous consumer electronics devices (such as the Nintendo Wii Motion Plus controller, remote-controlled helicopters, digital cameras and camcorders). The iPhone 4 was the first mobile phone with a MEMS gyroscope. As predicted, the debut has spurred a trend in phones and tablets that we expect to continue. Some of the more notable, current devices with gyroscopes include iPad 2, Motorola Xoom, Samsung Galaxy SII and LG Optimus Black. Further advances in the technology, such as smaller footprint, and integrated

motion processing solutions with multiple-axis gyroscopes, will make this feature increasingly available across consumer electronics devices.

Despite the benefits, a number of factors potentially hinder uptake for MEMS gyroscopes in consumer electronics devices. Cost remains an issue. MEMS gyroscopes add roughly $1 per axis to the bill of materials; which is significant for more price-sensitive applications, such as mobile phones. Similarly, power consumption is also an issue. Although companies such as STMicroelectronics have developed solutions that make the impact practically negligible, the gyroscope still taxes battery life in devices (higher-end) that are already pushing the limits of power maximization. Furthermore, there are already alternative solutions, such as multiple accelerometer and accelerometer plus magnetometer solutions that can provide similar benefits.

***User Advice:*** Handset vendors should use this technology as a competitive differentiator for their higher-end devices, especially those targeting specific market applications, such as GPS and navigation, imaging, health and fitness, and gaming. Vendors can also leverage the gyroscope to improve user interfaces. Similar advice can be applied to consumer electronics vendors that want to include MEMS gyroscopes in their devices. Enterprises and verticals such as healthcare should evaluate the benefits of improved accuracy from MEMS gyroscope-enabled devices; and compare them to current as well as alternative solutions (as MEMS gyroscopes will be limited to the high end in the next two years). For less cost- and power-sensitive markets, earlier implementation will be more viable.

Communications service providers (CSPs) and application developers should work together to provide optimized content and services to gyroscope-enabled devices.

***Business Impact:*** MEMS gyroscopes will provide a higher level of accuracy because of the additional data they obtain. Consumer benefits, such as improved user interfaces, a more immersive gaming experience, higher image quality and more accurate navigation and location, can be leveraged by CSPs, handset vendors and application developers. Improved accuracy can also be leveraged by enterprises for uses such as fleet management and navigation, as well as vertical industries such as medical for healthcare monitoring. In both segments, the gyroscope can be a valuable competitive differentiator.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Analog Devices; InvenSense; STMicroelectronics

***Recommended Reading:*** "Emerging Technology Analysis: MEMS Gyroscopes Provide Numerous Enhancements to Mobile Devices"

"Emerging Technology Analysis: Augmented Reality Shows What Mobile Devices Can Do"

"Competitive Landscape: Portable Navigation Devices, 2010"

"Forecast: Consumer Location-Based Services, Worldwide 2008-2014"

"Competitive Landscape: Nonoptical Semiconductor Sensors"

## Bluetooth 4.0

***Analysis By:*** Mark Hung

***Definition:*** Bluetooth 4.0 (BT4.0) is the follow-on standard to Bluetooth 3.0 that was introduced by the Bluetooth Special Interest Group (BT-SIG) in June 2010. It includes three specifications in one single standard:

- Classic Bluetooth: Bluetooth 2.1 + EDR.
- Bluetooth High Speed (HS): Bluetooth 3.0 + HS.
- Bluetooth Low Energy (LE): This is the new technology that is introduced in BT4.0.

With BT4.0, a certified device has the flexibility to pick one or more of the technologies to be considered BT4.0-compliant. For example, a sensor can adopt only the LE technology to conserve power, while a portable device can choose to implement both LE and Classic. Expect support for devices in the areas of sports and wellness, healthcare, human interface devices (e.g., computer mice) and entertainment devices. This technology can be integrated into watches, wireless keyboards, and gaming and sports sensors.

***Position and Adoption Speed Justification:*** The Bluetooth 4.0 specification was adopted in June 2010. More and more peripheral devices are emerging that need low-bandwidth, long-lasting connectivity to other host devices. Wibree was initially designed to accomplish this purpose; however, it conflicted with the long-term goals of Bluetooth, so it smartly merged its standardization efforts with the BT-SIG. With this standard, we expect enabled devices to last as long as two years without recharging. We also expect this standard to be widely popular and to quickly increase its penetration into a wide array of devices during the next five years. Bluetooth 4.0 is being incorporated into Bluetooth chips today, including CSR's BlueCore7000 and Broadcom's latest combo chip.

***User Advice:*** Bluetooth low-energy wireless will likely be a low-cost, mature and secure technology that can be used to eliminate cabling for peripherals. Vendors of many more products can now make the Internet part of their bill of materials.

***Business Impact:*** More and more devices will move from stand-alone to Internet-connected, enabling many more products to move from static states to dynamic states. Problem corrections and functionality updates will be made available more quickly.

***Benefit Rating:*** High

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Broadcom; CSR; Marvell Semiconductors; Qualcomm Atheros; Texas Instruments

## Pico Projectors

***Analysis By:*** Amy Teng; Nick Jones

***Definition:*** Pico projectors are very small projector modules that can be integrated into mobile devices, such as handsets or laptops or used to create highly-portable projector accessories for mobile workers. They can be implemented using several technologies including liquid crystal on silicon imaging chips with light-emitting diode or laser diode illumination, micro-electromechanical systems digital light processing technology or laser diffraction.

A small pico projector module in 2011 has a volume of 3 cc to 5 cc, making integration in personal devices (such as handsets) more practical. Challenges include low brightness, poor resolution and power consumption in battery-powered devices, cost (around $20 to $80 as a

component, depending on specification and technology), heat dissipation and usability. Future devices are likely to include features like keystone correction to facilitate use cases, such as table-top projection.

Laptop and media tablet use of this technology will require pico projectors with sufficient resolution to compete with their main screens, combined with innovative mechanical design.

***Position and Adoption Speed Justification:*** First-generation pico projector modules small enough to embed in mobile phones started to emerge in 2009 (a laptop using a pico projector was demonstrated in 2008). Some technologies, such as laser diffraction, have been impeded by the poor availability of key components such as green laser diodes.

We believe that smaller, second-generation components with better performance and power consumption will be required for large-scale adoption and all pico projection technologies will continue to evolve for several years. The user demand for built-in pico projectors in personal devices, such as mobile phones, laptops and tablet devices is low at this time and will take several years to establish.

***User Advice:*** We don't believe users will accept the compromises in terms of size, price, portability and battery life required for a pico projector built in to a mobile phone, so the likely short-term application is as an accessory for traveling workers. Built-in pico projectors, especially those using technologies such as laser diffraction (which doesn't require focusing), may be attractive for sales staff with a very short face-to-face time with key prospects, who want to display images or videos briefly on any available surface.

***Business Impact:*** Handset and laptop vendors should consider offering pico projectors as accessories and handset vendors with large portfolios should consider pico projectors in high-end business smartphones. Corporations with sales staff who have very short periods of face-to-face time with key prospects, should consider them as sales support tools.

Laptop and tablet vendors that want to create innovative form factors could explore pico projectors as alternatives to conventional displays beyond integrating them. In the longer term, pico projectors that work with image sensors may enable new gesture recognition technology (for example, sixth-sense technology).

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** 3M; Asia Optics; Himax Display; Light Blue Optics; Micron; Microvision; Texas Instruments; Young Optics

***Recommended Reading:*** "Emerging Technology Analysis: Pico Projectors, PC Technologies"

"Dataquest Insight: Teardown and Cost Analysis of Samsung's SPH-W7900 Projector Phone"

"Cool Vendors in Imaging and Display Devices, 2010"

"Dataquest Insight: Teardown and Cost Analysis of Lanye's N70 Projector Phone"

## Solar Power Mobile Devices

***Analysis By:*** Annette Zimmermann; Alfonso Velosa

***Definition:*** A phone equipped with solar cells that converts sunlight into electrical power, reducing or removing the need to charge the device from an electrical power source.

***Position and Adoption Speed Justification:*** The idea of solar-powered mobile devices has been around for some years, but has never seen any significant uptake. Solar-powered mobile chargers have been on the market for years, serving the need of frequent travelers. Prototypes and developments were announced some years ago by the Chinese vendor High-Tech Wealth, Japanese firm NTT DoCoMo and the German research institute, Fraunhofer-Gesellschaft. In 2009, Samsung, LG and ZTE started selling new solar-powered devices. The main selling point has been for users in emerging markets. The GSM Association (GSMA) estimated that around 500 million mobile users in emerging markets do not have regular access to electricity and would benefit from alternative charging solutions, such as solar devices, solar chargers or operators' solar powered charging stations that have recently emerged. Hence, Samsung and ZTE launched low-end devices in several African and Latin American countries, including Kenya (ZTE Simu Ya Solar), Uganda (ZTE) and Pakistan (Samsung Crest).

In mature markets, Samsung continues to launch high-end devices with solar panels on the battery cover labeling them as "green," with its most recent device being the Samsung Replenish (an Android-based device) launched with carrier Sprint on 8 May 2011. However, we still believe that this strategy is of concern due to the solar cell's rather long return on energy investment time, or charge back time. The general view of the industry is that it takes about 18 months to two years of energy consumption to equal the amount of energy consumption used in manufacturing the solar cell. This value depends on the size of the cells as well as the location (for example, those exposed to bright sunlight most of the time as in the Sahara, compared to a location in Scandinavia). The time for solar cells to equal their energy investment is estimated at 18 months to two years under constant exposure to sunlight, so the time for solar cells on mobile phones with a wide variety of exposure times to sunlight is on average much longer. This suggests that the actual environmental benefit sets in only when users keep their devices for longer than 18 months to two years. This is less of a concern in emerging markets where device replacement cycles last longer than 24 months, than in developed markets, where users sometimes replace after 12 to 18 months.

Apart from the large vendors, startup company Intivation is also investing in this market. Intivation provides a photovoltaic (PV) cell technology platform based on a single solar cell and boost converter — SunBoost3 — that powers mobile devices with sunlight. The strength of this technology lies in its capability to allow charging in indoor and low-light conditions. Devices with Intivation's technology have been deployed in 30 countries in less than two years — primarily Africa but also India, China and Germany. Device vendors that are using Intivation's technology include ZTE, Sharp and Umeox.

Barriers to adoption:

- Power efficiency: These PV solar cells take a significant amount of time to charge the phone for even a short phone call.
- Bill of materials (BOM) cost: PV solar cells such as these may add between $3 and $9 to the BOM for a mobile phone, depending on the size, technology, quality and power output of the solar cells involved. This represents a significant fraction of the cost for a phone, without a clear market demand for it at present. For comparison: a 3.5-inch capacitive touchscreen currently costs between $15 and $20, while a GPS chip costs less than $2.
- Usage patterns: The most common user habit — carrying a phone in one's pocket — causes the main problem and minimizes the chance to make full use (if any) of solar charging.

***User Advice:***

- **Device vendors:** Gartner advises against marketing campaigns that highlight the positive environmental impact of high-end solar devices, particularly those to be used in developed markets. This is in light of the fact that a small solar panel has a return-on-energy time span that exceeds by far the average life of a phone in developed markets. Using recycled material and offering efficient chargers are much better ways to put an environmental strategy into practice.
- **Device vendors:** When offering solar devices consider incorporating technologies that help to preserve battery life. Examples are micro-electromechanical systems (MEMS) and organic light-emitting diode (OLED) screens.
- **Operators in emerging markets:** Analyze the business case for offering solar devices as it could offer additional revenue streams due to potential higher service usage.
- **Device vendors:** When offering such products in emerging markets it is recommended to focus on low-cost phones. This meets the needs of the main target audience and the chances are higher that the solar panel will be effective, as opposed to in high-end devices with high energy consuming features.
- **Battery companies:** Check now what new requirements there are for batteries when used in conjunction with solar panels, and work closely with handset vendors.

***Business Impact:*** The impact is limited to: (1) users in emerging markets with infrequent access to electricity, as the technology works best in countries with high availability of solar energy. However, price could be an issue; (2) frequent (business) travelers, as the technology offers convenience for these users; and (3) engineers, miners, developers, people in nongovernmental organizations and military personnel, who spend a significant amount of time in rural locations without access to electricity.

***Benefit Rating:*** Low

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Intivation; LG; Samsung; Sharp; ZTE

***Recommended Reading:*** "Cool Vendors in Consumer Devices, 2011"

# Sliding Into the Trough

## Head-Mounted Displays

***Analysis By:*** Jackie Fenn

***Definition:*** Head-mounted displays (HMDs) are small displays or projection technology integrated into eyeglasses or mounted on a helmet or hat. Heads-up displays are a type of HMD that does not block the user's vision, but superimposes the image on the user's view of the real world. An emerging form of heads-up display is a retinal display that "paints" a picture directly on the sensitive part of the user's retina. Although the image appears to be on a screen at the user's ideal viewing distance, there is no actual screen in front of the user, just special optics (for example, modified eyeglasses) that reflect the image back into the eye. Other heads-up displays that are not worn by the user but are projected on a surface (for example, on a car or plane windshield) are not covered in this discussion. Some HMDs incorporate motion sensors to determine direction and movement (for example, to provide context-sensitive geographic information) or as the interface to an immersive virtual reality application.

***Position and Adoption Speed Justification:*** Commonly deployed in military applications, the technology is well-developed but has yet to find a vehicle for broad adoption. Several HMDs have targeted the gaming and video markets with little success. The availability of stylish, consumer-grade video eyeglasses may eventually drive adoption, for example, as a peripheral device for private video viewing on planes. However, recent attempts at this market have failed to take hold, such as Myvu's Crystal Personal Media Viewer, despite it being sold relatively broadly in gadget stores and enjoying considerable press from 2008 to 2009. Myvu itself appears to have become inactive, and its website is no longer functional. For this reason, we are moving the position of head-mounted displays past the Peak of Inflated Expectations, as we expect continuing disillusionment during the next couple of years. On the positive side, the growing popularity of augmented reality on mobile devices may provide some crossover impetus for similar functionality on a head-mounted form factor (for example, from Vuzix). Further improvements will focus on resolution, field of view, battery life, comfort and cost — all of which are constraining current adoption.

***User Advice:*** Consider HMDs for wearable or augmented reality applications where the user's hands are occupied with a task or where the user needs to be moving while accessing information — for example, to review work instructions, schematics or customer data.

***Business Impact:*** Outside of simple video viewing, impact areas will be in vertical markets where combining key information with real-world views improves safety and productivity (medical or engineering, for example). Long-term uses will be in entertainment, gaming and mobile communication, as well as in computing devices, simulation and training.

***Benefit Rating:*** Moderate

***Market Penetration:*** Less than 1% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** MicroVision; Rockwell Collins; Sensics; Vuzix

## Gesture Recognition

***Analysis By:*** Stephen Prentice

***Definition:*** Gesture recognition involves determining the movement of a user's fingers, hands, arms, head or body in three dimensions through the use of a camera or via a device with embedded sensors that may be worn, held or body-mounted. The most visible and easily accessible example is the Microsoft Kinect gaming controller, but a growing number of alternatives are now becoming available. In some cases (for example, gaming controllers such as the Nintendo Wii Balance Board or the Microsoft skateboard controller), weight distribution is being added to supplement the data available.

A more limited subset of gesture recognition (in 2D only) has become common with the recent development of multitouch interfaces (such as the Apple iPhone or Microsoft Surface), in which multiple finger touches — pinch and squeeze, flicks, and swipe-type gestures — are used to provide a richer and more intuitive touch-based interface.

With the growing familiarity and availability of this style of interface, the term "natural user interface" is coming into common usage to describe these interface systems. This acknowledges the lack of any intermediate devices between the user and the system, although both Nintendo and Sony use a wand type of device to better interpret movement.

***Position and Adoption Speed Justification:*** The commercialization of gesture interfaces began with handheld devices that detect motion, such as the Nintendo Wii's 3D controller, 3D mice and

high-end mobile phones with accelerometers. Camera-based systems are now entering the market strongly. The decision by Microsoft to make an SDK readily available for its Kinect gaming controller provided a huge boost for the platform, opening the way to a wide range of potential applications in multiple areas, including business and healthcare, as well as gaming. Microsoft Kinect combines camera-based full-body gesture and movement recognition with face and voice recognition to provide a rich interface. Such composite interfaces are likely to become more commonplace, especially in the consumer environment, and a sustained period of competitive feature enhancement looks likely between Nintendo, Sony and Microsoft, leading to ever-improving capabilities, including improved facial recognition and greater resolution. The inclusion of these capabilities onto increasingly powerful handheld devices and mobile platforms offers interesting possibilities, which will drive further developments in areas such as augmented reality.

Gesture recognition involves the effective use of a variety of input devices (to provide either 2D movements or full 3D information) and considerable data processing — to recreate wire frame models of body positions and vector-based dynamics (for speed and direction of movement), followed by the interpretation of these gestures into meaningful commands to an application. The conceptual design of a user interface based on gestures is a considerable task — both from a technical standpoint and from a cultural and anthropological perspective, especially in a global market where cultural sensitivity must be taken into account. Nevertheless, this is an area that is attracting considerable interest from researchers, and the ability to create mashup-style interfaces from readily available components makes experimentation accessible. The SixthSense project at MIT is a good example, linking the use of gesture recognition with augmented reality to explore a new generation of interactions.

While the benefits of gestural interfaces in gaming applications are clear, the creation of intuitive and logical natural user interfaces for business applications will take many years. The logical mapping of intuitive and standardized gestures into meaningful commands with which to control a business application is a significant challenge. The rapid adoption of media tablet devices and the continuing growth of smartphones have significantly increased the use of multitouch-based interfaces during the past 12 months. The establishment of well-understood "standard" touch gestures is now spilling over to larger devices, and a number of developers are creating solutions designed for a variety of platforms from handheld devices to large wall-mounted displays. For example, business-oriented solutions (such as those from iNUI Studio) are already appearing and are targeted at specific vertical business markets, using camera-based gesture recognition as part of portfolios of natural user interface solutions for handheld devices and wall-mounted displays. We anticipate the following:

- With high-profile launches in the gaming market, gesture recognition remains close to the peak on the Hype Cycle; the growing availability of options advances it from "emerging" to "adolescent" in terms of maturity.
- While mainstream adoption in gaming will happen fairly quickly (less than five years), the time to plateau in the enterprise space will be considerably longer.

***User Advice:*** Gesture recognition is just one element of a collection of technologies (including voice recognition, location awareness, 3D displays and augmented reality) that combine well to reinvent human-computer interaction. Enterprises should:

- Evaluate handheld and camera-based gesture recognition for potential business applications involving controlling screen displays from a distance. Consider business-oriented toolkits, as well as those targeted at the gaming sector.
- Consider how these may be combined with location-based information and augmented-reality displays.

- Look carefully at developments in the gaming sector; these will form the basis for a variety of early prototypes for business applications.

Even the simplest use of gesture, movement or touch can be introduced to existing products (especially in the handheld space) to enhance the user experience. Even almost novelty items (such as the Kymera Magic Wand, which can control devices at a distance with learned infrared commands — www.thewandcompany.com) can create engaging user experiences in an otherwise keyboard-dominated world.

***Business Impact:***

- The primary application for gestural interfaces at present remains the gaming and home entertainment market. However, the potential of hands-free control of devices and the ability for several people to interact with large datasets are opening up a wide range of business applications — including data visualization and analytics, design, retail, teaching, and medical investigation and therapy.

- As computing power moves from a single device to an "on-demand" resource, the ability to interact and control without physical contact frees the user and opens up a range of intuitive interaction opportunities, including the ability to control devices and large screens from a distance.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** 3DV Systems; eyeSight; GestureTek; Gyration; iNUI Studio; Microsoft; Nintendo; Oblong; PrimeSense; SoftKinetic; Sony

## Mobile WLAN Access Points

***Analysis By:*** Jon Erensen; David A. Willis; Michael J. King

***Definition:*** Mobile wireless LAN (WLAN) access points allow WLAN-enabled devices to connect to the Internet by using a third-generation (3G)/fourth-generation (4G) cellular or WiMAX connection. This capability can be part of a stand-alone mobile access point, such as the MiFi devices from Novatel Wireless, or a feature of an existing portable device, most likely a smartphone. The stand-alone access point or smartphone is recognized by the WLAN-enabled device as a typical wireless hot spot, and a connection is established using the WLAN. The difference compared with a typical WLAN access point is that a mobile WLAN access point uses a 3G/4G cellular or WiMAX connection instead of a Cable or DSL broadband connection to the Internet.

***Position and Adoption Speed Justification:*** Mobile WLAN access points were first introduced in the U.S. in mid-2009 by Novatel Wireless and have expanded to include many different carriers and regions. In addition to the dedicated mobile WLAN access points, high-end smartphones are increasingly incorporating this technology as a feature, and that has the potential to significantly increase adoption. Mobile WLAN access points can be used as an alternative to accessing the Internet through a digital cellular connection. They allow an end user to pay for one digital cellular contract and then connect multiple devices using Wi-Fi, instead of paying for a digital cellular connection for each device individually. This can save end users money by limiting the number of wireless data plans they need to pay for, and it can also allow them to forgo an embedded digital cellular connection and rely on Wi-Fi only. This can amount to significant savings in the cost of hardware. For example, an iPad with a 3G connection costs $129 more than a Wi-Fi-only iPad.

This is especially important as the number of potential devices with digital cellular connections increases. Notebook PCs, media tablets, video game handheld devices and e-book readers are all adding digital cellular connections, but they are not standard features. But there are potential hurdles ahead. If this feature is widely adopted, it has the potential to significantly increase data use on wireless networks, which could impact the overall performance of those networks. And with carriers switching to use-based pricing, this could be expensive, depending on the number of devices a user connects and the amount of data used. Using a smartphone-based mobile WLAN access point solution can drain the smartphone battery. With dedicated hardware such as the MiFi, the battery life is also limited, although you can charge most dedicated devices through a USB port if you are using it with a notebook PC.

***User Advice:*** Device manufacturers should consider embedding mobile WLAN access point technology into products including smartphones, media tablets and notebook PCs with cellular connections. We expect this technology to become a common feature on high-end devices as handset vendors and wireless carriers look to differentiate their products and increase average revenue per user.

For corporate users and consumers that have the need or desire to connect multiple portable electronics to the Internet where a fixed access point is not available, a mobile WLAN access point has the potential to be more cost-effective than paying for individual connections. It also can lower the cost of the device itself, because a user would require WLAN but not a 3G/4G cellular or WiMAX connection. Users also need to understand the data plans and pricing for mobile WLAN access points to avoid excessive fees.

***Business Impact:*** Mobile WLAN access points have the potential to lower data fees for users that use multiple devices, limit compatibility issues and lower the hardware cost by requiring only WLAN in devices rather than 3G/4G cellular or WiMAX connections. Adoption of mobile WLAN access points will give users flexibility in accessing the Internet from multiple devices without having to pay for an Internet connection for each individual device.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** 1010data; Apple; Cradlepoint; HTC; Huawei; LG; Motorola; Novatel Wireless; Palm; Samsung Electronics; Sierra Wireless; ZTE

## Mobile Data Intelligence

***Analysis By:*** Carolina Milanesi

***Definition:*** The goal of mobile data intelligence (MDI) is to measure, collect and analyze mobile data usage, allowing marketers to better understand user behavior and interest toward devices and data services.

***Position and Adoption Speed Justification:*** MDI helps businesses that seek to understand mobile users' usage patterns across multiple services. It is also becoming a key factor for communication service providers, which can use the data to maximize their return on investment to attract new subscribers, win over existing subscribers to new products and services, or retain the overall installed base. One of the most important objectives for mobile operators is to improve uptake rates while minimizing costs. To do so, operators need much more intelligence about how people use data services, and to understand which variables have the greatest impact on service.

This is not quite like mobile BI, which tends to be more enterprise-focused than consumer-focused.

Some mobile vendors such as Nokia and Samsung have been analyzing some of the data on mobile devices such as what features and applications users were using most. However, MDI is a relatively new trend aided by the proliferation of smartphones that allows for the tools needed to run this analytic to be run on a wider range of devices.

***User Advice:*** Communication service providers should use MDI to analyze user behavior, especially around smartphones and tablets to evaluate the data revenue opportunity in these two device categories to properly invest in subsidies on the most profitable devices.

Advertisers and other B2C-focused businesses could use MDI to measure responses to advertizing and to services offered over mobile devices to create more effective tools.

***Business Impact:*** MDI helps to drive better marketing by delivering information on users' behaviors and preferences.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Neuralitic; Tekelec; Umber

## Voice to Text on Mobile Devices

***Analysis By:*** Carolina Milanesi

***Definition:*** Voice to text on mobile devices refers to applications embedded in mobile devices that enable any spoken word to be converted into text, either an email or a text message.

***Position and Adoption Speed Justification:*** With touchscreen devices becoming mainstream, there is a need for an easier input mechanism for tasks such as email and text messaging. Thanks to applications available for iPhone and Android products, Vlingo has grown in popularity during the past year. The technology uses hierarchical language models (HLMs), which are based on statistical models, to predict the words that users are likely to say, and how words are grouped together. For accuracy, Vlingo uses significant amounts of automatic and continual adaptation. In addition to adapting the HLMs, the system adapts to many user and application attributes, such as learning the speech patterns of individuals and groups of users, learning new words, learning which words are more likely to be spoken into a particular application or by a particular user, and learning pronunciations of words based on usage. Dragon Dictation is another very popular app by Nuance that builds on Nuance's Dragon NatuallySpeaking line created for Windows PCs. Google Voice has also grown in popularity as consumers rely more and more on their mobile phones to act as navigation devices.

We have given voice to text on mobile devices only a moderate benefit rating due to the issues that remain around accuracy when it comes to dealing with people's accents and language nuances that limit the degree of accuracy of the conversion.

***User Advice:*** Voice to text can be quite effective for short, straightforward messages. It is less reliable for long, complicated messages, and when the speaker is in a noisy environment. Performance also depends on the user's clarity of speech. We expect performance to continue to improve.

***Business Impact:*** A good voice-to-text client will facilitate data input for touchscreen devices that are very popular in the current market, but which are not the most efficient devices for email and messaging. Once the applications are more reliable, organizations could consider employing them to enable users to fill in specific forms, such as expense claims or order forms.

***Benefit Rating:*** Moderate

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Google; Nuance; Vlingo

## Software-Defined Radio

***Analysis By:*** Jim Tully; Sylvain Fabre

***Definition:*** Software-defined radio (SDR) describes systems in which significant parts of the wireless function are implemented with software controlled devices, rather than hardware. In SDR, some, or all, of the physical layer functions are software-defined, and wireless devices are able to switch dynamically between protocols and frequencies under software control. A radio can be any piece of equipment that uses wireless signal transmission, or reception, in the radio frequency (RF) part of the electromagnetic spectrum — to transfer information. For example, mobile phones, mobile base stations and wireless networking in PCs. Situations where standards are changing and uncertain, or that require multiple standards, will find SDR to be most attractive. Smart antennas are an important part of SDR and are typically specified as an array antenna with programmable characteristics such as field width, frequency and waveform shape.

SDR has the potential to reduce device cost and complexity, as less radio hardware would be required to support many protocols. SDR could also enable advanced concepts (such as cognitive radio), in which devices dynamically negotiate protocol and spectrum use — depending on their needs, and the needs of other devices in the vicinity. The ultimate goal is that the RF and baseband components of the wireless device are fully programmable, and can switch frequencies and protocols in milliseconds. The critical element of SDR, is designing a programmable radio that operates over a broad range of frequencies. This is as challenging, if not more challenging, than implementing the baseband function.

***Position and Adoption Speed Justification:***

- While SDR technology has already been used in cellular base stations, it has had little impact on mobile devices.
- Chips implementing partial SDR solutions are available for use in mobile devices, such as laptop data cards; and for selected components of wireless systems, such as baseband processors.
- SDR is likely to be more attractive for use on high-end devices, like smartphones, which must support many different wireless standards and protocols.
- SDR will rely on relatively high-performance digital signal processor (DSP) technology. Current DSP-based processors, with the appropriate clock rate, consume too much power for most handsets; though significant developments are being made in power reduction. It will, however, take many years before SDR is used on a wide range of mobile devices. Nevertheless, Nvidia's recent acquisition of Icera shows that solid action is being taken in this area.

***User Advice:*** Communications equipment vendors should already be seriously evaluating this technology. In the long term, SDR has the potential to make mobile devices less expensive and more flexible.

***Business Impact:***

- SDR has the potential to reduce the cost of mobile devices, and bring them to market more rapidly, by lowering production costs. SDR enables multimode, multiband and/or multifunctional wireless devices that can be modified using software upgrades — performed in the field, or over the air.
- Manufacturers of mobile devices that include multiple radios should pilot SDR technology as it becomes available, and adopt it when the economic case is proven — and the performance and power consumption of SDR is acceptable.

***Benefit Rating:*** Transformational

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** BitWave Semiconductor; Icera; IMEC; mimoOn; Sandbridge Technologies; Silicon Hive; Tensilica; Vanu

***Recommended Reading:*** "Magic Quadrant for LTE Network Infrastructure"

"Forecast: Mobile Data Traffic and Revenue, Worldwide, 2010-2015"

"Emerging Technology Analysis: Self-Organizing Networks, Hype Cycle for Wireless Networking Infrastructure"

"Dataquest Insight: IPR Issues Could Delay Growth in the Long Term Evolution Market"

## Indoor Positioning

***Analysis By:*** Annette Zimmermann

***Definition:*** Indoor positioning uses information about the indoor location of mobile devices — derived from cellular networks, Wi-Fi access points (APs) or other technologies — to deliver a service.

***Position and Adoption Speed Justification:*** Indoor positioning has gained traction in enterprise environments for locating (employee) equipment and parts and goods. Although there are many use cases for indoor positioning on mobile devices in the consumer market, uptake has been very limited until now, with few test runs and even fewer commercial launches. The trade-offs between accuracy, costs and coverage of the different positioning technologies have been the main challenges to the uptake of indoor positioning in the consumer space. In addition, as with outdoor location-based services, marketers need to be convinced that there is user acceptance and demand (as evident from various Gartner user surveys) for location-based advertising.

Consumer location services have been focused mainly on outside areas. However, there are plenty of use cases inside buildings, such as when a user wants to walk from A to B (rather than driving) and, before leaving his or her current location, sets up the navigation tool or checks on interesting places that are close to destination B. Other scenarios that are even more interesting are shopping malls, airports, train stations, museums, exhibitions, conferences, night clubs and other large crowded places where people need to find their way around or there is the possibility

of providing them with a service. Brands, retailers and marketers could use indoor positioning as a tool to present context-enriched offerings, information and services to users.

The ultimate solution will be a combination of several technologies to provide indoor and outdoor positioning. Wi-Fi is most likely to emerge as the mainstream indoor positioning technology in the consumer space, due to its high accuracy and the ubiquity of Wi-Fi APs. Wi-Fi chips are incorporated mainly in smartphones, but devices with open OSs are moving quickly into lower price segments. In 2013, 792 million smartphones will be purchased, accounting for more than a third of all mobile devices sold.

The main indoor positioning technologies available include Bluetooth, RFID, Cell ID, Wi-Fi, Uplink Time Difference of Arrival (U-TDOA), GPS repeater and dead reckoning. We have described their advantages and disadvantages and how they work in specific reports (see, for example, "Location Technologies: Sensors, Tags, Beacons and More" and "Location Technologies: Wi-Fi, Satellite and Cellular").

Innovation is driven by a number of larger players, as well as by startups. Google has been looking at bringing maps to indoor environments and, in 1Q11, Navteq announced its own indoor map product, called Destination Maps (using Point Inside maps). The startup companies Point Inside and Micello have been building up a database of indoor maps of all major malls and airports in the U.S., which can be licensed to airlines and retailers that want to develop their own customer experience on top. A large U.S. retailer, Meijer, is using Point Inside's technology to let its customers search for and find the location of products, receive detailed product information, find out about sales and location-based promotions, and download highly personalized discounts and coupons.

The entrance of such a large player as Navteq into this space, as well as Point Inside's interesting business model, has moved indoor positioning forward in the Hype Cycle by a few positions from last year. Further progression on the Hype Cycle will come once user penetration starts to ramp up.

***User Advice:***

- Device vendors: Monitor developments in indoor positioning technology and recognize that it will make your existing location products much more compelling when the move indoors can be made.

Read Gartner's user survey results ("User Survey Analysis: Enhancing the Effectiveness of Communications Service Providers' Advertising Initiatives"), which clearly show users' interest in location advertising, information and coupons.

***Business Impact:*** The largest impact will be in the consumer space. As context services have become a key differentiator, the use of those services indoors will close an important gap in the current service landscape. Many key applications such as friend finder/social networks and location search should be able to be used just as well inside as outside. Addressing this point will make a solution much more attractive to users as, in the end, it will create opportunities for more frequent use.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Micello; Nokia; Point Inside; Polaris Wireless; Satsis; Skyhook

***Recommended Reading:*** "Cool Vendors in Consumer Mobile Services, 2011"

## Device-Embedded Biometric Authentication

***Analysis By:*** Ant Allan

***Definition:*** Device-embedded biometric authentication is a specialized use of biometric authentication methods to improve the endpoint security of mobile devices, such as PCs and phones, using capture devices ("sensors") and feature extraction and comparison software built into the device itself (see "Q&A: Biometric Authentication Methods" and the entry for biometric authentication methods on the "Hype Cycle for Identity and Access Management Technologies, 2011").

Because such a mobile device is essentially personal to one user, the mode is typically a one-to-one comparison of a probe biometric sample against the user's biometric reference stored on the device.

***Position and Adoption Speed Justification:*** Biometric authentication has, so far, been embedded in two classes of mobile devices — PCs and phones. Biometric-enabled PCs are available from most major vendors and typically use fingerprint biometric authentication, although one vendor has also introduced embedded face topography biometric authentication. Fingerprint technology has been available on mobile phones longer, but until recently, availability has been limited to certain markets, such as Japan.

Enterprises have adopted biometric-enabled mobile PCs to acquire an authentication method that offers greater user convenience than a legacy password and at a lower total cost of ownership (TCO) than a third-party biometric authentication product. A secondary goal has been to improve endpoint security of mobile PCs for the mobile workforce and to strengthen authentication to Active Directory (AD) and Windows networks, with biometric authentication pitched as an alternative to various token-based methods, such as smart cards. However, in the later case, the method is really only a proxy for the Windows password: AD doesn't "know" that the user used biometric authentication, and, potentially, a successful masquerade attack needs only knowledge of the user's Windows password. Furthermore, third-party tools may be required to fully manage configuration and usage.

The ostensible convenience of biometric authentication, based on its early appeal among some users, such as senior managers, appears to have been a key driver to the sale of biometric-enabled mobile PCs. However, usability issues with fingerprints have led to a level of user disenchantment. A few users (one or two in a thousand) continually struggle to use biometric authentication reliably — for physiological reasons (such as poorly defined ridges), or simply because they find it difficult to properly interact with the sensor (the biometric industry refers to such users unkindly as "goats") — and many users have problems some of the time. Furthermore, in many enterprises, biometric authentication has been presented as an option, not mandated, and many users have simply chosen not to use it for personal reasons.

Although there are significant numbers of biometric-enabled mobile PCs in enterprises, it is unclear how many enterprises and users are actually using the biometric authentication capabilities. And because the focus has so often been on convenience rather than security in many enterprises, all users are still able to authenticate with their Windows passwords, so there has been no net gain in security.

Although we have not yet seen significant enterprise adoption of fingerprint-enabled phones, Gartner believes that enterprise interest will increase as mobile phones become ever more capable and endpoint security for phones grows in importance. Biometric authentication will likely be more attractive on phones than on PCs because users will more strongly resist using alternative, token-based methods. As with PCs, authentication to the endpoint device may be leveraged to strengthen authentication to corporate networks. However, we expect similar kinds

of usability issues as with PCs. Furthermore, an attacker who acquires a user's phone will find a good selection of fingerprints that might be used for a facsimile attack.

Exploiting device-embedded authentication across the network and downstream applications is not a viable strategy when enterprises are increasingly looking to support access to their networks and systems from a wide range of endpoint devices, only some of which may support embedded methods. Users will not tolerate having to use different authentication methods, depending on which of their (corporate or personal) devices they choose to use at a particular time. What's more, using different authentication methods for different endpoints provides an uneven risk profile, making some access via certain endpoints potentially more vulnerable. Enterprises must aim for a consistent approach.

Largely for this reason, we have moved device-embedded biometric authentication back to the Trough of Disillusionment.

***User Advice:*** Device-embedded biometric authentication can improve user convenience and improve endpoint security, but because of technology constraints, it is rather less suited to strengthening authentication to networks and applications.

As already noted, usability issues remain with fingerprint methods. Even with continued improvement in fingerprint-sensor technologies, we expect "passive" biometric authentication (for example, using face topography) to provide more consistency and universality. Thus, it will become more prevalent during the next five years, particularly on phones, where front-facing cameras are increasingly common.

Enterprises may want to consider the advantages of adopting device-embedded biometric authentication in their next hardware refresh cycles for their mobile workforce PCs. However, client experience to date suggests that user adoption will be low unless use is mandatory, eroding potential benefits for endpoint security. Where the goal is improved security, users who cannot reliably use biometric authentication must be provided with an alternative, likely at a higher per-user cost. It is too early to adopt biometric-enabled smartphones, since this requirement places too great a restriction on the choice of handsets. In either case, for PCs or smartphones, mandating device-embedded biometric authentication as part of "bring your own device to work" policies is a nonstarter.

A more robust strategy for access to the network and downstream or Web applications is to leverage the endpoint (PC or smartphone) as just a capture device — mics for voice, user-facing cameras for face topography (or perhaps iris structure), keyboard for typing rhythm and so on — for back-end biometric authentication (see the entry for biometric authentication methods on the "Hype Cycle for Identity and Access Management Technologies, 2011").

***Business Impact:*** For mobile devices, such as PCs and phones, device-embedded biometric authentication provides endpoint authentication without the need for passwords or additional tokens. Thus, it has the potential to provide significant improvements in user convenience and reduced operational costs.

However, usability issues and a lack of consistency of technology across different endpoints and vendors will continue to limit the potential value, and the approach is unsuited for access to the network and downstream or Web applications.

***Benefit Rating:*** Low

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** AuthenTec; Toshiba

***Recommended Reading:*** "A Taxonomy of Authentication Methods, Update"

"How to Choose New Authentication Methods"

"Q&A: Biometric Authentication Methods"

## Micro Fuel Cells

***Analysis By:*** Jim Tully

***Definition:*** Micro fuel cells are an alternative to batteries as a power source for mobile devices. They may be small enough for integration inside the electronic equipment, or a little larger for use in an external power supply. The majority of portable fuel cells use hydrogen as the base fuel, but micro fuel cells usually extract it from methanol — a hydrogen-rich liquid. Although methanol-based cells can potentially provide 10 times the energy storage capacity of a lithium battery, they are not as good at delivering bursts of high power. This makes them more useful for battery charging than for primary power roles. They can be recharged almost instantaneously by adding more methanol — by either pouring it in or clipping in a new cartridge. This is a significant advantage over batteries, which can take several hours to recharge. Micro fuel cells are also environmentally friendly; the operating waste is only hydrogen and oxygen, which appears (in the form of pure water) as slightly increased humidity around the cell. Other forms of fuel cell, such as zinc-air and ethanol, are possible fuel sources for mobile devices — but are currently less prominent.

***Position and Adoption Speed Justification:*** Portable fuel cells are appearing in commercially viable packages, but they are relatively large. In recent years, two factors of note occurred to affect the status of micro fuel cells:

- The considerable publicity surrounding exploding laptop batteries.
- The authorization to carry fuel cells (and fuel cartridges) on commercial aircraft from January 2007.

Despite these factors, micro fuel cells have not progressed far along the Hype Cycle over the past few years. Truly portable micro fuel cells, that could be incorporated into devices such as mobile phones, are still limited to the concept and prototype stages — with no commercial products available. It is possible that the problems of exploding batteries have made people more cautious about fuel cells; creating a perception of their fuel (commonly methanol), or the hydrogen produced in the cell, as a potential hazard. The more surprising issue is the lack of progress following the aircraft authorization. The growing availability of electrical power at aircraft seats, and the ability of batteries to operate for the duration of many flights, could have negated this factor. Even so, the main driving force for mass-market expansion of micro fuel cells remains notebook computer users — rather than users of mobile phones, media players or other types of equipment — because of the higher power needs of notebooks compared with smaller portable devices.

Deployments are now occurring, but they center largely on military, exploration and other isolated environments. Demand from commercial users in mainstream enterprises has slowed during the past two years, probably as a result of travel restrictions. Cartridges giving three hours of laptop use are likely to cost approximately $5, which is acceptable for many situations — especially where urgency is involved. A bigger problem for deployment is the lack of immediate availability of cartridges, and the lack of a nationwide, or global, fuel supply infrastructure with appropriate standards for fuel quality, fuel concentrations, cartridge format, and so on. The latter problem is a more long-term issue and the main reason for our current "time-to-plateau" estimates.

Delayed market rollout is a cause of concern for startup vendors in this area; bigger vendors are better positioned to cope. The first practical mass-market use for micro fuel cells with portable devices is likely to be in stand-alone battery chargers for notebook computers and mobile phones — some such products are already available. More-integrated configurations will follow. One of the most interesting developments in recent times has been the user-refillable hydrogen cartridge system from Horizon Fuel Cell Technologies, which allows users to generate their own hydrogen fuel from water. Developments such as this could lead us to change our assumptions about this market. We will watch developments carefully.

***User Advice:*** Users of equipment in isolated areas should evaluate offerings in preparation for early adoption.

Vendors of equipment such as PCs should establish relationships with micro fuel cell companies if they believe important classes of customers will benefit from them. These vendors should add their weight to finding a solution to the fuel distribution problem.

***Business Impact:*** Longer working times will facilitate more-powerful mobile devices and applications.

Micro fuel cells have the potential to enable terminals with smaller footprints; because of their smaller physical size (for comparable energy ratings) compared with batteries.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Emerging

***Sample Vendors:*** Aquafairy; Hitachi; Horizon Fuel Cell Technologies; LG Electronics; NEC; Smart Fuel Cell; Sony; Toshiba

***Recommended Reading:*** "New Product Marks the Consumerization of Hydrogen Fuel Cell Powered Chargers for Mobile Devices"

"Cool Vendors in Consumer Energy Management, 2010"

## Bluetooth 3.0

***Analysis By:*** Mark Hung

***Definition:*** Bluetooth 3.0 and Bluetooth 3.0 + HS (collectively referred to as Bluetooth 3.0 or BT3.0; HS stands for "High Speed") are the official terms for the personal-area network (PAN) technology specifications from the Bluetooth Special Interest Group that was introduced in 2009. Bluetooth 3.0 includes all of the functionality of Bluetooth 2.1 EDR, in addition to the following new features:

- Generic test methodology
- Enhanced power control
- Unicast connectionless data

The HS version adds support for Generic Alternate MAC/PHY (AMP) and the 802.11 Protocol Adaptation Layer (PAL), which translates to a speed boost of up to 24 Mbps. Bluetooth v.3.0 + HS requires both Bluetooth and Wi-Fi technologies to be present. BT3.0 is intended to support the increased need for personal devices to transfer larger file types, such as music and video. As an estimate, a 1MB file that is transferred in one minute with Bluetooth 2.1 could theoretically transfer in less than six seconds with Bluetooth v.3.0 + HS using Wi-Fi.

***Position and Adoption Speed Justification:*** The Bluetooth v.3.0 + HS specification was approved on 22 April 2009. Expect Bluetooth transfers using Wi-Fi to be relatively trouble-free. With more than 2 billion Bluetooth-enabled devices, BT3.0 is expected to be a widely deployed capability as devices are replaced (typically every two years). Most of the current Bluetooth chipsets will migrate at least to the 3.0 specification. Expect BT3.0 to appear initially in notebook computers and high-end smartphones and then migrate during a five-year period to all devices that support Bluetooth today. Expect laptops to support the new HS specification, while smartphones will use either BT3.0 + HS or the newer BT4.0 technology. BT3.0 + HS (not BT3.0) may see its adoption stunted due to competition from Wi-Fi Direct.

***User Advice:*** For vendors, there is little technical or commercial downside to implementing BT3.0. Laptop vendors may find that Wi-Fi Direct is more straightforward, but they may wish to maintain compatibility with smartphones that use BT3.0 for lower power operation. For end users, no proactive early adoption is recommended. Instead, users should wait until the technology arrives in products at a negligible price premium. Expect this to occur by YE11.

***Business Impact:*** Businesses will have another option for peer-to-peer networking. The major issue for businesses will be controlling the use of the technology and ensuring that it complies with security requirements. The new higher rates should broaden Bluetooth's adoption.

***Benefit Rating:*** Low

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Broadcom; CSR; Marvell Semiconductors; Qualcomm Atheros; Texas Instruments

## Magnetometer

***Analysis By:*** Annette Zimmermann

***Definition:*** A digital compass, or magnetometer, is a sensor that measures the earth's magnetic field to determine the direction to the magnetic poles. The implementation of three-axis compasses or magnetometer sensors, combined with accelerometer sensors, is critical for mobile devices — to provide tilt compensation when the device is not held horizontally.

***Position and Adoption Speed Justification:*** The proliferation of location-based services has pushed more vendors to include a digital compass in their smartphones, including Nokia, Apple, Motorola, HTC and, more recently, Research In Motion. The magnetometer combined with a three-axis accelerometer is particularly helpful when the pedestrian navigation function is used, because it indicates the direction the user is facing. There are many use cases for this technology, and developers have recognized its benefit: providing numerous applications for iOS, Android, Symbian and Windows Phone 7 (Mango). We see mobile location games such as geocaching benefiting from this technology, especially in combination with GPS. Other games (not necessarily location games) can also make use of a digital compass. Augmented reality applications, indoor positioning and outdoor activities such as hiking and camping are other areas of application.

The strong market uptake of smartphones has increased the penetration of devices with integrated digital compass compared to last year — as this feature moves into more midrange devices such as the Huawei U8800 and the HTC Wildfire. Thanks to Google's Android platform — which promotes the use of various location services such as Google Maps, Google navigation and location search — magnetometers will almost automatically move along into lower price segments that vendors such as Alcatel, Huawei and ZTE are aiming at. Part of Nokia's strategy

has been to include this technology in more devices, but with its recent platform strategy change we may see the technology move into its midrange portfolio a little later — once the vendor is able to push Windows Phone 7 devices into the midtier (not expected before the end of 2012).

***User Advice:*** We expect the use of pedestrian navigation, and facilities for finding points of interest, to increase significantly during the next few years.

Device vendors with a GPS strategy should implement digital compasses, because these can be strong differentiators due to improved user experience.

Developers will expect this technology as a standard API for any smartphone platform.

***Business Impact:*** The uptake of this technology is closely linked to the rapid increase of GPS in mobile handsets.

An embedded compass makes a significant difference to pedestrian navigation. It makes reading and using digital maps more intuitive, because the maps rotate as the user moves.

The primary impact will be on consumers, who will use pedestrian navigation to explore new areas and cities.

The technology will also affect workers who rely heavily on navigation to do their jobs.

***Benefit Rating:*** High

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Apple; HTC; Memsic; Nokia; Research In Motion (RIM); Samsung

***Recommended Reading:*** "Predicts 2011: The Interconnected Consumer"

"Cool Vendors in Consumer Mobile Services, 2011"

"Cool Vendors in Context-Aware Computing, 2011"

## Phone Bar Code Reader

***Analysis By:*** Sandy Shen

***Definition:*** A phone bar code reader is a software client that works with a phone's camera to capture and decode bar codes.

***Position and Adoption Speed Justification:*** Bar code readers are used to decipher data so that users can quickly access content and eliminate the need for text input. Bar codes can be used to encode URLs, business cards, product information and marketing campaigns. For example, a company can put bar codes on printed advertisements, billboards, posters, brochures and product packages and users can scan the bar codes with a phone's camera to obtain the corresponding information.

Bar codes can be 1D, 2D or 3D (2D and 3D bar codes carrying more data than 1D codes) and may have a color scheme to include even more data. However, 3D bar codes need server support to decode data effectively and require a live data connection from a phone, which currently limits their market penetration. There is also a video bar code that streams a series of 2D codes to a phone to transfer larger volumes of content, such as ring tones, pictures, videos, games and files. There is no specific requirement for a camera phone, as a basic Video Graphics Array camera will work.

Problems with bar code readers include competing codecs and poor performance. There are about a dozen 2D bar code codecs and each may require a different reader. Many readers support multiple codecs, such as Data Matrix and QR Code, the two most often used, while other less used codes may require a special reader.

Users not familiar with the technology will find it difficult to capture a good image and the performance of the reader also affects the speed and accuracy of the reading, such as whether it can work when the bar code is partially damaged or when the lighting is poor.

Mobile carriers and device vendors sometimes preinstall readers onto a phone and users can also download them from application stores. However, due to low user awareness, the penetration remains low, which has a negative impact on bar code marketing initiatives.

***User Advice:*** Companies can use bar codes to create a cutting-edge image and develop relationships with their "tech savvy" customers. Mobile carriers can expect higher data traffic, content downloads and even advertising revenue if they have a hosting service.

***Business Impact:*** Companies can use bar codes to create a cutting-edge image and develop relationships with their "tech savvy" customers. Mobile carriers can expect higher data traffic, content downloads and even advertising revenue if they have a hosting service.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** 3GVision; Colorzip; Microsoft; MobileAMA; NeoMedia; Nokia; QuickMark; Scanbuy; Semacode

***Recommended Reading:*** "Mobile Check-In for Airlines: Lessons From a South American Airline"

"Dataquest Insight: Music Festival and Amusement Park Show Potential of Mobile Ticketing"

## Wireless Video — 2.4/5GHz

***Analysis By:*** Mark Hung; Jon Erensen

***Definition:*** Wireless video, broadly defined, is any over-the-air video transmission, whether it is broadcast (one-to-all), multicast (one-to-many) or unicast (one-to-one). This video stream can be transmitted either over the public spectrum (broadcast frequencies or WAN) or inside a home or enterprise using unlicensed spectrum (wireless LAN [WLAN]). We are limiting the definition of this technology to wireless video transmission using the 2.4GHz and 5GHz bands in a WLAN setting.

***Position and Adoption Speed Justification:*** Wireless video technologies can be categorized along several different axes:

- Spectrum: 2.4GHz, 5GHz or 60GHz.
- Standards-based or proprietary: Wi-Fi (IEEE 802.11) is the most popular physical-layer standard for WLAN.
- Network topology: Star (with a wireless router or access point [AP] in the middle) or peer-to-peer (P2P).
- Throughput: This is largely a function of the underlying physical-layer standard, although the use of compression at a higher layer can increase the overall throughput.

In the 2.4/5GHz bands, wireless video has largely standardized on the 802.11a/b/g/n specification, and it is expected to use 802.11ac when that standard is ratified at the end of 2012. Given the reach in these frequency bands (typically 100 to 200 feet in an indoor setting), both the star and P2P network topologies may be used. The star topology is typically used for whole-house video streaming, whereas P2P is used for in-room transmission. For whole-house video streaming, the application developers have usually used the APIs provided by the various OSs (e.g., Windows, Mac OS, iOS, Android and Linux) to enable the capability. However, for P2P video streaming, a few competing technologies have arisen that sit on top of 802.11 to support wireless video:

- Wireless Home Digital Interface (WHDI): This is a proprietary wireless video standard promoted by a single semiconductor vendor (Amimon), along with a number of Asian consumer electronics (CE) companies. It uses the traditional 5GHz spectrum and is largely based on conventional 802.11a technology.

- Intel WiDi: Intel's proprietary implementation of Wi-Fi Display as a prestandard technology. In addition, Intel enhanced the overall performance of the system by compressing the video signal before sending it out over the wireless medium.

- Apple AirPlay: Apple's proprietary technology that allows video streaming from an iPhone or iPad to a TV via a second-generation Apple TV. This is accomplished using standard 802.11n. Although it may seem that the device is streaming video directly to a TV, it actually operates in a star topology via the wireless router, AP or repeater.

- Wi-Fi Display: Wi-Fi Alliance's first wireless video standard, designed to ride on top of the Wi-Fi Direct technology that it has developed using a P2P topology. It supports 802.11n and future 802.11 standards, such as 802.11ac and 802.11ad.

Although Amimon is still pushing ahead with its WHDI standard, it has not seen much traction in the past and is not expected to be a major player in this market. For the other vendors, it is expected that most of them will coalesce around the new Wi-Fi Display standard once it has been ratified, and it will be adopted by the computing, communications and CE equipment manufacturers. This is demonstrated by the broad support it currently enjoys among the companies that are working on the standard. The standard is expected to be ratified by the end of 2011, and the first products supporting it will appear in 2012.

***User Advice:*** Although wireless video streaming is feasible in both the 2.4GHz and 5GHz bands, the user experience is much better in the 5GHz band due to the larger number of available channels. Therefore, users should ensure that all their equipment can support the 5GHz band for optimal performance.

Electronic equipment manufacturers (EEMs) should take advantage of the cost-downs in the chipsets to drive wider adoption of dual-concurrent (simultaneous 2.4 and 5GHz operation) routers and APs so that both data and video can be well-supported. Client device manufacturers (PCs, smartphones and CE) should enable 2.4/5GHz technology more widely in their product portfolio to take advantage of these capabilities.

***Business Impact:*** Wireless video can potentially improve corporate communications and training methods, thus improving efficiency and lowering travel costs. In CE and computing devices, wireless video may soon become a checklist item that manufacturers must implement on their platforms.

***Benefit Rating:*** Moderate

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Amimon; Apple; Broadcom; Cavium Networks; Intel; Qualcomm Atheros; Samsung; Sony

***Recommended Reading:*** "Emerging Technology Analysis: Consumer Electronics Technologies, Wireless High-Definition Multimedia Interface Cable Replacement"

## Embedded Wireless Cellular Modems

***Analysis By:*** Hugues J. De La Vergne

***Definition:*** Wireless cellular embedded modems are cellular data implementations that are delivered as embedded modems for notebooks and other forms of connected consumer electronics, such as connected media tablets or e-readers. Removable data cards and dongles have dominated the cellular modem category, but with the increase in speeds of cellular technologies to High-Speed Packet Access (HSPA) and Long Term Evolution (LTE), along with smaller form factors such as media tablets, embedded cellular modems have seen rapid growth, and that growth is expected to continue. Embedded modems supported all cellular data standards, such as general packet radio service (GPRS)/Enhanced Data Rates for Global Evolution (EDGE)/HSPA or cdma2000 Evolution Data Optimized (EV-DO), which includes revision 0, revision A and 1x radio transmission technology (1x RTT), but were limited because of the slower data rate; thus, end users did not want to be tied to a technology that would provide an unenjoyable Web-browsing experience. In late 2010, modules that also support LTE became available in volume.

***Position and Adoption Speed Justification:*** Although removable modems are a mature technology, embedded modems have started to gain momentum as more end users want their PC and consumer electronics devices to be regularly connected to the Internet. Growth in the embedded segment was limited historically because of users' concerns about having a device that supports an out-of-date cellular technology and the high prices of rate plans. End users preferred the flexibility that removable USB dongles offered, protecting buyers from rapid cellular technology changes. Historically, such changes have come several times faster than the normal laptop replacement cycle. Although cellular data cards often have lower durability and performance than embedded cellular data, the payback comes from greater notebook asset protection, because an obsolete card can readily be swapped out, whereas an embedded cellular solution can be difficult or impossible to change. In addition, USB dongles can also easily be shared in an organization. The software differences from operators provide challenges from a common image perspective. PC card solutions are declining rapidly as more and more notebooks remove slots and USB dongles are now dominant.

***User Advice:*** The cellular technology churn has finally slowed, especially on the introduction of LTE. LTE is reasonably stable and less disruptive, compared with the many High-Speed Downlink Packet Access (HSDPA)/High-Speed Uplink Packet Access (HSUPA) versions during the past few years. Organizations need to ensure software and image compatibility among the PC card versions. Multinational organizations should determine whether they should standardize on a single HSPA card and buy it unsubsidized to reduce support and integration costs, or whether they should buy subsidized cards on the local market.

***Business Impact:*** Cellular data cards will affect telecommunications strategies and economics for mobile users with notebooks, as organizations choose among the wireless communications options available. If the card is tied to a mobile operator, then the technology may have sourcing implications.

***Benefit Rating:*** Moderate

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Huawei; Kyocera; Novatel Wireless; Option; Pantech Wireless; Sierra Wireless; ZTE

***Recommended Reading:*** "Changes Coming for Embedded 3G in Notebooks"

## Mobile Browsers

***Analysis By:*** Michael J. King; Hugues J. De La Vergne

***Definition:*** The mobile browser is an on-device, client-side application that is resident on a mobile device. It provides access to content and applications from the Internet and, increasingly, in the cloud. Desktop and mobile browsers share many functions; however, increasingly, there are also differences, including the size of the screen, the power of the device (both processor and memory footprint), the speed of the network and the resources on the device. The browser for a mobile device has been considered a lower-functioning device than the browsers found on the desktop; as HTML5 and webkit-capable browsers find their way onto mobile devices, this is positioned to shift.

***Position and Adoption Speed Justification:*** Although browsers on mobile phones, in general, are relatively mature, the technology has been poorly adopted, because of the user experience it delivered. This has been exacerbated by inconsistent implementation of browser standards by the big smartphone vendors, which is also the reason this technology has moved backward on the Hype Cycle. During the next three years — with the adoption of HTML5 by many of the browsers and the standardization of resource (e.g., location, camera and accelerometer) access on smartphones — the adoption of mobile browsers for application access and content delivery will increase dramatically. (HTML5 enables significant offline caching of information for application functionality without a network connection, among other things.) The separation between the capabilities of the HTML5 browsers shipped on the devices and the standardization of interfaces, in terms of timing and delivery, will be a gating factor for cross-platform requirements.

Three categories of mobile browsers are supported across a variety of devices:

- Fully functional, HTML5-compliant, webkit-capable browsers — these are often found on smartphones and devices with OSs, such as RIM, Apple and Android. Most tablets support these types of browsers as well, although we envision most of them moving to desktop-derived browsers during the next two to three years.
- Middle-function browsers, with HTML and graphics support, but limited support for advanced feature sets or access to resources on the device — these are found on older versions of RIM OSs, Symbian devices and third-party support.
- Wireless Application Protocol and limited-function, text-based browsers — these are often found on feature phones.

The highly variable target for content and Web developers means that fewer than 20% of mobile applications developed are thin-client (or browser-based). With the adoption of HTML5 and the capabilities it provides, Gartner sees that percentage moving toward 40% to 50% during the next three years, particularly for informational or forms-based applications.

***User Advice:*** Enterprises should experiment with thin-client (browser-delivered) application design and content delivery for their end users and customers. Although standardized HTML5

implementations in the context of a mobile browser are likely to be three to five years out, the security and information delivery capabilities of mobile browsers may be an appropriate fit for a growing number of mobile application initiatives.

***Business Impact:*** The impact of the browser is threefold:

- For mobile device and platform vendors, the browser experience is a way to differentiate their products and entice a wider range of content owners to enable access via the mobile device.
- For content owners and application developers, the browser offers a secure, and increasingly rich, way to deliver a wide range of content types, and is another architecture to consider for that delivery.
- For enterprises, the mobilization of information will enable employees to depend less on device types and requirements of those individual platforms.

***Benefit Rating:*** High

***Market Penetration:*** 20% to 50% of target audience

***Maturity:*** Mature mainstream

***Sample Vendors:*** Apple; Google; Nokia; Openwave Systems; Opera; Research In Motion

# Climbing the Slope

## VoIP Over WLAN

***Analysis By:*** Sandy Shen

***Definition:*** This technology enables voice over Internet Protocol (VoIP) calls to be made over wireless LANs (WLANs).

***Position and Adoption Speed Justification:*** Consumers can install VoIP clients, such as Skype, Truphone and fring, to make calls over WLAN — mostly to avoid long-distance charges. Enterprises that have designed their WLAN infrastructure to support voice over WLAN (VoWLAN) requirements, can seamlessly transfer calls from mobile networks to gateways that use the enterprise PBX. Wi-Fi provides higher bandwidth and lower latency, and so better quality of service (QoS) than over mobile connections.

Adoption of VoWLAN services is helped by the increasing penetration of Wi-Fi-capable phones and VoIP clients dedicated to the phone. As a result of competitive pressure and customer demand, it also has support from mobile carriers that have, in the past, resisted VoIP calls. Some mobile carriers are routing the voice traffic over circuit-switched channels before routing it to the IP infrastructure. This can ensure better QoS than Wi-Fi or the packet-switched services of the mobile network, and can also fill the coverage gap for indoor and underground. Some carriers, such as KT, have used WiMAX instead of Wi-Fi to offer campuswide voice calls, though we don't expect WiMAX to be deployed on a large scale.

We don't expect VoWLAN to present an immediate threat to mobile carriers' voice revenue in the short term, because large voice bundles have driven down the costs per minute for local and domestic calls and VoIP is mostly used for international and roaming calls. On the other hand, this technology may help to improve the user experience as the QoS over WLAN is better than over cellular, and can generate revenue from enterprises.

***User Advice:*** Mobile carriers should explore the benefits of integrating popular VoIP clients into Wi-Fi-capable phones, as a way to attract and retain users. They can also consider routing a certified VoIP providers' traffic over circuit-switched channels to provide good QoS. Additionally, they should continue to develop alliances that facilitate seamless enterprise phone support, and make available as many Wi-Fi hot spots as possible — so that users can easily choose WLAN over mobile for VoIP calls.

VoIP providers should develop clients for popular smartphone OSs, provide a good user experience by integrating access to multiple popular VoIP services, and work with carriers and device vendors in distributing their services.

***Business Impact:*** VoWLAN services will have a limited downside impact on mobile carriers' revenue in the short term, given the inexpensive cost per minute for local voice calls. There is potential for an upside, if carriers skillfully promote the VoIP service to attract and retain users — especially those high average revenue per unit users who tend to take up more international and roaming services.

***Benefit Rating:*** Low

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Apple; fring; Kineto Wireless; Motorola; Nokia; Skype; Truphone

## 802.11n

***Analysis By:*** Tim Zimmerman; Michael J. King

***Definition:*** 802.11n is the latest wireless LAN (WLAN) standard ratified by the Institute of Electrical and Electronics Engineers (IEEE). Improvements in the technology have expanded the throughput and range that can be implemented in 2.4GHz or 5GHz. A single spatial stream operating in a 20MHz channel width can achieve 75 Mbps, compared with the 54 Mbps of a similar 802.11a or 802.11g solution. Dual-stream radios providing 300 Mbps at 5GHz using the bonded channel functionality are common in the market, and several vendors have introduced three-stream radios that can provide up to 450 Mbps. Theoretically, 802.11n is expected to deliver as much as 600 Mbps of networking performance using four spatial streams, but actual performance will depend on each vendor's implementation. Additionally, the performance of 802.11n in clients may be limited to less than the capacity of the infrastructure by the specific implementation, such as the number of antennas that are integrated into the device. Like previous 802.11 standards, 802.11n provides for a 20MHz channel width to enable backward compatibility with 802.11a, 802.11b and 802.11g (a/b/g) standards on the market.

***Position and Adoption Speed Justification:*** Since the ratification of the standard, the market movement to 802.11n has been swift. Many vendors continue to report that more than 70% of new access points being purchased are now 802.11n, although they continue to be purchased for different architecture considerations — autonomous versus coordinated, controller-based versus in the cloud, or with one, two or three integrated radios within the access point.

***User Advice:*** IT leaders should consider 802.11n for all their WLAN requirements, because there is no longer a premium to be paid, in comparison with 802.11a/b/g components. The number of radios within an access point, as well as the number of spatial streams supported and type of multiple input/multiple output (MIMO) support needed, will be determined by the enterprise WLAN requirements, including capacity and level of service. Vendors will still have points of differentiation that will not only improve wireless network performance in terms of capacity and

robustness of communication, but will also create the need for use case testing, because implementation choices will affect data, voice and video applications.

***Business Impact:*** 802.11n should be considered for all wireless LAN scenarios as mainstream adoption of the technology in small, medium or remote office environments, as well as in higher education and healthcare, continue to drive the technology deeper into the enterprise. IT organizations that have answered the call to implement wireless for conference rooms and reception areas can tackle the additional hurdles (such as voice over WLAN [VoWLAN]) that are impeding the implementation of 802.11n across the access layer. We believe that 802.11n will enable sufficient bandwidth and required capabilities (such as quality of service) for enterprises to consider moving not only data, but also voice and video for many enterprise applications to the WLAN.

***Benefit Rating:*** Moderate

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Aruba Networks; Cisco; HP; Motorola Solutions

***Recommended Reading:*** "Magic Quadrant for Wireless LAN Infrastructure"

"Toolkit: Technology Section of a WLAN RFP"

"Toolkit: Checklist for Building a Solid WLAN Access Layer"

"Critical Components of Any WLAN Site Survey"

## Multitouch

***Analysis By:*** Angela McIntyre; Jon Erensen; Leslie Fiering

***Definition:*** Multitouch refers to a touchscreen interaction technique in which multiple simultaneous touchpoints and movements can be detected and used for screen navigation or to control objects (such as sorting a series of pictures) on the screen. Various combinations of two or more fingers may be used together to create control gestures. A user may, for example, zoom into a picture or Web page by placing a thumb and an index finger on a touchscreen and then moving them apart. To zoom back out, the user would then move the same two fingers back together in a pinching motion.

Gestures can create shortcuts for performing a group of actions with a pen or a finger. The direction and shape of the gesture can dictate the exact actions. Good implementations provide visual clues regarding the effects of the gestures on the applications and even build on the gestures; for example, by providing acceleration if a "flick" or sweeping gesture is held long enough. Multitouch gestures supported by Apple's iOS are becoming a default standard. Multitouch-capable touchscreens are becoming the standard on smartphones and media tablets. But other devices, such as PCs, can use multitouch-enabled touchpad pointing devices instead of mice, as external peripherals, integrated into the keyboard of desktop PCs, or built into laptops near their keyboards. Multitouch can be implemented in multiple touchscreen technologies, including capacitive, resistive and optical.

***Position and Adoption Speed Justification:*** Products, such as the Apple iPhone, iPod touch, iPad and Android-based smartphones and tablets, are rapidly advancing the adoption of multitouch technology. The inclusion of this technology in Apple's products has attracted wide attention from competitors in these markets and vendors in adjacent markets looking to use multitouch to improve the user interface and create a differentiator with competing products.

Interest in multitouch technology is considerable, but to work well it requires tight integration between software (OS, user interface and applications) and hardware. Adapting an existing OS for multitouch capabilities takes considerable effort, but operating systems in addition to the iOS have added multitouch capabilities, including Microsoft Windows 7, the BlackBerry OS, Android, webOS, Ubuntu and Apple's Mac OS X Lion (expected in July 2011). There is strong momentum in the software application "ecosystem" for multitouch technology, and the adoption of multitouch is increasing rapidly in mobile phones, media tablets and portable consumer electronics devices. Multitouch applications on PCs have struggled to prove their value to consumers, but the inclusion of multitouch in OSX Lion accelerated consumer demand for this feature in PCs.

***User Advice:*** Multitouch is an enabling technology and does not, by itself, guarantee successful products.

Apple's successful introduction of the iPad will increase OEM experimentation on the market with new media tablet designs and innovative form factors for multitouch PCs. However, flooding the market with multitouch-enabled devices is no guarantee that consumers will embrace multitouch computing on PCs in 2011. Hardware OEMs must ensure that multitouch capabilities are tightly integrated with their devices' user interface, OS and applications.

Software developers need to ensure that their applications apply consistent gestures and user interface design rules throughout.

Semiconductor vendors targeting the touchscreen market need to provide user interface solutions and complete reference designs to capitalize on emerging opportunities. They must understand how many resources are required to customize touchscreen products for the consumer market. They must also plan ahead — using in-house software, applications and systems expertise — to shorten the time-to-market for new design wins.

***Business Impact:*** We expect multitouch-enabled touchscreens or touchpads to be widely adopted in smartphones, media tablets, notebook PCs and portable consumer electronics devices. Multitouch technology has the potential to transform the way consumers interact with the electronics they use every day, enabling totally new input and control mechanisms. As a result, multitouch will impact usage models and have a significant impact on product design. This impact can already be seen in handsets with full-screen devices lacking hardware keypads and buttons. Multitouch could have a similar impact in the PC market on the traditional keyboard/mouse input devices, especially if the media tablet form factor continues to gain traction.

In five to 10 years, PCs with multitouch are likely to grow from a negligible percentage of the market to the majority. Although most touch-enabled PCs are currently shipped for commercial use, the future transformation to multitouch PCs will be led by the consumer market and will be slower in business until touch-based applications have demonstrated proven benefits. Microsoft may lose significant market share to Apple if the Windows 8 OS does not provide a multitouch user interface on par with Apple iOS and Mac OS X.

***Benefit Rating:*** Transformational

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Acer; Apple; Atmel Corporation; Broadcom; Fujitsu; HP; Microchip Technology; Microsoft; N-trig; Next Window; Nissha; Palm; Panasonic; Synaptics

***Recommended Reading:*** "Cool Vendors in Multitouch User Interface, 2011"

"If Touch Works Everywhere Else, Why Not on PCs?"

"Dataquest Insight: Touch Technology; Will Windows 7 Do for PCs What the iPhone Did for Mobiles?"

"Dataquest Insight: Low-Cost All-in-One PCs Could Offer New Market Opportunities"

## Electronic Paper

***Analysis By:*** Jim Tully; Amy Teng

***Definition:*** Electronic paper refers to several reflective display technologies that do not require a backlight and can be viewed in conditions of moderate to good ambient illumination. They can be made very thin, producing a nearly paper-thin rewritable display that gives a similar user experience to that of printed paper. Electronic paper utilizes bistable pixels that remain in a particular state after the power is removed. For static images (for example, those typically found in e-books), this property gives electronic paper ultralow power consumption. Most of these technologies involve physical movement of (or within) the pixel to facilitate a change from light to dark, or to change color. The performance achieved has therefore been slower than other electronic displays, such as LCDs.

We class several technologies as electronic paper, including:

- Electrophoretic — This is the most mature electronic paper technology, notably supplied by E Ink. It utilizes organic plastics rather than glass, giving physical characteristics that are surprisingly rugged. The technology is based on pixels composed of charged particles suspended in a fluid. There is much interest in the development of the flexible versions of these displays, such as those produced by Polymer Vision (acquired by Wistron) and Plastic Logic. Faster versions are also being developed, with the ultimate aim of full video speeds.

- Electrowetting — An electrical charge causes a colored oil to spread across the surface of the pixel. Absence of the charge causes the oil to retreat into a tiny area at the corner of the pixel, producing a black color. The technology was developed mainly by Liquavista (acquired by Samsung).

- Micro-electromechanical systems (MEMS) — Notably driven by Qualcomm's Mirasol division, these displays employ tiny plates that move if a voltage is applied. In one position, the plate allows light to pass into the pixel and be reflected to the user as a visible pixel. In the other position, the light is absorbed.

Other related technologies use nanochemical changes, rotation of spherical-shaped pixels, and electrochromic properties.

Touch sensitivity can be added to electronic paper by adding a touch layer over the front or back of the display. Addition to the rear of the display offers the added benefit of a higher quality (and brighter) image, since reflected light does not need to pass through the touch-sensitive layer. Touch technology allows features such as the highlighting of words or adding handwritten notes in electronic books.

***Position and Adoption Speed Justification:*** The scope of this technology profile has been extended this year beyond the original monochrome electronic paper. It now encompasses several technologies, as outlined in the definition section. The position on the Hype Cycle is an average of these various subtechnologies, and we have moved it backward toward the trough as a result of this change.

The initial major applications for electronic paper are electronic books, signage (in retail and roadside applications), and small information-centric screens (in mobile phones and music

players). The most visible uses of the technology to date are in the Amazon Kindle, Sony Reader, and a number of other electronic-book products. The technology was also prominently used in Motorola's Motofone F3 mobile phone and Samsung's Alias 2 dual-hinge mobile phone. Some uses of electronic paper are clearly already in widespread use, but the real potential is for color and higher-speed versions that are still emerging.

Low power consumption is the main driver in most electronic paper applications. Low cost is another driver for low-end mobile phones and other applications such as smart labels and electronic tags and inexpensive mobile devices that do not require full-motion video. Another driver is the readability of these displays in bright sunlight, making them ideal for use outdoors and in car dashboards. These applications are likely to drive further commercialization during the next two to three years. Refresh speed and color support remain limiting factors for the current generation of electronic paper technology. The declining cost of LCDs and the increasing attractiveness of organic light-emitting diode (OLED) displays are challenging a number of application areas for electronic paper, and this is moderating some of the growth opportunities for the technology. However, the ultralow-power characteristics are unmatched by any other display technology, and this will be critically important in many applications.

***User Advice:*** Users and vendors should start to evaluate this technology in light of their specific business needs. Early adopters are likely to be in signage and in low-power consumer products. Automotive dashboard applications will also be important in view of the high contrast ratio of electronic paper.

Retailers should consider the use of smart labels or signage to facilitate price or promotional changes in store. However, ensure that the decision to deploy this technology is based on business requirements warranting use of the technology. Retail business models that have a large number of price or promotional changes on an ongoing basis can benefit from a shift to this technology, but the necessary change management associated with the execution should not be overlooked with this type of implementation.

***Business Impact:*** Use of wireless battery-powered signage is likely to bring significant benefits to some classes of business, notably in the retail sector.

***Benefit Rating:*** High

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** E Ink; Magink; Ntera; Qualcomm; Samsung Electronics; SiPix; Wistron

## AMOLED

***Analysis By:*** Tuong Huy Nguyen

***Definition:*** Active matrix organic light-emitting diodes (AMOLEDs) consist of pixels of electroluminescent organic compounds "printed" in a matrix onto a base layer. This base layer is currently glass and will be further developed to use flexible polymers in the future. Unlike liquid crystal displays, OLED displays do not require a backlight and consume very little power, making them suitable for battery-powered devices. AMOLEDs use a thin film transistor (TFT) to control the pixels.

***Position and Adoption Speed Justification:*** One of the biggest challenges for this technology is its lifetime compared with LCDs; but this depends on the application. In mobile phones, lifetime is slightly less important; because the replacement cycle ranges from 12 to 36 months, users are likely to upgrade prior to the end of life of the AMOLED. Furthermore, polymer LEDs have been

introduced in recent years and have been shown to have comparable lifetimes to LCDs. The other issue is yields, which factors into cost. AMOLED yields are approximately 60% to 70% (compared with more than 90% for LCDs). Further improvements in scale and technology for OLEDs during the next five years will allow this technology to be implemented in mass-market devices. Viewability in direct sunlight is also a problem for AMOLEDs, but the development of Super AMOLED has slightly mitigated this issue.

Although AMOLED for large (for devices 11-inches and above) continues to be too cost-prohibitive to be viable, many opportunities are available on other consumer electronic devices. Aside from mobile phones, AMOLED screens are currently used in a number of portable media players and digital still cameras. Although AMOLED displays continue to gain traction in the phone market, most AMOLED phones available are still Samsung devices. Capacity constraints have led vendors such as HTC to seek alternative display technology for their higher-end devices.

***User Advice:*** Vendors should implement this technology in their devices when pricing is competitive with LCDs. Potentially improved battery life (from lower power consumption) over LCDs should also be considered. Early adopters will have the advantage of a superior technology (such as handsets with better color, contrast and viewing angles, as well as better response times [benefiting video applications]). Vendors can also benefit from using this lower-power-consuming technology as part of their "green" initiatives. Since it is a technology value-add that consumers can easily recognize, AMOLEDs can also be used in higher-end devices to command premium retail prices.

***Business Impact:*** AMOLED screens are a lower-power, higher-performance alternative to traditional LCD screens. Recent developments have improved the life of these displays, making them competitive with LCDs. Although, AMOLED screens are more expensive than a comparably sized LCD (due to factors such as yield and scale), the manufacturing technology to make OLEDs is potentially of far lower cost (because it does not require additional components, such as a backlight or diffusers) than that used for LCDs. Moreover, OLEDs provide better color, contrast and viewing angles, as well as better response times (which are good for video and gaming applications), benefiting handset OEMs across their entire lineup. Vendors can also benefit from using this lower-power-consuming (emissive) technology as part of their green initiatives. Improved performance over LCDs will have the greatest impact in the midrange to high-end, while the cost savings will affect lower-end devices the most.

***Benefit Rating:*** High

***Market Penetration:*** 1% to 5% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Cambridge Display Technology; LG Electronics; Samsung Electronics; Sony; Universal Display Corporation

## Consumer Telematics

***Analysis By:*** Thilo Koslowski

***Definition:*** Consumer telematics are end-user-targeted vehicle-centric information and communication technologies (vehicle ICTs) and services. Network-enabled cars for consumers provide in-vehicle services, such as emergency assistance, Global Positioning System (GPS) navigation, traffic information, local search (for example, for charging stations or restaurants) and concierge services.

***Position and Adoption Speed Justification:*** As a result of growing consumer demand for telematics and vehicle ICT, automakers are increasingly exploring opportunities to offer cost-effective solutions that ensure sustainable business models without substantial upfront investments. Rather than having to develop the required technology (that is, communications hardware) and resource infrastructure (that is, call centers), in-house, automotive companies are looking to engage third-party providers with comprehensive offerings that will take over the development, management and billing of vehicle-centric services. In addition, companies are looking for automated, Web-based services that leverage online or server-based information and make it accessible in a vehicle. During the next two years, the supply chain for vehicle ICT offerings will change and focus on extending existing mobile applications and services (from the mobile and Internet services industries) to vehicles, in addition to creating specific automotive functions (for example, expanding existing application ecosystems, such as those based on Android applications, to the vehicle). Telematics service providers (TSPs) will face competition from new companies that will aggregate other third-party wireless content and develop core technological value propositions from a mobile device perspective. These companies include smaller software, hardware and content providers that target specific aspects of a holistic consumer telematics application and work closely with automakers or system integrators to ensure compatibility and reliability. Consumer telematics are also increasingly developed for the automotive aftermarket by TSPs and insurance providers.

***User Advice:*** As telematics services, applications, technology and content providers emerge, vehicle and device manufacturers (for example, consumer electronics companies) will have to choose the providers that best fit their business and technology requirements. Companies wanting to offer connected vehicle services to consumers should take advantage of the emerging offerings in the mobile- and location-based service space. The market is becoming more mature, and vendors have made significant investments in building the expertise, resources and partnerships that can help companies accelerate their vehicle ICT launches. Furthermore, vehicle manufacturers and device manufacturers must differentiate between core, vehicle-centric telematics offerings that are embedded in the vehicle (most safety and security applications) and personal telematics (primarily information and entertainment services), which consumers access by integrating portable devices with the vehicle. To enable device-to-vehicle and service-to-vehicle integration concepts, vehicle manufacturers must collaborate with consumer electronics companies, service and content providers and interfaces, and connectivity solutions. The introduction of electric vehicles (EVs) will give consumer telematics a boost, because seamless EV ownership experiences will greatly benefit from connected data services (for example, finding the next charging station and informing drivers of the available range left).

Consider your choices in a growing vendor supply chain by identifying best-of-breed technology providers instead of a single-solution approach. Both approaches have their benefits and disadvantages, but with increasing in-house expertise for the connected vehicle, automotive companies can be more selective in their partner choices to better balance innovation and cost objectivity factors (for example, innovation from connected vehicle offerings should reside with the automakers).

***Business Impact:*** Consumer telematics provide an opportunity to differentiate product and brand values (for example, infotainment access and human-machine interface experience), to create new revenue sources (subscriptions and mobile commerce), to collect vehicle-related quality and warranty information via remote diagnostics, and to capture consumer insights.

***Benefit Rating:*** High

***Market Penetration:*** 20% to 50% of target audience

***Maturity:*** Adolescent

***Sample Vendors:*** Airbiquity; ATX Group; Cross Country Automotive Services; Google; Hughes Telematics; Microsoft; Nokia; OnStar; WirelessCar

***Recommended Reading:*** "OnStar Anywhere Brings Telematics Service to All Auto Brands"

"U.S. Consumers Put Vehicle ICT Back on Their Wish Lists, but Feature Priorities Are Changing"

"OnStar Selects Android to Expand Its Ecosystem"

## Phone-Based Authentication Methods

***Analysis By:*** Ant Allan; Avivah Litan

***Definition:*** Phone-based authentication methods are those that make use of a mobile phone as an authentication token.

There are two popular options (see "Q&A: Phone-Based Authentication Methods"):

- A one-time password (OTP) software token for a mobile phone, which allows the phone to be used like a traditional OTP hardware token with a display and PIN pad
- An out-of-band (OOB) authentication method, in which a user and an authentication server exchange authentication information over a different channel from the one between the endpoint and the server

In both cases, the same mechanism can be used to provide transaction verification. While this is an important component of online customer security, especially in financial services, transaction verification is out of scope for this profile.

A few vendors now offer phone-based authentication methods based on X.509 credentials (keys and certificates), but we see little adoption as yet.

Some vendors offer biometric authentication methods using voice recognition, face topography or iris structure, which can exploit a smartphone's mic or user-facing camera as a capture device. But these are outside the definition of phone-based authentication methods discussed here.

***Position and Adoption Speed Justification:*** Phone-based authentication methods leverage "tokens" that users likely already possess, given the high market penetration of mobile phones, and provide a lower total-cost-of-ownership (TCO) alternative to OTP hardware tokens in some use cases.

In the consumer space, many banks have implemented OOB authentication using SMS or voice telephony during the past few years. With the ubiquity of SMS support on mobile phones in Europe and Asia/Pacific, OOB authentication using SMS has proved to be the most popular method in these regions. But while OOB authentication is often preferred by users over OTP hardware or software tokens, some users may have concerns about costs or liabilities or reject "unexpected" SMS messages as spam.

In other vertical industries, many enterprises have implemented OOB authentication for workforce remote access. Often, this is for lower-risk access (such as workforce self-service portals) or for contingent use (for example, enabling secure remote access for all in a business continuity context), but some enterprises are using it as a full substitute for OTP hardware tokens for VPN access to the corporate network.

The visibility of phone-based authentication methods increased over the past year, most notably when Google (in 2010) announced that it was offering both OTP software tokens for phones and

SMS-based OOB authentication for access to Google Apps, and when Facebook (in 2011) announced it was enabling SMS-based OOB authentication for user access

However, we have seen successful attacks against OOB authentication in online banking (see "Q&A: Phone-Based Authentication Methods" and "Where Strong Authentication Fails and What to Do About It"), lowering the level of assurance that can reliably be provided. But enterprises must take care to distinguish between attacks that can compromise a particular authentication method, allowing an attacker to masquerade as a legitimate user, and attacks that compromise the session post-authentication, which can circumvent whatever authentication method was used, allowing transactions to be manipulated.

OTP software tokens for mobile phones are less popular, but enterprises tend to prefer them for users with time-critical remote access needs, because OOB authentication methods can be vulnerable to cellular-network coverage, availability and latency problems. OTP software tokens also provide higher assurance than OOB authentication methods, and so suit higher-value access. Some vendors are driving adoption by offering zero-cost OTP software tokens (which still require licensed authentication infrastructure software or services, however).

The value of a phone as a token is eroded when the phone itself (rather than the user's PC) is the endpoint: The "second factor" is no longer distinct in this case, and the level of assurance falls. We note that some regulations explicitly require tokens to be separate from the endpoint (for example, the DEA interim final rule that mandates the use of "two-factor authentication credentials" for practitioners who sign electronic prescriptions; see "Good Authentication Choices for Healthcare Delivery Organizations"). For higher-risk use, enterprises must return to using discrete tokens (which we believe users will resist) or seek an additional or alternative method, such as biometric authentication (see "Q&A: Biometric Authentication Methods"). Note that, for example, biometric voice recognition can augment voice-based OOB authentication to provide a higher level of assurance.

However, phone-based authentication methods alone may still be suitable for medium-risk use cases. It is now evident that there is a significant volume of use cases where this is appropriate, that the incidence of these use cases is rapidly increasing, and thus that there will be productive use of phone-based authentication methods and adoption by 20% to 50% of the market within the next few years. Hence, Gartner has revised its projection that these methods will take more than 10 years to reach the plateau.

***User Advice:*** The popular phone-based authentication methods are a viable alternative to traditional hardware tokens for employee remote access and online external customer security. However, as for any authentication method, an enterprise must evaluate the potential benefits of phone-based authentication against the needs of each use case (see "How to Choose New Authentication Methods"), and choose among the options on the same basis.

Phone-based authentication methods have several advantages over OTP hardware tokens, X.509 smart tokens and the like:

- They eliminate the purchase and distribution costs of dedicated devices.
- End users do not have to remember to carry a dedicated device and will tend to take more care of a phone than a (to them) less useful device.
- A single phone can support OOB authentication and OTP software tokens from multiple organizations, so the user has only one device to carry.

OOB authentication to a mobile phone depends critically on network coverage and availability, and OOB authentication using SMS depends critically on network latency (although some vendors can address these issues, for example, by presending OTPs). OOB authentication may

be charged either per user per year or per transaction, depending on the vendor, with a per-transaction pricing model generally being more advantageous for low-volume users.

While OOB authentication using voice is typically more expensive than that using SMS, it is generally more reliable (no latency), provides better forensics (call logging) and can capture a recording of the user's voice for nonrepudiation and forensic purposes, or incorporate biometric voice recognition for higher levels of assurance and accountability. A risk with voice calls is that they can be illegitimately forwarded to unauthorized users' phones, whereas SMS messages cannot.

OTP software tokens offer a more robust solution than OOB authentication alone, approaching the reliability and level of assurance of OTP hardware tokens. However, users require a suitable smartphone, which not everyone will have. Depending on vendors' pricing schemes and usage volumes, the TCO for OTP software tokens may be higher or lower than for OOB authentication; they are typically lower cost than hardware tokens, and as mentioned earlier, some vendors offer them at zero cost. Enterprises must take into account the cost of over-the-air provisioning, registration and personalization, likely for multiple mobile operating systems (OSs) — Apple iOS, BlackBerry, Google Android, Symbian, Windows Mobile and so on.

Even though phone-based authentication methods may have been made obsolete for higher-risk use cases by the rise of the phone itself as the endpoint, it remains a viable method in at least the short term to midterm for low-to-medium-risk use cases and for users accessing services via their PCs.

However, as noted above, phone-based authentication methods — like any others — can be defeated by various attacks (see "Where Strong Authentication Fails and What You Can Do About It"). The best defense against trojan-based attacks that can compromise user transactions entered via the original channel (between the user's PC and the server) is to implement a layered fraud prevention approach (see "The Five Layers of Fraud Prevention and Using them to Beat Malware"), which includes OOB transaction verification, so that the user verifies the transaction details (for example, received in a text message). We recommend that the verification assertion use the OOB channel as well, to avoid any risk in using the potentially compromised originating channel. Mechanisms that generate a digital signature on the phone to provide transaction verification are emerging.

***Business Impact:*** Phone-based authentication methods provide authentication in a form that is independent of any particular PC or OS, at a lower cost than traditional OTP tokens, and with greater convenience for the user. Like OTP tokens, they enable user mobility and avoid the difficulties with remote technical support that X.509 smart tokens can run into. Furthermore, these methods help with "green" IT initiatives, because they avoid the need for further devices that will have an environmental impact.

Some phone-based authentication methods can provide additional value through transaction verification via the same mechanism (see "Q&A: Phone-Based Authentication Methods" and "Transaction Verification Complements Fraud Detection and Stronger Authentication"). This additional capability is not reflected in the benefit rating here: In situations where transaction verification is pertinent, the rating for combined phone-based authentication and transaction verification may be "high."

***Benefit Rating:*** Moderate

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Anakam; Authentify; Diversinet; Entrust; Fronde Anywhere; PhoneFactor; Quest Software; RSA (EMC); SecurEnvoy; SMS Passcode; Symantec (VeriSign); Technology Nexus; ValidSoft

***Recommended Reading:*** "A Taxonomy of Authentication Methods, Update"

"How Much Is That Token In the Window: What You Can Expect to Pay for New Authentication Methods"

"How to Choose New Authentication Methods"

"Where Strong Authentication Fails and What You Can Do About It"

"Q&A: Phone-Based Authentication Methods"

"The Five Layers of Fraud Prevention and Using them to Beat Malware"

## Embedded Cellular Data

***Analysis By:*** Hugues J. De La Vergne

***Definition:*** Cellular data implementations are embedded in notebooks, as well as in media tablets and other small form factor devices. The cellular or wireless WAN technology embedded in notebooks is typically wideband code division multiple access (WCDMA) or High-Speed Packet Access (HSPA). Some modules, primarily in emerging markets, also support cellular data standards, such as general packet radio service, Enhanced Data Rates for Global Evolution/HSPA or cdma2000 Evolution Data Optimized, which includes Revision 0, Revision A and radio transmission technology. Recently, modules that also support Long Term Evolution (LTE) were launched in many key markets, such as the U.S. Chips, such as Gobi from Qualcomm, have entered the market, providing close to global support of various standards and some level of upgradability.

***Position and Adoption Speed Justification:*** In the past, the volatility of cellular technology, and the limitations on roaming and expensive data plans made embedded cellular data impractical for broad deployment. However, cellular data has enjoyed a period of relative stability because of the launch of high-speed technologies, such as HSPA and the availability of LTE from 2010 through 2012, which greatly improves the Web-browsing experience. LTE speeds are fast enough such that LTE will be the driver that will give consumer electronics producers the confidence to embed cellular connectivity into CE devices. LTE should provide a stable platform for at least the next 24 to 36 months, which is key as many embedded CE devices have a 24- to 36-month life cycle. We have seen carriers starting to adopt daily or monthly pay-as-you-go service plans with a daily/monthly roaming cap that can reduce costs and speed up the ROI of buying embedded cellular data cards for a broader variety of users.

Embedded cellular data will be driven by end users who need to have their consumer electronic devices and laptops connected to the Internet. Although we have seen operators get more aggressive with rate plans in certain regions, high rate plans remain the largest impediment to growth. Many end users are paying for wired broadband at home and have a smartphone data plan and view potentially $40 to $50 per month for each additional device to be too expensive. Growth will expand much more quickly once operators move toward a "bucket" of data for individuals that they can allocate between their devices, similar to voice family plans that give the user the ability to share minutes between all mobile devices on their plans. Gartner expects these changes to expand rapidly in the coming 12 months as embedded modems grow from 68.4 million units in 2011 to surpass removable modems in 2012 with sales of 116.9 million units. Growth continues in the later years driven by products, such as media tablets and embedded modems, which will reach 333.1 million units in 2015.

***User Advice:*** Consider embedded cellular data technologies for vertical applications that have predictable use patterns and a clear ROI case. Also consider embedded cellular data technologies for targeted segments of the horizontal user population as the life cycle of embedded cellular data cards becomes more closely aligned with laptop replacement cycles, as technologies for upgrading modules improve and as pay-as-you-go service plans align closer with specific user requirements.

***Business Impact:*** Embedded cellular data technology will affect telecom strategies and economics for mobile users with notebook computers, media tablets and other connected form factors as organizations choose from a variety of wireless communications options. This move will have sourcing implications, because notebooks with embedded cellular data are being subsidized by mobile operators. Devices with bundled communications, such as e-book readers, personal navigation devices, digital photo frames and entertainment devices, offer business opportunities as well.

***Benefit Rating:*** Moderate

***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Early mainstream

***Sample Vendors:*** Dell; Fujitsu Technology Solutions; HP; Lenovo

***Recommended Reading:*** "Changes Coming for Embedded 3G in Notebooks"

# Off the Hype Cycle

## GPS

***Analysis By:*** Annette Zimmermann

***Definition:*** GPS is a global positioning technology that was introduced in the U.S. in 1996, and was originally developed for military purposes. To determine the position of a mobile device, the GPS system uses from two to six of its 24 satellites to a high level of accuracy — of within just a few meters.

***Position and Adoption Speed Justification:*** All the main handset vendors have adopted GPS in their portfolios. The technology has proven its functionality and reliability in the portable navigation device market, and has become even more relevant in the cellular device market — where the demand for rich media and applications such as social networking is growing. This trend has become even more evident with the launch of free navigation services by Nokia and Google.

There are other, less accurate, positioning technologies; for example, Cell ID positioning via the mobile network, or Wi-Fi — which has very low coverage in rural areas. These technologies will coexist, because certain services, such as friend-finder applications or location-based advertising, do not necessarily require high accuracy, and Wi-Fi and Cell ID serve as a fallback when GPS is not available (indoors or in "urban canyons"). Nevertheless, for car navigation, pedestrian navigation and (most importantly) emergency locating, GPS is the state-of-the-art technology.

There are other satellite systems developed in Europe (Galileo), China and Russia (Glonass) that are independent of the U.S. GPS system. Combined Glonass/GPS receivers have been on the market for several years, predominantly used by land marking and monitoring companies. Glonass/GPS chips for phones are currently being tested and the first device was launched in 2Q11. GPS and the Galileo system are also compatible; however, due to the delay of the latter (with its launch expected in 2014), the first chipset will not be tested and launched before 2012.

Galileo offers a few advantages over GPS: while the latter is under military control, the new system will be under civil control; also, Galileo is expected to deliver even higher accuracy. The European system will serve multiple purposes and industries, public services and commercial and governmental/emergency applications. However, it is obvious that penetration of Galileo-enabled devices will be low in the beginning, at least in the private sector.

Despite a number of shortcomings (including relatively high battery consumption, and the failure to work indoors) we moved GPS off the Hype Cycle this year. The technology has becomes a standard feature in devices with an open OS; not only at the high end, but also entering the midrange. Examples include Samsung's bada devices, several Android-based devices and Nokia's midrange Symbian devices.

***User Advice:*** Device vendors should consider complementary technologies; for example, gyroscopes, which enhance the experience of GPS-enabled services.

Enterprise users should evaluate the potential cost savings and productivity gains with GPS services — beyond resource and fleet tracking.

Enterprises relying heavily on navigation services should monitor the development of the GPS satellite replacements and think of alternatives in case of failure. It is worth noting that there is currently no alternative technology that can enable navigation solutions with the same accuracy and ubiquity.

***Business Impact:*** GPS-based services, such as pedestrian navigation, provide revenue opportunities for operators and service providers — keeping in mind flexible pricing schemes. The share of enterprises using mobile GPS applications is growing in the areas of CRM, sales force support and navigation. There are a few players, such as Antenna Software, that focus on providing geo-enabled platforms to enterprises; so that they can provide their sales force with supporting information while on the road, and track their field staff. These services have multiple benefits, because they increase the visibility of workforce location — and improve resource allocation and optimization while having the potential to increase mobile employee productivity.

***Benefit Rating:*** High

***Market Penetration:*** More than 50% of target audience

***Maturity:*** Off the Hype Cycle

***Sample Vendors:*** Apple; Garmin; HTC; LG; Motorola; Nokia; Research In Motion (RIM); Samsung; Sony Ericsson; TomTom

***Recommended Reading:*** "Cool Vendors in Context-Aware Computing, 2011"

"Cool Vendors in Consumer Mobile Services, 2011"

## Mobile Widgets

***Analysis By:*** Carolina Milanesi; Nick Jones

***Definition:*** Mobile widgets are small, usually simple, applications built using Web technologies such as JavaScript, XML, HTML and style sheets. Widgets are stored on a handset and are executed locally by a widget engine, which may be provided by the mobile browser or as a separate tool. Most widget technologies are available on smartphones; some are available on less-capable, enhanced phones. Widgets are a form of mobile application and, as such, can be downloaded from application stores and other mobile content providers.

***Position and Adoption Speed Justification:*** Widgets are not as capable as native binary applications, but can access Web services and are used to deliver a wide range of simple utilities, such as weather forecasts, ATM finders, social networking and stock tickers. Although standardization work is under way by the World Wide Web Consortium (W3C), there are many incompatible mobile widget technologies and frameworks, including Qualcomm Plaza, Bondi widgets, Opera widgets, Nokia Web Runtime, Yahoo mobile widgets and Access NetFront widgets. Mobile widgets also inherit the restrictions of mobile Web applications, such as the lack of standard ways to access many handset application programming interfaces. We have retired mobile widgets from the Hype Cycle because the technology is becoming absorbed into the wider market for Web and native application development technologies and tools, including HTML5 and the tools that deliver it.

***User Advice:*** Despite portability challenges, widgets provide a technology that can deliver simple applications to a large number of handsets using well-understood technology. Although fragmentation means that it may be necessary to create several versions of a widget to address a wide range of handsets, mobile developers should consider widgets for simple applications, especially those running on smartphones and accessing Web services.

***Business Impact:*** Widgets have had a high impact. They became one of the most popular technologies to deliver simple mobile applications that are platform-independent. For developers wanting to develop once and deploy to many, widgets were a good tool to do that. However, the enhancements on HTML5 have shortened the opportunity for mobile widgets, making this technology obsolete before it reached the Plateau of Productivity.

***Benefit Rating:*** Moderate

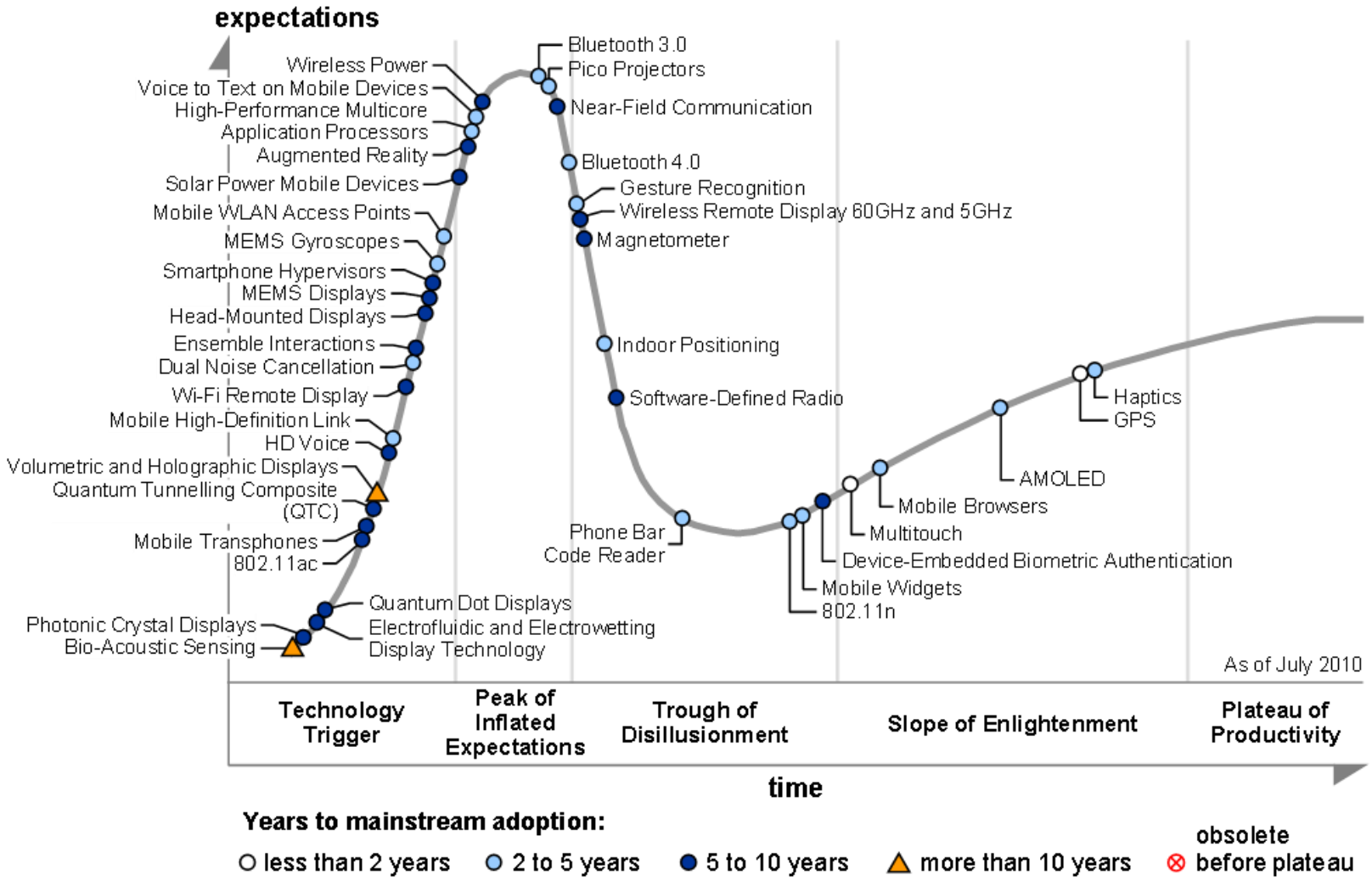
***Market Penetration:*** 5% to 20% of target audience

***Maturity:*** Off the Hype Cycle

***Sample Vendors:*** Nokia; Opera; Qualcomm; Yahoo

## Appendixes

**Figure 3. Hype Cycle for Mobile Device Technologies, 2010**



**Source: Gartner (July 2010)**

## Hype Cycle Phases, Benefit Ratings and Maturity Levels

### Table 1. Hype Cycle Phases

| Phase | Definition |
|---|---|
| *Technology Trigger* | A breakthrough, public demonstration, product launch or other event generates significant press and industry interest. |
| *Peak of Inflated Expectations* | During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers. |
| *Trough of Disillusionment* | Because the technology does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales. |
| *Slope of Enlightenment* | Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process. |
| *Plateau of Productivity* | The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase. |
| *Years to Mainstream Adoption* | The time required for the technology to reach the Plateau of Productivity. |

**Source: Gartner (July 2011)**

### Table 2. Benefit Ratings

| Benefit Rating | Definition |
|---|---|
| *Transformational* | Enables new ways of doing business across industries that will result in major shifts in industry dynamics |
| *High* | Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise |
| *Moderate* | Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise |

| Benefit Rating | Definition |
|---|---|
| *Low* | Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings |

**Source: Gartner (July 2011)**

### Table 3. Maturity Levels

| Maturity Level | Status | Products/Vendors |
|---|---|---|
| *Embryonic* | • In labs | • None |
| *Emerging* | • Commercialization by vendors<br>Pilots and deployments by industry leaders | • First generation<br>High price<br>Much customization |
| *Adolescent* | • Maturing technology capabilities and process understanding<br>Uptake beyond early adopters | • Second generation<br>Less customization |
| *Early mainstream* | • Proven technology<br>Vendors, technology and adoption rapidly evolving | • Third generation<br>More out of box<br>Methodologies |
| *Mature mainstream* | • Robust technology<br>Not much evolution in vendors or technology | • Several dominant vendors |
| *Legacy* | • Not appropriate for new developments<br>Cost of migration constrains replacement | • Maintenance revenue focus |
| *Obsolete* | • Rarely used | • Used/resale market only |

**Source: Gartner (July 2011)**

## RECOMMENDED READING

*Some documents may not be available as part of your current Gartner subscription.*

"Understanding Gartner's Hype Cycles, 2011"

"Competitive Landscape: Connected Handheld Gaming Devices"

"Contextual Smartphone Applications Will Exploit Augmented Reality"

"Emerging Technology Analysis: Augmented Reality Shows What Mobile Devices Can Do"

"Emerging Technology Analysis: MEMS Displays Cut Mobile Device Power Consumption"

"Emerging Technology Analysis: Voice-to-Text on Mobile Devices"

"Forecast: Consumer Location-Based Services, Worldwide 2008-2014"

"Forecast: Connected Mobile Consumer Electronics, Worldwide, 2008-2015, 1Q11 Update"

"Forecast: Mobile Devices, Worldwide, 2008-2015, 1Q11 Update"

"Cool Vendors in Consumer Devices, 2011"

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