PC MAGAZINE

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MAKING THE MOVE TO

SMART CITIES

DIGITAL EDITION
JUNE 2016

PC MAGAZINE

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JUNE 2016

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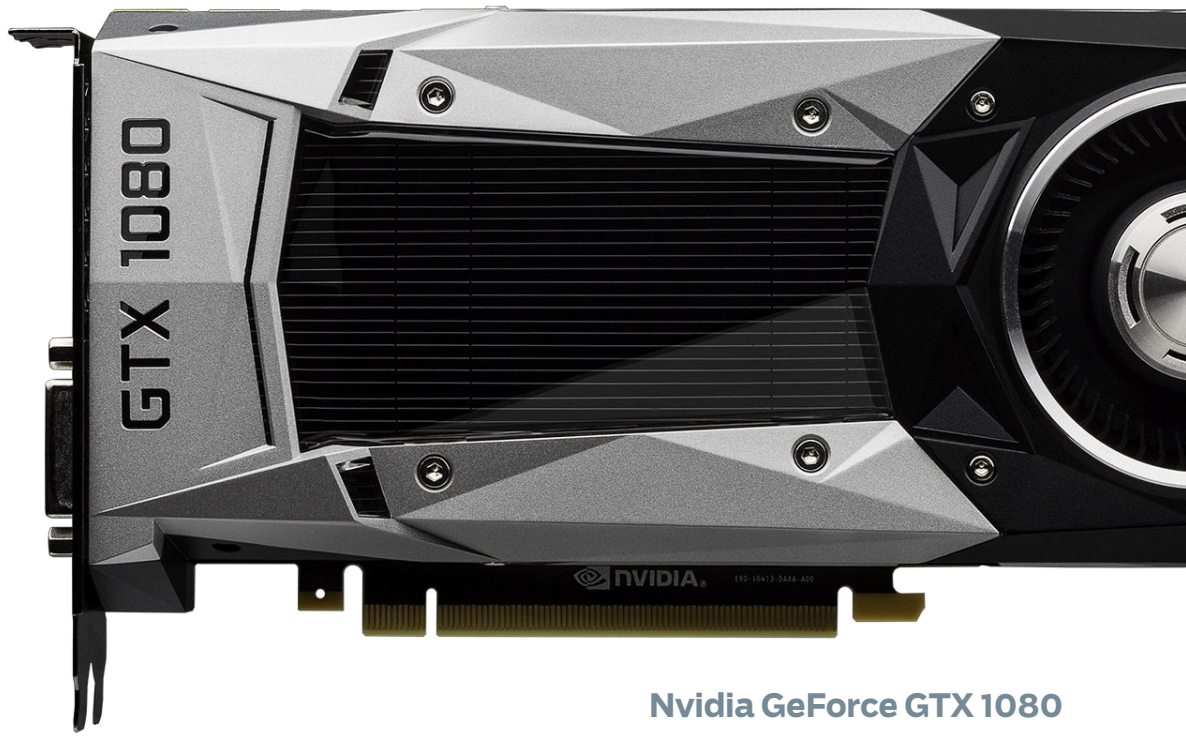

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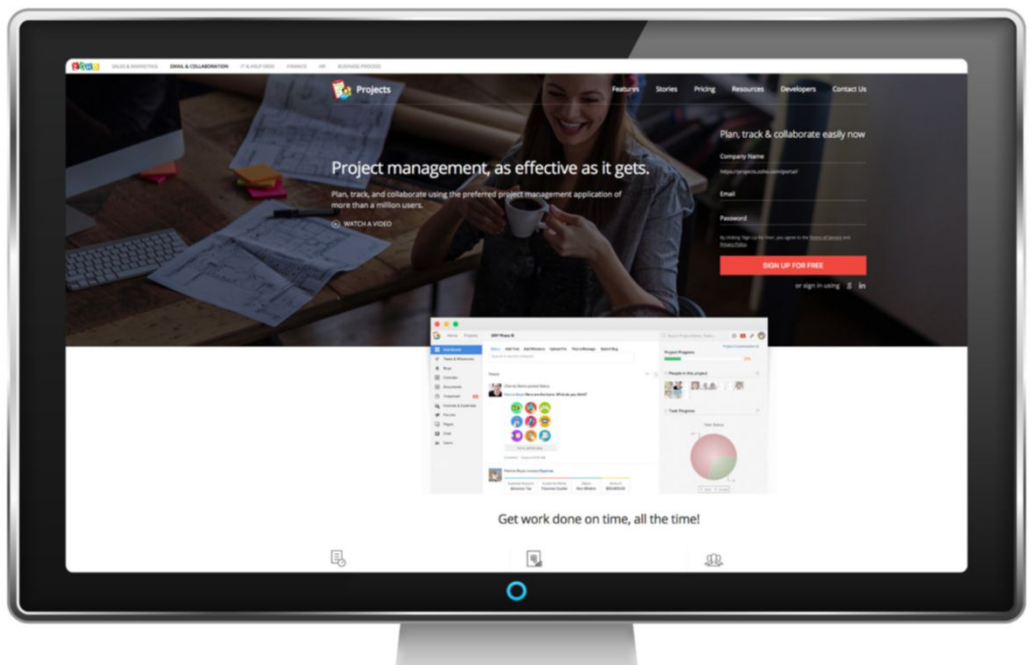

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SKINTRACK CAN TURN YOUR ARM INTO A TOUCHSCREEN

This solution enables continuous touch-tracking on the skin.

HOW SMARTWATCHES ARE CHANGING FOUR SEASONS

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> **An Apple car would require a sociological and attitudinal change in the public's vehicular taste.**
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DAN COSTA

Humanity's Engines of Innovation

My apartment in Jersey City is about half a mile from the Hudson River, so I never worried about flooding. Then Hurricane Sandy hit. Because of the storm surge and high tide, six feet of water rose on the street outside, completely covering the cars parked on the street. By the time the storm ended, 53 people had lost their lives, 250,000 vehicles were destroyed, and the total damage cost the New York City area more than $18 billion. This raised a whole host of questions: One of the most urgent is, how can we prevent disasters like this from impacting our cities going forward?

Cities are humanity's engines of innovation. More than half of the world's population lives in cities, and in developed countries, almost 75 percent live in urban areas. Population density breeds creativity, but it also puts incredible strain on the environment—and on city inhabitants as well. In this issue, we explore the ways that technology making cities smarter and better.

An interesting project to follow is the Smart City Challenge put forth by the Department of Transportation. The DOT received proposals from 78 cities, and Austin, Columbus (OH), Denver, Kansas City (MO), Pittsburgh, Portland (OR), and San Francisco are now competing for a $50 million grant. One idea is to create infrastructure that will interact directly with vehicles. The idea is that the city could dynamically adjust traffic patterns in real time to adapt to accidents or weather conditions. Think of it as Waze for an entire city.

Connecting cars and with urban infrastructure is a big and complex project, but not all smart city solutions need to be complicated. Right now, residents of Boston can use a simple app to report potholes. Street Bump uses a phone's accelerometer and GPS to record pothole locations. The city analyzes the data and has the worst potholes filled in as needed. The best thing about of this kind of technology is that it can work in any city. The civic need is the same, the code is the same; all we need is the same political will.

Of course, a consideration of smart cities would not be complete without a discussion of self-driving cars. In the last few months, autonomous cars went from an interesting concept to a reality on our roads. Every major automaker is experimenting with self-driving cars. Uber is investing millions to develop autonomous taxis that can replace its current fleet of human drivers. And every Tesla update takes a little more control from the driver and puts it into the hand of a computer. The promise here is more than just automation: Self-driving vehicles will mean less congestion, safer roads, and quicker commutes.

The road to smarter cities will be bumpy. The private sector innovates for profit, but cities are harder to lead. Rolling out these new technologies will require political leadership and willing taxpayers. But the tools are there today. Our cover story this month shows it is possible.

Finally, I want to thank our friends at ExtremeTech for letting us bring this coverage to PC Magazine readers. Jamie Lendino and his team of amazing writers push these boundaries every day. You can read more stories like this at ExtremeTech.com.

dan_costa@pcmag.com

Ransom War

We received a healthy response to Contributing Editor Brian Heater's feature, "How Ransomware Conquered the World" (in the May 2016 issue). Many of you had questions about deeper threats posed by ransomware and the steps you could take to guard your hardware. Here are two representative emails inquiring about additional prevention and recovery methods.

I enjoyed your ransomware article in May's issue. My question is, how do you recover once infected? Do you just reformat the locked drives, and reload from backups? Must you do more, like format the software or C: drive and then reload the operating system and all software and data? Must one go further and reset the motherboard bios and then reload everything from scratch? Is there a another strategy to follow when infected?
—Ronald Tellier

Many thanks for providing the very interesting and informative article. I wanted to ask whether you have a suggestion of how to best react when a computer (in a small home or office network) is infected despite, of course, using security software. My first step would be to disconnect it from the network and inform all other users (in a small team or family), but what would be the next prudent step? Assuming a backup is available, should the machine be shut down or left running until IT support arrives, for example? Is it possible just to wipe the SSD and install the backup?
—Baldur H. Vander

OUR ANSWERS:

You are smart people! You have backups!

The good news: As long as the backup software did not back up any infected files, it should be enough to reformat the drive and restore from a backup. I don't know of any ransomware that would require fiddling with the BIOS.

As for what to do on a network, I would absolutely shut down the affected computer. Many modern ransomware programs "reach out" to encrypt files on network shares, and they'll keep at it until stopped.

A true story: I have one such ransomware sample among the many malware tools I use for testing antivirus software. During a recent analysis, I ran the program in a virtual machine and kept a link open to a folder on the host that holds my log files. The dang thing "reached out" and encrypted my log files!

Security software company Webroot in particular claims that its unique journaling and rollback system lets it reverse the effects of any ransomware that gets past its initial scan. *[For more information about this feature, see our review of Webroot SecureAnywhere Antivirus in the May 2016 issue. —Ed.]* When I was testing it, I could not get my sample to cooperate, so I couldn't demonstrate this feature for myself. But I've seen very convincing demos.

—Neil J. Rubenking, Lead Security Analyst

Ask us a question!

Have a question about a story in *PC Magazine*, one of the products we cover, or how to better use a tech product you own? Email us at **letters@pcmag.com** and we'll respond to your question here. Questions may be edited slightly for content and clarity.

What's New Now

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TOP GEAR

This New AI Platform Can (Almost) Think for Itself

BY ROB MARVIN

Dag Kittlaus wants you to imagine buying a consumer electronics device in the near future. You take it out of the box, plug it into the wall, and unlock it with a biometric thumbprint—then the device comes to life. "Hi, nice to meet you," it says, before walking you through its setup via natural conversation.

That scenario isn't too far away, according to Kittlaus, who used TechCrunch Disrupt in Brooklyn in May as part of a coming-out party for Viv, a new voice-activated digital assistant. After three rounds of venture capital funding and more than a year in development, Viv is ready for primetime.

Viv is an artificial intelligence (AI) platform that gives developers and hardware makers the ability to imbue any product or interface with a conversational user interface (UI). It's AI that talks to you, but not in quite the same way as the machine-learning bots we're beginning to see in chat interfaces from Facebook, Microsoft, and others. It's less about intuitively surfacing relevant search results or product suggestions and more about having an actual conversation with an app or device in which the device is essentially thinking for itself.

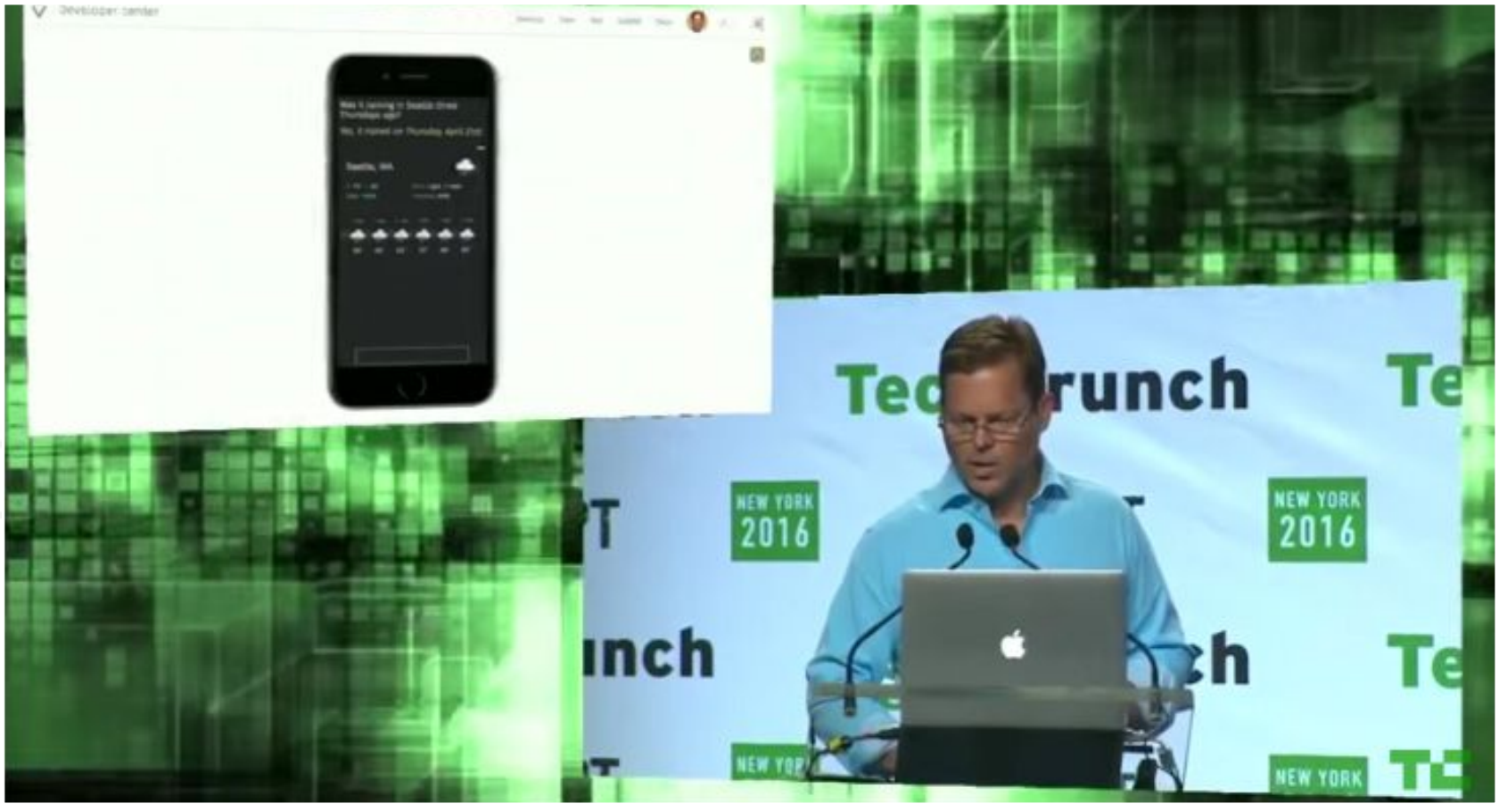
What went unsaid at Disrupt is that Viv is being positioned as the next evolution of personal assistants such as Cortana, Google Now, and yes, Siri. Kittlaus knows a thing or two about that; he's the co-founder and former CEO of Siri, which Apple acquired for more than $200 million in 2010. The biggest benefit of the AI explosion is convenience for everyday users, he says.

"AI will make mundane tasks easier to do, and approach user experience in a more personalized way. When you ask your app or device for something, you won't have to explain every bit of detail each time. It starts to know you," said Kittlaus. "Conversations are a natural way to interact with humans, and conversational UIs are just a more natural way to interact with your technology."

VIV WRITES ITS OWN CODE

Kittlaus said the start-up will partner with manufacturers to get Viv up and running in embedded devices, and will also give developers the ability to integrate Viv into their mobile app or software through Viv-as-a-Platform. He gave the first-ever Viv demo, asking Viv in different variations of natural language about the weather in several locations on various days, booking a hotel room, paying a friend back through Venmo, and sending flower arrangements for Mother's Day.

During the demo of Viv's developer center, Kittlaus explained how developers can teach Viv new concepts and intents and watch its speech recognition improve over time. What makes Viv's AI truly unique, though, is a patented computer-science breakthrough called dynamic program generation—it's software that writes itself.



"We've had a breakthrough with Viv in the way programmers work with computers. They're no longer required to teach machines step by step and code every single line," said Kittlaus. "Instead, you're describing what you want the system to do and modeling it, and the computer does the rest."

DISRUPTIVE TECH
Siri creator Dag Kittlaus debuts Viv, his new voice-activated digital assistant, at TechCrunch Disrupt.

This is where Viv stands apart from other digital assistants and even from other natural-language processing and machine-learning platforms like IBM Watson. In 10 milliseconds, Viv can write a 44-step program figuring out the context around a query. All that dynamic code generation in the background makes for a faster, more natural conversational UI.

"Our goal is ubiquity," said Kittlaus. "If Viv's conversational UI became the de facto interface for everything you do, that radically simplifies the tech norm."

The TechCrunch Disrupt moderator ended the conversation by asking whether Viv and other advances in AI will spell the end for the human race, as tech leaders including Stephen Hawking, Bill Gates, and Elon Musks have predicted. Kittlaus is skeptical. "I don't think this is the beginning of the end quite yet," he responded.

SkinTrack Can Turn Your Arm Into a Touch Screen

BY STEPHANIE MLOT

Smartwatch screens can feel maddeningly small when you're trying to navigate through apps. But why limit yourself to a 2-inch screen when there's so much prime real estate surrounding it? A Carnegie Mellon University research lab has introduced a solution that turns your arm and hand into an extended touch screen for your wearable device. Dubbed SkinTrack, it enables continuous touch tracking on the skin—in a most fashionable way.

Users wear a "harmless" (says CMU) high-frequency AC-signal-emitting ring, which communicates with electrodes in the watch's wristband to power interactive applications such as swiping, touching, and tracking. It even works when the skin is covered with clothing.

TOUCH AND GO
This technology, developed by a lab at CMU, might solve the problem of tiny displays on wearable devices.

SkinTrack, from the minds of the university's Future Interfaces Group, can handle app navigation, selection, scrolling, and confirmation. Say you're out for a run: You don't have to stop—panting and out of breath—just to look for your favorite motivational song on your wrist. Keep moving, and use the back of your hand and a right-swipe gesture to open the music player and launch the right tunes.

"As our approach is compact, non-invasive, low-cost, and low-powered, we envision the technology being integrated into future smartwatches, supporting rich tough interactions beyond the confines of the small touch screen," the Future Interfaces Group said in a paper.

Despite testing at 99 percent accuracy, SkinTrack faces a number of obstacles on the way to commercialization. Chief among them is sensing stability over time and the fact that slight changes to the body (hydration, sweat, and so on) can disorient the program. Researchers also cited the issue of powering the signal-emitting ring, as well as figuring out how much pressure is needed for each action.

STAYING ON TRACK
An AC-signal-emitting ring communicates with the electrodes in the smartwatch's wristband to power swiping, touching, and tracking.

How Smartwatches Are Changing Four Seasons

BY SOPHIA STUART

The AAA Five Diamond award-winning Four Seasons Resort Maui in Wailea might be on a laid-back island, but it's incorporating the latest tech to enhance hotel operations.

When the resort opened in 1990, the staff used landline telephony and two-way radios to handle logistics. Now driveway personnel are engaged in subtle smartwatch action on the forecourt, as well-heeled and celebrity guests approach in their cars. It's part of a test which may be expanded to the rest of the resort over the next year.

SYNCHRONIZE YOUR WATCHES

Wearable technology is proving to be a game-changer for this high-end Hawaiian hotel.

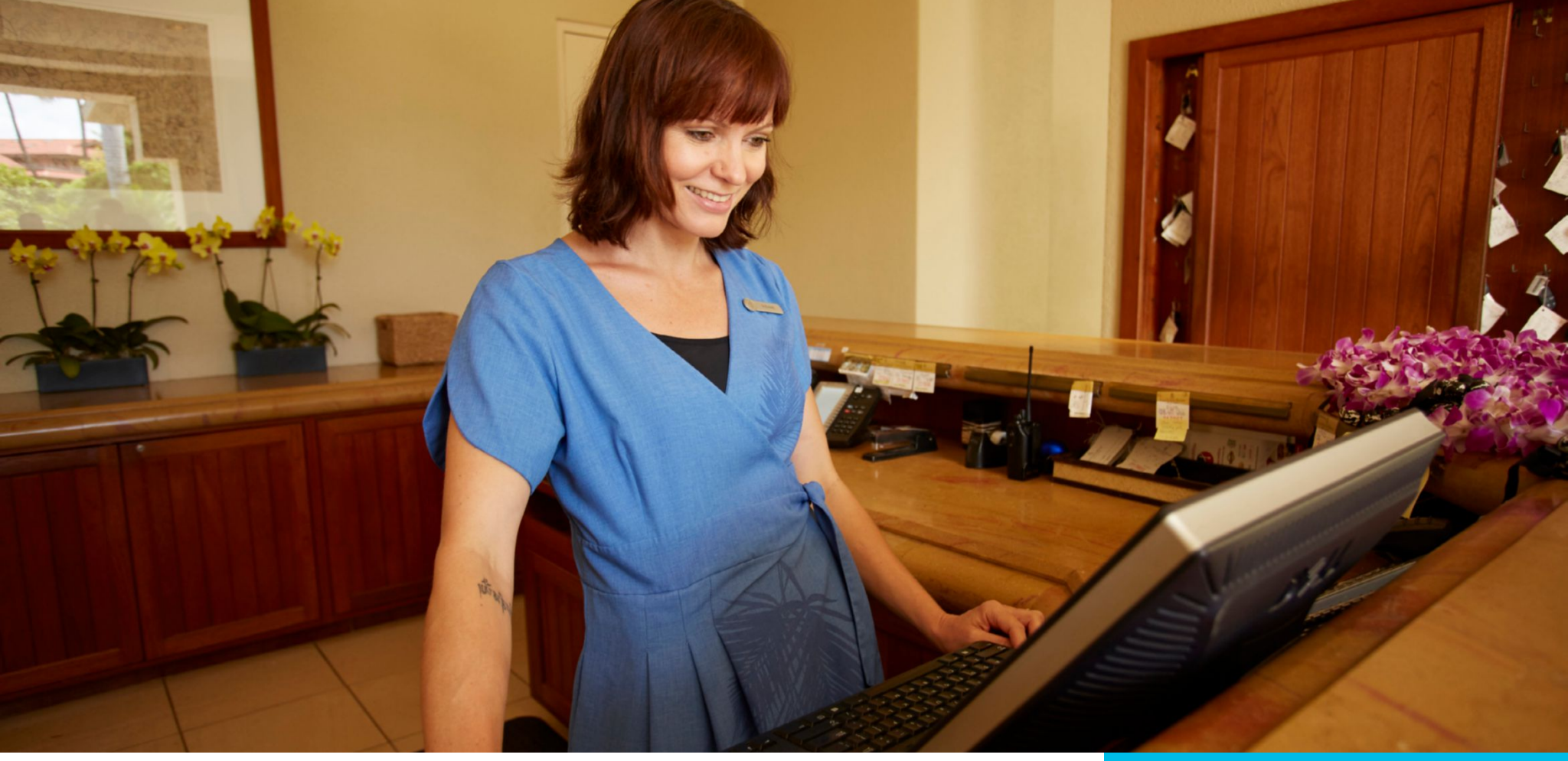
PC Magazine met with Marketing and Public Relations Manager Crissa Hiranaga, Guest Services Manager Alex Howell, and IT Director Jorge Gabriel in Hawaii to see the smartwatch system in action.

We all stood just inside the forecourt, facing the lush, tropical-plant-shaded driveway that encircles a fountain. Several members of the hospitality staff were dealing with arriving guests: directing them to the front desk and giving them the Hawaiian lei greeting, placing around their necks fresh orchids (for the women) or traditional black kukui nuts (for the men). Eli, the head doorman, looked down at his left wrist, touched his Pebble Steel smartwatch, quickly scrolled through what seemed to be several messages, and seconds later, his staff moved into formation as if by magic.

> **The process was impressively swift, and there was no messing about—this is a well-oiled machine.**

Two vehicles approached. An SUV with darkened windows pulled up right in front of the hotel entrance and Someone From Hollywood (one has to be discreet at the Four Seasons) disembarked. They were greeted by name (it was all in the watch message), their luggage was dispatched swiftly, a lei was draped over their shoulders, and they disappeared into the hotel.

ARRIVAL TIME
Driveway personnel can seamlessly coordinate their greeting procedures as each new guest arrives.



JUST CHECKING IN
The Pebble smartwatch streamlines the check-in process for guests at the Four Seasons Resort Maui in Wailea. The hotel staff relies on the two-way communication enabled by the device.

The second vehicle was much larger, and you could tell that there was a lot of luggage inside. It pulled into a side area and quickly unloaded, then continued on to the front entrance to deliver the guests into the air-conditioned comfort of their rooms. (The humidity in Hawaii has to be experienced to be believed.)

The process was impressively swift, and there was no messing about—this is a well-oiled machine. What made it more interesting was the virtual hush that accompanied the whole process, something that was possible only because of the smartwatch system with two-way response. There were none of the jarring walkie-talkie blasts of past hospitality processes and procedures. And no one ever said a walkie-talkie looked good; a smartwatch melds into its wearer's apparel.

"Wearables are a game changer for us in the hotel business," Howell told PC Magazine. "It's enabled us to both personalize the tech and streamline the whole experience. We never felt comfortable having staff looking at their phones, because the perception is that someone isn't working when they're doing that. The smartwatches are much subtler and, well, smarter."

Gabriel explained how it all works behind the scenes: "The most important thing, for us, is having that two-way communication. We have a rapid response back-end system that the watches take and receive messaging from."

But why the Pebble Steel? All agreed that form and function is important, but so is flexibility. "We wanted something elegant in wearables, but not flashy or garish," said Hiranaga.

"And we needed it to integrate with both iOS and Android," added Howell, "as well as with several U.S. mobile telephony carriers. We can't be locked into one system."

"It's remarkable how, since we've been doing this trial, the Pebble tech team have iterated on their back-end tech on a constant basis," agreed Gabriel.

Is all the tech mandated from the head office in Canada? Gabriel said innovation at the hotel or resort level is encouraged, as long as there's a willingness to share. "The group has 98 properties in 41 countries, so it's a huge undertaking to disseminate new tech. But we have several opportunities a year to come together as IT directors, at hospitality trade shows or internal Four Seasons IT events such as the next one in Orlando, FL this summer, see what's happening at other places, and get a sneak peek of upcoming cool stuff."

Future plans for the smartwatch trial include integration with the Four Seasons app. It allows guests to order room service with helpful photographs of menu items (especially useful for travelers who don't speak English), request spa services, schedule golf lessons, call housekeeping to remove trays or, if something goes horribly wrong inside the room, get help instantly without hanging on the telephone during busy front desk periods.

"Future plans for the smartwatch trial include integration with the Four Seasons app."

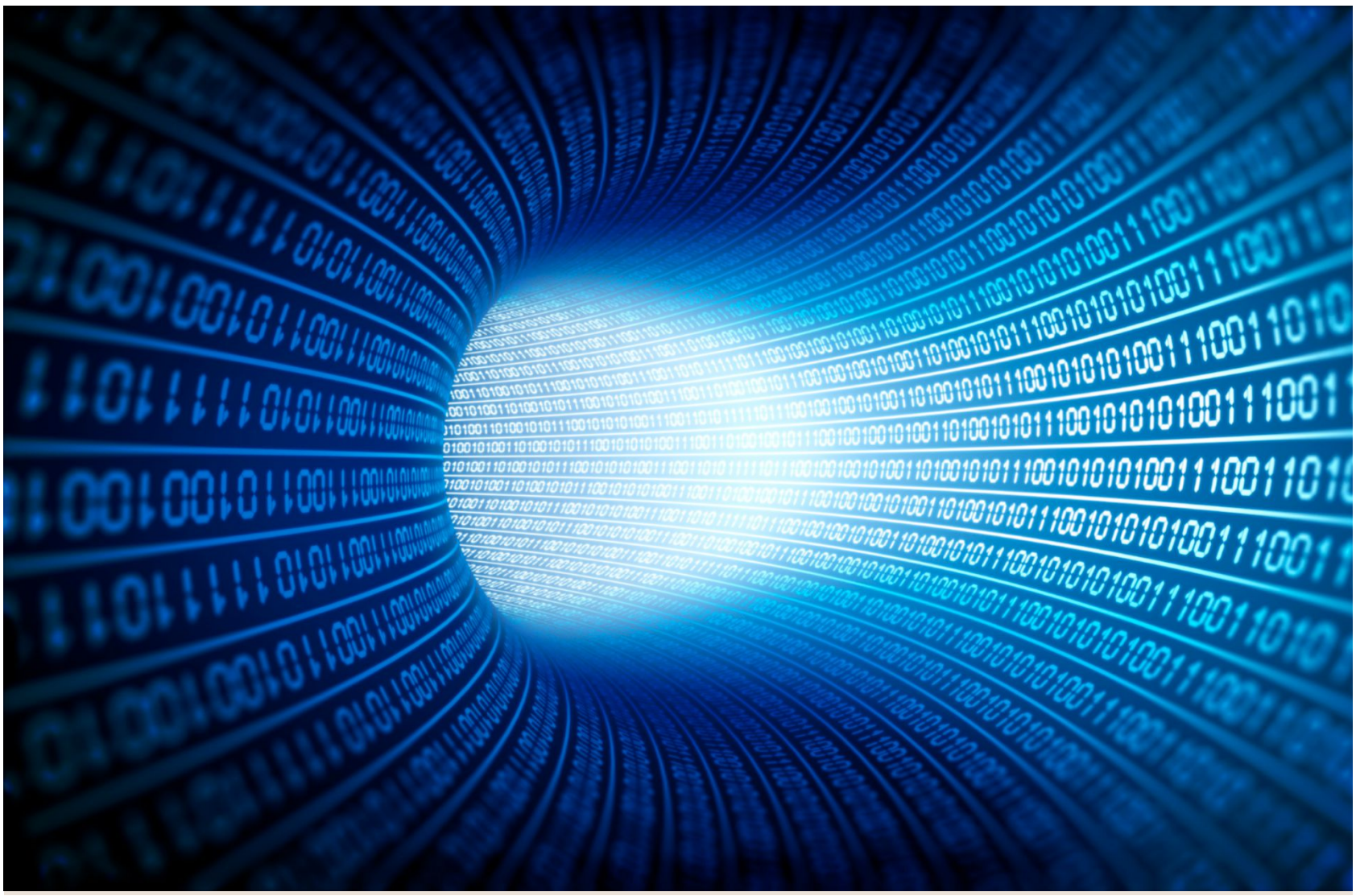
In the meantime, Gabriel is gathering data on the trial to share with fellow IT directors at the next internal tech conference at the new Four Seasons Orlando within the Walt Disney World Resort.

"I'll be there to work," said Gabriel hastily, as Hiranaga and Howell laughed.

That's the clever thing about technology. It can make the detailed machinations of business look seamless on the surface. At Four Seasons Resort Maui at Wailea, they might be delivering relaxing "island time," but they're doing it with big-city efficiency.

The Supercomputers That Are Exploring Quantum Cryptography

BY SOPHIA STUART



The Strategic Computing Complex is located in a classified area of the Los Alamos National Laboratory (LANL), so during a recent visit, *PC Magazine* met up with two of its supercomputing and quantum cryptography experts "outside the fence" at the LANL Research Library.

The complex, known as the Nicholas C. Metropolis Center for Modeling and Simulation, houses one of the largest supercomputing centers on the planet, where calculation, modeling, simulation, and visualization of complex nuclear weapons data in support of the Stockpile Stewardship Program is carried out.

DATA IN THE DESERT

We met with two experts at LANL's Strategic Computing Complex to see what they're up to at the secretive compound.

Among those allowed inside the fence are Randal Rheinheimer, deputy division leader for High Performance Computing at LANL, and Josip Loncaric, HPC Technology Futures Lead at LANL.

"I'm the big-picture guy, and Josip Loncaric is the detail-orientated one," Rheinheimer explains.

Essentially, Loncaric's role is to predict what's next for supercomputing. The MIT and Harvard grad left a gig at NASA's Langley Research Center to join LANL in 2003 because "LANL is the premier institution for physical research." The move was a little cloak-and-dagger—"They wouldn't tell me what I'd be working on because it was a hush-hush project," he says—but the project turned out to be Roadrunner, the first supercomputer to use a heterogeneous model.

IF YOU BUILD IT...
Supercomputer facilities construction is ongoing at Los Alamos National Laboratory.

Simply put (if such a thing is possible), the model was far advanced from the usual CPU setup, using massively parallel computing and adding clusters of CPU and graphics processing units (GPUs) for extremely accelerated performance. The approach paid off: Roadrunner was the first supercomputer to break the petaFLOP barrier, or one million billion calculations per second, before it was decommissioned in 2013.

> **When Trinity is completed, it should exceed the performance of a million simple laptops.**

Now Loncaric is busy deploying the Trinity supercomputer, which is expected to be one of the fastest in the world. In 2014, the National Nuclear Security Administration (NNSA) awarded Seattle-based supercomputer maker Cray a $174 million contract to develop Trinity, which should be able to perform full-scale, end-to-end weapons calculations—in 3D—to the highest accuracy possible.

"When Trinity is completed, it should exceed the performance of a million simple laptops," Rheinheimer explains.

Inside are "several advanced features, such as Intel's energy-efficient Xeon Phi processors with many integrated cores and very fast in-package memory, new storage tiers such as SSD-based Burst Buffers and disk-based Campaign Storage developed at LANL, and advanced power management features," Loncaric says. "Trinity design is driven by the memory footprint required to solve the most complex physics problems, with extreme performance to match."

ENTROPY ENGINE

Another use for LANL's computing expertise is in the field of quantum cryptography. Raymond Newell, who is the Principal Investigator at the Quantum Institute, joined us in the LANL Research Library, with an intriguing package in tow.

Newell, who also joined LANL in 2003, describes his job as "exploiting the weirdness of quantum mechanics to bring real benefit to pressing needs in national security."

Classical cryptography, as we now know, is not unbreakable. From the Enigma machine of WWII to the Secure Socket Layer (SSL) used on the Web today, it seems as if conventional methods may have run their course. LANL is involved in this field not only because it's an interesting physics problem to solve, but also because major corporations handling sensitive information, banks processing financial data, and governments passing classified secrets among its agencies require utmost secrecy.

Enter the photon that looks like it could be the way forward, using quantum cryptography to confound modern spies.

"No single photon can be cut in half," Newell explains. "They are indivisible. Furthermore, it's impossible to make a copy of a single photon. We have this thing called the quantum 'no cloning' theorem, which states that if someone is given an unknown quantum state, it is impossible for them to make a high-fidelity copy of it. A third tenet is what we call the 'uncertainty principle' [that] any attempt to extract information, to measure, make any measurement, will change it permanently, instantly, and forever. So I think you might be able to see why single photons might be an excellent vehicle for transmitting secrets."

"If someone is given an unknown quantum state, it is impossible for them to make a high-fidelity copy of it."

Newell's team at LANL developed techniques that allow this technology to work over fiber. It also secured patents for the QKarD, a handheld device that generates secret keys, using the quantum mechanics process described above.

Now they're onto something even more advanced: a random number generator, also using the principles of quantum physics, called an Entropy Engine (entropy in a computing context meaning randomness).

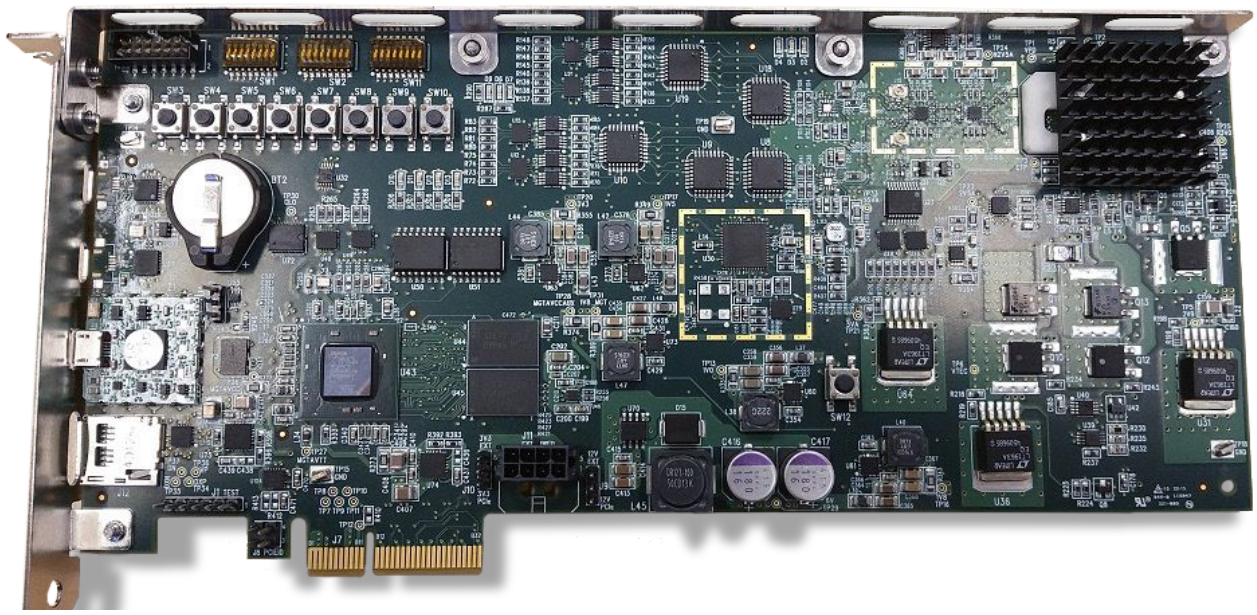
"Random number generation is a problem for all cryptographers," says Newell. "So what we have created is a device that generates unpredictable numbers at 200 megabits per second."

Newell pulls out what looked like a complex circuit board from a case. “The unpredictability of those numbers is rooted in their origin in a quantum optical field generated on the device inside this,” he says, turning the Entropy Engine over and back, “where we have an optical source and a detector. The optical source fluctuates very rapidly due to a photon bunching effect. Those fluctuations are detected by the optical sensor and then digitized.”

The intent is that this Entropy Engine can be placed inside a server, most probably within a cloud storage or virtualization environment. So when the server has a need to generate random numbers, a function call is made to the Entropy Engine, which then delivers them at extreme speeds.

Unfortunately, you probably don’t have room at home to install a supercomputer like they have at LANL or the coolant facilities required to keep it stable. But if you’re in the market for advanced cryptography, Newell’s team has worked with an outside partner to bring the Entropy Engine to market.

What we have created is a device that generates unpredictable numbers at 200 megabits per second.



STRENGTH IN NUMBERS
A peek at the circuitry inside the LANL’s Entropy Engine random number generator.

It’s now available via Whitewood Encryption Systems in Boston. As is the case in modern espionage, matters of national security, and even large-scale government or financial institutions, it’s a price-on-application sort of scenario.

In the meantime, the scientists at LANL are on to the next frontier in emerging technology. Stay tuned.

What We Love Most This Month

BY STEPHANIE MLOT

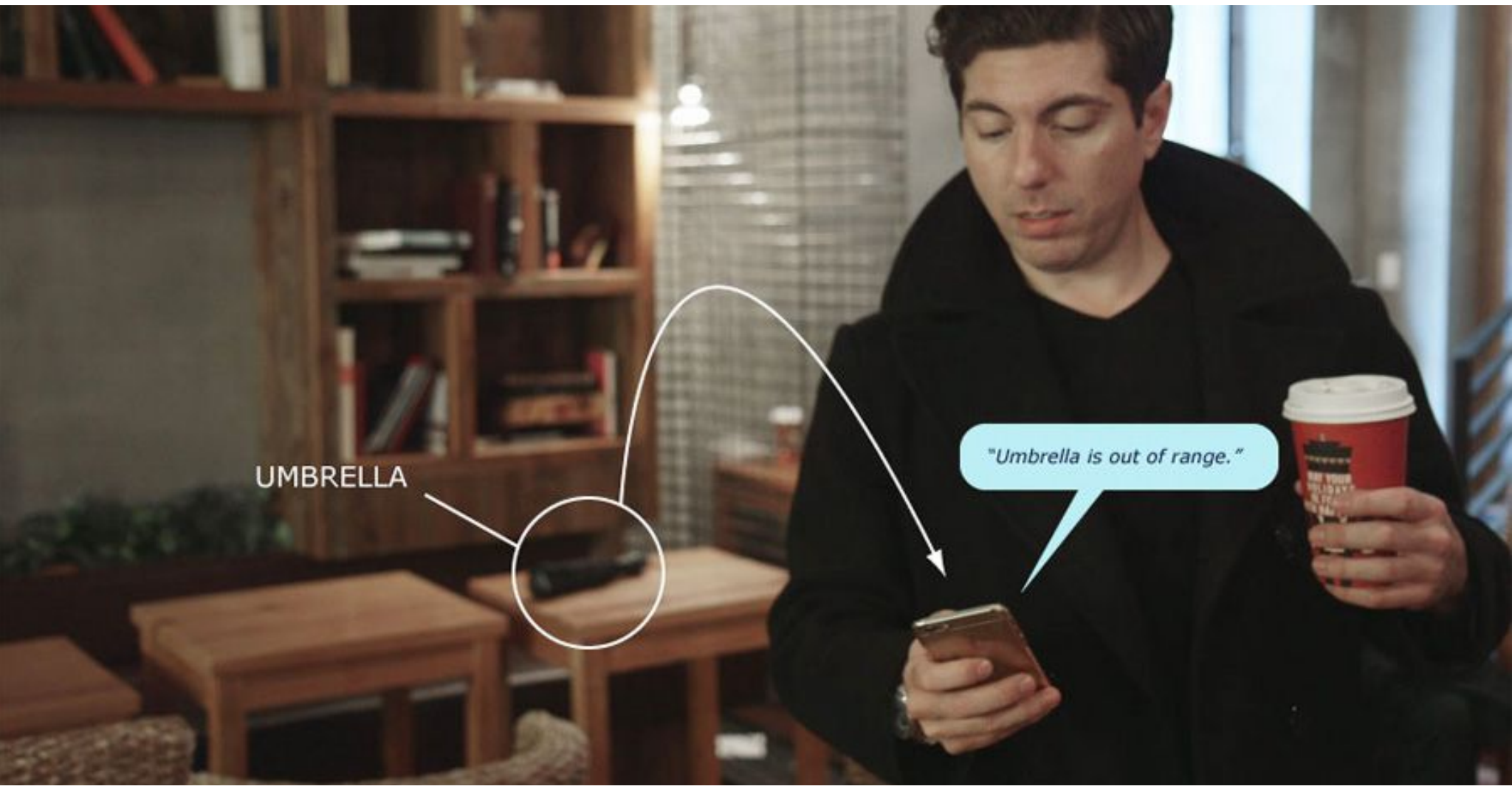
CANON POWERSHOT D30

Camping, roller-coaster riding, marshmallow roasting, fishing: Summer means the great outdoors. And the great outdoors means snapshots of family and friends wrapped up in their sleeping bags, making s'mores, and showing off the catch of the day. The sporty PowerShot D30 camera can dive to a depth of 82 feet, is shockproof to 6.5 feet, and is temperature-resistant from 14º to 104º F. It also comes with built-in GPS tracking, Sunlight LCD mode, and 32 predefined shooting settings.

$299.99 shop.usa.canon.com

What We Love Most This Month

BY STEPHANIE MLOT



DAVEK ALERT

Have you ever seen the rain comin' down on a sunny day? The Davek Alert umbrella syncs with your smartphone, so even on the brightest days, you won't forget to pack your bumbershoot. An embedded beacon chip broadcasts a "proximity signal" from the umbrella to your handset, letting you track the distance between them. Exceed 30 feet, and you'll receive a mobile alert. The service can be turned off or paused, for those days you'd rather not be reminded you left your brolly at home.

$125 davekny.com

What We Love Most This Month

BY STEPHANIE MLOT

DUO UNDERWATER MP3 PLAYER

Whether you hit the Y every week or use the backyard pool three months a year, swimming is terrific exercise. But it can lack the motivation a pump-you-up playlist supplies for running or lifting. The Duo is designed for swimmers: Sans earbuds, the two-piece unit uses bone conduction audio transmission to broadcast music through your cheekbones. With 4GB of flash memory and a lithium ion rechargeable battery, the Duo lets you listen to songs, podcasts, audiobooks, and the like for days without losing focus.

$119.99 finisinc.com

What We Love Most This Month

BY STEPHANIE MLOT

SAFETY TURTLE 2.0

Summertime, and the livin' is easy—unless you have small children and a backyard pool. Strap this "fun to wear" Turtle-adorned wristband onto your kid's arm, then grab a book and a lounge chair and relax. As soon as soon as the bracelet gets wet—whether someone splashed too hard or the toddler stuck a hand in the water to grab a floating toy—you receive an alert. Additional wristbands cost $59.95 each, and they can be attached to a pet adapter to keep Fido dry, too.

$149.99 safetyturtle.com

What We Love Most This Month

BY STEPHANIE MLOT

STERIPEN AQUA

Most modern campers have access to bathrooms and clean drinking water. But if ever you find yourself in a "Hunger Games" situation, the SteriPen makes a fine companion. Operating on four AA batteries, the "pen" can purify 50 to 150 liters of water at home (during boil-water advisories) or in the wilderness. Just press a button, place the device in water, and stir. The lightsaber-resembling stick uses UV light to deactivate microorganisms' DNA, so they can't reproduce and make you sick.

$49.95 steripen.com

Opinions

TIM BAJARIN

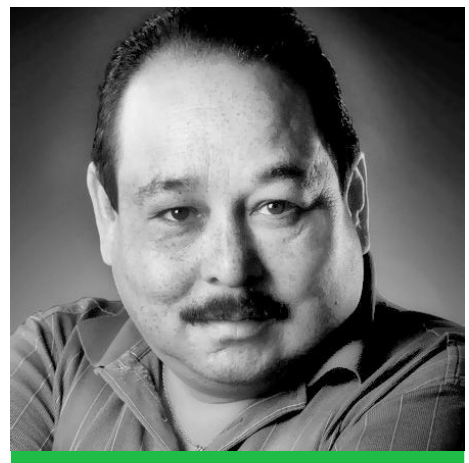
WILLIAM FENTON

DOUG NEWCOMB

> **The ultimate goal is to use these new technologies to *decrease* complexity.**

TIM BAJARIN
ARE SMARTPHONES BECOMING TOO COMPLICATED?

Are Phones Becoming Too Complicated?



Tim Bajarin is the president of Creative Strategies and a consultant, analyst, and futurist covering personal computers and consumer technology.

I was intrigued earlier this year by the HP Elite X3, a phablet that can be used as a smartphone, tablet, and even a full PC. This 5.9-inch Windows 10 smartphone runs on the new, high-powered Qualcomm 820 processor and 4GB of RAM and has 64GB of internal storage. On the surface, it's a great Windows Mobile phone, but what really makes it interesting is a special docking system that turns it into a PC. Using a phablet to run full Windows applications would normally be difficult, but with this docking system, the X3 can be connected to a larger keyboard and monitor to serve as the CPU, OS, and application layer.

The idea is not new; Motorola tried it unsuccessfully with the Atrix. And I have seen at least four or five similar designs in labs that never came to market. But HP's attempt begs a more important question: Are smartphones these days just too complicated?

Smartphone makers are cramming more and more functionality into smartphones, but this actually makes them more difficult to use. Part of the problem is that phone makers believe everyone wants to use these devices for "productivity." But we polled thousands of customers and found that about 80 percent of all smartphone users use only eight to 12 apps on a consistent basis, which include basics like email, messaging, social networking, news, games,

weather, and photo- and video-related apps and services. But only about 10 to 15 percent use them for serious productivity.

To put this in context, about 2.5 billion smartphones will be sold this year around the world, and most people will use them for very basic communication, social networking, and highly consumer-focused needs. Yet tech companies keep making their mobile operating systems more powerful so that they can meet the productivity needs of a minority group of users. The result is that smartphones have become more complicated and in some cases more difficult to use for an audience that will likely never become power users.

I understand that consumers want powerful devices that run any app or service on their phones and would balk at a phone that was limited in some way. Mobile OS vendors are aware of this and have added things like Apple's Siri, Google Now, and Microsoft's Cortana to help streamline the user experience. They are also using the power of next-generation mobile processors to increase the accuracy of their voice UIs, add cameras and software that can do better face recognition, and employ more accurate location and contextual information, and they're working on things like gestures and prediction.

The ultimate goal is to use these new technologies to decrease complexity. The good news is that there's actually a roadmap in place to get this done. With any luck, we should have some of these powerful new features in our hands later this year.

Why You Shouldn't Dismiss Georgia Tech's $6,600 Online CS Master's Degree

A $6,600 master's degree in computer science with a 55 percent acceptance rate and no GRE entrance exam? It's a seductive proposition for an undergraduate, to be sure. Since the Georgia Institute of Technology announced its Online Master of Science Computer Science degree—OMS CS, for short—in May 2013, the program has elicited wonder, enthusiasm, and trepidation.

Wary of the prospect of a public research institution working closely with private corporations, I count myself among the latter cohort. However, I'm not about to let my ideological reservations foreclose my curiosity, especially given that so many OMS CS students praise the program.

In the interest of giving OMS CS a fair hearing, I spoke with several members of the leadership, including David White, assistant dean for academics and executive director; Charles Isbell, senior associate dean and an instructor of two courses; and the dean of the College of Computing, Zvi Galil, all of whom proved forthcoming about the program's achievements and challenges and admirably generous with program details.

While I remain concerned about the long-term consequences of corporate partnerships, the OMS

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CS program has virtues that academics would do well to acknowledge. Individual courses aren't as large as enrollment stats suggest, the terms of the corporate partnerships aren't as draconian in practice as in print, and the yearning for greater scale and less expense is one that administrators should engage. The OMS CS is not quite as grand, but also not nearly as flawed, as early reports suggested.

OPENING ACCESS

Now entering its third year, the OMS CS program plays younger sibling to the MS CS program. The structures of the programs aren't quite parallel. For example, the brick-and-mortar version offers 11 areas of specialization, compared with four in the online version. Many of the ancillary services, such as career counseling, are still being developed for the online program. The programs share courses, faculty, and accreditation, though.

Perhaps the most remarkable difference is accessibility. Whereas the traditional MS CS degree costs Georgia residents $21,000, and twice as much for out-of-state students, the OMS CS costs a third as much; students can even qualify for financial aid. The number that tends to circulate is $6,600, though pricing depends upon the pace at which students complete the program.

Similar to other master's programs, OMS CS is 30 credit hours, or 10 three-credit courses. Given that Georgia Tech charges $170 per credit hour and $301 in university fees per semester, students could actually spend less than $6,000 with a three-course load. (Today, the average commitment is about 1.5 courses in the spring and fall and one course over the summer.) Theoretically, students could further diminish course loads were they to conduct a faculty-

directed project or theses, though, in practice, students tend to choose the 10-course track.

A second component to access is admissions criteria. To enroll in the OMS CS program, students need only maintain a 3.0 GPA or higher in computer science at an accredited undergraduate institution and pass a TOEFL exam if they're international. Once enrolled, students aren't fully admitted until they maintain a 3.0 GPA or higher in two foundational courses. Otherwise, there's no GRE and little mystery about the admissions process, which is comparatively generous—55 percent—especially when compared to Georgia Tech's MS CS program, which hovers around 15 percent.

Access is, of course, a double-edge sword: If a program is too open, classes bloat and at-risk students suffer. Thankfully, Georgia Tech has, at least for now, struck a reasonable balance. Despite the hoopla about "10,000 students" enrolling in the OMS CS program, that number doesn't refer to one class or one term, but rather to the program's overall enrollment. This spring, 3,358 students enrolled in the program. Leadership anticipates around 1,500 over the summer and about 4,000 in the fall. And comparable to many traditional lecture-based courses at public universities, courses don't exceed 300 or 400 students.

Access, of course, is a double-edged sword: If a program is too open, classes bloat and at-risk students suffer.

COMPARING THE CATALOGS

The moniker "Online Master of Science," is administrative, meaning that no such demarcation appears on diplomas. OMS CS students can even walk with MS CS students. Moreover, course listings contain subtle but meaningful differences from those on Udacity, the platform Georgia Tech chose for its OMS CS

program. First, OMS CS courses aren't available on Udacity. For example, a summer course entitled Software Analysis and Test, capped at 75 students, isn't listed in the Udacity catalog. While most basal courses are available to anyone on Udacity—I found versions of 21 of 23 OMS CS courses offered this spring—gratis versions don't include the same assignments, assessments, or credentials. That is, while Udacity content is machine-graded, Georgia Tech online classes relies upon a combination of online proctoring (Proctortrack) and dozens of good old-fashioned teaching assistants.

SCALING EXPECTATIONS

The OMS CS program has revealed many surprises. On one hand, students are using social media to self-organize support. The Google+ OMS community has more than 3,500 members, a significant portion of existing enrollment. By the same token, Georgia Tech leadership admits that it's struggling to keep pace with grading; while machine learning might address concerns in the future, for the time being, it relies upon dozens of teaching assistants.

The online program is also perhaps less diverse than you might expect. Whereas the MS CS program comprises largely international students, nearly eight in 10 students enrolled in the online program are US citizens, and more than one in 10 is from Georgia. Demographically, the OMS CS program isn't necessarily more diverse than the MS CS program, either. For example, even fewer women enroll online, which Georgia Tech leadership attributes to the discrepancy between domestic and international students.

"The pipeline problem for women in CS is more acute in the United States," explained Michael Terrazas, director of communications. "Our international applicants typically are much more gender balanced than our domestic students."

Finally, when you consider the age of students, the OMS CS program is older (33 to 34 years old) and more educated (more than 700 applicants have advanced degrees and more than 120 hold Ph.D. or terminal degrees). In this sense, the Georgia Tech online master's program is more in line with ventures such as General Assembly that enable professionals to advance skills and training.

While the OMS CS degree may not democratize higher education, it doesn't cannibalize it. As Georgia Tech's leadership put it candidly, the

OMS CS won't make that much money, even when it fully scales. Meanwhile, the traditional master's program is a veritable golden goose. In addition, all the buzz around Georgia Tech's OMS CS degree is driving interest in the university in general, and in its computer science programs in particular. Traditional undergraduate BS CS applications increased by 85 percent in 2014 and another 35 percent in 2015; MS CS apps jumped 30 percent in 2014 and 18 percent in 2015.

That said, these may be the fruits of leadership, and if and when other programs embrace online education tracks, traffic will likely level off. In the meantime, however, Georgia Tech has embarked on a provocation, and one that other schools would do well to watch.

"The Georgia Tech OMS CS program is more in line with ventures such as General Assembly."

The Next Big Thing for Connected Cars: Apps Drivers Actually Use

Car tech expert Doug Newcomb has written for *Popular Mechanics*, *Road & Track*, and other publications, and is the author of *Car Audio for Dummies*.

The current crop of smartphone apps for cars can remotely lock or unlock doors, check fuel levels, and locate vehicles on a digital map. And you can do most of this from halfway around the world—as long as you have a signal or maintain a subscription to a telematics system.

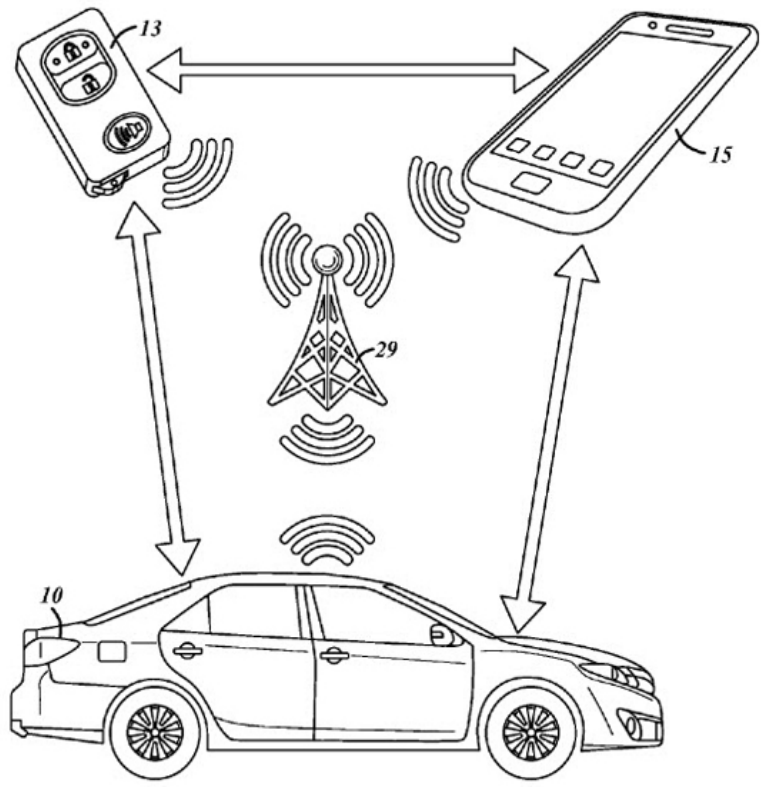
While these features and others have become fairly ubiquitous, some automakers have added novel twists. Audi Connect's Picture Navigation, for example, uses the geographic info embedded in digital photos sent from contacts (via text, email, and so on) to plot a destination in the car's nav system. And you may have seen the being-chased-by-bears TV commercial for Hyundai's Blue Link system, which works with a smartwatch. But these kinds of innovations have become few and far between.

For years we've been hearing that more (and better) apps are on the way, while automakers have attempted to engage with third-party developers to spur innovation. Ford and GM, for example, announced app development programs in early 2013, but so far nothing significant has come of it. Ford, however, is gaining some traction with its SecureDeviceLink that made its proprietary

AppLink platform available to other car companies, especially since Toyota signed on to support the platform last year.

It's high time for automotive smartphone apps to provide features that drivers can use on a daily basis, and a recent spate of patent filings indicates that they could be on their way.

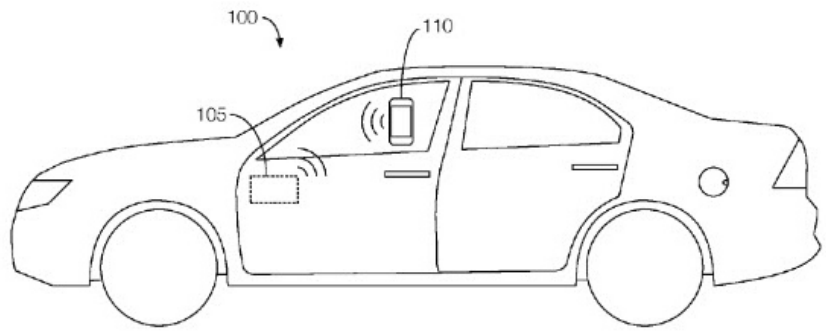
Few things are more frustrating than searching for errant car keys, and it always seems to happen when you're in a hurry. Soon there could be an official carmaker-sponsored app for that: Toyota recently filed a patent for a Smart Key Locator app to "enable a user of a vehicle to locate a missing or lost key for the vehicle." (Bluetooth-powered trackers such as the Simple Matters Ditto and TrackR Bravo, which attach a small dongle to whatever small, loseable object you like, already exist.)



You can read all the nitty-gritty tech details in the patent application, but basically, the key sends out a signal that a smartphone app can detect and use to determine the distance away from the key in feet. My hope is that they also add a "getting warmer" or "getting colder" directional capability.

While smartphones allow drivers to bring their music and contacts into the car (and many luxury vehicles often have individual driver preferences such as seat position and even radio presets tied to separate key fobs), Ford's Cooperative Occupant Sensing app goes much further.

The patent application shows that an app would reside on a driver or even a passenger's mobile device and make adjustments, for example, to the seats and even to the airbags based on their height, weight, and other factors.



According to the patent, it could even "present instructions for wearing a seatbelt in a particular manner" if the car occupant is pregnant. I'd just like it to automatically readjust my seat after a parking valet or car wash attendant has gotten it out of whack for the few seconds they're behind the wheel.

And finally, for performance enthusiasts who lament how technology is taking over cars, a patent recently filed by Bosch could literally get their motors running. It works with a "controller installed in a vehicle" that's "configured to receive a user-selected operating parameter obtained through a downloaded application."

According to the patent application, using a smartphone app, a driver could "interact with a store to directly select and obtain new calibrations for the vehicle" and "software that's used to modify vehicle performance (e.g. engine performance, brake performance, electronic stability control performance, etc.)" It added that the "changing of vehicle performance can include ... activating or deactivating vehicle functionality" such as "turning off acceleration limits." And a mockup of an app screen shows a "Drag Strip Mode" should appeal to most weekend-warrior track rats.

Of course, patents don't always result in features we'll see in production vehicles. But these and others I've recently noticed seem to indicate that the next wave of smartphone apps from the auto industry could bring features that drivers actually use.

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Reviews

CONSUMER ELECTRONICS

Amazon Kindle Oasis

Invoxia Triby

Raden A22 Carry

HARDWARE

Apple MacBook

Lenovo ThinkPad X1 Carbon

Maingear X-Cube Z170

Nvidia GeForce GTX 1080

Linksys EA-7500 Max-Stream AC1900 MU-MIMO Gigabit Router

SOFTWARE

Zoho Projects

Virtual Desktop

Kindle Oasis Is Thin, Light, Bright, and Very Pricey

The Kindle Oasis is the finest ebook reader Amazon offers. At $289.99, it's also the most expensive. For the price, you get the company's lightest and thinnest reader, a new design built around an ergonomic handgrip, and a leather charging cover that packs an additional battery. And the Oasis uses a brighter version of the E Ink Carta screen you'll find on the Kindle Paperwhite and Kindle Voyage. There's no doubt that it's the loveliest Kindle yet, but is it worth the $170 premium over the excellent Paperwhite? For all but the most well-heeled readers, the answer is no.

Amazon Kindle Oasis

$289.99

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PRICING, DESIGN, AND DISPLAY

Multiple configurations of the Oasis are available. The base Wi-Fi–only model costs $289.99 with Special Offers (which are ads that appear on-screen when you aren't reading) and $309.99 without ads. A 3G model (which lets you download books wherever you are, without the need for Wi-Fi) has a higher price of $359.99 with Special Offers or $379.99 without.

The Oasis uses a 6-inch Carta E Ink touch screen with a resolution of 1,448 by 1,072 pixels that squeezes 300 pixels into each inch for crisp, defined text. A new diffractive pattern within the screen and a boost in the number of backlighting LEDs—to ten, up from four in the Paperwhite and six in the Voyage—helps set it apart.

Amazon Kindle Oasis

PROS Sharp, bright screen. Long battery life extended by leather charging cover. Ergonomic design. Built-in accelerometer. Vast ebook store.

CONS Expensive. Not waterproof. Cover doesn't protect entire reader.

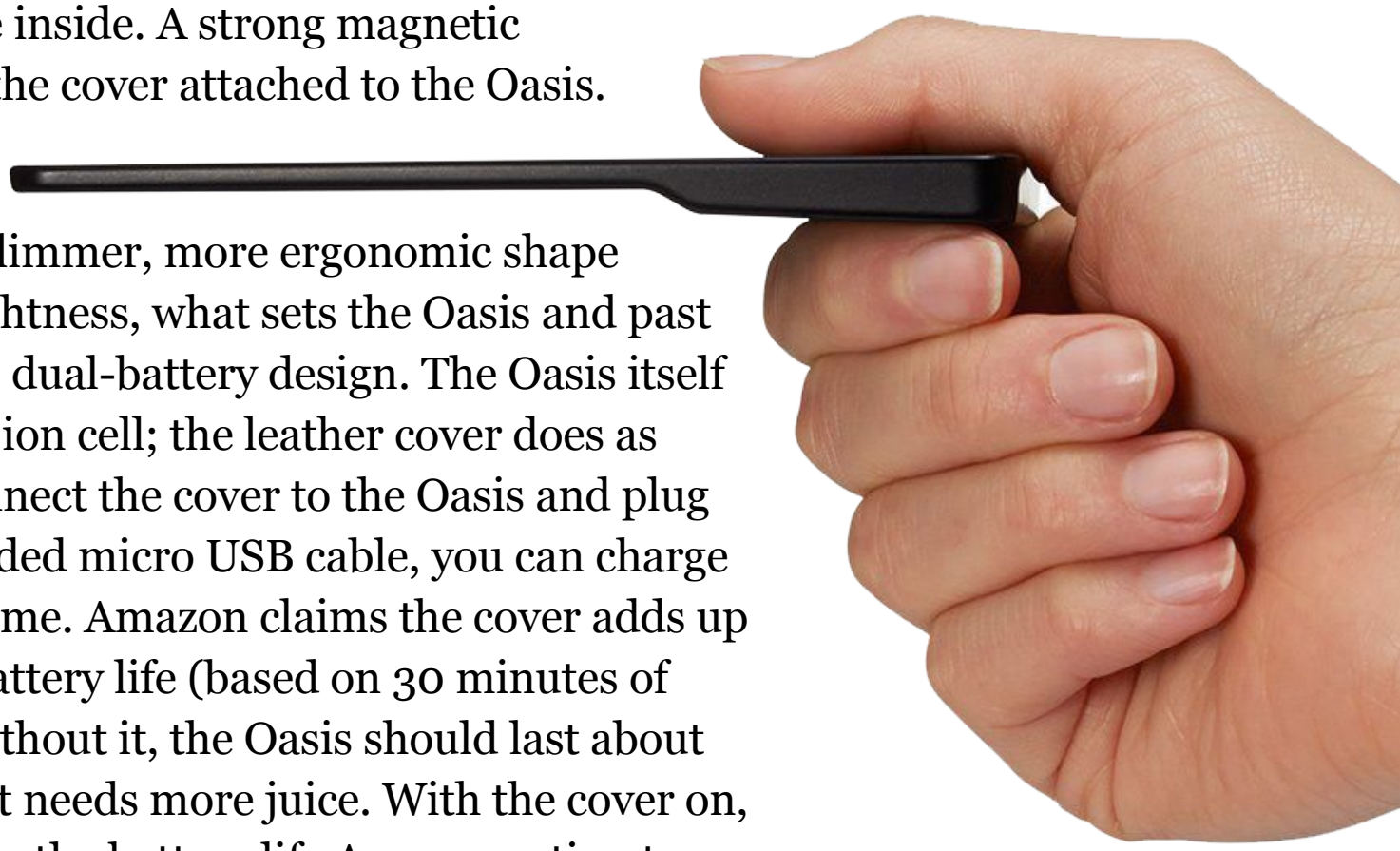
I was able to read in harsh sunlight, under office lamps, and in dim subway halls without issue. As with the Voyage, the screen on the Oasis is flush with the bezel.

The reader measures 5.63 by 4.80 by 0.13-0.33 inches (HWD). Instead of a uniform, flat surface, it resembles a wedge that's 0.13 inch at its thinnest point and has a raised 0.33 inch on the other end, which fits in your

SCREEN STAR
A new diffractive pattern within the display, along with more LEDs, lets you read in just about any kind of light.

palm like the spine of a book. The bump is where the battery and most of its weight is located, but the Oasis feels perfectly balanced. It also doesn't matter if you're right- or left-handed, as a built-in accelerometer automatically flips the screen based on how you hold it.

The Oasis weighs 4.7 ounces on its own and 7.36 ounces with the included leather charging cover attached. I preferred to read with the cover connected, as it gives the reader a more substantial feel. The leather cover, available in black, merlot (red), or walnut (brown), has an embedded Amazon logo on the front and soft felt on the inside. A strong magnetic connection keeps the cover attached to the Oasis.



SUBSTANTIAL READING
The thicker side of the Kindle Oasis rests in your palm like the spine of a book.

Aside from the slimmer, more ergonomic shape and improved brightness, what sets the Oasis and past Kindles apart is its dual-battery design. The Oasis itself contains a lithium ion cell; the leather cover does as well. Once you connect the cover to the Oasis and plug it in with the included micro USB cable, you can charge both at the same time. Amazon claims the cover adds up to nine weeks of battery life (based on 30 minutes of usage per day). Without it, the Oasis should last about two weeks before it needs more juice. With the cover on, that's nearly double the battery life Amazon estimates you'll get with the Kindle Voyage (six weeks).

One nitpick is that the case doesn't entirely cover the back of the Oasis—the battery bump remains bare. Three of the sides are also exposed, which makes sense since the top houses the power port, the Power button, and an LED charging indicator. As with previous Kindles, the Oasis has no headphone jack, so it offers no audiobook support. It's also not waterproof, which is disappointing given the premium price. For a waterproof ebook reader, check out the Barnes & Noble GlowLight Plus or the Kobo Aura H2O.

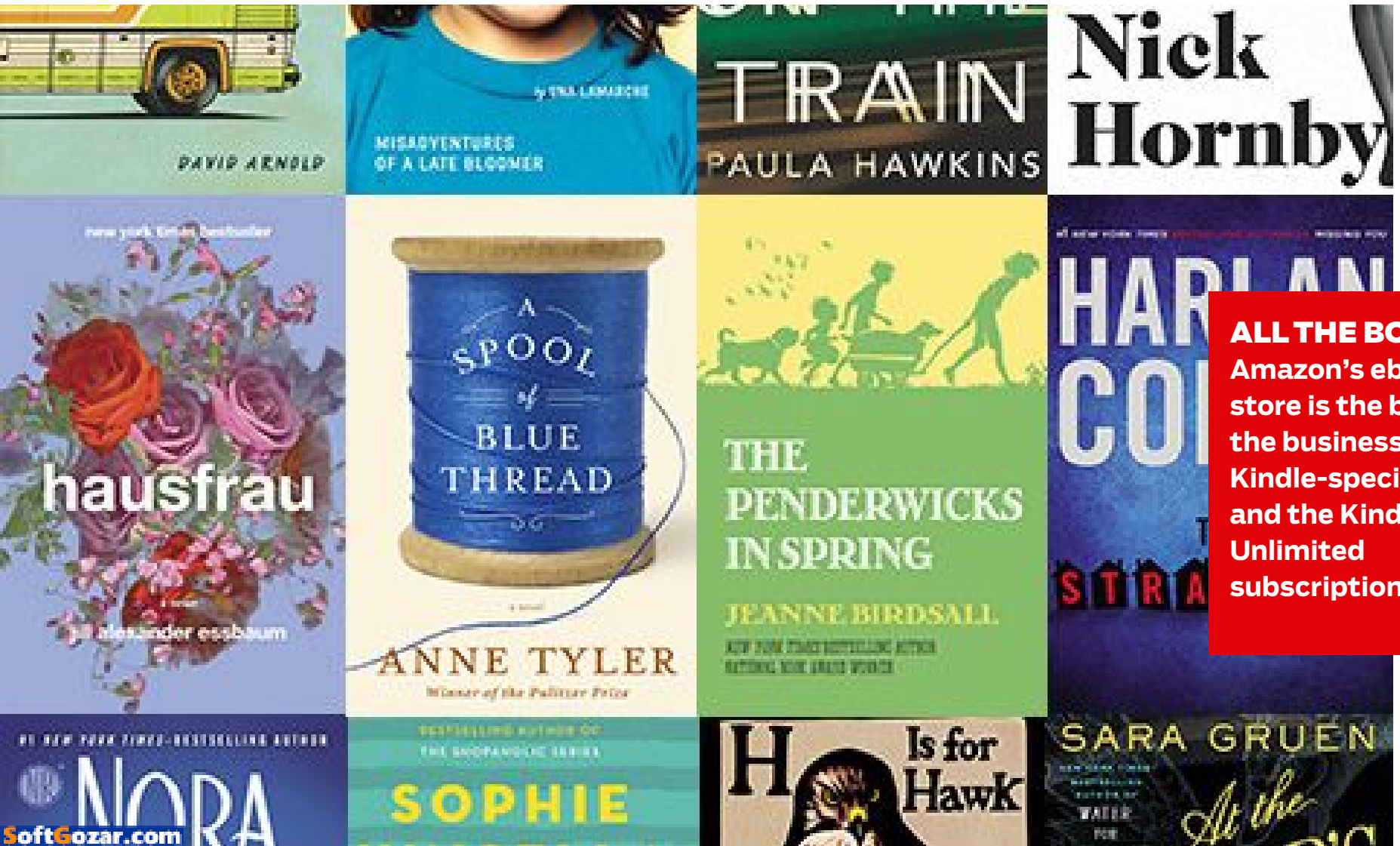
FEATURES AND APP STORE

The Oasis has the same 1GHz processor and 512MB of RAM as the Paperwhite. It connects via 2.4GHz 802.11n Wi-Fi or to AT&T's 3G network to download ebooks to its 4GB of internal storage (which is enough for thousands of titles). It offers no external memory support, but free cloud storage lets you access your ebook collection on any device that can download the Kindle app.

When you turn on the Oasis, you'll see the familiar row of icons at the top of the screen for Home, Back, Brightness (now indicated as a sun icon), Goodreads, Cart, Search, and Menu. Below the toolbar are the covers of three of your recent books, along with options to view your Library, Reading Lists, or Recommendations. Tapping Brightness also reveals Quick Options for Airplane Mode, syncing, more options for Wi-Fi networks, and a battery life indicator for both the Oasis and the charging cover.

If you already own a Kindle, you pretty much know what features to expect—the Oasis doesn't offer a significantly different software experience than any other model. But we'll cover some of the big things.

You can register a Goodreads account while setting up the Oasis; this involves selecting your favorite genres and rating books to better narrow down your preferences. The more titles you rate or add to your Want to Read list, the more are publicly visible on your Goodreads profile, and the better Amazon can tailor recommendations. You can also follow friends, see what other people are reading, and share passages.



ALL THE BOOKS
Amazon's ebook store is the best in the business, with Kindle-specific titles and the Kindle Unlimited subscription service.

Kindle FreeTime lets you create profiles for kids so you can set reading goals for them; it sort of gamifies reading by tracking accomplishments, awarding achievements, and encouraging better reading habits. You can also sign up for FreeTime Unlimited, which starts at $2.99 per month, and gives kids get unlimited access to hundreds of titles specificially curated for age-appropriateness.

Whispersync saves and synchronizes your last pages read across all of your devices and Kindle apps. I started reading Frank Herbert's *Dune* on the Oasis and easily picked up right where I left off on a Samsung Galaxy S6. X-Ray lets you see all of the passages across a book that mention relevant ideas, characters, or other topics of interest. For example, there are 427 mentions of Sirius Black in J.K. Rowling's *Harry Potter and the Prisoner of Azkaban*. About This Book provides further details. And you can link accounts using the Family Library feature, which makes it easier to share books.

The Oasis comes with a new typeface called Ember, but I'm not a fan. It looks like a barely-there Arial font that you'd find in a word processor. Amazon hasn't said whether Ember will be pushed to other Kindle devices, though I suspect it eventually will.

Amazon's ebook store remains the best in the business. In addition to buying books, you can subscribe to magazines and newspapers. Amazon offers a number of Kindle-exclusive titles. And Kindle Unlimited gives you access to more than a million books and thousands of audibooks for $9.99 per month (after a free one-month trial).

The Oasis supports native Kindle formats AZW and AZW3 and also TXT, PDF, MOBI, PRC, HTML, DOC, DOCX, JPEG, GIF, PNG, and BMP files. Still notably absent is EPUB, which limits your Internet and public library sharing options. That said, there are still plenty of ways to get free or cheap new ebooks.

"There's not doubt it's the loveliest Kindle yet, but is it worth the $170 premium over the excellent Paperwhite?"

COVER LINE
The Kindle Oasis comes with a leather cover that contains a lithium ion cell battery that extends the life of the device. You can charge the Oasis and cover simultaneously with the included micro USB cable.

READING AND CONCLUSIONS

Reading on the Oasis is sublime. Simply tap the right or left side of the screen to turn pages, as you would on any other touch-screen Kindle. You can also use the physical Page Turn buttons on the side, which I found to be perfectly situated beneath my thumb. I didn't have to move my hand at all while reading—I could just use my thumb to press both buttons. I flipped through *Dune*, *Prisoner of Azkaban*, and *It* without issue. The Oasis feels even more like an actual book than other readers thanks to its size and the leather cover.

The Amazon Kindle Oasis is the best ebook reader available. It has a brighter screen and longer battery life than any other reader we've tested. The physical buttons make reading even easier, and the built-in accelerometer is a nice touch. But there just isn't enough here to separate the $290 Oasis from the $200 Voyage, or, more important, the $120 Paperwhite. The Paperwhite's screen is just as sharp (if not as bright), it holds just as many books, and aside from the Page Turn buttons, the reading experience is virtually identical. It's still the best pick for the vast majority of readers, and remains our Editors' Choice. Amazon is hoping you will judge the Oasis by its cover, but as the saying goes, you shouldn't.

TIMOTHY TORRES

The Unique Triby Speaker Offers More than Audio

Invoxia Triby

$199

The Invoxia Triby ($199) is a Bluetooth speaker designed for use in the kitchen. It can play Internet radio stations without a connected device, you can write notes on its E Ink screen, and you can even use it to make VoIP calls to family members. It also has the distinction of being the first third-party product to use Amazon's Alexa voice assistant, previously available only on other Amazon products, such as the Echo, the Echo Dot, the Tap, and the Fire TV. The Triby's actual audio performance is mediocre, which makes it hard to justify its high price. But the Triby's unique function as a kitchen communication device makes it worth your consideration.

DESIGN

The Triby doesn't look like a typical speaker, with its display and handle-equipped design. Its metal grille and handle are both white, and a gray rubber cover conceals the rest of the black plastic device. (You can buy the speaker with a blue, green, or red rubber cover for an extra $10.)

The front of the speaker is dominated by the metal grille, with two Call buttons and one extra button in a column on the left, and two Radio buttons and one additional button on the right. A rectangular 2.8-inch E Ink display sits between the two columns. By default it shows the date and time, as well as the temperature and humidity (based on internal sensors). It also shows the current audio source when playing music and will display any message a user sends to the device from the Triby Android and iOS app.

Invoxia Triby

PROS Works with Amazon's Alexa voice assistant. Functional, magnetic design. E Ink screen for leaving notes. Free VoIP calls between Triby group members.

CONS Mediocre, underpowered sound. Not all Alexa functionality is available. Using Alexa drains the battery quickly.

DIGITAL POST-IT
This Bluetooth speaker features an unusual E Ink screen on its front panel that displays notes and images you send via the Triby app.

The top of the Triby is home to the handle, a sturdy, curved metal bar protected by the cover. Play/Pause and Volume Up/Down buttons sit on the top edge of the speaker, directly under the handle. The left side of the Triby holds a bright yellow plastic strip above an Emoji button, which I'll explain below. The right side contains a micro USB port for charging, plus the Setup button.

Finally, two rectangular magnetic strips on the back panel let you stick the speaker on your fridge or any other magnetic surface. They're very strong, so the

Triby can’t be knocked off or even nudged askew without effort. The cover prevents the metal of the magnets underneath from scraping against the surface of whatever you stick the Triby to. It’s not waterproof, however, so you shouldn’t get it wet.

ALEXA

The Triby is designed to be more of an audio assistant than strictly a Bluetooth speaker, putting it more in line with Amazon’s Echo products than with music-focused speakers. Alexa behaves here much the same as on the Echo or the Echo Dot. You can activate it with your voice by saying “Alexa” (or “Amazon” or “Echo,” if you change the wake-up word in the Alexa app), followed by a question or a command. Alexa can tell you the news, time, weather, and sports scores; answer simple questions; play music; set alarms and timers; and more.

KITCHEN MAGNET
Two powerful magnetic strips on the back of the Triby attach it firmly to metal surfaces.

The Triby’s Alexa support is pretty comprehensive, with two key omissions: You can’t access Spotify or Pandora with your voice (which is odd, as the speaker supports Spotify Connect, and you can even save your Spotify playlists to the Radio buttons), and you can’t use the Triby to pair Alexa with a home automation hub or smart lighting device (though you can control them with the Triby if you set them up using another Alexa device first).

To enable Alexa on your Triby, you’ll have to make a pretty big concession. Alexa keeps the Triby’s microphone constantly on so it can hear the wake-up word, which reduces the device’s battery life from an estimated two weeks to two days. If you keep the Triby on a counter or attached to a surface close to a power outlet or USB port, this isn’t a big deal; otherwise, you’ll have to charge the speaker frequently.

NOTES AND CALLS

The Triby also helps with household communication and information. When you first set it up via the app, you create a Triby group of which you're the administrator. Add the names of family members and friends you'd like to include in your Triby group, then direct them to download the Triby app on their devices and log in. Once they're in, you can all stay in contact with the Triby, using the speaker as an electronic notepad and voice communicator.

You can draw something in the app and post it on the Triby's E Ink screen as

if it were a Post-It or whiteboard note. The display shows the doodle, and the bright yellow plastic strip on the speaker's left side pops out like a flag. Anyone walking by the Triby can press the flag back into the device to show that the message was received, and even toggle through a handful of emojis using the button below it to send a simple, nonverbal response. Because the display isn't a touch screen and the Triby doesn't have many buttons, you can't send text responses to the user, only emojis.

You also have the option of communicating by voice. A free, built-in VoIP system lets you directly call and receive calls from users in your Triby group. The two Phone buttons can be assigned to individual members of your group through the app, and the two additional buttons under the Phone and Radio buttons can be assigned to additional users, or used to scroll through the list of users in your group. Voice quality on these calls is good, and you can call to or from the Triby even when you're not on the same Wi-Fi network.

The Radio buttons can be assigned to any streaming Internet radio station available through the Triby app (a large list, similar to the selection you'd find in an app like TuneIn, organized by country). Spotify users can also save playlists by holding down one of the Radio buttons for two seconds while the playlist is playing.

AUDIO PERFORMANCE AND CONCLUSIONS

You can find some excellent-sounding Bluetooth speakers for around $200. Unfortunately, the Triby isn't one of them. It distorted horribly on our bass test track, The Knife's "Silent Shout," as soon as I pushed the volume level past two-thirds. Of course, you probably shouldn't expect thumping club beats from a device stuck to your refrigerator door.

The Triby sounds better with less-bass-focused tracks, but never particularly big or powerful. The low, ominous bass line in Nick Cave and the Bad Seeds' "Red Right Hand" was almost nonexistent on the Triby, and Cave's deep, creepy voice lost much of its impact. The higher contours of his vocals and the bright keyboard notes came through clearly, but this song really needs some presence in the lows to sound appropriately menacing.

More upbeat, synthy music sounds better. Erasure's "Chains of Love," a song with little in the way of low end, came through crisp and clear, with the bright, tenor vocals and cheery pop beat getting all the presence they needed. This is clearly a speaker intended for listening to the radio or jazz while cooking, rather than driving a party.

If we were judging the Triby simply as a Bluetooth speaker, it would be a poor choice in this price range. But it's much more than a Bluetooth speaker, and it offers some interesting, useful features that simply can't be found in any other device. The E Ink display, voice calling, and Alexa support make the Triby a handy companion for the kitchen and an easy way to get in touch with your family while you're whipping up dinner.

If you just want Alexa alone with much better audio performance, the Amazon Echo is the clear winner—it doesn't stick to your fridge, but it costs $20 less. If you'd prefer to spend much less on a similar device, the Amazon Echo Dot is about on a par with the Triby sound-wise, is designed purely for providing Alexa access, and pairs with your existing Bluetooth speaker. If you're just looking for music, the Nyne Edge ($89.95) and the JBL Flip3 ($99.95) offer solid, splash-resistant performance for half the price of the Triby, and are ideal for setting on the counter while you cook.

WILL GREENWALD

Radon A22 Smart Carry-On Is Stylish, Too

Raden A22 Carry
$295
●●●●○

Raden's carry-on bag doesn't quite look like a giant iPhone, but it definitely takes inspiration from one. The A22 Carry is the most stylish hard-sided smart suitcase we've seen, delivering both a minimalist design and maximum capacity. The software features are a nice plus, but they could use an upgrade.

PHYSICAL FEATURES AND CARRYING CAPACITY

Raden's smart suitcase line comes in two sizes: the $295 A22 carry-on we tested, and the $395 A28 checked bag. The basic case is a big polycarbonate shell. It isn't entirely rigid—it'll bend when sat or stood on—but it won't break.

LET IT RAIN
The water-resistant flap around the edge of the zipper kept H^2O out of the case in almost all conditions, except for a slight amount during a heavy downpour. It did a better job of defeating watery incursion than competing bags.

Unlike tech-centric carry-ons we've seen from Hedgren and Bluesmart, the A22 has no easy-access outer pocket for your laptop or travel documents; it's one big egg with a long zipper that goes around the edge. The zipper has a water-resistant flap. Light rain didn't leak into the bag, although it created some condensation on the inside of the zipper flap. A little bit of a heavy downpour managed to get in, but less than with competing bags, and even that didn't damage the USB charging ports on the back of the bag, which worked just fine once they dried out. At the top is a TSA-friendly combination lock, which is easy to set but not app-enabled the way Bluesmart's is.

On the back, behind the handle, are two full-size USB ports for charging your gadgets and a micro USB port for charging the case's internal 7,800mAh battery. A single LED flashes white or blue depending on the case's pairing status.

The case has a dual-extension aluminum handle and four spinner wheels. It doesn't slide as effortlessly as the Hedgren, but I'm okay with that, as the Hedgren tended to float away on slick floors. The A22 comes in eight colors; I'd say don't get the white, as smooth white cases get marked up very easily (as mine did after just one trip in a checked baggage hold).

Raden A22 Carry

PROS Attractive design. Plenty of carrying capacity. Water resistant. Built-in battery, luggage scale.

CONS Buggy, iOS-only software. Location features rely on other Raden owners being nearby.

I packed the A22 for a week's business trip with room to spare, something I wasn't able to do with either the Hedgren Boarding S or the Genius Pack. It's a little bit larger and heavier than those bags: At 22 by 14 by 8 inches (HWD) and 7.5 pounds, the A22 fits all U.S. airline maximum size requirements but slightly exceeds some European ones. The little bit of extra room really pays off, though.

Inside are some nicely segregated fabric compartments. The two halves of the suitcase each has a fabric cover that keeps things in place, and there's a second pouch on the right-hand side. The case has no compression straps, but the all-the-way-around zippered compartment did just fine at containing my pants and jacket. Under another layer on the right side is the 7,800mAh battery, which is completely removable. You can take it with you to charge your gadgets on the go, which is a nice touch.

The battery is completely removable. You can take it with you to charge your gadgets on the go, which is a nice touch.

ROOM TO GO
The fabric-covered compartments are spacious enough to hold supplies for a weeklong trip and even to bring back a few souvenirs.

The A22 also comes with two really nice fabric bags: One is for dirty laundry and one contains an amenities kit with a sleep mask, a USB cable, and earplugs, but it's also perfect for holding your toothbrush and toothpaste. I found the laundry bag a superior alternative to Genius Pack's dedicated laundry pocket for segregating my dirty and clean clothes.

The battery didn't cause any security problems at a LaGuardia Airport carry-on checkpoint, and it didn't get extra scrutiny from the TSA as checked luggage on the way back. When a five-hour plane ride drove my phone's battery down to 35 percent before a long string of meetings, I was happy to use the A22 to recharge it on the 40-minute train ride up from the airport to Seattle—although at 1.2 amps, the battery isn't a quick-charging unit.

HOW SMART IS IT?

So far, Raden and Bluesmart are the only carry-ons we've seen with dedicated apps that work with built-in hardware. Raden's app is iOS-only, which is one strike against it, though Raden says it's working on an Android version. For now, it has three primary features. You can check the case's battery status, lift the handle to weigh the case (which is really convenient), and use Bluetooth location or Crowd GPS to find your case.

The locator initially tells you if your case is right nearby, if it's farther than about 10 feet away, or if it isn't visible to Bluetooth at all, which means beyond 30 feet. If your case isn't in sight, the Crowd GPS function should tell you if it's been detected by anyone else with a Raden app, anywhere else in the world. But few enough people own Raden cases right now that it didn't work for me.

Raden's approach is fine if you're worried about leaving your case at the airport pizzeria, but Bluesmart's GPS-based tracking is better for finding genuinely lost luggage.

Also, the app was buggy in testing. The UI was sluggish on the iPhone 5 I was using, and the app became unpaired from the A22 when I rebooted the phone at the airport, only re-pairing when I checked it again a few hours later. It's sure to get better with time; Raden acknowledged the pairing issue and said the

APP SMARTS
Raden's app works directlywith built-in hardware, but it's iOS-only for now and was slightly buggy when we tested.

company is working on it. And unlike with Bluesmart, the internal electronics are removable and upgradeable with time.

> **With the app, you can check the case's battery status and lift the handle to weigh the case, which is really convenient.**

CONCLUSIONS

At $295, Raden charges $100 less than Bluesmart does for a smart suitcase, so its price is safely within Samsonite territory. Of course, you can roll your own solution with a $100-to-$150 carry-on bag, a $25 backup battery, a $25 Tile Bluetooth locator, a $15 set of TSA locks, and a $10 portable luggage scale, but the cost of saving money means you'll have a lot of little pieces to carry around.

The Bluesmart bag offers more power and more flexibility: Its built-in battery is bigger, it has an Android app, and it does true GPS tracking. The Raden is lighter and better balanced than the Bluesmart, however, which tends to tip forward when you're pushing it on all four wheels. The cases have similar capacity overall, although the Bluesmart has a front laptop pocket.

The smart features here are a little bit of luxury, and not quite enough to make the Raden A22 an Editors' Choice. But I'm nitpicking, and the battery and built-in scale are defiitely nice extras to have. If the case's design appeals to you, you won't be disappointed when you take it on a trip.

SASCHA SEGAN

The 2016 MacBook Has Plenty to Like

Apple MacBook

$1,599 (as tested)

●●●◐○

The MacBook is Apple's thinnest and lightest laptop, though in the year since its original release, Windows systems have caught up in design and features. This MacBook keeps the original's slim profile thanks to a fanless design, and the Retina display remains, but it now has a Skylake-based Intel Core m5 processor with improved performance. Though there's plenty to like here, drawbacks include a limited I/O port selection and a sleek but shallow keyboard and trackpad that some might find uncomfortable. It measures up well against the Dell XPS 13 Touch, our top high-end ultraportable, but ultimately falls short in overall features and value.

DESIGN AND FEATURES

The aluminum laptop is now available in four colors including gold, silver, Space Gray (like our review unit), and Rose Gold (a metallic pink, which is the newest addition). Physically, not a lot has changed from last year's model. At 0.52 by 11.04 by 7.74 inches (HWD), the MacBook weighs 1.99 pounds, an imperceptible increase of less than an ounce. It fits easily in backpacks and shoulder bags made for 10-inch tablets or 13-inch laptops. To compare, the Lenovo LaVie Z HZ550 is a bit larger but lighter at 1.87 pounds, and the LG gram-14Z950 is larger and a tiny bit heavier at 2.08 pounds. HP's upcoming Spectre is thinner (0.41 inch), but it's heavier at 2.45 pounds. The MacBook should be on your short list if you often find yourself in coach class working on an airline tray table.

Apple MacBook

PROS Gorgeous, thin build. Weighs less than 2 pounds. Retina display. Long battery life. Available in four colors. Excellent-sounding speakers.

CONS Limited connectivity. No USB Type-C adapters included. USB Type-C not Thunderbolt-compatible. Shallow keyboard and trackpad take some getting used to. Internal upgrades can be made only at initial purchase.

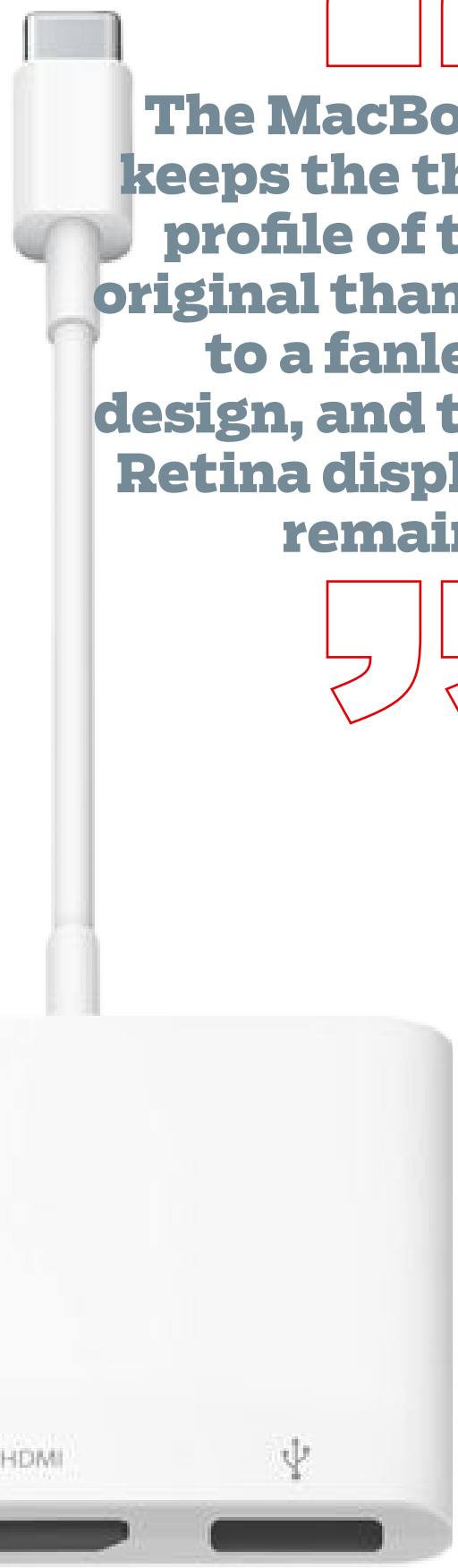
Also unchanged are the butterfly-switch keyboard and Force Touch trackpad. Both are less comfortable than traditional laptop keyboards and trackpads, as the keys offer very little travel, and the trackpad doesn't move at all. Haptic feedback vibrations on the trackpad make it feel as though you've clicked, and the sensor can detect pressure, so if you press a little harder, the

LAPTOP OF MANY COLORS
The 2016 MacBook comes four colors, including Rose Gold; other than that new hue, it's visibly unchanged from last year's model.

trackpad will click a second time and activate the Force Click function. In practice, it does feel like two separate physical clicks. You can use the trackpad's pressure sensitivity for signing your name on the trackpad, or to vary fast-forward or zoom speeds in programs such as QuickTime Player and Apple Maps. The shallow but clicky keyboard is tolerable for extended typing sessions, but traditional keyboards are more forgiving on your fingertips.

USB Type-C adoption has improved since the MacBook was introduced last year. You'll find the compact, unidirectional port on some phones, tablets, and Windows laptops, including the Dell XPS 13 Touch and Razer Blade Stealth. Apple now offers a USB Type-C–to–Lightning cable, so you can sync your iPhone to your MacBook. But because there's still only one port on the laptop, you'll have to unplug the AC adapter to do so. You'll also need a similar cable to connect to USB 3.0 peripherals such as external solid-state drives (SSDs) or flash drives, and for DisplayPort or Ethernet connections. None of these cables is included with the MacBook, though many are available from third-party companies including Belkin and Monoprice. Competing systems such as the XPS 13 Touch and LG Gram-14Z950 have old-style USB ports and thus don't need adapters. The 13-inch MacBook Air and MacBook Pro with Retina Display have USB 3.0 and Thunderbolt 2 ports but lack USB Type-C. They're also heavier and larger. If you're considering a MacBook, you'll have to decide if the sleek design is worth the inconvenience of the single port and required adapters.

Also disappointing is that Thunderbolt 3 support still isn't built into the MacBook. That means you won't be able to use your legacy Thunderbolt and Thunderbolt 2



"The MacBook keeps the thin profile of the original thanks to a fanless design, and the Retina display remains."

ACCESSORIZE
The USB-C Digital AV Multiport Adapter lets you connect the MacBook to an HDMI display, a USB device, and a USB Type-C charging cable.

drives, even if an adapter is available. New Thunderbolt 3 drives that are just coming to market are also a no-go. The only other physical port on the laptop is a 3.5mm headset jack on the left side. For wireless connectivity, the MacBook integrates 802.11ac Wi-Fi and Bluetooth 4.0.

The 12-inch IPS screen is a bright point. Its 2,304-by-1,440 resolution falls short of 4K (3,180 by 2,160), which you'll find on systems including the Razer Blade Stealth and Toshiba Satellite Radius 12 P25W-C2300-4K, but text and graphics are displayed smoothly, with sharp outlines and vivid detail. Full-HD (1080p) and scaled-down 4K videos looked excellent and played back without a hint of stutter in my testing. The speakers, located just above the keyboard, are loud and clear, which is rare in such a thin system.

Inside is 8GB of memory and a 512GB flash storage module. (The $1,299 model comes with 256GB flash storage and a slightly slower Intel Core m3 processor.) The MacBook's storage, memory, and CPU aren't upgradable after purchase, so you'll want to think in terms of future-proofing. If you can afford the $1,599 model, it's the one we'd recommend. The XPS 13 Touch and Microsoft Surface Book come with half the storage (256GB) but the same amount of system memory as the MacBook. Apple covers the system with a one-year standard warranty.

PERFORMANCE

An upgraded Intel Core m5-6Y54 processor with integrated Intel HD Graphics 515 powers the laptop and helps maintain its thin profile. The Core m5 processor is cooled without a fan, allowing the remaining space inside the chassis to be filled with more battery packs. As we continue to test more Core M–equipped laptops and tablets, we're seeing that they perform almost but not quite as fast as Intel Core i5–powered systems.

COOL AND T HIN
Apple is able to keep the thin profile of the MacBook thanks to fanless cooling. It weighs just 1.99 pounds, less than an ounce more than its predecessor.

Mac laptops can't run our PCMark and 3DMark benchmarks, so we couldn't compare those scores with PC counterparts. The system took 2 minutes 55 seconds to complete the Handbrake video encoder test and 5:17 for the Adobe Photoshop CS6 test. That's an improvement over last year's MacBook (3:39 on Handbrake, 5:24 on CS6), but systems with Core i5 processors such as the 13-inch MacBook Pro with Retina display, XPS 13 Touch, and Surface Book were significantly faster. The MacBook is fast enough to run these apps, though I'd rather have a thicker, beefier system with a Core i5 or i7 processor for editing photos and videos on a tight deadline.

Likewise, the new MacBook's 3D scores on the Valley test were better (15 frames per second, or fps, on Medium quality, and 6fps on High quality) than last year's model (9fps and 4fps respectively), which shows the improvement of Intel HD Graphics 515 over the older HD Graphics 5300. To compare, the Surface Book and Satellite Radius 12 P25W-C2300-4K returned almost playable frame rates (25fps at medium quality). In all the systems we've tested, integrated graphics haven't returned playable frame rates at the highest settings for any system with a screen resolution of 1,920 by 1,080 or higher. The MacBook might be able to run games with simpler graphics, like Dota 2 or Minecraft, but more taxing titles, such as Call of Duty: Black Ops and Sleeping Dogs, are likely to be frustrating at any detail level.

Recent Macs have been battery champs, and the new MacBook is no exception, returning an excellent 11 hours, 37 minutes, on our rundown test. That's 27 minutes longer than the MacBook Pro, and more than 2.5 hours longer than the XPS 13 Touch. The larger body and dual battery packs in the Surface Book helped it keep going for more than 15 hours, and thanks to its slower processor, the previous MacBook lasted an exceptional 14:10.

“I'd rather have a thicker, beefier system with a Core i5 or i7 processor for editing photos and videos on a tight deadline.”

CONCLUSION

Aside from the Rose Gold option, the new MacBook is visibly unchanged from last year's model, though its Skylake-based processor improves benchmark performance a bit. Battery life takes a hit due to that faster CPU, though. You can't deny the sleek design, but connectivity compromises you'll have to make may be deal breakers, particularly the single USB Type-C port and shallow keyboard. If these drawbacks are show-stoppers, and you still want an Apple laptop, the 13-inch MacBook Pro, though not as slim, offers more versatile connectivity and will likely be a better choice. In the end, the Dell XPS 13 Touch has a higher-resolution 3,200-by-1,800-pixel display, a more comfortable keyboard, USB Type-C with Thunderbolt 3, and additional ports, and it costs $150 less, so it remains our Editors' Choice for high-end ultraportable laptops.

JOEL SANTO DOMINGO

A Slender and Sturdy Laptop for Business Users

PC MAGAZINE EDITORS' CHOICE

With its slick and slim design, Lenovo's fourth-generation ThinkPad X1 Carbon is the kind of business laptop you'll gladly show off around the office. It retains the features we like, including a thin yet sturdy carbon fiber and magnesium construction, a good selection of I/O ports, and that excellent ThinkPad keyboard. On top of this, it's faster, has a higher-resolution screen, packs a longer-lasting battery, and is half a pound lighter than last year's model. Although this latest laptop lacks a touch screen, it does ring up for $300 less—and that makes a big difference.

Lenovo ThinkPad X1 Carbon

$1,533.60

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DESIGN AND FEATURES

The laptop's carbon fiber and magnesium body is thin, strong, and exceptionally light at 0.65 by 13.1 by 9.0 inches (HWD) and 2.54 pounds. That's thinner and lighter than last year's touch-enabled X1 Carbon, though the depth and width are about the same. It's also lighter (but larger) than ultraportable competitors including the HP EliteBook Folio 1020 and Apple's 13-inch MacBook Air. Granted, the latter two systems have smaller screens. There's no flex in any panel, which makes the laptop feel luxurious and durable.

Lenovo ThinkPad X1 Carbon

PROS Lightweight for a 14-inch laptop. 2,560-by-1,440 IPS display. Dual pointing devices. Long battery life. Comfortable keyboard. Durable. Three-year warranty.

CONS Lacks USB Type-C. New docking system. Ethernet requires dongle.

AN EASY LIFT
The system's carbon fiber and magnesium body is thin, strong, and exceptionally light. And it weighs in at just 2.54 pounds.

The keyboard is spill-resistant, and the system's hardy frame has been certified for several MIL-STD 801G tests, including high humidity, low and high temperature, blowing sand, vibration, mechanical shock, high altitude, and temperature shock. It's also been subjected to and passed Lenovo's tests for durability, drops, and electrostatic shock. Surviving a daily train commute should be a breeze.

The 14-inch screen has a 2,560 by 1,440 (WQHD+) resolution, with far more room than the 1080p HD you get on most mainstream laptops. The extra space can come in handy for viewing large spreadsheets or wide Web layouts. Vibrant colors and details in photos and high-resolution videos look gorgeous on the IPS display, even with the antiglare coating. In comparison, the HP EliteBook 745 G3 has a much duller display. Viewing angles on the Carbon X1 are excellent; this is a good thing, as the screen rotates to 180 degrees, so you can lay the laptop flat on your work surface. This makes the laptop ideal for showing small presentations, say, in a board meeting.

The backlit keyboard is among the best I've felt in my 15 years of reviewing laptops. Each chiclet-style key is full size and has a solid feel and key travel that's just right. The keys are shaped with a slight curve that makes the prospect of a long typing session much more attractive than if you were using the comparatively sparse keyboard on the Apple MacBook or the flappy add-on keyboard case on the Microsoft Surface Pro 4.

Vibrant colors and details in photos and high-res videos look gorgeous on the IPS display, even with antiglare coating.

A KEEPER KEYBOARD
The Lenovo ThinkPad Carbon X1's backlit keyboard feels like one of the best keyboards on a laptop—period.

It may seem like a 1990s throwback, but the pencil-eraser-shaped Lenovo TrackPoint controller is a feature some business users can't live without. It can be used concurrently with or in place of the one-piece TrackPad below the keyboard. Two physical mouse buttons and a scroll button sit between the TrackPad and the space bar. There's a biometric fingerprint reader on the right side of the palm rest that dovetails with the system's TPM chip and enterprise-class security.

Connectivity is excellent on this laptop. On the left side is the system's Power jack, OneLink+ docking port, a Mini DisplayPort jack, and a USB 3.0 port with always-on charging capabilities. On the right is a headset jack, two more USB 3.0 ports, and an HDMI port. Surprisingly for such a slim system, a hidden micro SD card slot and a SIM card slot for the optional 4G LTE modem are on the back of the laptop. (Our review unit did not have the modem installed.) OneLink+ may be a problem for veteran ThinkPad owners who currently use OneLink docks, because an adapter cable is necessary to use the new docking port. One notable omission is Ethernet connectivity, which your business may use to address speed and security concerns. But 802.11ac Wi-Fi and Bluetooth 4.1 are present for wireless connections.

You get 8GB of system memory and a 256GB solid-state drive (SSD) for storage. The drive comes with a few preloaded apps, including Dolby Audio, McAfee LiveSafe, and links to download Microsoft Office. But for the most part, the system is bloatware-free. The battery is sealed, so you can't swap it out for a freshly charged pack on the road—but battery life is excellent, so that shouldn't matter. Lenovo covers the X1 Carbon with a standard three-year warranty.

PERFORMANCE

An Intel Core i5-6300U processor with Intel HD Graphics 520 powers the laptop. Although it requires a fan for cooling, the system is still quite thin for a business laptop. The X1 Carbon's result on the PCMark 8 Work Conventional test (2,733) was above average. The Lenovo ThinkPad T450s and the Core i7–powered Acer TravelMate P645-SG-79QV edged out the X1 Carbon. But the system was faster than last year's X1 Carbon Touch, Dell Latitude 14 5000 Series E5450, and HP EliteBook 745 G3.

Multimedia performance is a lot stronger than you'd expect from a lightweight laptop. The X1 Carbon completed the Handbrake test in a class-leading 2 minutes 27 seconds and topped the CineBench scores with 298. Its time on the Photoshop test (4:29) was just behind the leading Acer Travelmate P645 (4:05), ThinkPad 450s (4:10), and last year's X1 Carbon Touch (4:14). In any case, you'll be able to complete light to moderate photo and video editing easily on the X1 Carbon. As usual for a business laptop, 3D performance is passable for a system with integrated graphics, but you shouldn't be playing games on your work PC anyway.

The system truly qualifies for all-day computing; it lasted 10:13 in our battery rundown test. That's pretty astounding, as last year's model stopped just shy of 9 hours, which is longer than most of the rest of the competition. Only the Apple MacBook (11:37) and MacBook Air (17:36) last longer.

CONCLUSION

Although it's about $100 more than the ThinkPad 450s, the new Lenovo ThinkPad X1 Carbon has a higher-resolution 14-inch screen and a sublime keyboard, it's a pound lighter, and it's covered by a longer warranty. The ThinkPad 450s has slightly better connectivity (Ethernet and VGA), a touch screen, and a removable battery pack. Even so, the X1 Carbon offers more than enough to earn our Editors' Choice award for business laptops.

JOEL SANTO DOMINGO

An SFF Gaming PC with Stellar Graphics, Low Price

PC MAGAZINE EDITORS' CHOICE

The Maingear X-Cube Z170 is a high-end gaming desktop that eschews the traditional PC tower build for a square design. Excellent hardware helps it deliver speedy performance in all areas, but graphics and gaming are where it really shines, matching or beating almost all of the competition for over $2,000 less than our former top pick, the latest Falcon Northwest Tiki.

Maingear X-Cube Z170

$2,930 (as tested)

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DESIGN AND FEATURES

Despite being billed as a SFF (small form factor) desktop, the Maingear X-Cube Z170 has a relatively large footprint, putting it somewhere between a

console-size PC such as the Tiki and a high-end gaming tower. It measures 13.3 by 16.3 by 18.3 inches (HWD), which is quite a bit bulkier than the also-boxy Velocity Micro Raptor Z40 (13 by 7.9 by 12.5 inches). That means you'll still have to make some room for it on the floor or a desk.

The system's Corsair Carbide Series Air 240 case, in black or white brushed aluminum, can be situated either vertically or horizontally, and rubber feet on the bottom can be moved for either orientation. All of the components in the enclosure are neatly and tightly put together, with no cords or drives hanging loose, and a windowed side panel makes them all easily viewable.

The front panel has two USB 3.0 ports, a headphone jack, and the Power and Reset buttons, along with a mesh grille for air circulation. Ports and plugs on the back panel include two USB 3.0 ports, two USB 2.0 ports, one USB Type-C port, three audio jacks, two PS/2 ports, and Ethernet. Video outputs include three DisplayPort, one HDMI, one DVI, and one VGA. The Falcon Northwest Tiki (2015) has several more USB ports, but the selection on the X-Cube Z170 should satisfy most hard-core gamers. It has no Bluetooth or

Maingear X-Cube Z170

PROS Powerful processing, graphics performance. Unique, box-like design. Plenty of cooling. Fast SSD.

CONS Little room for expansion. No wireless, Bluetooth connectivity.

ON THE SIDE
The X-Cube Z170 is built into the Corsair Carbide Air 240 case, which can be situated either vertically or horizontally.

Wi-Fi connectivity on board—you have to rely on Ethernet, which is fine, since most games benefit from its faster connection speeds.

You don't need any tools to access the X-Cube Z170's interior; you can remove the thumbscrews with your fingers. Right behind the glass on the left side is a set of LED lights that shine into the enclosure. Maingear packages a remote control for these, and you can configure the lights' color and behavior (such as strobe and fade). Storage comes by way of a hyper-fast 400GB PCIe-based solid-state drive (SSD) as the boot drive and a 4TB 7,200rpm hard drive for data; that's a generous amount, though the Tiki supplements the same-size boot drive with a 6TB hard drive. The system also has a single Nvidia GeForce GTX 980 Ti discrete graphics card. There's a free slot for one PCI Express x1 slot, so your expansion options for another graphics card are limited, since you'd have to remove the speedy PCIe

"Expansion options for another graphics card are limited, since you'd have to remove the speedy PCIe SSD."

SPEEDY PERFORMANCE
The X-Cube Z170 houses an impressive, hyper-fast 400GB PCI3 SSD and a 4TB, 7,200rpm hard drive.

SSD that the system comes with.

The Intel Core i7-6700K processor on the Asus Z170M-Plus motherboard is cooled by Maingear's Epic 120 closed-loop liquid cooling system, which requires a

radiator at the back of the case. (Three 120mm fans, two at the top and one at the rear, also help ensure good airflow.) Also preinstalled is 16GB of dedicated DDR4 RAM, with two open slots for adding more. As with many smaller desktops, such as the Digital Storm Eclipse, there's not a lot of room for expansion—just one slot that can fit a 2.5- or 3.5-inch SSD or hard drive.

Maingear knows that gamers don't like their systems cluttered with a bunch of preinstalled programs, so aside from Windows 10, there are none to be found on the X-Cube Z170, much like the Maingear Drift. Maingear covers the X-Cube Z170 with a one-year warranty.

PERFORMANCE

With an incredibly fast SSD and its CPU overclocked to 4.5GHz from 4GHz, the X-Cube Z170 is an outstanding performer. It scored near the top on our PCMark 8 Work Conventional test, with a commanding 4,211. Among gaming desktops, that score has been surpassed only by the Maingear Epic Torq (4,241); other top-tier systems, including the Falcon Northwest Tiki (2015) (which scored 3,593), the Origin Chronos (X99) (4,111), and the Maingear Drift (3,668) just couldn't keep up.

The X-Cube Z170 proved to a bit more average on multimedia tasks, though. It finished the Handbrake video encoding test in 52 seconds—that's not a bad time, and it's faster than last year's Maingear Drift (1:53), but the Falcon Northwest Tiki (0:33) and Origin Chronos (X99) (0:32) were both noticeably faster. The X-Cube Z170 finished the Photoshop CS6 test in 2 minutes 20 seconds, just edging out the Epic Torq (2:36), though not by much, and behind the Drift (1:43).

LIGHT MOVES
A set of LEDs on the left side shine into the enclosure. You can configure the color and the behavior of the lights, including strobe and fade.

Its graphics performance helped further distinguish the X-Cube Z170. Its 33,737 result on the 3DMark Cloud Gate test was topped only by the Falcon Northwest Tiki (44,953), and no other system has scored better on Fire Strike Extreme (8,641). The X-Cube's score is similar to that of the Epic Torq (33,911 on Cloud Gate, 8,214 on Fire Strike Extreme); expect both desktops to be able to play graphics-intense games at very high frame rates.

On our gaming tests, the X-Cube Z170 attained 178 frames per second (fps) on Heaven and 130fps on Valley, with the highest detail settings. In both cases, those results were better than those of the Tiki (105fps on Heaven, 112fps on Valley) and the Drift (80fps on Heaven, 90fps on Valley), demonstrating the system's gaming prowess. It beat the current Editors' Choice on both tests with Medium settings, too, reaching 280fps to the Tiki's 230fps on Heaven, and 182fps to the Tiki's 146fps on Valley. The X-Cube is simply a winner when it comes to graphics performance.

"With an incredibly fast SSD and its CPU oveclocked to 4.5GHz from 4GHz, the X-Cube Z170 is an outstanding performer."

CONCLUSION

The Maingear X-Cube Z170 offers plenty of processing power with its Intel Core i7 processor and sports a unique, boxy design. Although it's packed with plenty of great components and cooling, it doesn't leave a whole lot of room for expansion slots—what you see is what you get. But because its graphics capabilities are among the best we've seen in a SFF high-end gaming desktop, and because it runs $2,400 less than the Falcon Northwest Tiki, it's a relative steal and is our new Editors' Choice for the category.

BEN RADDING

The Fastest Video Card Yet: Nvidia GeForce GTX 1080

Nvidia GeForce GTX 1080

$599 (standard) or $699 (Founders Edition)

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PC MAGAZINE EDITORS' CHOICE

The GeForce GTX 1080 is Nvidia's first gamer-oriented video card using its new Pascal architecture—and it's a triumph. It may be bulky and expensive, but it's also the fastest gaming video card we've ever tested, and it's loaded with innovative technologies that could change the graphics game for years to come.

NEW FEATURES AND DESIGN

Nvidia's Pascal GPU not only uses a smaller 16nm process than its predecessor, Maxwell, but it also uses the newer FinFET transistor. By stacking transistors,

Nvidia can pack more into of them into a smaller area than ever before—which typically equals better performance. (This method has been used in NAND storage for a while.) The GTX 1080 sports 7.2 billion transistors, a full two billion more than the previous GTX 980 flagship card, even though the size of the die remains unchanged. Despite this, the thermal design power (TDP) rating for the GTX 1080 is only 15 watts higher (180 versus 165 watts). On top of this, the GTX 1080 requires only one 8-pin PCI Express power connecter; the GTX 980 needed two 6-pin plugs. The FinFET process also makes possible a dramatic increase in possible clock speeds. The GTX 1080's base clock speed is 1.6GHz—up from about 1GHz—and can boost to 1.73GHz under certain conditions. And you shouldn't be surprised to see some cards run faster still.

Nvidia GeForce GTX 1080

PROS Big performance jump over comparable previous-gen cards. Runs cool and quiet. Impressive clock speed and overclockability

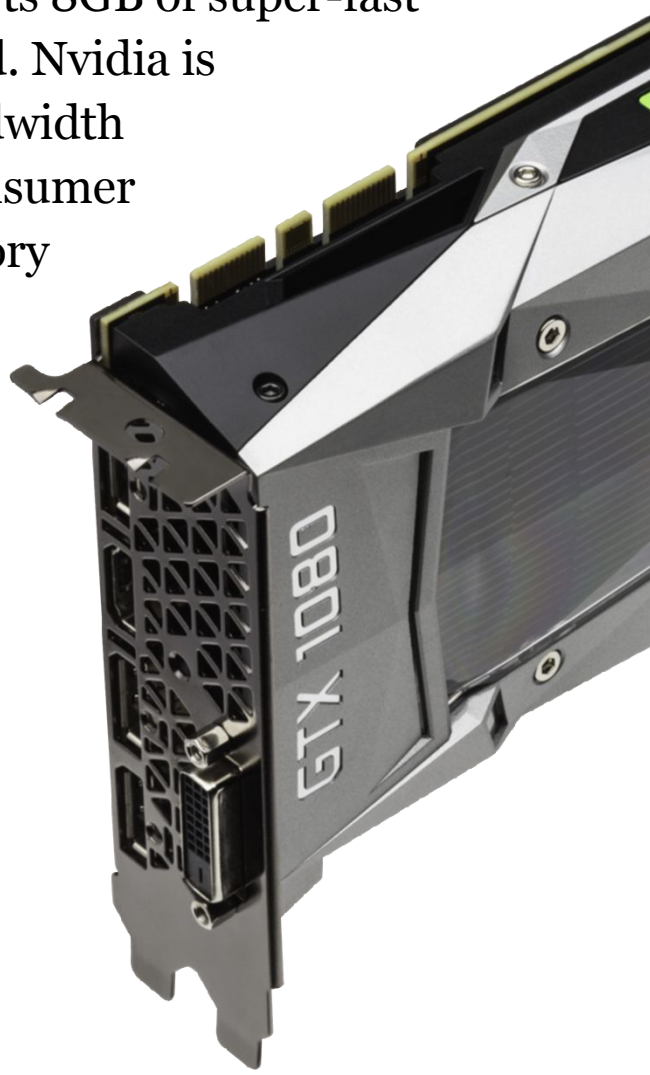
CONS Founder's Edition price bump feels like an early-adopter tax. Competing cards can be physically smaller.

The GTX 1080 features a blower-style design that exhausts heat out of the chassis, which is favored by Nvidia in its stock-card GPU designs. Most, if not all, of Nvidia's partners typically offer card designs with coolers that exhaust heat inside the case as opposed to expelling it from the rear edge. So there is a benefit to Nvidia's blower design, especially for those using it in a cramped or small-form-factor chassis.

MAKING THE MOST OF THE SPACE
Nvidia's Pascal GPU uses a new type of transistor called FinFET: Transistors get stacked in 3D space instead of being laid down side by side.

Nvidia is also introducing a new connector with the GeForce GTX 1080 that doubles the bandwidth available for multiple-card Scalable Link Interface (SLI) configurations. It's named the SLI HB Bridge ("HB" for "high bandwidth") and uses a two-lane configuration, as opposed to the single lane used by the previous connector. The downside to this approach is that the GeForce GTX 1080 natively supports only two cards in SLI, as it uses both connectors on the card. Nvidia states that three- and four-way SLI is theoretically still possible, and can be unlocked by requesting a special "Enthusiast Key," but doesn't recommend doing this. (You can, however, run two cards in SLI and use a third just for PhysX processing.)

Like all previous high-end GeForce cards designed by Nvidia, the GeForce GTX 1080 is a dual-slot card. (A few third-party "beast" GTX 980 Ti cards take up three slots.) The GTX 1080 is 10.5 inches in length, and is exactly the same height, width, and length as the GeForce GTX 980. It sports 8GB of super-fast Micron-made GDDR5X memory—a first in the GPU world. Nvidia is supposed to be switching to Generation 2 of its High Bandwidth Memory (HBM) next year, possibly with an ostensible consumer version of its "Big Pascal" card, which will allow the memory to be placed directly on the die. This will free up a lot of space on the PCB and allow for the GPUs to be a lot shorter, as we saw with AMD's Radeon R9 Fury. But for now, it's business as usual.



Out back, the card has five outputs, including three DisplayPort connectors that are certified for DisplayPort 1.2 but "ready" for the 1.3 and 1.4 upgrades, according to Nvidia. Though DisplayPort 1.2 is sufficient to run a 4K (3,840x2,160) monitor at 60Hz, DisplayPort 1.3 increases the bandwidth on the channel enough to support a 4K monitor at 120Hz, and version 1.4 ups it even more, to handle nascent 8K at 60Hz.

NEW TECHNOLOGIES

Dedicated gamers have been taking very creative screenshots for a while now, but they are, of course, limited by where the camera can go, and the resolution of the images. The Ansel software solves both of these problems by allowing for a free-ranging camera in any game that supports it, and by letting you capture massive high-res screenshots (with a key combination) that you can apply filters to or rotate as you see fit.

Simultaneous Multi Projection (SMP) lets the GPU project into 16 "viewports" simultaneously and in stereo. What this means for the VR world is a massive increase in rendering speed, as the previous generation of cards had to render each eye in sequence. It will also let you game on several monitors at once, and if you run three monitors with the side monitors angled towards you, it's able to reduce the distortion that occurs on objects and more accurately project one image across all three monitors.

Finally, Fast Sync is a new monitor-syncing mode that reduces both tearing and latency in extremely high-frame-rate scenarios, such as intense battle scenes or sports games.

PERFORMANCE AND OVERCLOCKING

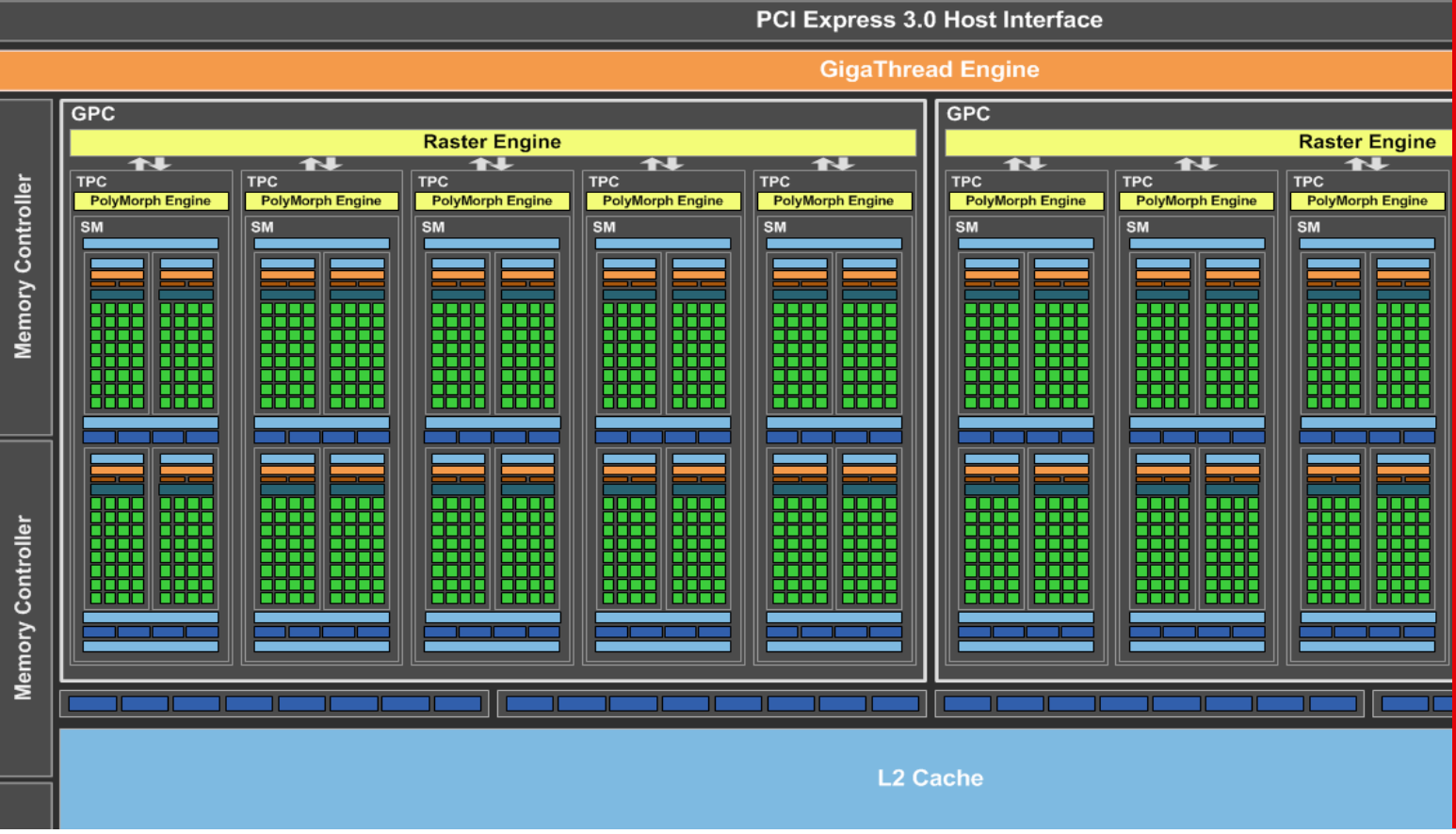
It came as no surprise that the GTX 1080 thoroughly dominated our benchmark testing, at almost every resolution from 1080p to 1440p to 4K (3,840 by 2,160). It bested every other card in 3DMark Fire Strike Ultra, its scores of 4,886 (overall) and 4,942 (graphics subscore) way ahead of those of its nearest competitor, the AMD Radeon R9 Fury X (3,914 and 3,963, respectively). Nothing came close to it on Tomb Raider, BioShock Infinite, Hitman: Absolution, Rise of the Tomb Raider, or on most Sleeping Dogs tests, though the Fury X just barely edged it out (by 2 frames per second, or fps) when the Extreme Graphics Preset test was run at 4K.

Even using the Ultra preset of the punishing Far Cry Primal, which is packed with lush foliage, detailed shadows, and otherwise exquisite detail, it came out on top, with frame rates of 88fps at 1080p (in second place was the GTX 980 Ti, with 78fps) and 41fps at 4K (the runner-up, the Fury X, could manage only 33fps). Even though the new Ashes of the Singularity draws more on the CPU than the GPU, the GTX 1080 was the champ with it, too (38.7fps at 1080p and 35.3fps at 4K, versus 37.3fps and 28.8fps for the 980 Ti).

It's quite remarkable when you consider that compared with the GTX 980 Ti, the GTX 1080 uses 70 watts less power, has fewer CUDA cores, and uses a narrower memory bus (though faster GDDR5 memory). This just goes to show the benefits that moving to a smaller process, refining the architecture, and enabling insane clock speeds can provide.

Only in one game could the Fury X best the GTX 1080: last year's Hitman. AMD's card was speedier at all resolutions (81.4fps versus 68.1fps at 1080, and 78.3fps versus 68.4fps at 1440p), but at 4K, the GTX 1080 was close enough (46.6fps versus 49.3fps) that it was almost a tie.

Because DirectX 12 (DX12) is still in its infancy, it's difficult to use for



PASCAL'S WAGER
This block diagram showing the design of Pascal gives an idea of the scope of the architectural changes that have resulted in the fastest—and most innovative—GPU we've ever seen.

comparisons at this point. But anecdotally, only the GTX 1080 could play Rise of the Tomb Raider at playable frame rates at 4K with DX12 rendering, and the Fury X (our previous DX12 leader) was highly competitive in Hitman, Ashes of the Singularity.

Using a beta version of EVGA's Precision X utility, we were able to push our review card's clock speed up just above 2GHz, which is a threshold unheard of until the GTX 1080. This translated to only minor bumps (3fps to 4fps) in our tests, but it's still impressive. Also of note is that only when we overclocked did we notice any fan noise from the GTX 1080 at all—it wasn't silent, but it was no louder than our CPU cooler.

CONCLUSION

The GeForce GTX 1080 is unquestionably the fastest single GPU in existence at this time, by a wide margin. And those eye-popping speed increases come with outstanding new features that serious gamers will love. Only the price of the premium Founders Edition card gives us pause: $699, versus $599 for the standard version. The GTX 1070, slated for release this summer at a price of $379, might prove a more attractive value. But if you want a high-end card for 4K gaming and VR future-proofing, and can afford the hefty outlay, there's little reason not to plunk your credit card down for this incredible video card.

JOSH NOREM

MU-MIMO, 802.11ac Boost The EA7500 to Excellence

PC MAGAZINE EDITORS' CHOICE

The Linksys EA7500 Max-Stream AC1900 MU-MIMO Gigabit Router represents the company's second foray into the Multi-User Multiple-Input, Multiple-Output (MU-MIMO) router arena. Like its predecessor, the EA8500 Max-Stream AC2600 MU-MIMO Smart Wi-Fi Router, the EA7500 can serve multiple clients simultaneously (rather than sequentially) without bandwidth degradation, though those clients must be equipped with a network adapter that supports the technology in order to take advantage of the increased throughput. That said, the EA7500 has plenty of I/O ports and management settings, and it delivered speedy throughput in our 2.4GHz, 5GHz, and MU-MIMO tests. It's our top pick for midrange routers.

Linksys EA7500 Max-Stream AC1900 MU-MIMO Gigabit Router

$199.99

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DESIGN AND FEATURES

The EA7500 is a dual-band 802.11ac AC1900 router with a maximum potential bandwidth of 600Mbps on the 2.4GHz band and 1,300Mbps on the 5GHz band. It's powered by a 1.4GHz dual-core Qualcomm processor and uses three detachable antennas for 3×3 data streaming. It can operate in router, bridge, and access point (AP) modes.

Identical in design to Linksys' EA8500 and AC2400 Dual Band Wi-Fi Router, the EA7500 measures 2.2 by 10.1 by 7.2 inches (HWD) and has a black finish and a backlit Linksys logo that is solid when the router is connected and flashes when there is a connection error. Other than the Linksys LED, there are no indicator lights on the front of this router. Around back are four Gigabit Ethernet ports, a WAN (Internet) port, a USB 3.0 port, and a USB 2.0 port, in addition to a reset button, a WPS button, and a Power switch.

The Linksys Smart Wi-Fi Web-based console offers plenty of settings and services for managing your router and clients, or you can use the Smart Wi-Fi Mobile app to control the EA7500 from your smartphone. The Main screen contains a list of Smart Wi-Fi Tools on the left and widgets for commonly used settings on the right. The Tools list features Network Map, Guest Access, Parental Controls, Media Prioritization, Speed Test, and External Storage settings. The Router Settings list includes Connectivity options for Internet and Local Network Settings, Advanced Routing, VLAN, and Basic

Linksys EA7500 Max-Stream AC1900 MU-MIMO Gigabit Router

PROS Speedy throughput in testing. MU-MIMO–enabled. Good port selection. Lots of management options.

CONS Mixed file transfer performance in testing. Pricey.

PLENTY OF PORTS
On the back of the router are four Gigabit Ethernet ports, a WAN port, a USB 3.0 port, and a USB 2.0 port.

Network Name, Password, and Time Zone settings. The Wireless settings screen is where you go to select a security mode (WEP, WPA, or WPA2/Personal/Enterprise/Mixed), enable MAC filtering, and create access schedules. Security options include Firewall, Internet Filtering, VPN Passthrough, and Port Forwarding, and there's a Troubleshooting screen where you can view DHCP client tables and resolve router-settings issues.

INSTALLATION AND PERFORMANCE

Installing the EA7500 is quick and easy. Once it's plugged in, enter linksyssmartwifi.com in your browser's address bar to launch the Welcome Page. From there, you have the option of using the Setup utility to configure the router, or you can do it manually. Setup analyzes your connections and walks you through the initial wireless settings (SSID and security) and router-password procedures. When setup is finished, you can create a free Smart Wi-Fi account to control your router and your home network from anywhere using a mobile app.

The EA7500 turned in impressive results in our 2.4GHz throughput tests.Its 97.3Mbps on the close-proximity (same-room) test was slightly faster than the 90Mbps of the Asus RT-AC68U Dual-Band Wireless-AC1900 Gigabit Router and the 95.9Mbps of the Synology RT1900ac , and a good deal faster than the Tenda AC1900 Wireless Dual Band Router AC15's 53.4Mbps. On the 30-foot test, it attained 52.1Mbps, beating the Synology Router RT1900ac (45.6Mbps) and the Tenda AC1900 AC15 (27.1Mbps) but not the Asus RT-AC68U (81.9Mbps).

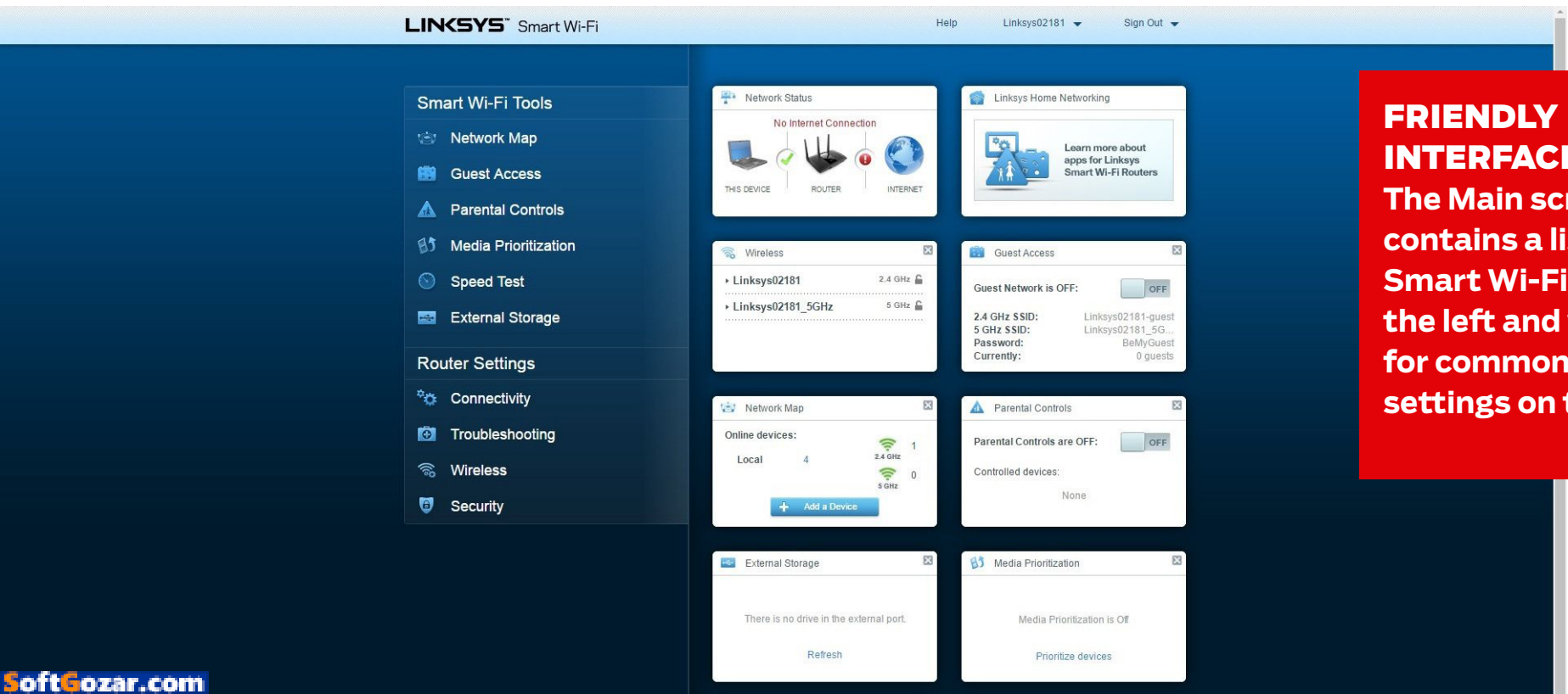
Performance was also very good in our 5GHz tests. On the close-proximity test, the EA7500 achieved 495Mbps, topping the Synology RT1900ac (479Mbps), the Asus RT-AC68U (290.5Mbps), and the Tenda AC1900 AC15 (304Mbps). The D-Link AC3200 Ultra

"The EA7500 can serve multiple clients simultaneously (rather than sequentially) with no bandwidth degradation."

Wi-Fi Router DIR-890L/R remains our all-time leader with a score of 558Mbps, but it is a much more expensive and powerful router. With its result of 298Mbps on our 30-foot test, the EA7500 was a tad slower than the Asus RT-AC68U (305Mbps) but much faster than the Tenda AC1900 AC15 (115Mbps) and the Synology RT1900ac (231Mbps).

To test MU-MIMO performance, we use three identical Acer Aspire E15 laptops equipped with Qualcomm Atheros QCA9377 wireless 802.11ac network adapters as the clients and an Intel Core i7–equipped desktop PC as the server. In our close-proximity MU-MIMO test, the EA7500 provided an average speed of 176Mbps to the three clients, surpassing the ASRock G10 AC2600 Gaming Router (148Mbps) and the Amped Wireless Athena RTA2600 (148.6Mbps) but not the Netgear Nighthawk X4S Smart Wi-Fi Router R7800 (210Mbps). Results were similar on the 30-foot MU-MIMO tests: The EA7500's speed was 81.2Mbps, trailing the Netgear Nighthawk X4S's 94.3Mbps, but faster than the ASRock G10's 48.6Mbps and the Amped Wireless Athena High Power AC2600 Wi-Fi Router RTA2600's 54Mbps.

We test a router's file transfer performance by moving a 1.5GB folder containing a mix of music, photo, document, and video files between a wired desktop and a USB drive connected to the router. The EA7500's read speed was 66.7MBps, putting it ahead of the TP-Link AC2600 Wireless Dual Band Router Archer C2600 (34.9MBps) and the Asus RT-AC88U (31.9MBps) but behind the Linksys Smart Wi-Fi Router AC 1900 (80MBps) and the Linksys E8350 (73.8MBps). The EA7500 didn't fare so well on our write tests, either—its speed of 27.8MBps was much slower than its read speed but still comparable to the 27.4MBps of the Asus RT-AC88U Dual-Band Router and the 30.7MBps of the TP-Link Archer C2600 (30.7MBps). The Linksys WRT1900AC had a write speed of 66MBps, and the Linksys EA8350 garnered 35.8MBps.



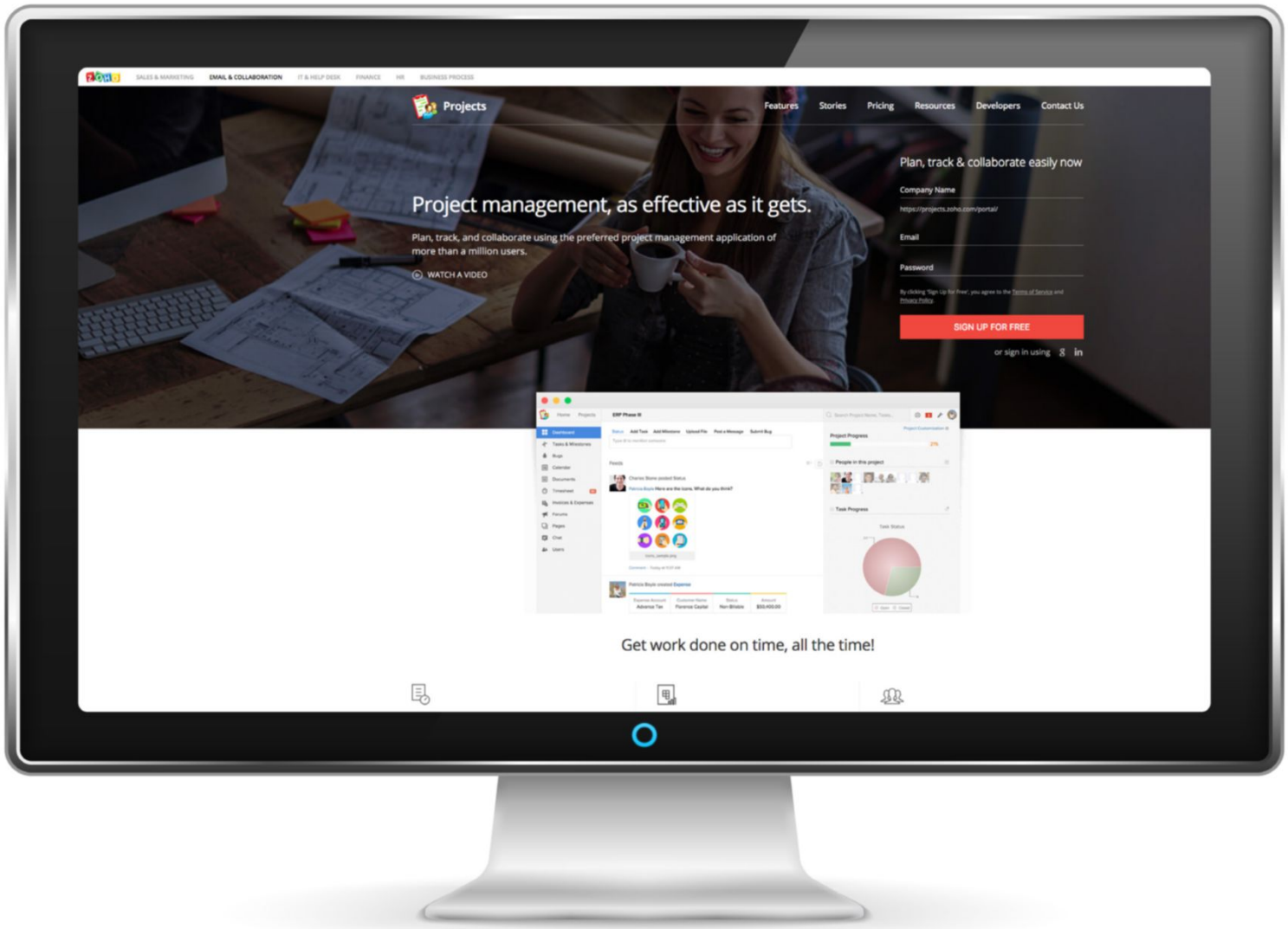
FRIENDLY INTERFACE
The Main screen contains a list of Smart Wi-Fi Tools on the left and widgets for commonly used settings on the right.

QUICK AND EASY INSTALLATION
Once you've plugged in the Linksys EA7500 router, the Setup utility analyzes your connections and walks you through the initial wireless settings (SSID and security) and router-password procedures.

CONCLUSION

The Linksys EA7500 Max-Stream AC1900 MU-MIMO Gigabit Router is an excellent choice if you're looking to bring 802.11ac Wi-Fi and MU-MIMO streaming to your home. At $199.99, it's at the high end of the price spectrum for a midrange AC1900 router, but you get your money's worth in terms of performance and features. It outperformed the Asus RT-AC68U in our close-proximity throughput tests and held its own against more expensive routers in our MU-MIMO throughput tests, and it offers a robust management console. Its strong performance and next-gen technology earn the EA7500 our Editors' Choice award for midrange routers.

JOHN R. DELANEY



Zoho Projects Makes Collaboration a Breeze

Zoho Projects

Free to $799 per year

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PC MAGAZINE EDITORS' CHOICE

Zoho Projects ($50 per month as tested; free option available), with a fresh look and added features, continues to lead the field of project management. It's one of only a few project management services that still offer a free level of service, so you can try it before you upgrade to a version with more features and support. If you buy Zoho Projects, you'll be getting a great product with ample add-on tools and services that allow your account to grow as your business and team grows.

The only other tool that compares in excellence in plan options and value (and also offers a free account) is Teamwork Projects. Both Zoho Projects and Teamwork Projects are Editors' Choice services for online project management.

PRICE AND PLANS

Since 2015, the prices for Zoho Projects' various service tiers have increased slightly, but the paid plans are competitively priced. Zoho Projects' free plan lets people try out the platform at their leisure. With any of Zoho Projects' plans, you can sign up for a free 15-day trial. There are restrictions, of course: You're limited to one project and a meager 10MB of storage space. And you don't get tools for time-tracking, budgeting, invoicing and expensing, recurrences and reminders, subtasks, and task duration, which are included in all the paid service levels.

Paid tiers of Zoho Projects offer a lot more. The Express account ($25 per month or $249 annually) lets you manage 20 projects and comes with 5GB of storage. You get unlimited projects and unlimited users. The Express package limits you to eight project templates, and you can view but not edit Gantt charts. Though Zoho Projects Express is a good deal, very small teams managing five or fewer projects might be better off with Teamwork Projects' Personal plan, which costs only $12 per month.

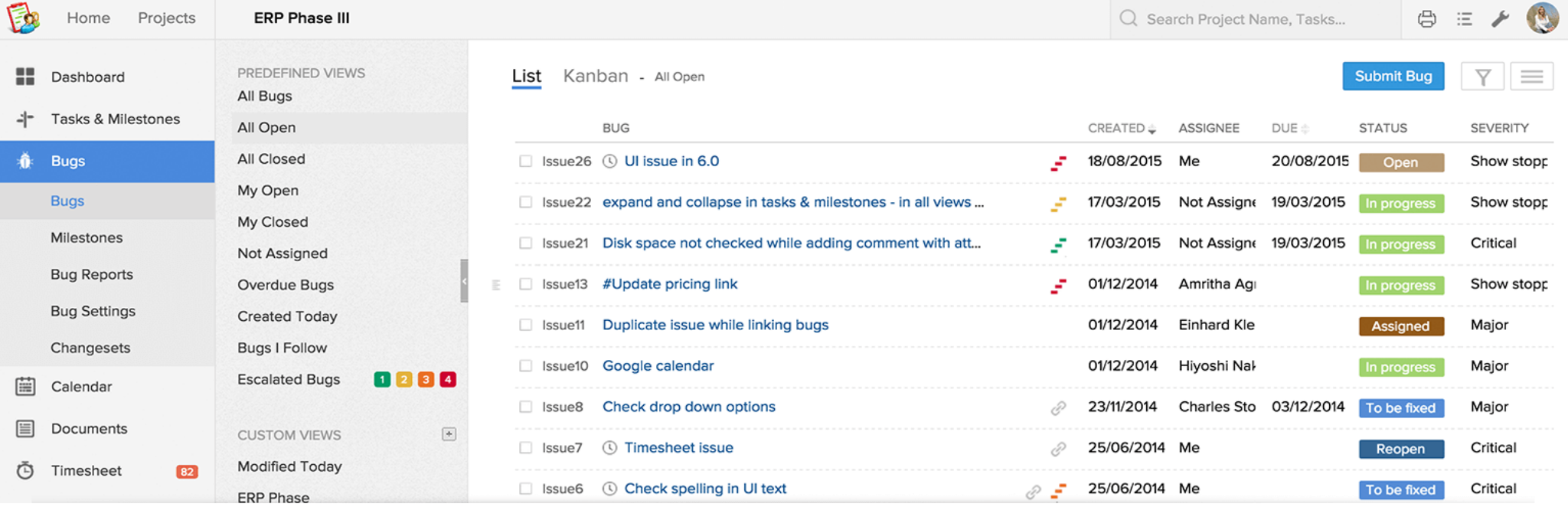
The next tier of service is Zoho Projects Premium ($50 per month or $499 per year). With this plan, you can manage 50 projects when you pay monthly, but you can manage as many as you want in the yearly plan. It includes 15GB of space and 10 project templates. That's close to the same deal you can get with Teamwork Projects, which charges $49 per month for 40 projects and 20GB of space. At the Premium level with Zoho Projects, Pages and Chat work across all projects—you're limited to just one project in the Express tier—and you can edit your Gantt charts (hooray!).

A special bug-tracking feature, which is essential for most teams working on software or interactive Web projects, is included to try out in the free account, but it's an add-on service for Express and Premium users at an additional $25 and $50 per month, respectively. You

Zoho Projects

PROS Feature-rich online project management platform. Includes plenty of integrations with other services. Easy setup and use. Responsive. Good value.

CONS Bug-tracking costs extra. Could support more drag-and-drop functionality.



can import bugs from CSV, XLS, and XLSX formats, as well as from Atlassian JIRA.

I love that with Zoho Projects, no matter the tier of service, you don't pay per user per month. Many other project management platforms charge by the seat. Zoho Projects also offers an Enterprise level of service for $80 per month or $799 annually, although enterprise features are not considered in this review.

CLEAN INTERFACE

The Zoho Projects site has a Facebook-like feed where you can post your status, add tasks and milestones, upload files, and more.

FEATURES AND INTERFACE

The Zoho Projects site has a clean and crisp appearance, and it's intuitive enough to let you figure out the basics of how to use it within a few minutes of creating an account. Two tabs in the upper left, Home and Projects, orient you easily, and a left-side rail serves as the primary navigation. The site has a Facebook-like feel to it, with streams of activity rolling down the page as they happen. The setup is similar to what you'll see in several other popular workplace platforms, such as Podio or Yammer, which are not project-management tools but often include those capabilities. In the feed, you can tell everyone your status, add a task or a milestone, upload a file, or post a general message. Business owners and team leads will appreciate that Zoho Projects prompts people to enable two-factor authentication to help keep accounts safer and more secure.

Setting up projects is simple, with plenty of room to create very complex projects. As you invite other team members to join your project workspace and start adding milestones to your calendar, you'll find the tools you need without having to search. Zoho Projects has a great layout and puts relevant options at your fingertips at the right time. I especially like that you can customize what appears in the right column to see relevant information about your project.

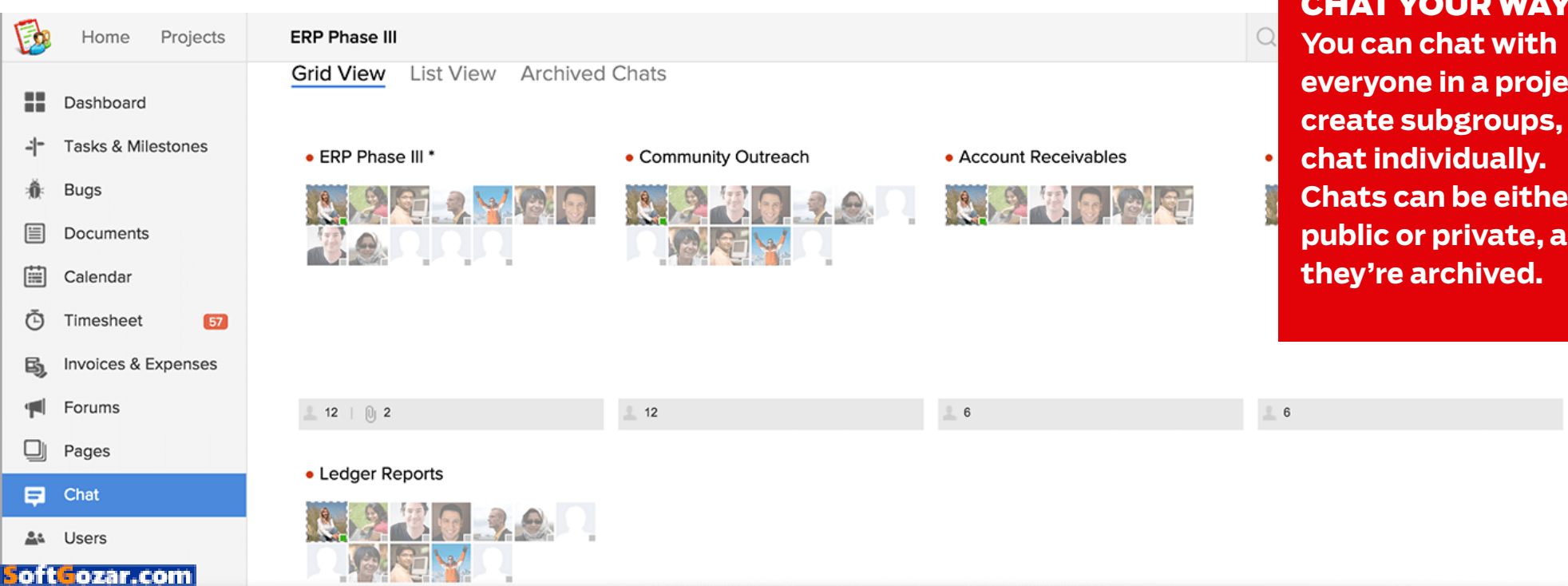
The site is also responsive. Click on a title to change a project name or enter

the number of hours someone has worked on a task, and the app moves in time with you. There's a bit more flipping back and forth from one full page reload to the next than I'd like, but for complex projects and tasks that have a lot of detail associated with them, the system works well. I do wish the site was more interactive, in terms of supporting drag-and-drop capabilities, for instance. I had a hard time figuring out how to create dependencies between tasks.

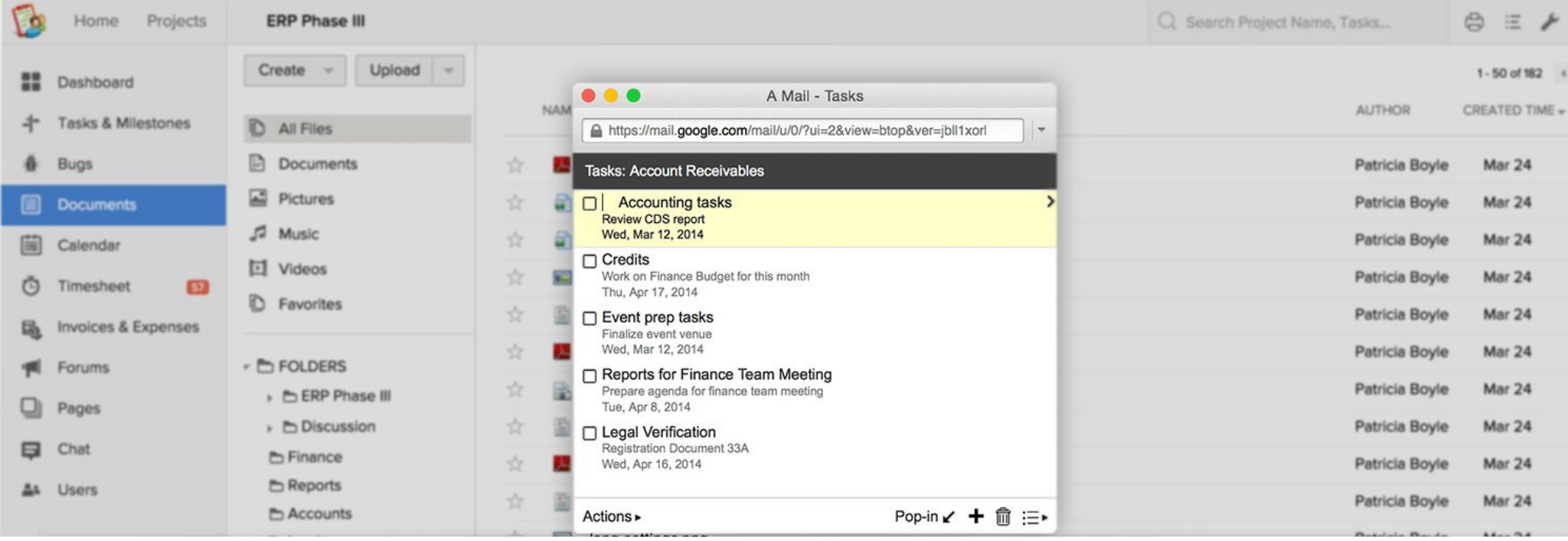
My favorite features in Zoho Projects are the ones related to chat and notifications. A live chat component is built right into the workspace, so you don't have to flip to another app when you need to quickly ask a colleague a question. You can create a chat with multiple people in it and return to the thread as needed. The chat history won't disappear when you log out. Notifications are well implemented: You can open some of them and interact directly from the notification itself. This interaction mechanism lets people reply to or comment on important matters quickly without leaving the screen where they were getting more important work done.

Zoho Projects gives you easy links in that left rail to jump among views. The project calendar, your timesheet, documents, and forums are all reachable with one click. You can also jump to Pages, which is static content where team member or project leaders might put important information that doesn't change frequently.

Tasks and Milestones are now separate entities (they were formerly treated as one). You can reach even more information about your project through them. The Tasks area in particular has some great options for letting you change how you view tasks: Classic, Plain, Dependency, and Kanban. The Task area also opens up the option to see Gantt Charts and Task Reports. Task Reports show how many tasks various people on the project have assigned to them, how many tasks are unassigned, and completion state as a percent.



CHAT YOUR WAY
You can chat with everyone in a project, create subgroups, or chat individually. Chats can be either public or private, and they're archived.



APPS AND INTEGRATIONS

One great aspect of Zoho Projects is that it works with many other apps and services. You can integrate it with Zoho software and services such as Zoho Books or Zoho Invoice to manage budgeting and invoices easily. As mentioned, Zoho Projects also works with Google Apps, meaning you can connect your Zoho Projects account to your Google account to import files directly from Google Drive. You can track high-priority events by exporting them to a Google Calendar. Finally, you can use Gmail to create tasks and record working hours even when you can't log into to your Zoho Projects account.

Dropbox, Box, OneDrive, Evernote, Github, and Bitbucket are all supported as integrated or add-on third-party services, too. It's not an especially long list, but it does cover many of the basics. And for the mobile worker, Zoho Projects is available as an iOS app and an Android app.

CONCLUSION

Zoho Projects packs in more features than many other project management tools, and the free trial gives you enough functionality to test the waters. Its interface has become more streamlined and easier to use than ever before, and it offers the tools teams need to manage projects and puts them into relevant places where anyone can easily find them. It still takes some time to get the hang of Zoho Projects, but not much. Overall, it's an excellent tool and PCMag's Editors' Choice for project management.

JILL DUFFY

Turn Your Everyday Computing Into Virtual Reality

PC MAGAZINE EDITORS' CHOICE

I'm typing this review in virtual reality. I have an Oculus Rift strapped to my head, and I'm staring at a giant text editor on a curved screen floating in front of my face. I can do this thanks to Virtual Desktop ($14.99), an app by Guy Godin. It's a fantastic way to use your VR headset, even if you don't have any VR-specific software for it. The idea behind Virtual Desktop is simple: Take your PC's desktop and project it as a virtual display through your VR headset. This may be an obvious concept, but using the app really shows that possible uses of VR headsets extend far beyond gaming—though you can use it to play non-VR games, as I'll explain.

Virtual Desktop

$14.99

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Valve is planning to tackle the idea in a much more gaming-specific way in SteamVR's upcoming Desktop Theater Mode. And Sony will offer a similar feature for non-VR PlayStation 4 content with PlayStation VR. But Virtual Desktop got here first, at least for PC users who own the HTC Vive or Oculus Rift.

RUNNING VIRTUAL DESKTOP

When you launch Virtual Desktop, which you download from Steam, you're prompted to choose between running it in SteamVR mode or Other VR mode. SteamVR mode activates the SteamVR interface, if it isn't already running, and then runs Virtual Desktop.

Virtual Desktop

PROS Simple, reliable use. Lots of customization options. Supports Windows-based games and media.

CONS Requires additional monitors for multi-screen display. Multiple screens can't be individually positioned and resized.

Choosing Other VR mode simply launches Virtual Desktop through your non-SteamVR headset (which, currently, is only the Oculus Rift until other SteamVR headsets are released). Since the Oculus Rift automatically runs the Oculus VR interface when you use it and can use SteamVR as an additional interface layer, both modes worked perfectly with our test Rift. The software also ran without a problem in SteamVR mode on our HTC Vive.

DESKTOPS IN SPACE

Virtual Desktop's default setting is a curved screen that takes up 115 degrees of your view, displayed as though it were 2 meters away.

After you choose the mode, Virtual Desktop opens to your preferred display settings. The default setting is a curved screen that takes up 115 degrees of your view, displayed as though it were 2 meters away. It also places you in the center of a purple nebula, with pleasant ambient music playing in the background. All these things can be easily changed within the Virtual Desktop settings, which appear in the middle of the screen when you run the software.

DISPLAY OPTIONS

You can choose between a curved or flat screen, adjust the size from 15 to 360 degrees, and set the simulated distance at half a meter to 10 meters. The distance doesn't affect the screen size at all, but rather adjusts the 3D effect to give the impression of it being closer or further away. You can also set the software to display side-by-side 3D (for older and more esoteric head-mounted displays that require manually adjusted video outputs), show a variety of performance charts, and mirror what the headset is seeing to a separate window on the computer's monitor. That last option is handy if you have more than one monitor, but it can produce a dizzying hall-of-mirrors if you look at it from your headset. You can also re-center the virtual screen based on wherever you're physically looking with a button.

Using the Virtual Desktop app really shows that possible uses of VR headsets extend far beyond gaming.

CHOOSE YOUR ENVIRONMENT

Choices include several different starscapes, a grassy hill at sunrise, a photo studio, and a home theater.

The most compelling setting to play with is Environment. The default is the aforementioned purple nebula, a colorful, 360-degree starscape that reminds me of the opening credits to Star Trek: The Next Generation. You can switch this background for two different black-and-reddish starscapes, the rings of a planet, a grassy hill at sunrise, a photo studio, or a home theater. You can also simply turn the backgrounds off and use Virtual Desktop as a screen floating in a sea of blackness.

I found the home-theater background to be the best, and also the most limited. Unlike the other backgrounds, home theater locks the screen at a set distance with a flat geometry. It also puts you in a virtual recliner, staring at this screen as if it were in an actual theater. It's a fantastic effect, though not so good for reading text; I found a closer, curved display to be better for that.

The backgrounds are generally simple photo cubes, with 3D-modeled environments in rarer, more advanced cases. There's also plenty of potential for creating your own or adding new ones through Steam Workshop, thanks to the included Environmental Editor. This is a separate program that you can select when you start Virtual Desktop that can take photo cubes, stereoscopic photo cubes, and 3D models and format them into Virtual Desktop backgrounds.

Virtual Desktop supports multiple monitors, but only with a curved virtual screen. It usually shows just the primary display in VR, but when Multi-Monitor mode is enabled, Virtual Desktop places all connected monitors together in a single, sprawling arc in front of you. I connected a second monitor to our test system, and Virtual Desktop showed both screens in a huge 180-degree wall that wrapped around me. This mode requires actual, physical monitors to be connected to the computer. Ironically, it doesn't support virtual desktops—in this case, meaning additional simulated displays that you could swap out with your main screen.

HOME VIEWING
The home theater background is an excellent effect, though it's limited; it locks the screen at a set distance with a flat geometry.

WHAT YOU CAN DO

Playing games in Virtual Desktop is easy. Any Steam game can be displayed on the virtual screen, though the ease of that will vary. I got Dark Souls 3 to run simply by selecting it in Steam. Broforce, on the other hand, required a visit to Virtual Desktop's Games tab, which exists for precisely this reason. If a game doesn't seem to run properly in Virtual Desktop when you launch it from Steam, just add it manually to a list in Virtual Desktop by selecting its executable. After I did that, Broforce ran just fine in VR.

Besides games, Virtual Desktop supports 360-degree panoramic photos and videos. Drag 360-degree photos onto the app's Photo tab, and load 360-degree videos either directly from your hard drive or by pasting a URL into the Video tab. I loaded and watched IGN VR's simultaneous all-around playback of all six text crawls from the Star Wars and prequel trilogies.

While wearing the Oculus Rift and HTC Vive, I also checked email, kept track of messages in Slack, watched some "Jessica Jones" on Netflix, and, of course, wrote this review. Everything worked perfectly well and gave me a reason to wear the Rift beyond the handful of games and demos available in the Oculus Store and at SteamVR.

A MUST-HAVE FOR VR ADOPTERS

Virtual Desktop is a must-have program for any Rift or Vive owner. It opens up the headsets for use beyond VR-specific apps and games. It's robust and extremely customizable, and it's fun to use, too. Virtual Desktop could use more options with screen generation and placement—for example, support for virtual desktops and monitors and the ability to move and resize multiple screens individually. For $15 software, though, it's an incredibly useful tool to have in your VR toolbox, and it earns an Editors' Choice for VR utilities.

WILL GREENWALD

Features

MAKING THE MOVE TO SMART CITIES

HOW INTEL LOST $10 BILLION—AND THE MOBILE MARKET

Making the Move to Smart Cities

From transportation to pollution to security and beyond, the smart cities of tomorrow will revolutionize everything about how we live.

BY BEN ALGAZE, AARON KRUMINS, AND GRAHAM TEMPLETON

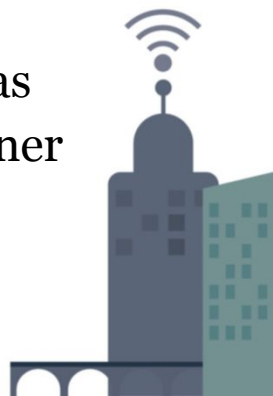
These days, the word "smart" can describe anything with a processor or a sensor and a connection to a network of some sort. You can argue that having some processing power for information and the ability to communicate with something makes a device "smart"—or a lot smarter than it was before. But what exactly does it mean to be a "smart city," or at least a smarter one?

Broadly speaking, it means an information and communication infrastructure (sometimes given the acronym ICT) that lets smart devices (such as smartphones, automobiles, thermostats, and water meters) connect to smart infrastructure (including problem reporting, traffic signals and information, parking systems, the electric grid, and billing systems) to improve quality of life and productivity in cities.

Around the world, cities have grown in importance based on their connections to natural and man-made transportation resources. Harbor cities used to be the hubs of shipping routes for trade, and railroads, highways, and airports made hubs of cities built in the middle of what was once nowhere. In today's information-centric world, upgrading and leveraging the ICT infrastructure will be a vital step in creating solutions to many issues for cities today—and improve overall quality of life.

TRANSPORTATION

The Department of Transportation, with help from Paul Allen's Vulcan Ventures, has sponsored a Smart City Challenge for midsize cities (by population). The finalists are Austin, Texas; Columbus, Ohio; Denver; Kansas City, Missouri; Pittsburgh; Portland, Oregon; and San Francisco, with a winner to be selected later this year. Because it is the DOT, the Smart City vision is



oriented toward transportation issues.

The automobile has heavily influenced American cities that have largely established themselves over the last century. Roads and automobiles changed city planning priorities in urban centers and industrial zones, and created suburbs and exurbs. The advent of smart and connected cars will also influence urban planning. But the ability to connect cars to smart infrastructure will also create new opportunities to do things differently, and ultimately change the way we

THE AUTONOMOUS GOOGLE CAR
The company claims it can detect objects as far as two football fields away, including pedestrians, cyclists, and even rogue birds.

The ability to connect cars to smart infrastructure will also create new opportunities to do things differently.

think about the design and layout of cities.

Although the most publicized car-technology topics are Google's driverless cars and the sophisticated semi-autonomous capabilities demonstrated by Tesla, Daimler-Benz, and other automakers, those cars count as smart vehicles that operate with data from their own sensors. The next stage would be vehicles that can exchange data among themselves (vehicle to vehicle, or V2V), allowing for reaction, avoidance, or planning for things that are far ahead or blocked. The most advanced stage would incorporate vehicle-to-infrastructure (V2I) communications, where information from road sensors and cameras about traffic conditions, parking

availability, and weather information can be communicated to cars.

The above possibilities raise the question of how to control for the different levels of car intelligence that will be on the road. That is part of the major planning issue confronting municipalities, cities, and counties. But in a future nirvana of connected vehicles and infrastructure, cars could travel much closer together safely, gracefully react to weather issues or road closures, use existing road infrastructure more intelligently (dedicating lanes virtually without physical construction), avoid most accidents due to driver error, and eliminate traffic caused by drivers looking around for parking spaces, among other improvements. All those things have the potential for big positive impacts on the cost of transportation, safety, and the environment.

The opportunities are huge, but so are the challenges. Transportation planners today are barely thinking about connected cars and infrastructure as they do long-term planning for road projects over the next 20 years. Moreover, the ways of funding today's road infrastructure—in large part fuel taxes at the federal and local levels—look backward rather than forward, and could suffer from increased use of electric and hybrid vehicles.

Many cities around the country are considering automobile alternatives such as light rail, which can require billions of dollars of public funding. This isn't to say they may not be right in some circumstances, but are they also comparing those projects with investment in autonomous vehicles and intelligent infrastructure?

On the regulatory side, the federal government may establish standards for autonomous operation. States creating their own standards can make for a difficult environment to introduce products—as was the case decades ago when emission controls first came into cars, and California created requirements that were difficult to meet for some models with earlier technologies.

ENERGY AND UTILITIES

We have a connected electric grid that lets utilities redirect power based on demand. What we don't have (broadly deployed, at least) is the intelligence to better monitor and control energy usage in homes, offices, factories, and warehouses, and to share that information effectively to better manage and conserve energy.

In newer buildings, much better intelligence is being built in, including the use of sensors to detect occupancy to manage HVAC and lighting. Progressive utility companies are increasingly offering incentives to developers for new construction to connect their systems to the grid, so that power consumption

can be monitored and massaged by the utility to better handle peak loads. Siemens and GE are two of the top companies providing solutions.

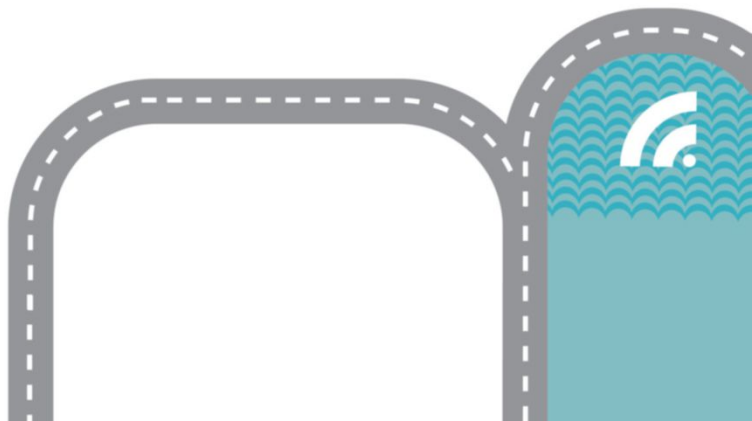
In some areas, utilities offer rebates on Nest thermostats in return for consumers allowing the company to vary temperatures by a couple of degrees during peak load times. Some utilities are also looking to employ dynamic energy pricing. In turn, they can offer incentives to consumers to reduce costs with intelligent appliances, which can schedule some activities for different times of the day and thus allow more efficient management of the grid. Not all utilities are municipally owned, so some amount of partnering will need to happen for cities on the cutting edge of "smartness" to convince investor-owned companies to participate in key initiatives.

THE NEST THERMOSTAT
You can manage your temperature settings remotely—or save even more money by letting utilities do so.

Water may be the new oil, and water conservation is paramount—especially in dryer areas of the Sunbelt. In contrast with electric, municipalities typically own and run water services. But unlike with electric service, smart water meters have been slow in coming, partly due to their cost and the increased labor required to retrofit existing homes. Smart water meters can detect leaks by analyzing flow over a period of time, and automatically report problems to the utility and the consumer. Even without smart meters, utilities are connecting billing data to applications services to help consumers better understand and monitor their usage. For example, the city of Austin enables consumers to connect their usage information to dropcountr.com, which enables mobile and Web access to water usage and useful comparisons to usage in neighboring homes.

PUBLIC SERVICES AND SAFETY

Beyond traffic and utilities, there are high-tech and commonsense-tech solutions to make cities safer,



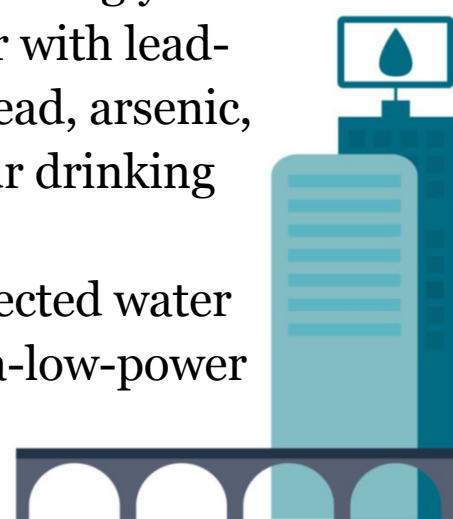
cleaner, and better. In Boston, for example, Citizens Connect lets residents use a mobile app to report and send photos of trash, potholes, and other non-emergency issues; city workers can even take a picture of the solved issue to post back so the public knows it's been addressed. The Paytix app allows the unlucky to pay parking tickets conveniently from a smartphone. An experimental app called Bumps will even detect bumpy streets as people drive on them and report back to the city to prioritize repairs.

On the higher-tech side, Panasonic and the City of Denver are partnering on a pilot project for smart LED street lamps in the Denver International Airport area. The lights will employ HD cameras that detect pedestrian traffic to dim and brighten the lights for energy efficiency and safety. The cameras feed traffic and parking space data to cloud backend systems, which will provide analytics and data to enable future mobile and vehicle applications. The pilot also includes a partnership with Xcel Energy, where solar panels on buildings will store excess energy in Panasonic solar photo-voltaic and lithium ion storage batteries that can be shared on the electric grid.

PROTECTING AGAINST POLLUTION AND NATURAL DISASTERS

Water is without a doubt one of the most important natural resources on the planet. The streams, lakes, and rivers that supply our cities are increasingly jeopardized by a wide range of contaminants—as the recent disaster with lead-contaminated water in Flint, Michigan, reminds us. In addition to lead, arsenic, copper sulfate, and a wide range of bacterium can also leach into our drinking supply and imperil residential communities.

One of the companies that have been pioneering the field of connected water sensors is Libelium. Its Waspmote Smart Water platform is an ultra-low-power



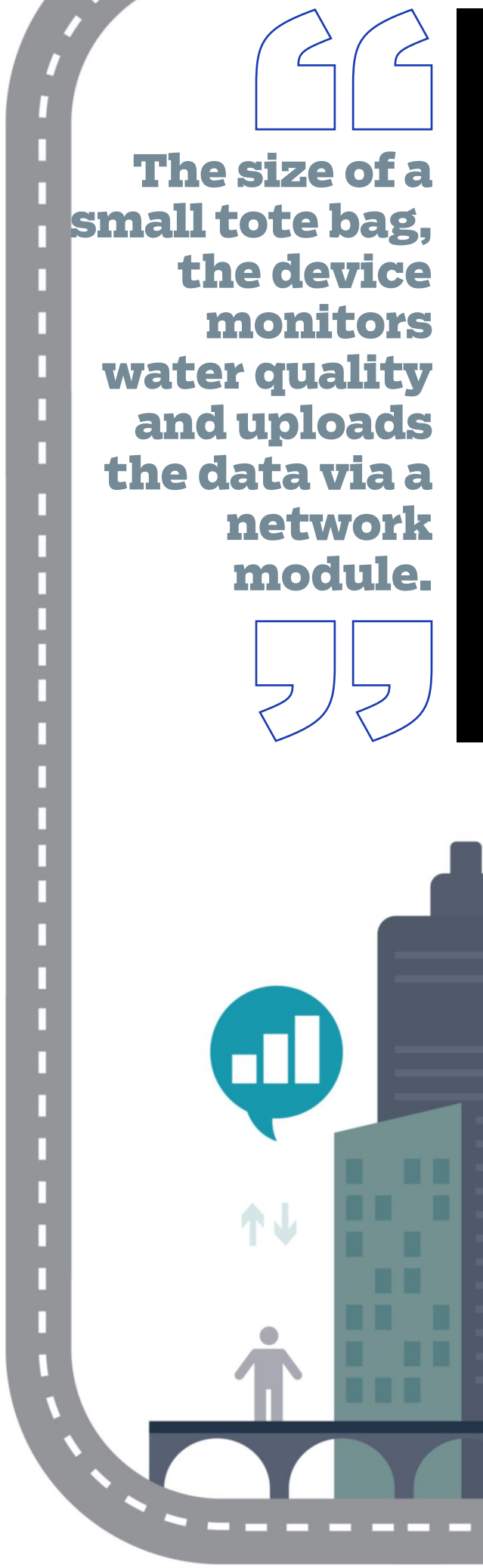
sensor node designed for use in rugged environments and deployment across smart cities. It is capable of measuring the pH, nitrates, dissolved oxygen, as well as lead and copper sulfate levels. Some of the applications for which it is indicated are potable water monitoring, detecting chemical leakage in rivers, and remote monitoring of swimming pools, spas, and hot tubs.

Another sensor likely to find itself playing a starring role in smart cities is the Carnegie Mellon Flamingo. Only about the size of a small tote bag, the device monitors water quality and uploads the data via a network module so that everyone who lives in the surrounding area can access the results. The device collects data at an ultra-high frequency, according to the company, enabling it to detect contamination events that might otherwise go unrecorded. It can be purchased online for $529, well within the reach of most home owners associations and municipal budgets. Another resource increasingly at risk from contaminants is the air we breathe. This is especially true in large urban communities; the video footage of Chinese cities bathed in smog leaves little doubt about the scope of the problem. But air pollution can be present even in cities without telltale signs of smog.

Many factories time their worst emissions to occur at night, when the populace won't notice the giant plumes of smoke accruing on the horizon. Even more so than water, therefore, having a widely distributed network of sensors is essential to combating the problem.

Libelium, the company behind Waspmote, also offers the Plug & Sense! Smart Environment Pro, which is equipped with a dust sensor capable of measuring air particulates down to 1 micrometer in diameter. This makes it much more responsive than the typical indoor air quality monitors, which only measure particulates as large as 2.5 micrometers. Capable of being run entirely on solar energy, the Plug & Sense! unit can be attached to telephone poles or electricity lines and runs virtually

“The size of a small tote bag, the device monitors water quality and uploads the data via a network module.”



AEROQUAL'S AIR QUALITY MONITOR
These can be used both indoors and outside to help governments and companies keep us breathing safely.

maintenance-free, connecting wirelessly to the Internet for data uploads.

Another approach to the issue involves equipping people with individual, portable air monitors, which when analyzed in concert, can provide a detailed picture of a city's air quality. A company called Aeroqual has launched a portable air quality monitor capable of detecting a broad range of pollutants, including hazardous gases and fine dust particulates.

As if there wasn't enough to fear in the modern urban environment, the specter of "dirty" bombs and nuclear contamination has grown enormously in the last decade. Invisible to the naked eye, radiation can only be detected with specialized sensors. The storied Geiger counter, once a bulky and expensive piece of laboratory equipment, is now available to anyone wishing to know the radiation levels in their city.

Most impressively, this can be done with the average phone. Joshua Cogliati and other researchers at Idaho National laboratories have devised a smartphone app that uses the phone's camera to detect gamma rays. This could be the ultimate solution to crowdsourcing the detection of radiation within a city. Just as apps like Waze can be used to detect traffic in real time, so might we use our smartphones to detect radiation events across an urban population. This also carries an important lesson about the smart cities movement itself, which will ultimately depend as much on a smart and responsive citizenry as it will on the devices and sensors in their neighborhoods.

ECONOMICS, SECURITY, AND THE BLOCKCHAIN

Modern cities are uniquely monstrous entities, often with millions of individuals creating billions of variables every day. Making cities smart is not a matter of tracking and coordinating all these variables in an efficient way; it's also about doing so safely and securely. If you think cyber war is a threat today, wait until it could shut off power to whole areas or individual homes, bring all transportation to a grinding halt, and even mess with the city gardeners! As we inherit the advantages of automation in civil planning, we gain the disadvantages as well.

But there's one up-and-coming software technology that was specifically designed to coordinate lots of things safely and securely: the blockchain, which was first brought to the public's attention through its use in the Bitcoin cryptocurrency. Also known as a cryptographically secured distributed ledger, a blockchain keeps a cloud-based copy of organized information (basically a spreadsheet) and continually performs the tough computational work of encrypting it all in close to real time. That sounds like exactly what we need, and in fact, cities in China, the United Arab Emirates (UAE), and elsewhere have been eyeing the technology for dealing with their smart city needs.

The idea is that by using a cryptographically secured and totally decentralized authority that can work at the speed of a computer, we should be able to keep power distribution, water treatment, self-driving transportation, and much more from ballooning beyond all practical limits as cities continue to grow. With a robust public blockchain in place, cities could provide payment options for every business—why use your old plastic card, losing a fraction of the payment to an intermediary like a bank or credit card company and driving up prices, when you can transfer money quickly and securely, directly to a business owner?

One up-and-coming software technology was designed to coordinate lots of things safely: the blockchain.

There are basically three reasons to turn to the blockchain for a smart city: You're an insurgent power in search of distinguishing features and the capacity to somehow continue your current, enormous rate of growth indefinitely (China); you're a holiday destination with an economic incentive to stay ostentatiously futuristic (Dubai, in the UAE); or you're becoming so unwieldy that the concept of continuing to organize via old-world systems is just absurd (Los Angeles, maybe?).

It's a risk, certainly, since any new technology can fail or, at least, fail to live up to long-term projections. There are many in the blockchain world who think it may not be able to live up to its incredible disruptive potential, and that it could be incapable of expanding much beyond its current scope. It takes an incredible amount of computing power to secure all those transactions and, more important, running all that computation requires a dizzying amount of electricity—by one estimate, running Bitcoin could soon take as much energy as Denmark.

Not just for smart cities, there are multiple pushes to avoid this fate. From the enormous open source collaboration of the Open Ledger Project to the more closed academic approach of bsafe.network, there are plenty of bids to fix the blockchain before it breaks, potentially tanking it. Their main goals are to figure out how to achieve all the blockchain's core functionality, with no downgrade to security, much more quickly and efficiently.

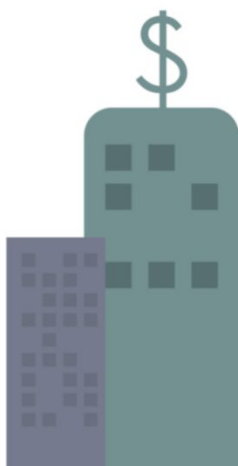
Even with a hypothetical Blockchain 2.0, however, one efficient enough to allow millions of transactions per day, we're going to need a method of power, both computing and electrical. The city could just provide all this and run the

blockchain as a pure social service, of course, but that would be extremely expensive. It would also centralize power, undoing some of the distributed nature of the service and potentially undoing one of the blockchain's core appeals to security.

> **Smart cities represent a new kind of thinking that could change everything about our perspective on how we live.**

The basic trade-off of all current blockchain designs is that someone has to donate the time and money necessary to process changes and secure them cryptographically. Classically, that has been achieved by coupling the blockchain to a cryptocurrency—in a sense, the blockchain needed Bitcoin just as much as Bitcoin needed the blockchain. This means that if you're going to make and maintain a blockchain, you'll need to provide some equivalent incentive. It could be simpler when dealing with a government and non-anonymous transactions, and could in principle come in regular U.S. dollars, rather than fancy crypto-bucks like Bitcoin or Ether. It could also come in the form of tax breaks or similar economic advantages, perhaps off-loading the burden to corporations with the most to gain by exploiting such schemes.

In any case, the blockchain is simultaneously one of the only software technologies that could possibly provide for the needs of a truly smart city, and a



potential dead end that accomplishes little while breaking the municipal bank. But regardless of the tech behind it, we need to move to more efficient and successful models of living: As is often pointed out by smart city advocates, about half the world's population currently lives in cities, but by 2050 that number is projected to increase to 66 percent. How will cities—both existing ones growing to all new sizes and new ones springing up in developing nations—manage their ballooning organizational problems and stay competitive in the global market? The answer might just be the blockchain.

CITIES WILL HAVE TO GET SMARTER

Albert Einstein once said, "We cannot solve our problems with the same thinking we used when we created them." Indeed, smart cities represent a new kind of thinking that could change everything about our perspective on how we live. The smart city could shrink the communities of modern urban environments, bringing people together with well-designed enhancements to the city's level of interactivity. Smart coordination could let people organize much more easily by providing geolocated digital services or easy event promotion to local citizens. It could also, in a more aggressive model, funnel people through their day so they end up being exposed to more social interaction, or more community culture. And it has the potential to remove a layer of bureaucracy between the community and its residents, letting those who live in a city play an even more direct role in how things in it get done.

Historically, technology has often solved big problems that let humans advance to the next stage of development. In his book *Triumph of the City,* Harvard University economist Edward Glaeser calls cities mankind's greatest invention, in part because they brought people closer together and fostered the interchange of ideas by people of diverse cultures, skills, and professions. But like with many of man's inventions, some problems are solved and new ones are created. If indeed cities are one of man's greatest inventions, information technology may be the only way to reinvent the city for tomorrow's world.

HOW INTEL LOST $10 BILLION

—AND THE MOBILE MARKET

About four years ago, the first plausible Intel smartphone was released: the Xolo X900. Although it couldn't match the more powerful devices of the day, it was a solid initial effort. More important, the Medfield SoC that powered the X900 was meant to be a beachhead, a harbinger, a sign of things to come.

BY JOEL HRUSKA

Four years and billions of dollars later, it's now clear that the long-awaited ARM-versus-x86 war won't be fought in the tablet or smartphone market. Intel recently canceled all of its publicly announced 14nm smartphone SoCs and most of its 14nm tablet SoCs that would have shipped in Android devices. The company is diving into 5G research and hopes to lead the industry in developing 5G products. But its 3G and 4G modems are still built on the 28nm process node at TSMC, even as competitors such as Qualcomm move to 14nm for their own products.

How did Intel manage to spend up to $10 billion dollars and have so little show for it? There's no single, simple answer—but there are definitely some smoking guns. To understand what went wrong for Intel, we need to consider the semiconductor industry as a whole.

OF FABS AND FOUNDRIES

The semiconductor industry is dominated by four companies: GlobalFoundries, Samsung, TSMC, and Intel. The first three are known as pure-play foundries or merchant foundries. Their business model is based on manufacturing silicon for other companies, not designing and launching products that they sell themselves. (Samsung does build some custom silicon for itself, but the bulk of its foundry business comes from external customers.)

Unlike the merchant foundries, Intel designs and builds both its fabrication plants and its microprocessors. Until the last few years, Intel never took foundry customers. Intel's recent attempts to break into the merchant foundry business by attracting a handful of high-margin customers wasn't all that successful and has yet to generate significant revenue for the company.

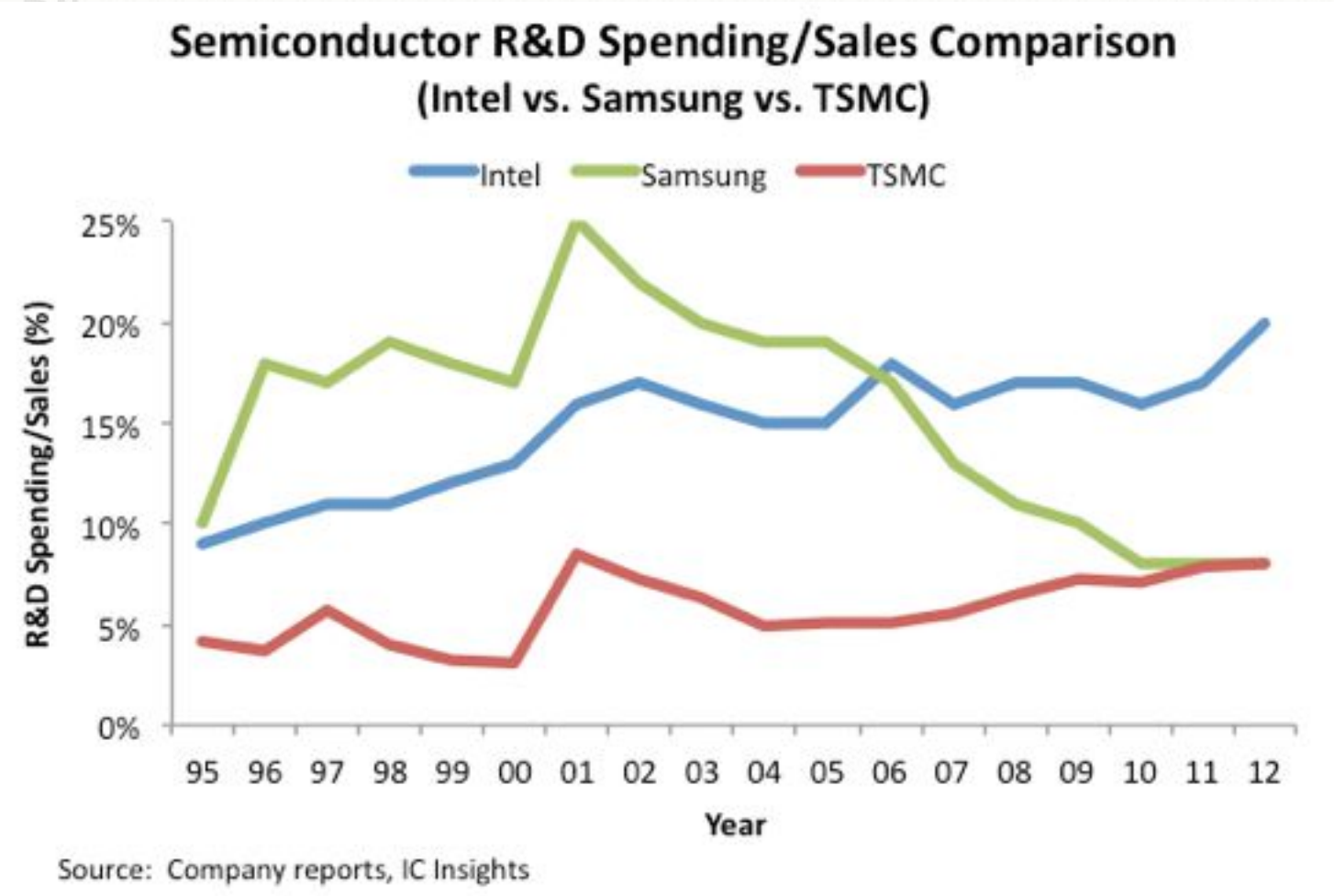
The distinction between merchant foundries and integrated device manufacturers (IDMs) like Intel is a critical part of why Intel's mobile efforts played out the way they did.

Intel's manufacturing strategy historically relied on rapidly adopting new process technology. The bulk of the company's revenue is derived from leading-edge nodes; older facilities were either upgraded or shut down as they became obsolete. TSMC pursues a very different optimization strategy. Although it also invests in leading-edge semiconductor technology, the bulk of TSMC's revenue is earned on older technology nodes.

As of the first quarter of 2015, 39 percent of TSMC's revenue was earned on technology nodes it deployed ten to 20 years ago. Fifty-four percent of its revenue came from nodes that were in volume production at least eight years

ago. Intel made limited use of older facilities to build its chipsets, but its business model is fundamentally different.

For most of 30 years, that difference didn't really matter. From the 1980s through 2010, Intel beat its low-volume RISC competitors and seized the data center by leveraging the economies of scale it created in the consumer PC market. It crushed its only serious competitor in the x86 market and forced AMD to sell its own fabs in an effort to survive.



COMPARING R&D SPENDING
This chart illustrates Intel's R&D expenses as a percentage of total sales as compared with Samsung and TSMC.

The pure-play foundries and Intel worked in parallel tracks, often contending with some of the same problems, but prioritizing and solving them in different ways. Intel built its foundries to rigorous standards using a philosophy it called "Copy Exactly." It prioritized high yields, focused almost exclusively on microprocessors, and enforced strict design rules. Intel products were designed to be built at Intel foundries with Intel tools, using Intel's established best practices.

In contrast, TSMC and the other merchant foundries designed their process nodes to meet the needs of many different clients. Their fabs prioritize throughput and flexibility while minimizing cost. Both models worked beautifully for their respective businesses—until their businesses started to collide.

THE LIMITS OF TECHNOLOGY

Intel's failure to gain traction in the mobile market highlights the flaws in treating technological progress as a roadmap for corporate success. Despite recent delays and its own decision to abandon its tick-tock model, Intel still owns the most technologically advanced foundries in the world. It's the only company to have deployed a true 14nm die shrink and it will be the first company to deploy a true 10nm node as opposed to a hybrid. All of this is true—as is the fact that Intel spent $10 billion in mobile with nothing to show for it.

The common explanation for why Intel lost the mobile market is that its x86 mobile processors either drew too much power or weren't powerful enough compared with their ARM counterparts. Intel's decision to sell its ARM division and XScale processor line in 2006 has been widely derided as a critical error. It's a simple, commonsense explanation with just one flaw: It mistakes symptoms for cause.

ALL THIS HAS HAPPENED BEFORE

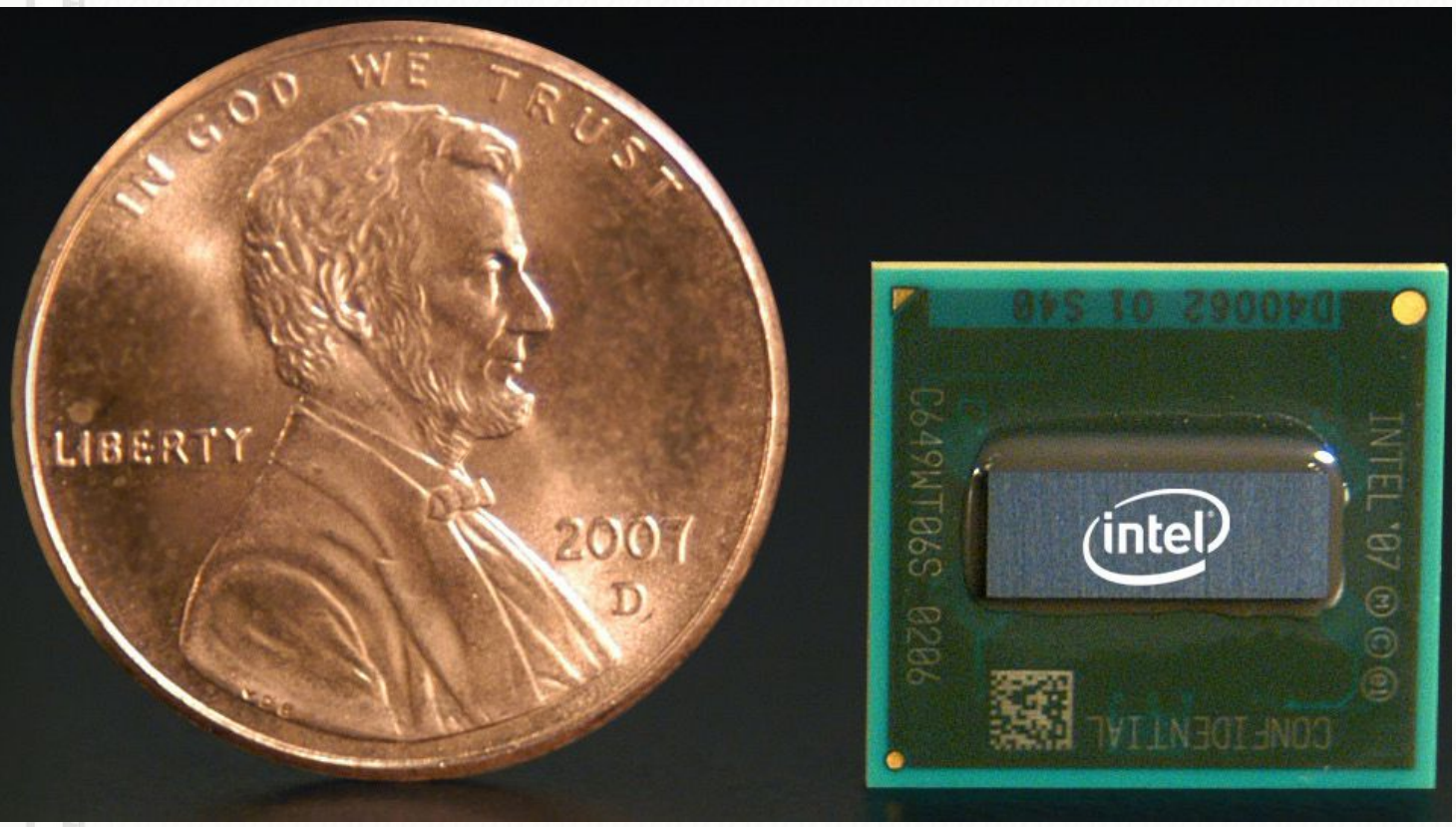
Intel's struggles in the mobile market didn't begin with Medfield, Moorestown, or even the decision to sell its ARM business and XScale chip division ten years ago. As EETimes reported in 2006: "Intel spent more than $10 billion to enter the communications business over the years, but the microprocessor giant lost its shirt—if not millions of dollars in the arena. The reported communications-chip sale is said to be part of Intel's plan to overhaul the company. Intel is also set to include the layoff or redeployment of 16,000 employees, according to speculation."

Change "communications" to "mobile," adjust the number of fired employees, and that paragraph could've been written today. Intel's problems in mobile aren't new; Santa Clara has been struggling to enter new markets for nearly 20 years. Other articles from 2006 emphasize that XScale sales had been fairly low, as had revenue from Intel's networking and communications division.

From Intel's perspective, selling XScale made sense. Building a mobile processor business around ARM cores would have limited Intel's ability to leverage its own IP and expertise in x86 manufacturing, while simultaneously cutting into its profits (Intel would have owed significant royalties to ARM if such a design ever became popular). Atom was already well into development in 2006, and Intel decided to bet on its own hardware expertise and software development skills.

ATOM AND THE RISE OF X86 EVERYWHERE

Contrary to popular belief, Intel wasn't caught completely off-guard by the rise of smartphones or the popularity of small, Internet-connected devices. Atom development began in 2004; the Silverthorne core that Intel debuted in 2008 had a TDP of just 2 to 3 watts at a time when most Core 2 Duo processors were stuck in 35-watt territory.



INTEL'S ORIGINAL ATOM CHIP
The company first envisioned mobile computing as an ecosystem of of netbooks and MIDs driven by its own X86 architecture.

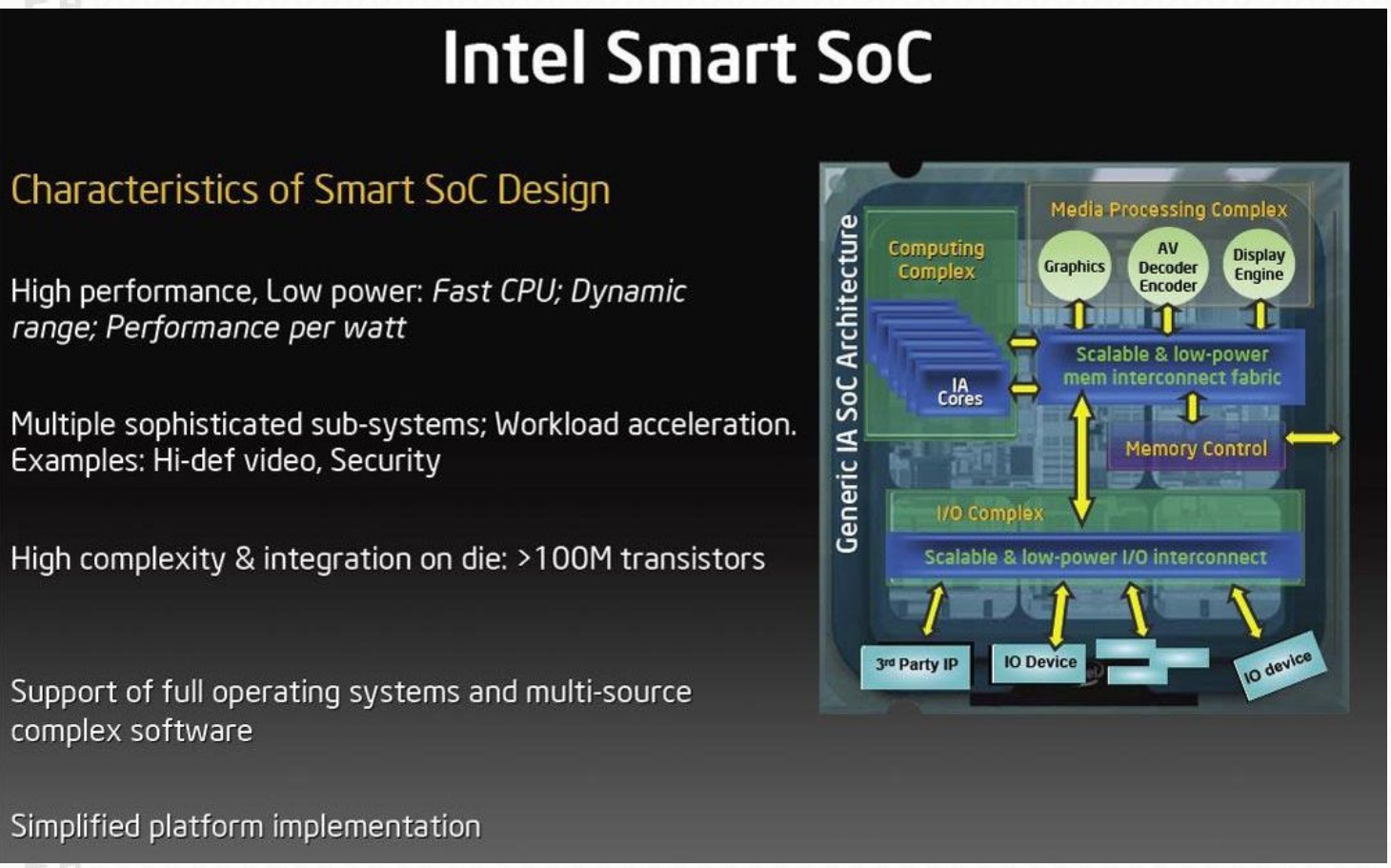
Most people remember Atom as the chip that launched a thousand netbooks, but that wasn't Intel's original plan. The company thought that nettops and netbooks would be a niche market for Atom, not the chip's primary platform. Atom and its successors were supposed to launch an armada of Mobile Internet Devices, or MIDs. Those devices seem hopelessly quaint today, but Intel was clearly thinking about the future of mobile computing. The company envisioned an ecosystem of netbooks and MIDs driven by its own custom x86 architecture, a goal the press dubbed "x86 everywhere."

CONFLICTING PRIORITIES

Clearly there were executives at Intel who understood how critical mobile would be to the company's long-term future and pushed for aggressive positioning and product ramps. Unfortunately, those efforts were stymied by others who were concerned about the impact Atom and the low-cost devices it was supposed to enable would have on Intel's primary business. MIDs and later

netbooks were supposed to be bare-bones, low-cost devices, useful as secondary machines and for basic tasks, but no more.

Intel's post-launch attitude toward Atom is best summarized as benign neglect. While the chip went through several revisions to integrate components and reduce costs, Intel refused to commit the resources that would have made Atom a best-in-class player in the mobile market. From 2008 to 2013, Intel launched a cost-reduced version of its Nehalem architecture, the Westmere 32nm die shrink, a new architecture with integrated graphics (Sandy Bridge), a high-end enthusiast platform (Sandy Bridge-E), a new 22nm CPU with FinFET technology (Ivy Bridge), another architectural refresh (Haswell), and a second-generation enthusiast platform (Ivy Bridge-E). That's two full tick-tock cadences for Intel's big-core business, but Atom didn't even make the jump to 32nm until 2012. Its single architectural refresh to date arrived in 2013, just after the launch of Ivy Bridge-E.



THE BIRTH OF ATOM

Intel was working on Atom SoCs in 2008, but its first fully unified chip didn't ship until 2012.

Despite being initially starved for resources, 32nm Atom chips were competitive in the midrange mobile market. With Medfield, Intel seemed to have turned a corner, but the company's designs generally failed to find much traction in the market. Only Intel's contra-revenue strategy won the company significant tablet market share, and those gains were only sustained through heavy losses.

Atom wasn't the problem—Atom was the solution Intel didn't have the guts to chase.

THE TOUGH DECISIONS INTEL DIDN'T MAKE

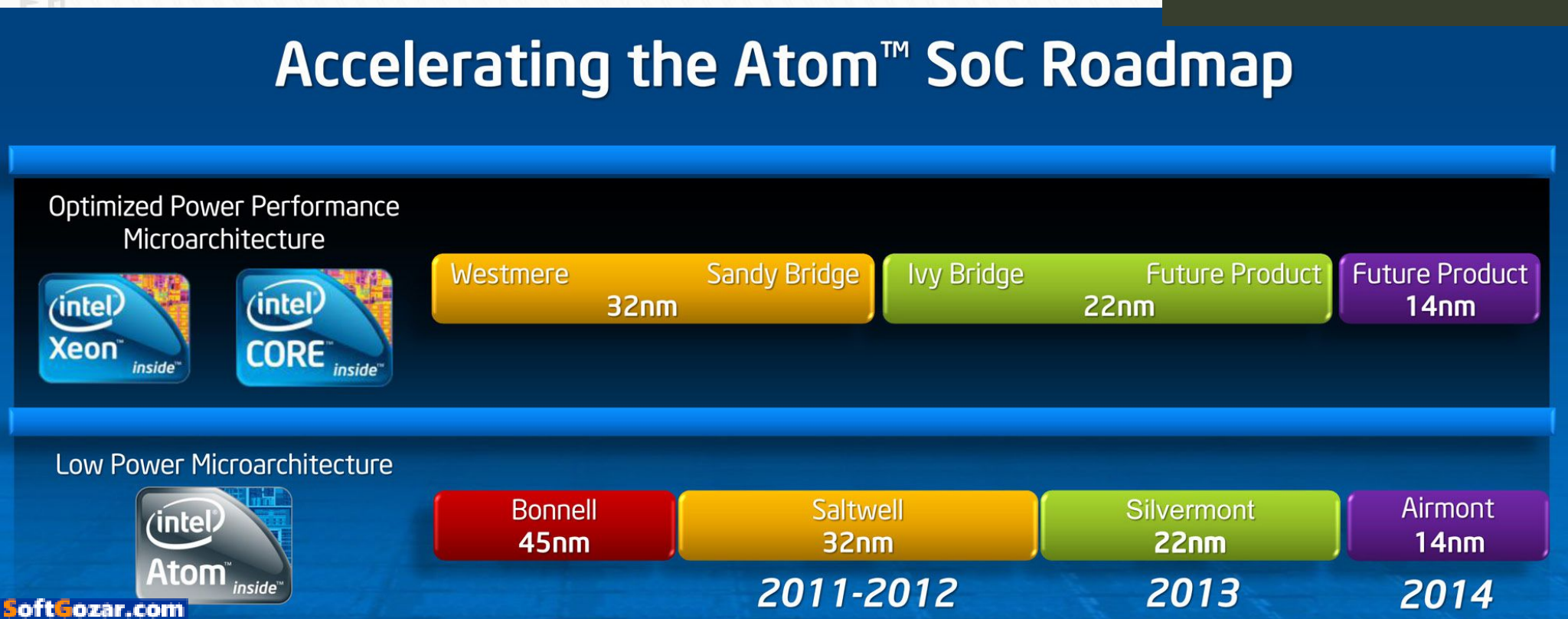
Intel failed to gain traction in mobile because it wasn't willing to risk upsetting the economic model that had transformed it into a titan of computing. The company's fabs, manufacturing strategies, and resources were geared toward large, expensive processors, not to churning out huge numbers of low-cost mobile cores. Prioritizing Atom over Core would've required the company to retool at least some of its fabs to emphasize throughput and lower costs in order to compete with the ARM processors built at Samsung and TSMC. It would have meant lower gross margins and less profit per unit sold.

Intel did take steps to improve its competitive standing vis-a-vis ARM and ARM's foundry partners, but it rarely took them quickly and often failed to follow through. Intel bought Infineon Wireless for $1.4 billion, but all of its publicly announced wireless products, including the XMM 7480 modem, are still built on 28nm at TSMC. Atom launched in 2008, less than 12 months after Steve Jobs unveiled the first iPhone. Even in 2007, smartphones relied on SoCs—but Intel didn't launch its first Atom-based SoC until 2012.

If Intel's decision to protect its core (Core) business and product margins was wrong, it wasn't crazy. Refitting fabs, building expertise in SoC design, and porting modems from TSMC would have required large cash infusions and take significant amounts of time. If Intel had launched Atom with an aggressive plan to put the chip in smartphones by 2010, things might have played out differently. By the time the

ACCELERATING THE ATOM

Intel tried to speed things up eventually, but both its 14nm process and the next-gen Goldmont CPU core were delayed.



company woke up to the threat it faced from ARM and merchant foundries, it was too late to make up the gap.

WHY INTEL'S FOUNDRY TECH COULDN'T SAVE ITS MOBILE BUSINESS

Intel's process technology leadership couldn't save the company's mobile division because it wasn't designed to do so. Smartphone and tablet OEMs wanted devices with integrated LTE radios, and Intel didn't have them. Even the SoFIA partnership with TSMC never came to market, apparently because Intel couldn't secure enough volume to kick-start production.

Intel's 14nm problems delayed its next-generation tablet processors from 2014 to 2015. Its 10nm node, once expected to secure enormous economies of scale over TSMC, has been pushed to 2017 as well. Although these delays probably didn't play a huge role in Intel's decision to leave the mobile market, they may have influenced it. In 2012, Intel still expected to be on 10nm by 2016 with extreme ultraviolet lithography (EUV) already in production. The now-canceled 450mm wafers weren't expected in-market quite this soon, but Intel did expect to recognize significant cost savings from moving to the larger wafers in the 2018-to-2020 timeframe—cost savings that could have further improved the company's standing against Samsung, TSMC, and GlobalFoundries.

If Intel had begun reorienting towards Atom when it launched the chip in 2008, it might have weathered these delays and cancellations without much trouble. Failing to do so left its beleaguered mobile business facing higher-than-expected costs and minimal revenue.

Intel didn't lose the mobile market because Atom's performance and power consumption didn't compete with ARM; research and evaluation showed that Atom was capable of matching ARM performance in multiple market segments. It lost the mobile market because it didn't make the changes that would have allowed it to compete on cost with products manufactured at TSMC and Samsung. The exacting rules and unique layouts that drove Intel to the top of one market could not be easily adapted to others, and Intel was unwilling to risk its position at the top of the conventional x86 market for a risky payoff in mobile. There's no evidence that keeping XScale or developing ARM products would have changed that—if anything, the ARM division would have been under even more pressure to ensure it never became a threat to the x86 business.

GET ORGANIZED

Tech Habits for Starting Your Day

TIPS

Be a Better Googler

HEALTH

Make the Most of Your Fitness Tracker

CONNECTED TRAVELER

Road Trip Tech for Families

Digital Life

Tech Habits for Starting Your Day

BY JILL DUFFY

Part of being organized is creating habits that help us get the most out of every day. When we rely on habits rather than deliberate actions that require conscious effort, we free up our brains for more important stuff. Morning is an ideal time for the habits that can lead to a high-productivity day. Here are five things you can do early in the day, every day, to get more done.

1. TRACK YOUR SLEEP

After you wake up, while sleep is still on your mind, check how much you slept the night before. If you wear a fitness tracker or smartwatch with a sleep-tracking function, look at your data. If not, estimate based on the time you went to bed.

People need sufficient sleep to be able to focus and be most productive. Not getting enough sleep can take a serious toll on your performance. One bad night's sleep isn't going to ruin you, but several nights like that in a row could. Although the exact amount of time a person needs to sleep varies, research shows that getting 6 hours or less of sleep, night after night, is not enough for most people. (Parents of small children: I'm sorry.) Aim for something in the ballpark of 7 to 8 hours, and more if you need it.

If you're not getting enough sleep, how can you fix it? Most people can't simply sleep later, because they have to wake up at a fixed time to prepare for work. Instead, you'll have to go to bed earlier. Figure out by what time you'd have to be in bed to get a solid 8 hours of sleep, and then set an alarm to remind yourself to go to bed. For example, if you need to wake up at 6:30 a.m., set a bedtime alarm for 10:30 p.m.

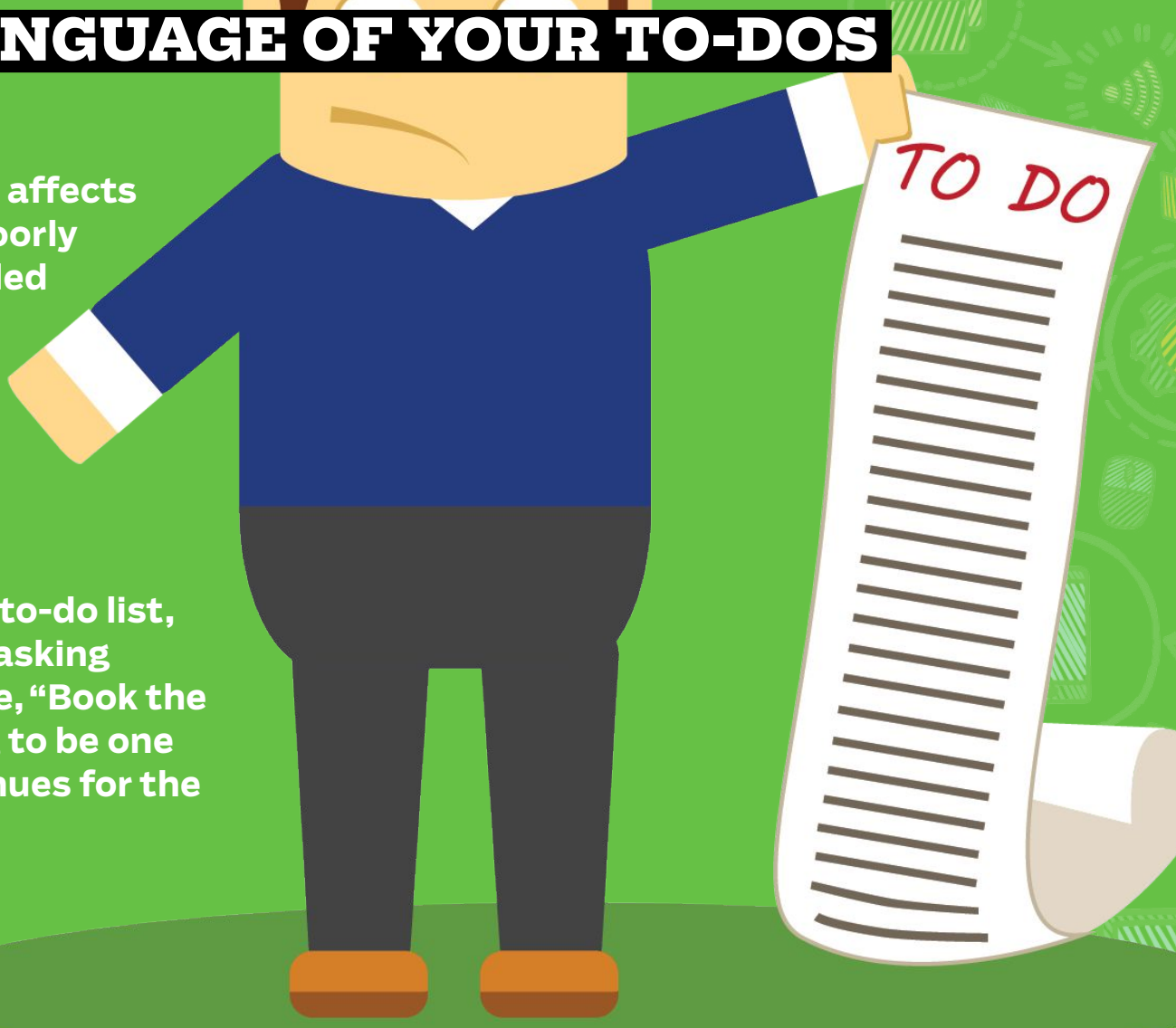
2. REVIEW YOUR CALENDAR AND TO-DO LIST

Has your productivity ever been derailed by an appointment or meeting that you forgot was on your calendar? Get in the habit of reviewing your calendar and important to-do items before your day gets going. It helps if you can tie this action to an existing habit, such as drinking coffee or riding the train during your morning commute.

Set a quick-access view in your phone that shows your daily calendar or to-do list. In iOS, you can customize the pull-down screen to show a summary of your calendar or tasks in the Today view. Android phone users can add a widget to their home screens or another custom view, depending on what their specific phone supports.

By default, your calendar probably notifies you about meetings a few minutes before they're scheduled to occur (and you know they're coming because you reviewed your calendar first thing in the morning). Take those notifications seriously—not to arrive at the meeting on time, but to wrap up your other work before you leave your

3. CHECK THE LANGUAGE OF YOUR TO-DOS



How we phrase our tasks greatly affects whether we complete them. A poorly written task on my to-do list ended up getting snoozed for three months. The problem wasn't my motivation to complete it. The problem was that the task wasn't written for success.

As you review your calendar and to-do list, be aware of what exactly you're asking yourself to do today. For example, "Book the corporate retreat" is way too big to be one task, but "Call three possible venues for the corporate retreat" is achievable.

4. DECIDE WHEN YOU WILL PROCESS EMAIL

Do you get sidetracked by email? Decide ahead of time, before you even start your workday, when you will process email. Pick three or four time slots when you will look at email and do something with the messages you see. Early in the day, while your willpower is still strong, vow to close your email program when it's not time to work with email.

Following through on your promise not to get caught up in email when you're trying to do real work is even more important in the morning. Research shows the interruptive effects of email are worse in the morning than in the afternoon for most knowledge workers.

If you use webmail and have a hard time breaking email's temptations, you can block your own access during just the morning hours using a browser extension such as StayFocusd. With StayFocusd, you can block your access between specific hours, such as 8:30 a.m. to noon, or limit how many minutes you can use the site during the times you set.

5. WATCH CAT VIDEOS

Think of some things you enjoy that you can do in about two minutes, and try to do some of them during a few short mid-morning breaks. Breaks rejuvenate us only when we do something we enjoy during them, and there's mounting evidence that breaks are most effective when we take them frequently but keep them relatively short.

In one interesting experiment, researchers found that a group of subjects who watched comedy clips before completing a series of tasks outperformed a control group by about 12 percent. And researchers in Japan who study the effects of cute images found that subjects who first looked at pictures of kittens and puppies were more careful at completing tasks than a group who looked at photos of adult cats and dogs or neutral objects.

So decide on something relatively quick that you enjoy, whether it's checking sports scores online or treating yourself to a fresh coffee, and don't feel guilty when you do these things during your morning breaks.

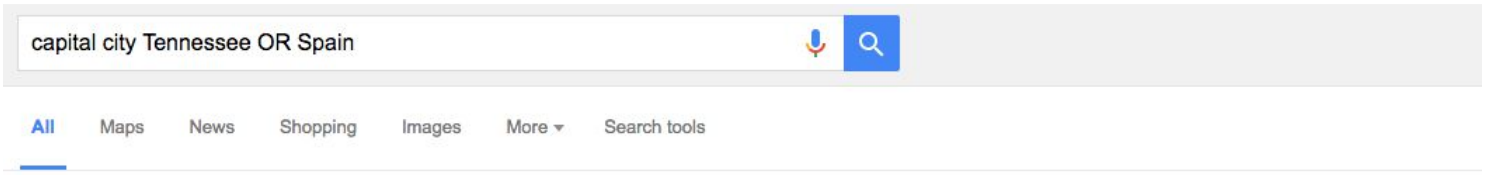
Be a Better Googler

BY EVAN DASHEVSKY

Google Search I'm Feeling Lucky

With a decade and a half behind it, Google search has evolved into a complex and versatile technology. But although you may use it every day, you probably don't know everything about Google search. Our tips will help you sharpen your search skills.

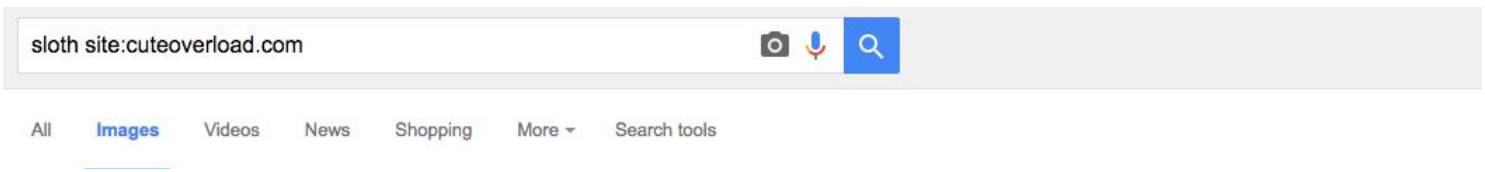
SEARCH MODIFIERS



Google's algorithm is adept at returning the information you're looking for, even when you aren't quite sure yourself. But when you know exactly what you need, refine your search results by using some basic modifiers.

- **Exclude terms by using a minus (-) symbol:** Say you want to learn about wildfires in the Amazon rainforest but not about Jeff Bezos's newest hardware. You can use the minus symbol to exclude all the terms you don't want: for example, *amazon fire -kindle -phone –tv*
- **Use "OR" to combine searches:** Use this modifier when you want to get two separate but related bits of information. Google usually ignores capitalization, but in this kind of search, you need to use an all-capped "OR." You'll see different results for *capital city Tennessee or Spain* than for *capital city Tennessee OR Spain*.
- **Use quotations to search for the exact order:**Searching *"Danny DeVito hair"* brings back only results that include all those words in that order. But a search for *Danny DeVito hair* (no quotation marks) brings back a different set of results. They'll have all those words, but not necessarily in the order you typed them in.

SEARCH QUALIFIERS

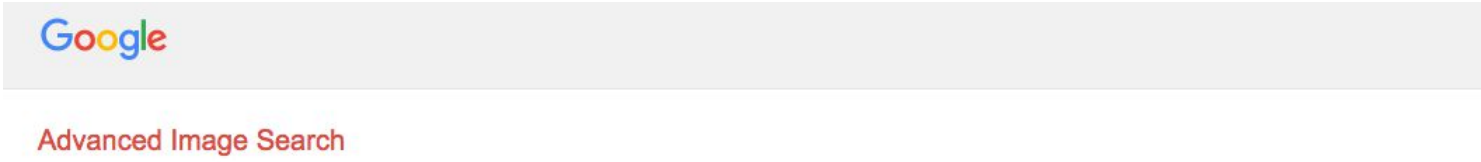


Google search supports a variety of search qualifiers that help to further filter your results.

- **Search inside a single website:** If you want results from within one site only, use site: followed directly by the site's URL. You must include the site's domain—*Galaxy S site:pcmag.com,* not *Galaxy S site:pcmag*.
- **Search titles only:** Use the qualifier intitle: to look for words in the webpage title. For example, *grasshoppers intitle:gross* returns only sites about grasshoppers that have the word "gross" in the title. Conversely, allintitle: returns links with multiple words in the title: for instance, *allintitle: cow meat yummy*.

- **Search URLs only:** Similar to the intitle: function, using inurl: or allinurl: lets you search just in the URL.
- **Search text only:** intext: and allintext: let you search only within the text of a site, leaving out the title and URL, which the search algorithm usually take into consideration. You can use these terms in conjunction with each other or with the previously mentioned modifiers.

BETTER IMAGE SEARCH



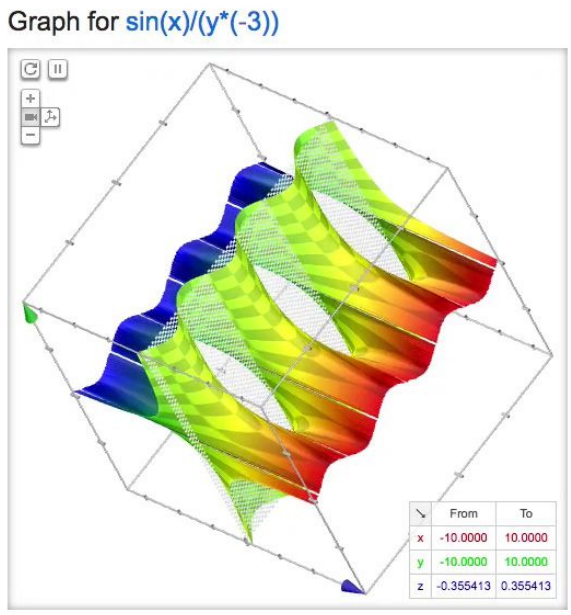
You can use many of the aforementioned search refiners in Google image searches. Get even more accurate results by clicking through to Google's advanced image search page, which lets you search by image size, region, file type, and even by specific colors.

Google also supports "backward" image searches on most browsers. This function lets you find information on an image file. For example, upload a picture of the Eiffel Tower, and Google almost surely will recognize it and give you relevant information. (It works with faces, too.) A backward search can direct you to websites where the uploaded image appears, and it can also show you images that are "visually similar."

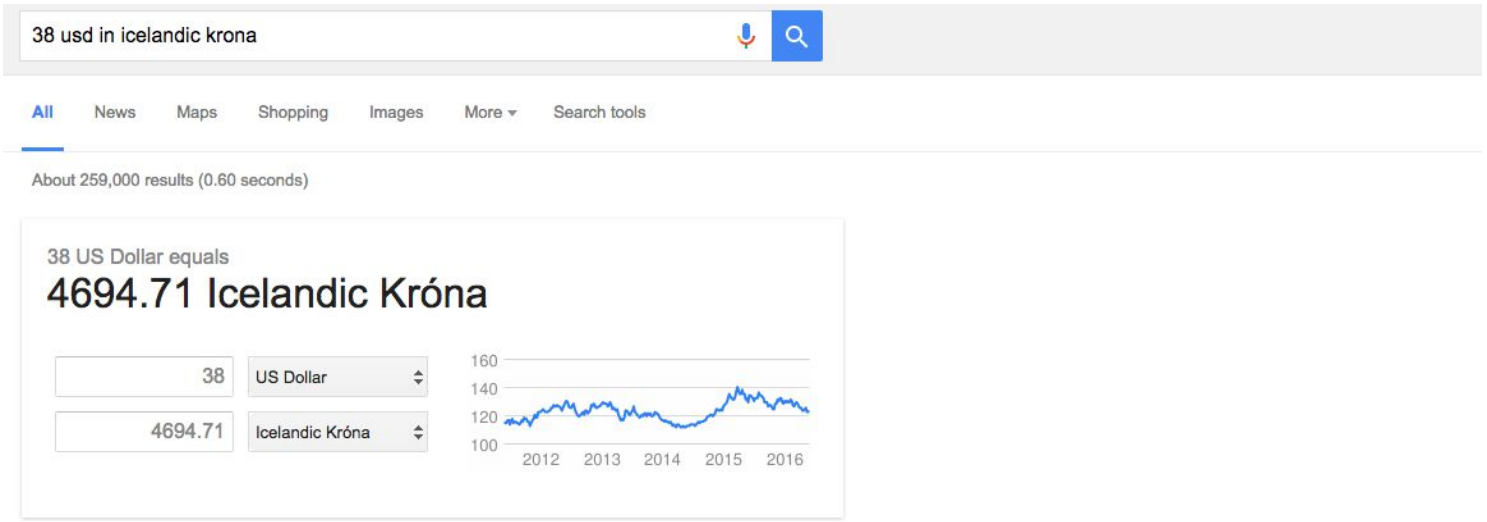
To perform a backward search, go to Google Images search and click the camera icon in the search bar. You can either upload an image or enter an image's URL that you'd like to search. Updated versions of Chrome, Firefox, and Edge even let you drag image files directly into the search bar.

MATH IN THE SEARCH BOX

Go ahead and do basic calculations right in your search bar. For example, searching *34+7* prompts a calculator below the bar with the correct answer already filled in. You can also ask Google to solve math questions in regular language; searching *what is 3 times 7* prompts the calculator and the correct answer. You can ask more complicated questions, like *what is 20% of $67.42,* and receive an answer—in fact, you can leave out the "what is" altogether.



CONVERT ALMOST ANYTHING



For simple conversions (say, 38 Celsius in Fahrenheit) Google not only gives you an answer (100.4, in this case), it also provides an interactive calculator for further converting. Google can supply the answer for some pretty zany conversions; for instance, *17.5 millimeters in light years* (for the record, it's 1.84979097 × 10-18 light years) but it doesn't supply the interactive calculator.

You can find currency conversion rates with just a few keystrokes. This function usually prompts an interactive calculator, too. You don't even need to know the official currency symbol ($, €, and so on) or ISO designator (USD for the U.S. dollar, GBP for the British pound), since Google's algorithm is able to discern sentence-style queries. For example, a search for *38 dollars in Iceland* returned the answer that (at the time of writing) $38 was equal to 4,373.80 Icelandic krona. (Note that Google has a disclaimer that it cannot guarantee the up-to-date accuracy of its exchange rates.)

NARROWING IN

- **Define words:** You can ask Google search to define unfamiliar words (or two-word phrases) using the define: (or definition:) qualifier. This prompts Google to return a card with the definition, pronunciation, and—when available—a detailed etymology.
- **Track packages:** You can track most packages in your search bar. Just paste the tracking number into the search bar, and Google recognizes it and provides a link to the tracking page.
- **Search file types:** The qualifier filetype: filters your search results by (you guessed it) file types. So to find downloadable PDFs featuring llamas, search llama filetype:pdf. To find downloadable Microsoft Word docs featuring our camelid friends, search llama filetype:doc.
- **Check the weather:** Search *weather,* and Google presents an interactive card with weather information, courtesy of The Weather Channel. By default,

a search for *"weather"* prompts an info card for the location of your IP address. You can also search *weather + [any location]* and find the weather report for just about anywhere in the world: for example, *weather Toledo, OH* or *weather Kabul Afghanistan*.

- **Get stock quotes:** Type in any publicly traded company's ticker symbol, and Google shows current price information for that company—*"GOOG"* (for Google), *"AAPL"* (for Apple), or *"YHOO"* (for Yahoo). Most of the larger exchanges are in real time; Google offers a comprehensive disclaimer about which exchanges are on a delay.
- **Sunrise, sunset:** Want to know when Mr. Sun will be showing up or checking out in your (IP's) area? Type in *sunrise* or *sunset*.
- **Flight times:** Type in your flight number, and Google returns a card with updated flight times as well as terminal and gate information.
- **Search with placeholders:** When you're trying to think of a song lyric or famous movie quote, but can't remember all of it, type as much of the phrase as you can remember, then place an asterisk (*) with a space on either side where the missing word(s) should be. Google is usually able to fill in the rest (for example, *Frankly my * I don't give a damn*).
- **Find local attractions:** Sometimes you find yourself in the middle of a strange city and have no idea what to do. Search *[city name] attractions* to prompt a long info card with nearby points of interest.

Make the Most of Your Fitness Tracker

BY JILL DUFFY

Activity trackers can do a real service in helping people better understand their fitness levels, weight management issues, and sleep. They can be great motivators to change, too. But they have limits. They don't solve health issues on their own. Instead, they help clarify and organize information about your body, so you can make some sense of it.

DOES ACCURACY MATTER?

I've read the same studies as everyone else about whether fitness trackers and the optical heart rate monitors on some of them are accurate. To a degree, accuracy isn't all that important. Fitness trackers aren't perfect, but they don't need to be for you to get what you need out of them.

With step counting, what matters is figuring out your baseline and deciding whether to maintain it or alter it over time. It doesn't matter if I took 9,852 steps today. But it does matter that on average, I get 10,000, and if my goal is to sit less and move more over time, I'd want that average to increase by, say, at least 2,000.

Some fitness trackers actually emphasize some sort of made-up "points" system instead of steps, which is likely an attempt to prevent people from getting distracted by the idea of "steps." Instead, points systems coax you to think about your overall movement and activity. Misfit's app, for example, lets you see step counts if you want, but it puts points front and center. The now-retired Nike FuelBand line of trackers did the same thing. Ultimately, fitness tracking is more about whether you're increasing your movement measurably from your baseline.

Resting-heart-rate accuracy is similar. Unless a specific medical condition requires you to keep a close and accurate eye on your resting heart rate, a ballpark figure or zone is good enough for the purpose of getting a sense of your fitness level. If my resting heart rate is 58 beats per minute (bpm) one morning and 62bpm the next, that's fine; it's not going to be the same every day. But if I take my own heart rate using my fingers and estimate it at 60bpm, and then I use a device that says my heart rate is 85bpm, that's too far off. One of my measurements is probably wrong.

LISTEN TO YOUR HEARTBEAT

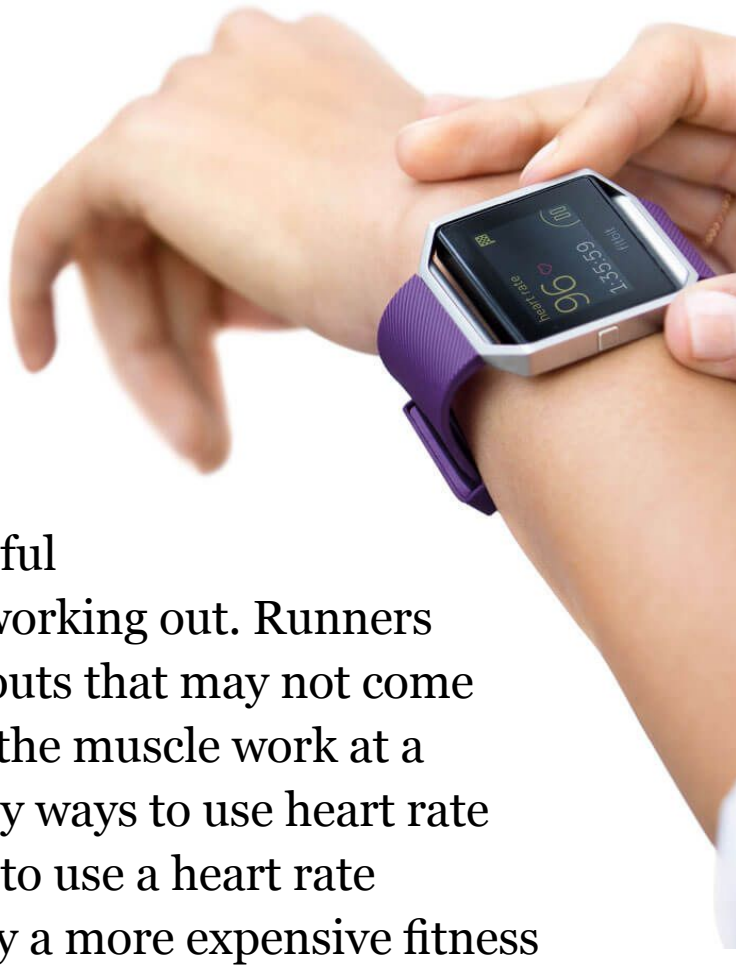
Unless you have a particular medical need to know exactly what your resting heart rate is, a ballpark number is good enough to go on.

Within a range, the accuracy of personal health-tracking devices such as fitness trackers and heart rate monitors—which are not regulated by the FDA—is not that big a deal. You just have to develop a reasonable sense of what it means for numbers to be within the same range. Sometimes you can guess by looking at the options fitness trackers provide for goals you can set.

DO YOU NEED A HEART RATE MONITOR?

Whether resting heart rate is something you need to track at all is another question entirely. Many people who ask me about fitness trackers say they want one with a heart rate monitor. "Okay. What will you do with your heart rate data?" I ask them.

The fact is, you don't need an optical heart rate monitor on a fitness tracker to record resting heart rate. There are free mobile apps that measure resting heart rate and log the data over time to give you a baseline average. Two examples are Runtastic Heart Rate Monitor (for Android and iOS) and Instant Heart Rate by Azumio (for Android, iOS, and Windows Phone).



Using heart rate data during exercise or for training is another story entirely. When you're active, heart rate information becomes really valuable. People who are just starting a fitness plan, for example, might need to check whether they are getting their heart rate high enough for the exercise to benefit them. Others might need to be careful not to strain their hearts too much if they are new to working out. Runners and bicyclists increase their endurance through workouts that may not come close to their maximum safe heart rate but that make the muscle work at a moderate rate for long periods of time. There are many ways to use heart rate data while working out, but if that's not how you plan to use a heart rate monitor, you should question whether you need to buy a more expensive fitness tracker that has one in the first place.

WHAT'S THE DIFFERENCE BETWEEN STEPS AND ACTIVITY?

If you're just trying to get off the couch more, step counting is fine. But if you actually have plans to get your heart rate up and work out, you need to start tracking activities.

"Activity," in fitness tracker parlance, comprises exercise and physical activity that you do for an amount of time. An activity might be a session on an elliptical

THE STATE OF BEING ACTIVE
Some fitness trackers can identify when you begin and end activities; others require a button press but give you control over start and stop times .

machine or playing basketball for fun. It can even be going for a brisk walk during your lunch hour. But walking periodically from your desk to the bathroom doesn't count.

The most useful activity trackers differentiate between activities and step counting. Some of them, such as the Fitbit Alta and Misfit Ray, automatically recognize when you start and end an activity. These devices notice when you jiggle and jostle your body more than normal.

Other trackers let you manually record an activity by pressing a button, which is better if you want fine control over your start and stop times, the way many runners do. The Garmin Vivoactive uses this method, as does pretty much every other device that's a hybrid runner's watch and fitness tracker. The Fitbit Charge HR also has a start/stop timer for activities, even though it doesn't double as a runner's watch.

You can track activities without a fitness tracking device if you use a good fitness tracking app. One of my favorites is Strava, which has a special feature for Premium members called Strava Suffer Score. When you record an activity with Strava and wear a compatible heart rate monitor (it also works with bike power meters), the app calculates a score that tells you not only how long you worked out but how hard. The score is based on which heart rate zones you reached and how long you stayed in them. That's a smart way to actually use heart rate data and activities to track and improve your fitness. In short, it's a whole lot smarter than checking daily step counts.

WHY ARE YOU TRACKING YOUR SLEEP?

It could be because you're curious about how much you sleep, or maybe it's because you sleep poorly and want to figure out why.

Those two reasons are radically different from one another. Any old sleep tracker will meet your needs if all you want to know is how many hours and minutes you sleep each night. But if you're trying to figure out what's wrong with your sleep, you need more information.

IN YOUR DREAMS
Fitness trackers can help you figure out if you're getting enough sleep and track your slumber over time.

Whether you're using a fitness tracker to measure sleep or a more elaborate bed-based device, like the Sleepace RestOn or Misfit Beddit, you need to start looking at how sleep data correlates with other factors in your life. If you're waking up needlessly throughout the night, you should also look at your sleep phases or sleep cycles to pinpoint how you're sleeping before you're disturbed. Being woken from a dead slumber and being stirred out of light sleep could have different causes.

Look at your sleep data in relationship to the other data you're recording, such as daily activity and food intake. Are there any correlations? Do you sleep poorly after a day of low activity, or do you toss and turn from pain in your legs after a long run? I don't know of any apps that do this well, but you might also want to independently track alcohol and caffeine intake when looking for factors that could be having an effect on your sleep.

GET IT TOGETHER

When you think about tracking for the long term, it makes sense to use technology where it's possible, rather than just tracking in your head or in a notebook. Technology helps us reduce errors from manual recording and spot trends over time. It can alert us when we slip and give us personalized suggestions for how to get back on track.

Road Trip Tech for Families

BY SASCHA SEGAN

Are kids today less patient than they used to be? I'm old enough to remember when "road trip" meant staring out the window of an Oldsmobile Delta 88 counting license plates. But I'm also a dad now, and honestly, my kid wouldn't put up with that. If you're lucky enough to have patient, well-behaved kids who daydream out the windows, bless you. For the rest of us, try this hardware and software checklist.

HARDWARE

Tablets. Tablets are the backbone of any efficient modern road-tripping operation. The $50 Amazon Fire is the ideal music and video playback tablet, affordable enough that each kid in the back seat can have one of their own. You can fill it with books, or use it to run Disney Radio so you don't have to listen to Disney Radio. Sign up for Prime Video or Amazon FreeTime, and cache your videos on a SanDisk Extreme 64GB MicroSD card, which you can find for $30. That way, you don't have to worry about streaming on the road.

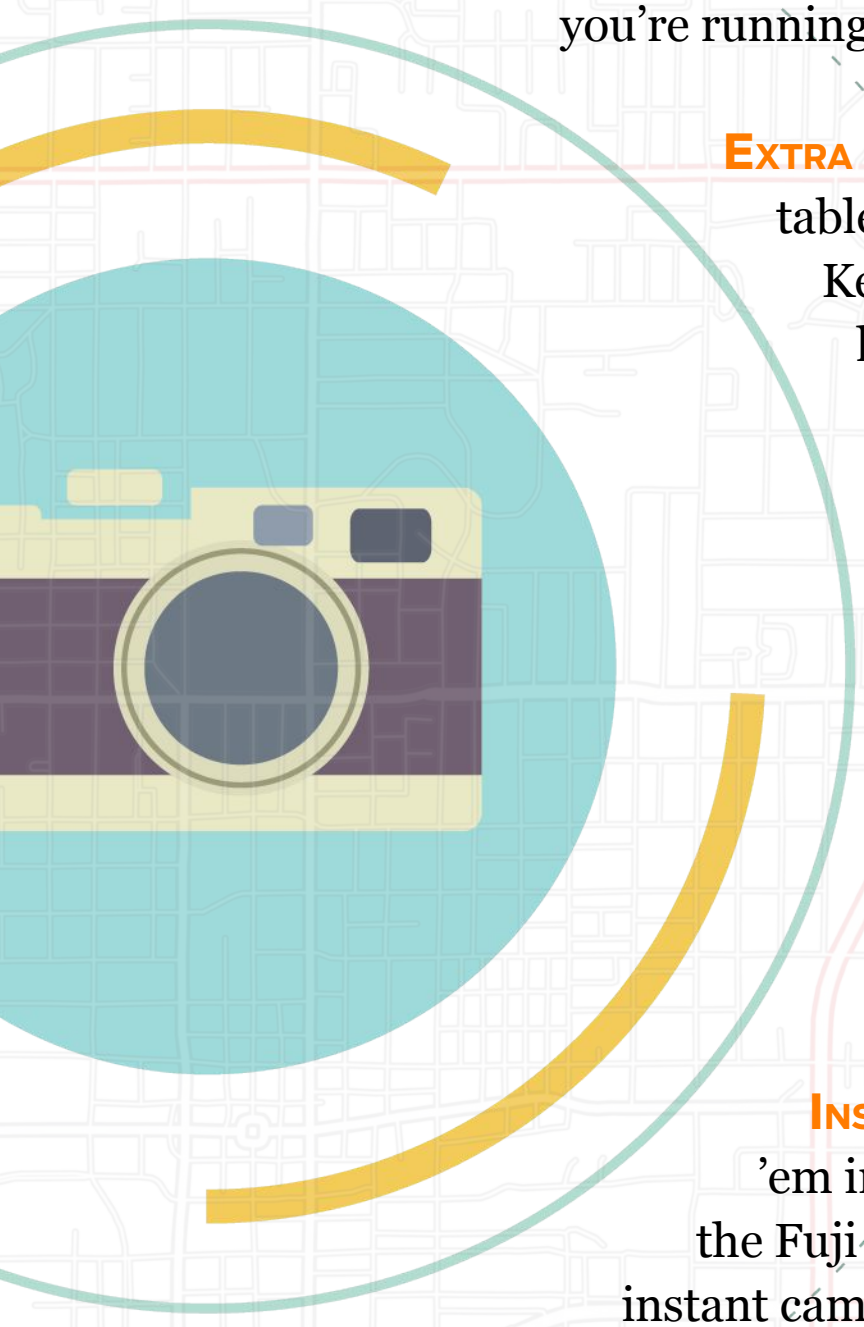
For more gaming-focused kids, iOS is still the gold standard, with the best array of kid-friendly games. Currently, the $399 iPad mini 4 is the way to go. If that's too rich for your blood, the $199 version of the Asus ZenPad S 8.0 runs Minecraft and media players very well.

Kid-safe headphones. Special children's headphones limit their volume to 80dB or 85dB to prevent hearing loss. We like the comfortably padded Nabi Headphones ($50) because they can grow with your child, with a Parent mode without the volume restriction. They also sound quite good for the price.

Internet. Using your phone as a hotspot should be fine for a family road trip. If you don't have a hotspot plan, or you're worried about going over your data limit, the H2O Bolt prepaid hotspot ($59.99) gives you 4GB over ten days for $25 on the AT&T network, perfect for a family vacation.

A power inverter. If you have a bunch of electronic devices in your backseat, you may want to recharge them on the road. Bestek's 200-watt Car Cup Power Inverter ($42.99) fits into the cup holder in your center console and gives you two AC ports and two USB ports. I wouldn't run a laptop off of it, but

it's fine for keeping phones and tablets charged, especially when you're running your phone as a hotspot.



Extra rechargeable batteries. You don't want your tablet to run out of batteries before the kids do. Keeping an Anker Powercore 10400 battery on hand can be a real life saver. With 10,400mAh of charging capacity, it can top up most smaller tablets entirely. It's $20—buy two.

A personal fridge. Oh, why not? You can keep sandwiches from getting squishy and prevent gas-station snack consumption. Amazon has a range of personal fridges available, all of which get similar reviews. The Uberchill runs about $50 and plugs into your cigarette lighter or power inverter.

Instant cameras. Want to get kids offline? Give 'em instant cameras. There's nothing digital about the Fuji Instax (about $55). This is an old-fashioned instant camera that goes straight from an analog image to film. If you buy the film as a 100-pack, you can get it down to $0.67 a shot. Pair this up with a roll of tape and a traditional scrapbook, and the kids can make a real hard-copy record of their journey.

SOFTWARE

As someone who has traveled around the world with a child, I've found all of these titles invaluable.

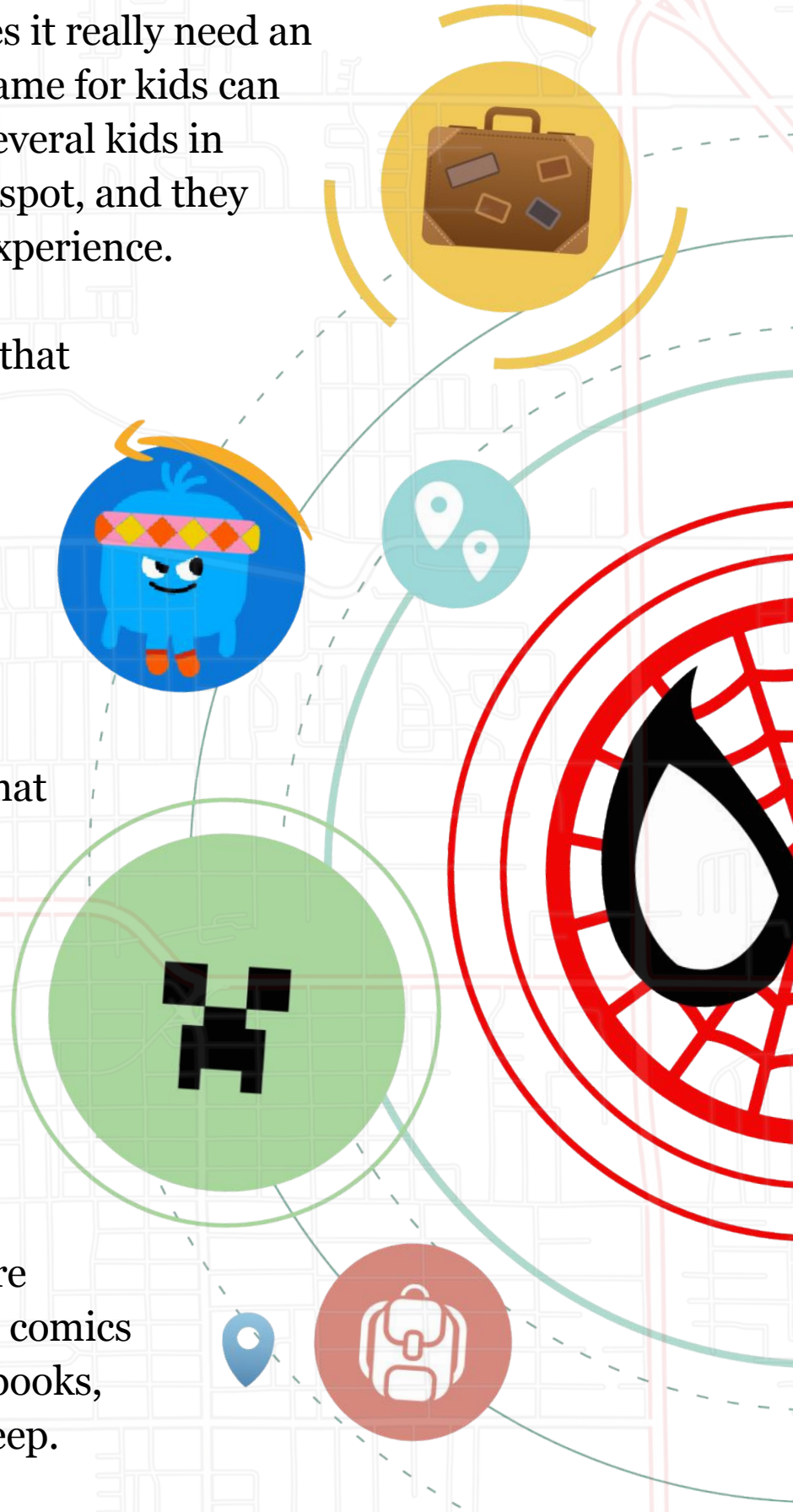
The Toca Boca suite. I'm a big fan of computer toys: open-ended experiences rather than games with a defined goal. For smaller children, the Toca Boca apps offer dozens of hours of violence-free, relatively mentally healthy experimenting. They're available on Android or iOS, and standouts include Toca Life: City, which is full of minigames, and Toca Builders, which is just baby Minecraft.

Minecraft PE. Speaking of Minecraft... Does it really need an explanation? The ultimate world-building game for kids can keep them endlessly occupied. If you have several kids in the backseat, use your phone to spawn a hotspot, and they can all play together as a local multiplayer experience.

Amazon Video. In terms of legal video apps that let you download movies for later viewing, Amazon is the best, in my experience. It's important to have locally stored videos for when you pass through those inevitable 2G phone zones. Netflix is also great, but when you hit that 2G zone, there goes your video.

VLC Media Player. If you have video files that you acquired elsewhere (say, from ripping your own DVDs), VLC will play them. No judgment.

Marvel Unlimited. I think this app is a sleeper, in terms of reaching a broad array of kids. If you have Wi-Fi signal, this app lets your kid read tens of thousands of Marvel comics, up to about six months before the present day. In my road-trip experience, comics tend to cause less car sickness than regular books, and the Marvel Unlimited library is really deep.



JOHN C. DVORAK

How the Apple Car Could Succeed and Why It Won't

Apple should market a large-screen TV set. People would pay a premium for its built-in features and design, and it would help spruce up the Apple Store sales engine. An actual Apple HDTV would prove once again that the company can revitalize a moribund CE category. But no, the little set-top box called Apple TV looks like all that's forthcoming in this category.

Instead, according to seemingly reliable rumors, prepare for the Apple Car, which is mind-boggling. Let's speculate together.

If you have been in an Apple Store recently, you see a large floor plan with far too many tables, each strewn with a bunch of MacBooks or iPhones or Apple Watches. Apple isn't going to build out large car dealerships with a bunch of models on the floor. Existing Apple stores have more than enough room for one car to be on display. This would draw in curious shoppers and easily top any interest in a 4K TV. The car would be placed near the back, so the public would have to walk by all the shiny iPhones and MacBooks. You'd have a couple of dedicated Apple employees there to sell the car, which would be delivered individually.

The next thing to consider is what kind of car Apple would design and build. It would have to be one of the best-looking cars out there. One false move, and Apple could squander billions and negatively affect its image. If the design is too weird or subject to ridicule, or if it picks up a derisive nickname such as "the dildo," "dog poop," "the dung beetle," "the pickle jar," or "the dork mobile," then it will be D.O.A.

Size is another consideration. Since the car is part of the luxury marketing generally employed by Apple, it cannot be the size of a diminutive Fiat 500. But should it be the size of the Tesla Model S? Or even the clunky Tesla Model X?

The Chevrolet Volt is the ideal size: a perfect mid-sized car that is very roomy. In fact, the Chevy Volt should be a design target in more ways than one, including the hybrid approach. I have tested most of the electric cars available and prefer the Volt, because you never get nervous about the battery dying. The white-knuckle fear that you'll run out of juice is real. The Volt, meanwhile, is about the right size for the Apple Store. A 3-series BMW would also be a good target size, as would the Lexus RC 350.

What else would make this car a winner? It would have to be well-made, self-driving, and modern, if not futuristic.

And here comes the rub: The price. While Apple has a captive market with its phones and computers, these luxury items are luxury for the masses. A high-school prom queen can own an iPhone, but so can the rest of the class. Will someone who would normally buy a Lexus, Audi, Mercedes, Tesla, or even a Cadillac decide to buy an Apple car instead? I can see them buying a wall-mounted Apple TV. But a car would require a sociological and attitudinal change in the public's vehicular taste. I'll have to see it to believe it.

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