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The Future will be... Worn

Mobile

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Point-of-View

Highlights

- Wearable technology has exploded in popularity as the devices have grown smaller and better able to interact with other systems. Experts see global sales of wearables hitting $30 billion by 2018.
- Today's wearables market is dominated by devices designed to help individuals pursue personal fitness and wellness goals. But this is likely just a start.
- Health and medical wearable sales are seen rising 30% a year. Infotainment devices are so popular that the segment might soon surpass fitness and wellness as the wearables category leader.
- Tomorrow's wearable innovations will likely emerge from efforts to overcome today's technological inhibitors, such as the need for better and smaller power sources and greater security.
- IBM® does not build wearables but we can help clients find success in the market using our IBM MobileFirst™ solutions, IBM cloud platforms, the new Apple-IBM partnership, and more.

Wearable technology trend is here to stay

Imagine viewing the earth from outer space without needing to travel. Or repairing an appliance without opening a user manual. Or leaving the hospital, worry-free, just hours after surgery. Whether it's an augmented reality device, a head-mounted display screen, or a remote medical monitor, wearable computing is turning science *fiction* into science *fact*.

Wearable computers or wearables are small electronic devices that are worn on or very near a person's body. Most of today's wearables are used simply to collect and display information about the person wearing them, or for creating and consuming visual and aural media. But because they can support complex computations, wearables have potential to move beyond just the execution of pre-coded logic. This makes the future of wearables virtually open-ended.

Wearable computing is booming as the devices become more sophisticated and can interact with more external systems. Most wearables support application programming interfaces (APIs), so developers can build additional applications and services that interact with the device-generated data. And because wearable devices provide unprecedented levels of information about the people wearing them (and their surroundings), they are enabling a new class of analytics and cognitive systems that many experts believe will fuel the future of information technology.

It's worth noting, too, that while the types of wearable computers and the uses for them are expanding, there are still some key inhibitors that could serve to limit continued expansion in the future. Any examination of the wearable space must keep these challenges in mind.

Wearables history and market

Today's wearables market is starting to take shape, with distinct market segments already emerging and well-known companies already offering wearable products. Yet, to fully understand the wearables of today, we must first consider how the devices have evolved.

The concept of wearing, rather than simply carrying, a helpful tool or implement is not new. The development of wearable devices goes all the way back to body-mounted abacuses and the earliest corrective optics.

Wearable innovations

It wasn't always clear at the time, but looking back, we can see some clear milestones on the road to the advanced wearable devices of 2015 and beyond:

- 1268: The first published reference to the use of lenses to correct human eyesight.
- 1759: The first practical wearable mechanical device, a pocket watch used to accurately measure distance at sea.
- 1961: The first computer considered to be wearable, a cigarette-pack sized analog device said to predict roulette wheel results at gambling casinos.
- 1980s: The first consumer wearables to gain wide popularity: the Sony Walkman cassette player and the Casio CFX-400 factorial calculator wristwatch.
- 1993: MIT grad student Thad Starner dons a wearable computer system designed in conjunction with Doug Platt, also of MIT, and, essentially, never takes it off. Starner, who would go on to lead development of Google Glass, is said to still wear a much-evolved version of the device today.

Figure 1 Wearable PC prototype from 1990s IBM TV ad

- 1997: IBM releases a wearable computer prototype and features it in its advertising (see Figure 1). Four years later, IBM unveils a prototype computer wristwatch based on the Linux operating system and offering wireless connectivity and X11 graphics.
- Early 2000s: Additional, more advanced consumer wearables are released with limited success, including the Fossil Wrist PDA and Poma, a wearable computer from Hitachi.
- Late 2000s: Chinese companies begin to release commercial versions of wristwatches that contain mobile phones.
- 2010s: Standards begin to emerge to govern wearable computer interaction and communication using Bluetooth, Wireless Personal Area Network (WPAN), and Wireless Body Area Network (WBAN).

Today, with the advent of next generation wearables such as smart glasses, fitness devices, and smart watches, wearable computing has reached a new plateau. Leading companies such as Samsung, Motorola, Google, and Apple are launching (or will soon launch) new wearable products, and IBM is developing solutions and middleware for the wearables industry.

Modern wearables have become more compact, aesthetically pleasing, and enjoyable to wear. The usability of wearable computing has improved by using voice and other innovative controls, and the applicability of wearable computing to real life is becoming clearer.

Today's wearables market

Wearable devices have already become more integrated with our daily lives, reaching into areas such as health and fitness, information and entertainment, healthcare, and even military operations and manufacturing. And the market keeps growing.

BCC Research, a respected market research company, has projected that worldwide sales of wearable devices will grow to $30.2 billion by 2018.[1] Of that total, the BCC report estimated that more than $22 billion will be spent on consumer-oriented wearables such as smart watches, fitness monitors, and so on, which it called "the fastest moving segment overall." The remainder will be spent on non-consumer devices such as those used in hospitals and in the military, according to the company's projections.

So where is all this wearables revenue coming from? And what kinds of wearables are expected to gain popularity fastest?

This document groups the devices into four general market categories that have been adopted by the wearables industry. Here are the segments and a brief explanation of where each stands today.

[1] *BCC Research Publishes New Report on Global Market for Wearable Computing Devices*, http://www.bccresearch.com/pressroom/ift/global-market-wearable-computing-devices

Fitness and Wellness

This is one of today's largest wearables segments and includes devices to monitor information about a person's health and fitness and then analyze and optimize that data for the user's specific needs. Already there are activity sensors that can measure distances walked or run, floors climbed, and calories burned. There are intelligent monitors that can track personal goals such as speed, heart rate, respiration, and even post-workout sleep patterns. And in the future, wearable technology now used mostly in medical settings will enter the health and fitness segment, with consumer wearables that will monitor blood pressure, glucose, blood-oxygen levels, hydration, and overall fatigue.

Demand in this segment is coming from various user groups such as professional athletes, recreational fitness enthusiasts, and managers of corporate wellness programs. A recent report from Consumer Electronics Association projects that more than 20 million personal health and fitness devices will be shipped in 2015, generating revenue of more than $1.8 billion (US).[2] Vendors that are already active in the fitness and health segment include Apple, Fitbit, Garmin, Jawbone, Nike, Polar, Sunto, and Timex.

Healthcare and Medical

Wearables in the healthcare and medical segment (sometimes called mHealth) are used for both therapeutic and rehabilitative purposes, helping patients and medical professionals track vital signs and symptoms using monitors that continuously measure vital organ activity, blood pressure, glucose level, muscle movements, and so on, without affecting the wearer's regular activities. This helps in evaluating the ongoing effectiveness of medications such as insulin and in monitoring patients after tests or procedures have been performed. Some of these devices transmit data to a continuously monitored central point or system, enabling an extra layer of patient oversight and that some experts think will help reduce mortality rates. Growing demand for in-home healthcare will only increase this trend and make wearable devices essential for both physicians and patients.

Another market research firm, Technavio, predicts that the Healthcare and Medical piece of the wearables market will more than triple by 2019, with growth projected at nearly 30% per year, due mostly to the aging population and an expected increase in conditions, such as diabetes management, that are ripe for wearable innovation.[3] Vendors that are already active in the healthcare and medical segment include Alivecor, GE, Imec, Medtronics, and Siemens.

Figure 2 Infotainment, fitness, and military wearables

Infotainment

This segment covers wearable devices that are used for information and entertainment, specifically the sending and receiving of real-time data about your physical environment, events in the news, various forms of recreation and amusement (including social media and gaming), and lifestyle applications such as smart clothing. Current trends indicate that Infotainment will eventually surpass today's wearables category leader, Fitness and Wellness, thanks to expected robust growth in the sale of smart watches, smart glasses, and in-vehicle wearables.[4]

[2] *Record-Breaking Year Ahead: CEA Reports Industry Revenues to Reach All-Time High of $223.2 Billion in 2015*, http://www.ce.org/News/News-Releases/Press-Releases/2014/Record-Breaking-Year-Ahead-CEA-Reports-Industry-Re.aspx

[3] *TechNavio Says the Global Smart Wearable Healthcare Devices and Services Market Will More Than Triple by 2019*, http://www.marketwatch.com/story/technavio-says-the-global-smart-wearable-healthcare-devices-and-services-market-will-more-than-triple-by-2019-2015-03-20

[4] *Global Wearable Technology Market is Expected to Reach USD 5.8 Billion in 2018*, http://www.prnewswire.com/news-releases/global-wearable-technology-market-is-expected-to-reach-usd-58-billion-in-2018-transparency-market-research-186754711.html

Google's early Google Glass devices and the 2015 introduction of the Apple Watch have brought added credibility and increased awareness of wearables for Infotainment. Continued growth in the gaming industry is also driving the development of new Infotainment wearables, particularly so-called *augmented reality devices* and *heads-up displays* that can enhance the gaming experience. And as the sector grows, it will expand into areas such as in-vehicle wearable integration (such as cameras and sensors capable of feeding road-hazard information to a driver's head-mounted display), devices for assisted tourism, and personal safety devices. Vendors already competing in this space include Apple, Google, LG, Oculus, Razor, and Samsung.

Industrial and Military

The use of wearable computing devices is now *expected* in certain industries, and in particular among soldiers and military personnel. Wearables in this segment are typically aimed at improving safety and efficiency, increasing accuracy, or gaining greater awareness of one's surroundings, whether on the battlefield or, when applied to industry, a busy manufacturing floor.

Military and industrial uses of wearable computing already include augmented reality headsets that offer hands-free access to maps, maintenance guides, and other information about specific tasks. There are also arm-mounted or leg-mounted terminals, smart glasses, and even smart clothing that can continuously track and transmit the user's location or detect the presence of dangerous gases. Vendors already competing in this space include Eurotech, Honeywell, iKey, Motorola, Nymi, and Parvus.

The future of wearables

We've just mentioned some of the most frequently talked about wearable innovations of the future, from new ways to monitor the sick to wearables that could make it safer to drive a vehicle.

But predicting the future of wearables would require the proverbial crystal ball. The nature of innovation is that it surprises us.

The driving forces of innovation are easy to identify, however. The biggest advances, the game-changers, typically emerge from efforts to overcome inhibitors and limitations that were once thought insurmountable.

To see the future of wearables, try to envision how tomorrow's great thinkers will defeat today's most difficult technical challenges.

Key inhibitors and challenges

Here are the leading technological and societal factors that are expected to inhibit growth and drive innovation in the wearables market for the foreseeable future:

- **Power**

  The biggest technical challenge is power. Wearable devices, by nature, are small and mobile, so they require small, efficient batteries to operate.

  Current social and environmental trends favor rechargeable rather than disposable batteries, but they must be easy to recharge and capable of powering a device for at least one typical usage cycle (such as a complete work shift or 24-hour period) without recharging.

  Alternatives to batteries are being developed, including new types of clothing with built-in solar panels. There is also ongoing research into smart textiles, including non-invasive piezoelectrical fibers that generate electricity as they are stretched.

  A related challenge is heat, because any device that consumes power must also dissipate heat. Here again, smart textiles could provide an answer by employing cooling fibers based on melt/resolidify technologies (which could have a side benefit of cooling for the wearer, too).

- **Network bandwidth**

  As wearables proliferate, demands on their supporting Wi-Fi and cellular networks will grow. And while network coverage areas continue to expand, the bandwidth needs of these *always on* devices, which often transmit or receive streaming content, will further stress public and enterprise networks.

- **Pricing and aesthetics**

  For consumer-oriented wearables, price and aesthetics are the biggest potential inhibitors. Adoption rates will depend greatly on the price of each new device and the cost to connect it to appropriate networks. Luckily for consumers, technology prices typically go down over time. However, other, less predictable factors will also influence adoption rates, such as size, form factor, and overall usability. Body placement and each user's personal sense of fashion, including the ability to conceal the device when wanted, will also be important.

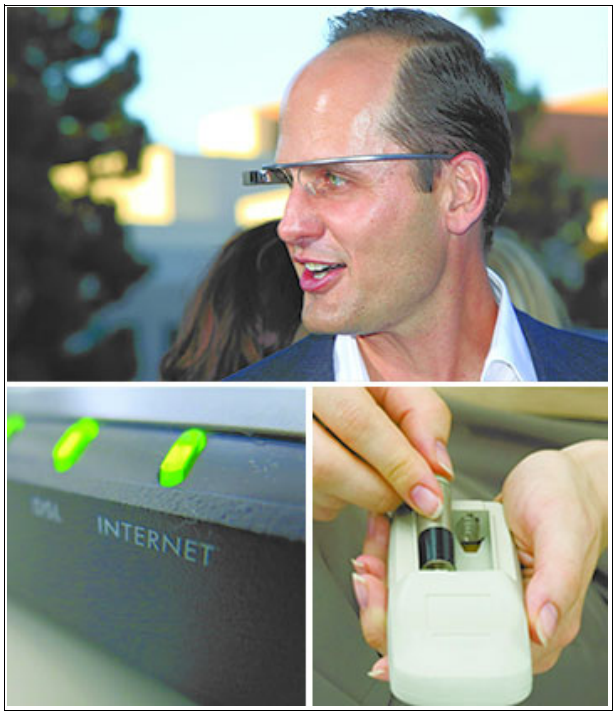

Figure 3 Challenges: Aesthetics, power, and bandwidth

- **Workplace culture and adoption**

  Inhibitors must also be overcome in the workplace. Enterprises that already face security-related complexities in permitting camera-equipped smartphones to be used at work must now expand their bring-your-own-device (BYOD) policies to cover wearables. Yet, while smartphones are relatively easy to spot when carried into a work environment (and easy to turn off if the company requires it), wearables are more readily concealed and in some cases cannot be turned off. And if they are used for confidential work-related activities, additional challenges emerge in encrypting and protecting the data being accessed.

  Even wearable users face adoption challenges. Users who might already have difficulty managing their notebook or desktop PC must now learn to manage additional devices with comparatively few interface options and immature support programs. There are cultural challenges, too, as witnessed in the backlash that arose with the release of Google Glass. The potential that a wearable device can record images and audio of others without their knowledge has raised serious concerns, with many organizations and institutions outlawing the use of such devices on their premises.

- **User interaction**

  The nature of wearable devices restricts the ways users can interact with them. There might be room for a button or two, and perhaps a touch-sensitive area (such as the temple piece on Google Glass), but wearables typically have very limited displays and provide only minimal physical feedback. In fact, the relative difficulty of interaction and the lack of so-called killer apps are typically cited as reasons for the higher-than-normal return rates witnessed thus far for the latest generation of smart watches.

  The need for easy user interaction will make hands-free and voice-activated operation a key attraction of future wearable devices, provided that limitations regarding background noise and vocal accents can be overcome. Another alternative is to interact with the wearable through a companion app on a mobile device, such as a smartphone or tablet. This expands interface options but adds complexity and potential confusion as to which app controls each of the user's wearable devices. Still another application would be the use of wearable keypads or gesture-tracking devices capable of controlling everything from televisions to industrial robots.

- **Accessibility**

  Even when using notebooks and desktops, where there is ample power, storage, and connectivity, accessibility by differently abled individuals is a daunting challenge. The issue may be even greater for wearables given the limited interface options described earlier.

  Voice interfaces on wearable devices can help users overcome some physical impairments, but they are subject to poor microphone performance and background noise and can fail due to vocal accents or impaired speech. Visual interfaces are complicated by variable lighting conditions, display translucence (which makes some things difficult to read against certain patterned or colored backgrounds), and the demands of protective and prescription glasses.

- **Security**

  Consumer wearables can collect data ranging from the user's physical location to personal fitness and health details, while wearables used in industry can transmit confidential business plans and trade secrets. So the devices must be configured to protect the data they collect and the interfaces they use to communicate with the wearer, with other devices, or with remote systems (an interaction which, while required by some manufacturers, can violate some companies' IT security rules). And as the segment expands and users start wearing multiple devices at once, additional steps will be needed to prevent one device from interfering with or taking control of another device, whether

accidentally (due to network conflicts, for example) or intentionally (such as to display advertising).

The security threats with wearables go in both directions. When a leading US government official had a wirelessly controlled heart pacemaker implanted, concerns that hackers could gain illicit access to the device ultimately led officials to modify it to prevent that from occurring. But what if the user of the device does the hacking? Could an unscrupulous employee claim a fitness incentive bonus or insurance discount by altering the signals from his company-supplied fitness monitor to report regular daily exercise that never really happens?

- **Privacy**

With wearables, as with other devices, user privacy can be a relative term. A person who is willing to share her fitness monitor data with a healthcare provider might not want to share that same data with her employer. But what if the device is owned by her employer? Could the employer require access to that fitness data as a condition of employment? It's easy to see why privacy is a complex issue.

Privacy concerns also arise from non-wearers, since the presence of wearable devices may be difficult to discern. Privacy advocates found it easy to spot the first Google Glass wearers, and there were reports of confrontations over potential unwanted video recording of others. But what will happen as wearable technology advances and the devices become harder to spot?

The standard of care required for data collected from wearables is still evolving. Governments are already publishing new regulations on the use and storage of mobile and personal data, particularly at the enterprise level. Examples include Japan's Personal Information Privacy Law, the Canadian Privacy Act, and the European Union Data Protection Directive.

What's next: How IBM can help

IBM is not in the business of building wearable devices but offers a range of solutions and capabilities that can enable our clients to rapidly achieve success in the wearables market:

- IBM MobileFirst solutions
- Apple Partnership
- Internet of Things (IoT) solutions
- Embedded development
- IBM Cloud platforms

IBM MobileFirst helps enterprises implement their mobile strategy with an open mobile application platform for smartphones and tablets. Whether deployed on-premises or as a private cloud solution, MobileFirst helps companies efficiently develop, run, and manage native, hybrid, and mobile web apps.

The MobileFirst platform applies to the wearables market in two ways. First, many wearables rely on a mobile app to allow the wearer to interact with the device and its data, so the success of the solution depends greatly on the ability to design, build, test, and manage the associated mobile app. Second, a rising number of new wearables are running smartphone-style operating systems (such as Android and Tizen), which makes a platform such as MobileFirst ideal for developing and managing the wearable device code, too.

A new **IBM-Apple partnership** was announced in 2014 with the goal of combining the market-leading strengths of each company to create a new class of business apps and bring IBM big data and analytics capabilities to Apple's popular iPhone and iPad devices. The partnership has already led to new apps that will transform how businesses and employees work.

Of particular interest is the Apple iOS 8 operating system and its support for wearable devices through the HealthKit and WatchKit development frameworks. The HealthKit platform enables healthcare and medical wearables to publish and share data in a way that lets users access data from multiple devices in a single place on their Apple system. WatchKit supports development of apps and solutions for the highly anticipated Apple Watch and its new glanceable interface, which is expected to open a new set of use cases that have been either inconvenient or impossible with regular smartphones and tablets.

In 2008, IBM set a bold agenda for a Smarter Planet®. This global movement aims to infuse the systems that

drive human progress and economic growth with new levels of instrumentation (billions of smart sensors and mobile devices), interconnectivity (countless networks, applications, and data centers), and intelligence (real-time data transformed into actionable insights at massive scale). Today, these inter-related technologies are often referred to as the **Internet of Things**.

The Internet of Things includes wearable devices and related solutions that generate actionable intelligence or insight by instrumenting and connecting real-world objects to IT systems and processes, often using limited resources. In October 2014, IBM launched the Internet of Things Foundation, a cloud service that provides device connectivity, messaging, and analytics in a massively scalable fashion. It also exposes data from the connected device into IBM Bluemix™ (the IBM Platform-as-a-Service offering), allowing you to rapidly compose analytics applications, visualization dashboards, mobile apps, and more based on data from wearables and other devices.

It can be difficult to develop software that runs effectively and securely in constrained environments such as wearables, where system resources, connectivity, and battery power may be limited. So **embedded development** scenarios are increasingly common, with control software built directly into the firmware and application stacks that run on each device.

IBM Rational® Rhapsody® is a tool suite that allows systems engineers and software developers to create embedded and real-time applications. It can be applied to the development of wearables and other intelligent devices in automobiles, consumer electronics, healthcare, industrial automation, and more.

We offer a wide range of **IBM cloud platforms** and solutions, from Bluemix (Platform-as-a-Service) and IBM Softlayer (Infrastructure-as-a-Service) to various Software-as-a-Service offerings.

These cloud platforms can help developers build new wearable devices quickly and then scale up to global deployments in a cost effective manner. In fact, one of the leading global manufacturers of fitness monitors uses the IBM Softlayer cloud platform.

Resources for more information

For more information about the concepts highlighted in the paper, see the following resources:

- IBM MobileFirst:

  http://www.ibm.com/mobilefirst/us/en

- IBM MobileFirst Platform Foundation

  http://www-03.ibm.com/software/products/en/mobilefirstfoundation

- IBM-Apple Partnership:
  - IBM:

    http://www.ibm.com/mobilefirst/us/en/mobilefirst-for-ios

  - Apple:

    http://www.apple.com/business/mobile-enterprise-apps

- IBM and the Internet of Things:

  http://www-01.ibm.com/software/info/internet-of-things

- IBM Internet of Things Foundation:

  http://www-03.ibm.com/software/products/en/internet-of-things-foundation

- IBM Continuous Engineering:

  http://www.ibm.com/ibm/continuousengineering/us/en

- IBM Rational Rhapsody:

  http://www-03.ibm.com/software/products/en/ratirhapfami

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- Natesan Venkateswaran, Senior Engineering Manager
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- Timothy Hahn, Chief Architect
- Wouter Denayer, Technical Leader

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