The Universität der Bundeswehr München (Bundeswehr University Munich) is significantly expanding its Cyber Defence Research Center (CODE). CODE was established in 2013 with the objective to bring together experts from different faculties and scientific disciplines as well as expertise from industry and government agencies to conduct research in the cyber and information space. CODE pursues a comprehensive, integrated, and interdisciplinary approach to implement technical innovations and concepts for the protection of data, software, and ICT infrastructures in accordance with legal and commercial framework conditions. It has already established important strategic partnerships in this area. The objective of the expansion is to unite the research initiatives of the Bundeswehr and the Federal Government in the area of Cyber Defence and Smart Data and to establish the CODE Research Center as the primary point of contact in the cyber and information domain of the Bundeswehr and the Federal Government.

Research and teaching in the area of cyber security is already being carried out as part of the Bachelor’s and Master’s programs in the Computer Science Department. According to current planning, a new international Master’s program in Cyber Security will be launched on January 1st, 2018. The Universität der Bundeswehr München will therefore be appointing eleven Professors for its Computer Science Department on October 1st, 2017.

The Universität der Bundeswehr München is looking for personalities with outstanding scientific qualifications to fill these professorial positions, who will also contribute actively to the CODE research center. Besides excellent research work, the new professors are expected to develop demanding lectures, practicals, and seminars for the new Master’s program in Cyber Security and to provide excellent teaching in their respective specialist area. Applicants are also expected to carry out teaching in the Bachelor’s programs in Computer Science and Business Informatics, and to work closely with the other departments at the Universität der Bundeswehr München. The Professorships will be provided with eight excellently equipped laboratories housed in a new building that is to be completed in the near future.

The candidates must have an excellent scientific track record, as demonstrated by a habilitation or equivalent scientific achievements, as well as significant excellent publications in academic journals. Proven teaching experience in their respective specialist area is highly desired. The new Professors should have an international perspective, e.g., based on participation in international research projects, and experience in acquiring third-party funding. The duties will also include active participation in the university’s academic self-administration.

The Computer Science Department at the Universität der Bundeswehr München is seeking Professors for the following specialist areas of its Cyber Defence and Smart Data Research Center:

**University Professorship (W3) in Cryptography**

When it comes to transmitting, storing, and processing data, cryptographic methods are crucial to ensure that the data remains confidential, authenticated, and uncorrupted. The remit of the Professorship includes encryption algorithms, random number generators and key management as well as their practical application within communication protocols – both from a provider’s and an attacker’s perspective.

**University Professorship (W3) in ICT Threat and Malware Analysis**

The complexity and heterogeneity of communication networks and ICT infrastructures requires a systematic assessment of potential attack vectors in order to derive priorities for protection mechanisms. Besides malware as a mass phenomenon in the form of viruses, Trojan horses and encryption-based ransomware, the Professorship also focuses on constructing sandbox analysis environments to identify malicious code in third-party software, such as smartphone apps and other software downloaded from the web.

**University Professorship (W3) in Business Intelligence Security**

Networked applications, IT services, and operating environments generate vast amounts of data that can be used for various purposes, including the detection of potential attacks, but the sheer amount of such data prevents any manual processing. The research tasks involved in the Professorship in Business Intelligence Security include big data and smart data algorithms for the aggregation, the correlation, and the analysis of large data amounts associated with security events for the purpose of providing specific support for decision processes concerning the prevention, the detection, and the response to attacks.

**University Professorship (W3) in Cyber Physical System Security**

The combination of networked applications with mechanical and electronic components, such as in industrial production facilities, assistance systems, and energy supply systems, has many advantages – but it also involves the risk that these cyber physical systems can be compromised or sabotaged through cyber attacks. The Professorship focuses on the information security characteristics of cyber physical systems with their specific framework conditions, such as the constrained resources of embedded systems, real-time capabilities, and physical access by attackers.
University Professorship (W3) in Privacy Enhancing Technologies

The development and procurement of complex software systems must comply with legal and sector-specific regulations, which must already be taken into account during the requirements analysis and planning stage. Ultimately, proof of compliance must also be demonstrated, e.g., by means of a certification.

The Professorship in Data Protection and Compliance focuses on the methods and tools needed for the technical implementation of requirements resulting from, for example, the European General Data Protection Regulation and the new German IT Security Act, and it will also develop IT concepts for the implementation of the privacy-by-design paradigm.

University Professorship (W3) in Usable Security and Privacy

In order to fully investigate and resolve security incidents, evidence must be gathered and analyzed while maintaining the integrity of the chain of custody.

In order to deal with sophisticated attacks that are increasingly leaving fewer traces in compromised IT systems, the concealment of traces, the use of encryption and, for example, requirements regarding the automation and the scalability of digital forensics, the Professorship will research new approaches to analyzing the main and background memories of mobile and stationary systems as well as networked applications, among others topics.

University Professorship (W3) in Secure Software Development

The security of software crucially depends on the priority assigned to information security attributes during the requirements analysis, system design, and programming as well as the associated testing and approval procedures.

In the Professorship in Secure Software Development, the two disciplines of software engineering and security engineering overlap. It deals with methods, algorithms, and tools required for the implementation of software according to the secure-by-design, secure-by-default, and secure-in-deployment paradigms.

University Professorship (W3) in IT Vulnerability Management and Security Testing

Programming errors, insufficient adaptation to new operating environments, and negligent use of IT systems often lead to vulnerabilities that allow attackers to obtain unauthorized access to processed data or even take control of entire systems.

The Professorship in IT Vulnerability and Security Testing will deal with the systematic handling of such vulnerabilities in IT systems and testing methods for their identification and assessment, so that, for instance, penetration tests of networked applications can be employed to determine areas in which the security levels need to be improved.

University Professorship (W3) in Open Source Intelligence and Situation Assessment

Information security and data protection necessitate the implementation and use of technical mechanisms that are too complex to apply for many users. E-mail encryption procedures, for instance, have only been utilized by IT experts for decades because the time and effort necessary for their use is much too high compared to their subjective benefits.

The Professorship in Usable Security and Privacy will investigate user-friendly approaches to security and data protection procedures and to the implementation of graphical interfaces for human-computer interaction in order to enhance the usability and therefore ensure the extensive employment of important protective measures.

The University of Munich offers academic programs directed primarily at Officer Candidates and Officers, who can obtain Bachelor’s and Master’s degrees within a trimester system. Depending on spare capacity, civilian students are allowed to enroll. The study course is complemented by interdisciplinary elements in an integrated program entitled „studium plus“.

Preconditions of employment and the legal duty positioning of Professors are based upon the “Bundesbeamtentgesetz”. Employment as a "Beamtin/ Beamter" requires that the candidate is not older than 50 at the date of appointment.

The University seeks to increase the number of female Professors and thus explicitly invites women to submit applications. Severely disabled candidates with equal qualifications will receive preferential consideration.

Please submit your application documents marked as Confidential Personnel Matter to the Department Head of the Computer Science Department at the Universität der Bundeswehr München, 85577 Neubiberg, by October 15th, 2016.
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Evolving MPI+X
Toward Exascale

This installment highlighting the work published in IEEE Computer Society journals comes from IEEE Transactions on Parallel and Distributed Systems.

David A. Bader, Georgia Tech

The recent trend in high-performance computing (HPC) to adopt accelerators such as GPUs, field-programmable gate arrays, and coprocessors has led to significant heterogeneity in computation and memory subsystems. Application developers typically employ a hierarchical message passing interface (MPI) programming model across the cluster’s compute nodes, and an intranode model such as OpenMP or an accelerator-specific library such as compute unified device architecture (CUDA) or open computing language (OpenCL) for the CPUs and accelerator devices within each compute node. To achieve acceptable performance levels, application programmers must have in-depth knowledge of machine topology, compute capability, memory hierarchy, compute-memory synchronization semantics, and other system characteristics. However, explicit management of computation and memory resources along with a disjointed programming model mean that programmers must make tradeoffs between performance and productivity.

In “MPI-ACC: Accelerator-Aware MPI for Scientific Applications” (IEEE Trans. Parallel and Distributed Systems, vol. 27, no. 5, 2016, pp. 1401–1414), Ashwin Aji and his colleagues from Virginia Tech, Argonne National Laboratory, North Carolina State University, and Rice University present a unified programming model and runtime system for HPC clusters with heterogeneous computing devices. Specifically, they introduce MPI-ACC, an evolutionary step in the MPI+X programming model, which is the de facto standard for distributed memory clusters. By evolving an already popular programming model, the authors make it easier to modernize the code of existing MPI-based applications.

Aji and his team note that when invoking a data-movement routine in MPI-ACC, programmers can simply describe additional data attributes specific to the within-node elements—such as the GPU command queue, execution stream, or device context—without changing the MPI standard. MPI-ACC’s runtime system employs user-specified data attributes to not only perform end-to-end data movement across the network but also synchronize with in-flight GPU kernels to achieve efficient overlap of communication with computation. The authors contrast their simple descriptive approach with the complex prescriptive approach of existing GPU-aware MPI implementations. They argue that although other approaches provide end-to-end data movement support between GPUs, they don’t have a mechanism to express the data’s execution attributes, which puts the burden of overlapping communication with computation on end users.

The investigators also performed in-depth analysis of how MPI-ACC can be used to scale in-production scientific applications such as an epidemic spread simulation and a seismology simulation. They further show that the MPI-ACC’s pipelined end-to-end data movement, scalable intermediate resource-management techniques, and enhanced execution progress engine outperform baseline implementations that use MPI and CUDA separately.

MPI-ACC evolves and unifies the MPI+X programming model. Its expressive and familiar interface allows programmers to describe the appropriate computation or communication targets, and its runtime system automatically achieves efficient cluster utilization.

David A. Bader is a professor and chair of the School of Computational Science and Engineering, College of Computing, Georgia Tech. Contact him via www.cc.gatech.edu/~bader.
The IEEE Computer Society’s lineup of 13 peer-reviewed technical magazines covers cutting-edge topics ranging from software design and computer graphics to Internet computing and security, from scientific applications and machine intelligence to cloud migration and microchip manufacturing. Here are highlights from recent issues.

**Computer**

Supply-chain globalization presents many security challenges, a topic explored in *Computer’s* August 2016 special issue.

**IEEE Software**

Software architecture principles epitomize architecture’s function: to clearly define a system design’s necessary constraints without prescribing all design details. According to “Harnessing the Power of Architectural Design Principles,” from *IEEE Software’s* July/August 2016 issue, a good set of principles can provide context and justification for design decisions and can foster team collaboration and communication.

**IEEE Internet Computing**

As the Internet grows in size and complexity and plays a more important role in modern society, measuring the network becomes increasingly critical to guide its continued evolution. However, the difficulty and ethical implications of conducting Internet experiments make it challenging to obtain an accurate and representative understanding of the network’s behavior, according to *IEEE Internet Computing’s* July/August 2016 special issue on measuring the Internet.

**IEEE Security & Privacy**

*IEEE S&P’s* July/August 2016 security smorgasbord special issue covers a range of topics, including changes necessary to keep pace with new technologies, biometrics as an identity-verification method in airports, the benefits and repercussions of collecting privacy-sensitive data in gaming, security implications for creating mobile software-defined networks, and new types of malware.

*Computing in Science & Engineering*

The author of “The Power to Create Chaos,” which appears in *CiSE’s* July/August 2016 issue, says computers are the only research tools that, by design, exhibit chaotic behavior. A minimal change to a computation’s input can change its output in many significant ways. Scientific software developers and users should be aware of this and set up safety nets for protecting themselves against unfortunate surprises.
IEEE Cloud Computing

“Software-Defined Networks Meet Cloud Computing,” from IEEE Cloud Computing’s May/June 2016 issue, reviews the advantages of software-defined networks and looks at their potential for living in the cloud, potentially providing on-demand, high quality, less expensive networking capabilities.

IEEE Computer Graphics and Applications

Perceptual computer graphics is a rich research area, largely because it focuses on the human element. IEEE CG&A’s July/August 2016 special issue on quality assessment and perception in computer graphics includes four articles that explore innovative techniques in areas such as computational aesthetics in games.

IEEE Intelligent Systems

IEEE Intelligent Systems’ July/August 2016 special issue on new directions includes articles on semantics-based intelligent human–computer interaction, minimizing fatigue damage in aircraft structures, and satisfiability degree analysis and deductive reasoning.

IEEE MultiMedia

The volume of multimedia data handled daily is growing rapidly. Computational quality modeling is thus becoming an important, yet challenging, research topic. In the past decade, researchers have proposed a rich variety of quality models. The articles in IEEE MultiMedia’s July–September 2016 special issue cover different computational-quality modeling techniques and applications.

IEEE Annals of the History of Computing

Introduced with the 1972 extension of Japan’s Tōkaidō Shinkansen high-speed rail line, the COMTRAC (computer-aided traffic control) command-and-control system efficiently runs the service’s complex, high-frequency operations. “History of COMTRAC: Development of the Innovative Traffic-Control System for Shinkansen,” from IEEE Annals’ April–June 2016 issue, introduces the system’s technological features and reviews its 50-year history.

IEEE Pervasive Computing

The key challenge for designers of future displays will be creating innovative systems that deliver value. The research presented in IEEE Pervasive Computing’s July–September 2016 special issue showcases some of the challenges—and potential solutions—in making pervasive displays more useful and user-friendly. As new display and sensing technologies become available, pervasive displays could emerge as one of the core components of a future ubiquitous computing infrastructure.

IEEE Micro

Nonvolatile processors (NVPs) integrate nonvolatile memory to preserve on-chip state during power emergencies. NVPs can work on tasks even when there are only short periods of power, making them a promising solution for energy-harvesting scenarios in which the available power supply is unstable and intermittent. The authors of “Nonvolatile Processor Architectures: Efficient, Reliable Progress with Unstable Power,” from IEEE Micro’s May/June 2016 issue, explore NVP design across different architectures and power sources, and propose an efficient, heterogeneous microarchitecture.

Computing Now

The Computing Now website (http://computingnow.computer.org) features up-to-the-minute computing news and blogs, along with articles ranging from peer-reviewed research to opinion pieces by industry leaders.
Trying Wearable Technology on for Size

Smart watches, fitness trackers, Google Glass, and digital clothing are all examples of wearable technology, the focus of this *ComputingEdge* issue.

Wearables incorporate computing, communications, or other advanced electronics capabilities into clothes or accessories. They are types of ubiquitous computing that enable users to carry their technology on them, rather than just with them as is the case with smartphones.

The authors of *IT Professional*’s “Beyond the Wearable Hype” say that some wearable devices are just companions to smartphones and don’t warrant mass adoption. They then look at some emerging wearable products that they say are truly useful.

In *IEEE Pervasive Computing*’s “From Fishing Trips in Alaska to Cherry Blossoms in Japan: Martin Källström’s Take on Wearable Cameras,” Narrative Inc. CEO Källström discusses the origin of his company’s Narrative Clip, the challenges in building the wearable camera, and the future of wearable video- and image-capture technology.

In “Worrying about Wearables,” from *IEEE Internet Computing*, the authors state that as wearables become more pervasive, security and privacy will become even greater issues.

Although current smartwatches are limited in various ways, their capabilities will probably continue to evolve and grow. However, it’s still unclear which user-centered needs a smartwatch might satisfy, notes “Smartwatch Innovation: Exploring a Watch-First Model,” from *IEEE Pervasive Computing*.

*Computer*’s “Legal Issues with Wearable Technology” discusses how the proliferation of wearable devices has raised numerous thorny legal concerns and notes that it is difficult to predict how the issues will be resolved.

“Instrumenting Our World, Ourselves, and Our Livestock,” from *IEEE Pervasive Computing*, covers the many different approaches to instrumentation of the world around us, including the use of wearables, and discusses related issues such as privacy.

*ComputingEdge* articles on topics other than wearables include the following:

- Software naming conventions affect code readability and review, and thus are very important to developers, according to *IEEE Software*’s “Code Clarity.”
- *IEEE Computer Graphics and Applications*’ “Art in the Digital Age” features some of the latest advances and applications in computer graphics technology.
Wearable computing has become a new dress code that’s further integrated into our daily lives. However, the latest generation of devices, such as the FitBit and Apple Watch, are companions to smartphones that don’t yet warrant mass adoption in society. We therefore embarked on a journey to discover some emerging wearable products that are not only improving our lives but are also serving a real need in society.

**Education through Programmable Bracelets**

Education for teenagers between the ages of 9 and 14 forms the very foundation of their future. According to statistics collected by the US National Center for Women & Information Technology, between 2000 and 2012, the number of first-year undergraduate women interested in majoring in computer science declined by 64 percent. Jewelbots are programmable friendship bracelets targeted at teen and preteen girls (Figure 1). Right out of the box, girls can easily learn the fundamentals of computer science by programming the bracelets using basic if/then statements while engaging with their friends and expressing themselves. “They are not just pretty jewelry; they are a powerful communication tool that is designed to get the girls excited about programming and computer science,” says co-founder Brooke Moreland.

Moreland and her team recently held “Take Your Daughter to Hack Day,” a multi-city, day-long hack event for daughters of all ages and their parents or guardians to come together to build software and hardware projects of all kinds. The event was a huge success in

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**Figure 1. Programmable friendship bracelets for teens and preteens. Users program the bracelets via basic if/then statements for engagement and communication with friends (photo courtesy of www.jewelbots.com).**
Pet Wearable that Enables Clinical Research

Ever wondered how your pets are doing while you are at work? Davide Rossi at FitBark has a solution. FitBark is FitBit for your pets; it tracks their health the same way you would track yours (Figure 2). Surveys show that 75 percent of pet owners feel guilty when they go to work, and more than 95 percent consider their pets to be part of the family. Filling that information gap by monitoring your pet’s heart rate, activity, and respiration elevates the understanding of your pets to a higher level.

However, Rossi is tackling a bigger problem. “We are mapping out information and data points for academia,” he says. “Analytical studies take six months to complete at the expense of hundreds of thousands of dollars. We provide this data at scale and seamlessly.” FitBark is currently working on a clinical study with a top US institution to examine whether you get improved sleep while your pet is on your bed. This type of clinical research is useful on multiple levels, including understanding pet behaviors across breeds and testing pet medications. To find out more, visit www.fitbark.com and download the video at http://tinyurl.com/q4ja8jr.

Wearable for the E-Commerce Revolution

Consumer wearables are a crowded market, so Kinetic has decided to focus on wearables for businesses. Kinetic is a wearable wrist-watch combined with a device that attaches to your belt (Figure 3). The continued growth of e-commerce means that each box in these massive distribution warehouses needs to be moved manually, increasing the risk of back injury for workers and costs for companies. Kinetic uses full 3D motion sensors to spreading the word that “girly girls” can code. There is a need for coding in the school curriculum, and Jewelbots is leading the charge through wearables. To find out more, visit www.jewelbots.com and refer to the video at https://vimeo.com/127438820.
determine lifting signatures that can identify whether workers are bending their backs or just their knees when lifting. This type of data helps prevent back injuries and provides useful data points for ergonomics research.

Wearables in the workplace aren’t a new concept, but the advancement in sensor technology allows for a multitude of data points to be collected, cleansed, and analyzed. “Our pilots with big shopping distribution companies in the last several months have delivered 80 percent reduction on high-risk postures,” says Kinetic CTO Aditya Bansal. “This means cost savings for employers and [an] improved workplace environment for employees.” To find out more, visit http://wearkinetic.com.

Life-Saving Wearable for Industry

Another innovative company, Vandrico, has developed a messaging and communication platform that ties wearables together with information flow and decision making. The platform, called Canary, is being used in conjunction with shovel monitoring software to detect when critical equipment failure has occurred and subsequently notify those at risk using wearable technology. Canary has multiple other uses, especially in industries in which real-time communication and decision making can save lives.

“We want to look at things completely differently and to stop thinking about wearables as an extension to the smartphone,” says Jess Sloss, customer success lead at Vandrico, “and to develop standalone sustainable wearable technology.” To find out more, visit http://vandrico.com and watch the video at https://www.youtube.com/watch?v=u8tnYt30L-A.

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Matthew Lee is an investor at Pereg Ventures, a New York-based venture capital fund. He received an MBA from London Business School with a focus on entrepreneurship. Contact him at matt.lee@peregventures.com.

Maria R. Lee is a full professor in the Institute of Creative Industries and the Department of Information Technology and Management at Shih Chien University, Taiwan. Her research interests include wearable computing, big data analytics, e-commerce, and knowledge management. Lee is an IT Professional editorial board member and the program chair of the IT in Practice Symposium at the IEEE Computer Society Signature Conference on Computers, Software, and Applications (COMPACS). Contact her at maria.lee@g2.usc.edu.tw.

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A typical Tuesday morning for me this past semester is perhaps similar to that of many working parents of young children. The alarm on my cell phone alerts me at 5:00 am. After starting eggs to boil and preparing some oatmeal in the pot, I proceed to the shower and then to get dressed. Next, I head upstairs to two sleeping boys. I shake the 10 year old, who reluctantly awakens and heads to the bathroom after making sure that his cell phone charged the night before. Then I walk a few paces to the room of the three year old, whom I awaken and lift out of the bed to take into the bathroom before getting him dressed. By 6:50 am, my younger son has oatmeal and Curious George and my older son and I look into my bedroom to let my wife know that we’re leaving the house. We arrive at the university and walk across the parking lot to my office at 7:05, just ahead of the school zone traffic. We eat breakfast, the 10 year old reviews his homework, and I start my e-mail responses. At 8:00, we walk over to my son’s elementary school, which is adjacent to campus. I return to the office at 8:30.

The point of this story is that, on one Tuesday, I happened to look at my cell phone health meter and apparently prior to 8:30 am, I had already walked just under a mile and seven flights of stairs. A cellular phone isn’t a dedicated wearable device, but the principles are the same. Early publications in wearable devices in 1999 (such as the work by Mark Billinghurst and Thad Starner1 and Alex Pentland2) suggest that wearable devices have the objectives of mobility, context awareness, and augmented reality. In effect, the technology is meant to create a “human-computer symbiosis.”1 Initial applications included standalone devices that concentrated on exposing information about human actions and facilitating enhanced communications between actors.

More than 15 years later, the principles are much the same. Big Data techniques and increased capacity in memory devices have enhanced the amount of information that can be processed. Distributed and cloud computing infrastructures have facilitated the ability to share and correlate information across actors, thus allowing a level of collaborative intelligence. Finally, the Internet of Things seems to bring all these techniques within one context. While augmented reality isn’t central to all approaches, Google Glass and other technologies enable visual displays that are more agile than ever before. In browsing the most highly cited papers on “wearable” technologies in 2015, the top 10 (as shown by Google Scholar) concentrate on health-related monitoring in wearable devices either by independent sensors or within fabric.

These devices and their connectivity to databases provide a significant service to their human counterparts, but at what cost? With the risk of discrimination related to genetics information, medical records are more sensitive today than ever before. The emphasis on international cybersecurity will soon be overshadowed by individual-to-individual security domestically. Moreover, there’s the potential for users to maliciously exploit information from wearable devices, such as cheating on tests or evading law enforcement.

As an Internet computing researcher, several areas concern me that will have to be addressed by our community.

- Collaborating on and leveraging individual personal, perhaps biological and location-based, information while still preserving privacy. Researchers will need to develop special containers for collaborating on packets of information that can be aggregated to create or enhance intelligence for individual users while ensuring a safe level of security.
- Incorporating morality into wearable technology protocols. There will be a strong need to
develop organic procedures for wearable devices’ operations that prevent misuse. This is, of course, a difficult challenge – particularly if we seek general approaches.

- Preventing the intentional and malicious insertion of erroneous information. Perpetrators that penetrate networks of personal wearable technologies and insert malicious information can negatively affect devices’ operation. With the large majority of devices supporting the healthcare domain, information security will be a significant concern and challenge.

Considering the innovations in materials, the strides coming in the next several years will far exceed the steps made in the last two decades. As information flows from device to device, person to person, and cloud to cloud, privacy will remain a key issue. So, while my morning timeline for making oatmeal and watching Curious George might not be a concern for national security, it’s still important that thieves can’t track a person’s highly synchronized morning ritual as a result of a wearable device.

This is an interesting avenue to consider, and only one of the considerations in our September/October 2015 special issue on wearable Internet. In this issue, the authors highlight several wearable Internet technologies in healthcare and design. I hope you enjoy reading about the advances of this field, and I would like to thank our guest editors, Mohamed Ali Kaafar and Ross Travers Smith, our Associate Editor in Chief Anirban Mahanti, and our reviewers for leading the development of this issue.

References

M. Brian Blake is the provost and executive vice president of academic affairs at Drexel University. As a professor of computer science and electrical engineering, his research interests are in service-oriented computing, adaptive distributed systems, and Web-based software engineering. Blake has a PhD in information and software engineering from George Mason University. Contact him at mbblake@gmail.com.

This article originally appeared in IEEE Internet Computing, vol.19, no. 5, 2015.
In recent years, there has been a lot of commercial activity related to smartwatches—but this is not the first time we’ve seen smartwatches. In 2002, Microsoft announced the Smart Personal Object Technology (SPOT) watches, which became available in 2004. Around that same time, Fossil released its Fossil Wrist PDA, which ran the Palm OS. These early devices did not see widespread success, and all were pulled from the market. So although I’m pleased with the current activity, as a wearable computing researcher, I also know it’s important to examine contemporary smartwatches to ensure they address real user needs. This will be essential for long-term success.

Certainly, the technology ecosystem of today differs from that of the early 2000s. Smartphones alone are radically different. When the early smartwatches were made, neither the iPhone nor Android smartphones were on the market. In the intervening years, we have seen the huge adoption of these mobile platforms and associated shifts throughout the industry. The app store model of both the iOS and Android has also opened up opportunities for third parties to develop software and deploy it at scale. Today’s smartwatches use this modern mobile infrastructure, with Bluetooth links to a user’s phone, to leverage mobile apps as well as to more broadly connect to cloud services.

Not surprisingly, one dominant use of smartwatches is as a platform for interacting with notifications provided by the user’s mobile phone. But are these devices really about making phone notifications better, or are there other opportunities? What user-centered need might a smartwatch fulfill?

**Disruptive Innovation Theory**

One approach for analyzing smartwatches and their possible positioning is to use Clayton Christensen’s theory of disruptive innovation. Christensen articulated several types of innovation and disruption.

First, there are sustaining innovations, which aim to improve existing products or services. This typically happens by making small, incremental improvements in an iterative fashion. Occasionally, there are radical sustaining innovations, which introduce a different type of technology but have the same goal as sustaining innovations of better solving an existing problem. Christensen also pointed out two different forms of disruptive innovation. One is a low-end disruption, where a new entrant makes a product that is cheaper and worse than an incumbent and then, through sustaining innovations, improves the offering. The other is new market disruptions, which take a technology and use it to solve a different problem, thus creating a new market.

Using this framework, we can see both how the current smartwatches are being positioned as well as understand opportunities for future products and research.

A Sustaining Innovation for a Smartphone

One view of smartwatches is as improving the mobile phone experience: a sustaining innovation in the context of smartphones. As noted, many smartwatches depend on a mobile phone for operation—examples include the Apple Watch, Android Wear watches, and Pebble watches. Although some smartwatches are gaining independence from the phone (with direct Wi-Fi connections instead of being tethered with Bluetooth), the applications and overall experience is still closely tied to the mobile phone experience.

An obvious example of how smartwatches target improving the phone experience is the role of notifications. All of the smartwatches expose notifications from mobile phone apps onto the user’s wrist. By having a watch, the user gains a “glanceable” view of the notification, which would otherwise require pulling out a phone. The watch provides improved access time for the notification and enables some quick interactions for simple tasks. For example, the watch can be used as a remote control for the music player or to respond to messages with preselected responses. The watches also provide ways to escalate to the phone when tasks become too complex. For example, one of the commands available for an Android Wear notification is to open the associated app on the phone.

In this smartphone context, the smartwatch provides an enhanced...
experience, making some common tasks faster. However, does the benefit of the watch outweigh the associated (actual or perceived) burden of wearing it? A question often asked is, why wear a smartwatch? Many people have abandoned wrist watches for the modern equivalent of a pocket watch (the smartphone). People seemingly feel that the phone is good enough as a timepiece, or they have otherwise adapted to not having time on their wrists. From this perspective, the phone is already providing the needed functionality of time and application notifications. Although the smartwatch might save a few seconds when checking a notification, this is not a fundamentally new function.

A similar argument might be made against smartphone apps. The smartphone is already capable of running the application and has more resources to do so (larger user interface, faster processor, and so on). Does making that information faster to access justify the associated tradeoffs? In other cases, some people indicate that they have too many phone notifications already, and putting them on the wrist would be even more disruptive.

Returning to the notion of sustaining innovations, quicker access time might not be the right dimension that needs to be improved for these individuals. Or, if access time is going to drive adoption, it might need to be applied to address different user needs.

A Radical Sustaining Innovation for a Watch
Given the name smartwatch, another view we can take of these devices is how they serve the role of being a watch. More specifically, what would it mean for a user to replace a traditional digital dumb watch (with its associated simple LCD and minimal interactive capabilities) with a smartwatch and richer interactions?

Such a device would primarily be a watch, doing everything a traditional watch would do. However, it would also bring along more capabilities, such as notifications and applications. This approach would be a radical sustaining innovation: taking the traditional performance values of a watch and enhancing them with a radically different technology—in this case, the general-purpose displays, applications, and so on of smartwatches. One of the advantages of targeting existing (digital) watch users is that they have already committed to the idea of wearing a watch. The watch is already providing value to the user, and this approach extends that with additional capabilities.

The smartwatches from Pebble are somewhat in line with this view. For example, one of the key design aspects of the Pebble is a focus on a long battery life, making the product more like a watch than a phone. Instead of needing to charge the watch daily like a phone, they targeted an experience in which the watch could last longer (advertising up to a week between recharges). This feature was accomplished through different technology design choices, such as using a bi-stable LCD, more conservative CPU, and buttons instead of a touchscreen. The use of physical buttons also more closely resembles interactions on a digital watch relative to the touchscreen of other smartwatches, which are closer smartphone interfaces.

In my recent work, I took this perspective as a hypothesis. I conducted a survey of current digital watch wearers to understand their current watch practices with the idea that those findings could be used to better inform smartwatch designs. Based on the data collected, there are several notable findings and gaps between current smartwatches and digital watches. For example, many of our participants were concerned about the durability of their watches, wore inexpensive watches (relative to smartwatch prices), or articulated desires for a specific aesthetic that is fulfilled by the large ecosystem of digital watches but is lacking in current smartwatch designs.

Many of the participants liked the digital watch face provided on smartwatches—in particular, the combination of date or day of week with the time. In contrast, some participants raised concerns about adding extra information and preferred more traditional watch faces (“it has no confusing writing or symbols”). Additionally, participants only used a few of the digital watch features in general. In some cases, participants didn’t even know about basic capabilities of their watch (such as the watch timer). More broadly, if we think about enhancing the capabilities of a watch with smart features, it will be very important to consider the associated increase in complexity. Adding too many new features or the wrong type of features might lose the watch-like feel of the device.

A Disruptive Innovation
Given this analysis, it is not clear that a smartwatch is about being a better watch, or that there is large user-centered value for being a companion to a smartphone. It seems that the utility of a smartwatch could be in some other domain. This perspective aligns with Christensen’s last category of innovations: disruptive. It is unlikely that smartwatches are low-end disruptions (they are not a cheaper, worse version of current products). However, they could be a new market disruption. In this context, smartwatches would be viewed as taking a technology and applying it to a different domain to solve a new problem. The technology in this case is closely related to mobile phone technology (small color touchscreens, fully capable computing platforms in very small form factors, and so on).

If we consider this hypothesis, then it is not about making a better watch or enabling smartphones. “Smartwatch” could be a misnomer for this category of device. Although the technology is anchored in both smartphones and watches, these might be poor models for the role of a “smartwatch.” And if this is the case, there is an open question—what is a smartwatch for? What
user-centered task is the smartwatch uniquely positioned to solve?

As an industry and academic community, we do not seem to have many likely candidates, and finding these could require a significant amount of exploration—and there will likely be many dead ends. One bright side is that today’s smartwatches have software APIs and app stores, which make it reasonably straightforward for developers and researchers to extend these platforms with new capabilities. Some smartwatches, like the Pebble, also have provisions for extending the device with hardware add-ons.

Although using a smartwatch for notifications does provide fast access times, it might be that a notification is the wrong type of content or that it does not fully take advantage of having a rich compute platform worn on the wrist. What other interactive computing tasks might be accomplished by having this type of wearable?

Having used prototype wearables day in and day out for years myself, one area that seems underexplored is taking advantage of the fact that the device is with the user for long periods of time. While developing new behaviors is often a difficult task for uses, once a person comes to expect the device to be there, they can start to depend on it. This type of capability links back to early ideas presented in “Man-Computer Symbiosis” by J.C.R. Licklider and was the inspiration for some early wearables. This notion of long-term use likely complements the microinteractions afforded by a wearable and creates a qualitatively different experience relative to a handheld mobile experience.

It might also be interesting to consider what it means to think of the watch as a first-class compute device instead of merely a peripheral. Although current smartwatches allow for short bursts of interaction, it is not clear that transitioning to the phone to handle more complex tasks is the right model of use.

For a long time, email and Web browsing were tasks that were seen as too difficult to accomplish on mobile devices; you needed a desktop PC (or laptop) to accomplish those tasks. However, as the phone hardware and software improved, those traditionally desktop tasks became effective on mobile devices in many circumstances. Today, many large technology companies are shifting their products away from desktops and laptops and are adopting a mobile-first strategy.

Is there an analogy for the relationship between this new generation of smartwatches and smartphones? What would be needed for a smartwatch to replace a smartphone? Few people would argue that a smartwatch of today could replace a smartphone, just as early smartphones were poor replacements for PCs. However, this watch-first approach could be a plausible future and might be the key for their long-term success.

TOWARD WATCH FIRST

If we move toward a watch-first model for smartwatches, or even if we take other more sustaining views of smartwatches, there are still some challenges to overcome. While being mounted on the wrist affords a quick glanceable interaction, the wrist does not afford more complex or longer interactions. This aspect can be seen by examining the dispositions of a watch. For interactive use, the arm with the watch must be raised, and the second hand is needed to touch the watch. This pose would not afford longer term use.

One way to overcome this issue would be to allow input when the watch is in the glanceable state without requiring the second hand. There have been a variety of novel sensing approaches that can sense hand movement from the wrist that might be suitable. Another approach would be to make two-handed use easier. For example, the watch face could be easily detachable with a magnetic or mechanical clasp (Figure 1), letting the user detach the watch, use two hands or thumbs for input, and quickly return the device to its traditional watch mode.

Another issue with smartwatches is that there are already a lot of cultural meanings associated with watches. This influences mental models of the device. My discussion around what the smartwatch is intended to do captures some of those aspects. Furthermore, while the watch is a technical artifact that has already been adopted and is generally well understood, converting the watch into an interactive device can create some confusion. If the smartwatch user receives a notification alert with a vibrotactile stimulus, the natural response is to glance at the watch to see the message. However, in a social setting, looking at your watch also has strong signals—it can indicate that you’re concerned about the time, need to go, or are bored with the conversation.
The onlooker only sees the glance at the watch and is largely unaware of the additional context of the interaction. As such, it is easy to draw the wrong conclusion when observing such an interaction.

This effect is likely a problem beyond smartwatches, where the incorporation of interactive technology into other wearable items, such as jewelry, might create similar unintentional social signals. Maybe the smartwatch should look less watch-like to alleviate this issue? More broadly, there is a challenge of exposing the wearable user’s interaction with the device in a way other people can understand, so they know when the user is (or is not) interacting with it and what he or she is doing with the technology.

I have been using and researching wearables for most of my career, so I’m excited by the prospect of smartwatches. However, we still must be cautious and look beyond the novel technology to understand what role these devices can play in a user’s life. How are smartwatches being positioned with respect to technologies with which users are already familiar: dumb watches and smartphones? Are these the right metaphors, or are there bigger opportunities in adopting a watch-first model and applying smartwatch-like devices to solve other problems for the user? If the latter is the case, there needs to be a lot of exploration to uncover the possible uses of this type of technology. Ideally, we could develop user-centered methods for finding and evaluating new market disruption technologies.

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Kent Lyons is principal scientist at Technicolor Research. Contact him at kent.lyons@technicolor.com.

Interview

From Fishing Trips in Alaska to Cherry Blossoms in Japan: Martin Källström’s Take on Wearable Cameras

Marc Langheinrich, Università della Svizzera Italiana (USI), Switzerland
Nigel Davies, Lancaster University, UK

If Microsoft’s SenseCam has pioneered visual life-logging—the act of attaching a camera to your neck and taking a picture every 30 seconds—Martin Källström’s Narrative Clip has brought it to the masses. The tiny wearable started out life as the “Memoto Wearable Camera” on Kickstarter in November 2012, raising over half a million US dollars more than its original funding goal of $50,000. After its launch in early 2014, the company saw over 100 million pictures uploaded in its first eight months of operations alone. With its next version of the clip being released later this year—featuring GPS and accelerometer sensors just as its predecessor, but now with a new eight megapixel camera, an 86° lens, and added Wi-Fi and Bluetooth support, all in a package weighing just 28 grams—we sat down with Narrative’s CEO and founder Martin Källström to talk about his thoughts on the future of wearable cameras.

When did you first get the idea for the Narrative Clip?

Narrative was actually the result of a very deliberate ideation project, where I spent three months generating business ideas. From the start, the idea was to look at the possibility of a wearable camera and what could be achieved with that. Of course, there’s lots of research available on what happens and what the benefits might be, and all that research pointed out that the challenge wasn’t to capture photos but to provide value to the user after capture. For example, to provide software that summarizes your life in a brief but sufficiently detailed way that you can gather value as a user from making an effort to wear the camera in the first place.

I also saw an opportunity in this space because photos are such a huge driver of everything online, from social media to news and more. In addition, photos are immediately consumable—as opposed to video, which always takes time to consume. Also, this was in 2011, and wearable technology was on the rise. But there was no one really occupying that space, applying cutting-edge technology to the intersection of photos and wearable technology. So there clearly was an opportunity to explore what could be achieved in that space.

Initially, however, we dismissed the idea because of the form factor we envisioned for such a camera. We simply assumed that the camera would need to be at least five-by-five centimeters and maybe a couple centimeters thick, and we figured that no consumer would be interested in having that kind of device attached to their clothing. So we looked at other ideas, but then during the project, we came upon a teardown of an SD card, like a memory card for a camera with a Wi-Fi chip [the Eye-Fi product], which was mind-blowing. Looking at the miniaturization achieved in that product made us reconsider the concept of a wearable camera and realize that maybe the actual device wouldn’t need to be large at all; maybe it could be made very, very slim. So that was the concept that grabbed my attention above all others in the ideation.

Part of the reason it grabbed me was emotional, because I lost both my parents to cancer and the photos I have of them, while valuable, only capture moments we realized were beautiful moments, because we were having so much fun together, the weather was nice, or maybe we were giving each other presents or having a family outing, so we took photos. The photo albums I have of my time with them, they were limited in scope, because life is so much more than those beautiful moments. So to me, the idea of a wearable camera, it meant that I could fill in the gaps and capture everyday moments without consciously deciding to capture them in photos.

Of course, it also made sense business-wise because of the positioning...
between the huge trend of photos and of wearable technology.

Was the ideation process focused specifically on wearable technology, or was it just a very general “I’m looking to do some kind of a start-up”?

It was actually a very general process. I had specific requirements in mind, but they were still broad, like I wanted to work with a business-to-consumer company because my former company was a business-to-business company and I felt I already learned the lessons of that and also, to a certain extent, grown tired of doing a business with very long sales cycles and so on. I had learned that a subscription business or a subscription-based revenue model can be very profitable if you develop it correctly, so I wanted to incorporate that to some extent. And I wanted the business idea itself to touch social media as well. But those were the three categories that I looked at, and the scope of ideas that came out of that was very wide.

For example, I marched into an idea of creating a data-driven book publishing company, where I would create series of books instead of just one-off editions so that if you were into kite surfing, I could create 12 books of interviews with kite surfers and so on, which you could subscribe to. Much like a magazine, but with books instead. So, yes, it was a very general process.

Interesting. You could have just as easily ended up with a Fitbit or the Amazon Kindle, or a whole wealth of different things. So are people using the Narrative Clip in the way that you thought they would?

Yes. My personal view of how I would use the Clip is, as I described, to capture everyday moments. But then of course, people have adopted it for a wide variety of uses. For example, a lot of people have more specific areas to use this, like sports or travel or specifically with their families and so on. But what we see from the user pattern is that there is a large group of users who don’t use it for only special events but actually use it any day of the week. For example, we don’t see any pattern of usage during weekends. It’s more prominent during weekdays if you look at the user base as a whole.

So it averages out over the entire user base to actually be very much in line with what my expectations were. What has been mind-blowing is the variety and the richness of the content that people publish out of their life logs. When we just look at the “public moments” stream in the app and on the Web, every day people post stuff ranging from Thailand to fishing trips in Alaska to Spring cherry blossoms in Japan to San Francisco streets. So I wasn’t prepared—I didn’t know that it was going to be so rich. I hadn’t envisioned what that would look like. Now, I’m very happy with that result.

So it sounds like you’re saying there are two groups—those who use it like a GoPro to record something cool they’re doing, and then those who want to capture everything because they never know when they’re going to do something cool. Do you think eventually everyone will transition into the capture mode?

I actually can’t say that we are seeing any signs of transition like that. Rather, we’re seeing strong viewpoints from users on how they prefer to use the Clip. The ones who use it as much as possible and for everyday use, they do it out of curiosity or an attitude that it will better their lives or that it’s their rights as a citizen to capture their perspective of what they experience. But the people who buy for a specific purpose, they are set on that purpose.

Of course, for us, as a company, it would be really good to be able to achieve that transition. But we haven’t been able to generate that kind of mindset change in users. People have a specific idea of why they purchase a Narrative Clip and to date, what we see is that people pretty much stick to that idea.

That’s not what we would have expected. We would imagine you get people ping-ponging between the two. One would wear it for a while in this mode of “This will be really useful for everything,” and, of course, one would forget for a while and then go, “Oh, something special, I’ll wear it.” And then think, “Oh, there’s product value
here. Wouldn’t it be crazy if I wore it all the time?”

Indeed, what you’re describing is a very typical use case. We don’t see users transitioning from an individual use case into an everyday use. But on an individual user base, even for the ones who have decided “I should try to use this as much as possible,” what is typical is what you’ve described—you drift in and out of that habit. And of course that might be due to how far we have progressed in making the service effortless and the device effortless to use. The Clip 2, for example, has amazing image quality and ease of use due to the connectivity and the modular mounts that surpass that of the first version of the Clip by a magnitude, I would say. When we achieve a higher user value, if people perceive that it gives them value, we think they will choose to use it to a larger extent than the average user currently uses the Clip.

Currently, on average, an active user uses the Clip five and a half days per month. Of course, that’s averaged over the users who use it every day and the users who use it maybe once every other month. I don’t have the median for that, unfortunately. And then during such a day, on average, an active user captures 568 photos—at two photos per minute, that would be about two and a half hours of wearing the Clip.

Do you have a sense of the number of people who use it once and then say, “That’s not for me”?

I don’t have a specific percentage, but it is quite high. I feel that people are purchasing the device very much out of curiosity, so we need to work on lowering the threshold to actually find the value in using it. For the Clip 1, because it doesn’t have its own connectivity, when we need to involve a laptop and user experience just to get started with capturing photos, that can be a hassle for some people, which isn’t their fault. So we can do a much better job in communicating what they need to do to get set up and how they should use it to find the most value. That’s something that we are working on.

It’s the same for many other devices like ours. I saw, for example, that the Fitbit—which is a very simple device—had a successful “onboarding” rate of somewhere around 86 percent initially, and then they got it up to 92 percent or something like that. And our device, just to give you an idea of the magnitude, we are below Fitbit in our own onboarding completion because it is a more complex setup. But I’m not in the business just to sell as many as possible. I want to provide as much value as possible. So to me, that’s a failure of our company, when a user purchases a unit and can’t even successfully try it out before giving up.

But I also think that consumer patterns online are such that we have a lot of people buying things on a whim, so we need to take this into account as well. Not everyone will buy the camera because they have a specific idea. Maybe they’re just attracted to a specific image they saw or a recommendation they read, and they haven’t made a very deliberate decision—and they have the money to spend. So that’s something that we are improving: the onboarding completion rate and the retention rate of users. The user experience is a never-ending topic for us.

Have you seen differences in the way that the Clip is used in different countries or cultures?

Not very much. I only have one interesting data point to share, which is that users in Japan use the Clip far more than users in any other country. Japanese people seem to have a different relationship with the Clip, not only using it more often but also better engaging with the resulting photos.

Half of our users are in the US, since that’s where we do all of our marketing, but we can’t make any conclusions as to the interest in the device based on sales figures between different markets. We can only see that specifically for Japan, people tend to use it much more there, even though there are only around, I think, 1,000 or 1,200 users in Japan.

Do you plan on adding any search features to the Clip?

We believe that search is valuable and we actually have a search engine in place. However, it’s only in the back end. It isn’t exposed to users because we haven’t formulated a user search experience that we are satisfied with. It comes down to, basically, tagging of the photos, because right now, what we have are tags of locations, and that’s not perfect. We have location tags on maybe 5 percent of photos, so, for example, a user could search for and find photos from Austin. So that’s maybe where we’ll start, and then we will evaluate other tagging, like semantic tagging.

It is very hard to produce tagging that is intuitive for the users, because it becomes so general. If we apply object recognition and allow the user to search for a car or dog or house or forest, this doesn’t offer deep value. It just satisfies curiosity. You search for dogs, and you maybe see a few dogs, and the value is not much more than seeing a few dogs. When you want to find a specific photo, it’s so rare that we can tag this the way you would search for it so we cannot achieve good results. Even if you remember there was a dog at that location, and you search for “dog,” it is unlikely that we actually tagged the photo with the word “dog,” just because of the randomness of how photos are taken.

But presumably it’s not just about the tagging, because you’re taking periodic photos, without you actually framing the shots. There is a difference between “I’ve seen the photo in the past and I want to get that photo” versus “I remember an event and I want to see if there was a photo of that event.”

That also goes back to this serendipity of just exploring the last few days of photos. It’s rare, at least for myself, that the specific event I was looking for had the best photos from that day. I often discover other photos that are really
great, because I captured just the right look on the face of a friend or a funny occasion. And it’s so much down to chance, that it happens, that you can’t sort of plan for that to happen, and that also affects the searchability of the photos in the end.

For example, we had a rental car recently, and when we returned it, the company said we had scratched it. Three of us were wearing Narrative Clips, and we were convinced that the scratch was on the car when we picked it up. So we reviewed data from the Clips, but none of the photos captured the car. There were photos of the steering wheel and of the trunk as we loaded stuff in, but nothing of the side panel, where you stay back and see the whole car. But as you say, when you mine back through those photos, you see all sorts of things you completely forgot. So I can see the search functionality as being an interesting and difficult challenge related to the user experience.

And if we look at very, very long term, I actually view the Narrative as “very low frame-rate video,” like we have one frame every 30 seconds. Now, we could increase the frame rate up to the point where you can be pretty sure to capture that scratch mark if you just had been looking at that general direction. But then to consume and store all that data would be very tedious. I think there will always be a tradeoff there.

If we look 10 or 20 years ahead, Moore’s law would dictate that we’ll be able to capture 24/7 video if we want to. Still, it will be very hard to consume. If I want to watch myself getting coffee or if I have a sequence of myself getting coffee, I will never look at the full sequence, because it takes two minutes of what will be very boring video. So key frame selection becomes even more important as the frame rate increases.

It’s a tradeoff. You don’t have another lifetime to look back at the video you captured. As the number of photos you take increases, then the summarization has to become more aggressive. And then the search becomes more interesting—it’s possible we never showed you that photo because we “optimized” it out of your past. But how far back do people reach, or what kind of general user patterns do you see?

I think in October, we implemented the calendar function in our app at the top of the smartphone UI. And we saw a large shift in user patterns. People were jumping back to previous points in time to a much larger extent, because just scrolling down further was very tedious. But I actually don’t have any quantified data on that currently, but there is a varied use of patterns. People are not only looking at photos from just the last day or so.

I would love for people in the future—30 to 50 years from now—to know that they can go back in time to explore their relatives’ past lives.

What about yourself… how far back do you usually go?

I have a few specific events that I go back to from time to time. When I went to visit a friend last year, it’s someone I see very rarely and I remember the dates, so I can revisit the photos. And I do it when I want to show other people something. When I communicate with somebody else and tell them about something, I go back further than just a few days. But when I just browse the photos myself, I only look at the last couple of days.

Do you have a sense of what happens to these photos when people die, for example? People are going to have a big bank of their memories. What’s your take on that in terms of what you do with the photos? Can other people access the photos?

When we grow as a user base, what I would like to implement is for users to be able to say that if they don’t access their account in a certain amount of time, then this relative can access the data, or if that relative presents a death certificate, then we can transfer access. But we have yet to explore the legality and related technicalities of that.

I would love for people in the future—to know that they can go back in time to explore their relatives’ past lives, as well as their ancestors’ lives. That would be the ideal for me, because that’s something that we could achieve. But for now, our company is so young. The oldest photos in our database are one and a half years old.

But we never look at the users’ photos. They are private to the users. So they won’t be transferred to the general public or to the properties of our company or anything like that. They will be deleted in the end if no one claims ownership of photos that are no longer accessed by anyone.

As a user, that is reassuring, especially compared to most online services, where I really have no idea what’s happening to my data.

I would also like to have a search function in general, so that, for example, if you opt in for it, anyone can ask for photos like, “Does anyone have a photo from Stockholm on this date?” And then we can do an algorithmic search and ask users, “Would you like to share your photo with this user, who wants the photos for this purpose?” So you could search the entire database of users, across time and space, but you would not get real-time results. Only as users opt in to sharing their photos would you see results pouring in.

And we know that it is possible for the Swedish government to, by court order, say that we need to share photos from the database, but we would tell the user if we received such a court order. That’s not something we can get around; it’s not legally possible.
Have you looked at storing the images in encrypted form, where only the user has the key and you genuinely have no access?

We've done some research into that, and it's technically complex to achieve. At some point, we need to analyze the photos to provide the user experience that makes the photos valuable to you. But if we decrypt the photos, then that's a point where a government organization, for example, could install a program that spies on specific users.

So storing them in an encrypted form would be trivial, but you'd have to be able to decrypt them to provide the value you think customers want, and as soon as you can do that, then in a sense, you might as well not encrypt them.

We are actually storing them encrypted on disk. So if anyone runs away with the physical disks, they will not be able to access the photos. But we can't say that they are secure from everything that can go on, because although they're secure to the furthest extent possible from hacking attempts, we can't do anything if we receive a court order. If someone orders us to send us all the photos that this user posts, and maybe orders us not to tell the user, then it would be very hard for us not to comply. We could fight the order in court, and we would, but we might not be successful.

If you think 5 to 10 years out, what do you think the mounting is going to look like? Do you think it's going to get to a point where a large number of people are wearing them, and there's an accepted best practice regarding how to wear them? Because where you wear them makes such a big difference.

What would the ideal mounting for a Narrative Clip look like?

That's something we're beginning to explore, but it's not until we have the Clip 2 out that we—and our users—can explore different mounting options, which we can then do serious research on to determine the best way to wear the wearable camera. What we do know is that we do need is flexibility, because people have so many different use cases. Flexibility is key. There's no one set way that everyone will be able to use it, unless, perhaps, if wearable glasses, like Google Glass, become as common as headphones. Then, on the glasses would perhaps be the best place for a wearable camera.

But to me, the resistance to that is far too great to overcome, because it's currently impossible to create a pair of glasses that don't make you look like a cyborg and that don't alienate you to other people, which is something that the form factor of the Narrative Clip rarely does in my experience. So there are, as with everything, tradeoffs. I can't predict where it's going. And we've already seen that usage patterns very quickly change, based on how the people you are with feel about the product.

We've already seen that usage patterns very quickly change, based on how the people you are with feel about the product. I behave differently depending on who I'm with. Maybe I'll put the Clip away completely if I know someone is uncomfortable, or I will just make sure it's not pointing directly at them if we're sitting down and having dinner, for example.

It's interesting, because you don't seem to have had the same sort of backlash that Google got with its glasses. Is there something specific you attribute that to?

We had a very conscious design process, where we developed a concept with the balance between being subtle enough to not be distracting, but honest enough to be recognizable as a recording device. At first, we had the lens in the middle of the device, which made it look like a third eye of the person. It was very distracting. It wasn't until we made the camera square—because it was round at first—and moved the lens up to the corner, that it sort of disappeared out of view.

But then we made the beveled edge of the camera shiny so that it picks up light in the vicinity, so people can see that there's a gleam around the lens, which makes them perceive it as a camera to some extent. And that's something that we quantified in user testing. With the Clip 2 now, what people perceive as a camera has shifted, so the design of the camera lens on the Clip 2 is a bit different. We want that honest outlook, and I think that makes people more comfortable with the device. It's not trying to hide or look like something else.

If you think of something like the GoPro, which also hasn't had as much backlash, it's clear that the user is recording a specific set of events—going mountain biking or something—so it seems the perceived usage is important. With the Google Glass, it wasn't always obvious how people were going to use the images or what Google might do with the images. But you have a different model.

It's something about glasses—if you ask someone to take off their glasses, you're actually being rude to that person. So when you have glasses on with a camera, you're sort of putting yourself in a position of power, where it's rude to ask you to stop taking photos and that, I think, is alienating people to some extent. Another issue is that the Google Glass mode of streaming videos lets you stream to your Google Plus account, which is public by default.

With Narrative Clip, it always takes two decisions for a photo to become public. First, you decide to wear the camera. Then, you look at the photos and you decide to share them. We might implement a streaming function in the future, but I think people feel safe because of that level of security.
There’s definitely a tangible difference between you taking a photo of someone on this Clip, which they could throw away before the photo gets anywhere, versus with glasses. By the time one has noticed you’ve taken a photo, it could already be on the Web. But one final question: did you envision this as a niche technology that would aid something like the GoPro, or as something as pervasive as a cell phone?

That’s an interesting question, because you can speculate in either direction and see the scenario playing out. But if cameras become totally pervasive in the sense that we are always on camera and our entire life is recorded, then I believe that, perhaps, wearable cameras will not be the optimal form factor. Maybe the cameras will be everywhere in our houses and in the streets, and there will be some sort of system for me to gather the photos of the things that I’ve been experiencing instead. The social shift that would need to happen, or that would happen as a result of everyone having wearable cameras, would allow many more devices, and even walls, doors, and chairs, to have cameras.

There was an interesting series of “future technology” videos made by Microsoft, where they showed their vision of how you would interact with technology and with each other through technology. Everybody was interacting with each other through screens on walls and on tablets, but cameras—which were obviously abundant—were invisible. Everybody was on camera all the time, but the cameras were nowhere to be found. The wearable camera must be very valuable to be as abundant as the mobile phone, or it needs to become effortless. But I do believe that wearable cameras will become very pervasive in the future.

Nigel Davies is a professor of computer science at Lancaster University. Contact him at nigel@comp.lancs.ac.uk.

Marc Langheinrich is an associate professor in the Faculty of Informatics at the Università della Svizzera Italiana (USI), in Lugano, Switzerland, where he heads the Research Group for Ubiquitous Computing. Contact him at langheinrich@ieee.org.


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Legal Issues with Wearable Technology

Brian M. Gaff, McDermott Will & Emery, LLP

The proliferation of devices that can be worn and used anywhere has raised a number of legal issues. How these issues will be resolved is difficult to predict.

Wearable technology—smartwatches, FitBits, Google Glass, and the like—has become increasingly popular. These devices can provide information and entertainment, and they can collect and disseminate data derived from the wearer’s actions. This raises several interesting legal questions. Who owns this data? Is the wearer’s privacy being compromised? How about the privacy of others near the user? Can the wearer unwittingly infringe another’s intellectual property? How will apparel manufacturers handle intellectual property (IP) protection as technology is integrated into clothing?

For an expanded discussion on this topic, listen to the podcast that accompanies this column at www.computer.org/computing-and-the-law.

DATA OWNERSHIP
Wearables typically collect all types of data about the wearer. Much of that data is arguably highly personal. But what becomes of that data? Certainly the wearer can process it with myriad apps and upload and share it with others. So what claim, if any, does the wearable’s manufacturer or app provider have on that data?

Consider those devices that record one or more of the wearer’s vital signs with the goal of providing feedback on fitness or exercise routines. Broadly speaking, that data indicates the wearer’s activity level, including, for example, whether he is sitting, standing still, walking, or running. If the device has access to GPS data—directly or via a link to a GPS-enabled smartphone—the wearer’s activity level can be coupled with location information. Collected over time, this data provides a rather detailed profile of the wearer, giving insight to his daily schedule and habits.

Companies that want to engage in targeted marketing would find such profile data very valuable. Advertisements for goods and services could be sent to wearers based not only on their location, but also on their health and habits as determined or inferred from the vital-sign data.
Is this what wearers want? Or, more importantly, do wearers want third parties to have access to their personal data—their profiles—for marketing purposes? If a wearer owns his data, he typically has the final decision on who has access to it.

But it’s a different situation if the wearer doesn’t own his data or has consented to others using it. So, any agreements between wearers and wearable device manufacturers or any related app providers should be carefully considered. Those agreements should clearly state who owns the data and whether and how it can be accessed or used by anyone other than the wearer. Even if an agreement expressly states that the wearer owns the data, it still might give a third party a right to access and use it.

Agreements should also cover instances in which data is uploaded to company-provided clouds as a convenience to the wearers, and whether that changes the ownership picture. Companies that don’t articulate this in straightforward language run the risk of an unfavorable outcome in related litigation.

Wearers also need to take responsibility for reading and understanding such agreements. Clicking through a license, which typically signifies agreement with its terms, without understanding the substance is unadvisable, particularly when highly personal data is at stake. When considering the use of a wearable device, wearers must ultimately decide whether they’re willing to relinquish some or all control over their data in return for the device’s real or perceived benefits.

THE PRIVACY ISSUE
Privacy concerns are closely related to the ownership issue: wearables collect highly personal and sensitive data that might reveal significant details about a person’s private daily routines. Although there are potential benefits to this, there are also serious privacy concerns about such data falling into nefarious hands.

Consider a case in which a wearer’s data is uploaded to a cloud service that is later hacked. A diligent criminal might be able to determine the identity of the wearer, potentially facilitating identity theft. More concerning, however, is that the criminal might be able to ascertain the wearer’s daily activities, right down to locations and times. This could increase the risk—and precision—of stalking.

Given the serious potential consequences of a wearable data breach, steps must be taken in advance to protect against it. At a minimum, the data should be encrypted to minimize potential damage. There should be no reasonable way for a hacker to understand the data he obtains. In addition to encryption at the cloud level, implementing similar protective measures at the wearable level would prevent, or at least frustrate, proximity-level hacking—for example, via RFID or Bluetooth. Protections such as these should keep the wearer’s data safe and will likely reduce the liability of companies that are victims of hacking.

Anonymizing data—that is, stripping out anything that would connect it to a particular user—can address the privacy issue, particularly if the data is to be used for marketing purposes. At that point, the data is no longer “personal” and arguably can’t expose individuals to the typical risks associated with a data breach.

Certain countries or regions have laws in place that are designed to protect the privacy of personal data that’s transferred across international borders. To the extent that companies with access to wearable data want to share it across borders, it’s advisable to review the pertinent laws to ensure compliance. For example, to transmit personal data out of the EU, companies must comply with the EU’s laws regarding international transfer. This is a complex area that should be discussed with an attorney.

Companies facing these and other privacy issues should have a comprehensive privacy policy in place. Such a policy should address the rights and responsibilities of the company and the end users or wearers. The particulars of a well-crafted and clearly worded privacy policy are beyond the scope of this discussion and should be discussed with an attorney.

INTELLECTUAL PROPERTY
IP protection of wearable technology is similar to what’s available for other technologies. For example, utility patents might cover certain aspects of the wearable’s hardware or software. Design patents might cover the wearable’s appearance or other ornamental, nonfunctional elements. Trademarks might provide similar protection. The software might be copyrighted as well.

In general, companies should seek multiple forms of IP protection—akin to building a protective enclosure around their technology. This increases the likelihood of comprehensive protection, including protection from imported counterfeit products that under certain circumstances can be seized at the US border.

Whether using a wearable can expose the wearer to an allegation of IP infringement is an intriguing question. For example, consider a wearable that includes a camera the wearer can use to record his surroundings. Does making that recording and uploading it, or potentially making it available in real time, constitute copyright infringement? Some events, such as sporting events, expressly prohibit rebroadcast without consent. Given that many wearables are unobtrusive and might not be easily detected, how would this be policed? Would spectators have their
wearables confiscated before entering a stadium? Or would this kind of use constitute what copyright law calls fair use and, therefore, be permissible? These are unsettled questions that will likely not be resolved until they’re raised in a future lawsuit.

Another related issue is whether using a wearable to record your surroundings would constitute an invasion of privacy with respect to any person who is recorded without their knowledge or consent. Questions about whether the recorded person had a reasonable expectation of privacy in that setting would be raised. In addition, many jurisdictions have laws restricting or prohibiting surveillance and wiretapping without court authorization. There might be a criminal penalty to the extent the recording violates those laws.

As wearable technology is increasingly adopted, it’s reasonable to presume that it might evolve from an accessory to being incorporated into apparel. For example, one can envision clothing with conductive fibers and integrated sensors wirelessly linked to a processing and display apparatus. Apparel manufacturers are familiar with using trademarks and copyrights to protect their designs. However, as they move into this technology-rich space, it’s incumbent on apparel manufacturers to consider IP protection like utility patents to cover their technology. This is probably unfamiliar territory for many apparel manufacturers, so consulting with an IP attorney to develop a comprehensive protection strategy is a wise course of action.

As wearables become more prevalent, we’ll likely see disputes over how they’re made, sold, and used. Many of these disputes will probably raise the recurring and difficult issue of how best to apply old laws to new technology. In these situations, courts can struggle to interpret a law and its applicability to technology that didn’t exist or wasn’t even contemplated at the time the law was written. For now, that means it will be difficult to predict outcomes.

BRIAN M. GAFF is a Senior Member of IEEE and a partner at the McDermott Will & Emery, LLP law firm. Contact him at bgaff@mwe.com.

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COMPUTER ENTREPRENEUR AWARD

In 1982, on the occasion of its thirtieth anniversary, the IEEE Computer Society established the Computer Entrepreneur Award to recognize and honor the technical managers and entrepreneurial leaders who are responsible for the growth of some segment of the computer industry. The efforts must have taken place over fifteen years earlier, and the industry effects must be generally and openly visible.

All members of the profession are invited to nominate a colleague who they consider most eligible to be considered for this award. Awarded to individuals whose entrepreneurial leadership is responsible for the growth of some segment of the computer industry.

DEADLINE FOR 2017 AWARD NOMINATIONS DUE: 15 OCTOBER 2016

AWARD SITE: https://www.computer.org/web/awards/entrepreneur
www.computer.org/awards
This quarter’s contributors to our Reddit site include posts about the many different ways we instrument our world, ourselves, and our stuff. Along with these topics come the inevitable discussions of privacy, power, and, of course, sheep. We also received more posts about drones—including drones for sheep.

**INSTRUMENTING OUR STUFF**

Smartphones continue to accrue sensors both inside and out. When on the outside, perhaps we can call such sensors “smart barnacles.” We also need easier ways to recharge our sensor-hosting phones.

**Acoustic Accoutrements**

The most intriguing contribution this quarter is a collaboration between Disney Research Pittsburgh and Carnegie Mellon University called “Acoustruments.” These are inexpensive plastic devices that you attach on or around your phone to provide new kinds of interactive control through acoustic manipulation (see Figure 1). Acoustruments take audio input from the phone’s speaker at one end of a tube or cavity and feed it back into the phone’s microphone at the other end. Along the way, you can alter the sound by changing various physical elements, such as the size and shape of the cavity, the continuity of the channel, and the number and placement of holes—much the way wind instruments manipulate sound.

The authors provide building blocks that allow for interaction controlled by touch, grip, sliders, rotators, and more, with high accuracy. The devices require no batteries or power sources—just acoustic input (see www.disneystudios.com/publication/acoustruments for more information and a video). However, you might end up with a clunky look and feel with phones such as the Moto X, which positions its microphone ports on the phone’s display surface and back surface.

**Turning Air Pressure into Gold**

Barometric sensors made their way into phones just a little over three years ago (and only recently into the iPhone), but PressureNet was there at the beginning, with its vision of building the largest network of such sensors. Barometric phone sensors were intended to improve altitude measurements for GPS locations and elevation readings. With its strong crowdsourced sensing community, PressureNet now has over a billion atmospheric readings, and the collection is growing by about 5 million readings a day. This has become a great material for improving weather forecasts, and PressureNet is now working on selling the data as a service to researchers and forecasters.

This is another example of crowdsourced sensing becoming profitable. To read more about PressureNet and its plans and tools, and how it is addressing privacy concerns, see www.pressurenet.io/blog/to-users-community-update.

**Powering Our Stuff**

The more we rely on our phones, the more we require convenient charging. One member of our subreddit contributed a link to Ikea’s new scheme for recharging mobile devices. As reported by Gizmodo’s Adam Clark Estes (http://gizmodo.com/ikea-just-made-it-crazy-easy-to-add-wireless-charging-t-1698047498),1 Ikea will sell furniture with built-in wireless charging. If you don’t want new furniture, they will sell you a special drill bit that allows you to make the appropriate hole in almost any existing piece of furniture in which you’d like to install their new inductive charging device. If you don’t want to drill any holes, they offer a cute wireless...
charging pad you can slap down wherever you’d like to recharge your device. And if your phone isn’t already equipped with Qi inductive charging capabilities, they even offer phone cases that will bring that functionality to your phone. One way or another, you’ll be able to recharge that phone wirelessly!

INSTRUMENTING OUR ENVIRONMENT

Beyond sensing on phones, contributors this quarter posted information about instrumenting our environments with a variety of sensors and actuators.

Paying Local Experts

While crowdsourcing things like weather readings benefits from a passionate community, finding that community for some tasks can be very difficult. Online labor markets such as Mechanical Turk (www.mturk.com) work best for unskilled, relatively low-paid work. What if you need a community of experts? In the case of the Umati Project from UC Berkeley, the answer is to bring the work physically to the expert community in the form of kiosks, and then offer a convincing incentive.

The Umati Project’s Community-Sourcing Vending Machine (see Figure 2) dispenses candy as the very desirable payment for grading endless introductory-level CS exams via its touchscreen interface. Grad school, of course, is not survivable without candy. For more explanation, photos, and a video, check out http://represent.berkeley.edu/umati.4

Turning Buttons into Gold

Amazon is trying out several ways of instrumenting the home environment to make it easier for consumers to purchase products as soon as the thought crosses their minds. We mentioned Amazon’s Echo in a past column (www.amazon.com/oc/echo). Another approach, the Dash Button, is a small device consumers attach to a surface near where they use things like detergents, lotions, and coffee. When running out of the product, the consumer just presses the button to order more.

Removing friction from the buying process might help Amazon grab a larger share of the consumables market. How much friction does the button remove compared to ordering by phone? Results remain to be seen, but as Adrienne LaFrance points out in The Atlantic, (www.theatlantic.com/technology/archive/2015/03/the-amazon-button-is-real/389234),5 “People don’t always want to pull out their smartphone right after using the last paper towel on the roll.” For Amazon’s video about the Dash Button, see www.youtube.com/watch?v=NMacTuHPWFIL. Might our future refrigerators be covered with reordering buttons instead of kids’ photos and drawings?

Industrial Instrumentation

Aside from home environments, there are many compelling reasons to instrument industrial environments. The French commercial creativity services company, Sid Lee, offers a delightful dashboard showing the current status of the many items they have instrumented in their office (http://dashboard.sidlee.com). If you don’t see a readout moving as you’d expect, remember the time zone of the instrumented office—it could be everyone is at home sleeping.

Another company, SeeControl, has helped many commercial customers save money and reduce energy consumption, including a leading US manufacturer of carpets. Energy prices that vary hourly at the carpet manufacturer’s Western US plants caused financial losses. Furthermore, the company wanted to predict when machines on the production floor would give out. Using eGauge’s electrical submeters and SeeControl’s IoT cloud service and tools, the company was able to meter...
and visualize their energy consumption. After one month, the company had a full shop-floor enterprise-scale energy management system. See http://startupfocus.saphana.com/introducing-seecontrol-the-first-turnkey-iot-solution-for-enterprise-customers for more information about this use case.5

Shepherds of Progress
But what if the environment you want to instrument consists of sheep in the hills and fields of Wales? If you have not already viewed the viral video of Extreme Shepherdng from the “Baaa-Studs” (www.youtube.com/watch?v=D2FX9rviEhw), it’s well worth watching. Sheep and sheepdogs instrumented with Samsung’s Smart LED technology make for illuminating outdoor farm art. For behind-the-scenes information about how they did it and how much of it was real (almost all, apparently, with the “very able” sheepdogs doing most of the work) see www.youtube.com/watch?v=FxedtAM2j7g.

INSTRUMENTING OURSELVES
Readers continue to post items about wearable technology. Interestingly, the only post about Apple’s new watch touched on the company’s retail strategies to ensure that returned watches have as much gold in them as when they were purchased. Instead, we cover more fitness clothing and a Google Glass app.

My Clothes Are Smarter than I Am
One contributor shared CNN Money’s article positing that the biggest growth area for fitness devices will be smart clothing (http://money.cnn.com/2015/03/20/technology/fitness-wearables-smart-clothes/index.html).7

The article mentions three brands. First, Indian startup Lechal’s smart shoe was originally designed to help the visually impaired navigate via haptic feedback telling the user which way to turn. Lechal now offers both shoes and insoles instrumented to measure distance, calories, and steps. The shoes store the results, and you can download the data via an app when you’re done exercising (see Figure 3). Building step sensing directly into the shoes might help avoid some of the inaccuracies found with devices that don’t sense the user actually putting his or her weight into the step.

The second company, Glofaster, offers a jacket for runners that senses speed and heart rate and can flash lights along the sleeve if you’re not exercising hard enough.

The third company is Sports Performance Tracking, whose vest contains a GPS unit to measure speed and distance. This vest is oriented toward teams and can tell you how well each player is doing in a game. It can also tell you if a player is working so hard that a potential injury...
is possible. The latter feature sounds very useful, but we wonder if the former feature could cause individual anxieties that reduce the sense of teamwork.

My Accessories Are Better Speakers than I Am
Another post on wearables covers Rhema, an application that uses Google Glass to provide feedback to speakers about their pace and volume. The researchers evaluated a variety of ways to display the feedback to speakers via the glasses, including color-coded warnings, words, and graphs. They experimented with both continuous and occasional feedback but settled on providing feedback every 20 seconds in the form of the words “louder” or “slower” as needed. They tested the system on 30 native English speakers and also used Mechanical Turk workers as audience members to judge whether video-taped speakers behaved differently when wearing the glasses in terms of using filler words, making eye contact, appearing stiff or uncomfortable, or seeming distracted. Find out more about this University of Rochester research at http://phys.org/news/2015-03-wearable-technology.html.

The reported results are encouraging, although we believe there is a class of speakers that will feel even more foolish if they’re caught wearing smart glasses while giving a talk. Also, we’re not sure how the system adapts to different spaces with differing volume requirements. We’re reminded that worried public speakers are often prompted to find comfort through pretending their audience is not wearing clothes. I’ve never understood why that wouldn’t make the speaker even more worried, but if it actually works for anyone, then there’s a clear augmented reality application for smart glasses for public speaking.

THE NEW WORLD ORDER
This quarter several community members contributed posts concerning privacy issues and how the future is shaping up regarding our increasing use of technology and smart devices.

Barbie Hears Everything
The most popular post this quarter flags privacy issues behind Mattel’s new “Hello Barbie” doll. Caitlin Hu’s article for Quartz tells us that while Barbie can finally hold a conversation (a long-standing request from children), the Wi-Fi-connected toy also sends everything Barbie’s playmate says back to the company (http://qz.com/362891/new-hello-barbie-records-kids-voices-and-sends-the-intel-back-to-mattel). If the child playing with Barbie presses a button on the doll’s belt, Barbie will ask a question and record the child’s response and send it to the cloud. In the cloud, ToyTalk’s software processes the audio for its content. This content helps trigger an appropriate response from Barbie.

ToyTalk uses these recordings over time to learn children’s names, interests, and conversational styles. The company will also use these recordings “for other research and development or internal purposes” and may also “share extracted data and transcripts … from which any personal information has been removed” with third parties.9 Mattel says this information will not be used to target advertising to children, but some parents remain concerned about the privacy implications of this new functionality for the famous doll.

On the other hand, maybe adaptive conversation will prove more acceptable than pre-programming Barbie to say “math class is tough!” (www.youtube.com/watch?v=NO0cvqT1tAE).

A View into 2017
According to Parks and Recreation’s final season, future (2017) technology companies are still using people’s personal data in uncomfortable ways, and they’re still forcing U2 music onto people’s personal devices. Sean O’Kane’s article in The Verge extracts the show’s key predictions of our technological future (www.theverge.com/2015/2/23/8095109/parks-and-recreation-series-finale-future-technology). Personal devices become clear glass displays, wearables are rare but goofy, everyone uses cumbersome gestures to interact with devices, and drone delivery exists but seems a bit frightening. Also, Ron Swanson shoots a drone out of the sky, but that probably isn’t too surprising to fans of the show.

Comparing Two Lives
Another reddit member posted a short documentary by Ivan Cash (via an article in The Atlantic, www.theatlantic.com/video/index/386579/how-do-you-function-without-a-cellphone) about our dependence on smartphones. This topic often seems trite, although this documentary is rather sweet. It compares the lives of a San Francisco designer who has never owned a smartphone and a teenage girl who hasn’t gone a day without hers since she received it. The video is called “How Do You Function Without a Cellphone?” The designer is happy to be without a phone, although he believes he might eventually need one due to the devices’ great utility. The teenager wonders whether cell phone use prevents her and others from living physically enough in the moment. She knows that time is passing her by quickly.

These all seem like valid points, although the minutes spent showing the differences in the two walking might be pushing the matter a bit. The walking designer always looks happy and engaged with his surroundings, while the teenager is always head-down and furiously texting while walking. Such matters are rarely so cut and dry.

THE SKIES ARE ALIVE WITH COPTERS
Even if Parks and Recreation does not fully endorse drone delivery, our community continues to be fascinated by the topic.

The Ultimate Selfie
Instead of taking a photo of yourself before and after you skateboard down the mountain or run up it, you can have a complete video of the event to show the world. 3DR’s IRIS+ or new Solo
quadcopters can automatically follow you and film you while you go—almost like having your own mobile aerial film crew. You can also fly the devices manually with a controller or from a wearable or mobile device, and you can draw a path on a map and the drone will follow that path making it great for mapping applications.

The IRIS+ gives you 15 to 20 minutes or more of flight/filming time and is available for well under US$1,000. The new Solo, available for pre-order at US$1,000, makes it even easier for ordinary people to get high-quality footage right out of the box (see Figure 4). Check out the posted video at www.youtube.com/watch?v= _yOCTgVqmeQ or look for more information at 3DR’s website (www.3drobotics.com).

Fewer Nasty Letters
In a recent column, we covered new regulations from the FAA regarding the safe and legal flight of drones. Bloomberg Business also reports that the FAA is trying to take a kinder and more forgiving approach to ensuring the safety of our airspaces (www.bloomberg.com/news/articles/2015-04-14/drone-homevideos-on-youtube-no-longer-provoke- faa-wrath).\textsuperscript{12} While doing dangerous, illegal things will still get you in trouble, the FAA hopes to encourage voluntary compliance through educating individual drone operators about safety issues and current laws and regulations. Apparently, they will no longer hunt down authors of YouTube drone videos to send them harsh letters or scare them into removing the videos. So, be safe and do the right thing, but go ahead and post that nice aerial video of your personal speed boating record.

And Finally, More Sheep
In his video (https://youtu.be/yD9KUB7QzZI), Paul Brennan introduces Shep, the world’s first drone sheepdog. The video shows the view from the drone as it moves a herd of sheep through a narrow passage from one field to another in Carlow, Ireland. Maybe the next iteration of farm LED art from the “Baa-a-studs” will use a swarm of drones instead of actual sheepdogs to move sheep in ever more artistic patterns.\textsuperscript{F}

\textbf{REFERENCES}


\textbf{Mary Baker} is a senior research scientist at HP Labs. Contact her at mgbaker@hp.com.

\textbf{Justin Manweiler} is a researcher at the IBM T.J. Watson Research Center. Contact him at jmanweiler@us.ibm.com.
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Code Clarity

Gerard J. Holzmann

YOU PROBABLY WOULDN’T consider using a single letter for a global variable in a large application, nor would you think it wise to use an overly long name like integer_loop_index_variable in a simple for loop. Naming is important because it affects the readability of your code and the ease with which you can find your way around when reviewing code. Naming conventions aren’t meant to help the compiler. A compiler has no trouble distinguishing names, no matter how long, short, or obscure they are. But to us humans, the names we use can matter a great deal.

Most coding standards contain naming conventions, and they often have rules that try to regulate the use of white space: where you put your comments, spaces, and braces. Clearly, if a C compiler doesn’t care about the particular naming convention you follow, it cares even less about your use of white space. There’s a difference between the two, though. Formatting choices are relatively easy to change after the fact with Unix tools such as indent. It’s much harder to change a program to adhere to a different naming convention than the original programmer used, assuming of course that he or she used one in the first place.

If you write a lot of code, you’re probably familiar with the problem that you have to quickly think of a name for a new function, while your main focus is to keep track of the logical flow of a new algorithm you’re implementing. Who hasn’t used quick names like blurb() or doit() and then forgotten to go back to replace those temporary names with something a little more meaningful? Like most programmers, I’m guilty of this. I did a quick check of the latest version of the Spin model-checker code (http://spinroot.com) that I maintain. Among the 643 function definitions, I saw function names such as do_same() and even the very helpful blip(). Clearly I can’t be accused of having followed any particular naming convention there.

You often hear that the best function names are verbs and the best object names are nouns. The intuition is that from the function name you should be able to deduce what it does. The principle is fine as a starting point, but the problems begin if we try to make it a hard rule. For instance, would our programs improve if we renamed the familiar function strlen() as something like compute_length_of_string()? Similarly, would it be any clearer if we renamed atoi() as a verb-based variant like convert_text_to_number()? Besides knowing what a function does, it can be just as important to know what type of input a function takes and what type of result it returns. From a name like strlen, we can easily deduce that the function takes a string as an argument and returns an integer as a result. The fact that it must do a conversion to achieve that feat doesn’t really need to be spelled out in this case.

Choosing Function Names

Some projects use the rule that all function names should start with an abbreviation of the datatype that the function returns and an indication of the function scope. We could, for instance, use the prefix u32g_ for functions that return a 32-bit unsigned integer with global scope. In larger projects, we often also see the
rule that function names must contain a prefix that includes the name of the module in which they’re defined. This could extend the required prefix to something like u32g_nov, and so on. For our innocent string length function, this could mean that its name could grow all the way to u32g_gbl_compute_length_of_string(). Proponents of this convention will likely say that it now makes it clear how to safely use the function and where its definition is. Meanwhile, we’ve already used more than 32 characters just to name one function.

Other than the name length, this approach has several problems. I’ll name just three. First, if you’re the programmer, you have to already know every part of the prefix before you can identify and use a function. If you don’t, you have to look up the function definition first. Obviously, having the unknown module name be part of the unknown function-name prefix doesn’t help you locate it faster than before. Second, if you have to look up the function definition or function prototype to determine the full name, it would hard to miss also seeing the function return type and scope. Third, there are surely better ways to check that your program is type-safe than using an easily violated naming convention. Are there extra penalty points for retaining the prefix u32_ for a function that now returns a signed 64-bit result? Getting back to the uncontrolled growth of function name length: does this really improve code clarity?

When Longer Isn’t Better
Should there then be a limit on function name length? The C99 standard requires that a C compiler distinguishes at least 31 significant initial characters in all names of functions and identifiers. The standard wisely also recommends that “implementations should avoid imposing fixed translation limits whenever possible.” Most, if not all, C compilers have taken this recommendation to heart and don’t impose any limit on the number of significant characters in identifier names.

Technically, though, it can be considered implementation dependent what happens if you have two identifier names that differ only in the part that follows a common prefix of 31 or more characters. Many coding standards for safety-critical code therefore rule out identifier names longer than 31 characters. Thirty-one characters is enough to distinguish $26^{31}$ or $7.3 \times 10^{43}$ different names, which is enough to give $10^{23}$ different names to every one of the estimated $7.5 \times 10^{18}$ grains of sand on earth. So why would you ever need a longer name?

To get a point of reference for the types of naming conventions practitioners follow, I looked at the length of function names in the most recent Linux distribution (version 4.3). Figure 1 summarizes the results. I counted 390,312 distinct function names in the roughly 15 million LOC (18.6 million including the header files). Of those names, 97.5 percent are 31 characters or fewer. The remaining 2.5 percent cover 9,766 functions with names longer than 31 characters. The two longest names have 65 characters.

We can also look at earlier Linux versions to see whether the naming discipline has changed much over the years. To do this, I went back to Linux 2.4.18 from around 2002. That version had a mere 3.7 million LOC and 60,834 functions. As we know, code always grows with time, no matter what the application is.

This earlier code had a different distribution of function name lengths. In it, 99.5 percent of the functions had a name shorter than 32 characters, and just 310 functions had names longer than 31 characters. The two longest were 50 characters. Those names are interesting though, because they differ only in the last four characters:

idetope_onstream_space_over_filemarks_forward_fast(…)

idetope_onstream_space_over_filemarks_forward_slow(…)

FIGURE 1. The length of function names in the Linux 4.3 source code. (The numbers in the chart are the percentages for each section.) A very small portion of the functions have names longer than 31 characters, with two functions reaching 65 characters. On the other end of the spectrum, 15 functions have a single-letter name. Most of these functions are single-line functions or dummies that just return a fixed value to the caller.
We can see the effect if we plot the distribution of function names used in these two Linux versions (see Figure 2). Over time, a shift occurred toward using not just more code but also longer names. In the 13 years from version 2.4 to 4.3, the median function name length increased from 14.0 to 17.5.

The growth trend is still more pronounced if we look at identifier names in general and not just function names. For instance, the longest identifier name in Linux 4.3 reached a whopping 104 characters.

Perhaps unsurprisingly, we see the same trend in the flight software NASA develops for its space missions. Over time, longer and longer identifier names have tended to get used, with some particularly striking extreme name lengths. For instance, the longest function name in the flight code for a recent mission reads almost like a sentence at 71 characters. Over approximately 18 years, the median function name length in flight code has increased from 18 characters in 1997 to 21 characters today.

So if this trend has always existed, we can try to calculate when the C epoch began, just like we can calculate the moment of the big bang by using the known rate of expansion of the universe to reason backward to the time when all mass would have had to originate from a single point.

The minimum function name length is obviously one character, but that would give us only 26 functions to play with. So, it’s perhaps better to put the minimum length at two characters. If we put the average growth rate of function names optimistically at one character every three years and take the current median name length of 17.5 in Linux code, then time must have begun about \((17.5 - 2.0) \times 3 = 46.5\) years ago. That gives us a date in 1969.

Although this exercise stretches the limits of what’s reasonable, the date actually turns out to be close to correct. The development that ultimately led Dennis Ritchie to the early design of C was Ken Thompson’s B language, which itself was a derivative of Martin Richards’s BCPL (Basic Combined Programming Language) from approximately 1969. The oldest version of a C compiler, which Dennis wrote in 1972 for the PDP-11/20 minicomputer, has survived, so we can look at that code to see how function names were
chosen then. The median length of the 52 function names in the 1972 C compiler was a little over six characters, with no function name being longer than nine characters or shorter than three.

Let’s pick one more data point in 1985, with the source code from the cmd and libc subdirectories in the 8th edition of the research version of Unix. This code had 3,432 function definitions with, surprisingly perhaps, a median length of still no more than six characters. By this time, the longest function name had grown to 19 characters. There’s a slight rub here, though, in that the long function names were actually contributed by colleagues from outside the Unix group. For the code written by people from the Unix group itself, the longest function name was still no more than 14 characters.

We can do a similar experiment by also measuring the average and longest lengths of all identifier names. The numbers are now much larger, of course. The 1972 C compiler code had 2,845 unique identifiers, the 1985 Unix code had 592,416, and the 2002 and 2015 Linux code had 3,821,169 and 20,961,560, respectively. The longest identifier in these code bases grew from 9 to 23 to 70 to 104 (see Figure 3). Figure 3 shows that, happily, unlike the rate of expansion of the universe, the rate of increase of name lengths isn’t accelerating, so we may be reaching a new equilibrium.

How you name functions and identifiers clearly affects code clarity, but it would be hard to capture this fact into a single rule or a simple naming convention that you could apply uniformly to all code. It comes down to the judgment of the programmer whether a verb or a noun best captures the intent of a function. Clearly, very long names should be rare, and very short names are best for things that don’t require much attention. Beyond that, there’s little anyone could sensibly say about naming.

The statement “640 Kbytes of RAM should be sufficient for anybody” is often attributed to Bill Gates, spoken when PCs with 64 Kbytes of RAM were common. We could say that the implicit supposition from the C language standards that “31 characters ought to be sufficient for any identifier” has similarly been overtaken by reality.

**Reference**


Gerard J. Holzmann works at the Jet Propulsion Laboratory on developing stronger methods for software analysis, code review, and testing. Contact him at gholzmann@acm.org.

Art in the Digital Age

The genre of “computer art” began in the 1950s, when long exposure photography was used to capture images created by an oscilloscope manipulating electronic waves on a small fluorescent screen. Through the 1960s, most works of computer art were created using plotters and impact printers by the scientists and engineers who had access to emerging computing technology. By the 1970s, artists were learning to program, and some universities began to integrate computers into the fine arts curriculum. The widespread adoption of computers and the availability of off-the-shelf paint programs in the 1980s brought computer art to the masses. At the same time, computer graphics and special effects were beginning their takeover of the entertainment industry through Hollywood films, TV shows, and video games. By the 1990s, the term computer art was fading, and computers were becoming a mainstream part of arts and entertainment.

Immersive VR Painting

Today, the entertainment industry is a driving force for new computing technology. Science and engineering endeavors will certainly benefit from virtual and augmented reality, but the true market pull comes from entertainment applications. These new platforms for digital art require novel software tools to aid digital artists in creating immersive environments. One example, demonstrated on the Oculus Rift at the Sundance Film Festival earlier this year, is a tool that allows artists to paint directly in virtual 3D space using simple gestures and hand movements. Known as Quill, this tool was used to create Oculus’ latest fully immersive VR film Dear Angelica. Quill was built as an internal tool and Oculus currently has no plans to release it to the public. However, Quill uses the Oculus Touch 3D controllers, which are expected to be released by the end of 2016.


In another example, Google recently launched its VR painting application, known as Tilt Brush, which was developed for the HTC Vibe VR headset (see Figure 1). Users can select brushes and colors from a palette and then use the controller to create 3D paintings. Artists are not limited to traditional paint color options, but can also choose to create in materials such as denim, fire, and snow. The Tilt Brush app is intuitive enough to allow anyone to create immersive 3D artwork, and both the artist creating the piece and the viewers admiring it in...
the future can walk through the artistic environment. The Tilt Brush app is on sale at Steam for $29.99. This app requires the HTC Vibe headset, which is also available from Steam for $799.

For more information, visit www.tiltbrush.com.

Digital Art, Without the VR
Readers who are feeling an urge to create digital art but don’t have a VR headset may want to consider the desktop application Krita. This open source software application for concept artists, digital painters, and illustrators has been in development for more than 10 years and is available on Windows and Linux. Krita offers a customizable user interface, a configurable popup palette for selecting colors and brushes, and a variety of brush engines along with brush stabilizers to smooth out brush strokes for artists with shaky hands (see Figure 2). Since 2013 Krita has been supported by the Krita Foundation, which runs yearly Kickstarter campaigns to fund new features. The 2016 campaign target of €30,000 will be used to improve the text tools and update the vector objects to SVG.

For more information, visit https://krita.org.

Computer/Robot-Generated Art
Can a computer be more than just a tool used by a human to create art? Can you teach a computer to create art? This was the fundamental question posed by the Next Rembrandt Project, where researchers from Delft University of Technology, ING, Microsoft, and two art museums collaborated to see if a computer could be taught to paint in the style of Rembrandt. By carefully analyzing Rembrandt’s paintings, including the proportions and relative distances of facial features, the demographics of the subjects, and the height profile and specific pigments used in the painting, the researchers were able to develop an algorithm for creating a new work of art in the style of Rembrandt (see Figure 3).

For further information, visit https://www.nextrembrandt.com.

The International RoboArt Competition was created by Andrew Conru, founder of Compute.org and an amateur painter, to further developments in artificial intelligence, image processing, and robotics. In the first of five planned annual competitions, 14 university and high school teams built robots that either autonomously create artwork (with minimal human assistance for tasks such as refilling paint canisters) or create artwork with human assistance. The robots were allowed a starting palette of only eight colors but were able to mix them to form new colors. The teams were allowed to use existing artwork to drive their artistic process; however, each team was required to include photo references for all prior artwork used to create its entry. The winners were determined based on a combined score provided by professional judges (60 percent of the score) and the voting public (40 percent of the score), with the first-place entry in the automatically generated artwork category receiving a $30,000 prize (see Figure 4).

For further information, visit http://robotart.org.

Contact department editors Lisa Avila at lisa.avila@kitware.com and Mike Bailey at mjb@cs.oregonstate.edu.
Finding the Wearable Technology Job You Want

For this issue of ComputingEdge, we asked Tom Suder about career opportunities in the field of wearable technology. Suder is the president and founder of Mobilegov, which provides customers with mobile services such as application development. He is also strategic adviser for the University of Central Florida’s Mixed Emerging Technology Integration Lab, which focuses on the R&D of innovative mobile technology and Web 2.0 applications. He coauthored the article “The New Wearable Computing Frontier” in IT Professional’s September/October 2015 issue.

ComputingEdge: What careers in wearable technology will see the most growth in the next several years?

Suder: The careers that will see the most growth include those involving cutting-edge wearable development and device management as a service. I think security will also be huge. People worry that their wearable devices will be hacked, which is a significant risk.

ComputingEdge: What advice would you give college students to provide them with an advantage over the competition?

Suder: You want to select a career that will be hot in the future and to develop expertise in that area. Also, I would check to see what the university I attended was working on. This could help identify up-and-coming fields because some of the latest R&D is done in university labs.

ComputingEdge: What advice would you give people changing careers midstream?

Suder: Do it. You only live once. You have to do something you are passionate about. We are all going to live and work longer. The years of...
working at IBM for 30 years and getting the gold watch are over.

**ComputingEdge**: What do you consider to be the best strategies for professional networking?

**Suder**: I recommend an “all-of-the-above” strategy. You should go to trade shows from industry leaders such as Samsung and Apple. You should go to general technology shows of any kind. There are all sorts of tech meet-up groups in many disciplines. I would also recommend networking in interesting non-tech groups such as those involving wine or art.

**ComputingEdge**: What should applicants keep in mind when applying for wearable-computing jobs?

**Suder**: You need to know the technology backward and forward. You need to use the technology and understand it. Wearable technology is an emerging field, and you have the opportunity to be one of the few experts in it.

*ComputingEdge*’s Lori Cameron interviewed Suder for this article. Contact her at l.cameron@computer.org if you would like to contribute to a future *ComputingEdge* article on computing careers. Contact Suder at tsuder@mobilegovt.com.

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CALIFORNIA STATE UNIVERSITY, EAST BAY (Hayward, CA)

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**JOB ID: 16-GA-3789. PRODUCT MARKETING ENGINEER – in PLANO, TX** to develop technical solutions in strategic growth areas; present & implement solutions with customers; define & drive network & IT transformation growth strategies. Up to 10% domestic/ int’l travel required. **JOB ID: 16-TX-3725. To apply mail resume to Ericsson Inc. 6300 Legacy Dr, R1-C12 Plano, TX 75024 indicating appropriate Job ID.**

**SOFTWARE ENGINEER – ATG.** Harland Clarke Corp. has an opening for the position of Software Engineer – ATG in San Antonio, TX to contribute to all steps within the systems development life cycle including functional/non-functional requirements gathering/validation, analysis, design, construction, testing, & implementation. To apply mail resume to Harland Clarke Corp, Attn: Diana [16-TX6174.66], 15955 La Cantera Parkway, San Antonio, TX 78256.

**IT PROFESSIONALS: Established IT company has multiple openings for the following positions: Software Engineer (Lead), Database Administrator, & Programmer Analyst (BS deg. or the equiv. in CS, Engg. (any) or related & 24 mo. of relevant industry exp. Will consider candidates w(combination of education &/or work exp. considered to be equiv. to a bachelor’s degree in CS, Engg. (any) or related & 24 mos. of relevant industry exp). Solutions Architect (BS deg. In CS, Engg. (any), BUS or related & 24 mos. of relevant industry exp. Will consider candidates w(combination of education &/or work exp. considered to be equiv. to a bachelor’s deg. in CS, Engg. (any) or related & 24 months of relevant industry exp). Quality Assurance Analyst (BS deg. or equiv. in CS, Engg. (any) or related & 24 mos. of relevant industry exp. Will consider candidates w(combination of education &/or work exp. considered to be equiv. to a bachelor’s deg. in CS, Engg. (any) or related & 24 months of relevant industry exp). Lead Software Developers & IT Project Manager (MS deg. or equiv. in CS, Engg. or related & 12 mos. of relevant industry exp). We will consider applicants with a relevant bachelor’s deg. & at least 5 yrs. of relevant industry exp. for these positions).**

**Oracle America, Inc.** has openings for

**TECHNICAL MANAGER**

positions in Redwood Shores, CA.

Job duties include: Analyze requirements and deliver functional and technical solutions. Travel to various unanticipated sites throughout the United States required. May telecommute from home.

Apply by e-mailing resume to Swarnali.bag@oracle.com, referencing 385.19233.

Oracle supports workforce diversity.

**SOFTWARE DEVELOPER**

positions in New York, NY.

Job duties include: Design, develop, troubleshoot and/or test/QA software.

Apply by e-mailing resume to ari.kermaier@oracle.com, referencing 385.16476.

Oracle supports workforce diversity.

**SOFTWARE ENGINEER – ATG in San Antonio, TX** to contribute to all steps within the systems development life cycle including functional/non-functional requirements gathering/validation, analysis, design, construction, testing, & implementation. To apply mail resume to Harland Clarke Corp, Attn: Diana [16-TX6174.66], 15955 La Cantera Parkway, San Antonio, TX 78256.

**CONSULTANT**

positions in Frisco, TX.

Job duties include: Analyze requirements and deliver functional and technical solutions. Travel to various unanticipated sites throughout the United States required. May telecommute from home.

Apply by e-mailing resume to zein.shivji@oracle.com, referencing 385.16095.

Oracle supports workforce diversity.
Microsoft Corporation currently has the following openings (job opportunities available at all levels, including Principal, Senior, and Lead levels): Redmond, WA


Artists and Art Directors (all levels, including Leads and Managers): Responsible for designing and creating art assets that meet or exceed industry standards for quality while supporting Microsoft Game Studio (MGS) business goals. http://bit.ly/MSJobs_Art


Consultants: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. Requires domestic and international travel up to 25%. http://bit.ly/MSJobs_Technical_Delivery

Consultants: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. Roving Employee—requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. http://bit.ly/MSJobs_Technical_Delivery

Content Developer/Engineer (All levels, including Leads and Managers): Responsible for the design, development, deployment, vision, and business strategy for content creation, acquisition, production, editorial, and publishing activities at Microsoft. http://bit.ly/MSJobs_Content_Publishing

Data Scientist: Manipulate large volumes of data, create new and improved techniques and/or solutions for data collection, management and usage. http://bit.ly/MSJobs_Data_Applied_Science


Designers: Develop user interface and user interaction designs, prototypes and/or concepts for business productivity, entertainment or other software or hardware applications. http://bit.ly/MSJobs_Design

Evangelists/Technical Evangelists: Collaborate with sales teams to understand customer requirements, promote the sale of products, and provide sales support. http://bit.ly/MSJobs_Tech_Evangelist


Hardware Dev., Test or Design Engineers, Hardware Engineers, Electrical Engineers, Design Engineers (all levels, including Leads and Managers): Design, implement and test computer hardware that add strategic value to the company. (http://bit.ly/MSJobs_Hardware_Dev_Eng)(http://bit.ly/MSJobs_Electrical_Eng)


Premier Field Engineers: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Roving Employee—requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. http://bit.ly/MSJobs_Support_Delivery

Researchers/Scientists: Conduct research and lead research collaborations that yield new insights, theories, analyses, data, algorithms, and prototypes and that advance state-of-the-art of computer science and engineering, as well as general scientific knowledge. http://bit.ly/MSJobs_Research


Associate Architect: Responsible for selling consulting engagements for IT solutions which includes estimating, scoping, and writing statements of work that set expectations and limit risk. Requires domestic and international travel up to 50%. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5810/go/job


Business Analytics Specialist: Identify and synthesize data to support business requirements for adoption of cloud technologies. https://jobs-microsoft.icims.com/jobs/5801/go/job

Business Analytics Specialist: Build, analyze, and present data driven findings for financial plan design and segment program management. https://jobs-microsoft.icims.com/jobs/5755/job

Category Manager: Overseer launch readiness and front end experimentation. Requires domestic and international travel up to 25%. https://jobs-microsoft.icims.com/jobs/5967/go/job

Consultant: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. Roving Employee - requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5804/consultant/job

Data Scientist: Manipulate large volumes of data applying principles of mathematics and statistics. https://jobs-microsoft.icims.com/jobs/5773/job

Designer (UX Designer): Develop user interface and user interaction designs, prototypes and/or concepts for business productivity, entertainment or other software or hardware applications. Requires domestic and international travel up to 25%. https://jobs-microsoft.icims.com/jobs/5707/go/job

Firmware Engineer II: Responsible for developing or testing computer software and firmware applications, systems or services. https://jobs-microsoft.icims.com/jobs/5741/go/job

Optical Engineer: Design tools, technologies and processes for next generation optical systems. https://jobs-microsoft.icims.com/jobs/5731/go/job

Product Engineer: Design, implement & test computer hardware products that add strategic value to the company. Requires int'l. travel up to 50%. https://jobs-microsoft.icims.com/jobs/5790/go/job

Security Software Engineer: Responsible for developing static and runtime analysis capabilities so that software security bugs in code can be found quickly and with high confidence. https://jobs-microsoft.icims.com/jobs/5782/go/job

Senior Consultant: Deliver design, planning, and implementation services that provide IT
solutions to customers and partners. Roving Employee—requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5791/go/job

Senior IT Service Ops Analyst: Examine how data processing operations can be applied to the needs of Microsoft product and engineering teams to improve the user experience and productivity with Microsoft’s flagship products, including Windows, SCCM, and Intune. https://jobs-microsoft.icims.com/jobs/5832/go/job

Senior Partners in Learning Manager: Develop and manage global initiatives for School Leaders, working closely with corporate and field stakeholders. Requires domestic and international travel up to 50%. https://jobs-microsoft.icims.com/jobs/5791/job

Senior Sales Excellence Manager: Develop and maintain Information Technology tools, data platform, reporting, Business Intelligence (BI) and infrastructure that support the operational systems for U.S. Dynamics sales and partner organizations. https://jobs-microsoft.icims.com/jobs/5774/senior-sales-excellence-manager/job

Senior Support Escalation Engineer: Install, configure, support and troubleshoot issues related to Microsoft technologies. Requires travel up to 50% with work to be performed at various unknown worksites throughout the U.S. https://jobs-microsoft.icims.com/jobs/5688/job

Solution Architect: Architect software, platform, services, hardware or technology solutions. https://jobs-microsoft.icims.com/jobs/5822/go/job

Solution Architect/Specialist: Enhance the Microsoft Customer relationship from a capability development perspective by articulating the value of Microsoft services and solutions & identifying competition gaps in targeted accounts. Roving Employee—Requires travel up to 100% with work to be performed at various and unanticipated worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5747/go/job

Technology Solutions Professional: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. Requires travel throughout U.S. up to 50% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5772/technology-solutions-professional/job

MOUNTAIN VIEW, PALO ALTO, SUNNYVALE, CA


Data Scientist: Manipulate large volumes of data, create and develop new insights, theories, analyses, data models and/or solutions for data collection, management and usage. http://bit.ly/MSJobs_Data_Applied_Science


Hardware Dev., Test or Design Engineers, Hardware Engineers, Electrical Engineers, Design Engineers (all levels, including Leads and Managers): Design, implement and test computer hardware that add strategic value to the company. (http://bit.ly/MSJobs_Hardware_Dev_Eng(http://bit.ly/MSJobs_Electrical_Eng)


Cloud Solution Architect: Architect software, platform, services, hardware or technology solutions. Requires travel up to 25% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5771/job

SAN FRANCISCO, CA

Premier Field Engineers: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Roving Employee—requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. http://bit.ly/MSJobs_Support_Delivery


Senior Premier Field Engineer, Platforms: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires travel up to 75% with work to be performed at various unknown worksites throughout the U.S. https://jobs-microsoft.icims.com/jobs/5704/job

TAMPA, FL

Premier Field Engineer: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires travel up to 50% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5718/premier-field-engineer/job

Solution Specialist: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. Requires up to 50% of domestic travel to perform work at unknown customer sites. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5710/job

TEMPE, AZ

Solution Architect: Architect software, platform, services, hardware or technology solutions. https://jobs-microsoft.icims.com/jobs/5831/go/job

WAUKESHA, WI

Cloud Solution Architect: Design, plan, and implement cloud deployments to move customer workloads to Azure. Roving Employee—requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5785/go/job

FORT LAUDERDALE, FL


Solutions Sales Professional/Specialist/Technology Solutions Professional: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. http://bit.ly/MSJobs_Solution_Sales

Solutions Sales Specialist, Education: Enhance Microsoft customer relationship from capability development perspective by articulating value of services & solutions & identifying competition gaps in targeted accounts. Requires travel up to 25% with work to be performed at various unknown worksites throughout the U.S. and Latin America. https://jobs-microsoft.icims.com/jobs/4796/go/job
Technology Solutions Professional: Drive product win rates by proving the value of products to customers and partners. Requires domestic travel up to 75% telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5866/go/job

NEW YORK, NY

Solutions Sales Professional/Specialist/Technology Solutions Professionals: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. https://jobs.microsoft.icims.com/jobs/5778/technology-solutions-professionals

Cloud Solution Architect: Architect and deploy Microsoft cloud solutions for customers. Requires travel up to 20% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5720/go/job

Consultant: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. Requires domestic and international travel up to 25%. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5792/go/job

Premier Field Engineer: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5869/premier-field-engineer/go

Premier Field Engineer: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires travel up to 50% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5721/go/job

Solution Specialist: Enhance the Microsoft Customer relationship from a capability development perspective by articulating the value of Microsoft services and solutions and identifying competition gaps in targeted accounts. Roving Employee - Requires travel up to 100% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5671/go/job

Technology Solutions Professional Devices: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5695/go/job

WILSONVILLE, OR

Hardware Dev., Test or Design Engineers, Hardware Engineers, Electrical Engineers, Design Engineers (all levels, including Leads and Managers): Design, implement and test computer hardware that add strategic value to the company. (http://bit.ly/MSJobs_Hardware_Dev_Eng)(http://bit.ly/MSJobs_Electrical_Eng)

FARGO, ND

Consultant, Partner Technical: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. https://jobs.microsoft.icims.com/jobs/5833/go/job

HOUSTON, TX

Solutions Sales Professional/Specialist/Technology Solutions Professionals: Enhance the Microsoft customer relationship from a capability development perspective by articulating the value of our services and solutions and identifying competition gaps in targeted accounts. http://bit.ly/MSJobs_Solution_Sales

Technical Account Manager: Assist with the successful implementation of Microsoft technologies, focusing on delivery quality through planning and governance. Requires travel up to 25% throughout the U.S. https://jobs.microsoft.icims.com/jobs/5735/go/job

IRVINE, CA

Premier Field Engineer: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires travel throughout U.S. up to 50% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted https://jobs.microsoft.icims.com/jobs/5825/premier-field-engineer/job

Premier Field Engineer, Lync: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires domestic travel of up to 75% to perform work at various unknown worksites. https://jobs.microsoft.icims.com/jobs/5692/go/job

Technology Solutions Professional: Improve the Enterprise Mobility business metrics (revenue and scorecard) through excellence in technical sales strategy and execution. Requires travel throughout U.S. up to 50% with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs.microsoft.icims.com/jobs/5778/technology-solutions-professional/go

IRVING, TX

Service Engineers/Managers, Service Operations Engineers, and Systems/Operations Engineers/Field Reliability Engineer: Re-


Premier Field Engineer, SharePoint: Provide technical support to enterprise customers, partners, internal staff or others on mission critical issues experienced with Microsoft technologies. Requires domestic travel up to 50%. https://jobs-microsoft.icims.com/jobs/5768/job

Senior Consultant – ERP: Deliver design, planning, and implementation services that provide IT solutions to customers and partners. Requires up to 75% travel with work to be performed at various unknown worksites throughout the U.S. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5719/job

ISELIN, NJ


LOS ANGELES, CA
Senior Consultant Deliver: design, planning, and implementation services that provide IT solutions to customers and partners. Requires domestic and international travel up to 50%. Telecommuting permitted. https://jobs-microsoft.icims.com/jobs/5824/go/job

RENO, NV

Multiple job openings are available for each of these categories. To view detailed job descriptions and minimum requirements, and to apply, visit the website address listed. EOE.

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CAREER OPPORTUNITIES

**Egencia LLC.**

currently has openings for the following opportunities in our Chicago, IL office (various/levels/types:)

**Software Engineers:** (728.SWE-EGC-AUG)
Design, implement, and debug software for computers including algorithms and data structures.

**Database Developers:** (728.DBD-EGC-AUG)
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

Send your resume to: Egencia/Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004.
Must reference position and Job & Job ID# listed above.

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**Expedia, Inc.**

currently has openings for the following opportunities in our San Francisco, CA office (various/levels/types:)

**Software Engineers:** (728.SWE-SF-AUG)
Design, implement, and debug software for computers including algorithms and data structures.

**Database Developers:** (728.DBD-SF-AUG)
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

Send your resume to: Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004.
Must reference position and Job & Job ID# listed above.

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**Hotwire, Inc.**

currently has openings for the following opportunities in our San Francisco, CA office (various/levels/types:)

**Software Engineers:** (728.SWE-HW-SF-AUG)
Design, implement, and debug software for computers including algorithms and data structures.

**Database Developers:** (728.DBD-HW-SF-AUG)
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

Send your resume to: Hotwire/Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004.
Must reference position and Job & Job ID# listed above.
Faculty Position in Distributed and Secure Hardware Systems at the École polytechnique fédérale de Lausanne (EPFL)

The School of Engineering (STI) of EPFL invites applications for a faculty position in electronic design for distributed and secure hardware systems at the tenure-track assistant professor level at the EPFL Lausanne campus.

Research activities should relate to one or more of the following subjects: safe and secure circuit design and design tools, hardware components and design methods for Internet of Things (IoT), automotive electronic systems, dependable system-on-chip architectures.

Research activities with an emphasis on experimental approaches and links with industry will be strongly encouraged so as to benefit from the unique experimental facilities that will be made available at the EPFL Lausanne campus in electronics and communication engineering.

As a faculty member of the School of Engineering, the successful candidate will be expected to initiate an independent and creative research program and participate in undergraduate and graduate teaching. Internationally competitive salaries, start-up resources and benefits are offered.

EPFL, with its main campus located in Lausanne, Switzerland, is dynamically growing and well-funded institution fostering excellence and diversity. It has a highly international campus at an exceptionally attractive location boasting first-class infrastructure. As a technical university covering essentially the entire palette of engineering and science, EPFL offers a fertile environment for research cooperation between different disciplines. The EPFL environment is multi-lingual and multi-cultural, with English often serving as a common interface.

Applications should include a cover letter with a statement of motivation, curriculum vitae, list of publications and patents, concise statement of research and teaching interests, and the names and addresses of at least five referees. Applications must be uploaded in PDF format to the recruitment web site:

go.epfl.ch/iel-search

Formal evaluation of candidates will begin on December 1st, 2016 and continue until the position is filled.

Enquiries may be addressed to:
Prof. Giovanni De Micheli
Search Committee Chair
Email: iel-search@epfl.ch

For additional information on EPFL, please consult the web sites: www.epfl.ch, sti.epfl.ch and iel.epfl.ch.

EPFL is committed to increasing the diversity of its faculty, and strongly encourages women to apply.

The University of Alabama in Huntsville

The Department of Computer Science of The University of Alabama in Huntsville (UAH) invites applicants for a tenure-track faculty position at the Assistant Professor level beginning January 2017. The incumbent will augment the department’s emphases in at least one of the following areas: cloud computing, particularly secure cloud computing; mobile computing, particularly secure mobile computing; or data science, particularly big data applications. Outstanding candidates who couple cybersecurity with other areas of computing could also be considered.

A Ph.D. in computer science or a closely related area is required. The successful candidate will have a strong academic background, perform funded research, be able to carry out research in areas typical for publication in well-regarded academic conference and journal venues, and be keen on undergraduate education.

The department has a strong commitment to excellence in teaching, research, and service; the hire should have good communication, strong teaching potential, and research accomplishments.

UAH is located in an expanding, high technology area, next door to one of the largest research parks in the nation. Nearby are the NASA Marshall Space Flight Center, the Army’s Redstone Arsenal, and many high-tech industries. UAH also has an array of research centers, including in information technology, modeling and simulation, etc. In short, collaborative research opportunities are abundant, and many well-educated and highly technically skilled people are in the area. There is also access to excellent public schools and housing.

UAH has approximately 8000 students. UAH Computer Science offers the BS, MS, and PhD degrees in Computer Science and the MS and PhD degrees in modeling and simulation. Approximately 200 undergraduate majors and 175 graduate students are associated with the unit. Faculty research interests are many and include cybersecurity, mobile computing, data science, software engineering, visualization, graphics and game computing, multimedia, AI, image processing, pattern recognition, and distributed systems. Recent NSF figures indicate the department ranks 30th in the nation in overall federal research funding.

Interested parties should submit a detailed resume with references to Chair, Search Committee, Dept. of Computer Science, The University of Alabama in Huntsville, Huntsville, AL 35899. Qualified female and minority candidates are encouraged to apply. Initial review of applicants will begin starting in late Summer 2016 and will continue until a suitable candidate is found.

The University of Alabama in Huntsville is an affirmative action/equal opportunity employer/ minorities/ females/ veterans/ disabled.
Apple Inc. has the following job opportunities in Cupertino, CA:

Software Engineer Applications (Req#9J3MGR) Crte & dvlp iOS apps for iAd Workbench.

Software Engineer Applications (Req#A4Z36R) Dsgn, build & suppt new critical infrstrctural sysms & frameworks.

Software Development Engineer (Req#A4D32A) Dsgn & dvlp radio frqncy SW for mobile devices.

Mechanical Quality Engineer (Req#9MJMA8) Des future Apple prod from a quality side (des for quality). Travel req’d: 30%.

Systems Design Engineer (Req#9GGV7H) Anlyz Radio Frqncy (RF) sys prfrmrnc for var wireless technolgies. Eval prototype sys by prfrmrng exprmnts & tests in the lab.

Software Engineer (Req#9WJSYL) Des & Dev security server solutions for various Apple prdcts incldng iOS devices & Mac.

Systems Design Engineer (Req#9A6LQ2) Des & dev SW for telecom systs. Travel req 20%.

Engineering Project Specialist (Req#9UYNUA) Supp retail eng team deliv mob & web-bsd sol for cust.

Engineering Project Lead (Req#9XSSRA) Resp for leading cross-func data center infrastr projects w/ Apple internal groups.

Product Design Engineer (Req#9TDUWS) Dsgn instrumntation to measre & calibrate acoustic perfmrnce of Apple devces. Travel Req’d 15%.

Software Quality Assurance Engineer (Req#A7T2XX) Dsf test approaches & plans for func test areas, expanding current test cases & exec req tests.

Software Development Engineer (Req#9TX4UQ) Plan & excute certfc -tion tstng on the iOS cellular prdcts, iPhone & iPad.

Professional Services Consultant (Req#9SAT24) Improve data qty, create & leverage new reporting tools & enable faster decision making.

Machine Learning Engineer (Req#9X6SC3) Support global sales planning & operations teams with analytcs to inform decision-making.

Software Engineer Applications (Req#9Z4VSR) Des, dev & test distrib & scal feat for iTunes Store servers & testing platform.

Software Development Engineer (Req#9XC37K) Res, dev, & improve sig processing & spch rec tools.

Engineering Project Analyst (Req#9S7VJL) Coord ongoing efforts to research, ID, qualify & negotiate new data lic.

Software Development Engineer (Req#9EVUPC) Architect & des client code frameworks for iOS & Mac OS apps to eval the qual of the prod.

Product Design Engineer (Req#9DCTN6) Des mech compnts & enclosure of both prtble & dsktp comp prds. Travel req 20%.

Hardware Development Engineer (Req#9TWNG9) Resch, dev & intgrt display mod prcss, equip, & mats. Travel req 15%.

Web/iOS Developer (Req#9K4QN4) Dsgn & dev iOS apps in Objective-C & Swift to support Sales Training & Communications, & support web dev as needed.

Software QA Engineer (Req#9UB273) Dsgn & dev tests, tools, & frameworks to enable reduction of manual testing. Work w/ dvlpmt team to rrv functionality.

Mechanical Quality Engineer (Req#9DZVHX) Contrib to the des. of future Apple prod’s w/ a focus on des. for quality. Travel req’d 30%.

Software Development Engineer (Req#9DH38Q) Prfrm cell certifica -tion testing of iOS dvcs against 3GPP protocol specs.

Technical Product Manager (Req#9E3QW) Work as platform advocate for reporting & data tools rspnsbl for platform design & arch.

Software Development Engineer (Req#9LWPCU) Dsgn, dvlp, & mdfy carrier configs, tools, & frmrwks.

Software Engineer Systems (Req#9XZVDY) Dsgn & dev SW prducts for Applecare retail & repair centers.

Software Engineer Applications (Req#9TNU95) Des and dev sw systms based on machine learning and algorithms.

Software Development Engineer (Req#9T67HY) Resp for studying & improving the speed & memory of WebKit.

Software Engineer Applications (Req#9VB58J) Des, dev & support Apple’s messaging infrastructure.

Software Development Engineer (Req#9X83JZ) Des & dev scal J2EE based data services using SOA for Apple advertising (iAd) on mobile devices.

ASIC Systems Analyst (Req#A2TU38) Analyze tech data req’s for NICE ICM sys to promote efficiencies taking into acct biz envrnmnt & IT framework.
Apple has the following job opportunities in Cupertino, CA:

**Software Development Engineer (Req#9NW445)** Dev & des SW for Apple Maps framework.

**Software Development Engineer (Req#A853DN)** Dsgn & implmntt Apple’s client & server strgy fr the SW updt sys of Apple prdcts.

**Software Development Engineer (Req#9XUTJU)** Dsgn & dvlv Cellular SW features.

**Software Engineer Systems (Req#9U3QK8)** Bld, spcify, dsgn, dvlv, & launch Apple’s sensing tech prdct chrctrztn & prdtctn instrumentatwn sw. Travel req 25%.

**ASIC Design Engineer (Req#9LUQE U)** Interface w/ all disciplines to get frctonal prdcts to millions of customers quickly.

**Hardware Development Manager (Req#9L5N5L)** Lead & superv HW Dev Eng in the pow sys des environment.

**Hardware Development Engineer (Req#9Y9M9W)** Des & execute HW & eng valid & character tests for keys solutions, frm proof-of-concept to mass prod. Travel req’d 25%

**ASIC Design Engineer (Req#9R533A)** Drive chip lvl electrical anlyss of high perf processors.

**Software Engineer Systems (Req#9TDDV2L)** Dsgn & dvlv cmmnts of a lrg & cmpx SW app.

**Software Engineer Applications (Req#9HRV77)** Des & dev Public Key Infrastructure (PKI) & cryptograghic svcs.

**Software Developer (Req#9YZ3HW)** Dsgn & dvlv data anlyts for the Manufacturing Operation Mngmnt team.

**Software Engineer Applications (Req#9X53SQ)** Supp NoSQL database infrastructure. Build SW & sys to coord infrstr & app thru automation.

**Software Development Engineer (Req#A4Z35E)** Dsgn & build scalable Hadoop based data presssing infrastructure.

**Software Engineer Applications (Req#9V4U6J)** Dsgn, dvlv & sprrt SW for Apple’s Payment Gateway (APG).

**Software Quality Assurance Engineering Manager (Req#9Y7RL7)** Mng team of engs. Comm resps, priorities & deadlines to direct reps.

**Hardward Development Engineer (Req#9Q13E2Z)** Resp for camera tst dvlpmnt, prdtnt tst implmntn, sys valdtn, dsgn verifctn, & buchmrknk of Apple camera prdcts. Travel req 25%.

**Software Quality Assurance Engineer (Req#A4S3ZW)** Des, implmnt, execute test plans & test suites based on specification docs.

**Software Development Engineer (Req#9GWR5S)** Des & Build iTunes desktop apps.

**Systems Design Engineer (Req#9SYTNP)** Eval the latest iPad, iPhone, and Apple Watch HW syms in field & Lab. Travel req’d: 25%.

**Reliability Engineer (Req#9DCSXXH)** Prfrm reliability evals of comp HW to idntfy high risk failure modes early in the dsgn lifecycle. Trvl req 15%.

**Hardware Development Engineer (Req#9D2UHP)** Archtct, dsgn & dvlv intrgrtn prcss for advncd key modules, from cnctp to high vlm prdtnt. Trvl req 30%.

**Software Engineer Applications (Req#9ZZ4DJ)** Research, dsgn, dvlv, implmntn, rw & trbsht SW for highly avilbl & large scale core svcs.

**Software Engineer Applications (Req#9KRR8X)** Dsgn & dvlv SW for Big Data apps.

**Software Engineer Applications (Req#A7A4R2)** Dvlv, create, implmnt, & sprrt the web app dvlpmnt of Sales Training App using large scale & high prfmg, OO intrnt technlgs.

**Software Development Engineer (Req#9URUXN)** Dsgn & dvlv wrlss drvs in kernel & user space running on App Processor & on wrlss chpsts.

**Spatial Data Integration Engineer (Req#9VVTCXK)** Resp for spatial data intrgrtn for Apple Intnl-bsd svcs.

**Software Engineer Applications (Req#9TSTW8)** Des, dev & impl apps to prevent fraud transactions in Apple Online Store, iTunes & other business areas of Apple Inc.

**ASIC Design Engineer (Req#9H3TDF)** Dev SW & verify GPU HW.

**Software Development Engineer (Req#9FVS5S)** Dsgn, architect, & implement SW features and improvements.

**Software Development Engineer (Req#9M4JIC)** Create & exec det’ld tst plns for antenna pasv & OTA perf.

**Software Engineer Applications (Req#9VJSW5)** Des & dev SW to enhance & scale content plfrms.

**Software Engineer Applications (Req#9SYRLB)** Dsgn, dvlv, & maintain core srch components that serve millions of customers worldwide.

**Software Development Engineer (Req#A3WNK8)** Debug & provide sol’s for Op Sys, HW, & embdd sys.

**Software Development Engineer (Req#9CZU87)** Dvlv tech for large scale syss, spkn lang, big data, & A.I.

**Software Development Engineer (Req#9FNU5B)** Dsgn & dvlv Bluetooth SW & drivers for dvcs & accessories.

**Hardware Development Engineer (Req#9NYMUS)** Dsgn, dvlv, & chrctrz led & laserbsd optical syss. Trvl req 25%.

**Software Development Engineer (Req#9CRTFW)** Rspsble for tstng & validation of pre-release SW.

**Systems Design Engineer (Req#9DPVWR)** Rspsble for electromagnetic compatibility (EMC) dsgn of electronics prdcts including comprts, cellular phns, & other dvcs.

**Software Development Engineer (Req#9XD3PQ)** Des & dev real-time comm SW for FaceTime.

**Software Development Engineer (Req#A58NHC)** Des & dev SW for mobile advert syss.

**Software Engineer Applications (Req#9VS5LE)** Dsgn, dev & deploy data warehouse & anlytics solutions for mltply business groups at Apple.

Refer to Req# & mail resume to Apple Inc., ATTN: I.J., 1 Infinite Loop 104-1GM, Cupertino, CA 95014. Apple is an EO/AA m/f/disability/vets.
Apple Inc. has the following job opportunities in San Francisco, CA:

Software Engineer Applications (Req#9W8TDU) Des & dev SW for large-scale online web services, data pipelines & data warehouse sys.

Refer to Req# & mail resume to Apple Inc., ATTN: L.J., 1 Infinite Loop 104-1GM, Cupertino, CA 95014. Apple is an EOE/AA m/f/disability/vets.

Apple Inc. has the following job opportunities in Sacramento, CA:

Information Systems Engineer (Req#9ZT3CA) Dsgn, dvlp & support SW deployment processes.

Apple Inc. has the following job opportunities in Austin, TX:

Technical Support Engineer (Req#A2N2PB) Sprrt various Channel Service bus actvts related to the Service Transformation prgrms. Travel req. 20%.

Microsoft Corporation currently has the following openings (job opportunities available at all levels, including Principal, Senior and Lead levels):

REDMOND, WA


Business Program Manager: Plan, initiate, and manage technology and business projects. Requires domestic and international travel up to 25%. https://jobs.microsoft.icims.com/jobs/5696/go/job

Hardware Engineering Program Manager: Coordinate program development of hardware products or systems, working w/ development & product planning teams. Requires dom., regional & intl. travel up to 50%. https://jobs.microsoft.icims.com/jobs/5696/go/job

Program Manager II: Coordinate program development of computer software applications, systems or services, working with development and product planning teams. Requires domestic and international travel up to 50%. https://jobs.microsoft.icims.com/jobs/5849/go/job

Program Manager: Plan, initiate, and manage technology and business projects. Requires domestic, regional, and international travel up to 25%. https://jobs.microsoft.icims.com/jobs/5843/go/job

Senior Business Program Manager: Plan, initiate, and manage technology and business projects. Requires domestic, regional, and international travel up to 25%. https://jobs.microsoft.icims.com/jobs/5855/go/job

Senior Program Manager: Lead the end-to-end strategy and execution plan development for the EBC customer experience, demos, interactive vignettes and displays and in-room technology experiences. https://jobs.microsoft.icims.com/jobs/5786/go/job

Senior Research Program Manager: Responsible for participating in multiple research projects and interface with researchers and engineers. https://jobs.microsoft.icims.com/jobs/5776/go/job


MOUNTAIN VIEW, PALO ALTO, SUNNYVALE, CA


CAMBRIDGE, MA


Multiple job openings are available for each of these categories. To view detailed job descriptions and minimum requirements, and to apply, visit the website address listed. EOE.
TECHNOLOGY

Expedia, Inc.

currently has openings for the following opportunities in our Bellevue, WA office (various/levels/types.)

Software Engineers: (728.SWE-AUG) Design, implement, and debug software for computers including algorithms and data structures.

Database Developers: (728.DBD-AUG) Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

Business Development Managers: (728.1553) Use data-driven analysis to identify, evaluate, and drive strategic business opportunities, alliances and/or joint ventures.

Application Engineers: (728.894) Identify opportunities to automate application release process and help to implement potential solutions.

BI Developers: (728.1942) Design and develop reporting solution using SQL Server, SSIS, SSAS, and SSRS as per business requirements.

Regional Head of Partners: Connect: (728.947) Implement process in region and ensure that process has buy in from relevant departments it effects. 20-25% travel to various unanticipated sites throughout the U.S. and internationally required.

Business Analysts: (728.1740) Formulate and apply mathematical modeling and other optimizing methods to develop and interpret information.


Managers, Software Development: (728.1770) Manage team of developers in implementing high quality web-based applications and high volume transactional services, including design, development, and deployment of new business functionality.

Program Managers: (728.1335) Responsible for microcomputer software product design features and coordinating development of software among functional groups through product release.

Directors, International Tax: (728.1796) Provide tax advice, develop international tax strategy, and drive the implementation of solutions. Travel to various unanticipated sites throughout the U.S. and internationally required.

Technical Product Managers: (728.TPM-AUG) Gather detailed business requirements from stakeholders and work closely with technology staff to translate requirements into functional designs and specifications.

Reporting and Analysis Managers: (728.2373) Support, influence, and challenge business decisions with data and analyses.

Send your resume to: Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004. Must reference position and Job & Job ID# listed above.

Egencia LLC

currently has openings for the following opportunities in our Bellevue, WA office (various/levels/types.)

Software Engineers: (728.SWE-EGB-AUG) Design, implement, and debug software for computers including algorithms and data structures.

Database Developers: (728.DBD-EGB-AUG) Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

Send your resume to: Egencia/Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004. Must reference position and Job & Job ID# listed above.
**Hotwire, Inc.**
currently has openings for the following opportunities in our Bellevue, WA office (various/levels/types:)

**Software Engineers: (728.SWE-HW-AUG)**
Design, implement, and debug software for computers including algorithms and data structures.

**Database Developers: (728.DBD-HW-AUG)**
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

**Transport Managers: (728.1564)**
Plan, and coordinate transportation activities of Hotwire organization that provide transportation services. Travel to various unanticipated sites throughout the U.S. required.

Send your resume to: Hotwire/Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004.
Must reference position and Job & Job ID# listed above.

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**Orbitz Worldwide, LLC**
currently has openings for the following opportunities in our Chicago, IL office (various/levels/types:)

**Software Engineers: (728.SWE-ORB-AUG)**
Design, implement, and debug software for computers including algorithms and data structures.

**Database Developers: (728.DBD-ORB-AUG)**
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems.

**Web Designers: (728.2188)**
Define visual hierarchy and treatment for range of optimizations and new features of products throughout entire lifecycle.

**SEO Analysts: (728.2101)**
Responsible for execution of search engine optimization (“SEO”) strategies and tactics and supporting SEO manager in day-to-day functions by analyzing, optimizing, and reporting on natural search performance.

Send your resume to: Orbitz/Expedia Recruiting, 333 108th Avenue NE, Bellevue, WA 98004.
Must reference position and Job & Job ID# listed above.
Oracle America, Inc. has openings for SOFTWARE DEVELOPER positions in Mineola, NY. Job duties include: Design, develop, troubleshoot and/or test/QA software. Apply by e-mailing resume to ankush.chadha@oracle.com, referencing 385.14493. Oracle supports workforce diversity.

Oracle America, Inc. has openings for CONSULTANT positions in Minneapolis, MN. Job duties include: Analyze requirements and deliver functional and technical solutions. Implement products and technologies to meet post-sale customer needs. Travel to various unanticipated sites throughout the United States required. Apply by e-mailing resume to scott.king@oracle.com, referencing 385.19352. Oracle supports workforce diversity.

Oracle America, Inc. has openings for APPLICATIONS DEVELOPERS positions in Chicago, IL. Job duties include: Analyze, design, develop, troubleshoot and debug software programs for commercial or end-user applications. Write code, complete programming and perform testing and debugging of applications. Travel to various unanticipated sites throughout the United States required. Apply by e-mailing resume to scott.bockelman@oracle.com, referencing 385.19134. Oracle supports workforce diversity.

Intuit Inc. has openings for the following positions in Santa Clara County, including Mountain View, California or any office within normal commuting distance:

**Product Managers (Job code: I-440):** Design and bring to market revenue generating, customer-driven software products and services that deliver great customer experiences.

Positions located in San Diego, California:

**Offering Program Managers (Job code: I-1981):** Plan and drive the delivery of high-quality software releases, working closely with product managers and engineering managers to ensure products exceed customers’ expectations. **Software Engineers (Job code: I-2057):** Apply software development practices to design, implement, and support individual software projects. **Senior Software Engineers in Quality (Job code: I-300):** Apply senior level software engineering practices and procedures to design, influence, and drive quality and testability of products and services.

Positions located in Plano, Texas:

**Senior Network Engineers (Job code: I-1975):** Implement and support new network technologies in our on-premise, hybrid and cloud environments. Some travel may be required to work on projects at various, unanticipated sites throughout the United States.

To apply, submit resume to Intuit Inc., Attn: Olivia Sawyer, J203-6, 2800 E. Commerce Center Place, Tucson, AZ 85706. You must include the job code on your resume/cover letter. Intuit supports workforce diversity.
Help build the next generation of systems behind Facebook’s products.

Facebook, Inc.
currently has the following openings:

Openings in Menlo Park, CA (multiple openings/various levels):

**Technology Audit Manager (6060J)** Work collaboratively with engineering and our external auditor to design solutions for mitigating financial statement risk. **Quality Assurance Lead Engineer (6620J)** Execute manual and automated tests, and identify actionable bugs quickly. **Operations Research Scientist (8697J)** Identify business problems and solve them by using various numerical techniques, algorithms, and models in Operations Research, Data Science, and Data Mining. **Product Security Engineer (8055J)** Provide security guidance on a constant stream of new products and technologies and drive internal security and privacy initiatives. **Data Scientist, Analytics (4233J)** Apply your expertise in quantitative analysis, data mining, and the presentation of data to see beyond the numbers and understand how our users interact with our core products. **HCM Integrations Specialist, People Insights and Engineering (8320J)** Serve as the subject matter expert on Workday integrations and be familiar with Workday administrative functions including tenant configuration, data loads, and maintenance. **Data Engineer, Analytics (8282J)** Design and build data reporting and visualization needs for a product or a group of products. **Application Engineer, Mobile (8531J)** Architect highly available, scalable, and secure systems and build application features in their entirety. **Optical Engineer (OE816J)** Research and develop advanced optical components and systems, including but not limited to, imaging and display systems. **User Interface Engineer (935J)** Implement the features and user interfaces of Facebook products on all web related stacks (desktop web, mobile web, etc.). **Software Engineer (Computer Systems Analyst) (3248J)** Responsible for the analysis, design, and development of business software systems. **Production Engineer (7488J)** Participate in the design, implementation and ongoing management of major site applications and subsystems.

Openings in Seattle, WA (multiple openings/various levels):

**Soft Goods Engineer (7045N)** Lead exploration, design, development, and production of soft goods within the Oculus hardware products.

Openings in New York, NY (multiple openings/various levels):

**Software Engineer (NYSWEB816J)** Create web and/or mobile applications that reach over one billion people & build high volume servers to support our content. Bachelor’s degree required. **Software Engineer (NYSWEM816J)** Create web and/or mobile applications that reach over one billion people & build high-volume servers to support our content, utilizing graduate level knowledge. Master’s degree required.

Mail resume to: Facebook, Inc. Attn: SB-GIM, 1 Hacker Way, Menlo Park, CA 94025.

Must reference job title & job# shown above, when applying.
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